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TO: Livestock Producers
Livestock Agribusiness Segment
Researchers & Educators
Others in Animal Agriculture

RE: 1985 Animal Science Research Report (ASRR)

The 1985 ASRR is the biggest, and we believe best, that we have published so far, with information for all segments of Animal Agriculture. This has been accomplished in spite of reductions in appropriations, livestock income, faculty and staff, and with escalating costs, and is a real tribute to the continuing commitment and innovativeness of our scientists and support staff.

Keep in mind, however, that much of the research reported today was initiated two to five years ago. With continuing resource constraints the flow of useful research results is bound to decrease dramatically.

The purpose of this research report is to provide technology for Animal Agriculture. What is its significance? Most of today's critical problems in Animal Agriculture were caused by external forces (national debt, lack of export, high interest rates, high costs), and the individual producer can do little about them.

What the individual producer can do is apply all available technology, and be the best possible manager, and maximize profit in his/her operation in today's economic environment. It is to this end that this publication is intended.

Yours truly,

Robert Totusek, Head
Animal Science Department

RT/csw

CENTENNIAL DECADE 1980 • 1990

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RESEARCH IN PROGRESS

PURPOSE FOR PUBLICATION

The information given in this publication is for education purposes only. The articles have been subjected to peer review for scientific merit, adequacy of experimental procedures and correctness of interpretation. Mention of a trademark, proprietary product or vendor does not constitute a guarantee or warranty of the product nor does it imply its approval or disapproval to the exclusion of other products of vendors that may also be available.

Some chemicals and products used in the research have not been approved for commercial use at the time of this publication. Research is necessary to determine the value as well as the safety of new products and procedures. The value of products tested may not be similar under other feeding or management conditions.

Research Report Committee

Confidence in Research Results

Variability among animals can lead to problems in interpreting experimental results. When animals on one treatment gain more rapidly than those on another treatment, it may be that, by chance the animals on the first treatment were faster gaining animals than those on the second, or it may be that the first treatment caused the animals to gain faster. Scientists use statistical analysis procedures to calculate the probability that such differences are due to chance rather than treatment.

In some of the articles in the Animal Science Research Report, the writers state that two averages are "significantly different" or the notation "$P < .05$" is used. This means that the probability the differences referred to in the article resulted from chance is less than 5 in 100. In other words it is quite unlikely that the results obtained were due to chance and it is likely that the treatment caused the differences that were observed.

In some articles there are tables of values with a $\pm$ and another value, such as: $3.6 \pm .5$. The 3.6 is called the mean, or average, of the sample of animals that was studied and is an estimate of the mean of the larger group of animals from which the sample came. The .5 is called the standard error and is a measure of the precision of the estimation procedure. This means that the probability is .68 that the value being estimated by the sample mean is within one standard error of the estimate.

Some papers report "correlation" coefficients. These are measures of positive or negative relationships between traits or variables. Positive relationships mean that when one variable is higher than average the other variable tends to also be higher than average. Negative correlations mean that larger than average values in one trait are associated with smaller than average values of the other trait. Correlations range from -1 for negative to $+1$ for positive relationships. The nearer the values are to 1 or -1 the stronger the relationship. When a correlation is statistically significant there is strong evidence that the relationship found was not due to chance. Correlation does not mean cause and effect but rather gives us insight into potential relationships between traits.

Statistical analysis procedures benefit scientists by helping them place the proper amount of confidence in their experimental results. Readers of these research reports can also benefit from the proper interpretation of the statements from the statistical analysis.

PRODUCTIVITY OF VARIOUS TWO-BREED CROSS COW GROUPS

R.R. Frahm[1] and D.M. Marshall[2]

Story in Brief

Performance of various two-breed cross cow goups (Hereford X Angus, HA; Angus X Hereford, AH; Simmental X Angus, SA; Simmental X Hereford, SH; Brown Swiss X Angus, BA; Brown Swiss X Hereford, BH; Jersey X Angus, JA and Jersey X Hereford, JH) producing 1,721 three-breed cross calves over a seven year period was evaluated. Cows ranged in age from three to nine years and were mated to two sire breeds each year (Charolais and Brahman, two years; Charolais and Limousin, four years; Limousin and Gelbvieh, one year). Calves were born in the spring and weaned at an average age of 205 days. Compared to average birth weights of calves from HA and AH cows (81.3 lb), calves from S and B cross cows were averaged 5.5 lb heavier, and calves from J cross cows averaged 4.2 lb lighter. Frequency of calving difficulty for SA cows (21.7%) was greater than for AH, BH and J cross cows (averaged 10.1%). Weaning rate averaged 81.2% for J cross cows, 74.2% for HA, AH, SA and BA cows and 68.9% for SH and BH cows. Compared to the weaning weight of calves from HA and AH cows (averaged 472 lb), calves from S, B and J cross cows were 10, 12 and 7% heavier, respectively. Compared to the average weight of HA and AH cows (928 lb), S cross cows were 8% heavier, B cross cows were 4% heavier and J cross cows were 11% lighter. Jersey cross cows weaned the heaviest calves as a proportion of cow weight. Calf weaning weight per cow exposed to breeding, a measure of cow productivity, averaged 353 lb/cow for HA and AH cows. Compared to HA and AH, productivity was 7% greater for SH and BH cows, 13% greater for BA and JH cows and 17% greater for JA cows.

(Key Words: Crossbreeding, Cow productivity, Hereford, Angus, Simmental, Brown Swiss and Jersey.

Introduction

Crossbreeding has become increasingly accepted and recommended for commercial beef production. In addition to potential heterosis benefits from crossbreeding, the wide variety of cattle types currently available allows considerable flexibility in matching complementary breed types to local environmental resources and management systems. Thus, it is important to characterize breed types for an array of performance traits affecting economic merit.

The present study is a portion of a comprehensive research project designed to evaluate lifetime productivity of various two-breed cross cows when mated to bulls of a third breed. Efficient production of weaned calves is an important component contributing to the overall efficiency of producing retail beef. The objective of this study was to evaluate and compare cow productivity and calf performance to weaning of various two-breed cross cow groups.

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[1]Professor [2]Graduate Assistant

Materials and Methods

Data used in this study were collected from 1976 through 1982. Crossbred females were produced in 1973, 1974 and 1975 by Angus (A) and Hereford (H) cows mated to H, A, Simmental (S), Brown Swiss (B) and Jersey (J) bulls to produce eight two-breed cross groups (HA, AH, SA, SH, BA, BH, JA and JH). Two-breed cross heifers were mated to Shorthorn and Red Poll bulls to produce three-breed cross calves at two years of age (Belcher et al., 1978). Data used in the present study were collected from these cows as three- to nine-year-olds when mated to relatively larger sire breeds (Table 1).

Table 1. Mating design[a].

Year of calf birth	Cow age(s)	Sire breeds	No. sires[b]
1976	3	Charolais	4
		Brahman	3
1977	3, 4	Charolais	9(3)
		Brahman	3
1978	3, 4, 5	Charolais	8(4)
		Limousin	8
1979	4, 5, 6	Charolais	8(3)
		Limousin	8
1980	5, 6, 7	Charolais	8(4)
		Limousin	8
1981	6, 7, 8	Charolais	8(6)
		Limousin	8
1982	7, 8, 9	Limousin	7
		Gelbvieh	7

[a]Each crossbred cow group (Hereford x Angus, Angus x Hereford, Simmental x Angus, Simmental x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus and Jersey x Hereford) and calf sex (steer and heifer) was represented in each sire, cow age and year.

[b]Number in parentheses is the number of sires previously used.

Two sire breeds were used each year: Charolais and Brahman for two years, Charolais and Limousin for four years and Limousin and Gelbvieh for 1 year. The number of bulls of a given sire breed used in a given year ranged from three to nine. Some of the Charolais bulls were used more than one year. In a given year, each bull was mated to approximately the same number of cows, and bulls were randomly assigned to cows within each crossbred cow group X cow age subclass. Cows were bred predominantly by artificial insemination, however, some were bred by natural service in single sire breeding pastures.

Cows were managed on native tall grass and bermudagrass pastures at the Lake Carl Blackwell Research Range near Stillwater. Supplementary prairie hay and cottonseed meal were provided as needed in the winter months to meet protein requirements and to assist cows in maintaining condition adequate for rebreeding.

The breeding season started May 1 and lasted for approximately 75 days. Thus, calves were born mostly in February and March. Calves remained with their dams with no creep feeding until weaned in the fall at an average age of 205 days. Cows were closely observed during the calving season and each birth was assigned a calving score by the herdsman (1=no difficulty, 2=minor assistance without mechanical puller, 3=moderately difficult pull, 4=hard pull, 5=Caesarian birth and 6=abnormal presentation). Birth data for abnormally presented calves and twins were deleted prior to analysis. Calves receiving a calving difficulty score of 3, 4 or 5 were considered as being difficult births. At weaning, each calf was weighed and assigned a subjective condition score (1=very thin to 9=very fat) and conformation score (13=average choice). Cows were weighed prior to the start of the breeding season and at weaning.

Calving rate, percent live calves and weaning rate are all based on the number of cows exposed to breeding. Percent live calves was calculated based on the number of calves alive approximately 24 hours after birth. Crossbred cow group means for percent weaned were used as weighting factors for individual 205-day weights in calculating pounds of weaning weight per cow exposed to breeding. Cows were generally culled for failure to conceive two consecutive years or because of serious soundness or disposition problems. Crossbred cow group means for calving rate, percent live calves and weaning rate were calculated within years and then averaged over years.

Results and Discussion

Cow Reproductive Performance

Crossbred cow group means for reproductive traits are presented in Table 2. Calving rate averaged 88.3 % for J cross cows, 81.0 % for HA, AH, SA and BA cows and 73.7 % for SH and BH cows. Percentage of cows producing a live calf 24 hours after birth averaged 86.5 % for JA cows

Table 2. Cow reproductive performance.

Crossbred cow group[a]	% calves born[b]	% live calves[b]	% calves weaned[b]
HA	83.0	80.2	76.1
AH	81.0	76.6	73.2
SA	81.1	75.9	72.5
SH	73.8	69.3	67.9
BA	78.7	76.7	75.0
BH	73.6	71.1	69.8
JA	89.7	86.5	83.2
JH	86.8	81.6	79.2
Chi-square	40.0**	40.9**	30.9**

[a]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b]Based on number of cows exposed to breeding.
**P<.01.

80.9 % for HA and JH cows, 76.4 % for AH, SA and BA cows and 70.2 % for SH and BH cows. Percentage of cows producing a calf at weaning averaged 81.2 % for J cross cows, 74.2 % for HA, AH, SA and BA cows, and 68.9 % for SH and BH cows. Angus cross cows consistently produced a higher percentage of calves than Hereford cross cows. Excluding the HA and AH groups, calving rate and weaning rate, respectively, averaged 83.2 % and 76.9 % for Angus crosses and 78.1 and 72.3 % for Hereford crosses. The overall reproductive performance of these cows was somewhat lower than normal due to artificial insemination during a restricted breeding season under extensive range conditions.

Cow Weight and Calf Preweaning Traits

Cow weights, calf birth weights and calf weaning weights are presented by crossbred cow group and cow age in Table 3. The dam age X crossbred cow group subclass least squares means for cow weight indicate that J cross cows reached a higher proportion of their mature weight at an earlier age relative to the other cow bred types evaluated. Three-year-old cow weight as a percentage of mature weight averaged 87.8, 88.4, 88.1 and 94.4% for HA and AH, S, B and J cross cows, respectively. This helps explain the higher relative weights at birth and weaning of calves from J cross cows at younger ages. Weights of these cows at two years of age (Belcher et al., 1978) as a percentage of mature cow weight averaged 71.9, 72.7, 72.3 and 78.6 % for HA and AH reciprocal, S, B and J cross cows, respectively.

Birth weights of calves from J cross cows were heavier, relative to other crossbred dam groups, among three- and four-year-old dams than among mature dams. Compared to birthweight of calves from HA and AH cows, calves from S and B cross cows, respectively were 6 and 6% heavier for three-year-old cows, 66 and 11% heavier for four-year-old cows and 6 and 5% heavier for mature cows, whereas calves from J cross cows were 3, 4 and 9% lighter for three-year-old, four-year-old and mature cows, respectively.

Similar to the pattern of the crossbred cow group X cow age interaction for birth weight, weaning weights of calves from J cross cows were higher relative to other crossbred cow groups when the cows were three and four years of age than when the cows were mature. Compared to weaning weights of calves from HA and AH cows, calves from S, B and J cross cows, respectively, were 9, 11 and 9% heavier for three-year-old cows, 12, 14 and 7% heavier for four-year-old cows and 10, 13 and 4% heavier for mature cows. For these same cows as two- year-olds, Belcher et al. (1978) reported calf weaning weights of 370, 419, 437 and 417 lb for calves from A X H reciprocal, S, B and J cross cows, respectively. Compared to calves from A x H reciprocal cross cows, calves from S, B and J cross cows were 13, 18 and 13% heavier, respectively. Crossbred cow group least squares means for cow weight, calf birth weight and calving difficulty are presented in Table 4. Averaged over all age groups, HA cows were 37 lb heavier than AH cows. Compared to the average weight of HA and AH cows (928 lb), S cross cows were 75 lb (8%) heavier, B cross cows were 33 lb (4%) heavier and J cross cows were 106 lb (11%) lighter.

Calves from HA cows were 4.4 lb heavier at birth than calves from AH cows. Compared to the average birth weight of calves from HA and AH cows (81.4 lb), calves from S and B cross cows averaged 5.5 lb heavier, and calves from J cross cows averaged 4.2 lb lighter.

Table 3. Least squares means for cow weight, calf birth and weaning weight by crossbred cow group and cow age.

Crossbred Cow group[a]	No. calves born	Cow wt, lb cow age group 3	4	Mature	Calf birth wt, lb cow age group 3	4	Mature	Calf weaning wt, lb cow age group 3	4	Mature
HA	210	895	941	999	81.1	83.8	85.8	459	470	478
AH	205	838	911	974	75.0	77.6	85.1	448	478	489
SA	242	939	1012	1053	81.8	86.0	89.7	500	527	534
SH	176	930	1019	1060	84.2	85.8	91.7	487	536	534
BA	189	895	950	1012	81.3	86.9	88.0	500	531	547
BH	171	902	979	1027	83.3	92.2	92.2	505	549	542
JA	272	798	822	836	73.6	78.0	76.3	494	509	498
JH	256	794	833	851	78.0	76.9	79.2	494	509	507
Overall	1721	873	933	977	79.8	83.3	86.0	485	514	516

[a]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

Frequency of calving difficulty for SA cows (21.7%) was greater than for AH, BH and J cross cows (averaged 10.1%). The only other significant (P<.05) difference was between HA (17.4%) and JA (7.2%) cows. Crossbred cow group rankings for calving score were similar to those for percentage of calving difficulty.

Least squares means for average daily gain from birth to weaning, weaning weight and weaning scores are presented in Table 5. Calves from HA cows had the slowest rate of gain from birth to weaning (1.88 lb/day) and were exceeded by calves from AH cows (1.93 lb/day), SH and J cross

Table 4. Least squares means for cow weight, calf birth weight and calving difficulty.

Crossbred cow group[a]	No. calves born	Cow weight		Calf birth weight		Calving difficulty	
		lb	% HA,AH	lb	% HA,AH	Score[b]	%[c]
HA	210	946^{e}	102.0	83.6^{f}	102.7	1.53^{de}	17.4^{de}
AH	205	908^{f}	98.0	79.2^{g}	97.3	1.36^{def}	10.2^{ef}
SA	242	1001^{d}	108.0	85.8^{ef}	105.4	1.58^{d}	21.7^{d}
SH	176	1003^{d}	108.2	87.3^{de}	107.3	1.45^{def}	13.9^{def}
BA	189	952^{e}	102.7	85.3^{ef}	104.9	1.40^{def}	15.7^{def}
BH	171	970^{e}	104.6	89.1^{d}	109.5	1.29^{ef}	9.5^{ef}
JA	272	818^{g}	88.2	76.1^{h}	93.5	1.29^{f}	7.2^{f}
JH	256	825^{g}	88.9	78.0^{gh}	95.9	1.39^{def}	13.4^{ef}
Overall	1712	928		80.9		1.41	13.6

[a]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b]1=no difficulty, 2=little difficulty, 3=moderate difficulty, 4=major difficulty and 5=Caesarian.
[c]Percentage of calves with a calving score of 3, 4 or 5.
[defgh]Means in the same column not sharing a common superscript differ ($P<.05$).

cows (averaged 2.07 lb/day), SA cows (2.13 lb/day) and B cross cows (averaged 2.17 lb/day). Weaning weights of calves from S, B and J cross cows exceeded those of calves from HA and AH cows (averaged 418 lb) by 46, 57 and 31 lb (10, 12 and 7 percent), respectively.

Calves were quite uniform at weaning with respect to condition scores (averaged 5.0). Weaning conformation scores ranged from 13.8 for calves from S cross cows to 13.0 for calves from J cross cows. Thus, calves from all crossbred cow groups had quite acceptable conformation.

Estimates of Cow Productivity

Least squares means for cow productivity traits are presented in Table 6. Ratios of calf weight to cow weight or to cow metabolic weight (cow weight$^{.75}$) have often been calculated in studies as estimators of cow efficiency. Based on the ratio of calf weaning weight to cow weight, J crosses weaned the greatest percent of cow weight (61.9%), followed by B crosses (averaged 55.7%), AH and S crosses (averaged 52.4%) and HA (50.3%). Compared with the average of HA and AH cows, the calf weaning weight to cow weight ratios for S crosses were similar, and those for B and J crosses were 8 and 20% greater, respectively. The ratio of calf weaning weight to cow metabolic weight (cow weight$^{.75}$) favored S, B and J cross cows by 3.4, 9.3 and 14.7%, respectively.

Table 5. Least squares means for calf average daily, gain, weaning weight and weaning scores.

Crossbred cow group[a]	No. calves weaned	Avg daily gain		Weaning weight		Weaning scores	
		lb/day	% HA,AH	lb	% HA,AH	Condition[b]	Conformation[c]
HA	198	1.88[h]	98.8	470[g]	99.8	5.0	13.2[h]
AH	196	1.93[g]	101.2	472[g]	100.2	5.1	13.4[g]
SA	221	2.13[e]	112.0	520[de]	110.5	5.1	13.8[d]
SH	165	2.09[f]	109.8	516[e]	109.6	5.1	13.8[de]
BA	183	2.18[d]	114.4	527[de]	111.9	5.0	13.6[f]
BH	165	2.16[de]	113.6	531[d]	112.9	4.9	13.6[ef]
JA	254	2.05[f]	107.7	500[f]	106.3	5.1	12.9[i]
JH	242	2.07[f]	108.6	503[f]	106.8	5.1	13.0[i]
Overall	1624	2.06		505		5.0	13.4

[a]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b]Condition score equivalents: 1=very thin to 5=moderate to 9=very fat.
[c]Conformation score equivalents: 12=low choice, 13=average choice and 14=high choice.
[defghi]Means in the same column not sharing a common superscript differ (P<.05).

Table 6. Least squares means for measures of cow productivity.

Crossbred cow group[a]	No. Calves weaned	Calf weaning wt/cow wt		Calf weaning wt/cow wt$^{.75}$		Calf weaning wt per cow exposed	
		lb/lb	% HA,AH	lb/lb	% HA,AH	lb	% HA,AH
HA	198	$.503^{e}$	97.8	2.78^{f}	98.3	357^{e}	101.3
AH	196	$.526^{d}$	102.2	2.88^{e}	101.7	348^{f}	98.8
SA	221	$.527^{d}$	102.4	2.95^{d}	104.3	379^{d}	107.5
SH	165	$.519^{d}$	100.9	2.91^{de}	103.0	351^{ef}	99.4
BA	183	$.559^{c}$	108.6	3.09^{c}	109.5	399^{c}	113.1
BH	165	$.554^{c}$	107.7	3.07^{c}	108.6	373^{d}	105.6
JA	254	$.620^{b}$	120.5	3.29^{b}	116.4	412^{b}	116.9
JH	242	$.617^{b}$	119.9	3.29^{b}	116.4	397^{c}	112.5
Overall	1624	.553		3.03		377	

[a]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[bcdef]Means in the same column not sharing a common superscript differ ($P<.05$).

A very useful measure of total herd productivity is the pounds of calf weaned per cow in the breeding herd. On this basis, HA cows were 2.5 percent more productive than AH cows. Compared to the average of the HA and AH reciprocal crosses (average 353 lb cow), SA and BH cows were 24 lb/cow (7 percent) more productive, BA and JH cows were 46 lb/cow (13 percent) more productive and JA cows were 60 lb/cow (17 percent) more productive. The SH cows were similar in productivity to HA and AH cows.

Conclusion

These data indicate that important differences exist in herd productivity among the various two-breed cross cow groups evaluated. For specific production objectives under various management systems practical by Oklahoma cattlemen, these data provide basic information useful in selecting specific crossbred cows and designing crossbreeding systems that will maximize production efficiency.

Literature Cited

Belcher, C. G., et al. 1978. Productivity of two-year-old crossbred cows producing three-breed cross calves. Okla. Agr. Exp. Sta. Res. Report MP-103:105.

FEEDLOT PERFORMANCE OF THREE-BREED CROSS CALVES PRODUCED BY VARIOUS TWO-BREED CROSS COW GROUPS

D.M. Marshall[1] and R.R. Frahm[2]

Story in Brief

Over a seven year period, feedlot data were collected on 1,514 three-breed cross steers and heifers produced by Hereford X Angus (HA), Angus X Hereford (AH), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows mated to Charolais, Brahman, Limousin and Gelbvieh bulls. Calves entered the feedlot each year at weaning and were fed to an anticipated low choice carcass grade. Compared to calves from HA and AH cows (averaged 476 lb), initial weights were heavier for calves from S, B and J cross cows by 10, 12 and 5%, respectively. Compared to the average slaughter weight of calves from HA and AH cows (1102 lb), calves from S and B cross cows were 9% and 6% heavier, respectively, and calves from J cross cows averaged 4% lighter. For the entire feeding period, average daily gains for calves from HA, AH, S and B cross cows (averaged 2.53 lb/day) exceeded that of calves from J cross cows by 8%. Daily gains of calves from S cross cows exceeded gains of calves from HA cows by 4%. Calves from S cross, BH and HA cows were on feed an average of 261 days, followed by calves from BA, AH and JH (averaged 248 days) and JA (237 days). Compared to the average daily feed intake of calves from HA and AH cows (18.5 lb/day), calves from BA cows consumed 9% more and calves from S cross and BH cows consumed 5% more feed per day. Feed conversion favored calves from HA and AH cows (7.43 lb feed/lb gain) over calves from SA, BA and JH cows by an average of 5% and calves from JA cows by 7%.

(Keywords: Crossbreeding, Feedlot Performance, Angus, Hereford, Simmental, Brown Swiss, Jersey)

Introduction

This study is one of a series designed to evaluate and compare lifetime productivity of two-breed cross cows when mated to bulls of a third breed. The preceeding paper characterized cow productivity and calf preweaning performance for these cows. Evaluation of cow breed types for use in commercial beef production should be based on a wide spectrum of important production traits. Thus, the objective of this study was to evaluate feedlot performance of three-breed cross calves from various two-breed cross cow groups when fed a finishing ration from weaning to a low choice carcass grade.

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[1]Graduate Assistant [2]Professor

Materials and Methods

Feedlot data were collected on 1,514 three-breed cross calves (771 heifers and 743 steers) over a seven year period. The calves were born in the spring (1976-1982) from Hereford X Angus (HA), Angus X Hereford (AH), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows mated to Charolais, Brahman, Limousin and Gelbvieh bulls. Only two sire breeds were used in a given year and they were randomly assigned to one-half of the cows in each crossbred cow group. Cow ages ranged from three to nine years.

Calves were reared with their dams on native tall grass and bermudagrass pastures at the Lake Carl Blackwell Research Range west of Stillwater. Calves were born mostly during February and March and were weaned in October at an average age of 205 days. Immediately after weaning, calves were transported to feedlot facilities at the Southwestern Livestock & Forage Research Station near El Reno, OK.

Calves were fed ad libitum the diet shown in Table 1. Feed intake data were available for the last five years of the study when calves of a given three-breed cross and sex were fed together in a randomly assigned pen. Feed intake was measured on a pen basis. Feeding facilities consisted of two pole barns open to the south, each with 14 concrete floored pens. Each pen was 36 ft wide x 47 ft long with 21 ft of length under a roof. Because of the limited number of pens, contemporary calves from HA and AH reciprocal crosses were combined in a single pen.

Table 1. Composition of feedlot diet.

Ingredient	Percent in diet (as fed) 1976-78	1979-82
Corn	39	78
Milo	39	0
Ground alfalfa hay	8	8
Cottonseed hulls	4	4
Sugarcane molasses	5	5
Supplemental pellets[a]	5	5

[a]Supplemental pellets consisted of 67.6% soybean meal, 12% urea, 10% calcium carbonate, 8% salt, plus Aurofac, Vitamin A and trace minerals.

Based on visual appraisal of finish and feeling degree of finish over the loin and ribs, and hands-on appraisal of finish, calves were individually removed from the feedlot for slaughter when an anticipated low choice carcass grade was attained. Cattle were weighed and appraised for finish and selected individuals sent to slaughter at two week intervals.

The actual weaning weight was used as the initial feedlot weight. A shrunk final weight was obtained on each animal prior to shipment for slaughter. Average daily gain was calculated separately for the first 120 days on test, after 120 days and for the overall feedlot test period. Final age was the age of the calf when the final live weight was obtained.

Results and Discussion

Weights, Gains, Final Age and Days on Feed

The intended target of slaughtering cattle at a low choice carcass was achieved quite well. On a scale of 9=high Good, 10=low Choice and 11=average Choice, the average carcass grade over all groups was 10.0. Average carcass grades for crossbred groups ranged from 9.8 to 10.1. Thus, the following comparisons concerning feedlot performance are made among crossbred groups fed to a similar carcass grade.

Least squares means are presented for these traits by crossbred cow group in Table 2. Initial weights of calves from HA and AH cows (averaged 476 lb) were exceeded by weights of calves from S, B and J cross cows by 49, 58 and 26 lb (10, 12 and 5%), respectively. Compared to the average final live weight of calves from HA and AH cows (averaged 1102 lb), calves from S and B cross cows were 101 lb (9 percent) and 67 lb (6%) heavier, respectively, and calves from J cross cows averaged 46 lb (4%) lighter. Calves from JH cows were 26 lb (3%) heavier at slaughter than calves from JA cows.

For the first 120 days on feed, daily gains were similar for calves from AH, SA and SH cows (averaged 2.80 lb/day), exceeding gains of calves from HA and J cross cows by .11 and .31 lb/day, respectively. Calves from HA and B cross cows (averaged 2.74 lb/day) gained .25 lb/day faster than calves from J crosses. After 120 days on feed, there was relatively less variation in daily gains among crossbred cow groups. Gains were similar for calves from HA, AH, S and B cross cows (averaged 2.31 lb/day) and exceeded gains of calves from JA cows by .19 lb/day. Calves from SA, SH and BH cows gained faster than calves from JH cows (2.34 vs 2.20 lb/day).

Over the entire feedlot period, daily gains of calves from HA, AH, S and B cross cows (averaged 2.53 lb/day) exceeded gains of calves from J cross cows by .19 lb/day (8%). Calves from S cross cows gained .09 lb/day (4%) faster than calves from HA cows. Relative to other crossbred cow groups, postweaning growth rates of calves from J cross cows were less than preweaning growth rates (Frahm and Marshall, 1985). This likely reflects the effects of high milk producing ability relative to mature size of the Jersey crosses (Belcher et al., 1979).

Averaged over all crossbred cow groups, calves were on feed 253 days and were slaughtered at 461 days of age. Calves from S cross, BH and HA cows were fed an average of 261 days, followed by calves from AH, BA and JH cows (averaged 248 days) and calves from JA cows (237 days). Calves from HA cows were 9 days older at slaughter than calves from AH cows. Compared to the average final age of calves from HA and AH cows (462 days), calves from S cross cows were 11 days older, calves from B cross cows were similar in age and calves from J cross cows were 13 days younger.

Feed Intake and Feed Conversion

Least squares means for feed intake and conversion are presented by crossbred cow group in Table 3. Compared to the daily feed intake of calves from HA and AH cows (18.5 lb/day), calves from BA cows consumed 1.7 lb/day (9%) more, calves from S cross and BH cows consumed 1.0 lb/day (5%) more and calves from J cross cows had similar intakes (18.2 lb/day). Compared to feed conversion of calves from HA and AH cows (7.43 lb feed/lb gain), calves from SA, BA and JH consumed .37 lb (5%)

Table 2. Least squares means for feedlot traits.

Crossbred cow group[a]	No. calves	Initial wt		Final wt		Average daily gain				Final[b] age, days	No. days fed
						1st 120 days	After 120 days	Overall			
		lb	% HA,AH	lb	% HA,AH	lb/day	lb/day	lb/day	% HA,AH		
HA	175	472^{g}	99.1	1105^{e}	100.3	2.69^{d}	2.27^{cd}	2.47^{d}	98.7	466de	258^{cd}
AH	169	481^{g}	100.9	1098^{e}	99.7	2.78^{c}	2.29^{cd}	2.54^{cd}	101.3	457^{f}	249de
SA	210	529^{cd}	111.1	1199^{c}	108.9	2.80^{c}	2.36^{c}	2.56^{c}	102.2	470^{cd}	263^{c}
SH	161	522^{d}	109.7	1206^{c}	109.5	2.82^{c}	2.34^{c}	2.56^{c}	102.2	475^{c}	265^{c}
BA	175	534^{c}	112.0	1171^{d}	106.3	2.78^{cd}	2.29^{cd}	2.51^{cd}	100.4	462^{ef}	250de
BH	159	534^{c}	112.0	1166^{d}	105.9	2.76^{cd}	2.31^{c}	2.51^{cd}	100.4	463^{def}	259^{cd}
JA	236	498^{f}	104.6	1043^{g}	94.7	2.49^{e}	2.12^{e}	2.31^{e}	92.5	447^{g}	237^{f}
JH	229	507^{e}	106.5	1069^{f}	97.1	2.49^{e}	2.20^{de}	2.36^{e}	94.3	450^{g}	246^{e}
Overall	1514	509		1131		2.71	2.27	2.47		461	253

[a]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b]Average age of cattle when removed from the feedlot for slaughter at an anticipated low choice carcass grade.
[cdefg]Means in the same column not sharing a common superscript differ ($P<.05$).

more feed per lb gain and calves from JA cows consumed .54 lb (7%) more feed per lb gain. Calves from SH and BH were intermediate in feed conversion (averaged 7.63 lb feed/lb gain) and differed significantly (P<.05) from BA and JA. Excluding the HA and AH groups, calves from H cross cows consumed .16 lb (2%) less feed per lb gain than calves from A cross cows.

Table 3. Least squares means for feed intake and conversion.

Crossbred cow group[a]	No. pens	Daily feed intake lb/day	Daily feed intake % HA,AH	Feed/gain lb/lb	Feed/gain % HA,AH
HA, AH	20	18.5[d]	100.0	7.43[b]	100.0
SA	20	19.7[bc]	106.6	7.71[cd]	103.8
SH	20	19.4[c]	105.0	7.60[bc]	102.3
BA	20	20.2[b]	109.2	7.88[de]	106.1
BH	20	19.4[c]	104.8	7.65[bc]	103.0
JA	20	18.2[d]	98.4	7.97[e]	107.3
JH	20	18.1[d]	98.2	7.82[cde]	105.2
Overall	140	19.1		7.72	

[a]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[bcde]Means in the same column not sharing a common superscript differ (P<.05).

Conclusions

Important differences exist among crossbred cow groups evaluated in this study with respect to calf feedlot performance. Relative to the other crossbred cow groups, postweaning growth rate of J cross calves was inferior to their preweaning growth, while the opposite was true for calves from HA and AH cows. This apparently reflects the effects of cow milk yield relative to potential calf mature size or growth rate. Calves from S and B cross cows performed well, both before and after weaning, with respect to growth rate.

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CARCASS EVALUATION OF THREE-BREED CROSS CALVES PRODUCED BY VARIOUS TWO-BREED CROSS COW GROUPS

D.M. Marshall[1], R.R. Frahm[2] and L.E. Walters[2]

Story in Brief

Carcasses from 1506 three-breed cross calves produced by Hereford X Angus (HA), Angus X Hereford (AH), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows mated to Charolais, Brahman, Limousin or Gelbvieh bulls were evaluated over a seven year period. Calves were placed in a feedlot at weaning and fed ad libitum a finishing ration until being individually removed for slaughter as each calf attained an estimated low choice carcass grade. As per design, rib-eye marbling and carcass grade did not vary significantly among crossbred cow groups. Compared to carcass weights for calves from HA and AH cows (averaged 703 lb), carcasses of calves from S, B and J cross cows, respectively, averaged 9% heavier, 6% heavier and 5% lighter. Carcass weight per day of age was similar for calves from S and B crosses (averaged 1.3 lb/day) and exceeded the average of calves from HA and AH cows by 6%. External fat thickness of calves from HA and AH cows (averaged .60 in) was .10 in greater than for calves from S cross and JA cows and .14 in greater than for calves from BH and JH cows. The average rib-eye area of calves from HA and AH cows (12.7 in^2), was .8 in^2 smaller than that of calves from S cross cows, but .6 in^2 larger than that of calves from JA cows. Calves from J cross cows had slightly more estimated KHP fat than did calves from HA and SH cows (3.3 vs 3.1%). Dressing percentage was greater for calves from AH, SH and BH cows (64.3%) than for calves from HA and J cross cows (averaged 63.4%).

(Keywords: Crossbreeding, Carcass traits, Angus, Hereford, Simmental, Brown Swiss, Jersey)

Introduction

This paper is one of a series reporting evaluation of productivity of various types of two-breed cross cows when mated to terminal cross sires. Preceeding papers characterized crossbred dam groups for the cow-calf and feedlot segments of production. Carcass merit of calves should also be considered when evaluating cow breed types for use in commercial beef production, especially in a terminal crossing system in which all calves are slaughtered. Relatively few studies have included both steers and heifers in carcass evaluation of breed types. The objective of this study was to evaluate carcass traits of three-breed cross calves from various two-breed cross cow groups, when calves were fed to a low choice carcass grade.

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Materials and Methods

Carcasses from 1,506 three-breed cross calves (769 heifers and 737 steers) were evaluated over a seven year period. The calves were born in the spring (1976-1982) from Hereford X Angus (HA), Angus X Hereford (AH), Simmental X Angus (SA), Simmental X Hereford (SH), Brown Swiss X Angus (BA), Brown Swiss X Hereford (BH), Jersey X Angus (JA) and Jersey X Hereford (JH) cows. Cows ranged in age from three to nine years and were mated to Charolais, Brahman, Limousin or Gelbvieh bulls. Only two sire breeds were used in a given year and were randomly assigned to one-half of the cows in each crossbred cow group.

Following weaning in the fall at an average age of 205 days, the three-breed cross calves were placed in a feedlot and fed a corn or conr-milo finishing diet. Based on visual appraisal of finish and feeling degree of finish over the loin and ribs, calves were individually removed from the feedlot upon attaining an estimated low choice carcass grade and sent to a commercial slaughter plant. During the time cattle were being slaughtered, cattle were weighed and appraised for finish and selected individuals were sent to slaughter at two week intervals. After a minimum 48-hour chill, carcasses were evaluated for marbling and were assigned quality grades by university personnel.

Crossbred cow group means for percentage of calves weaned, calf survival in the feedlot and calf carcass weight were used in the calculation of carcass weight per cow exposed to breeding. Estimated yield of retail lean cuts per cow exposed to breeding was calculated by multiplying the mean estimated cutability by the mean carcass weight per cow exposed to breeding for each crossbred cow group.

Results and Discussion

Carcass Trait Evaluation

Least-squares means for carcass weight traits, fat thickness and rib-eye area are presented by crossbred cow group in Table 1. Compared to the average carcass weight of calves from HA and AH cows (703 lb), calves from S and B cross cows, respectively, produced 65 lb (9%) and 43 lb (6%) heavier carcasses. Calves from JA and JH cows, respectively, produced 44 lb (6%) and 28 lb (4%) lighter carcasses than calves from HA and AH cows. Carcass weight per day of age was greater for calves from AH cows (1.55 lb/day) than for calves from HA or J cross cows (averaged 1.50 lb/day). Calves from S and B cross cows attained similar carcass weights per day of age (averaged 1.63 lb/day), and exceeded the average of calves from HA and AH cows by 6%.

External carcass fat thickness was greatest for calves from HA and AH cows (averaged .60 in) and least for calves from BH and JH cows (averaged .45 in). Compared to the average for calves from HA and AH cows (12.7 in^2), rib-eye area was .8 in^2 (6%) larger for calves from S cross cows and .6 in^2 (5%) smaller for calves from JA cows. Calves from B cross (13.1 in^2) and JH (12.4 in^2) cows were similar to that of calves from HA and AH cows.

Least-squares means for estimated KHP fat, dressing percentage, cutability, marbling and quality grade are presented in Table 2. Calves from J cross cows had slightly more estimated internal (KHP) fat than did calves from HA and SH cows (3.31 vs 3.08%). Carcasses of other groups had an average of 3.19% KHP fat.

Dressing percentage was greater for calves from AH, SH and BH cows (64.3%) than for calves from HA and J cross cows (averaged 63.4%). Calves from SA and BA cows had intermediate dressing percent-ages (averaged 64.0%).

Estimated cutability was significantly greater for calves from BH, S and J cross cows (averaged 49.8%) than for calves from HA cows (49.2%). Cutability was significantly greater for calves from JH cows than for

Table 1. Least squares means for carcass weight traits, fat thickness and rib-eye area.

Crossbred cow group[a]	No. carcasses	Carcass wt		Carcass wt/ day of age		Fat[b] thickness		Rib-eye[b] area	
		lb	% HA,AH	lb/day	% HA,AH	in	% HA,AH	in^2	% HA,AH
HA	175	701^{e}	99.7	1.51^{e}	98.6	.61^{c}	102.6	12.6^{f}	99.8
AH	168	705^{e}	100.3	1.55^{d}	101.4	.58^{cd}	97.4	12.7^{ef}	100.2
SA	208	767^{c}	109.1	1.63^{c}	106.6	.50^{ef}	84.8	13.5^{c}	106.5
SH	159	769^{c}	109.4	1.63^{c}	106.2	.49^{efg}	82.8	13.3^{cd}	105.1
BA	173	745^{d}	106.0	1.62^{c}	105.8	.54de	90.1	12.9^{def}	101.7
BH	158	747^{d}	106.3	1.62^{c}	106.0	.47^{fg}	79.5	13.2^{cde}	104.3
JA	236	659^{g}	93.7	1.49^{e}	97.0	.50^{ef}	84.8	12.1^{g}	95.5
JH	229	675^{f}	95.9	1.51^{e}	98.3	.45^{g}	75.5	12.4^{g}	97.9
Overall	1506	721		1.57		.52		12.8	

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b] Measured at the 12th rib.
[cdefg] Means in the same column not sharing a common superscript differ (P<.05).

Table 2. **Least squares means for KHP fat, dressing percentage, cutability, marbling and quality grade.**

Crossbred cow group[a]	No. carcasses	Estimated KHP fat, %	Dressing percentage, %	Cutability, %	Marbling score[b,d]	Quality grade[c,d]
HA	175	3.10^{gh}	63.7^{fgh}	49.2^{g}	5.1	10.0
AH	168	3.18^{fgh}	64.3^{e}	49.4^{fg}	5.1	10.1
SA	208	3.19^{efgh}	64.0^{ef}	49.8^{ef}	5.1	9.9
SH	159	3.06^{h}	64.3^{e}	49.8^{ef}	5.0	9.8
BA	173	3.22^{efg}	63.9^{efg}	49.5^{efg}	5.0	10.0
BH	158	3.18^{efgh}	64.3^{e}	49.7^{ef}	5.2	10.1
JA	236	3.33^{e}	63.4^{gh}	49.8^{ef}	5.0	9.9
JH	229	3.28^{ef}	63.2^{h}	49.9^{e}	5.0	9.9
Overall	1506	3.19	63.9	49.6	5.1	10.0

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b] <5=small, 6=modest amount of marbling.
[c] 9=Good +, 10=Choice -, 11=Choice avg.
[d] Differences in marbling score and quality grade among crossbred cow groups were not significant (P>.05).
[efgh] Means in the same column not sharing a common superscript differ (P<.05).

calves from AH cows (49.9 versus 49.4%). There were no significant differences in cutability among S, B and J cross groups.

On the average, calves were slaughtered at the intended low choice carcass grade with little variation among crossbred cow groups. Crossbred cow group means ranged from 5.0 to 5.2 for marbling score (averaged 5.1) and ranged from 9.8 to 10.1 for carcass quality grade (averaged 10.0).

Presented in Table 3 are measures of production of carcass weight per cow exposed to breeding and estimated boneless, closely trimmed retail cuts per cow exposed to breeding. Characterization of crossbred types by these measures takes into consideration cow reproduction, calf survival, calf carcass growth and cutability. Production of carcass weight per cow exposed was 18 lb/cow (3.5%) greater for HA cows than for the AH cows. Compared to the average of HA and AH groups, production of carcass weight per cow exposed averaged 13 lb/cow (2.6%) less for the BH group, similar for SH and JH groups and 28 lb/cow (5.4%) greater for SA, BA and JA groups. Excluding the HA and AH groups, A crosses produced 5.7% more carcass weight per cow exposed than H crosses, largely reflecting the advantage in reproductive performance of the A cross cows over the H cross cows (Frahm and Marshall, 1985). Similar rankings were attained for production of retail cuts per cow exposed to breeding. The HA group produced 7 lb (2.8%) more retail cuts per cow exposed than the AH group. Compared to the average of HA and AH (255 lb/cow), production of retail cuts per cow exposed averaged 7 lb/cow (2.6%) for SH and JH cows and 17 lb/cow (6.5%) greater for SA, BA and JA cows. Excluding the HA and AH cows, A cross cows produced 5% more retail cuts per cow exposed than H cross cows.

Table 3. Production of carcass weight and estimated retail cuts per cow exposed to breeding.

Crossbred cow group[a]	Carcass weight per cow exposed[b]		Retail lean cuts per cow exposed[b]	
	lb/cow	% HA,AH	lb/cow	% HA,AH
HA	527	101.7	258	101.3
AH	509	98.3	251	98.7
SA	547	105.5	271	106.5
SH	520	100.4	260	102.2
BA	551	106.4	273	107.4
BH	505	97.4	251	98.7
JA	540	104.3	269	105.6
JH	525	101.3	262	103.0
Overall	529		262	

[a]H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b]Based on number of cows exposed to breeding.

Conclusion

While maternal traits are generally emphasized in studies evaluating cow breed types, carcass merit of calves is also an important consideration, especially in a terminal breeding program. With the exception of carcass weight, magnitudes of differences among crossbred cow groups in this study were relatively small for the traits evaluated. In general, both steer and heifer carcasses of all breed groups were quite acceptable and desirable from a consumer standpoint.

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ECONOMIC EVALUATION OF TOTAL BEEF PRODUCTION FROM VARIOUS TWO-BREED CROSS COW GROUPS

D.M. Marshall[1] and R.R. Frahm[2]

Story in Brief

A systems approach was used to evaluate economic efficiency of calf production of various two-breed cross cow groups (Hereford X Angus reciprocal crosses, HAx; Simmental X Angus, SA; Simmental X Hereford, SH; Brown Swiss X Angus, BA; Brown Swiss X Hereford, BH; Jersey X Angus, JA and Jersey X Hereford, JH) in a terminal crossbreeding system. Crossbred cow group differences in reproductive performance, feed requirements, calf growth rate, calf survival, calf carcass merit and cow salvage weight were considered in the system. Land area for the breeding herd was held constant and supplemental feed was purchased as needed to meet requirements. Feedlot nutrients were purchased as needed to allow calves to attain a low choice carcass grade. The number of cow-calf units per herd for the specified land area was greatest for J cross cows and lowest for S cross cows. Herds using SH and BH cows required the most replacement heifers to maintain constant herd size (herds using J crosses required the fewest), but gross returns from the sale of cull cows were also greater for SH and BH cow groups. Gross returns from the sale of slaughter calves was greatest for herds using BA, J cross and HAx cows and lowest for herds using S cross cows. Total costs were greatest for herds using SH cows and lowest for herds using JA and SA cows. The relative advantages and disadvantages of the various cross- bred cow groups tended to largely offset one another, resulting in small differences among groups in relative profitability of slaughter calf production. Gross margin per herd, used to evaluate relative profit- ability among crossbred cow groups, was greatest for the BA group. Herds using J cross, HAx, BH and SH cows produced slightly lower gross margins, followed closely by herds using SA cows. However, rankings for gross margin changed when the cost of replacement heifers was varied. Rankings changed only slightly when the cost of feedlot TDN was varied. In a separate analysis in which calving rate was held constant across crossbred cow groups, gross margins for slaughter calf production were highest for herds using SH cows, followed in order by herds using B cross, HAx, SA and J cross cows.

(Key Words: Crossbreeding, Economic efficiency, Angus, Hereford, Simmental, Brown Swiss and Jersey)

Introduction

This study is a portion of a comprehensive research project evaluating lifetime productivity of various two-breed cross cow groups (Hereford X Angus reciprocal crosses, HAx; Simmental X Angus, SA; Simmental X Hereford, SH; Brown Swiss X Angus, BA; Brown Swiss X Hereford, BH; Jersey X Angus, JA and Jersey X Hereford, JH) when mated

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to bulls of a third breed. To accurately determine the net worth of a crossbred type to the entire beef industry, it is necessary to evaluate crossbred types for a variety of important production traits, taking into consideration all production segments (i.e., cow-calf, stocker-feedlot and slaughter-packing). Important differences among the two-breed cross dam groups have been reported for milk production (Belcher et al., 1979), nutrient requirements (Marshall et al., 1982), cow productivity and calf performance to weaning (Frahm and Marshall, 1985), calf feed- lot performance (Marshall and Frahm, 1985) and calf carcass characteristics (Marshall et al., 1985). Crossbred cow group rankings were quite variable across the spectrum of traits evaluated, suggesting relative advantages and disadvantages of each crossbred type. The objective of this study was to evaluate economic differences among these two-breed cross cow groups, utilizing biological differences from experimental results and economic considerations under specified management situations.

Materials and Methods

Economic comparisons of crossbred cow groups were evaluated using a simulated beef production system that included the cow herd, feedlot and slaughter phases. A spring calving season was assumed and calves were weaned in the fall at 205 days of age. Replacement heifers were purchased in the spring at one year of age and exposed to bulls during the summer breeding season. Pregnant heifers entered the cow herd in the fall when calves were weaned from the existing cow herd.

Crossbred cow groups were compared under two alternative cow culling systems: CULL1, nonpregnant cows and heifers were culled at weaning time in the fall; CULL2, nonpregnant cows and heifers were culled in the fall and cows and heifers without a live calf in the spring were culled at the end of the calving season. In addition, 1 percent management culls (sold at weaning) and 2 percent annual cow death loss were assumed for each crossbred cow group.

Land size for the breeding herd was fixed at 1000 acres. Within each culling system, the given land area was assumed sufficient to provide pasture for 100 HAx cow-calf units (cows of approximately 1000 lb mature size), including replacements, under typical north central Oklahoma range conditions. Supplementary cottonseed meal and bermuda-grass hay were purchased to allow cows to meet protein and energy requirements. Nutrients required for the feedlot segment of production were purchased as needed. All calves entered the feedlot immediately after weaning and were fed a corn-milo finishing ration until attaining a low choice carcass grade.

The carrying capacity (or equivently, herd size) for a given cross-bred cow group was a function of the land requirements of the breeding herd, reproductive performance and culling alternative. A sufficient number of replacement heifers were purchased to maintain a constant herd size from year to year, even though herd size varied during the year. In addition, the proportion of yearling replacement heifers, first calf cows and older cows remained constant over years. Crossbred cow group comparisons were made over one production cycle and measured from weaning one year to weaning the next year. For greater precision in calculations, fractions of animals were allowed to exist. Hence, it is desirable to think in terms of numbers of animals per herd, where herd is the total conglomeration of cattle produced under the specified land area restriction.

The bioeconomic model considered crossbred cow group differences for reproductive performance, nutrient requirements, calf growth rate, calf survival, carcass composition and cow salvage weights. The performance data assumed in the analysis were based on actual research data from these crossbred cow groups and reported in three preceeding papers of this series. Crossbred cows were mated to Red Poll and Shorthorn bulls as two-year-olds and to Charolais, Brahman, Limousin and Gelbvieh bulls at subsequent ages. All three-breed calf performance data used in this analysis were the average of steer and heifer performance. Nutrient requirements of yearling replacement heifers and two-year-old cows were calculated from NRC (1974), based on weights and first lactation milk yields measured on these crossbred cow groups (Belcher et al., 1978). Nutrient requirements of older cows were based on individual feed intake data of drylotted cows (Marshall et al., 1982).

It is uncertain if existing environmental conditions allowed cows to reproduce at rates typical of the respective crossbred cow groups. Under the assumption that the levels of pasture and supplement provided were appropriate for cow size and lactation level, and should provide adequate nutrition for all crossbred cow groups to reproduce at the same level, an additional analysis was done in which a constant calving rate of 90 percent was assumed for all crossbred groups.

Since land area utilized by the breeding herd was the same for each crossbred dam group (within a given culling system), pasture costs were not considered. In addition, the cost of establishing existing herds was assumed to be the same for all crossbred cow groups and thus was ignored. Relative profitability of crossbred cow groups was estimated by substracting all costs for a given herd, except fixed herd costs, from total gross returns. Thus, crossbred cow groups were compared on gross margin per herd. Differences among crossbred cow groups in gross margin per herd would be equivalent to differences in net income per herd. Gross margin was calculated for selling calves at weaning and for selling calves at slaughter. Three different product end points were considered for slaughter calf production: live weight, carcass weight and boneless, closely trimmed retail cuts.

Economic coefficients assumed for cattle and feedstuffs were based on a six year (1977-1982) average of Oklahoma prices. The cost of cottonseed meal and bermudagrass hay were set at $.1221 and $.0200 per pound of dry matter, respectively. The cost of nutrients for feedlot calves was set at $.0790/lb TDN. To test the sensitivity of crossbred cow group rankings to the relative cost of nutrients for the breeding herd versus the feedlot, the cost of feedlot TDN was later varied.

Calf prices were averaged over steers and heifers. Prices assumed for weaned weight, live slaughter weight, carcass weight and retail cuts were $.65, $.61, $.95 and $1.91/lb, respectively. Yearling replacement heifers were purchased for $.65/lb, calculated as a $.05/lb premium over feeder heifer prices (variations in heifer costs were later examined). Nonpregnant heifers were sold for $.60/lb (the price of slaughter heifers) and cull cows were sold for $.39/lb.

A breeding cost of $15.60 was charged per cow exposed to breeding. This figure assumes that a bull was purchased at $1200, maintained at a cost of $300/year, serviced 30 females per year, and was sold for $700 after three years of service. A direct cost of $20 per difficult birth was assumed in this study. This figure was obtained by charging $4 per non-Caesarian difficult birth and $100 per Caesarian birth and assumes that 17 percent of all difficult births required Caesarian sections (unpublishd data). Effects of calving difficulty on subsequent calf mortality and fertility were assumed to be reflected in weaning rates.

Other operating costs were based on enterprise budgets supplied by the Oklahoma Cooperative Extension Service. Per head costs of $50 for cows remaining in the herd for the full annual production cycle, $30 for cows culled in the spring and $28 per yearling heifer were charged to cover veterinary supplies and services, utilities, labor, machinery and miscellaneous expenses of the breeding herd. Non-feed expenses for the feedlot segment included a charge for veterinary supplies and services of $5.50/head, a marketing cost of $13.25/head and a lot charge of $.05/head/day fed.

Cumulative capital expenditures and returns were updated monthly and interest expense or interest income was computed at monthly intervals, assuming an annual interest rate of 13 percent. Interest was not charged on fixed herd costs, since the value of these were assumed to be the same for all crossbred cow groups.

Results and Discussion

All tabular results are presented by crossbred cow group and culling system. Comparisons among crossbred cow groups were made within culling system. Comparisons of culling systems were not generally made since the intent of including alternative culling systems was not to aid in making management decisions, but rather to determine whether or not crossbred cow group rankings differed over different culling systems. Except when noted otherwise, rankings among crossbred cow groups were consistent over culling alternatives.

Herd inventory for various classes of cattle are presented in Table 1. These results are quite useful in evaluating relationships between nutrient requirements, reproductive performance, culling system and replacement rate. The number of cows calving was fixed at 100 for the HAx group. Since land area available for the breeding herd were the same for each crossbred dam group, fewer animals were maintained for those groups with higher land requirements. Under culling system CULL1, for example, compared to the HAx group, the number of cows calving was greater for the J crosses by an average of seven cows per herd, while the B and S groups averaged nine and 13 cows less, respectively. Lower reproductive rates required that a higher proportion of nutrients be used for development of replacement heifers, leaving less land available for pregnant and lactating cows. The number of heifers purchased and the number of heifers and cows sold were greater under culling system CULL2 than under system CULL1, since most of the cows culled in the spring under system CULL2 would have become pregnant and retained in the herd under system CULL1.

Considerably more yearling heifers were purchased for herds using SH and BH cows than for herds using other crossbred cow groups because of the poor rebreeding performance of these cows under extensive range conditions and the lower reproductive rate of heifers during the limited breeding season. The latter factor affected the SH group in particular. For example, the number of yearling heifers needed for the SH group was greater than for the BH group, even though the number of cows culled (sold) was similar for those two groups. The fewest cows and nonpregnant heifers were sold and fewest replacements were needed in systems using J cross cows.

The number of calves weaned and slaughtered depended primarily on the number of cows calving, but also on calf survival. Under culling system CULL1 for example, HAx cows produced 7.9 more calves than BA cows

Table 1. Herd inventory for various classes of cattle.

Crossbred cow group[a]	No. cows calving		No. yearling heifers purchased		No. cows sold		No. nonpregnant heifers sold		No. calves weaned		No. calves slaughtered	
	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	100.0	100.0	17.1	21.5	12.8	17.1	2.3	2.9	88.9	88.7	87.7	87.4
SA	88.1	87.4	17.1	22.9	12.1	17.2	3.2	4.3	78.0	77.3	76.6	75.9
SH	83.9	82.5	34.0	40.2	18.0	20.8	14.4	17.0	76.5	75.2	76.2	74.9
BA	92.1	92.1	18.0	20.1	15.0	17.3	1.2	1.3	86.2	86.1	85.2	85.0
BH	87.8	87.3	26.6	29.4	19.0	20.6	5.9	6.5	81.9	81.4	79.4	78.9
JA	105.6	104.6	7.9	11.8	5.0	8.2	.8	1.2	97.3	96.6	96.0	95.3
JH	107.5	106.1	11.1	17.0	8.4	13.6	.6	.9	97.7	96.6	95.7	94.7

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

at birth, but the difference was reduced to 2.7 calves at weaning and 2.5 calves at slaughter. Compared to the SA group, there were 4.0 more BA calves at birth, but 8.2 and 8.6 more calves at weaning and slaughter, respectively. The consequences of these differences are discussed later in the paper. Even though the numbers of cows calving in herds using HAx cows were the same under both culling systems, the cow age distribution varied, resulting in slightly more calves weaned and slaughtered under culling system CULL1 than under CULL2.

Non-feed expenses per herd for the cow-calf phase to weaning and the feedlot phase are presented in Table 2. Variation among crossbred cow groups in dollars spent purchasing yearling heifers contributed the most of any source to variation in total expenses. The expense of purchasing yearling heifers was greatest for the SH and BH groups and least for herds using J cross cows. Non-feed operating expenses for the breeding herd were generally higher for those groups with higher numbers of cows and heifers, but the magnitudes of differences were relatively small. Jersey cross cows produced the most milk, especially in proportion to body size, and thus supplement requirements per cow were similar to other groups even though the J cross cows were smaller. Total herd supplement costs were greatest for J cross cows and least for SH cows. Replacement heifers were purchased in the spring when pasture conditions required little supplementation. Thus, herds using SH cows had relatively low supplement costs, since this group had a relatively high proportion of heifers.

The gross returns per herd when calves were sold at weaning are presented in Table 3. The proportion of total gross returns, consisting of income from the sale of cull cows and nonpregnant heifers, was greater for culling system CULL2 than for CULL1. Both reproductive performance and salvage weight contributed to the amount of returns from these sources. Returns from the sale of cull cows was greatest for SH and BH cows, intermediate for BA, SA and HAx cows and lowest for J cross cows. However, rankings of S and B crosses differed over culling systems. Under system CULL1, cull cow returns wer $789/herd greater for BA than for SA cows, and $137/herd greater for BH than for SH cows. However, under system CULL2, cull cow returns were $227/herd greater for SA than for BA cows, and $302/herd greater for SH than for BH cows. These changes in rank occurred because a higher proportion of pregnant B cross cows produced a live calf at birth as compared with S cross cows. Rankings for gross returns from the sale of nonpregnant heifers were the same as rankings for number of nonpregnant heifers sold.

If calves were sold at weaning and calves from all crossbred cow groups were sold at the same price per unit weight, returns were greatest for calves from J cross cows, followed in order by calves from B cross, HAx and S cross cows. Total gross returns per herd were greatest for herds using SH and B cross cows, as a result of the large numbers of culled cows.

Even though feed costs comprised a large proportion of total non-fixed herd expenses (Table 2), differences in feed costs among crossbred cow groups were relatively small. This is largely due to crossbred groups with higher per calf feed requirements (i.e., S and B crosses) had fewer calves in the feedlot. The largest difference in feed costs under culling system CULL1 was the $3250 greater feed costs for calves from JH cows than for calves from SH cows. Although the lot charge depended on the number of calves fed and length of the feeding period, crossbred cow group differences in non-feed operating costs in the feedlot primarily reflected differences in number of calves fed. Total

Table 2. Non-fixed expenses per herd for calves sold at weaning or at slaughter.

Crossbred cow group[a]	Expenses to weaning ($/herd)								Feedlot expenses ($/herd)					
	Yearling heifer purchase		Non-feed operating costs		Supplement		Total		Feedlot TDN		Feedlot operating costs		Total herd expenses $/herd	
	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	5444	6834	8926	9110	7963	7807	22,333	23,751	22,588	22,291	3744	3647	48,665	49,689
SA	6125	8180	8252	8421	7938	7669	22,314	24,270	21,600	21,033	3371	3207	47,285	48,510
SH	11,250	13,289	8924	9159	7064	6811	27,237	29,259	20,639	19,962	3136	2966	51,012	52,187
BA	6209	6920	8406	8569	8036	7936	22,651	23,425	23,386	23,219	3582	3526	49,619	50,171
BH	8651	9554	8511	8687	7335	7207	24,497	25,448	21,453	21,139	3280	3194	49,230	49,781
JA	2401	3569	8673	8888	9093	8899	20,167	21,356	23,286	22,936	4036	3929	47,489	48,220
JH	3362	5170	9115	9267	8983	8683	21,460	23,120	23,889	23,293	4076	3893	49,425	50,306

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.

[b] Culling system: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

Table 3. Gross returns per herd when calves sold at weaning.

Crossbred cow group[a]	Nonpregnant heifers		Cull cows		Weaned calves		Total	
	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	809	1016	4509	5843	26,583	26,290	31,902	33,149
SA	1265	1690	4622	6369	25,708	25,232	31,596	33,291
SH	5250	6202	6711	7669	24,541	23,887	36,502	37,758
BA	433	483	5411	6142	28,860	28,730	34,705	35,355
BH	2103	2323	6848	7367	27,087	26,758	36,039	36,448
JA	269	399	1577	2571	31,411	31,007	33,256	33,977
JH	187	287	2653	4264	31,480	30,845	34,320	35,396

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

non-fixed herd expenses for slaughter calf production were lowest for SA and JA groups and greatest for herds using SH cows.

Gross returns from the sale of slaughter calves was estimated at three product endpoints: live weight, carcass weight and retail cuts (Table 4). The use of carcass weight favored groups with relatively high dressing percentage and the use of retail cuts favored groups with high dressing percentage and high cutability. However, crossbred cow group rankings were quite similar for each product end point and culling system combination. Gross returns from the sale of slaughter calves was greatest for herds using J cross cows, followed by herds using BA and HAx cows. The relatively heavy weights of calves from S cross cows did not completely compensate for their smaller numbers of calves per herd,

Table 4. Gross returns per herd when calves sold at slaughter.

Crossbred cow group[a]	Gross returns at three end points, $/herd						Total returns at three end points, $/herd[c]					
	Live weight		Carcass weight		Retail cuts		Live weight		Carcass weight		Retail cuts	
	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	56,420	55,703	56,061	55,275	55,440	54,586	61,739	62,561	61,379	62,133	60,758	61,445
SA	53,346	52,142	53,088	51,776	53,031	51,623	59,234	60,201	58,976	59,835	58,919	59,682
SH	52,137	50,572	51,727	50,105	51,420	49,698	64,098	64,443	63,688	63,976	63,381	63,569
BA	57,894	57,532	57,362	56,966	56,919	56,487	63,738	64,157	63,207	63,592	62,764	63,112
BH	53,089	52,405	52,824	52,095	52,509	51,734	62,041	62,095	61,776	61,785	61,461	61,424
JA	59,633	58,764	58,850	57,922	58,976	57,976	61,478	61,734	60,695	60,892	60,812	60,947
JH	60,505	59,092	59,450	57,899	59,591	57,913	63,345	63,643	62,290	62,450	62,431	62,464

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.
[c] Includes returns from the sale of culled females (Table 3) and slaughter calves.

Table 5. Gross margins ($/herd) for selling calves at weaning or slaughter.

Crossbred cow group[a]	Weaned calves		Slaughter calves - value based on three end points					
			Live weight		Carcass weight		Retail cuts	
	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	9,568	9,398	13,074	12,872	12,714	12,444	12,093	11,756
SA	9,282	9,021	11,949	11,691	11,691	11,326	11,634	11,172
SH	9,265	8,499	13,086	12,256	12,676	11,789	12,369	11,382
BA	12,054	11,930	14,119	13,987	13,588	13,421	13,145	12,941
BH	11,542	11,000	12,810	12,314	12,546	12,004	12,231	11,643
JA	13,088	12,621	13,989	13,514	13,206	12,672	13,323	12,727
JH	12,860	12,276	13,920	13,338	12,865	12,145	13,006	12,158

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

resulting in lower gross returns per herd. Herd total gross returns, including returns from the sale of slaughter calves and culled cows, were greatest for herds using SH and BA cows.

Gross margin for selling calves at weaning or slaughter are presented in Table 5. For production systems in which calves were sold at weaning, gross margin per herd was greatest for J cross cows, followed in order by B cross, HAx and S cross cows. Gross margins for slaughter calf production was greatest for the BA group at all 3 product end points. Herds using J cross, HAx, BH and SH cows produced slightly lower gross margins, followed closely by herds using SA cows. Crossbred cow group rankings for gross margin for slaughter calf production were similar across product end point and culling system with the only rank changes being between groups for which pair-wise differences were very small.

Rankings for J crosses reflect their advantage in reproductive performance and moderate preweaning growth rate, but relatively poor postweaning calf feedlot performance. Brown Swiss crosses had moderate reproductive performance, produced the heaviest calves at weaning and had relatively good postweaning performance. Hereford X Angus reciprocal cross cows had moderate reproductive performance, produced the lightest calves at weaning, but their calves were the most efficient in the feedlot. The S crosses ranked last in gross margin, despite relatively high weaning weights and good feedlot performance. The low ranking of the SH group was largely because of poor reproductive performance under the extensive range conditions. The relatively high energy requirements for SA cows contributed to their low rankings. Another important factor in the ranking of S crosses, especially for the SH group, was preweaning calf losses. As mentioned previously, the number of calves alive at 24 hours after birth and the number weaned, in proportion to the number of cows calving, was lowest for S crosses. Females which went into the pregnant herd in the fall, but failed to wean a calf, had to be maintained for much or all of the year (depending on when the calf died and the culling system assumed). This was less desirable than a cow failing to become pregnant.

Differences among crossbred cow groups for gross margin when calves were sold at slaughter were quite small, reflecting the trade-offs among the relative merits and disadvantages of the various crossbred groups. The relative economic advantage of BA and J cross cows over HAx, S cross and BH cows was considerably less when calves were sold at slaughter than when calves were sold at weaning. The better feedlot performance for calves from HAx, S cross and BH cows indicates that feedlot operators should pay less per unit weight for calves from J cross and BA cows at weaning. It is interesting to note that crossbred cow groups which produced the highest average milk yields (i.e., BA and J crosses) also produced calves which were less efficient (in terms of feed conversion) in the feedlot. Unfortunately, had a reasonable land charge for the breeding herd been included in expenses, all crossbred cow groups would likely have been operating at a loss. This would seem consistent with the economic situation many cattlemen have experienced in recent years.

In experimental data collected previously for this project, A cross cows have consistently had better reproductive performance than H crosses. On the other hand, H crosses have consistently had superior feed conversion, among drylotted cows producing weaned calves and among feedlot calves. Results from these economic analyses indicate that the relative advantages and disadvantages of A and H crosses were apparently offsetting when all segments of production were considered, resulting in similar gross margins for A and H cross cows.

The extent to which environmental conditions allowed cows to reproduce at rates typical for these crossbred cow groups is uncertain. However, the extensive range conditions apparently failed to provide sufficient energy for desirable reproductive performance for the larger S and B cross cows, in particular. Presented in Table 6 are gross margins for herds producing weaned calves or slaughter calves, when a constant birth rate of 90 percent was assumed for all crossbred cow groups. If calves were sold at weaning, B cross cows produced the highest gross margins, followed in order by J cross, SH, HAx and SA cows. If calves were sold at slaughter, herds using SH cows produced the highest gross margins, followed closely by B cross cows. Herds using HAx cows produced slightly lower gross margins, followed closely by herds using SA and J cross cows. The SH and BH cows had the lowest

Table 6. Gross margin ($/herd) for selling calves at weaning or slaughter, assuming a constant birth rate of 90 percent.

Crossbred cow group[a]	Weaned calf production		Slaughter calves - value based on three end points					
			Live weight		Carcass weight		Retail cuts	
	CULL1[b]	CULL2[b]	CULL1	CULL2	CULL1	CULL2	CULL1	CULL2
HAx	9,822	9,664	13,344	13,154	13,020	12,761	12,435	12,107
SA	9,728	9,503	12,412	12,195	12,212	11,881	12,208	11,775
SH	11,633	11,123	15,846	15,295	15,556	14,927	15,484	14,722
BA	12,803	12,638	14,926	14,746	14,475	14,260	14,123	13,869
BH	13,518	13,083	14,635	14,257	14,561	14,127	14,435	13,944
JA	11,954	11,447	12,814	12,301	11,953	11,387	11,957	11,336
JH	12,141	11,530	13,175	12,565	12,072	11,334	12,141	11,284

[a] H=Hereford, A=Angus, S=Simmental, B=Brown Swiss and J=Jersey.
[b] Culling systems: CULL1, open cows were culled at weaning in the fall; CULL2, open cows were culled in the fall and cows without a live calf at the end of the calving season were culled in the spring.

reproductive rates among the crossbred cow groups evaluated, and thus their relative profitability improved the most by assuming a constant birth rate. These calculations (Table 6) ignore potential increased feed costs associated with increased reproductive performance.

It has been assumed in this analysis that economic coefficients are known with certainty. If the assumed coefficients were to change, the results of this analysis would likely change as well, unless all economic coefficients changed proportionally. One concern in this study was the cost of replacement heifers. It was assumed that the cost of producing yearling replacement heifers from these two-breed crosses was the same per unit weight for all crosses. In a fully integrated system, the efficiency of purebred herds producing the crossbred replacements would be considered. Since the cost of producing replacement heifers was not known, the sensitivity of crossbred cow group ranking to cost of replacement heifers was examined by calculating gross margin at alternative replacement costs.

Figure 1 shows gross margins for calves sold at weaning, under culling system CULL1, at low, moderate and high costs of purchasing replacement heifers. The moderate cost represents the cost previously assumed, while low- and high-cost heifers, respectively, were purchased at $50/head below the $50/head above the cost of moderate-cost heifers. Results indicate that crossbred cow group rankings were fairly stable over the range of heifer costs evaluated, although magnitudes of differences in gross margins increased as heifer costs increased. The SH group was most affected by varying heifer replacement costs because of the larger number of yearling heifers required for this group. For example, the gross margin of the HAx cows was $608 less than that for SH cows at the low heifer cost, but $1,215 greater at the high heifer cost.

Figure 2 shows gross margins for slaughter calf production under culling system CULL1 at high, moderate and low heifer costs, assuming retail cuts as the product endpoint. The SH group ranked second in gross margin at low heifer costs, but ranked next to last at high heifer costs. However, the magnitudes of differences were relatively small. At low and moderate heifer costs, the largest difference between pairs of crossbred dam groups was between BA and SA (difference was $1,945 and $1897 for low and moderate, respectively). At high heifer costs, the largest difference was between JA and SA groups ($2,011).

Figure 3 shows gross margins for production of retail cuts under culling system CULL1 when the cost of feedlot TDN was set at levels 25 percent below (low) and 25 percent above (high) the originally assumed price (moderate). Crossbred dam group rankings were quite stable over the range of feedlot TDN costs evaluated, with the only changes in rank occurring between groups for which gross margins were similar.

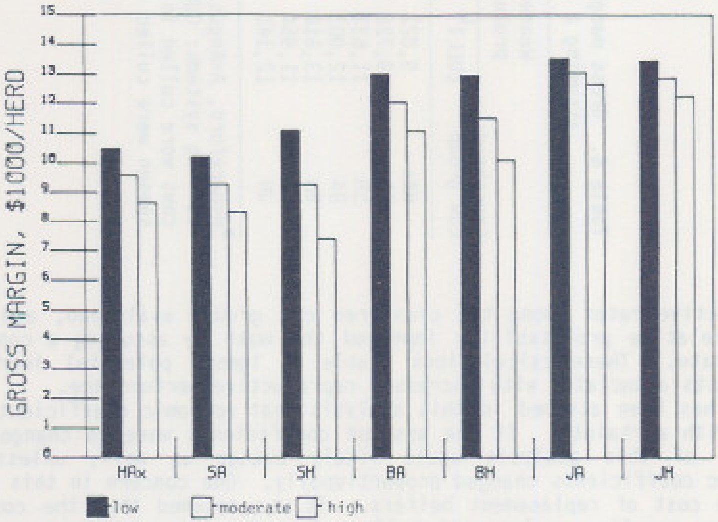

Figure 1. Gross margins at low, moderate and high replacement heifer costs under culling system CULL1 when calves are sold at weaning.

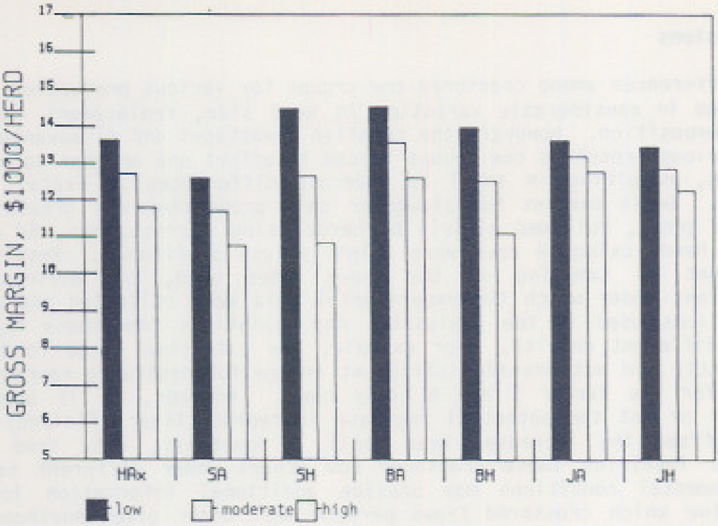

Figure 2. Gross margins at low, moderate and high replacement heifer costs under culling system CULL1 when calves are sold at slaughter.

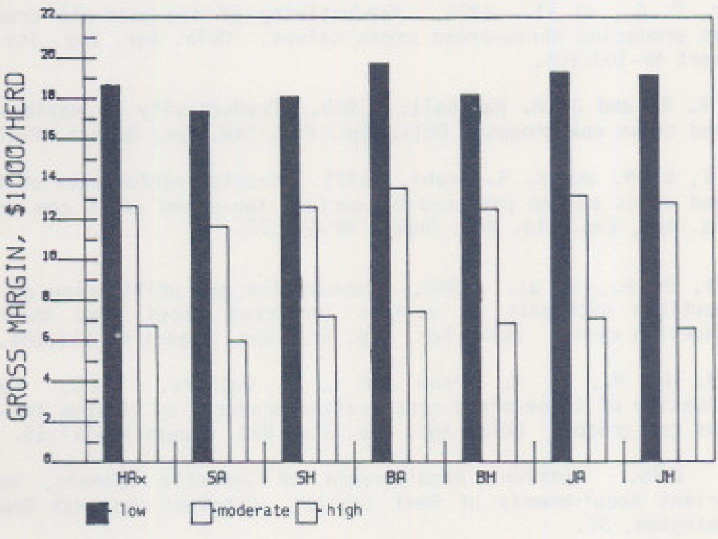

Figure 3. Gross margins at low, moderate and high costs of feedlot TDN under culling system CULL1 when calves are sold at slaughter.

Conclusions

Differences among crossbred cow groups for various production traits resulted in considerable variation in herd size, replacement rate and herd composition. However, the relative advantages and disadvantages of the various crossbred cow groups tended to offset one another to varying degrees, resulting in small to moderate differences in overall gross margin. Gross margins for slaughter calf production was greatest for the BA group, followed closely by herds using J cross, HAx, BH and SH cows. Herds using SA cows were slightly less profitable. Results are dependent on sampling of the breed types used, the environmental conditions under which the experimental data were collected and on the assumptions used in the analysis. Any deviations from these may have given different results. For example, the extensive range conditions apparently did not provide sufficient energy for desirable reproductive rates for the larger S and B cross cows. However, it is uncertain whether or not the potential increase in reproductive efficiency would have offset the increased feed costs. Hopefully, data from other studies involving these crossbred cow groups under different sets of environmental conditions may provide additional information to help determine which crossbred types perform best under given environmental conditions.

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PERFORMANCE TRENDS OF TESTED BOARS AT THE OKLAHOMA SWINE EVALUATION STATION

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Story in Brief

Performance data from 2263 boars tested from 1971 to 1983 at the Oklahoma Swine Evaluation Station were used to evaluate time trends for average daily gain, age at 230 pounds, backfat thickness, and loin eye area. There has been a general improvement in growth rate and feed efficiency. Both backfat thickness and loin eye area have decreased over time. To the extent that these results reflect the changes in genetic merit in the Oklahoma Swine industry they indicate improvement in all traits measured except for loin eye area.

Introduction

Swine testing stations aid in the identification of superior boars by providing a constant environment under which boars from various herds can be tested together. Examination of the time trends at such a station will illustrate the performance changes that have occurred during the life of the station. These changes are partially due to the changes in genetic merit of the herds that test boars at the station. The purpose of this study was to evaluate the changes in performance of boars tested at the Oklahoma Swine Evaluation Station.

Materials and Methods

The Oklahoma Swine Evaluation Station was bulit in 1970. The station originally had one barn with 24 open-front pens measuring 5 by 15 ft. A second barn was constructed in 1975 which increased capacity to 48 pens. Pens of three boars and one barrow or two boars and two barrows were tested until 1974. From 1975 to 1981 all pens contained three boars. In 1982 and 1983 each pen contained either three boars or two boars and a barrow. Pigs within a pen were progeny of one sire. One test in the spring and one in the fall were conducted from 1971 to 1974 and in 1982 and 1983. There were two tests conducted each season from 1975 to 1981. Pigs were put on test when the pen averaged 70 lb. There was a change in off-test weight from 220 lb to 230 lb in 1975.

When the pigs reached off-test weight average daily gain and pen feed efficiency were measured. In addition there was a scanogram (Ithaco Scanogram, Model 721) estimate of back fat thickness and loin eye area obtained. Feed efficiency for pens containing barrows was adjusted to a boar-equivalent basis. Backfat thickness was the average of measurements taken at the shoulder, the last rib and the last lumbar vertebra. Loin eye area was measured at the tenth rib. Backfat thickness and loin eye area were adjusted to 230 lb with adjustment factors recommended by the National Swine Improvement Federation.

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These results describe the performance of 2263 Chester White, Duroc, Hampshire, Spot and Yorkshire boars tested from 1971 though 1983. The number of boars of each breed for each year is shown in Table 1. Berkshire, Landrace and Poland China boars were also tested at the station but were excluded from these analyses due to the small number of boars from these breeds.

The analysis procedure allowed estimation of yearly means and the average yearly change in performance for each breed. The means were adjusted for the effects of season and test group.

Table 1. Number of boars tested at the Oklahoma Swine Evaluation Station

	Breed				
Year	Chester White	Duroc	Hampshire	Spot	Yorkshire
1971	11	31	28		6
1972	8	34	29	9	17
1973	11	42	32	23	20
1974	17	43	17	21	25
1975	38	62	32	37	39
1976	42	66	50	49	60
1977	31	71	28	61	58
1978	30	90	43	28	53
1979	20	94	27	34	75
1980	14	93	19	12	94
1981	35	64	33	13	54
1982	17	33	16	5	23
1983	9	33	15	9	30

Results and Discussion

The trends for average daily gain and age at 230 lb are shown in Figures 1 and 2. There has been a genral improvement in growth rate over the 12 years shown. The improvement has been most pronounced in the Hampshire and Yorkshire breeds. The breeds are not substantially different in growth rate overall except that the Chester White boars were consistently the slowest growing. Feed efficiency generally improved at the station over the 13 years of this study although the trend lines show considerable fluctuation (Figure 3).

All breeds showed a decrease in backfat thickness through the 1970's (Figure 4). This trend appears to have levelled off or has possibly reversed in the recent years. There has been a large decrease in loin eye area in all breeds (Figure 5). There were few differences between breeds for these traits except that Hampshire boars generally had the least backfat and the largest loin eye area.

Regressions of performance on time are shown in Table 2. These tell the average change per year for each trait in each breed. They are consistent with the graphs presented previously. There has been a significant improvement in average daily gain in all breeds except Chester White. The improvement in Age at 230 pounds was significant only in the Hampshire boars. Feed efficiency showed significant

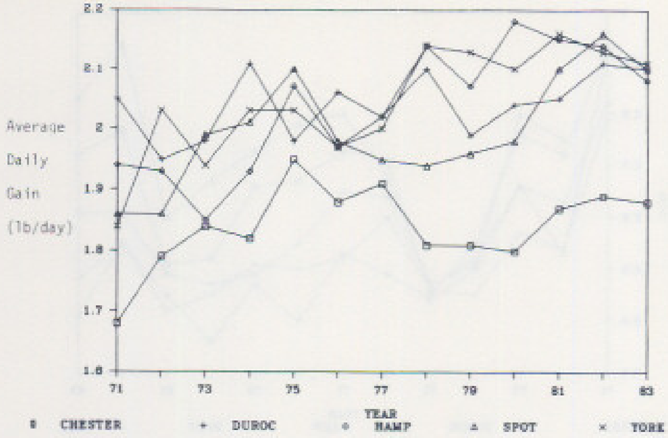

Figure 1. Average daily gain (lb/day).

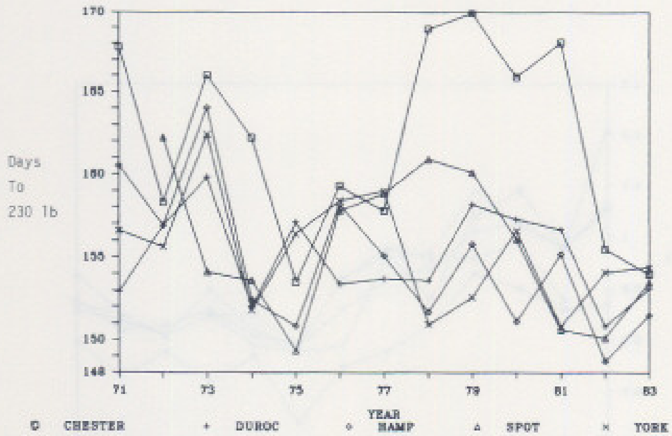

Figure 2. Days to 230 lb.

improvement in Duroc, Hampshire and Yorkshire boars. There was a significant decline in both backfat thickness and loin eye area in all breeds. The regression coefficients do not illustrate the large amount of year to year fluctuation that was present, especially for age at 230 pounds and feed efficiency.

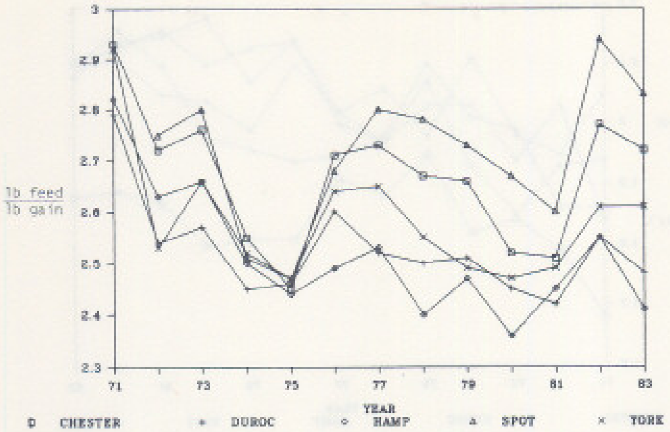

Figure 3. Feed efficiency $\frac{\text{lb feed}}{\text{lb gain}}$

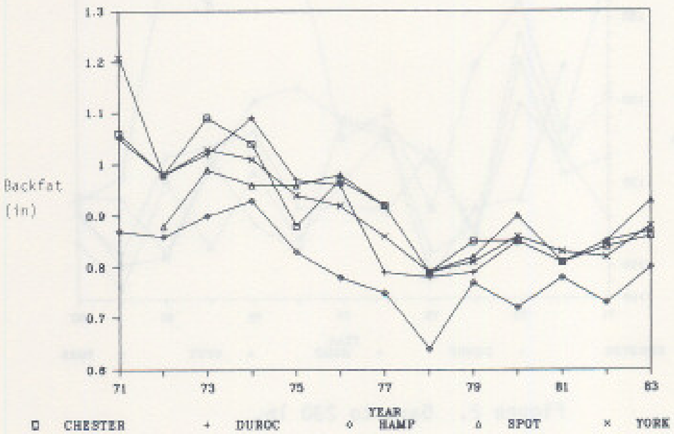

Figure 4. Backfat (in)

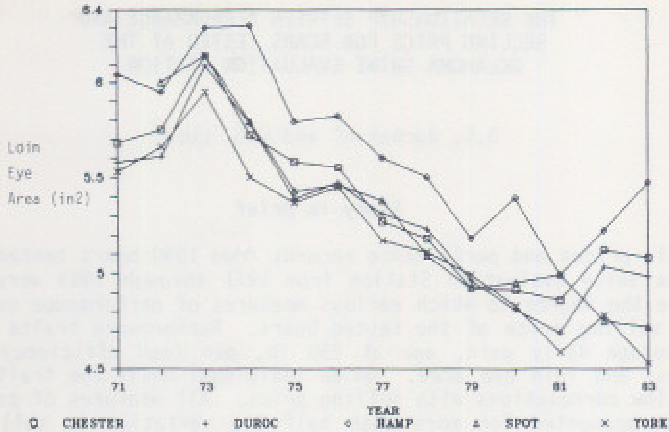

Figure 5. Loin eye area (in^2)

Table 2. Average yearly change in performance of boars at the Oklahoma Swine Evaluation Station.

	Breed				
Trait	Chester White	Duroc	Hampshire	Spot	Yorkshire
Avg. daily gain (lb/day)	.007	.007**	.022**	.007**	.019**
Days to 230 lb	-.367	-.131	-.733**	-.191	-.371
Lb feed/ lb gain	-.009	-.013**	-.023**	.007	-.013**
Backfat (in)	-.021**	-.021**	-.013**	-.004**	-.024**
Loin eye area (sq in)	-.088**	-.089**	-.091**	-.064**	-.104**

**p<.01

These changes may be due to several factors including real genetic changes in herds that have supplied boars for the Evaluation Station. The breeders that bring boars to be tested may have learned the characteristics or management of young boars that will enable them to perform well in the station or they may have simply decided that it is worthwhile to bring some of their superior boars to the station.

If these changes are the result of genetic changes in the Oklahoma swine industry they are generally encouraging. They indicate that pigs in commercial herds that purchase boars from the Evaluation Station should be faster growing, more efficient and leaner than pigs of 10 to 15 years age. They also indicate that they will have a smaller loin eye measurement.

THE RELATIONSHIP BETWEEN PERFORMANCE AND SELLING PRICE FOR BOARS TESTED AT THE OKLAHOMA SWINE EVALUATION STATION

D.S. Buchanan[1] and W.G. Luce[2]

Story in Brief

Sale prices and performance records from 1090 boars tested at the Oklahoma Swine Evaluation Station from 1971 through 1983 were used to evaluate the degree to which various measures of performance contributed to the selling price of the tested boars. Performance traits evaluated were average daily gain, age at 230 lb, pen feed efficiency, backfat thickness and loin eye area. On an individual basis the traits all had fairly low correlations with selling price. All measures of performance together accounted for more than half the variation in selling price only in Chester White boars. Average daily gain generally had the largest influence on selling price.

Introduction

Central test stations such as the Oklahoma Swine Evaluation Station have been in use for several years to promote the use of performance records, to evaluate potential herd boars from a variety of herds and to provide a source of boars with performance information for the commercial boar market. The Oklahoma Swine Evaluation Station has been testing boars since 1971. Most of the tested boars, if they met the performance requirements, were sold in an auction held following the end of the test. This information was used to evaluate the contibution of each of the measures of performance to the selling price to see if the buyers were willing to pay a premium for the boars with superior performance.

Materials and Methods

There have been 2263 boars from the Chester White, Duroc, Hampshire, Spot and Yorshire breeds tested at the Oklahoma Swine Evaluation Station since 1971. Nearly all boars that met minimum performance standards (generally upper 80 percent of the boars in a test) have been offered for sale at an auction after the end of the test period. From the boars offered for sale 1090 have actually sold. Failure to sell may have been the result of poor performance, unsoundness, lack of demand or a decision on the part of the owner not to offer the boar for sale. Berkshire, Poland China and Landrace boars were also tested but were not included in these analyses due to insufficent numbers.

Prospective buyers have access to a sale catalog that provides information on ownership, breeding of the boar and performance information on average daily gain, age at 230 lb, pen feed efficiency, backfat thickness and loin eye area. In all cases a pen includes boars with the same sire. An index value which combined information on

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average daily gain, backfat thickness and pen feed efficiency was also included. The formula for this index has changed several times during the life of the station but the relative importance of the three traits in the index has not undergone large changes.

The relationship between selling price and each measure of performance was estimated by obtaining the correlation between the price and each trait after accounting for variation due to year, season, test group and breed. The contribution of each trait to the selling price was obtained by simultaneously calculating partial regressions of price on all measures of performance. These regression coefficients were obtained for each breed separately. Traits that did not contribute significantly to selling price were eliminated from the equation one at a time until only those traits with a significant contribution remained.

Results and Discussion

Correlations between selling price and each performance trait are shown in Table 1. All are relatively small with the measures of growth rate having the largest tendency to be associated with a high selling price. Despite their small values they are all significantly different than 0.

Table 1. Correlations between selling price and performance traits of boars at the Oklahoma Swine Evaluation Station.

	Performance traits				
	Average daily gain	Age at 230 lb	Pen feed efficiency	Backfat thickness	Loin eye area
Price	.265	-.221	-.191	-.136	.097

Table 2. Partial regressions of price on measures of performance of boars tested at the Oklahoma Swine Evaluation Station.

Breed	Average daily gain ($/.1 lb per day)	Age at 230 lb ($/day)	Pen feed efficiency ($/.1 lb feed /lb gain)	Backfat thickness ($/.1 in)	Loin eye area ($/.1 sq in)
Chester White	176.05			-158.70	
Duroc	21.53	-3.27	-10.34	-62.11	
Hampshire	169.41	-8.67		-50.38	14.01
Spot	56.62				
Yorkshire	41.01	-3.22	-34.49		-8.60

The partial regressions of selling price on each trait are shown in Table 2. These values tell the average change in selling price per unit change in the performance trait while holding all other variables constant. They show that in all breeds average daily gain contributed to selling price with a range of $21.53 to $176.05 paid for each .1 lb per day increase in gain. Despite the large correlation between average daily gain and age at 230 lb there was an additional significant partial regression of selling price on age at 230 lb in the Duroc, Hampshire and Yorkshire boars. Pen feed efficiency contributed significantly to selling price in Duroc and Yorkshire boars. Backfat thickness contributed significantly to selling price in Chester White, Duroc and Hampshire boars with a range of $50.38 to $158.70 more paid for each .1 in decrease in backfat thickness. Loin eye area had a significant contribution to selling price only in the Hampshire and Yorkshire boars. These values were the most unusual in that buyers paid $14.01 more for each .1 sq in increase in loin eye area of Hamphsire boars while they paid $8.60 more for each .1 sq in decrease in loin eye area of Yorkshire boars.

The percentage contribution of all measures of performance together on selling price is shown in Table 3. The first value for each breed represents the percentage contribution of just the performance traits to selling price. The second value represents the percentage contribution of the performance traits plus the effect of the owner of the boar. The difference between the two values should indicate the relative importance of the name of the owner in determining the selling price of the boar. The performance traits alone accounted for 27 percent of the variation in selling price of Spot boars, 66 percent of the variation in selling price of Chester White boars and about 40 percent of the variation inselling price of the boars of the other three breeds. In all breeds other than the Chester White including the effect of the owner greatly increased the values shown. The remaining variation would be due to several factors. In some cases a premium is paid on certain boars which rank high in the test group because of a desire on the part of buyers to own the winners. The general appearance of the boar also plays a large role in how much buyers are willing to pay. This appearance may have little to do with performance so would not contribute to variation due to the performance traits.

Table 3. Percentage contribution on performance traits on the selling price of boars tested at the Oklahoma Swine Evaluation Station.

Breed	Performance alone	Performance plus owner name
Chester White	.66	.72
Duroc	.40	.72
Hampshire	.41	.69
Spot	.27	.61
Yorkshire	.40	.73

Performance does appear to have had an effect on the selling price of tested boars although not a large effect in most breeds. The owner of the boar had a large effect on the selling price. Test stations were established, in part, to educate swine producers on the use of performance records. Buyers are apparently paying at least some attention to the importance of good performance records and are also concerned with the reputation and the breeding program of the owners of the boars. These are both desirable results of the educationl process involved in having test stations.

GROWTH PERFORMANCE OF THREE- AND FOUR-BREED CROSS PIGS INVOLVING THE DUROC, YORKSHIRE, LANDRACE AND SPOTTED BREEDS

D.G. McLaren[1], D.S. Buchanan[2], R.K. Johnson[3] and R. Vencl[4]

Story in Brief

Purebred and crossbred boars were mated to two-breed cross females to produce all possible three- and four-breed crosses involving the Duroc, Yorkshire, Landrace and Spotted breeds. A total of 3,456 pigs were evaluated for pen feed efficiency and for individual postweaning average daily gain and probed backfat thickness. Genotype by environment interactions, namely breed by year-season and (for gain) breed by parity, were found to be highly significant in these data. The fact that relative performance of the breeds varied in different year-seasons and parities made it difficult to draw overall conclusions as to breed performance. Certain results, however, did appear reasonably consistent. Duroc sired pigs grew more efficiently than other breed groups. They were also leaner than other three-breed cross pigs involving the same dam breeds, whereas Landrace sired pigs were fatter. No real differences between pigs sired by purebred and crossbred boars were apparent for feed efficiency, average daily gain or probed backfat thickness. This would suggest that mating two-breed cross rather than purebred males to females of different breeding would have little or no impact on these traits in offspring produced.

(Key Words: Crossbred Boars, Growth Performance.)

Introduction

A project aimed at evaluating purebred and crossbred performance of Duroc, Yorkshire, Landrace and Spotted breeds of swine was conducted at the Oklahoma Agricultural Experiment Station between 1976 and 1979. As part of this project, three- and four-breed cross litters were produced over five consecutive farrowing seasons starting in fall of 1977 at the Southwest Livestock and Forage Research Station, El Reno.

Litter performance of different two-breed cross females, and the effect of crossbred versus purebred boars on conception rate, have been reported previously (Buchanan, et. al. 1983). This report will summarize the growth and feed efficiency data from pigs farrowed during the fall of 1977 and the spring and fall of 1978 and 1979 at El Reno.

Materials and Methods

Seedstock for the three- and four-breed cross phase of the experiment was produced at the Stillwater Experimental Swine Farm by mating purebred Duroc, Yorkshire, Landrace and Spotted males and females in all possible combinations to produce purebred and two-breed cross offspring. Boars were selected for use in the second phase of the

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experiment based on an index of age and backfat thickness at 220 lbs. Boars from each breed group were transported to El Reno to be used as herd sires each season. Crossbred gilts were sent to El Reno upon detection of estrus.

Generally three boars from each breed group were used at El Reno each season, although for some breeds in some seasons as few as two and as many as five different boars were used. Purebred boars were mated to crossbred females to produce all possible three-breed cross litters, and crossbred boars were mated to crossbred females to produce four-breed cross litters. The breeding season extended over an eight-week period starting in mid-May and mid-November each year. The total number of litters farrowed per breed group is given in Table 1. Only gilts were farrowed in the first season (fall 1977). In subsequent seasons about half the litters were from second parity sows and half from gilts. A total of 309 gilt and 178 sow litters were analyzed in this study.

Table 1. Number of litters farrowed, and pigs completing gain test, for each mating type[a].

Breed of sires[b,c]	No. of sires	Breed of dams[b,c]					
		D-Y	D-L	D-S	Y-L	Y-S	L-S
D	7				22(168)	26(163)	28(212)
Y	17			27(192)	23(151)		24(189)
L	15		20(146)		25(189)		23(150)
S	14		27(189)	26(187)		23(181)	
D-Y	15						31(192)
D-L	15					30(174)	
D-S	15				34(250)		
Y-L	14			34(242)			
Y-S	15		35(268)				
L-	15	29(213)					

[a]Number of pigs in parentheses.
[b]Reciprocal crosses combined (ie. D-Y = D x Y and Y x D)
[c]D = Duroc, Y = Yorkshire, L = Landrace, S = Spotted.

Females were maintained thoughout gestation in pasture lots and hand-fed 5 lb of a 15% protein ration daily. Litters were farrowed in a barn with individual crates and slatted floors. Sows and litters were moved to a nursery approximately one week post-farrowing, where they remained in individual pens until weaning at six weeks of age. Creep feed was made available, and male pigs castrated, at three weeks of age.

Pigs were moved to a confinement finishing house for gain test approximately two weeks post-weaning, and penned in groups of 12-20 pigs per pen by breed of sire (Duroc, Yorkshire, Landrace, Spotted or Crossbred). A one week adjustment period was allowed before pigs were weighed on test at approximately nine weeks of age. A 16% crude protein ration was fed ad libitum until average pig weight per pen was approximately 120 lb. A 14% crude protein ration was fed ad libitum for the duration of the test period. Pigs were weighed off test weekly at 220 lb, at which time probed backfat thickness was measured. Total gain, total feed consumed and total days on test were obtained for each pen. During the five seasons of this phase of the experiment, 880 four-breed cross pens and 133 three-breed cross pens were tested.

Results and Discussion

Feed Efficiency

Statistical analysis of the pen data indicated no significant differences between average daily feed consumption for the different breed of sire groups. Highly significant differences in feed efficiency, however, were found between breeds of sire and year-seasons, as well as a significant breed of sire by year-season interaction. This interaction indicated that differences in feed efficiency between sire breed groups were not consistent from one year-season to the next.

Pen feed efficiency means by breed of sire and year-season are presented in Table 2, and illustrated graphically in Figure 1. Differences between sire breeds were only significant in the spring of 1978 and fall of 1979 farrowed pigs (although differences in the fall 1978 group approached significance). It should be noted that pigs farrowed in the fall of 1977 suffered badly from Atrophic Rhinitis, and those farrowed in the spring of 1979 from Mycoplasmal Pneumonia. It is conceivable that disease stress prevented expression of potential differences in feed efficiency between breed groups in these two year-seasons.

Table 2. Pen feed efficiency (lb feed/lb gain) least-squares means by year-season farrowed and breed of sire.

Breed of sire	Year-season farrowed*					
	77F	78S	78F	79S	79F	Mean
Duroc	3.20	3.03^{a}	3.06	3.13	3.11^{a}	3.11^{a}
Yorkshire	3.22	3.16^{ab}	3.24	3.20	3.188^{ab}	3.20^{ab}
Crossbred	3.27	3.19^{ab}	3.11	3.19	3.26^{ab}	3.20^{b}
Landrace	3.24	3.32^{a}	3.09	3.16	3.30^{b}	3.22^{b}
Spotted	3.18	3.37^{b}	3.18	3.22	3.20^{ab}	3.23^{b}

*1st two numbers represent the year, the letter represents the season (S=spring, F=fall) eg 77F=fall 1977.

^{ab}Means in a column with different superscripts differ significantly.

Duroc sired pens were significantly more efficient than both Landrace and Spotted sired pens in the spring 1978 farrowed group, and more efficient than Landrace sired pens in the fall 1979 farrowed group (see table 2). As is evident, particularly from Figure 1, Duroc sired pigs were consistently more efficient relative to the other breed groups throughout the experiment. The significant breed by year-season

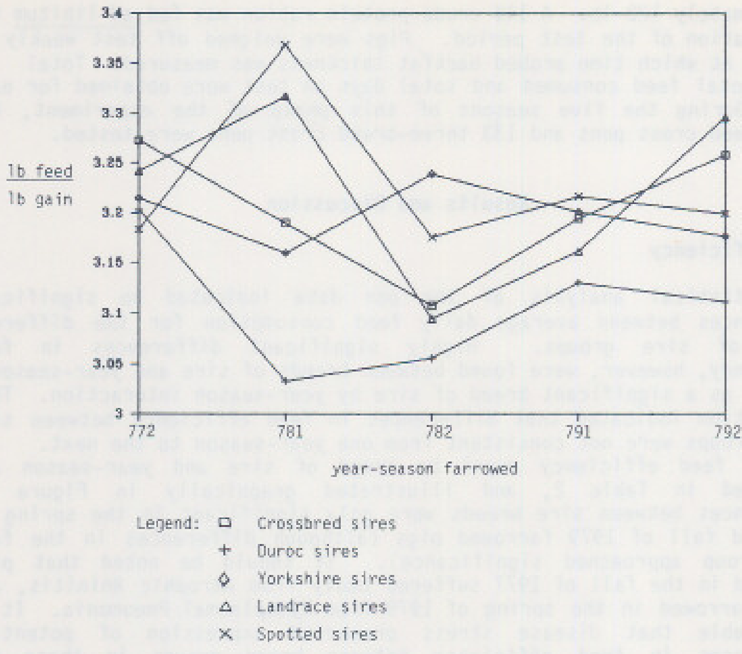

Figure 1. Pen feed efficiency for growing-finishing pigs by year-season.

throughout the experiment. The significant breed by year-season interaction was due to the similarity of the breeds for the fall 1977 and spring 1979 farrowings, and changes in rank by breed groups other than the Duroc sires in other year-seasons. A contributor to this may be that a different set of boars were used each breeding season. It is possible that specific sires selected were more important than the breed the sires were from, with the exception of the consistent advantage for Duroc sired pigs.

Comparing average feed efficiency for purebred sired pens to that for crossbred sired pens revealed no significant difference in any individual year-season or overall. This would suggest that mating two-breed cross rather than purebred males to females of different breeding would have little or no impact on subsequent feed efficiency of offspring produced.

Backfat Thickness

Sex of pig, breed of pig, year-season farrowed and the breed by year-season interaction were all highly significant for probed backfat thickness at 220 lb. Breed group means for backfat thickness are presented in Table 3. Backfat differences between breeds were significant in all but the first year-season of the experiment.

However, caution must be employed in interpreting breed differences due to the significant breed by year-season interaction. The interaction reflects the fact that breeds ranked differently in different year-seasons.

Table 3. Probed backfat thickness least-squares means by breed of pig.[a]

Breed of sires[b,c]	Breed of dam[b,c]					
	D-Y	D-L	D-S	Y-L	Y-S	L-S
D				.99	.98	1.01
Y		1.08	1.02			1.05
L	1.11		1.11		1.08	
S	1.07	1.09		1.06		
D-Y						1.07
D-L					1.00	
D-S				1.09		
Y-L			1.08			
Y-S		1.07				
L-S	1.09					

[a]inches
[b]Reciprocal crosses combined (ie. D-Y = D x Y and Y x D)
[c]D=Duroc, Y=Yorkshire, L=Landrace, S=Spotted.

Despite many changes in ranking of breeds in different year-seasons, certain consistant results were observed. Rank of the three sire breed groups mated to Yorkshire-Landrace dams was consistent from one year-season to the next and, for all practical purposes, consistent for the three sire breed groups with Landrace-Spotted dams. Duroc-Landrace x Yorkshire-Spotted pigs were the leanest four breed cross pigs in all but the first year-season. Pairwise comparisons between purebred breeds of sire mated to the same breed of dam revealed that Landrace sired pigs were fatter than the alternative purebred sired pigs for each breed of dam each year-season (i.e. Landrace x Duroc-Yorkshire pigs were fatter than Spotted x Duroc-Yorkshire pigs each year-season; Landrace x Duroc-Spotted pigs were fatter than Yorkshire x Duroc-Spotted pigs each year-season; etc.). Similarly, Duroc sired pigs were leaner than the alternative sired pigs for each breed of dam each year season. When comparing average backfat of all purebred sired pigs and all crossbred sired pigs, no significant difference was found between the three- and four-breed cross pigs either overall or in any individual year-seasons data.

Average Daily Gain

Sex of pig, breed of pig, year-season farrowed and the breed by year-season interaction were all highly significant for postweaning average daily gain, as they were for probed backfat. However, parity of the dam (whether pigs were born to a gilt or to a second parity sow), and the interaction of breed and parity, although non-significant for backfat, were highly significant for average daily gain. Thus interpretation of breed effects is even more complicated than for backfat. Not only did breeds rank differently for gain in different year-seasons, but also depending upon parity of the dam. The data were therefore analyzed separately by parity. For both parity one and two the terms sex, breed, year-season and the breed by year-season interaction remained highly significant.

Mean average daily gains are presented by parity and breed of pig in Tables 4 and 5. Considering how sire breeds ranked in each parity within each breed of dam group, rank changes were evident for all but the Yorkshire-Spotted dams. However, when considering only purebred sired pigs, the only rank change was for Duroc and Yorkshire sired pigs with Landrace-Spotted dams. Duroc sired pigs from second parity sows grew .07 lb/day faster than Yorkshire sired pigs, whereas Yorkshire sired pigs gained .09 lb/day faster than Duroc sired pigs in gilt litters. In addition to rank changes, differences between breed groups were of noticeably different magnitudes in different parities in many cases.

In addition to summarizing breed performance, an important consideration is the comparison of pigs sired by purebred versus crossbred boars. Average daily gain of crossbred sired pigs from second parity litters was not found to be significantly different from that of purebred sired second parity litter pigs in any year-season's data, or overall. For pigs farrowed in gilt litters, significant differences in growth rate were found in two year-seasons. Crossbred sired pigs farrowed in the spring of 1978 grew significantly faster than purebred sired pigs. However the reverse was true in the fall of 1979 pigs, the three breed cross pigs gaining an average significantly faster than the four breed cross pigs. Overall, no significant difference was detected between growth rate of purebred and crossbred sired pigs.

Table 4. Parity 1 postweaning average daily gain least-squares means by breed group[a].

Breed of sire[b,c]	Breed of Dam[b,c]					
	D-Y	D-L	D-S	Y-L	Y-S	L-S
D				1.58	1.55	1.51
Y		1.54	1.57			1.60
L	1.44		1.54		1.37	
S	1.43	1.45		1.48		
D-Y						1.52
D-L					1.41	
D-S				1.49		
Y-L			1.50			
Y-S		1.59				
L-S	1.51					

[a] lb/day
[b] Reciprocal crosses combined (ie. D-Y = D x Y and Y x D)
[c] D=Duroc, Y=Yorkshire, L=Landrace, S=Spotted.

Table 5. Parity 2 Postweaning average daily gain least-squares means by breed group[a].

Breed of sire[b,c]	Breed of Dam[b,c]					
	D-Y	D-L	D-S	Y-L	Y-S	L-S
D				1.62	1.62	1.58
Y		1.57	1.63			1.51
L	1.70		1.58		1.56	
S	1.45	1.56		1.57		
D-Y						1.54
D-L					1.56	
D-S				1.64		
Y-L			1.60			
Y-S		1.55				
L-S	1.63					

[a]lb/day
[b]Reciprocal crosses combined (ie. D-Y = D x Y and Y x D)
[c]D=Duroc, Y=Yorkshire, L=Landrace, S=Spotted.

Work will continue to further characterize the important genotype by environment interactions evident in this data. In addition, information obtained from this crossbreeding experiment will be pooled and evaluated in order to establish the expected relative efficiencies of the Duroc, Yorkshire, Landrace and Spotted breeds in alternative crossbreeding systems.

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INFLUENCE OF LACTOBACILLUS ACIDOPHILUS ON SERUM CHOLESTEROL LEVELS

S. E. Gilliland[1], C. R. Nelson[2], and C. Maxwell[1]

Story in Brief

The uptake of cholesterol by Lactobacillus acidophilus occurred only when the culture(s) was growing in the presence of bile under anaerobic conditions. Strains of Lactobacillus acidophilus isolated from the fecal flora of pigs varied with regard to the ability to assimilate cholesterol from a laboratory growth medium. Dietary supplementation with L. acidophilus RP32, which was selected for its ability to grow well in the presence of bile and to assimilate cholesterol from the laboratory medium, significantly inhibited ($P<0.05$) increases in serum cholesterol levels of pigs fed a high cholesterol diet. Supplementation with L. acidophilus P47 which was selected for its ability to grow in the presence of bile and lack of ability to remove cholesterol from the growth medium, failed to have a similar effect. This indicates that certain strains of L. acidophilus can act directly on cholesterol in the gastrointestinal tract, and thus may be beneficial in reducing serum cholesterol levels.

(Key Words: Lactobacillus acidophilus, cholesterol, cultured dairy products)

Introduction

Results from a seven year study conducted by the Lipid Research Clinics Program (1984) indicates that reduction of total plasma cholesterol can lower the incidence of coronary heart disease in that relatively small portion of the population suffering from primary hypercholesterolemia. Because of the associated risk of heart disease there has been a thrust toward finding ways to lower plasma cholesterol levels in such people.

Consumption of certain cultured dairy products can result in reduction of serum cholesterol (Grunewald, 1982; Hepner et al, 1979; Mann, 1977; Mann and Spoerry, 1974). Conclusions from some of these studies have indicated that the starter culture bacteria produce metabolites, during their growth in milk, which inhibit cholesterol synthesis in the body. None have suggested that the decrease in serum cholesterol levels was related to a direct action of the bacteria in the cultured milk products on cholesterol in the intestinal tract.

The objectives of this study were to determine whether L. acidophilus would assimilate cholesterol and to confirm whether or not consumption of selected strains would significantly prevent an increase of serum cholesterol in pigs fed a high cholesterol diet.

Materials and Methods

A broth culture of L. acidophilus was inoculated (1 percent) into 10

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ml of sterile lactobacilli MRS broth (Difco Laboratories) containing 1 percent pleuropneumonia-like organism (PPLO) serum fraction (Difco Laboratories) as the cholesterol source and 0.3 percent dried bile (oxgall). The broth was incubated anaerobically 24 h at 37 C. Cells were removed from the broth by centrifugation and resuspended in a volume of distilled water equal to that of the original broth culture. A colorimetric method (Rudel and Morris, 1973) was used to determine the amount of cholesterol in the resuspended cells and spent broth.

Pigs were selected as an animal model to determine if selected cultures varied in their ability to influence serum cholesterol since their digestive system, distribution of coronary arteries, and atherosclerotic tendencies resemble that of the human (Ratcliffe and Luginbuhl, 1971). Since L. acidophilus exhibits host specificity in the intestinal tract, strains of L. acidophilus of pig origin were tested. Rectal swabs were obtained from 4 to 6 month old pigs in the Oklahoma State University swine herd and from a commercial producer. The fabric portion of the swab was broken off into a sterile plastic bag and placed in ice water for transport to the laboratory. The swab was aseptically transferred to a tube containing sterile diluent, appropriate dilutions were prepared and the material was plated on a medium selective for lactobacilli. Plates were incubated at 37 C in a partial CO_2 atmosphere. Cultures were isolated from individual colonies and identified using established procedures (Gilliland, et al, 1980).

Cultures of selected strains of L. acidophilus were grown in 2.4 l of sterile MRS broth for 18 hour at 37 C. Cells were harvested by centrifugation and resuspended in two times their weight of cold sterile 10 percent nonfat milk solids (NFMS). The resulting concentrated culture was dispensed in 2 g portions into sterile cryogenic vials, frozen and stored in liquid nitrogen until used.

Eighteen five-week old Yorkshire gilts from seven litters were randomly assigned to individual metal pens and subsequently to three treatment groups to provide six pigs per treatment. The location of each pig was random with respect to treatments.

All pigs were fed a corn base diet without added crystaline cholesterol (Table 1) twice daily (0.28 kg each feeding) for a one-week adjustment period. During the experimental period which began the second week, all pigs were fed the corn diet supplemented with crystaline cholesterol to supply approximately 1,500 mg of cholesterol per day initially. On days 1 through 7 of the feeding trial, all pigs were fed 0.41 kg of feed at each feeding. For days 8-10 the amount of feed for each was increased to 0.69 kg per feeding. If any feed was left after a 2 hour period it was removed from the pens. Water was available at all times.

In addition to the corn base diet Group 1 (control group) was fed 50 ml of sterile 10 percent NFMS, Group 2 was fed 50 ml of 10 percent NFMS containing 5×10^{10} cells of L. acidophilus P47, and Group 3 was fed 50 ml of 10 percent NFMS containing 5×10^{10} cells of L. acidophilus RP32 once daily (at the evening feeding). The desired numbers of cells of L. acidophilus were provided by adding the appropriate amount of frozen concentrated cultures after thawing. The milk with and without lactobacilli was fed to the pigs in individual bowls just prior to feeding the corn base diet each evening.

Blood samples were taken from each pig after a 12 hour fast by anterior vena cava puncture during the experimental period on days 0, 5, and 10 to be analyzed for total serum cholesterol. Serum from each sample was analyzed for total serum cholesterol using an enzymatic assay kit (Sigma Chemical Co.).

Table 1. Composition of corn base diet used in pig feeding trial.

Component	Amount (kg)
Ground shelled corn	153.5
Butter	27.2
Dried Sweet Whey	72.6
Soybean meal	98.0
Salt	0.9
Dicalcium phosphate	5.4
Calcium Carbonate	3.3
Vitamin and trace mineral premix[a]	1.5
Total	362.4[b]

[a]Vitamin trace mineral premix supplied 1760 mg riboflavin; 8,800 mg pantothenic acid; 8,800 mg niacin; 8.8 mg vitamin B_{12}; 176,000 mg choline chloride; 1,760,000 I.U. vitamin A; 176,000 I.U. vitamin D_3; 4,400 I.U. vitamin E; 44 mg menadiane dimethyl-primidionol bisulfite; 39.6 mg selenium; 299.2 mg iodine; 19.8 g iron; 11 g manganese; 2.2 g copper; and 39.6 g zinc per kilogram of premix.

[b]After mixing with a Marion Mixer (Rapids Machinery Co., Marion, Iowa) 78.7 kg was removed for adjustment period feeding and 450 g cholesterol (purity at least equivalent to USP; Sigma Chemical Co., St. Louis, MO) was added and mixed into the remaining 283.7 kg. Including that from the butter, the diet contained 1775 mg cholesterol/kg.

Results and Discussion

Cholesterol was taken up by L. acidophilus in the broth medium containing PPLO serum and oxgall only during anaerobic growth of L. acidophilus.

Individual strains of L. acidophilus exhibited considerable variation with regard to the ability to assimilate cholesterol. For example L. acidophilus RP32 removed more cholesterol from the growth medium and accumulated more in the cells than did strain P47 (Table 2).

Table 2. Assimilation of cholesterol by Lactobacillus acidophilus during anaerobic growth in MRS broth containing PPLO serum and oxgall.

	Cholesterol (μg/ml)[a]		
Culture	Control Broth	Spent Broth	Cells
RP32	67.2	40.6	28.6
P47	67.2	61.4	8.2

[a]Each value represents the average from 3 trials.

In the feeding trial all pigs appeared to remain healthy and there were no significant differences in weight gains among the treatment groups. Consumption of the diet fed was not a problem and intake did not differ among treatment groups. The pigs were fed a diet high in cholesterol in order to cause an increase in serum cholesterol. All groups exhibited increases in serum cholesterol during the feeding trial as expected (Table 3). The mean serum cholesterol concentration for all treatament groups on day 0 was between 52 and 56 g/dl; there were no significant differences among groups ($P>0.05$). There were no significant interactions among treatments and days ($P>0.05$). The mean serum cholesterol values on Day 5 for the control group and P47 group had increased significantly ($P<0.05$) to 69.10 and 72.01 g/dl respectively. The group receiving L. acidophilus RP32 did not exhibit a significant ($P>0.05$) increase from day 0 to day 5. The mean concentration for the latter group on day 5 was significantly lower ($P<0.05$) than for the P47 group. The mean value of the RP32 group on day 10 was also significantly lower ($P<0.05$) than both the control and P47 groups. None of the groups exhibited significant increases from day 5 to day 10 ($P>0.05$).

Table 3. Influence of feeding cells of Lactobacillus acidophilus on serum cholesterol levels in pigs on a high cholesterol diet.

	Cholesterol (mg/dl)[a]		
Group	Day 0	Day 5	Day 10
Control	52.23 (1.88)^{C1}	69.10 (3.91)^{CD2}	74.44 (4.64)^{C2}
L. acidophilus P47	55.58 (4.70)^{C1}	72.01 (3.02)^{C2}	73.48 (4.68)^{C2}
L. acidophilus RP32	52.84 (3.00)^{C1}	61.48 (3.30)^{D1}	62.29 (4.91)^{D1}

[a]Each value is the mean from six pigs; numbers in parentheses = standard deviation; values in same column followed by different superscript letters are significantly different ($P<.05$); values in the same row followed by different superscript numbers are significantly different ($P>.05$). There were no significant interactions among days and treatments ($P>.05$).

Some strains of L. acidophilus have the ability to assimilate cholesterol as indicated by the appearance of cholesterol in the cells during growth which was associated with decreases in the concentrations of cholesterol in the growth medium during anaerobic growth in a medium containing bile. The amount of bile required to enable the cultures to remove cholestrol from the growth medium was not in excess of the levels normally encountered in the intestines. Thus, the conditions required in the in vitro system for cholesterol uptake by L. acidophilus would also be expected to occur in the intestinal tract. This should enable the organism to assimilate at least part of the cholesterol ingested in the diet, thus making it unavailable for absorption into the blood. A similar action could be exerted on endogenous cholesterol in the intestines.

Both strains of L. acidophilus selected for use in the pig feeding trial exhibited resistance to bile; however, strain RP32 exhibited maximal ability and strain P47 exhibited minimal ability to assimilate cholesterol in vitro. These two strains were selected for the feeding trial to determine if the difference in ability to assimilate cholesterol would influence any effect that consuming cells of L. acidophilus might have on serum cholesterol levels in the pigs. The significantly lower levels of serum cholesterol in the pigs that received the "cholesterol-assimilating" strain (RP32) further supports the idea that the ability of L. acidophilus to cause reductions in serum cholesterol is a result of the direct action of the culture on cholesterol.

Further research is needed to determine the mechanism of cholesterol uptake and to determine whether or not ingestion of cells of a selected strain of L. acidophilus could decrease serum cholesterol levels in adult humans with primary hypercholesterolemia.

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COLLAGEN AS A LEAN OR FAT MEAT REPLACEMENT IN PORK SAUSAGE

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Story in Brief

Collagen was used to replace various levels of either lean or fat meat (5, 10, 15 or 20 %) in pork sausage and stored at 0 C to determine the effect of collagen level and storage period on the quality characteristics of the sausage. Sensory evaluation indicated that products with collagen were indistinguishable from the control suggesting that collagen may be used as a suitable replacement for either the lean or fat tissue in pork sausage.

(Key words: Collagen, replacement, fat or lean.)

Introduction

Pork sausage is one of the more common meat items on the breakfast menu. In fiscal year 1983 alone, 1,114,663,000 pounds were prepared and processed under federal inspection. With such large volume of sausage products on the market, there has been a definite trend to develop products suitable fo use as extenders. Collagen is one such product that is under investigation.

Hydrolysates of beef or pork skin used to replace non-fat dry milk in cooked sausage formulation had greater water holding and fat holding ability. The higher protein content of the hydrolysate gave the sausage emulsion improved stability during cooking (Satterlee and Zachariah, 1973). The effect of food grade collagen substitution on the functional properties of coarse beef bologna by replacing lean meat at 10, 20 or 30 % levels indicated the potential of this ingredient (Schalk, 1981). Collagen also has been used in fine-emulsion bologna, replacing lean meat at 5, 10 or 15 % levels while keeping fat content constant at 25 % (Gielissen, 1981). The addition of wet collagen to ground beef at 0, 10 or 20 % levels as a lean meat replacement and the mixed products stored at -15 C for 2 weeks had no change in the eating quality characteristics (Chavez, 1983). Collagen has been used in various bakery products such as whole wheat muffins, sweet wheat loaf, corn meal muffins, plain cakes, carrot cake, oatmeal cookies and in plain and wheat bread spatzle (Ebro et al., 1979, 1980).

The purpose of this investigation was to determine the feasibility of substituting collagen for varying portions of the total lean tissue or the fat tissue of pork sausage.

Materials and Methods

Forty-five kg of raw pork shoulders and 10 kg of pork back fat were purchased from Ralph's Packing Co.(Perkins, Oklahoma) for the four replications in this experiment. After manually separating the fat tissue from the shoulders, the fat trim, lean trim and pork back fat were each

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ground separately once through a 1.27 cm plate into separate containers and sampled at random locations in their containers for fat determination by the modified Babcock method for cream (AOAC,1980).

Eight number 10 cans of food grade bovine hide collagen were used for this study. The calculated amounts of ground lean, ground fat and bovine hide collagen for each of the nine formulations (Table 1) were mixed with 61.6 g salt, 2.2 g sage, 4.4 g ground red pepper and 8.8 g ground black pepper using a Hobart paddle type mixer for 2 min.

Table 1. Pork sausage formulations.

Code	Tissue replaced	Level %	Lean g (1)	Fat g (2)	Collagen solid (3)	Collagen water (4)
C00	none	0	2776	1224	0	0
L05	lean	5	2576	1224	91	109
L10	lean	10	2376	1224	182	218
L15	lean	15	2176	1224	273	327
L20	lean	20	1976	1224	364	436
F05	fat	5	2776	1024	91	109
F10	fat	10	2776	824	182	218
F15	fat	15	2776	624	273	327
F20	fat	20	2776	424	364	436

(1) based on the 10 % average fat content of the 4 lots of lean tissue. (2) based on the 75.4 % average fat content of the 4 lots of fat tissue. (3) solid obtained from filtration. (4) aqueous portion obtained from filtration of collagen from the cans.

The resulting sausage mixture was ground once through a 0.64 cm grinder plate to provide uniform distribution of fat, lean and collagen. Supralon casings were filled with sausage using a mechanical stuffer to produce twelve 300 g chubs.

Triplicate samples from each formulation and the fibrous portion of the food grade collagen were used to determine the amount of moisture, protein and fat according to the AOAC methods (1980).The protein content of collagen was calculated as a percentage of nitrogen times 5.56 (Henrickson et al. 1984).

Twelve chubs prepared from each formulation were randomly assigned to 0, 2, 4 or 6 weeks of storage. At the end of each storage period, samples from each formulation were obtained for taste panel evaluation for color, juiciness, texture, flavor and overall acceptability of the cooked sausage using a semi trained laboratory panel. The panel used a descriptive scale, a modification of a score card, suggested by Stone et al.(1974), the modification being a line across each subjective trait, 14 cm long, with anchor points at 2cm interval. The left end point of the line was given a value of 0 with each succeeding anchor point assigned values in increments of 1 with the right end point having a value of 7. The vertical lines marked by each panelist on the score card were converted to numerical values using a template. Patties from each formulation were cooked on a pre-heated electric griddle set at 162.8 C and turned over every 5 min until each side had been cooked for a total of 10 min.

The results were analyzed statistically for analysis of variance and where differences were found the means were separated by Duncan's method.

Results and Discussion

Chemical Composition

The chemical composition of the collagen and the nine different pork sausage formulations are shown in Table 2. Collagen from all the four lots revealed similar percentages of fat, protein and moisture. The factor 5.56 was used to convert the percent nitrogen to percent protein in the collagen. Although the addition of collagen may affect the total protein in the pork sausage, the factor 6.25 was still used to calculate the percent protein. The amont of protein contributed by collagen, on a weight basis, is a small fraction of the total protein contributed by the other components of the sausage, i.e., the lean and fat tissue. Therfore any calculation involving a different factor for collagen would yield protein values that are slightly higher than the protein values of the control sausage.

The sausage formulations with replaced lean tissue possessed similar percentages of fat, protein and moisture. The percentage of fat decreased while the percentage of moisture increased when fat tisssue was replaced. The decrease in fat was attributed to the low fat content of collagen.

Table 2. Chemical composition of collagen and pork sausage.

Product	fat %	protein %	moisture %
Collagen	0.40	19.53	79.09
	0.31	18.00	79.15
	0.33	17.56	78.27
	0.31	19.97	78.80
C00	29.86	13.68	55.19
L05	30.02	13.34	55.18
L10	28.66	12.94	56.39
L15	29.56	12.49	56.59
L20	28.88	12.74	58.12
F05	27.44	13.87	56.61
F10	24.66	13.58	58.30
F15	20.29	14.60	63.90
F20	17.17	14.42	67.45

Sensory Evaluation

Sensory evaluation was conducted to determine if the taste panelists could discriminate any differences in the quality attributes of the pork sausage such as cooked color, juiciness, texture, flavor and overall acceptabilty. The semi-trained laboratory panelists found no significant differences in the quality attributes of the cooked pork sausage patties involving both types of replacement (Table 3.) except for the fat

Table 3. Effects of storage time and replacement of lean or fat meat with collagen on the mean values of sensory attributes(*) of pork sausage.

sensory trait	collagen level	Storage weeks 0	2	4	6
Color	C00	4.76	4.09	4.00	4.12
	L05	4.45	4.25	4.76	4.16
	L10	4.42	4.50	3.92	3.97
	L15	4.15	4.25	4.08	4.00
	L20	4.22	3.81	4.58	3.89
	F05	4.48	4.58	4.18	4.16
	F10	4.79	4.14	4.11	3.73
	F15	4.79	3.84	3.90	4.21
	F20	4.20	4.14	4.17	4.28
Juiciness	C00	4.40	3.75	3.40	3.17
	L05	4.15	3.87	4.18	3.56
	L10	3.97	3.84	3.79	3.71
	L20	4.18	3.95	4.25	3.44
	F05	4.22	3.54	3.59	3.18
	F10	4.11	4.18	3.74	3.34
	F15	3.98	3.43	3.11	3.04
	F20	3.96	3.54	3.89	3.43
Texture	C00	3.76	3.44	3.39	2.99
	L05	3.81	3.73	3.95	3.29
	L10	3.77	3.53	3.57	3.66
	L15	3.91	3.21	3.19	3.47
	L20	3.63	3.78	3.82	3.05
	F05	4.04	3.81	3.61	3.46
	F10	3.86	3.99	3.46	3.22
	F15	3.91	3.34	3.36	3.20
	F20	3.96	3.54	3.89	3.43
Flavor	C00	4.72	4.24	3.72	3.83
	L05	4.40	4.13	4.34	4.03
	L10	4.02	4.17	4.05	3.95
	L15	4.18	4.16	4.38	3.86
	L20	4.02	3.62	4.08	3.96
	F05	4.19	4.17	4.05	3.78
	F10	4.17	4.35	4.21	3.93
	F15	4.01	3.11	3.80	3.65
	F20	3.85	4.18	3.82	3.66
Over all acceptability	C00	4.76	3.97	3.74	3.40
	L05	4.45	3.98	4.39	3.80
	L10	4.02	4.26	4.01	4.04
	L15	4.16	3.87	4.22	3.54
	L20	4.08	3.49	4.14	3.63
	F05	4.30	3.97	3.74	3.40
	F10	4.47	4.53	3.72	3.86
	F15	4.25	3.02	3.61	3.53
	F20	3.92	3.88	3.77	3.29

* Values based on eight-point scales where 7 = very desirable color or very juicy or very fine or intense pork flavor or like moderately; 1 = very undesirable or very dry or very coarse or extremely off flavor or dislike moderately.

replaced patties at 15 % level which had a significantly lower taste panel score for flavor. This difference may primarily be attributed to differences among the panelists (P< 0.05). There were also no significant differences in these quality attributes due to storage periods of the fat tissue replaced sausages; no sinificant differences in the color and flavor due to storage. These sausages, however, were found to be less juicy (P<0.05) and less acceptable (P<0.05) at weeks 4 and 6 compared to week 0. The patties at week 6 also were found to have a less desirable (P<0.05) texture compared to patties at week 0.

Differences in the juiciness, flavor and overall acceptability of the cooked patties were probably not detected because of the differences among panelists. It is also possible that the spices used in the formulations may have shielded the effect that collagen may have had upon the juiciness and flavor of the patties.

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EFFECT OF COOKING METHOD ON THE CHOLESTEROL CONTENT OF HAMBURGER PATTIES

R.L.Henrickson[1] and B.R.Rao[2]

Story in Brief

Cooking hamburger patties on an Instant Burger Cooker did not result in any appreciable reduction in the cholesterol content. Even though the fat content of some hamburger brands decreased slightly their cholesterol level showed an increase suggesting that cholesterol may also be present in the structural lipids (intracellular membranes and structures) in addition to external and intramuscular fat.

(Key words: Cook method, cholesterol, hamburger.)

Introduction

Animal tissues contain a great variety of steroids of which cholesterol is quantitatively the most important. It is a constituent of all body tissues and therefore appears to be necessary for the integrity of the animal cell. Man derives his cholesterol stores by two processes, by endogenous synthesis and by absorption of dietary cholesterol. Since it is a universal constituent of all animal cells, cholesterol occurs in all foods of animal origin.

Cholesterol is involved in the organization and permeability of cell membranes. Progestagens, glucocorticoids, mineralocorticoids, androgens and estrogens are the major steroid hormones derived from cholesterol. It is a precursor of vitamin D which is important in the control of calcium and phosphorus metabolism. Reduction in blood cholesterol levels by dietary means is difficult under conditions consonant with good nutrition. The daily intake of cholesterol in the mixed diet of an adult varies from 200 to 360 mg.

In spite of many useful roles played by cholesterol in the human body, a school of thought exists that diets of animal origin high in cholesterol are responsible for certain cardiovascular diseases. Even though the average cholesterol content of cooked meats is less than 100 mg/ 100g, the increasing consumption of fast foods necessitates a closer look at the cholesterol levels in these foods. Janciki and Appledorf (1974) reported a decrease in the cholesterol content of beef patties broiled or grill fried compared to raw ones while microwave cooking had no effect. However, they noticed no significant difference between cooking methods.

This investigation was undertaken to determine whether a new type of cooker (Instant Burger) affected the cholesterol content of cooked hamburger when compared to a conventional grill.

Materials and Methods

Hamburger patties each weighing approximately 4 oz (raw) were obtained from two local fast food outlets (Brands B and C) and from OSU

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food service center (Brand A). All the patties after wrapping in wax coated paper were packaged in freezer paper and stored at -10 C.

The fast food outlets also provided cooked patties. The raw Brand A patties were cooked on an electrical griddle preheated to 350 F, to medium well degree of doneness. This constituted the conventional cooking method. The cooked patties were wrapped in freezer paper and stored at -10 C.

Cooking the patties using the Instant Burger (Smokaroma Inc. Boley O.K. 74829) was the new method of cooking. Two patties were cooked at a time to medium well done. The cooked patties were transferred on to a wax coated paper, wrapped and stored in a freezer at -10 C along with all other cooked patties until analysis (not more than a week).

Chemical analysis: The patties were analyzed for protein, ether extract and moisture following the AOAC methods (1980).

Cholesterol determination: The cooked patties were ground through a 1/8 in plate of a hand grinder and 2 g were weighed into a stainless steel container attachment of a Sorvall Omnimixer. Crude fat was extracted with a chloroform methanol mixture 2:1 by volume (Hubbard et al. 1977). The chloroform extract was evaporated to dryness using a water bath at 60 C with a thin stream of air flowing over the sample and finally dried to a constant weight in a hot air oven at 60 C. The dried fat was redissolved in ethyl ether to known volume and 1 ml was pipetted into a clean test tube and once again dried at room temperature (about 25 C). Cholesterol was determined spectrophotometrically using o-phthaldialdehyde reagent (Bachman et al. 1976). The results were expressed as mg cholesterol per 100 g of sample.

Results and Discussion

Brand A burgers (Table 1) showed a moderate increase in the cholesterol level due to Instant Burger cooking even though their fat content was slightly decreased. The Brand B patties (Table 1) had a slight increase in the cholesterol level and a slight decrease in the fat content when cooked on Instant Burger. The Brand C patties (Table 1) cooked on the Instant Burger had a moderate decrease in their cholesterol

Table 1. Chemical composition and cholesterol values of hamburger patties cooked by Instant Burger and Conventional methods

Sample	Instant Burger cooked				Griddle cooked			
#	Pro %	Mois %	Fat %	Chol mg/100g	Pro %	Mois %	Fat %	Chol mg/100g
Brand A	24.9	58.8	14.8	27.06	26.5	53.9	17.0	22.53
Brand B	24.6	59.2	15.6	30.44	28.1	54.5	17.0	28.84
Brand C	23.6	59.5	16.6	27.58	26.4	47.5	26.5	33.43
Average (54 patties)	24.4	59.2	15.7	28.48	27.0	52.0	20.2	28.3

value and a moderate decrease in the fat content. These results are not in general agreement with Janciki and Appledorf (1974) who reported that the method of cooking, broiling, grill frying or microwave cooking, had no significant effect on the cholesterol content of cooked beef patties.

Brand C patties conventionally cooked had 26.5 % fat and those cooked on Instant Burger had 16.6 % fat (Table 1). This increased loss of fat from Brand C patties on Instant Burger cooking may be responsible for their low cholesterol values compared to conventionally cooked ones. The conventionally cooked Brand A patties (Table 1) had an aveage fat content of 17.0 % while the same patties cooked on Instant Burger showed an average fat content of 14.8 %. Similarly the Brand B (Table 1) conventionally cooked and Instant Burger patties had a fat content of 17.0 and 15.6 percent respectively. Even though the fat content of Brand A and Brand B decreased slightly, their cholesterol levels showed an increase which suggested that cholesterol may also be present in the structural lipids (intracellular membranes and structures) in addition to the external and intramuscular fat which is in agreement with Rhee et al. (1982).

When the data were summarized (54 patties per cooking method) from all samples (Table 1) it was observed that the cholesterol level of the cooked patties did not differ greatly due to the method of cooking. Eventhough the patties cooked by the Instant Burger unit contained less fat (15.7 %), the cholesterol level was not greatly different from the patties cooked by the conventional method although their fat content was much higher (20.2 %). Patties cooked on the Instant Burger possessed more moisture but less protein than patties cooked by the conventional method. Therefore it may be concluded that the cholesterol type lipids are also present within the lean portion of the ground beef patties and not directly related to the total fat content of the cooked patties.

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EFFECT OF COOKING METHOD ON THE FAT CONTENT OF HAMBURGER PATTIES

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Story in Brief

Hamburger patties prepared using an Instant Burger Cooker had 4.5 % less fat than those cooked on a griddle. The data suggested that the Instant Burger method would provide a lower calorie content per cooked patty.

(Key words: Cook method, fat content, hamburger.)

Introduction

Consumers presently are very conscious of the nutritive content of foods as this is related to their health. The segment of the population which is at risk to coronary heart disease are advised to be cognizant of their dietary intake of cholesterol (Reiser, 1978). Some epidemiological studies have demonstrated positive correlations between high fat consumption and colon cancer (Reddy, 1981) and pancreatic cancer (Wyndler, 1975). Janciki and Appledorf (1974) recommended microwave cooking of ground beef patties for persons on low fat diets as this method provided less crude fat than broiling or grill frying.

This investigation was undertaken to determine whether a new type cooker(Instant Burger) affected the total fat content of cooked burgers compared to the griddle method.

Materials and Methods

Hamburger patties each weighing approximately 4 oz (raw) were obtained from two local fast food outlets and from OSU food service center (Brand A). All the patties after wrapping in wax coated paper were packaged in freezer paper and stored at -10 C.

The fast food outlets also provided both raw and cooked patties, Brand B and Brand C. The raw Brand A patties were cooked on an electrical griddle preheated to 350 F, to a medium well degree of doneness. This constituted the conventional cooking method. The cooked patties were wrapped in freezer paper and stored at -10 C.

Cooking the patties using the Instant Burger (Smokaroma Inc. Boley O.K. 74829) was the other method of cooking. Two patties were cooked at a time to medium well done. The cooked patties were transferred on to a wax coated paper, wrapped and stored in a freezer at -10C along with all other cooked patties until analysis (not more than a week).

Chemical analysis: The patties were analyzed for protein, ether extract and moisture following the AOAC methods (1980).

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Results and Discussion

The chemical composition of the ground beef patties (Fig. 1) shows the fat content of patties cooked by the Instant Burger method to have 4.5 % less fat than those cooked by the regular grill method. When one considers that 1 g of fat contains 9.02 calories, this would suggest that beef patties cooked by the Instant Burger method provide a lower calorie intake per patty. Janciki and Appledorf (1974) reported a similar decrease in crude fat content of ground beef patties cooked by microwave, but found no difference in the fat levels of patties cooked by broiling or grill frying. Therefore, based on these data, one may conclude that Instant Burger cooking of hamburger patties may be beneficial for persons on a low fat diet as well as for that segment of the population prone to the risk of cardiovascular diseases and for all other people who are concerned about fat in the diet.

It is of further interest to note that beef patties cooked by the Instant Burger method retained 7.2 % more moisture than those cooked on the grill. This greater moisture level would indicate more palatability in the form of a juicier burger. Eventhough the protein content of Instant Burger cooked patties was 2.7 % lower than the grilled patties, the protein level would still be adequate for good human nutrition.

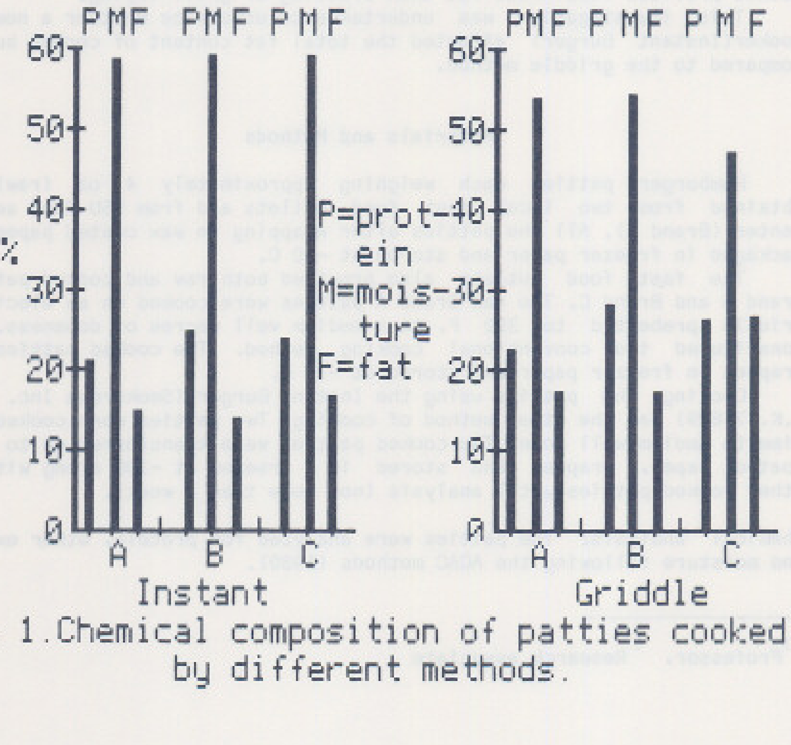

Fig 1.Chemical composition of patties cooked by different methods.

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INFLUENCE OF TEMPERATURE, TIME, AND SOLVENT ON COLLAGEN AND SALT-EXTRACTABLE MEAT PROTEINS

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Story in Brief

This study was conducted to gain some understanding of the functional attributes of fibrous hide collagen as a potential ingredient in processed meats. Fibrous collagen was used to replace either 0, 10, 20, 30 or 100% of minced muscle. The meat portion (meat and/or collagen) was treated with either 3% NaCl or 3% NaCl + 0.44% sodium tripolyphosphate and the resulting slurry was heated at either 50, 60 or 70C for either 0, 15, 30, 45, 60, 75 or 90 min and nitrogen solubility was determined.

Protein denaturation, as monitored by changes in nitrogen solubility, was manifested as a reduction in solubility for the 0% collagen (100% muscle) substitution level or an increase in solubility for the 100% collagen level. The degree of these responses was dependent on the solvent used as demonstrated by greater release of soluble nitrogen for 3% NaCl + 0.44% STPP than 3% NaCl at the 100% collagen substitution level and 50C.

(Key words: Collagen, Functional attributes, Meat proteins).

Introduction

The basic functional property of proteins is their solubility and in the case of muscle food the response to subsequent heat treatment. These two essential factors will determine the efficacy of using a novel protein, hide collagen, as an additive or extender in processed muscle foods.

Loss of nitrogen solubility is one of the most readily measurable properties of proteins and has been used widely as a criterion for denaturation. Monitoring changes in solubility for various fractions of muscle as a consequence of heat denaturation; to determine whether the functional performance of combinations of meat and extender proteins is greater in combination than the sum of their individual performance; were some of the earlier studies.

It was the purpose of this experiment to study changes in nitrogen solubility as a indication of protein response to various hydrothermal conditions and to gain more knowledge concerning the functional properties of hide collagen as a potential ingredient in processed meat items.

Materials and Methods

Materials

The Eastern Regional Research Center at Philadelphia, PA, provided

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comminuted native wet collagen, frozen in No. 10 cans and classified as product No. 1, based on pH, particle size, protein denaturation, and viscosity.

Methods

All collagen was removed from frozen storage (-13C) and thawed at 40C. It was strained through a Bunchner funnel to separate the fibrous and liquid portions of the material. A ratio of 2.18:1 (solids:liquid) was obtained. This ratio was determined so a constant proportion of solids to liquid could be maintained if more collagen were needed for conducting further experiments. Following filtration, the liquid and solids were recombined and thoroughly mixed. This standardized material was packaged in 250 g portions into 454 g freezer containers for -13C storage.

A beef inside round from a choice grade carcass was removed from frozen storage and thawed at 4C, manually freed of separable fat and superficial connective tissue, ground once through a 1.25 cm plate and ground twice through a 4.8 mm plate. Fifty gram portions of the minced muscle were packaged in plastic bags for storage at -13C. The individually packaged frozen meat and collagen were thawed (4C) as necessary for experimentation. Food-grade NaCl, granular food-grade sodium tripolyphosphate (STPP), and distilled water were used to formulate the extracting solutions.

Three percent NaCl and a combination of 3% NaCl and 0.44% STPP were used as the extracting solutions. Meat replaced with 0, 10, 20, 30 or 100% levels of collagen served as the meat portion. Fifteen and nine-tenths grams of the meat block were weighed into a 400 ml blender cup and blended with 159.1 gms of extractant at 6400 rpm for one minute using a Sorvall Omni-mixer. The resulting slurry was blended for an additional min following a three min rest period. This preparation of 175 gms of slurry was repeated four times to obtain sufficient sample for the heat treatment. The four blends were combined and the pH of the composite blend was adjusted to 6.00 with either 1N NaOH or 1N HCl.

Table 1. Effect of Solvent and Collagen Substitution on Meat Slurry pH Prior to Ajustment to pH 6.00[a,b]

Collagen Level (%)	3% NaCl (pH)	3% NaCl + 0.44% STPP (pH)
0	5.46 (0.15)	6.57 (0.07)
10	5.45 (0.06)	6.62 (0.15)
20	5.52 (0.13)	6.81 (0.11)
30	5.67 (0.08)	6.87 (0.13)
100	7.38 (0.17)	8.38 (0.22)

[a]Values in parentheses represent the standard deviation.

[b]Mean of 8 observations.

Fifty grams of the resulting slurry were weighed into each of 12 test tubes for heat treatment in an oscillating water bath at either 50, 60 or 70C depending on the treatment conditions. Two tubes were removed at 15 min intervals until 90 min had elapsed. Upon removal from the water bath, the contents of each tube were immediately filtered through Watman No. 4 filter paper and the filtrate was placed in an ice bath.

The original slurry, in excess of that needed for heat treatment, was used for determination of the nitrogen content of the time-temperature control (0 min. heating time). The meat slurry was weighed into a 50 ml teflon tube and placed in an RC2-B refrigerated centrifuge for centrifugation at 10,000 rpm for 10 min. The resulting slurry supernatant was filtered through eight layers of cheese cloth and the filtrate was used in the nitrogen analyses.

Kjeldahl nitrogen was obtained using the Tecator 1013 digestion unit and the Kjeltec 1030 autoanalyzer and pH was measured. In addition to the 6 fifteen min intervals, nitrogen analysis was conducted in duplicate on the unheated filtrate obtained from the previously described centrifugation step.

Experimental Design and Data Analysis

The experiment was conducted using a Randomized Complete Block Design with a split-plot arrangement of treatments. In each block, 5 collagen levels, 3 temperature levels, and 2 phosphate levels denote the main-unit treatment factors for a total of thirty possible treatments (5 X 3 X 2) and within each treatment, seven time intervals represent the subunit treatment factors. Each treatment was replicated three times for a total of three blocks.

The data were anlyzed using Statistical Analysis System (SAS). F-tests from the analysis of variance was performed to determine if significant differences occurred between levels of each treatment and the significance of any two-way interactions among whole unit treatment factors, and between whole unit treatment factors and subunit treatment factors. The presence of quadratic trends in the data associated with time of heating was verified using the general linear models procedure of SAS.

Results and Discussion

Effect of Temperature and Time

The premise on which this experiment was based is that heat denaturation results in changes in solubility depending on the severity of the heat treatment. The quantity of soluble nitrogen was significantly reduced, when the meat slurry was exposed to heat, as a result of the heat induced denaturation and subsequent coagulation of meat proteins (Table 2). The major reduction in solubility occurred during the initial 15 min of heating for 50, 60 and 70C. From 30 to 90 min of heat treatment, the amount of soluble nitrogen maintained a relatively constant value for each of the three temperatures studied. However, a step-wise loss in solubility was observed as temperature increased for 50 to 70C at all the time intervals from 30 min onwards. This step-wise reduction indicated that sufficient energy became available to overcome the resistance to heat denaturation of more thermally stable proteins soluble in either of the solvents studied. Since myosin is the most abundant and one of the more heat sensitive

Table 2. Effect of temperature, time, and solvent on soluble nitrogen (%) for 0, 10, 20, 30 and 100% meat replacement with collagen[1,2]

Time (min)	50C 3%NaCl	50C 3%NaCl + 0.44%STPP	60C 3%NaCl	60C 3%NaCl + 0.44%STPP	70C 3%NaCl	70C 3%NaCl + 0.44%STPP
			0% Meat Replacement			
0	0.128[a]	0.160[a]	0.124[a]	0.099[a]	0.111[a]	0.156[a]
15	0.094[b]	0.115[b]	0.080[b]	0.092[a]	0.058[b]	0.069[b]
30	0.094[b,c]	0.098[c]	0.068[c]	0.079[b]	0.055[b]	0.061[b,c]
45	0.092[b,c]	0.094[c,d]	0.065[c]	0.075[b]	0.054[b]	0.060[b,c]
60	0.088[bc]	0.093[c,d]	0.064[c]	0.075[b]	0.052[b]	0.058[c]
75	0.085[c]	0.088[d]	0.062[c]	0.070[b]	0.050[b]	0.059[c]
90	0.089[b,c]	0.088[d]	0.062[c]	0.074[b]	0.052[b]	0.057[c]
			10% Meat Replacement			
0	0.103[a]	0.133[a]	0.116[a]	0.143[a]	0.112[a]	0.141[a]
15	0.089[b]	0.098[b]	0.074[b]	0.083[b]	0.058[b]	0.058[b]
30	0.087[b]	0.093[b]	0.074[b]	0.083[b]	0.058[b]	0.058[b]
45	0.085[b]	0.093[b]	0.064[c]	0.067[c]	0.056[b]	0.054[b]
60	0.083[b]	0.089[b]	0.064[c]	0.069[c]	0.056[b]	0.045[b]
75	0.083[b]	0.091[b]	0.064[c]	0.069[c]	0.056[b]	0.056[b]
90	0.081[b]	0.090[b]	0.064[c]	0.068[c]	0.057[b]	0.058[b]
			20% Meat Replacement			
0	0.092[a]	0.124[a]	0.086[a]	0.111[a]	0.104[a]	0.095[a]
15	0.084[a,b]	0.089[b]	0.068[b]	0.073[b]	0.057[b]	0.056[b]
30	0.082[a,b]	0.087[b]	0.064[c]	0.066[b,c]	0.058[b]	0.057[b]
45	0.083[a,b]	0.085[b]	0.058[b,c]	0.061[c]	0.057[b]	0.057[b]
60	0.081[b]	0.082[b]	0.059[b,c]	0.062[c]	0.060[b]	0.059[b]
75	0.083[a,b]	0.084[b]	0.060[b,c]	0.062[c]	0.059[b]	0.060[b]
90	0.081[b]	0.083[b]	0.060[b,c]	0.061[c]	0.057[b]	0.056[b]
			30% Meat Replacement			
0	0.084[a]	0.109[a]	0.078[a]	0.087[a]	0.062[a]	0.091[a]
15	0.076[b]	0.083[b]	0.064[b]	0.067[b]	0.051[b]	0.051[b]
30	0.071[b]	0.077[b]	0.059[b,c]	0.062[b,c]	0.052[b]	0.050[b]
45	0.075[b]	0.077[b]	0.057[b,c]	0.059[b,c]	0.053[a,b]	0.052[b]
60	0.074[b]	0.075[b]	0.056[b,c]	0.056[c]	0.054[a,b]	0.052[b]
90	0.075[b]	0.077[b]	0.053[c]	0.056[c]	0.056[a,b]	0.051[b]
			100% Meat Replacement			
0	0.006[e]	0.001[e]	0.017[d]	0.004[e]	0.000[e]	0.002[c]
15	0.005[e]	0.022[d]	0.034[c]	0.024[d]	0.044[d]	0.047[b]
30	0.016[d]	0.028[c]	0.050[b]	0.033[c]	0.051[c,d]	0.054[a,b]
45	0.022[c,d]	0.036[b,c]	0.058[a]	0.027[c,d]	0.055[c]	0.052[a,b]
60	0.029[b,c]	0.036[b,c]	0.062[a]	0.046[b]	0.058[b,c]	0.054[a,b]
75	0.035[a,b]	0.040[a,b]	0.060[a]	0.046[b]	0.065[a,b]	0.059[a]
90	0.041[a]	0.046[a]	0.059[a]	0.056[a]	0.071[a]	0.060[a]

1 Means in columns not followed by the same letter are significantly different ($p < 0.05$).
2 Each value is a mean of six observations with predicted values

proteins, the majority of the initial reduction in solubility at the 15 min heating period for 50 and 60C could be accounted for by the denaturation of myosin with further reduction at 70C representing the denaturation of more thermally stable components of the salt-extractable fraction.

During the initial 15 to 30 min heating periods (Table 2), the loss of solubility is a time dependent response. The denaturation of protein constituents coagulable at 60C would be expected to be time-dependent at temperatures equal to or greater than 60C. The dependence on time was observed during the initial 15 to 30 minutes, any further changes in solubility would be temperature dependent as evidenced by decreased soluble nitrogen as temperature increased at these prolonged heating periods. Therefore, temperature dependency occurs as a result of increasing stability associated with the more thermally resistant proteins in solution.

Effect of Collagen Replacement

The heat treatment control (0 min time interval) illustrates that replacing portions of the minced muscle with hide collagen reduced the quantity of nitrogen soluble in either 3% NaCl (Table 2) or 3% NaCl + 0.44% STPP. Quantitative determinations of salt-soluble protein in various meats used in the processing industry revealed that approximately 7% of muscle is salt-extractable.

There are two opposing reactions affecting the quantity of soluble nitrogen as a result of heat denaturation; precipitation of heat coagulable muscle proteins and thermal solubilization of collagen. At 50C the loss in solubility attributed to the heat denaturation of salt-extractable muscle proteins influenced to a greater extent the quantity of nitrogen in the filtrate whereas at 60C with 3% NaCl as the extractant and at 70C for both solvent conditions (Table 2) and disparity associated with collagen substitution levels was not as distinct after 30 min of heating. This pattern for these three hydrothermal conditions may be due to more complete coagulation of the salt-extractable muscle proteins and an opposing increase in solubility associated with thermal hydrolysis of collagen and consequently reducing the disparity associated with greater dilution of muscle proteins by collagen.

Table 2 illustrates that at all hydrothermal conditions studied for 100% collagen substitution, the amount of nitrogen in the filtrate increased with increasing temperature and time at a given temperature. In the presence of 3% NaCl at 50C there was no significant increase in solubility until 30 min, whereas at 70C under the same solvent conditions there was a marked increase in solubility attributable to the thermal hydrolysis of collagen after heating for 15 min.

The initial decrease in solubility at 50C may be due to a release of newly synthesized tropocollagen molecules that have not undergone extensive crosslinking. The shrinkage temperature of collagen (Ts = 39C) is marked by a sudden release of soluble collagen as a consequence of the disruption of the secondary structure. The primary bond responsible for stabilizing the collagen triple helix is extensive hydrogen bonding associated with structural water and the hydroxyl group of hydroxyproline. At 70C, sufficient heat may be present to break the continuity of the interchain waterbridges, the hydroxyproline related stability, and the aldol type crosslinkages associated with hydroxylysine.

The initially sharp increase in soluble nitrogen at 70C and 15 min of heating time for 100% collagen (Table 2) changed to a more gradual increase for the remaining time increments. This initial increase may represent more extensive rupture of collagen crosslinks of mature collagen in addition to the soluble material released at 50C. At the remaining heating time any increase in collagen solubility may be due strictly to the denaturation of more mature collagen fibrils. The same response for 100% collagen with 3% NaCl as the solvent was observed at 60C. There was a gradual increase in the percent soluble nitrogen from 0-45 min, after which the soluble nitrogen leveled off at approximately 0.060% nitrogen that was comparable to the values for 70C under the same solvent conditions.

Effect of Solvent

STPP increased the amount of protein solubilized in the presence of 3% NaCl as evidenced by more soluble nitrogen in the filtrate. This effect was evident for all heating conditions for 0% collagen substitution (100% meat). A comparison of the unheated sample (0 min time interval) and the 15 min time interval reveals that the difference associated with the use of STPP was greater before heat treatment than following 15 min of heating at 50C (Table 2). This observation suggested that the protein components, (i.e. myosin) most susceptible to heat coagulation,were affected more by the action of STPP. This may be due to the larger portion of myosin available for the action of STPP as compared to other proteins rather than a preferential association of STPP and myosin.

The improved solubility attributable to the action of STPP was not observed for 10, 20 and 30% collagen substitution levels at 70C for heating periods longer than 15 min (Table 2). Therefore, it is understandable why replacing portions of muscle tissue with a rather insoluble protein such as hide collagen reduces tha total amount of protein extractable with either solvent. This dilution effect is consistent with other research workers in that they reported a decrease in the quantity of sarcoplasmic and myofibrillar proteins as collagen replacement of meat increased. The equality of the values for the two solvent conditions at 70C and heating times longer than 15 min may be due to the opposite manner in which collagen and salt-extractable proteins manifest protein denaturation and solubilization in 3% NaCl and 3% NaCl + 0.44% STPP. At 70C those factors contributing to a decrease in soluble nitrogen (i.e. muscle protein dilution by collagen and heat coagulation of muscle proteins) are no longer predominant and subsequently thermal hydrolysis of collagen dominates and consequently increases the quantity of nitrogen in the filtrate. Therefore, thermal hydrolysis reduces the disparity between the two solvent conditions.

The solubility increase associated with the use of STPP at 0, 10, 20 and 30% collagen substitution levels is a result of the effect of increased pH and ionic strength on the muscle tissue component of the meat block. Table 1 illustrates that pH, prior to adjustment to 6.00, was significantly greater in the presence of STPP and it is also correct to assume that ionic concentration was greater when STPP was combined with NaCl than when NaCl was used alone. Also, the initially small particle size, the mechanical action of the omni-mixer and the high ratio of extractant to the meat block would facilitate the diffusion and action of the solvent in regard to the solubilization of the meat proteins.

In regard to solvent effects on the fibrous collagen used in this experiment, Table 2 reveals that at 50C, 3% NaCl and 0.44% STPP produced an increase in soluble nitrogen for the 100% collagen above that found using 3% NaCl alone as the extractant. The collagen solubilized at 50C may represent newly synthesized tropocollagen since this substituent has not undergone significant crosslinking and is stabilized by weak hydrogen bonds. Therefore, the addition of STPP and subsequent pH and ionic strength effects may destabilize the hydrogen bonds to the point that allows more complete release of the soluble component after heating at 50C for 15 min. The increased pH from 7.38 to 8.38 produced by STPP (Table 1) would change the net negative charge on the protein and thus affect the solubility of tropocollagen by increasing the repulsive forces on the protein and consequently improve hydration.

At 60 and 70C, solubility increased less with time in the presence of STPP. Other researchers using native hide collagen reported that at 6% NaCl, hydration was reduced at pH values greater than 5.00. This was attributed to a shielding of water by either Na or Cl ions at these extreme pH's. The reduction in hydration may explain the difference in solubility associated with pH changes. However, the temperature effect was preeminent since at both solvent conditions more collagen is solubilized at 70C followed by 60C and 50C respectively. A consideration of what portion of the thermally solubilized collagen was due to newly synthesized collagen and what portion was due to mature collagen would aid in understanding the mechanism of action on fibrous hide collagen.

Conclusion

The degree of response was dependent upon the solvent, as demonstrated by a greater release of soluble nitrogen, for 3% NaCl + 0.44% STPP, at the 0, 10, 20, and 30% collagen substitution levels; where as, 3% NaCl elicited the greatest release of soluble nitrogen for 100% collagen at 50C.

ANALYSIS OF CARCASS TRENDS IN AN OKLAHOMA YOUTH BARROW SHOW

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Story in Brief

Carcass data from 1294 barrows - 144 Berkshire, 151 Chester White, 207 Duroc, 194 Hampshire, 132 Poland China, 114 Spot, 152 Yorkshire and 200 Crossbreds - slaughtered in the Oklahoma City 4-H and FFA Livestock Shows from 1972 to 1984 is presented. The barrows were the top end of each respective breed selected by a judge in the live show.

In general barrows had significantly higher backfat thickness, smaller loin eye area, shorter carcass length and decreased estimated percent carcass lean from 1982 to 1984 as compared to all previous years. The Hampshire breed tended to be superior in all carcass traits measured except carcass length.

(Key Words: Swine Shows, % Lean, Length, Backfat, Loin Eye Area)

Introduction

Many individuals involved in the swine industry, including swine producers, educators, meat processors and others, have expressed concern over the changes in type of animals selected by live show judges in barrow shows in recent years. These barrows appear to be fatter, shorter, lower to the ground, larger and more wasty in the head and jowl and less desirable in carcass merit. Thus, data from barrows slaughtered in the Oklahoma City 4-H and FFA Livestock Show from 1972 to 1984 were analyzed to determine if changes had occurred in various carcass measurements.

Materials and Methods

The Oklahoma City 4-H and FFA Livestock Show has from 1400 to 2700 barrows exhibited each year. From 1972 to 1984, the top two to five animals of each breed weight class were slaughtered. The actual number slaughtered per breed weight class was the same within any one given year. However, the number slaughtered per breed each year varied depending on the number of weight classes per breed.

The barrows were slaughtered at Cornett Packing Company, Oklahoma City and processed at Schwab Meats, Oklahoma City. Adjusted slaughter weight, carcass length, backfat thickness and loin eye area were obtained from 1968 to 1984. The percent lean pork of carcass and 10th rib fat depth is also reported for 1980 to 1984.

The adjusted slaughter weight was based on cold carcass weights and a standard dressing percentage of 71.7, 72.0, 72.4, and 72.7 percent for carcasses weighing 143 lb and less, 144-168, 169-176 and 177 lb and up,

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respectively. The average adjusted slaughter weights were 221.5, 223.4, 225.2, 235.2, 252.4, 253.4, 241.8, 243.0, 251.3, 239.7, 251.3, 245.5 and 247.6 lb for years 1972 to 1984, respectively. Increases in maximum weight allowed in the show of 10 lb in 1975 and an additional 10 lb in 1976 through 1984 account for the marked increases in adjusted slaughter weights for these years. Carcass length, backfat thickness and loin eye area were adjusted to a 220 lb equivalent each year using adjustments recommended by the National Association of Swine Records.

Results and Discussion

Records on 1294 barrows that were slaughtered form 1972 to 1984 were analyzed (table 1). The Spot breed was not recognized as a separate breed class until 1974. Prior to 1974, Spots were considered Polands and were in the Poland class.

Average adjusted backfat thickness for barrows of each breed and each year is presented in table 2. Barrows were fatter in the last three years, 1982 through 1984, than in all previous years ($P<.05$). The yearly average adjusted backfat thickness ranged from 1.297 to 1.411 inches from 1982 to 1984 as compared to 0.988 to 1.199 inches in the earlier years. The increase in backfat thickness in recent years probably reflects the emphasis by some live show judges and breeders to promote the thicker, deeper bodied pigs that are actually fatter. In breed comparisons, the Hampshires with an average backfat thickness of 1.093 inches were leaner ($P<.05$) than all the other breeds.

The average adjusted loin eye area for barrows of each breed and each year is show in table 3. Average adjusted loin eye area tended to decrease in a linear manner ($P<.05$) over time. The loin eye areas of 4.20 and 4.12 sq. in. for 1983 and 1984 were smaller ($P<.05$) than all previous years. The largest average loin eye area was 6.13 sq. in. for 1972 which was the earliest year measured and this value was higher ($P<.05$) than all subsequent years except 1975 which was 6.03 sq. in. The Hampshire breed had the largest ($P<.05$) average adjusted loin eye area of 5.54 sq. in. among all breeds. The Spot and Duroc breeds had the smallest loin eye areas of 4.97 and 4.98 sq. inches, respectively, which were smaller ($P<.05$) than all the other breeds except the Yorkshire breed's loin eye area of 5.13 sq. in.

The average adjusted carcass length for barrows of each breed and each year is shown in table 4. Carcass length tended to increase from 1972 to 1981 with the 33.8 in. reported in 1981, being longer ($P<.05$) than all other years. Carcass length tended to decrease from 1981 to 1984 with the 30.7 inches for barrows in 1984 being shorter ($P<.05$) than all previous years. The increase in carcass length from 1972 to 1981 reflected the emphasis by purebred breeders, live show judges and others to produce a longer hog. The decrease shown in carcass length from 1981 to 1984 probably illustrates the tendency of some live show judges and breeders to emphasize a shorter, deeper set and thicker hog. The Yorkshire breed had the longest carcass length of 32.7 in. and was longer ($P<.05$) than all other breeds. The Poland breed was shorter (31.8 in.) than all the other breeds ($P<.05$).

The average percent lean of the carcass as shown in Table 5 was estimated from 1980 to 1984 using the procedures recommended by the National Pork Producers Council. The barrows tended to decrease in percent carcass lean over time with the barrows in the most recent year, 1984, having the lowest percentage of 50.72. This value was less ($P<.05$) than all previous years. The Hampshire breed had the highest

Table 1. Number of barrows of each breed slaughtered per year.

Breed	Year of Show													Total
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
Berkshire	12	9	14	14	12	12	12	12	9	8	8	12	10	144
Chester	15	13	15	15	12	12	12	10	10	9	8	12	8	151
Duroc	15	13	14	15	12	12	20	16	15	14	16	24	21	207
Hampshire	15	15	15	15	12	11	16	13	11	12	11	26	22	194
Poland	14	12	5	14	11	12	11	11	9	9	9	9	6	132
Spot	-	-	9	15	12	12	12	10	9	9	9	9	8	114
Yorkshire	13	13	15	15	11	12	13	9	9	9	9	12	12	152
Crossbred	14	15	15	15	12	12	15	14	12	12	11	30	23	200
Total	98	90	102	118	94	95	111	95	84	82	81	134	110	1294

Table 2. Average adjusted backfat thickness of barrows of each breed per year (in.)

Breed	Year of Show													Overall Avg.[1]
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
Berkshire	1.33	1.05	1.11	1.15	1.09	1.13	1.11	1.14	1.07	0.92	1.34	1.38	1.26	1.163^{ab}
Chester	1.25	1.00	1.02	1.07	1.07	1.05	1.07	1.17	1.09	1.02	1.27	1.38	1.34	1.130^{b}
Duroc	1.20	1 05	1.04	1.00	.99	1.07	0.98	1.10	1.08	1.01	1.29	1.53	1.37	1.158^{b}
Hampshire	1.03	0.91	0.96	1.01	.98	0.99	1.13	1.01	0.96	0.95	1.22	1.37	1.30	1.093^{c}
Poland	1.15	1.08	1.05	1.11	1.11	1.05	1.22	1.07	1.15	0.97	1.24	1.33	1.44	1.142^{b}
Spot			1.09	1.14	1.15	1.13	1.18	1.18	1.17	1.05	1.34	1.45	1.39	1.198^{a}
Yorkshire	1.29	1 00	1.07	1.08	1.03	1.04	1.09	1.13	1.08	1.02	1.34	1.50	1.37	1.155^{b}
Crossbred	1.17	0.94	0.99	1.03	1.06	1.02	1.04	1.15	1.01	0.96	1.35	1.35	1.31	1.134^{b}
Overall Avg.[1]	1.199^{c}	$.995^{gh}$	1.038^{fg}	1.073^{def}	1.061^{ef}	1.062^{ef}	1.094^{de}	1.116^{d}	1.072^{def}	$.988^{h}$	1.297^{b}	1.411^{a}	1.337^{b}	

[1] Any two means without a common superscript differ significantly (P< .05).

Table 3. Average adjusted loin eye area of barrows of each breed per year (sq. in.)

Breed	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Overall Avg.[1]
	Year of Show													
Berkshire	5.76	5.33	5.87	5.98	5.47	5.06	6.01	4.98	4.44	4.78	4.21	4.13	3.90	5.15^{c}
Chester	5.98	5.51	5.79	5.82	5.69	5.51	5.90	4.83	4.40	5.10	4.54	4.14	3.90	5.27^{bc}
Duroc	6.08	5.42	5.60	5.46	5.84	5.32	6.01	5.26	4.81	4.82	3.97	3.72	3.74	4.98^{d}
Hampshire	6.59	5.81	6.27	6.20	6.02	5.41	6.38	5.29	4.86	5.56	5.13	4.62	4.65	5.54^{a}
Poland	6.02	5.56	5.13	6.30	5.92	5.48	5.71	4.94	4.61	5.40	4.39	4.22	4.03	5.34^{b}
Spot			5.50	5.86	5.42	5.17	5.64	4.40	4.38	4.86	4.45	3.74	4.18	4.97^{d}
Yorkshire	5.98	5.78	5.48	5.98	5.49	5.43	5.50	4.03	4.14	4.58	4.13	4.47	4.31	5.13^{cd}
Crossbred	6.40	5.94	6.35	6.62	5.80	5.74	6.22	4.91	4.83	5.09	4.56	4.28	4.04	5.32^{b}
Overall Avg.[1]	6.13^{a}	5.64^{c}	5.83^{c}	6.03^{ab}	5.71^{c}	5.39^{d}	5.95^{ab}	4.89^{e}	4.59^{f}	5.04^{e}	4.40^{f}	4.20^{g}	4.12^{g}	

[1] Any two means without a common superscript differ significantly (P<.05).

Table 4. Average adjusted carcass length of barrow of each breed per year (in.)

Breed	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Overall Avg.[1]
	Year of Show													
Berkshire	31.4	31.3	31.7	31.3	32.6	32.4	32.7	33.2	33.1	33.9	32.8	31.9	30.9	32.2^{c}
Chester	31.4	31.6	32.0	31.3	32.0	32.0	32.5	33.1	32.9	33.7	32.5	31.5	31.4	32.1^{c}
Duroc	30.9	31.3	31.7	31.3	32.4	32.5	33.3	33.4	32.8	33.7	32.7	31.4	30.5	32.1^{c}
Hampshire	31.2	31.5	32.2	31.6	32.1	32.5	33.0	33.3	32.8	33.4	32.4	31.6	30.5	32.0^{c}
Poland	30.7	30.9	31.8	30.8	31.5	32.2	32.2	32.6	32.3	33.4	33.2	31.7	31.1	31.8^{d}
Spot			32.0	31.5	32.3	32.6	32.9	33.2	33.2	34.1	33.4	32.2	30.5	32.5^{b}
Yorkshire	31.8	32.4	32.4	32.1	32.9	32.9	33.8	34.3	33.8	34.7	33.4	31.6	30.7	32.7^{a}
Crossbred	31.1	31.6	31.8	31.4	32.1	32.4	33.2	33.1	33.3	33.8	32.4	31.4	30.7	32.0^{c}
Overall Avg.[1]	31.2^{g}	31.5^{f}	32.0^{e}	31.4^{fg}	32.2^{d}	32.4^{d}	33.0^{bc}	33.2^{b}	33.0^{bc}	33.8^{a}	32.8^{c}	31.6^{f}	30.7^{h}	

[1] Any two means without a common superscript differ significantly (P<.05).

Table 5. Average percent lean of carcasses of barrows of each breed per year (in.)

Breed	1980	1981	1982	1983	1984	Overall Avg.[1]
			Year of Show			
Berkshire	54.46	55.19	52.21	51.75	50.38	52.64[cd]
Chester	54.46	56.16	52.94	51.13	48.99	52.75[bcd]
Duroc	56.31	55.44	51.85	50.46	49.16	52.16[d]
Hampshire	56.37	58.16	56.24	54.74	52.40	55.04[a]
Poland	53.74	57.43	53.16	51.97	50.02	53.50[bc]
Spot	53.74	55.48	52.81	49.07	49.46	52.18[d]
Yorkshire	53.33	54.60	52.39	52.66	51.73	52.85[bcd]
Crossbred	56.35	56.12	53.61	53.45	51.39	53.69[b]
Overall avg.[1]	55.04[b]	56.12[a]	53.14[c]	52.34[d]	50.72[e]	

[1] Any two means without a common superscript differ significantly (P<.05).

Table 6. Average 10th rib fat depth of barrows of each breed per year (in.)[1]

Breed	1980	1981	1982	1983	1984	Overall Avg.[2]
			Year of Show			
Berkshire	.86	.88	1.11	1.14	1.26	1.06[b]
Chester	.84	.88	1.18	1.28	1.48	1.12[a,b]
Duroc	.71	.87	1.06	1.25	1.40	1.10[a,b]
Hampshire	.73	.78	.88	.89	1.25	.95[c]
Poland	1.04	.82	1.03	1.17	1.37	1.07[b]
Spot	.94	.89	1.13	1.43	1.54	1.18[a]
Yorkshire	.86	.88	1.04	1.12	1.22	1.04[b]
Crossbred	.72	.88	1.04	1.00	1.30	1.03[b,c]
Overall avg.[2]	.82[c]	.86[c]	1.05[b]	1.11[b]	1.33[a]	

[1] Average slaughter weights were 251.3, 239.7, 251.3, 245.5 and 247.6 lb. for 1980 through 1984 respectively.

[2] Any two means without a common superscript differ significantly (P<.05).

percent carcass lean of 55.04 which was greater (P<.05) than all other breeds.

The average 10th rib fat depth which is used in estimating the percent lean pork of the carcass is shown in Table 6. Barrows tended to increase in 10th rib fat depth measurements each year from 1980 to 1984 with the 1.33 inches reported for 1984 being higher (P<.05) than all previous years. Among breeds, the Hampshire breed had the least 10th rib fat depth of .95 in. which was less (P<.05) than the other breeds except the Crossbreds.

The data from the barrows slaughtered in this show reveals a trend in the last three years of fatter, shorter pigs with less loin eye area and estimated percent carcass lean. Although the barrows slaughtered in this show cannot be considered a representative sample of the industry, they do reveal a declining trend in carcass merit in all breeds which many people feel is alarming.

ANALYSIS OF TRENDS IN OKLAHOMA SWINE CARCASS CONTESTS

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Story in Brief

Data from 946 market hogs - 277 Durocs, 321 Hampshires and 348 Crossbreds - entered by producers in the State Fair of Oklahoma "Golden Pork Chop Contest" (a swine carcass contest) from 1968 to 1984 were analyzed. Backfat thickness was greater for pigs slaughtered in 1983 and 1984 than in all previous years. Carcass length tended to increase from 1968 to 1981 and then decrease from 1982 to 1984. The animals decreased in loin eye area in a linear manner over time from 1973 to 1984 with the loin eye area in 1983 and 1984 being smaller than all previous years. Pigs slaughtered in 1983 and 1984 had lower percentage carcass lean than animals slaughtered in all previous years.

Data from 536 market hogs - 76 Durocs, 101 Hampshires and 359 Crossbreds entered by producers in the Oklahoma National Barrow Show Performance Contest from 1975 to 1983 were also analyzed to determine performance trends. Pigs increased in average daily gain over time. Backfat thickness tended to decrease from 1975 to 1979 and increase in all subsequent years. Carcass length increased over time with the pigs in the first year being shorter than the pigs in all subsequent years. Loin eye area tended to decrease over time with the loin eye area in 1983 being smaller than all previous years. Percent carcass lean was significantly lower for the pigs slaughtered in 1983 than all previous years except 1980. Average pounds of lean pork produced per day on test was greater for pigs slaughtered in 1979 and 1980 than all subsequent years.

(Key Words: Swine, Carcass Trends, Backfat, Length, Loin Eye Area)

Introduction

There has been considerable concern recently that less emphasis is being placed on carcass merit by many swine breeders. It appears that some swine carcass traits such as loin eye area and backfat thickness may be actually becoming inferior as reported by the popular press. Data from pigs slaughtered in the Golden Pork Chop Contest, an Oklahoma State Fair Swine Carcass Contest, from 1968 to 1984 and the Oklahoma National Barrow Show Performance Contest from 1975 to 1983 were analyzed to determine if changes had occurred in various carcass measurements.

Materials and Methods

The Golden Pork Chop Contest and the Oklahoma National Barrow Show Performance Contest are open to any pork producer in the world; however,

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the vast majority of entries have been from Oklahoma. In the Golden Pork Chop Contest, all animals from 1968 to 1984 were slaughtered at Cornett Packing Company, Oklahoma City, and processed at Schwab Meats, Oklahoma City. In the Oklahoma National Barrow Show Performance Contest, the animals were slaughtered and processed at Wilson's Foods, Oklahoma City from 1975 to 1980. From 1981 to 1983 the Oklahoma National Barrow Show animals were slaughtered at Cornett Packing Company, Oklahoma City and processed at Schwab Meats, Oklahoma City.

Slaughter weight, carcass length, backfat thickness and loin eye area were obtained in both contests each year except loin eye area was not measured for the Golden Pork Chop Contest from 1968 to 1972. Data for percent carcass lean was obtained for the Oklahoma National Barrow Show starting in 1979 and the Golden Pork Chop Contest starting in 1980.

Adjusted slaughter weight was determined by using carcass weights and a standard dressing percentage of 71.7, 72.0, 72.4 and 72.7% for cold carcasses weighing 143 lb and below, 144-168, 169-175, and 176 lb and up, respectively. Carcass length, backfat thickness and loin eye area were adjusted to a 220 lb equivalent each year using adjustments recommended by the National Association of Swine Records. The percent lean pork of carcass was determined using the formula recommended by the National Pork Producers Council. Premium winners in both contests were required to have acceptable pork quality and meet certification standards adopted by the National Association of Swine Records.

Golden Pork Chop Contest

All animals entered in the Golden Pork Chop Contest were farrowed after March 1 of each year and were exhibited and slaughtered in September of the same year. Only barrows were exhibited from 1968 to 1977 with both barrows and gilts being exhibited in 1978 through 1984. Winners in the contest were determined by the percent lean cuts of adjusted live weight from 1968 to 1972, ham-loin index from 1973 to 1979 and percent lean pork of carcass weight from 1980 to 1984. No attempt was made to determine average daily gain or to consider any growth data in the contest.

The average adjusted slaughter weights were 207.7, 213.9, 214.2, 222.7, 221.5, 217.3, 232.7, 232.2, 238.7, 240.1, 237.0, 225.6, 219.8, 233.8, 225.9, 227.4 and 223.5 lb for each year from 1968 through 1984, respectively. Increase in maximum weight allowed in the contest from 240 to 250 lb accounts for the large increase in slaughter weight in 1974.

Oklahoma National Barrow Show Performance Contest

All animals entered in the Oklahoma National Barrow Show Performance Contest were farrowed after February 1 and weighed and identified with an ear tattoo at one of approximately 14 weigh stations in Oklahoma in early April. The animals were then exhibited, weighed and slaughtered in Oklahoma City in August. Both barrows and gilts were accepted in the contest.

Winners from 1975 to 1978 were determined by considering carcass merit, average daily gain and soundness using the following formula: Daily Gain X 75 + Ham-Loin Index + Soundness Score. Soundness scores were determined by a committee of three using a range of scores from 1 to 20 with 20 being ideal.

Winners from 1979 to 1983 were determined by pounds of muscle produced per day on test adjusted for soundness score and on-test weight as outlined by Stevermer et al., (1979). The show was discontinued at the end of 1983.

Average starting weights were 31.7, 47.6, 41.2, 42.2, 42.5, 42.6, 48.8, 39.8 and 43.7 lb for the years 1975 through 1983, respectively. Average adjusted slaughter weights were 231.5, 240.4, 241.0, 259.9, 265.8, 261.9, 251.1, 241.0 and 248.4 lb for the years 1975 through 1983, respectively.

Results and Discussion

Golden Pork Chop Contest

The number of pigs of each breed slaughtered each year from 1968 to 1984 in the Golden Pork Chop Contest is shown in table 1. Statistical analysis was conducted only on the Duroc, Hampshire and Crossbreds because the number of pigs representing the other breeds was small. These three breeds represented 946 of the 1129 total animals slaughtered.

The average adjusted backfat thickness for each year is shown in table 2. There was generally a decrease in backfat thickness over time until 1980. From 1981 to 1984 backfat tended to increase with backfat thickness for the pigs in 1983 and 1984 being greater ($P<.05$) than all previous years. This reflects the emphasis swine breeders placed on a decreasing percent fat and increasing percent lean until recent years when it appeared that breeders were placing less emphasis on carcass traits. No significant differences were noted in backfat thickness among breeds but the Hampshires tended to be trimmer than the Durocs and Crossbreds.

The average adjusted carcass length for each year is shown in table 3. There was generally an increase in carcass length from 1968 to 1981 with the animals slaughtered in 1980 and 1981 being longer ($P<.05$) than all other years. The animals slaughtered in 1982 through 1984 were shorter ($P<.05$) than those slaughtered in 1980 and 1981. The general increase in carcass length from 1968 to 1981 reflected the emphasis by purebred breeders, commercial producers, live show judges and others to produce a longer hog. The decrease in length for 1981 to 1984 probably illustrates the tendency of some live show judges and breeders to emphasize a shorter, deeper set and thicker hog. The crossbreds tended to be longer than the other two breeds and were significantly longer ($P<.05$) than the Hampshires.

The average adjusted loin eye area for each year is shown in table 4. The animals tended to decrease in loin eye area in a linear manner ($P<.01$) over time with the pigs slaughtered in 1983 and 1984 having a smaller loin eye area ($P<.05$) than pigs slaughtered in all previous years. The Hampshires had the largest average loin eye area (5.88 sq. in) which was significantly larger ($P<.05$) than the Durocs (5.29 sq. in).

The average 10th rib fat depth which is used in estimating the percent lean pork of the carcass is shown in Table 5. The 10th rib fat depth was greater in 1983 and 1984 than all previous years, except 1980. No significant differences were noted among breeds but the Hampshires tended to have less 10th rib fat depth than the other two breeds.

The average percent lean pork of the carcass for each year is shown in table 6. Pigs tended to decrease in percent lean over time. The

Table 1. Number of pigs of each breed for each year at the Golden Pork Chop Contest.

	Year of Show																	
Breed	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Total
Berkshire	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	2	2	7
Chester	4	2	3	1	9	3	3	8	2	1	5	0	3	2	4	9	12	71
Duroc	11	16	12	23	19	19	19	18	12	6	17	11	8	29	14	22	21	277
Hampshire	34	42	30	52	14	13	22	14	19	20	9	6	2	14	5	11	14	321
Poland	6	6	6	6	4	3	6	2	2	1	0	1	0	1	1	4	4	53
Spot	0	0	0	0	1	0	4	0	2	1	3	6	2	0	2	2	4	27
Yorkshire	3	2	4	0	0	0	0	4	1	0	4	2	0	0	1	4	0	25
Crossbred	17	13	20	17	24	20	33	18	24	9	9	15	18	23	18	25	40	348
Total	75	81	75	99	71	58	87	64	62	38	48	41	33	71	45	79	102	1129

Table 2. Average adjusted backfat thickness for each year in the Golden Pork Chop Contest (in.).

	Year of Contest																	
Breed	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Overall Avg.[1]
Duroc	1.21	1.25	1.23	1.15	1.19	1.17	1.13	1.11	1.13	1.22	1.03	1.10	1.11	1.14	1.20	1.26	1.22	1.17[a]
Hampshire	1.12	1.12	1.14	1.14	1.07	1.06	1.04	0.97	1.08	1.11	0.98	1.04	1.07	1.09	1.19	1.17	1.25	1.11[a]
Crossbred	1.16	1.18	1.18	1.13	1.10	1.12	1.07	1.13	1.13	1.07	1.18	0.99	1.07	1.09	1.17	1.22	1.25	1.14[a]
Overall Avg.[1]	1.16[bc]	1.18[bc]	1.18[bc]	1.14[cd]	1.12[cde]	1.12[cde]	1.08[def]	1.07[ef]	1.11[cde]	1.13[cde]	1.06[f]	1.04[f]	1.08[def]	1.11[cde]	1.18[ab]	1.21[a]	1.23[a]	

[1] Any two means without a common superscript differ significantly (P< .05).

Table 3. Average adjusted carcass length for each year in the Golden Pork Chop Contest (in.).

	Year of Contest																	
Breed	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Overall Avg.[1]
Duroc	30.25	30.56	30.01	30.66	30.22	31.33	31.35	31.30	31.33	31.96	32.46	32.38	32.66	32.88	32.57	32.38	31.63	31.55[ab]
Hampshire	30.31	30.76	30.40	30.82	30.50	31.31	31.42	31.52	31.77	31.46	32.06	32.63	32.79	32.95	32.41	32.73	32.57	31.23[b]
Crossbred	31.01	30.92	30.70	30.84	30.79	31.25	31.10	31.51	31.35	32.16	32.26	32.61	33.16	33.27	32.75	32.59	31.77	31.73[a]
Overall Avg.[1]	30.52[f]	30.74[f]	30.37[f]	30.77[f]	30.51[f]	31.30[e]	31.29[e]	31.45[de]	31.48[de]	31.66[cd]	32.26[b]	32.54[b]	32.99[a]	33.03[a]	32.64[b]	32.61[b]	31.88[c]	

[1] Any two means without a common superscript differ significantly (P< .05).

Table 4. Average adjusted loin eye area for each year in the Golden Pork Chop Contest (sq. in.).

Breed	Year of Show												Overall Avg.[1]
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
Duroc	5.14	6.23	5.93	5.62	5.52	5.81	5.78	5.41	4.90	4.96	4.32	4.21	5.29^{a}
Hampshire	5.58	6.50	6.41	6.14	6.26	6.02	6.07	5.53	5.08	5.80	4.67	4.46	5.88^{b}
Crossbred	5.34	6.28	6.12	6.21	5.42	5.61	5.94	5.23	4.99	4.94	4.89	4.52	5.44^{ab}
Overall Avg.[1]	5.35^{d}	6.34^{a}	6.15^{ab}	5.99^{ab}	5.73^{bc}	5.81^{c}	5.93^{bc}	5.30^{d}	4.97^{e}	5.06^{e}	4.71^{f}	4.42^{f}	

[1] Any two means without a common superscript differ significantly ($P<.05$).

Table 5. 10th rib fat depth for each year in the golden pork chop contest (in.)

Breed	Year of Show					Overall Avg.[1]
	1980	1981	1982	1983	1984	
Duroc	0.88	0.73	0.78	1.10	.94	$.89^{a}$
Hampshire	0.75	0.77	0.74	0.98	.89	$.85^{a}$
Crossbred	0.97	0.86	0.82	1.04	.98	$.95^{a}$
Overall avg.[1]	$0.93^{b,c}$	0.78^{d}	$0.79^{c,d}$	1.03^{a}	$.95^{a,b}$	

[1] Any two means without a common superscript differ significantly ($P<.05$).

Table 6. Percent lean of carcasses for each year in the Golden Pork Chop Contest.

Breed	1980	1981	1982	1983	1984	Overall Avg.[1]
			Year of Show			
Duroc	57.40	56.54	56.43	52.35	53.25	54.88[a]
Hampshire	58.70	56.88	59.41	54.02	53.96	55.66[a]
Crossbred	56.17	56.00	56.06	54.51	53.68	54.93[a]
Overall avg.[1]	56.70[a]	56.42[a]	56.65[a]	53.97[b]	53.61[b]	

[1] Any two means without a common superscript differ significantly (P<.05).

animals slaughtered in 1983 and 1984 had a lower (P<.05) percent carcass lean than the animals slaughtered in all previous years. Again this trend probably reflects the lack of emphasis being placed on carcass traits by many leaders of the swine industry. No significant differences were noted among breeds but the Hampshire breed tended to have higher percent carcass lean than the other two breeds.

National Barrow Show Performance Contest

The number of pigs of each breed evaluated annually from 1975 to 1983 in the Oklahoma National Barrow Show Performance Contest is shown in table 7. Statistical analysis was conducted on the Duroc, Hampshire and Crossbred pigs which represented 536 head of the 595 total evaluated.

The average daily gain of pigs for each year is shown in table 8. The pigs tended to increase in average daily gain over time with the pigs from 1975 to 1977 having lower average daily gain (P<.05) than the pigs in all subsequent years. The crossbreds tended to gain faster than the Durocs or Hampshires.

The average adjusted backfat thickness for each year is shown in table 9. Backfat thickness tended to decrease each year from 1975 to 1979 and increase in subsequent years. The trend reflects the lack of emphasis being placed in recent years on reducing backfat thickness. The animals slaughtered in 1978 and 1979 had less backfat (P<.05) than animals slaughtered in all subsequent years. No significant differences were noted among breeds but the Hampshires tended to have less backfat thickness than the other two breeds.

The average adjusted carcass length for each year is shown in table 10. The adjusted carcass length tended to increase over time with the pigs in the first year (1975) being shorter(P<.05) than the pigs in all subsequent years. Little difference was noted for carcass length among the three breeds analyzed.

The average adjusted loin eye area for each year is shown in table 11. Loin eye area tended to decrease over time (P<.01) with the loin eye area in 1983 being smaller (P<.05) than all previous years. No significant differences were noted among breeds but Hampshires tended to have larger loin eyes than the other two breeds.

Table 7. Number of pigs for each year at the Oklahoma National Barrow Show Performance Contest

Breed	Year of Show 1975	1976	1977	1978	1979	1980	1981	1982	1983	Total
Berkshire	0	2	0	0	1	2	0	0	0	5
Chester White	2	5	1	2	2	3	0	0	3	18
Duroc	10	15	12	7	4	7	3	11	7	76
Hampshire	18	25	15	14	9	2	5	3	10	101
Poland	0	0	0	1	0	0	0	0	0	1
Spot	1	6	7	5	0	4	1	0	0	24
Yorkshire	0	0	9	0	0	1	0	0	1	11
Crossbred	17	46	55	47	44	39	49	38	24	359
Total	48	99	99	76	60	58	58	52	45	595

Table 8. Average daily gain for each year at the Oklahoma National Barrow Show Performance Contest [1,2]

Breed	Year of Show 1975	1976	1977	1978	1979	1980	1981	1982	1983	Overall[3] Avg.
Duroc	1.59	1.51	1.58	1.58	1.66	1.42	1.59	1.53	1.73	1.57[a]
Hampshire	1.56	1.46	1.56	1.66	1.62	1.48	1.63	1.83	1.60	1.57[a]
Crossbred	1.57	1.57	1.61	1.64	1.71	1.74	1.69	1.72	1.78	1.67[a]
Overall Avg.[1]	1.58[de]	1.51[e]	1.58[de]	1.63[bcd]	1.69[ab]	1.68[ab]	1.68[ab]	1.69[ab]	1.73[a]	

[1] Any two means without a common superscript differ significantly (P<.05).

Table 9. Average adjusted backfat thickness for each year at the Oklahoma National Barrow Show Performance Contest (in.)

Breed	Year of Show 1975	1976	1977	1978	1979	1980	1981	1982	1983	Overall[1] Avg.
Duroc	1.19	1.24	1.13	1.08	1.10	1.31	1.17	1.24	1.21	1.19[a]
Hampshire	1.11	1.17	1.06	1.00	1.01	1.41	1.16	1.31	1.12	1.11[a]
Crossbred	1.23	1.15	1.12	1.11	1.08	1.25	1.22	1.28	1.22	1.17[a]
Overall Avg.[1]	1.18[cd]	1.19[cd]	1.10[de]	1.06[e]	1.07[e]	1.27[ab]	1.21[bc]	1.27[ab]	1.19[cd]	

[1] Any two means without a common superscript differ significantly (P<.05).

Table 10. Average adjusted carcass length for each year at the Oklahoma National Barrow Show Performance Contest (in.)

Breed	Year of Show 1975	1976	1977	1978	1979	1980	1981	1982	1983	Overall[1] Avg.
Duroc	31.1	30.7	31.6	32.3	31.3	32.2	33.1	31.9	33.2	31.7[a]
Hampshire	31.2	31.6	31.6	32.1	32.2	31.6	32.5	31.9	32.0	31.8[a]
Crossbred	30.9	31.7	31.6	32.3	32.0	32.1	33.0	32.2	32.5	32.1[a]
Overall Avg.[1]	31.1[f]	31.3[e]	31.6[de]	32.2[bc]	32.0[cd]	32.1[bc]	33.0[a]	32.2[bc]	32.5[b]	

[1] Any two means without a common superscript differ significantly (P .05).

Table 11. Average adjusted loin eye area for each year at the Oklahoma National Barrow Show Performance Contest (sq. in.)

Breed	Year of Show 1975	1976	1977	1978	1979	1980	1981	1982	1983	Overall Avg.
Duroc	5.69	5.13	4.61	4.41	5.23	4.71	5.13	4.44	4.18	4.83[a]
Hampshire	6.13	5.42	4.87	4.93	5.39	5.16	5.12	4.69	4.33	5.24[a]
Crossbred	6.22	5.48	4.71	5.07	5.31	4.93	4.93	4.95	4.20	5.05[a]
Overall Avg.	6.01[a]	5.34[b]	4.73[c]	4.81[c]	5.32[b]	4.91[c]	4.96[c]	4.83[c]	4.23[d]	

[1] Any two means without a common superscript differ significantly (P<.05).

The percent lean pork of carcass and average pounds of lean pork produced per day on test for each year is shown in tables 12 and 13, respectively. The percent carcass lean was significantly lower (P<.05) for the pigs slaughtered in 1983 than all previous years except 1980. The average pounds of lean pork produced per day on test was greater (P<.05) for pigs slaughtered in 1979 and 1980 than subsequent years. Hampshires tended to have more percent lean of carcass than the Durocs or Crossbreds. Crossbreds produced more pounds of lean pork per day on test (P<.05) than the other two breeds.

The comparison of barrows vs gilts is shown in table 14. Barrows had greater (P<.05) average daily gain, backfat thickness and carcass length than gilts. Gilts had greater (P<.05) loin eye area and percent lean of carcass than barrows. Little difference existed between barrows and gilts for pounds of lean pork produced per day on test.

Data from the Oklahoma National Barrow Show and the Golden Pork Chop Contest reveal a trend in recent years of fatter pigs with decreased loin eye area and estimated percent carcass lean. This trend probably reflects the lack of emphasis being placed by many leaders of the swine industry on carcass traits.

Table 12. Percent lean of carcass for each year at the Oklahoma National Barrow Show Performance Contest.

Breed	1979	1980	1981	Year of Show 1982	1983	Overall Avg.[1]
Duroc	55.02	52.53	57.41	54.08	53.55	54.06[a]
Hampshire	56.24	55.40	59.14	54.85	53.86	55.72[a]
Crossbred	54.51	53.07	56.31	55.73	52.64	54.69[a]
Overall avg.[1]	54.82[b]	53.09[c]	56.62[a]	55.33[a,b]	53.09[c]	

[1] Any two means without a common superscript differ significantly (P<.05).

Table 13. Average pounds of lean per day on test for each year at the Oklahoma National Barrow Show Performance Contest.(lb.)

Breed	1979	1980	1981	1982	1983	Overall Avg.[1]
	Year of Show					
Duroc	.688	.590	.602	.564	.639	.605[a]
Hampshire	.673	.650	.614	.659	.578	.627[a]
Crossbred	.712	.738	.649	.656	.669	.685[b]
Overall avg.[1]	.704[a]	.713[a]	.643[b]	.637[b]	.642[b]	

[1] Any two means without a common superscript differ significantly (P<.05).

Table 14. Barrows vs gilts at the Oklahoma National Barrow Show Performance Contest[1,2]

	Barrows	Gilts
Avg. daily gain, lb.	1.65[a]	1.59[b]
Adj. backfat, in.	1.24[a]	1.13[b]
Adj. carcass length, in.	32.12[a]	31.72[b]
Adj. loin eye area, sq. in.	4.70[a]	5.26[b]
% lean of carcass	53.07[a]	55.75[b]
Lb./lean per day on test	0.65[a]	0.67[a]

[1] Any two means without a common superscript differ significantly (P<.05).

[2] There were 256 barrows and 339 gilts exhibited.

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POSTPARTUM WEIGHT LOSS INFLUENCES OVARIAN FUNCTION OF RANGE COWS

R.P. Wettemann[1], K.S. Lusby[2] and J. Rakestraw[3]

Story in Brief

Fall calving Hereford cows were used during four years to determine the effects of postpartum weight loss on ovarian function and reproductive performance. Percentage of cows with ovarian function, based on progesterone in blood plasma, and pregnancy rate can be reduced by body weight loss before or during the breeding period. If cows lose weight before and during the breeding period luteal function after estrus may also be reduced.

(Key Words: Cow, fertility, nutrition, postpartum, progesterone, reproduction)

Introduction

Loss of weight after calving may result in a longer interval to estrus and conception and pregnancy rate may be reduced. Reproductive responses of range cows vary tremendously between years because of available nutrients, body energy reserves and climatic conditions. The objectives of this experiment were to evaluate the effects of postpartum weight loss of fall calving cows, before and during breeding, on presence of ovarian function during the breeding period, ovarian function immediately after estrus and pregnancy rate.

Materials and Methods

Mature Hereford range cows calving in September and October during four consecutive years were used to evaluate the effects of postpartum weight loss on ovarian activity and reproductive performance. Results of weight changes and reproductive performance of years 1, 2 and 3 were reported previously (Rakestraw et al., 1983, 1984). A total of 217 cows in body condition scores (1 = emaciated,9 = obese) that averaged 6.7, 6.9, 5.5 and 5.4 at calving during 1980, 1981, 1982 and 1983, respectively, were assigned to the following treatments at calving: (1) Maintain weight from calving through rebreeding, (2) Lose about 10 percent of the first postcalving weight by the beginning of breeding and be fed the same as Group 1 during breeding, and (3) Maintain weight from calving to the beginning of breeding, followed by a loss of 10-15 percent of the first postpartum weight during the breeding season. Cows were maintained on native range and supplemental hay and protein were fed to obtain the desired weight changes.

The breeding season was 60 days commencing about December 1 each year. Estrus was detected by sterile bulls with chin-ball markers before breeding and with fertile bulls during breeding. Blood plasma samples were collected at weekly intervals during the breeding period. Progesterone in plasma was quantified to assess ovarian activity.

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[1]Professor [2]Associate Professor [3]Graduate Assistant

Ovarian activity was defined as the presence of greater than 1 ng/ml of progesterone in plasma for two successive weeks.

Results and Discussion

Body weight losses during the four years were influenced by climatic conditions and available forage. Weight losses for the four years from calving to breeding ranged from .6 - 4.4% for Group 1, 3.0 - 17.1% for Group 2 and .9 - 2.2% for Group 3. During breeding, weight losses for the 4 years ranged from 3.1 - 8.5% for Group 1, 1.6 - 6.6% for Group 2 and 9.5 - 14.5% for Group 3.

The percentage of cows in estrus during the breeding period was not significantly influenced by treatment, however there was a tendency for more cows that maintained weight to exhibit estrus (Table 1). The number of days from calving to the first estrus, for those cows that initiated estrous cycles was not significantly influenced by treatment but cows that lost weight before breeding tended to have a longer interval.

Table 1. Influence of postpartum weight changes on reproductive characteristics of fall calving cows.

	Treatment		
Criteria	Maintain weight	Lose weight before breeding	Lose weight during breeding
Cows (no)	70	71	76
Cows in estrus (%)	89	76	79
Calving to estrus (da)	58	69	58
Ovarian activity at start of breeding (%)	49[a]	28[b]	38[b]

[a,b]Treatment in rows differ ($P<.05$).

Percentage of cows with ovarian activity during the first two weeks of breeding was influenced by treatment. Forty-nine percent of the cows that maintained weight until and during breeding had functional ovaries at the start of breeding and only 28% of the cows that lost weight before breeding had ovarian activity. Also, fewer cows that were fed to lose weight during breeding had ovarian activity during the first two weeks of the breeding period. Reduced ovarian function in these cows could be associated with reduced nutrient intake and rapid weight loss during the time estrous cycles were initiated.

The percentage of cows with increased progesterone in plasma (luteal activity) during the first week after behavioral estrus was significantly influenced by treatment in two of the four years (Table 2). In 1980-81, when cows lost weight during the breeding period only 41% had increased progesterone after estrus whereas 93% of the cows that maintained weight had luteal activity. In 1982-83, luteal activity after estrus was reduced in cows that lost weight either before or during breeding compared to cows that maintained weight. Although the effect was not significant, in 1981-82 71% of the cows that lost weight before breeding had luteal activity after estrus compared to 100% of the cows that maintained weight. Nutrient intake, ambient temperature and body condition are probably factors that influence the occurance of luteal activity after estrus. For example, luteal activity after estrus was extremely reduced for cows on all treatments in 1983-84. This may be associated with the thinner body condition that all cows were in at calving and breeding during that year and extremely cold weather during the breeding period. These data indicate that weight loss after calving may result in estrus without normal development of a corpus luteum.

Table 2. Influence of postpartum weight changes of fall calving cows on luteal activity after estrus.

Treatment	Year 80-81	81-82	82-83	83-84
Maintain weight	93[b]	100	94[b]	33
Lose weight before breeding	79[bc]	71	64[c]	40
Lose weight during breeding	41[c]	92	62[c]	20

[a]Percent of cows with increased progesterone in plasma during the week after estrus.
[b,c]Treatments in columns differ ($P<.05$).

Postpartum weight change influenced the pregnancy rate (Table 3). In 1980-81 only 50% of the cows that lost weight during breeding were pregnant compared to 79% of the cows that maintained weight and 88% of the cows that lost weight before the breeding period. In 1981-82, pregnancy rate tended to be reduced in cows that lost weight either before or during breeding but pregnancy rate was not significantly influenced by treatment in 1982-83. Extreme variations in pregnancy rates between years may be associated with nutrient intake, temperature and body condition. Pregnancy rate was reduced for all treatment groups in 1983-84 when cows were thinner and were exposed to very cold environmental temperatures. Those cows that lost weight either before or during breeding had the lowest pregnancy rates during these adverse conditions.

Table 3. Influence of postpartum weight changes on pregnancy rate (%) of fall calving cows.

Treatment	Year 80-81	81-82	82-83	83-84
Maintain weight	79[a]	87	89	59[a]
Lose weight before breeding	88[a]	53	84	19[b]
Lose weight during breeding	50[b]	65	85	28[b]

[a,b]Treatments in columns differ ($P<.05$).

This experiment demonstrated that if cows are in good body condition at calving, this will not insure adequate rebreeding of fall calving cows. Percentage of cows with ovarian function at the start of breeding and pregnancy rate can be influenced by weight loss before or during the breeding period. If cows lose weight before or during the breeding period, the percentage of cows with normal luteal function after estrus may be reduced.

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THE RELATIONSHIP BETWEEN PREPARTUM NUTRITION AND POSTPARTUM PLASMA GLUCOSE, BODY WEIGHT CHANGES, BODY CONDITION SCORE CHANGES AND REPRODUCTIVE PERFORMANCE IN BEEF COWS

G.E. Selk[1], R.P. Wettemann[2] and K.S. Lusby[3]

Story in Brief

Seventy-two Hereford range cows (3-6 years of age) were used in 1983 and 45 Hereford cows (2-3 years of age) were used in 1984 to determine the effect of prepartum nutrition on postpartum plasma glucose, body weight and condition score changes and the subsequent reproductive performance. Four nutritional treatment groups before calving were used each year of the study. Blood samples were obtained weekly after calving, whereas weights and condition scores were recorded biweekly.

Nutritional treatments, body weight change and condition score change were not related to postpartum concentrations of glucose in the plasma. However, those cows that became pregnant in 1983 had greater concentrations of plasma glucose than those that failed to conceive. In the second year (1984), the differences in plasma glucose concentrations between cows conceiving and those that did not were not significant but cows that conceived tended to have greater concentrations of glucose in the plasma than those that did not conceive. This study suggests that postpartum concentrations of plasma glucose may be related to the potential for conception during the breeding season.

(Key Words: Body condition score, cow, glucose, nutrition, postpartum, reproduction)

Introduction

Prepartum nutrition is an important factor that regulates reproductive performance of beef cows. The physiological links between the nutritional status of the beef cow and the onset of postpartum estrus and eventual conception have not been elucidated. Plasma glucose is a primary source of energy of most mammalian cells. Previous research indicates that concentrations of plasma glucose prepartum could be altered by changing amounts of supplemental feed to gestating beef cows. The purpose of this study was to investigate the response of plasma glucose in beef cows postpartum to prepartum nutrition and to evaluate the relationships between plasma glucose, changes in body weight, body condition score and reproductive performance.

Materials and Methods

Pregnant Hereford cows grazing native range near Stillwater, Oklahoma were assigned to one of four nutritional treatment groups. In November, 1982 (72 cows), and in November, 1983 (45 cows), cows were blocked by age and body condition score and assigned to treatments.

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Group 1 cows were supplemented to maintain their November weights until calving in March and April. Groups 2, 3 and 4 were restricted in supplementation, so as to lose 5 percent of their November weights by January 20 (approximately 45 days prior to calving). After January 20, Group 2 was continued on the restricted diet so they would lose another 5% of their weight before calving. Group 3 cows were supplemented the same as Group 1 cows from January 20 to calving. Cows in Group 4 were given 140 percent the supplemental feed given to Group 1 cows during the last 45 days of gestation. In 1982-83 cows were 3 to 6 years old, and in 1983-84 all first or second-calf heifers were used. Supplement consisted of differing amounts of soybean meal. During the first year, cows were group fed their supplement and during the second year cows were individually fed 3 days per week. Cows were maintained on range pasture with supplemental hay and approximately 4 pounds of 40% protein cubes were fed daily postpartum. In 1983 the severity and length of the winter season depleted hay supplies by May and forage quality and quantity was limited. In the early spring of 1984, standing forage and hay were both more available. Table 1 summarizes the treatments.

Table 1. Supplementation scheme used in 1983 and 1984 calving cows.

	Fall-Jan. 20	Jan. 20-Calving	Postpartum
Group 1	Maintain Fall weight	Maintain Fall weight	NRC for lactating cow
Group 2	Lose 5% of Fall weight	Lose 5% of Fall weight	Same as Group 1
Group 3	Lose 5% of Fall weight	Same as Group 1	Same as Group 1
Group 4	Lose 5% of Fall weight	Fed 140% of Group 1	Same as Group 1

Cows were weighed and body condition scores were assigned biweekly from the beginning of the trial until 85 days postpartum. Body condition scores were determined by at least two individuals and utilized a scale of 1 = emaciated, to 9 = obese. Tail vein blood samples (20 ml) were obtained weekly after calving until 85 days postpartum. An anticoagulant (oxalic acid) was added to each sample and the samples were cooled in an ice bath. Samples were centrifuged and the plasma was decanted and stored at -20 C until assayed for glucose, via an enzymatic, colorimetric procedure.

Weight and condition scores were evaluated by analyses of variance. Treatment effects on plasma glucose were analyzed by split-plot analysis of variance over time. Glucose means for cows that became pregnant were compared with those that failed to conceive by Hotelling's test of multivariate regression coefficients.

Results and Discussion

Body weights of the cows that calved in 1983 are depicted in Figure 1. Body weights and scores were similar for cows on all treatment groups

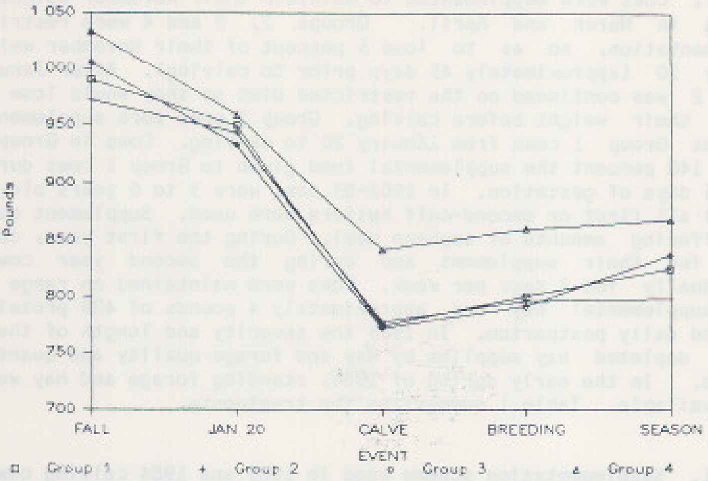

Figure 1. Mean body weights in fall, at Jan. 20, after calving, at the start of the breeding season, and 30 days into the breeding season for cows calving in 1983.

in November. Cows on all treatments lost weight by January 20. Group 1 lost 2.7% of the fall weight whereas Groups 2, 3, and 4 (fed together) lost 5% of their November weight. Group 4 had lost 18% of the fall weight after parturition and Groups 1 and 2 had lost 20% of the fall weight. Group 3 had lost 22% of the fall weight after calving. Body condition scores indicated that the 1983 cows were in a negative nutritional state until calving. Initial body scores (November) were similar for all groups (mean = 5.6). However, the Group 4 cows had a slightly greater body condition after calving and at the start of the breeding season. All Groups had average condition scores less than 5.0 after calving. Only slight improvement in mean body condition scores was observed by the start of the breeding season (May 1). A particularly long, late winter season delayed the availability of summer grasses until late May, and prematurely depleted the hay supplies. The slow recovery of body weights and body condition scores after calving are evidence of the weather-related nutritional stresses. The undesirable reproductive performance of the cows in 1983 reflects the weight and condition losses incurred by all groups of cows before calving and slow gains after calving (Table 2). There was no effect of prepartum treatment on concentrations of glucose in plasma postpartum or on reproductive performance. Weight change or condition score change (from fall) was unrelated to plasma glucose after calving. Postcalving weight change and condition score change were correlated (r = .52, P<.01). Multivariate regression curves for plasma glucose concentrations, by week postpartum, for cows that became pregnant or failed to conceive during a 90 day breeding season are shown in Figure 2. Plasma glucose concentrations in cows that became pregnant were greater (P<.05) during the first 12 weeks after calving compared to concentrations in cows that did not conceive. The shapes of the regression curves were similar (P>.5).

Table 2. Mean conception rates and days to conception by treatment group for cows calving in 1983.

	Group 1	Group 2	Group 3	Group 4
Total cows	18	17	18	19
Cows pregnant (no.)	7	2	4	8
Cows pregnant (%)	39	12	22	42
Mean days to conception	103 ± 11	98 ± 35	102 ± 11	85 ± 3

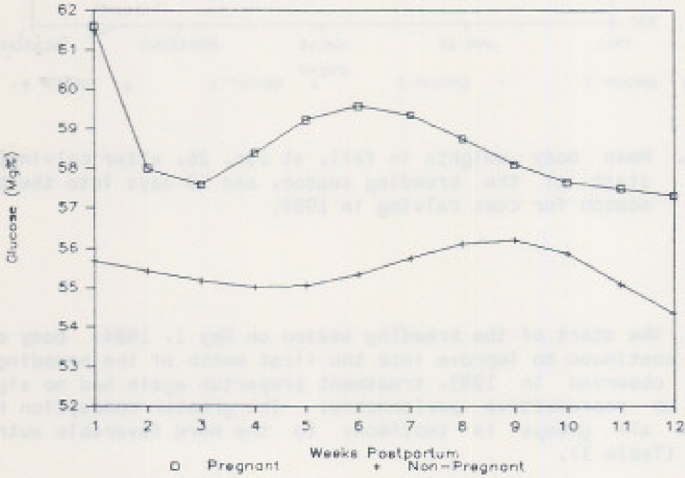

Figure 2. Multivariate predictions of plasma glucose by week postpartum for cows that became pregnant versus cows that failed to conceive in 1983.

For cows on the 1984 trial, weight losses were similar from November until the time of nutrition change in January to those in the previous year. Group 1 cows maintained their body weight from November until January 26. Groups 2, 3 and 4 lost 5% of the fall weight by January 26. Weight losses were quite similar for all four Groups from January until after calving. Contrary to the postpartum weight changes in 1983, all cows calving in 1984 consistently gained weight after calving and continued to gain during the breeding season. The condition scores of the cows in 1984 further indicate less nutritional stress after calving than in 1983. Mean body condition scores for all four Groups were above

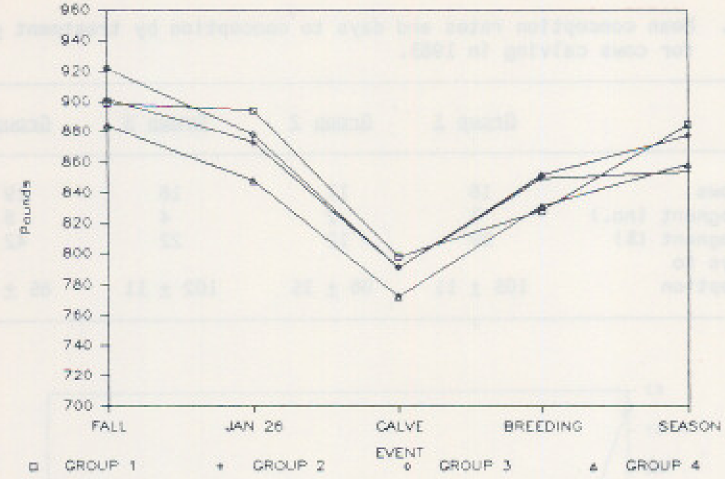

Figure 3. Mean body weights in fall, at Jan. 26, after calving, at the start of the breeding season, and 30 days into the breeding season for cows calving in 1984.

5.0 by the start of the breeding season on May 1, 1984. Body condition scores continued to improve into the first month of the breeding season. As was observed in 1983, treatment prepartum again had no significant effect on reproductive performance. The greater conception rates for cows in all groups is testimony to the more favorable nutrition in 1983-84 (Table 3).

Table 3. Mean conception rates by treatment group for cows calving in 1984.

	Group 1	Group 2	Group 3	Group 4
Total cows	12	10	10	13
Cows pregnant (no.)	11	8	6	9
Cows pregnant (%)	92	80	60	69

Similar to the results in 1983, treatment had no effect on postpartum concentrations of plasma glucose, and body weight change, body condition score change and plasma glucose were unrelated. The correlation between body weight change and condition score change from fall to post-calving was similar to that in 1983 ($r = .52$, $P<.01$). Multivariate regression curves of plasma glucose for cows that became pregnant and those that failed to conceive are plotted in Figure 4.

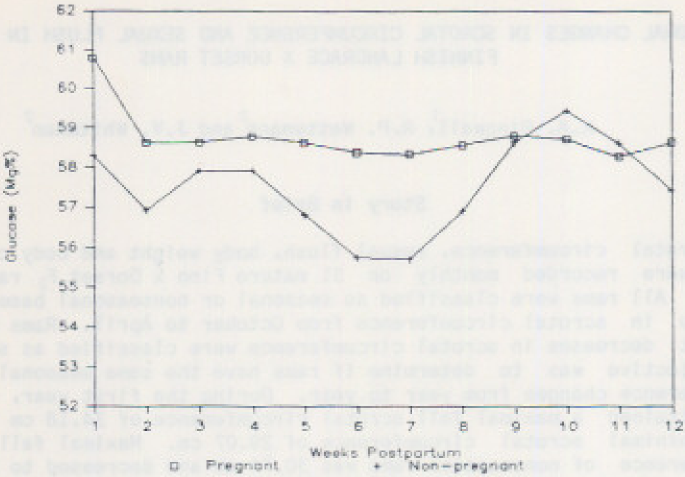

Figure 4. Multivariate predictions of plasma glucose by week postpartum for cows that became pregnant versus cows that failed to conceive in 1984.

Although glucose concentration was slightly higher in cows that conceived, the curves were not significantly different. There was a tendency for the shapes of the curves to be different (P = .09). Similar to data from 1983, glucose in plasma of cows that eventually conceived was consistently greater than for cows that failed to conceive. The alterations in the magnitude of the differences in plasma glucose for cows that became pregnant and those that did not could be attributed to the difference in the severity of nutritional stress endured by the cows in their respective years.

Plasma glucose concentrations are quite variable within a single cow or between different cows due to the many physiological factors regulating glucose. One blood sample will not give an accurate indication of the long-term glucose status of a cow. The results of this study indicate that plasma concentrations of glucose may be related to the potential of beef cows to become pregnant, especially in those that have been under nutritional stress.

SEASONAL CHANGES IN SCROTAL CIRCUMFERENCE AND SEXUAL FLUSH IN MATURE FINNISH LANDRACE X DORSET RAMS

K.A. Ringwall[1], R.P. Wettemann[2] and J.V. Whiteman[2]

Story in Brief

Scrotal circumference, sexual flush, body weight and body condition score were recorded monthly on 31 mature Finn x Dorset F_2 rams for 2 years. All rams were classified as seasonal or nonseasonal based on the decrease in scrotal circumference from October to April. Rams with the greatest decreases in scrotal circumference were classified as seasonal. The objective was to determine if rams have the same seasonal scrotal circumference changes from year to year. During the first year, seasonal rams attained a maximal fall scrotal circumference of 34.18 cm followed by a minimal scrotal circumference of 29.07 cm. Maximal fall scrotal circumference of nonseasonal rams was 30.74 cm and decreased to 29.83 cm in the spring. Change in scrotal circumference of individual rams was consistent from the first year to the second. Both ram classes had seasonal changes in sexual flush, but nonseasonal rams had greater intensity and quantity of flush throughout the year. We conclude that seasonal rams have repeatable annual changes in scrotal circumference. The majority of nonseasonal rams had similar circumference changes during the year as seasonal rams, but the magnitude of the changes was greatly reduced.

(Key Words: Rams, reproduction, scrotal circumference, season, testes)

Introduction

The most limiting factor to increased efficiency of sheep production is seasonal infertility. The term seasonal is used to mean the lack of optional fertility during some periods of the year. Seasonal reproduction is partially dependent on the duration of light in a day, and both ewes and rams undergo physiological changes throughout the year. The mature ram is well suited for studying methods to improve fertility because the primary reproduction organ, the testis, can be readily observed and measured. Plus, the ram has distinct color changes of the skin (sexual flush) which occur with changing reproductive stages.

Several breeds have been evaluated for changes in scrotal circumference throughout the year. Suffolk, Lincoln, Columbia and Polypay rams have a minimal scrotal circumference in January and February in North America (Mickelsen et al., 1982). Suffolk and Managra breeds in Manitoba have maximal scrotal circumference in September through November and minimal circumferences during March to April (Sanford and Yarney, 1983). Rambouillet in Oklahoma have a maximal scrotal circumference in October to November, with the smallest circumference in February to March.

If rams with constant scrotal circumference are more independent of changes in daylength, these rams may sire daughters that are less

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seasonal in their reproductive cycles. The ability to identify rams and verify that they are less responsive to light cues has not been reported. The purpose of the following study was to identify rams which have the least and greatest change in scrotal circumference from fall through spring and to determine if these rams repeat the same scrotal circumference profile from year to year.

Materials and Methods

Thirty-one F_2 Finn x Dorset rams, born during the springs of 1980 and 1981, were maintained under Oklahoma pasture conditions until spring of 1984. Rams were managed in a single group throughout the study, with the exception of the May and June breeding period. Rams were weighed each month and supplemented with alfalfa and grain when forage was limited during dry and (or) winter periods. Condition scores (on a scale of 1 = extremely emaciated to 9 = fat deposits over the lumbar vertebrae and ribs) were assigned each month.

Starting in May 1982, two independent scrotal circumference measurements were made on each ram while the ram was resting on his rump. The testes were held firmly in the lower portion of the scrotum and measured with a fiberglass tape measure. The testes were palpated between scrotal circumference measurements for testicular or epididymal abnormalities.

Sexual flush was also monitored throughout the study. Flush was scored for quantity and intensity. The intensity of flush was scored: 0 = no color, 1 to 3 = shades of pink, 4 to 5 = light red, 6 to 7 = red, 8 = dark red, and 9 = purple. The quantity of flush was scored: 0 = none, 1 = a band of color no wider than 1 cm within each inguinal region, 2 = a band of color no wider than 3 cm within each inguinal region, 3 = a band of color wider than 3 cm but still within each inguinal region and not including the teat, 4 = a band of color which included the inguinal area, the teat and spotting of color between the two teats, and 5 = a solid band of color across the two teats and including both inguinal regions.

For the purpose of evaluating the consistency of changes in total circumference, rams with the greatest (n=8) and least (n=7) change in scrotal circumference between October and April were selected from the original 31 rams. The degree of change was calculated by subtracting the mean March and April scrotal circumference from the mean October to November scrotal circumference. Rams that had the greatest decrease in scrotal circumference from fall to spring were classified as seasonal and rams with the least change were classified as nonseasonal. The classification of rams was based on measurements from October 1982 to April 1983.

Data were analyzed by multivariate analysis of variance (MANOVA) performed on the regression coefficients. A full sinusoidual regression model with 12 months per period was fit to each ram for the variables scrotal circumference, sexual flush, body weight and condition score. The independent variables for the model were month, sine of month, cosine of month, month X cosine of month and month X sine of month.

Results and Discussion

Scrotal circumference for seasonal rams changed at a greater rate each month during 24 consecutive months ($P<.01$, figure 1). Seasonal rams had maximal scrotal circumferences during September of each year (34.18

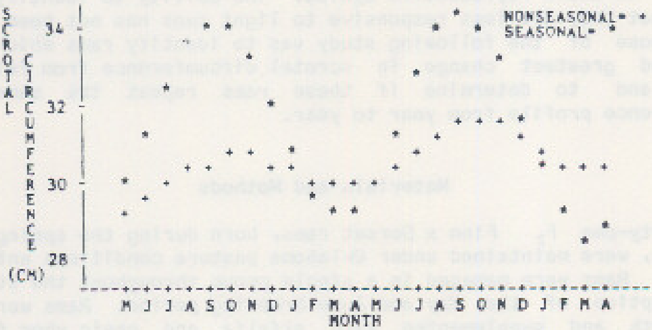

Figure 1. Scrotal circumference of seasonal and nonseasonal rams over a two year period.

and 34.39 cm). In contrast, nonseasonal rams had maximal scrotal circumferences of 30.74 cm in November of the first year and 31.59 cm in October of the second year. Seasonal rams had minimal scrotal circumferences during March of both years (29.07 and 28.58 cm) and the minimal scrotal circumferences for nonseasonal rams were 29.83 cm during April of the first year and 30.28 cm during March of the second. However, there was an interaction for scrotal circumference between ram classification and month. Seasonal rams had the largest scrotal circumference during the fall months, but the smallest during the early winter months. The only time of year that nonseasonal rams had a larger scrotal circumference than seasonal rams was from February through April (figure 1). During the normal fall breeding season, rams less responsive to season had smaller scrotal circumferences.

The classification of the rams based on the degree of scrotal circumference change from fall to spring was essentially the same for both years. The Spearman correlation coefficient for ram ranks between years was .82 (P<.001). Initially, when ranked from the least scrotal circumference change to the greatest, nonseasonal rams ranked 1st to 7th, while seasonal rams were 8th to 15th. Except for two rams, all seasonal rams remained in the upper half, and nonseasonal rams remained in the lower half when ranked on scrotal change the second year. The rams were not reclassified based on scrotal change during the second year, but maintained their seasonal and nonseasonal designation from the first year.

The influence of season on intensity of sexual flush is summarized in figure 2. Maximal flush intensity preceeded maximal scrotal circumference by one month for both ram classes. The flush intensity profiles were different for the two ram classes (P<.05) Seasonal rams had maximal flush intensity prior to nonseasonal rams the first year but both groups were similar the second year. The quantity of flush was also affected by ram class (P<.04, figure 3). Nonseasonal rams had a larger area of flush during the fall which was also the time of maximal flush intensity (figure 3).

Nonseasonal rams had heavier body weights throughout the study (P<.05). However, there were no significant differences in seasonal weight changes between the two ram classes. Body condition also tended to be greater (P<.10) for nonseasonal rams during the two year study.

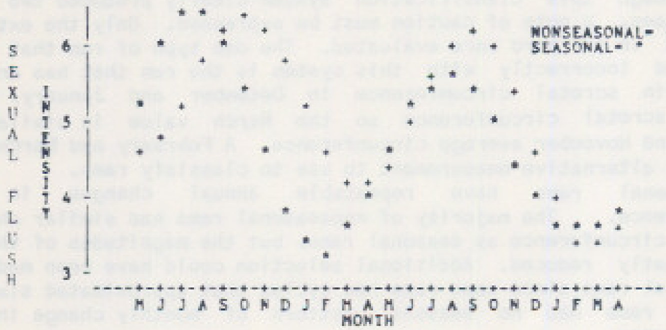

Figure 2. Sexual flush (intensity) of seasonal and nonseasonal rams over a two year period.

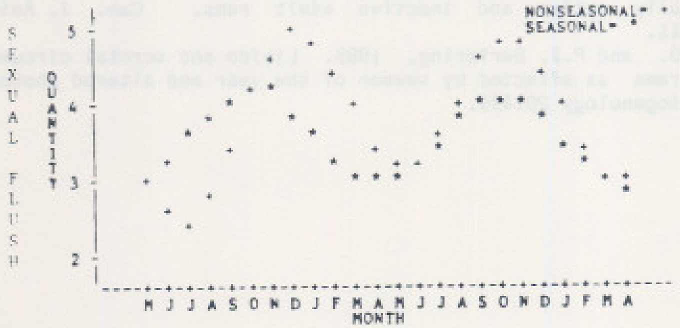

Figure 3. Sexual flush (quantity) of seasonal and nonseasonal rams over a two year period.

The seasonal change in body weight and condition score were expected since the rams were maintained under pasture conditions and subjected to seasonal changes in pasture forage. However, two sources of evidence indicate that change in scrotal circumference is not strongly influenced by change in body weight. Nonseasonal and seasonal rams were similar in body weight change, but the scrotal circumference profiles were distinctly different for the two ram types. In addition, change in scrotal circumference for individual rams was consistent from the first year to the second (Spearman rank correlation = .82, P<.001) but individual change in body weight was not consistent (Spearman rank correlation = -.39, P>.5).

Although this classification system clearly produced two distinct ram classes, a note of caution must be expressed. Only the extremes of the rams in our herd were evaluated. The one type of ram that could be classified incorrectly with this system is the ram that has an extreme decline in scrotal circumference in December and January, but then regains scrotal circumference so the March value is similar to the October and November average circumference. A February and March average may be an alternative measurement to use to classisfy rams.

Seasonal rams have repeatable annual changes in scrotal circumference. The majority of nonseasonal rams had similar changes in scrotal circumference as seasonal rams, but the magnitudes of the change were greatly reduced. Additional selection could have been made within nonseasonal rams since some rams had cycles that approximated six months, while 4 rams had no seasonal pattern of monthly change in scrotal circumference.

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SEASONAL CHANGES IN TESTOSTERONE AND LUTEINIZING HORMONE IN THE SERUM OF MATURE F_2 FINNISH LANDRACE X DORSET RAMS CLASSIFIED AS SEASONAL OR NONSEASONAL

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Story in Brief

Thirty-one mature Finn x Dorset F_2 rams were classified as seasonal or nonseasonal based on the decrease in scrotal circumference from October 1982 to April 1983. Rams with the greatest decreases in scrotal circumference were classified as seasonal. Eight seasonal and seven nonseasonal rams were selected to evaluate changes in serum LH and testosterone during April, July and October of 1983 and January of 1984. Concentrations of LH and testosterone in serum were quantified before and after two infusions of 1 ug of GnRH at an hourly interval. During January, serum testosterone was greater ($P<.05$) before GnRH infusion for nonseasonal rams compared to seasonal rams. The greatest ($P<.05$) concentrations of testosterone in serum were during October for both ram classes. The response of testosterone in serum to infusion of GnRH was similar between ram classes each month except in January when seasonal rams had less testosterone than nonseasonal rams. Both ram classes had the greatest ($P<.05$) serum LH concentrations in April and nonseasonal rams had greater ($P<.05$) serum LH than seasonal rams during October and January. Rams classified as seasonal or nonseasonal based on changes in scrotal circumference have idfferent reproductive endocrine functions.

(Key Words: LH, rams, reproduction, scrotal circumference, season, testosterone)

Introduction

The mature ram is well suited for studying seasonal changes in reproductive activity. Scrotal circumference in the ram can be readily measured, seasonal anatomical changes can be recorded for individual rams, and rams can be classified as seasonal or nonseasonal based on scrotal changes (Ringwall et al., 1985). Seasonal rams have consistent annual cycles in scrotal circumference, while nonseasonal rams have a less conspicuous change in scrotal circumference throughout the year.

Recent investigations have determined the roles of LH, testosterone and gonadotropin releasing hormone (GnRH) in rams. Determination of endocrine changes for seasonal and nonseasonal rams could help clarify the association between observed scrotal circumference change and hormonal changes associated with alterations in daylength. The purpose of this study was to compare reproductive endocrine changes in seasonal and nonseasonal rams during April, July, October, and January.

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Materials and Methods

Thirty-one F_2 Finn x Dorset rams, born during the springs of 1980 and 1981, were maintained under Oklahoma native bermuda pasture conditions until the spring of 1984. Rams were managed and classified as seasonal and nonseasonal (Ringwall et al., 1985). Rams with the greatest (n=8, seasonal) and least (n=7, nonseasonal) change in scrotal circumference between October and April were selected from the original 31 rams. Unequal numbers between ram classes resulted from the death of one ram.

Intravenous catheters were placed in the venae cavae of seasonal and nonseasonal rams in April, July, and October of 1983 and January of 1984. Rams were exposed to natural photoperiods except on the day of blood sampling when they were exposed to continuous light. Rams were isolated from ewes and fed at 0600 h and 1300 h. Blood samples (10 ml) were obtained at 30 min intervals from 0730 h to 1530 h. After a blood sample was taken at 1530 h, 1 ug of GnRH (courtesy of National Hormone and Pituitary Program, Baltimore, Maryland) was infused into the cannulae. Blood samples were obtained at 15 min intervals until 1630 h, then an additional 1 ug of GnRH was infused. Blood samples were obtained every 15 min until 1730 h, then blood samples were taken every 30 min until 2030 h. Blood samples were immediately placed on ice, stored at 4 C for 24 h, centrifuged at 2000 x g for 30 min and serum was frozen until hormones were quantified. Testosterone was quantified by radioimmunoassay in samples obtained at 1130, 1330, 1530, 1600, 1630, 1700, 1730, 1830, 1930 and 2030 h. LH concentrations were quantified by radioimmunoassay in all samples.

One way analysis of variance was used to evaluate the effects of ram class within date or date sampled within ram class on concentrations of LH and testosterone prior to GnRH infusion, the magnitude of LH spikes (serum LH concentration greater than two standard deviations above the mean for the individual ram within a date) and the concentrations of serum LH and testosterone after infusion with GnRH.

Serum LH response to GnRH was calculated as the difference between the LH concentration in the serum sample prior to each infusion of GnRH and the serum sample obtained 15 min post GnRH infusion. Serum testosterone response to GnRH was calculated as the difference between testosterone concentration in the serum sample prior to the first infusion of GnRH and the serum sample obtained 30 min after the second GnRH infusion. The time period selected to evaluate response to GnRH infusion coincided with the periods of maximum response to GnRH. The quick release and decline in LH resulted in two response periods while the slow increase in testosterone produced only one maximum period of serum concentration of testosterone.

Results and Discussion

Seasonal Effects on Concentrations of Testosterone in Serum.

Prior to GnRH infusion, nonseasonal and seasonal rams had similar concentrations of testosterone during April, July and October (table 1). In January, nonseasonal rams had greater testosterone in serum than seasonal rams ($P<.05$). Serum testosterone concentrations were similar before and after GnRH infusion between seasonal and nonseasonal rams except during January, when seasonal rams had reduced ($P<.05$) testosterone concentrations compared to nonseasonal rams.

Table 1. Mean secretory patterns of LH and testosterone in serum during April, July, October and January in nonseasonal (N) and seasonal (S) mature F_2 Finn-Dorset rams.

Hormone (ng/ml)	Ram Class	April	July	October	January
LH concentration					
Mean	N	3.04^{a}	1.24	1.45^{c}	1.69^{c}
	S	1.86^{a}	1.03	$.72^{d}$	$.74^{d}$
Spikes/8 h (no)	N	1.88	1.50	2.25	2.38
	S	2.29	1.86	2.57	1.71
Spike magnitude	S	8.92^{ac}	5.82	4.51^{c}	5.67
	S	5.22^{ad}	4.68^{a}	2.49^{d}	3.41
Testosterone concentration					
Mean	N	3.49	4.20	6.41^{a}	4.24^{c}
	S	3.28	4.18	5.61^{a}	2.53^{d}

[a,b]Means with different superscripts within a row are different (P<.05).
[c,d]Means with different superscripts in columns for the same trait are different (P<.05).

Concentrations of testosterone in serum of nonseasonal rams wee similar during April, July and January (table 1) but concentrations were greater in October. Seasonal rams had similar monthly variations in serum testosterone as nonseasonal rams. Seasonal rams responded similarly to GnRH during April, July and October, but the January testosterone response was less than October (table 2, P<.01).

Seasonal effects on concentrations of LH in serum.

Nonseasonal rams had greater (P<.05) concentrations of LH in serum than seasonal rams during October and January (table 1). Nonseasonal rams had greater concentration of LH during spikes than seasonal rams in April (P<.05) and October, but the ram classes had similar concentrations during July and January (table 1). The number of LH spikes was similar for seasonal and nonseasonal rams during each month (table 1).

The increase in LH concentrations in serum following the first infusion of GnRH was similar between ram classes during April (table 2). In July, seasonal rams tended to respond less than nonseasonal rams to GnRH and during October and January seasonal rams had reduced concentrations of LH in the serum after the first infusion of GnRH (table 2, P<.05). The response of LH after the second infusion of GnRH was similar between ram classes for all months (table 2).

The increase in LH following the first minus the second infusion of GnRH was similar between classes of rams during April (table 3). In July, the response in LH concentration in serum following the second infusion of GnRH minus the first was greater for seasonal rams (table 3, P<.05) and a similar trend was observed during October and January.

Table 2. Mean secretory patterns of LH and testosterone in serum in response to GnRH during April, July, October and January in nonseasonal (N) and seasonal (S) mature F_2 Finn-Dorset rams.

Hormone (ng/ml)	Ram Class	April	July	October	January
LH response to GnRH					
1st infusion	N	32.67[a]	22.69	24.14[bc]	23.00[c]
	S	30.40[a]	17.44[a]	13.01[bd]	17.90[d]
2nd infusion	N	32.86[a]	23.54	21.73[b]	23.07
	S	32.11[a]	32.40[a]	20.16[b]	24.00
Testosterone response to GnRH					
2nd infusion	N	6.17	6.89	6.29	5.20
	S	7.16[a]	6.89[a]	7.79[a]	5.73[b]

[a,b] Means with different superscripts within a row are different (P<.05).
[c,d] Means with different superscripts in columns for the same trait are different (P<.05).

Table 3. Mean secretory LH in serum after the second GnRH infusion minus the first GnRH infusion during April, July, October and January in nonseasonal (N) and seasonal (S) mature F_2 Finn-Dorset rams.

Ram Class	April	July	October	January
	Difference in LH Response ng/ml			
N	0.19	0.85	-2.41	0.07
S	1.17	14.96[a]	7.15	6.10

[a] P<.05

Seasonal trends were evident within each ram class for serum LH concentrations prior to GnRH infusion. Concentrations of LH were greatest in April (P<.05) followed by a decline in July for both ram classes. Nonseasonal rams reached a minimal concentration of LH in July and LH gradually increased through October and January (table 1). In contrast, concentrations of LH in seasonal rams continued to decline until October and remained at low concentrations in January (table 1).

The magnitudes of the LH spikes for nonseasonal rams were greatest (P<.05) during April and then declined to similar concentrations during July, October and January (table 1). The magnitudes of LH spikes for seasonal rams were greater (P<.05) for April and July than October and January (table 1).

Conclusion

Testosterone concentrations were greatest in October for both ram classes and the main difference in testosterone concentrations between the two classes is that seasonal rams had decreased testosterone concentrations in January. Seasonal rams had an increase in serum LH response to a second GnRH infusion compared to the first GnRH infusion, while nonseasonal rams did not. Results of this study support the concept that changes in scrotal circumference of rams is related to seasonal changes in endocrine function.

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REPRODUCTIVE DEVELOPMENT AND PERFORMANCE OF HEREFORD HEIFERS CALVING AT 24 OR 30 MONTHS OF AGE

J.E. Goodrich[1], E.J. Turman[2], R.P. Wettemann[2], D.S. Buchanan[3], and K.S. Lusby[3]

Story in Brief

A three year study involving 129 weaner and yearling Hereford heifers compared calving at 24 or 30 months of age. The heifers calving at 24 months were fed at a high level (1 lb/day gain) during the winter as weaner heifers. The heifers to calve at 30 months were fed at a moderate (0.5 lb/day gain) or low (no gain) after reaching 600 lbs body weight. The results suggest that if weaner heifers are fed at a high level the winter prior to breeding, delaying calving until 30 months may not improve conception rates at either the first or second breeding or greatly reduce the postpartum interval to conception. Heifers calving at 30 months weaned heavier calves, suffered less calving difficulty and required less supplemental feed during the winter prior to the first breeding. However, calving problems were not eliminated since approximately 50 percent of the 30 months calvers required assistance compared to over 70 percent of the 24 months calvers.

(Key Words: Beef Heifers, Calving Age, Reproduction, Calving Difficulty, Rebreeding)

Introduction

Two of the most important problems associated with calving heifers at 2 years of age are increased calving difficulty and delayed rebreeding. One way to reduce these problems is to delay calving of replacement heifers. Unfortunately, since the most common system of production is to calve in a single season, the heifers will not calve first until three years of age. Although reducing problems associated with earlier calving, delaying calving of replacement heifers until three years of age results in the loss of one year of production from the cow.

An alternative that might combine advantages of both 2- and 3-year old calving would be to calve heifers first at 30 months of age. Results reported previously from this station (Lusby et al., 1979) suggest that heifers calving at 30 months of age will have improved conception rates at both first breeding and rebreeding after calving, and will wean heavier calves than heifers calving at 24 months of age. Therefore, this study was conducted to further investigate the feasibility of calving replacement heifers at 30 months of age and to compare two levels of nutrition prior to first breeding of the heifers that calve first at 30 months of age.

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Materials and Methods

This study was conducted at the Livestock and Forage Research Laboratory, (Ft Reno), El Reno utilizing a total of one hundred twenty nine Hereford heifers obtained in the fall of three consecutive years from an experimental herd at the Lake Carl Blackwell range near Stillwater. The heifers obtained each year had been born in the spring of that year or the previous fall to cows of similar breeding bred to similar bulls in both seasons of a given year. Thus, heifers of similar breeding could be bred to calve in the same season at either 24 or 30 months of age. Trial 1 begun in the fall of 1979, used 20 heifers calving at 24 months, and 20 heifers calving at 30 months. Trial 2 consisted of two replications, initiated in the falls of 1980 and 1981, and involved a total of 30 heifers calving at 24 months, and 59 heifers calving at 30 months. All fall-born heifers were bred in the spring at 21 months to calve at 30 months, and all spring-born heifers were bred at 15 months to calve at 24 months.

Before breeding, heifers were wintered on dormant native grass range supplemented with cottonseed meal and ground milo or ground corn to gain according to their respective treatments. All heifers ran together on native tall-grass pasture during the two summers they were on the experiment, with no effort made to control weight changes. During the second wintering period the bred heifers ran together and were fed at the Moderate level used in previous Fort Reno studies, which is the appropriate amount of cottonseed meal fed to heifers grazing dormant native grass range to allow them to lose 10 percent of their fall weight (approximately November 15) through and including the loss at calving.

In trial 1, the first wintering period was from November 29, 1979 to April 17, 1980. Heifers to be bred at 15 months were fed at the High level used in earlier Ft Reno studies, which was the amounts of ground milo and cottonseed meal necessary to achieve an average gain of 1.0 lb/day during the entire period. Heifers to be bred at 21 months were fed at the same level as the younger heifers until they reached a mean body weight of 600 lb, after which they were fed at the moderate level used in previous Fort Reno studies involving developing heifers to be bred to calve at 24 months of age, which was to gain .5 lb/day until the end of the wintering period. The heifers were randomly assigned to two fertility-tested Hereford bulls during the first breeding season from May 1, 1980 to July 20, 1980.

In trial 2, the first wintering periods began on November 14, 1980 and November 12, 1981 for replications 1 and 2, respectively, and ended the following May 5 for each replication. Heifers to be bred at 15 months were fed similarly to those in trial 1, with the exception of ground corn being fed instead of ground milo. Heifers to be bred at 21 months were fed similarly until each heifer reached 600 lb, after which they were fed to either maintain their weight until the end of the wintering period (30 month-maintain), or fed to gain .5 lb/day until the end of the wintering period (30 month-gain). The breeding season lasted from May 7 to July 7 each year. The heifers were randomly assigned to single-sire breeding groups with three fertility tested Angus bulls used in replication 1, and two different fertility tested Angus bulls used in replication 2. Heifers in both trials were rebred using two fertility tested Hereford bulls assigned at random to single sire breeding groups. The respective replications of each trial ended when the calves were weaned.

Data were analyzed by analysis of variance, Student's t-test, and Duncan's multiple range test.

Results and Discussion

Trial 1: At the beginning of the trial, the weaner heifers to be bred to calve at 24 months were 103 lb lighter than the yearling heifers to be bred to calve at 30 months (Table 1). The younger heifers gained .95 lb/day to weigh 550 lb by the beginning of the breeding season. The 30 mo heifers averaged .55 lb/day gain to reach an average weight of 593 lb. Weight loss during the second wintering period was near the desired level of 10% (24 mo calvers = 10.3%, and 30 mo calvers = 8.9%).

Conception rate during the first breeding season was very good and similar for both groups (100% and 95% for the 30 mo and 24 mo calvers, respectively). The average date of conception was similar for both treatments.

Calf birth weight was similar for the two groups of heifers, but the younger heifers suffered more calving difficulty than did the 30 mo heifers (calving difficulty scores of 3.21 vs 1.89) and a greater number of heifers had difficult calvings (72% vs 50%). The 24 month calvers

Table 1. Performance of heifers calved at 24 or 30 months of age.

Item	(TRIAL 1) 24 Month	30 Month
No. of Heifers (11/29/79)	20	20
Heifer Weights (lbs)		
Beg. 1st Winter (11/29/79)	405	508
Beg. 1st Brdg. (5/1/80)	558	593
Beg. 2nd Winter (11/13/80)	821	924
Beg. 2nd Brdg. (5/5/81)	793	843
Weaning (10/13/81)	971	1027
First Breeding Season:		
Conception Rate (%)	95	100
Date of Conception (Avg)	May 31	May 24
Calving Data:		
No. heifers calving	18	20
No. live calves	9	14
Calf Birth Wt (lbs)	79	77
Heifers Req. Assist. (%)	72	50
Calving Diff. Score (Avg) (Scale = 1 to 5)	3.2	1.9
Second Breeding Season:		
Conception Rate (%)	84	88
Post Partum Interval to Conception (days)	91	75
205 Day Adj Wn Weight (lbs)	407	425
Supplemental Winter Feed per Heifer 1st Winter (lbs)		
Cottonseed Meal	325	371
Milo	736	462

also lost more calves at calving (50% vs 30%) but losses were excessive in both groups. Excessive calving problems and deaths were the result of a combination of factors, with one of the most important being the necessity to change herdsmen just prior to the start of the calving season. In addition, there was a large number of heavy calves. The average birth weight of calves that died was 81.9 lbs compared to 76.6 lb for the live calves.

During the second breeding season conception rates were similar (24 mo = 84%, and 30 mo = 88%), but the postpartum interval to conception was 16 days longer for the 24 mo heifers. Adjusted weaning weights were 18 lb heavier for calves from 30 mo heifers. The 30 mo heifers weaned a greater percentage of calves (65%) than did the 24 mo heifers (50%) but this was influenced by calf losses at calving. Under the conditions of this study, the 24 mo heifers required 19 lb less CSM and 274 lb more ground milo per heifer during the first wintering period (139 days) than did the 30 mo heifers.

Trial 2: This trial included 30 heifers calving at 24 months that were started on trial an average of 124 lbs lighter than the 30 mo heifers (Table 2). The 24 mo heifers gained .97 lb/day to weigh 563 lb by the beginning of the breeding season. The two groups of 30 mo heifers gained at different rates during the first wintering period (.71 lb/day and 1.0 lb/day, respectively) to reach respective weights of 639 lb and 703 lb at the beginning of the breeding season. Weight losses during the second wintering period were not influenced by the previous treatment and were 7.7%, 7.4%, and 8.1% of their November 15 weight for 24 mo, 30 mo-Maint, and 30 mo-Gain, respectively. Treatment did not influence conception or date of conception during the first breeding season.

The 30 mo-Gain heifers gave birth to the heaviest calves (81 lb), followed by the calves from the 30 mo-Maint heifers (76 lb), and the 24 mo heifers (72 lb). The heifers calving at 24 months of age suffered more calving difficulty (calving difficulty score 2.9 vs 2.2). A greater number of 24 mo heifers had calving difficulty (72%) than did the 30 mo-Maint and 30 mo-Gain heifers (53% and 50%, respectively). Calf losses at birth were less than 3.5% for all treatments. Compared to trial 1, calf losses and calving difficulty were greatly reduced in trial 2. However, it is important to note that the percentage of heifers requiring some level of assistance was the same in each trial, and at least 50% of the older heifers required assistance.

The postpartum interval to conception was similar for the 24 mo heifers (91 days) and the 30 mo-Gain heifers (84 days). Conception rates during the second breeding season were slightly less for the 24 mo and 30 mo-Maint heifers (80% and 83%, respectively) than for the 30 mo-Gain heifers (93%). Adjusted weaning weight of calves from the 24 mo heifers (400 lb) was lighter than that of the calves from the 30 mo-Maint heifers (458 lb) and the 30 mo-Gain heifers (453 lb). The number of calves weaned per number of heifers exposed was similar for 24 mo heifers (90%) and 30 mo-Gain (93%), but slightly less for 30 mo-Maint (83%).

During the first wintering period (172 days) the 24 mo heifers required an average of 27 lbs more CSM and 178 lbs more corn per heifer than did the 30 mo-Gain heifers. They also required 70 lbs more CSM and 232 lbs more corn than did the 30 mo-Maint heifers.

Body condition scores of the heifers ranged from about 6.5 at the beginning of the second winter to about 5.2 at rebreeding after calving and the 24 mo heifers were consistently 0.3 of a score lower than the 30 mo heifers. Body weights were not significantly different between the

Table 2. Performance of Heifers Calved at 24 Months of Age or 30 Months of Age Fed to Maintain or Gain Weight After Reaching 600 lbs Until Breeding.

Item	24 Month	30 Mo-Maint	30 Mo-Gain
	(TRIAL 2)		
No. of Heifers (11/13)	30	31	28
Heifer Weights (lbs)			
Beg. 1st Winter (11/13)	395	515	523
Beg. 1st Brdg. (5/7)	563	639	703
Beg. 2nd Winter (11/13)	798	922	954
Beg. 2nd Brdg. (5/7)	706	805	823
Weaning (10/13)	869	971	984
Body Condition Scores (Avg) (Scale = 1 to 9)			
Beg. 2nd Winter (11/13)	6.3	6.6	6.5
End 2nd Winter (4/15)	5.7	6.0	5.9
Beg. 2nd Brdg. (5/7)	5.0	5.3	5.3
Weaning (10/13)	5.7	6.0	5.8
First Breeding Season:			
Conception Rate (%)	96	100	100
Date of Conc. (Avg)	May 22	May 25	May 25
Calving Data:			
No. heifers calving	29	28	28
No. live calves	27	27	28
Calf Birth Wt (lbs)	72	76	81
Heifers Req. Assist. (%)	72	53	50
Calv. Diff. Score (Avg) (Scale - 1 to 5)	2.9	2.2	2.2
Second Breeding Season:			
Conception Rate (%)	80	83	93
Post Partum Interval to conception (Days)	91	87	84
205 Day Adj Wn Wt (lbs)	400	458	453
Supplemental Winter Feed per Hfr 1st Wint (lbs)			
Cottonseed Meal	483	413	456
Corn	432	200	254

30 mo-Maint heifers (971 lb) and the 30 mo-Gain heifers (984 lbs) by the end of the trial, however heifers that calved at 24 mo were about 100 pounds lighter when the calves were weaned.

Considering the results from both trials, it is apparent that when weaner heifers are fed at a level as high as was used in this trial, delaying calving until 30 months did not improve conception rates for either the first or second breeding season, or reduce the postpartum interval to conception. This was not unexpected since the high level in previous Ft Reno studies, although costly, had given good reproductive performance in young heifers. Heifers calving at 30 months of age did wean heavier calves than the heifers calving at 24 months of age. In addition, heifers calving at 30 months of age had less calving difficulty than did the heifers calving at 30 months of age; their calving difficulty was less severe; and they required less supplemental feed the winter prior to breeding.

Economic Analysis:

An analysis of costs and returns for calving at 24 months vs 30 months was made using the COWHERD E microcomputer program developed by Dr. Keith Lusby, Animal Science Dept., and Dr. Odell Walker, Agricultural Economics Dept., Oklahoma State University. The budgets developed by this analysis suggests that calving heifers at 30 months is a favorable alternative when they could be maintained on forage following weaning until 1 year of age, and subsequently fed to weigh at least 600 lbs by the beginning of the breeding season. Calving at 30 months would also be advantageous when cash outlay for additional feed is high, and heifers must be fed greater amounts in order to conceive by 15 months of age. However, when cash outlay for additional feed is potentially low, calving at 24 months may be justified.

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INFLUENCE OF HIGH DIETARY PROTEIN ON REPRODUCTIVE FUNCTION IN DAIRY CATTLE: A PROGRESS REPORT

H.J. Howard[1], E.P. Aalseth[2], L. Dawson[3], G.D. Adams[4], L.J. Bush[5]

Story in Brief

In the first year of a 2 year study, 82 dairy cows were fed moderate (15%) and high (20%) crude protein diets from 10 ± 4 to 145 days postpartum. High protein increased milk production by 4 lbs per day over the entire experiment. Nutritional stress as indicated by body weight and body condition change appeared similar between the two groups during early lactation. Plasma urea was elevated 12 mg/100 ml in cows fed the high crude protein diet. Interval to first estrus, interval from calving to conception, services per conception and percent pregnant were similar between cows on the high versus moderate levels of crude protein.

(Key Words: Dietary protein, fertility, days open, body condition)

Introduction

Average milk prodution has increased by over two times for all United States dairy herds and by over one and one-half times in DHIA dairy herds in the past thirty years. In order to realize the milk producing potential of these high producing cows, quality and quantity of diet have increased substantially. Since peak dry matter intake usually lags behind peak milk production by some four to eight weeks, the protein and energy components in the diet must be higher initially in hopes of meeting the cows requirements during early lactation.

Of primary concern in this study is the effect of high dietary protein on rebreeding performance. Recent reports have indicated crude protein percentages above 16% may be detrimental to reproduction (Folman et al., 1981; Jordan and Swanson, 1979). It has been suggested that diets high in protein may alter the uterine environment in such a way that fertilization failure and/or early embryonic mortality are enhanced (Jordan et al., 1983). According to National Research Council recommendations, a 1300 lb cow in her second lactation, milking 60 lbs per day with a milk fat % of 3.5 would require a diet of 15% crude protein to meet her requirements (NRC, 1978). However, if that same cow was milking at 100 lbs per day, a diet containing 19% crude protein would be necessary. This is well within the range of dietary concentrations of crude protein thought to be detrimental for reproductive performance.

The objective of this study was to compare two levels of dietary crude protein on: 1) fertility, 2) onset of estrus and ovarian activity, 3) concentration of plasma metabolites as indicators of nutritional status, 4) feed consumption, 5) body weight and body condition score changes as indicators of nutritional stress and 6) milk production over the first 145 days postpartum.

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Materials and Methods

Sixty Holstein and 22 Ayrshire cows of second lactation or greater were randomly assigned to receive either moderate (15%) or high (20%) levels of crude protein in the diet, beginning 10 ± 4 days from calving. Cows were allotted to diets according to breed, lactation number and date of calving. They were fed a complete mixed ration formulated for the level of crude protein desired, consisting of 45% sorghum silage and 55% grain concentrate on a dry matter basis. Protein levels were varied by modifying the amount of corn and soybean meal in the concentrate. Cows were individually fed three times daily to the limit of consumption for the first 145 days postpartum. Daily feed intake and feed refusals were recorded. Dietary dry matter and protein intake were determined on a weekly average basis. Weight and body condition scores were recorded every two weeks through the duration of the study to follow any changes in nutritional stress that may occur. The body condition scoring system was as described by Aalseth et al. (1983), using a 1 to 9 scale (1 = extremely thin, 9 = over-conditioned). Weekly average milk production was caclulated from daily milk production. Average milk fat and milk protein were determined from samples taken from four consecutive milkings during each week. Plasma urea-nitrogen and B-hydroxybutyrate concentrations were measured on a weekly basis to determine metabolic status.

To monitor reproductive performance, cows were: 1) palpated weekly to follow uterine involution, ovarian function, and later to diagnose pregnancy, 2) bled once weekly for progesterone analysis to determine onset of ovarian activity, 3) observed twice daily for behavioral estrus and bred on the first and subsequent heats 55 or more days postpartum.

Results and Discussion

Data presented represent the initial year of a two year study. The data were averaged over lactation number and breed for each diet. Cows fed the high protein diet produced 7 lbs more milk per day at the peak of lactation, and had 4 lbs more milk per day averaged over the whole experiment (Table 1). Percent milk fat and protein were not altered by level of crude protein in the diet.

Table 1. Dietary intake and productive characteristics of dairy cattle fed two levels of crude protein.

	% Crude Protein	
	15	20
Cows per treatment	43	39
Crude protein (% of dry matter)[a]	14.6 ± .03[b]	19.5 ± .03
Dry matter intake (lbs/day)[a]	48.8 ± .3	49.8 ± .3
Actual milk (lbs/day)[a]	59.5 ± .4	64.4 ± .5
4% fat corrected milk (lbs/day)[a]	58.9 ± .4	62.8 ± .5
Milk fat %[a]	3.97 ± .02	3.87 ± .02
Milk protein %[a]	3.3 ± .01	3.3 ± .01

[a] Weekly average over the experiment.
[b] ± Standard Error

Losses in body weight and condition were similar for cows on both diets, thus cows on either diet appeared to experience the same magnitude of nutritional stress during early lactation. The high protein cows had an initial average weight of 1385 lbs and an initial condition score of 5.4 that decreased to 1373 lbs and 5.0 by weeks 5 and 7, respectively. The moderate protein group had an initial average weight of 1354 lbs and initial average condition score of 5.3 that decreased to 1339 lbs and 4.8 by weeks 5 and 7, respectively. Both groups of cows regained initial body condition by the end of the experiment.

Protein intake on a dry matter basis was calculated as a percentage of NRC requirements based on body weight, milk production, percent milk fat and lactation number. At week 5 of the experiment moderate protein cows were consuming 100% of NRC requirements for protein and high protein cows were consuming 120%. Protein intake, as a percentage of requirements increased linearly over the experiment reaching levels of 123% and 167% by completion of the experiment for cows on medium and high protein diets, respectively. The influence of different levels of crude protein on its metabolism was apparent after 1 week on the diets based on plasma urea levels. Further increases in plasma urea were small. By week 5 cows on high protein diets averaged 27 mg urea/100 ml, about 12 mg/100 ml above cows fed moderate protein.

Reproductive performance did not appear to be affected by different levels of dietary crude protein (Table 2). Onset of estrous behavior, interval from calving to conception and percent pregnant while on experiment were similar for cows on both diets. While the high protein group had an apparent advantage of .3 services per conception, limited cow numbers per treatment prevent any definite conclusions.

Table 2. Reproductive performance for dairy cattle fed two levels of crude protein.

	% Crude Protein	
	15	20
Cows per treatment [a]	42	35
Interval to first estrus (days)	41.1 ± 3.3 [b]	36.3 ± 2.7
Interval from calving to conception (days)	85.3 ± 4.2	81.3 ± 4.0
% Pregnant	81.8	88.6
Services/conception (cows conceiving)	1.6 ± .2	1.3 ± .1
Services/conception (total services/total cows)	2.0	1.7

[a] Cows with abnormal uterine involution were eliminated from the reproductive data.

[b] ± Standard Error

In summary, there may not be a conflict between a dairy cow's dietary requirements for protein needed for lactation and reproductive performance. However, these conclusions are based on a limited number of observations. Completion of the second year of this controlled experiment should provide a confident answer concerning the effect of high dietary protein on reproduction in dairy cattle.

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RESPONSES OF DAIRY COWS TO DIFFERENT AMOUNTS OF WHEAT MIDDLINGS IN THE CONCENTRATE MIXTURE

C. Acedo[1], L. J. Bush[2], and G.D. Adams[3]

Story in Brief

A feeding trial was conducted with 18 lactating dairy cows to compare the nutritional value of rations containing different amounts of wheat middlings. Concentrate mixes containing none, 40, or 60 % wheat middlings comprised 60 % of the total ration, with alfalfa hay used as the forage component. Cows were assigned near the peak of lactation to treatment sequences of a switchback design with three 4-wk periods. There was a significant quadratic trend for a reduction in milk yield as the level of middlings in the ration increased, being more pronounced at the highest level. Similar feed consumption for all treatment groups indicated no ration acceptability problems when middlings comprised as much as 60 % of the concentrate mix. Blood urea and ruminal ammonia concentrations at 3 hours after concentrate feeding were similar for all groups.

[Key words: Wheat middlings, dairy cows, intake, ruminal ammonia, blood urea]

Introduction

Although wheat middlings (mids) are a widely used byproduct for livestock feeding, the amount that can be used to advantage in formulating concentrate rations for dairy cows has not been well defined. The amount used is often limited to no more than one-fourth of the concentrate mixture because of concern about an adverse effect on palatability or reduced animal performance. Pelleting has proved beneficial in alleviating the problem of lowered palatability of mixtures containing a high proportion of mids; however, few trials have compared the effect of different levels of mids on milk yield. Van Horn (1982) fed cows rations in which wheat mids comprised up to 45 % of the concentrate (25 % of the total diet) without an adverse effect on milk yields, feed intake or milk fat test. In an experiment designed to determine the effect of pH on ammonia trapping, Kertz et al. (1983) fed dairy cows a concentrate mixture containing 60 % wheat mids and observed no significant effects on feed intake in comparison to mixtures containing 51 % or 36 % mids, respectively. In a previous experiment at this station (Acedo, 1984), inclusion of up to 40 % mids in the concentrate mixture tended to reduce milk yield of cows with no effect on feed intake.

This experiment was conducted to determine the effect of a relatively high proportion of wheat mids in the concentrate mixture on feed intake and milk yield of lactating dairy cows.

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Materials and Methods

Eighteen lactating Holstein cows were used in a feeding trial to compare concentrate mixtures containing (a) None (b) 40 % and (c) 60 % wheat mids. The total ration consisted of 60 % concentrates and 40 % alfalfa hay. The three concentrate mixtures were calculated to be isocaloric and isonitrogenous, with variation in crude fiber content minimized to the extent considered feasible (Table 1). To accomplish this, each added pound of mids substituted for .15 lb corn, .64 lb sorghum grain and .21 lb of cottonseed meal. The wheat mids had 17.4 % protein and 13.1 % acid detergent fiber, on a dry basis. All the concentrate mixes were pelleted (3/8 inch pellets). Cows were fed concentrate and hay separately, with sufficient amounts provided to allow for a small amount of weighback by each cow.

Table 1. Composition and calculated analysis of concentrate mixtures.

Item	Control	40% Mids	60% Mids
Ingredients, % as fed			
Corn, ground	28.5	22.5	19.5
Sorghum grain, ground	43.0	17.5	5.0
Wheat middlings	--	40.0	60.0
Cottonseed meal	13.0	4.5	--
Molasses, liquid	6.0	6.0	6.0
Dicalcium phosphate	1.0	1.0	1.0
Salt	1.0	1.0	1.0
Sodium bicarbonate	1.0	1.0	1.0
Magnesium oxide	.5	.5	.5
Calculated analysis, as fed			
NE , Mcal/lb	.73	.73	.73
Total protein, %	15.2	15.2	15.2
Crude fiber, %	3.2	4.5	5.1
Soluble nitrogen, % of total N[a]	22.4	23.3	40.0

[a]Solubility in .15N NaCl.

A switchback design was used, with three 5-week periods. The cows were assigned to four blocks based on date of calving and then to treatment sequences. Milk yield was recorded at each milking and samples for fat test were taken at four consecutive milkings each week. A sample of hay and each of the concentrate mixes was taken weekly and analyzed for protein and dry matter. At the end of each period, samples were taken for determination of blood urea and ruminal ammonia concentrations at approximately 3 hours after concentrates were fed.

An "in situ" dacron bag nitrogen disappearance study was performed to provide additional information about utilization of protein in wheat mids. One cannulated Hereford cow was used for the experiment which consisted of two feeding periods. In the first, the cow was fed 60%

control concentrate and 40% alfalfa hay for a 10-day adaptation period followed by a 3-day incubation period. In the second feeding period, the cow was fed in the same manner, but the control concentrate was substituted by wheat middlings. The cow was fed three times daily. Dacron bags (5 x 10 cm) with a mesh size of 20 to 40 microns were used for the incubation of control concentrate and wheat middlings samples in both periods. Duplicate samples of each feed were incubated for 4, 8, 12, 24, and 72 hr.

Results and Discussion

Milk yields of cows fed rations containing wheat middlings were lower than those of cows fed the control concentrate (Table 2). Although the yield of cows fed the concentrate containing 40 % mids did not differ greatly from the control, there was a significant (P<.05) quadratic trend for reduction in milk production as the percentage of mids was increased in the concentrate. The reduction in milk yield was particularly pronounced for cows fed the mixture containing 60 % mids. Similarly, Waldern and Cedeno (1970) observed that cows fed a concentrate mix containing a high proportion of wheat mixed feed produced significantly less milk than cows fed a control concentrate. Considering both the present trial and others in which cows were fed concentrate mixtures containing up to 40 or 45 % mids (Acedo, 1984; Van Horn, 1982), it was concluded that no appreciable decline in milk yield should be expected from use of wheat mids in the ration unless the percentage exceeds around 40 % of the concentrate. Use of as much as 60 % mids to replace high energy feed grains and an oilmeal supplement to some extent may indeed result in lower milk yield than could otherwise be expected. On the other hand, use of mids to replace lower energy ingredients would not be expected to have the same effect.

Table 2. Responses of cows fed experimental rations.

Item	Control	40% Mids	60% Mids
Feed intake, lb/day			
Concentrate DM	26.8	27.7	27.1
Hay DM	17.6	18.0	17.2
Total DM	44.4	45.7	44.3
Total protein	8.1	8.3	7.9
Milk Yield			
Milk Yield, lb/day[a]	57.6	56.9	54.6
Fat test, %	3.6	3.7	3.7
FCM, lb/day	54.3	54.2	52.3
Rumen ammonia, mg/dl	8.2	8.3	8.5
Blood urea, mg/dl	22.7	21.0	21.8

[a]Significant quadratic trend (P<.05).

Dry matter intake was similar for all treatment groups (Table 2), which indicated no problem with acceptability of a pelleted concentrate mixture containing as much as 60 % mids. This was in agreement with results of other studies in which mixtures with a similar percentage of mids were fed to dairy cows. Thus, it appears that intake of pelleted mixtures with a high percentage of mids is not a factor that need limit the use of this ingredient in dairy rations.

Blood urea and ruminal ammonia concentrations at 3 hours after feeding concentrates were similar for all treatment groups (Table 2). Thus, the trend for higher concentrations of these with increasing levels of mids observed in a previous trial (Acedo, 1984) was not evident in this trial. The difference in results in the two trials can be attributed partly to the fact that cows in the present trial received dietary protein more in excess of requirements than did those in the previous trial (i.e., 136 to 139% vs. 123 to 126% of requirements). In this trial, efficiency of protein utilization did not appear to be a factor limiting the value of the rations for milk production.

Solubility of nitrogen in wheat middlings has been observed to be greater than that of some other feedstuffs. However, the values for solubility of nitrogen in an NaCl solution did not differ greatly for the control and the 40% mids concentrate mix, whereas that for the 60% wheat mids concentrate was considerably higher (Table 1). In the dacron bag trials, the incubation time of 72 hr was considered too long to be meaningful in regard to degradation of wheat middlings by rumen bacteria in dairy cows. Therefore, the rate of degradation was calculated for the 4 to 24 hr period. Nitrogen disappearance rate for protein in wheat middlings was higher than that in concentrate when the cow was fed wheat middlings; however, when the cow was fed control concentrate, disappearance of nitrogen from the concentrate was more rapid (Table 3).

Table 3. Dry matter and nitrogen disappearance rates.

	Dry matter disappearance				Nitrogen disappearance			
	Conc. fed		Mids fed		Conc. fed		Mids fed	
Time[a]	CC	Mids	CC	Mids	CC	Mids	CC	Mids
72	92.4	89.2	97.2	89.9	--	95.8	--	96.0
24	91.7	70.8	81.5	70.3	83.7	91.8	63.8	74.4
12	63.2	70.5	57.9	58.1	53.8	88.5	40.7	51.1
8	61.2	67.7	53.4	52.0	48.9	87.4	40.8	43.6
4	51.2	64.8	37.6	36.1	43.3	79.0	27.7	26.0
Rate[b]	9.07	.85	6.09	3.59	6.49	4.13	3.35	5.20

[a]Incubation time in hours
[b]Rate of disappearance, % N or DM/hr, 4 to 24 hr of incubation.

The time needed for the disappearance of one-half of the original amount of nitrogen in the substrate was less for wheat middlings than that for the control concentrate. Thus, there was some evidence that rate of degradation of protein in wheat mids was more rapid than that in a control concentrate containing typical ingredients; however, inconsistency of the results provides little basis to account for the difference in performance of cows fed rations containing different amounts of mids.

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NITROGEN SOURCE AND DIGESTION IN DAIRY COWS

A.L. Goetsch[1] and F.N. Owens[2]

Story in Brief

Cannulated dairy cows were fed 55 percent concentrate diets at 90 percent of ad libitum intake with no supplemental nitrogen (basal diet; 11.1 percent crude protein) or diets supplemented with urea, casein or soybean meal to increase crude protein content to 15 percent. Ruminal organic matter digestion was not affected by diet. Disappearance of starch in the rumen tended to be lower for the soybean meal diet (54.5 vs 60.8, 63.8 and 62.9 percent for soybean meal, basal, urea and casein diets, respectively), while total tract acid detergent fiber digestion was lowest for the basal diet (26.3 vs 39.5, 38.8 and 40.5 percent for basal vs urea, casein and soybean meal-fed cows, respectively).

Key Words: Protein, Rumen Digestion, Fiber Digestion, Soybean Meal.

Introduction

In one previous trial, efficiency of microbial growth was increased from below 10 to over 15 g of microbial nitrogen per kg of organic fermented in the rumen when plant protein (soybean meal or cottonseed meal) was added to a 50 percent concentrate, 12 percent protein diet to increase the crude protein content to 17 percent (Goetsch et al., 1984). Such a change could be due to changes in the rumen population or in concentrations of specific nutrients for ruminal microbes. These include ammonia, peptides, amino acids, branched chain volatile fatty acids, certain minerals and B-vitamins. This trial was conducted to investigate the effect of source and level of dietary nitrogen on digestion and microbial efficiency in the rumen of dairy cows.

Materials and Methods

Four cannulated dairy cows (three Ayreshires and one Holstein; 1047 lb) in late lactation were fed diets (Table 1) twice daily and milked two times each day. The basal diet contained no supplemental nitrogen (11.1 percent crude protein). Urea, casein or soybean meal was substituted for corn starch in the basal diet to 15 percent crude protein levels. The soybean meal diet was fed in a 14 day preliminary period to determine ad libitum consumption. Intakes were restricted to 90 percent of this amount throughout the experiment.

Periods lasted 14 days with sampling on the last three days of each period. Feed, duodenal and fecal samples were obtained and subjected to all or part of the following analysis: dry matter, ash, nitrogen, acid detergent fiber, starch, chromium, nucleic acid-N and ammonia-N. Means were statistically contrasted.

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[1]Former Research Associate [2]Professor

Table 1. Diet compositions, % of dry matter[a].

Ingredient	Diet			
	Basal	Urea	Casein	SBM
Corn starch	7.2	6.0	3.4	----
Urea	----	1.2	----	----
Casein	----	----	3.8	----
Soybean meal	----	----	----	7.2
Ground milo	43.5	43.5	43.5	43.5
Dehydrated alfalfa pellets	20.0	20.0	20.0	20.0
Chopped sorghum silage	25.0	25.0	25.0	25.0
Cane molasses	1.5	1.5	1.5	1.5
Dicalcium phosphate	1.5	1.5	1.5	1.5
Limestone	.5	.5	.5	.5
Trace mineralized salt	.5	.5	.5	.5
Chromic oxide	.3	.3	.3	.3

[a]Crude protein contents were 11.1, 15.0, 14.9 and 15.1%, respectively.

Results and Discussion

Ruminal and total tract digestion of organic matter were similar for all diets (Table 2) but lower than anticipated. Silage was cut at a late stage of maturity which may explain the low diet digestibility. Ruminal starch digestion was lower for the soybean meal than the urea diet. This may be due partially to the dietary level of corn starch. Postruminal starch digestion of the soybean meal diet compensated for depressed digestion of starch in the rumen. The acid detergent fiber content of the soybean meal diet was slightly greater than in other diets and ruminal acid detergent fiber digestion tended to be highest with this diet.

Table 2. Digestion measures.

Item	Diet			
	Basal	Urea	Casein	SBM
Organic matter digestion, % of intake				
Ruminal, true	44.9	45.6	46.1	42.9
Postruminal	9.5	12.3	11.4	12.7
Total	54.4	57.9	57.9	55.6
Starch digestion, % of intake				
Ruminal	60.8	63.8	62.9	54.5
Postruminal	3.3	1.6	2.3	15.6
Total	64.0	65.4	64.2	70.1
Total acid detergent fiber digestion, % of intake	26.3	39.5	38.8	40.5
Nitrogen disappearance, % of intake				
Ruminal (total)	3.0	22.0	6.0	6.0
Ruminal (non-microbial)	36.5	48.8	43.9	42.1
Total	42.1	58.2	59.3	55.6
Microbial efficiency, g microbial nitrogen/kg organic matter intake	15.0	15.2	15.5	15.3

Addition of protein to the diet increased (P<.05) fiber digestibility. Slower degradation of soybean meal than the other protein sources in the rumen would provide products of protein degradation more continually over the 12 hour feeding cycle which might increase fiber digestion.

Nonammonia nitrogen flow to the duodenum was equal to 97, 78, 94 and 94 percent of nitrogen intake for basal, urea, casein and soybean meal diets, respectively. Microbial efficiency (Table 2) was similar for all groups, contrasting with the earlier experiment in which intact protein supplementation of a 12 percent crude protein basal diet increased MOEFF from 10 to over 15 g N per kg organic matter truly fermentation in the rumen (Goetsch et al., 1984). In the previous trial, urea supplied 18 percent of the protein in the basal diet so protein byproducts may have been lower in that trial. Further, feed intake in the earlier experiment was slightly greater than in this trial which would elevate passage rate through the rumen. A faster ruminal passage rate may increase the effect of natural protein on microbial efficiency.

Assuming that urea and casein are totally degraded in the rumen, ruminal N disappearance with the basal diet was lower than anticipated. In most cases urea has not influenced escape of dietary protein, so it was surprising that ruminal escape of dietary N was increased by 10 percent with urea feeding in this trial. An increased rate of particle disintegration with urea supplementation would be expected to enhance passage rate of ruminal particles and decrease the extent of disappearance of basal dietary N, but ruminal OM digestibilities do not reflect such a change.

In summary, N level and source had little impact on site of digestion of nutrients with the exception of ADF. Total tract digestion of ADF was increased by N supplementation regardless of N source as has been observed previously (Kropp et al., 1977; Weakley et al., 1983). This may have been due to deficiency of ammonia-N in the rumen in this trial but not in the other trials. In this study, an ammonia deficiency would have been expected to reduce microbial efficiency based on in vitro studies but microbial efficiency values did not increase with added protein or non-protein nitrogen.

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NITROGEN SOURCE AND DIGESTION IN RUMEN CULTURES

M.A. Funk[1], A.L. Goetsch[2] and F.N. Owens[3]

Story in Brief

Semi-continuous rumen cultures were fed 55 percent concentrate diets with no supplemental nitrogen (B; 9.2 percent crude protein) or diets supplemented with urea (U; 13.2 percent crude protein), casein (C; 12.1 percent crude protein) or soybean meal (S; 12.4 percent crude protein). Digestion of organic matter, starch and nitrogen did not differ with nitrogen source but acid detergent fiber digestion was increased by addition of all sources of N (29.7 vs 39.9, 41.7 and 44.4 percent for B vs U, C and S treatments, respectively). Microbial efficiency and composition of bacterial cells were not altered by nitrogen source or level.

Key Words: Protein Source, Soybean Meal, Urea, Fiber Digestion.

Introduction

Ruminants can be maintained entirely on nonprotein nitrogen (NPN), but level of production generally is lower with NPN than with protein in the diet. This may be due to ruminal or post-ruminal differences. Supply of microbial protein may be inadequate to satisfy the amino acid requirements of high producing ruminants. In the rumen, ammonia nitrogen permits most species of ruminal microbes to survive though some bacteria require preformed N compounds such as amino acids or peptides for survival or growth. This trial was conducted to investigate the effect of level and source of dietary nitrogen on digestion and microbial efficiency in semi-continuous rumen cultures. It was conducted in tandem with a trial in which similar diets were fed to dairy cows (Goetsch and Owens, 1985).

Materials and Methods

Twelve culture flasks were used in a completely randomized design trial for 14 days. Ruminal fluid, buffer, finely ground substrate (Table 1) and a magnetic stir bar were introduced into 250 ml Erlenmeyer flasks and incubated at 39 C. Twice daily, flasks with a fluid volume of 200 ml were stirred to a homogeneous mix and 37 percent of the volume (75 ml) was removed. Fresh substrate, buffer and water were injected into the cultures to obtain a discontinuous removal rate equal to 3.1 percent/hour. Cultures were gassed with CO_2 at transfer times. Days 1 through 6 were for culture stabilization and samples were taken on days 7 through 14. Effluent material was analyzed for dry matter, ash, N, acid detergent fiber (ADF), starch, total nucleic acid-N (NAN), ammonia-N, NAN and ammonia-N. Bacterial cells were isolated by centrifugation (IBC) and bacteria and protozoa were counted.

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[1]Former Undergraduate Student [2]Former Research Associate
[3]Professor

Table 1. Diet compositions.

Ingredient, % of dry matter	Diet B	U	C	S
Corn starch	7.2	6.0	3.4	----
Urea	----	1.2	----	----
Casein	----	----	3.8	----
Soybean meal	----	----	----	7.2
Ground milo	45.3	45.3	45.3	45.3
Ground alfalfa hay	20.0	20.0	20.0	20.0
Dried sorghum silage	25.0	25.0	25.0	25.0
Dicalcium phosphate	1.5	1.5	1.5	1.5
Limestone	.5	.5	.5	.5
Trace mineralized salt	.5	.5	.5	.5

Results and Discussion

Protozoa numbers were not maintained but decreased over time so that levels from day 7 to 14 were lower than found in vivo (Table 2).

Table 2. Numbers of bacteria and protozoa, pH, ammonia-nitrogen concentration and composition of isolated bacterial cells.

Item	Diet B	U	C	S
Bacteria numbers, $X10^{10}$/ml	6.2	5.5	7.2	6.3
Protozoa numbers, $X10^{3}$/ml	.4	6.9	7.7	1.7
Culture pH	6.7	6.8	6.7	6.7
Isolated bacteria cells				
Nitrogen, % of dry matter	7.1	6.7	6.5	7.0
Nucleic acid-nitrogen, % of nitrogen	20.2	29.7	22.7	20.2
Ash, % of dry matter	13.1	18.4	19.2	16.4

Dilution rates were the same for liquid and solid which may have washed out protozoa. In the rumen, protozoa associate with particles and pass more slowly than liquid. Numbers of protozoa tended to be higher with U and C diets. With the low protein treatment, protozoa were absent and ADF digestion was reduced (Table 3). This may reflect protozoal involvement in physical disruption of fiber though ADF digestion was not reduced with low protozoal numbers with soybean meal as a source of protein. N content of IBC was similar for all treatments (Table 2) but, the NAN:N ratio of IBC for U cultures tended to be slightly greater than for other diets.

Extent of OM digestion tended to be greater for C and S than for B and U diets (Table 3) and was slightly greater than ruminal OM disappearance of similar diets in vivo (Goetsch and Owens, 1985). Starch digestion was similar for all diets and higher than in vivo ruminal

Table 3. Digestion measures for the 8-day collection period.

	Diet			
	B	U	C	S
Organic matter digestion (true), % of input	50.8	50.6	54.2	54.0
Starch digestion, % of input	90.6	90.0	90.2	89.2
Acid detergent fiber digestion, % of input	29.7[a]	39.9[b]	41.7[b]	44.4[b]
Nitrogen disappearance, % of input	49.2	45.7	50.9	51.0
Nitrogen passage, mg				
Input	168.0	239.2	219.9	223.6
Outflow				
Total	215.9	238.5	256.5	249.0
Microbial	55.4	52.1	56.9	60.2
Feed	90.1	137.6	114.2	116.3
Ammonia	70.4	48.8	85.4	72.5
Microbial efficiency, g microbial nitrogen/kg organic matter fermented	10.6	9.9	10.0	10.7

[a,b]Means in a row with different superscripts differ (P<.05).

starch disappearance (Goetsch and Owens, 1985). This difference may be due to finer grinding of the diet for use in vitro or to culture conditions. In vitro, grain settled due to lack of culture agitation. Settled particles are more subject to washout in vivo than in vitro due to their particle size, specific gravity and proximity to the exit point. Extent of ADF digestion and treatment differences observed in vitro were similar to those observed in vivo (Goetsch and Owens, 1985).

Conversion of feed N in vitro to ammonia and to microbial matter was similar for all treatments and was slightly lower than measured in the rumen of cows (Goetsch and Owens, 1985). Extent of digestion of N for the U diet tended to be lower than for C and S diets. Since many bacteria in the rumen which hydrolyze urea are facultative anaerobes, urease activity in this anaerobic culture media may have been low. Microbial efficiency was lower in vitro than in vivo (Goetsch and Owens, 1985), but differences due to source or level of N were negligible in both trials. Similarities between in vitro and in vivo responses to these protein sources and levels indicate that in vitro procedures may be useful to predict animal responses to diet changes providing specific ruminal factors such as passage rate and gut volume are not altered by treatments.

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EFFECT OF SARSAPONIN IN THE RATION OF LACTATING DAIRY COWS ON RUMEN FERMENTATION AND PRODUCTION PERFORMANCE

F.R. Valdez[1] and L.J. Bush[2]

Story in Brief

The effect of daily supplementation of sarsaponin to a complete ration was determined using 16 Holstein cows in their first lactation. A switchback design with three 4-wk periods was used. Treatments were: 1) 70 g of sarsaponin/ton of air-dry feed. 2) No sarsaponin (control). Complete rations were formulated daily in a proportion of 55:45 concentrate:silage (dry basis), and equal quantities were fed individually three times a day. No significant differences in milk production (45.8 and 45.3 lb/day), fat test (3.5 and 3.5 %) and milk protein percentage (2.8 and 2.8 %) were observed between groups of cows fed sarsaponin and control rations. Rumen ammonia (4.8 and 4.7 mg/dl) and blood urea (10.4 and 10.5 mg/dl) were similar for the respective treatment groups. Molar percentage of individual ruminal volatile acids also were similar for the two treatment groups.

[Key Words: Sarsaponin, Steroidal glycoside, Digestion, Milk yield, Dairy cows.]

Introduction

Peekstok (1979) observed a stimulating effect of sarsaponin, a steroidal glycoside, on anaerobic fermentation of organic matter in activated sludge waste treatment systems. Enhancement of anaerobic fermentation in ruminant digestion of starch and fibrous feedstuffs could have some beneficial effect in utilization of many livestock feeds.

There is a possibility that changes in fermentation patterns, due to enhancement of ruminal fermentation, may improve the utilization of nutrients by the animal. Grobner et al. (1982) observed a higher total nitrogen output (P<.05) in continuous flow fermenter systems treated with 30 ppm sarsaponin. In contrast, Goetsch and Owens (1984) observed increased ruminal and total N digestion due to the addition of 44.1 ppm of sarsaponin to the ration of cannulated dairy cows. Ruminal and total tract digestibilities of organic matter were also increased.

The objective of this experiment was to determine the effect of sarsaponin supplementation on responses of lactating dairy cows under conditions where dietary intake of natural protein was limited in relation to NRC requirements.

Materials and Methods

Sixteen Holstein cows in their first lactation were started on experiment 6 to 10 weeks postpartum. A switchback design with two blocks (eight cows per block) and three 4-wk periods was used. Cows were as-

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signed at random to each block and then to treatment sequences. The treatments were: 1) 70 g of sarsaponin[3] (SARS)/ton of air-dry feed. 2) No sarsaponin (control). Complete rations were formulated daily in a proportion of 55:45 concentrate:silage (dry basis), and approximately equal quantities were fed in individual pens three times a day (1100, 1900 and 0300 hours). The cows had free access to water. Milk weights were recorded daily and samples taken at four consecutive milkings each week were analyzed for fat and protein percentage. Daily feed weigh-backs were taken to determine weekly dry matter (DM) and protein intake. Each cow was weighed two times each week to obtain an average body weight for purpose of calculating ration allowances. Intake of natural protein was restricted by including only enough soybean meal in the ration for each cow so that sufficient natural protein was supplied to meet 80% of estimated NRC requirements. Urea was added to provide protein equivalent value equal to 15% of the total protein requirement for each cow.

Blood and rumen fluid samples were taken the last day of each period 3 to 4 hr after the 11:00 AM feeding. Blood was withdrawn from the tail vein with vacutainer tubes and rumen fluid was sampled by stomach tube. The respective samples were analyzed for blood plasma urea, ruminal ammonia concentration and individual ruminal volatile fatty acids.

Results and Discussion

Addition of sarsaponin to the ration resulted in no significant difference (P>.05) in milk production, fat percentage or milk composition (Table 1). Intake of natural protein was restricted in relation to the NRC requirements for total protein (Table 1); therefore the possibility existed for the cow to benefit from bypass of more natural protein or increased microbial synthesis of protein in the rumen. Production responses provided no indication of any benefit from the addition of sarsaponin to the ration. This is in agreement with results of a previous feeding trial where natural protein was less restricted (Valdez et al., 1984), and also with the observation of Goetsch and Owens (1984) that ruminal nitrogen digestion tended to be greater for cows fed a diet supplemented with 44.1 ppm of sarsaponin than for cows fed a control diet. Whether or not a positive response to supplementation with sarsaponin would be obtained with older cows in not known. Roffler et al. (1978) reported no increase in milk yield of first lactation cows as protein concentration in the ration increased, whereas a positive response was obtained in multiparous cows.

No significant difference was observed between treatment groups in DM intake and body weight change. The level of SARS supplementation used in this trial had no adverse effect on feed intake. Moreover, it is doubtful that energy intake limited production by the cows since they were allowed as much dry matter as they would consume with natural protein content adjusted weekly to maintain the desired restriction of this component of the ration.

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[3]Source of sarsaponin was Sevarin, a commercial product manufactured by Distributors Processing, Inc., Porterville, CA 93257.

Table 1. Milk yield and feed intake.

ITEM	SARS	CONTROL
Milk yield, lb/day	45.8	45.3
Fat test, %	3.5	3.5
Milk protein, %	2.8	2.8
Total protein intake, lb/day[a]	5.0	5.0
Protein intake/requirements, %	99.7	99.7
Dry matter intake, lb/day	44.0	43.7
Body weight change, lb/period	2.3	-1.0

[a]Including protein equivalent value from urea.

Ruminal ammonia and blood urea concentrations were similar for both treatments (Table 2), suggesting very little or no effect on urease inhibition by sarsaponin, even when urea supplementation was increased to provide 15 % of the total protein required, as compared to 10 % in a previous feeding trial (Valdez et al., 1984). In contrast, Grobner et al. (1982) reported a decrease in ammonia levels in *in vitro* fermenters when 60 ppm of sarsaponin was added to the substrate.

Molar percentages of acetic, propionic, butyric and valeric acids as well as total VFA concentration were similar for both treatment groups (Table 3). In contrast, Goodall (1980) observed higher propionic acid and lower acetic acid ($P<.05$) in steers when feedlot diets were supplemented with 60, 120, and 240 ppm of sarsaponin.

Table 2. Blood urea and rumen ammonia levels.

ITEM	SARS	CONTROL
	-------(mg/dl)-------	
Rumen ammonia	4.8	4.7
Blood urea	10.4	10.5

Table 3. Rumen volatile fatty acids.

ITEM	SARS	CONTROL
Total VFA concentration, mM/	153.5	144.7
Individual VFA, molar %		
Acetic	63.1	63.4
Propionic	22.6	22.2
Butyric	13.0	13.1
Valeric	1.3	1.3

Supplementation of rations for lactating dairy cows with 70 g of sarsaponin/ton of air-dry feed did not have a beneficial effect on milk production, fat percentage, dry matter intake or body weight change.

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EFFECT OF SARSAPONIN ON IN SITU DIGESTION OF A COMPLETE DAIRY RATION

F.R. Valdez[1], M.A. Faldet[2], F.N. Owens[3], and L.J. Bush[3]

Story in Brief

Disappearance of nitrogen (N), organic matter (OM) and acid detergent fiber (ADF) of a grain supplement (Gr), hay, soybean meal (SBM), and a complete dairy ration with sarsaponin (S) and without sarsaponin (NS) was measured <u>in situ</u>. Two rumen cannulated animals, in a cross-over design, were fed a complete ration of concentrate:silage (55:45) three times a day. The total ration had 15.5% crude protein and sarsaponin was added at a level of 70 g/ton of air-dry feed. Disappearance of OM, N, and ADF was greater for SBM than for all other substrates. ADF disappearance from grain was greater than from S and NS and disappearance from S tended to be lower than from the NS ration. N disappearance was not significantly different for Gr, hay, S and NS. OM disappearance from S was less than from NS and hay.

[Key Words: In situ digestion, Sarsaponin, Dry matter disappearance, Rumen.]

Introduction

Goodall (1980) reported that sarsaponin caused a reduction of passage of liquids and solids from the rumen and the total digestive tract. Zinn and Owens (1980) reported that 10 to 20 % of the starch of high grain feedlot diets were excreted in the feces. The reduction of this nutrient loss, by slowing the rate of passage, could result in an improvement in animal performance when using mixed diets by improving both starch and fiber digestion.

Peekstok (1979) observed a stimulating effect of sarsaponin on anaerobic fermentation in biological waste treatment systems. The enhancement of anaerobic fermentation in ruminal digestion of starch and fiber could have an effect on fermentation patterns. Goodall (1980) observed that total digestive tract nutrient digestibility tended to be roughly 6 % higher as a result of supplementing rations with 100 ppm of sarsaponin. Particulate and liquid flow rates to the abomasum averaged 15.6 and 17.0 % lower for diets containing 100 ppm of sarsaponin.

The objective of this study was to evaluate the <u>in situ</u> rate of disappearance of different components of a protein supplement, roughage, grain, and a complete ration with and without sarsaponin.

Materials and Methods

Two rumen-cannulated animals, one large framed Angus steer and a Hereford heifer, were fed a complete ration suitable for lactating dairy cows. It contained 15.5% crude protein (CP), and consisted of concentrate:silage (55:45, dry basis) fed three times a day (1100, 1900

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and 0300 hours). A cross-over design that involved two 12-day periods was used. Ration treatments were: (1) 70 g of sarsaponin/ton of air-dry feed and (2) no sarsaponin (control). The initial eight days of each period were used for adjustment, and during the following 72 hr different substrates were incubated in situ in dacron bags (5 x 10 cm) with a pore size of 55 microns. Substrates were a complete ration with 70 g sarsaponin/ton of air-dry feed (S) and the same ration with no sarsaponin (NS), a roughage source (hay), SBM and a basal grain. The latter three were the ingredients of the complete ration. These were attached to a 50 cm string with a weight at the end so that they would stay submerged in the ventral part of the rumen in order to have a complete and uniform exposure to microbial action. Measurements of rate of digestion were made for different incubation times (4, 8, 12, and 72 hr) during each period. After incubation, the bags were washed, dried for 72 hr at 55 °C and later analyzed for dry matter (DM), organic matter, nitrogen, and acid detergent fiber.

Results and Discussion

Whether the animals were fed the ration with sarsaponin or the one without sarsaponin had no significant effect on the rate of disappearance of the substrates from dacron bags during incubation. Therefore, values for each treatment obtained from the two animals were averaged without regard to the ration fed.

Rate of disappearance of ADF, N and OM were greater for SBM than for all other substrates (Table 1). ADF disappearance for S tended to be lower than from NS, whereas ADF disappearance from the grain supplement was higher than from S and NS substrates. This is in contrast to results of Goetsch and Owens (1984) who observed greater ADF digestibilities for rations supplemented with 60 g sarsaponin/ton of ration. Also, Zinn et al. (1983) reported small increases in ADF digestion due to sarsaponin supplementation.

Rate of disappearance of N tended to be greater for the substrate without sarsaponin as compared to grain, hay and S. In contrast, Goetsch and Owens (1984) reported that ruminal N digestion tended to be greater for cows fed 60 g/ton of sarsaponin. On the other hand, Zinn et al. (1983) observed that duodenal flow of feed N increased when sarsa-

Table 1. Rate of disappearance for nitrogen, organic matter and acid detergent fiber.

Substrates	N	OM	ADF
Soybean meal	2.53[a]	2.60[a]	2.44[a]
Hay	0.40[b]	0.50[d]	0.45[c]
No Sarsaponin	1.00[b]	0.80[c]	0.34[c]
Sarsaponin (S)	0.54[b]	0.60[d]	0.12[c]
Grain	0.75[b]	1.20[b]	0.72[b]

[abcd]Means in a column with different superscripts are different (P<.05).

ponin was supplemented to high concentrate, high protein diets. Organic matter disappearance from S and hay was lower than from NS and grain (P<.05). Less nitrogen and organic matter of rations supplemented with 60 g/ton of sarsaponin may be degraded in the rumen and by-passed to the small intestine. More research is required to explain the conflicting results from this and other trials.

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EFFECTS OF DIETARY SARSAPONIN CONCENTRATION ON FERMENTATION AND DIGESTION IN SEMI-CONTINUOUS RUMEN CULTURES

F.R. Valdez[1], A.L. Goetsch[2], L.J. Bush[3]

Story in Brief

Sixteen *in vitro*, semi-continuous rumen cultures were used to determine the effect of sarsaponin concentration (0, 30, 50 and 70 g/ton air dry feed) on fermentation. The basal diet consisted of ground corn, soybean meal, and ground alfalfa with a 55:45 concentrate:roughage ratio. Numbers of protozoa decreased linearly while bacterial numbers tended to increase with increasing levels of Sarsaponin. Culture pH was similar for all treatments. Nitrogen digestion tended to be lowest for the highest concentration of sarsaponin. Microbial nitrogen production was similar for all groups. Acid detergent fiber digestion increased linearly with increasing concentrations of Sars. in the diet.

[Key Words: Sarsaponin, *In vitro* fermenters, Digestion, Steroidal glycosides.]

Introduction

Sarsaponin, a steroidal glycoside, has been used in rations for finishing cattle. There is some evidence that it has an effect on microbial growth through the stimulation of anaerobic fermentation (Peekstok, 1979). There is a possibility that sarsaponin could improve productivity through more efficient utilization of feed by ruminant animals.

The objective of this experiment was to determine the effects of sarsaponin concentration in semi-continuous *in vitro* fermentors under controlled conditions on fermentation of feed by rumen cultures.

Materials and Methods

A modification of a semi-continuous *in vitro* digestion system was used. Sarsaponin (SARS) was added at concentrations of 0, 30, 50, and 70 g/ton to a substrate consisting of 55% concentrate on an air dry-basis (Table 1). A total of 16 rumen cultures were in a completely randomized experiment with four cultures per treatment. The experiment lasted 22 days with sampling conducted on the last 12 days. Sarsaponin was administered as Sevarin (Distributors Processing, Inc., Porterville, CA), a commercial product containing a high percentage of steroidal sasaponins extracted from the plant *Yucca shidigera*.

Initially, each fermentor contained 150 ml buffer (McDougall, 1948) preheated at 39 ^{0}C, and 50 ml rumen fluid obtained from two mature Hereford heifers fed a 58 % concentrate diet of ground corn and chopped alfalfa. At 12-hour intervals (0645 and 1845), 50 ml samples were removed from each culture via suction with a plastic syringe and a mix

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Table 1. Composition of basal substrate.

Item	%
Ground Corn	45
Ground Alfalfa	45
Soybean Meal	10

of .5 g substrate and 50 ml buffer was introduced into each fermentor flask through short tube. Cultures were then gassed with carbon dioxide for 15 seconds.

The initial 10 days of the experiment served as a stabilization period. Samples were obtained daily at 1845 hours pH was measured immediately. Samples were dried at 55 ^{o}C and analyzed for dry matter (DM), ash, nitrogen (N), acid detergent fiber (ADF), starch, nucleic acids and ammonia nitrogen (NH_3-N).

Bacterial and protozoal counts were conducted in duplicate. Protozoal numbers were determined with phase contrast microscopy at a magnification of 100 X. Bacteria were enumerated with a Petroff-Hauser chamber at a magnification of 600 X.

Data were analyzed by analysis of variance, and treatments were tested for linear and quadratic effects and a contrast of control diets versus supplementated diets with sarsaponin was made.

Results and Discussion

There was a tendency for bacterial numbers to increase with increasing levels of SARS. When the control was contrasted with the average of all treatments, the difference was found to be statistically significant (Table 2). The higher bacterial numbers were also associated with a significant linear decrease (P<.05) in numbers of protozoa from 3.6 x 10^4/ml to 2.9 x 10^4/ml respectively, as concentration of SARS increased from 0 to 70 g/ton.

Table 2.- Numbers of bacteria and protozoa.

	SARS concentration, g/ton				
Item	0	30	50	70	SE
Bacteria, X 10^{10}/ml	1.2[a]	1.2	1.3	1.3	.09
Protozoa, X 10^4/ml	3.6	3.3	2.8	2.9	.2

[a] Significantly different from average of other means (P<.05).
[b] Linear effect (P<.05).

The pH values for all treatments varied from 6.76 to 6.78 (Table 3). Slyter (1966) reported that cultures maintained at pH 6.7 normally contained most types of bacteria often found in large numbers in the rumen of cattle.

Ammonia-N values for all treatments were similar, with a range in total concentration of 4.6 to 4.9 mg/dl (Table 3). This is in contrast to results reported by Grobner et al. (1982), where NH_3-N values were depressed upon addition of 60 ppm of SARS to fermentor diets.

Addition of sarsaponin in the diet had a quadratic effect on starch digestibility ($P<0.1$), increasing digestion up to a concentration of 50 g/ton, and then decreasing with a concentration of 70 g/ton (Table 4). There is no explanation for this decrease, similar to that observed by Zinn et al. (1983) with high concentrate diets containing 60 g of sarsaponin per ton. Increasing starch digestibilities may be associated with an increase in the number of bacteria. Higher starch digestibility ($P<.05$) was observed for the average of all treatments with SARS than for control. Apparent digestibility of ADF increased linearly with increasing levels of SARS approaching significance ($P<.10$) (Table 4).

Table 3.- Culture pH and NH_3-N concentration.

Item	SAR Concentration, g/ton 0	30	50	70
pH	6.77	6.77	6.78	6.76
NH_3-N, mg/dl	4.7	4.8	4.9	4.6

Table 4.- Nutrient utilization.

Item	SAR Concentration, G/Ton 0	30	50	70
Apparent digestibility, %				
Starch[a]	96.4	97.6	98.2	97.4
ADF[b]	10.2	21.5	30.6	47.7
Net digestibility, %				
Feed nitrogen	67.4	67.4	63.9	49.8
Organic matter[c]	52.9	68.7	60.7	59.7
Microbial efficiency, g MN/kg OM ferm.	44.7	32.7	30.1	33.5

[a] Significant difference between control vs. Trts. ($P<.05$).
[b] Linear effect ($P<.10$).
[c] Linear effect ($P<.08$).

There was no significant difference (P>.05) among treatments in nitrogen digestion, which tended to be lowest at the highest level of SARS. Similar non-significant differences were observed for microbial-N and microbial efficiency (Table 4). In contrast, Zinn et al.(1983) reported increased microbial protein synthesis, and decreased ruminal-N digestion by cultures with 60 g/ton of SARS in high concentrate diets. Differences among treatments in net organic matter digestibility approached significance (P<.08), and a significant contrast (P<.05) was observed between treatments with SARS over control (Table 4), similar to observations by Goetsch and Owens (1984).

Sarsaponin caused changes in fermentation in the semi-continuous fermentation trial, as evidenced by an increase in net digestibility of organic matter and apparent digestibility of ADF and starch. Sarsaponin also increased numbers of bacteria and decreased numbers of protozoa with increasing concentrations.

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ASSOCIATIVE EFFECTS OF UNTREATED AND AMMONIATED WHEAT STRAW DIETS AND ALFALFA FED TO SHEEP

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Story in Brief

Thirty-five and twenty-eight wether lambs (50 lb) were individually fed ad libitum once a day untreated (US) or ammoniated wheat straw (AS) in combination with different proportions of high quality roughage (HQR) as alfalfa hay (ALF) or dehydrated alfalfa pellets (DEHY) (100:0; 67:33; 33:67 and 0:100 for US/AS:ALF:DEHY) in two separate experiments. The substitution of HQR produced a linear increase (P<.01) in organic matter (OM) intake for both types of straw diets. Digestibility of dietary organic matter (OMD) was linearly increased in both US and AS diets as the proportion of HQR increased. For US:HQR up to 33:67, the digestibility of dietary neutral detergent fiber (NDFD) remained similar, while a reduction was observed with AS based diets. Ammoniation of straw increased OM intake, OMD and NDFD.

Associative effects observed between straw and HQR varied depending on the type of straw and the HQR. With US:ALF diets, negative associative effects were observed for total diet OMD and NDFD, while positive associative effects were observed for OMD and NDFD with AS:ALF diets. DEHY depressed NDFD of the total diet for both types of straws.

Ammoniation of straw resulted in a similar metabolizable energy intake between the 100:0 AS diet and that observed with 67:33 US:HQR in the diet. A higher level of production could be expected from diets of AS plus HQR, particularly with DEHY. Calculated metabolizable energy intakes indicate that mature non-pregnant, non-lactating ewes could be maintained on a diet of 67:33 AS:ALF while a ratio of 33:67 would be required with US based diets.

Key Words: Ammoniation, Wheat Straw, Alfalfa, Associative Effects, Digestibilities, Sheep.

Introduction

The poor digestibility and low voluntary intake of low quality roughages result from their low protein content and extensive lignification of cell walls. Both physical processing and chemical treatment have been used to improve the feeding value of low quality roughages such as wheat straw (Streeter and Horn, 1980). Alfalfa hay is a good source of supplemental protein and minerals and a logical choice for addition to low quality roughages, such as wheat straw, to increase the extent of ruminal organic matter digestion by correcting for nutrient deficiencies.

The objective of this study was to determine the effect of combining alfalfa hay (ALF) or dehydrated alfalfa pellets (DEHY) with untreated (US) and ammoniated (AS) wheat straw in different proportions, on feed intake, apparent digestibility of organic matter (OMD) and neutral detergent fiber (NDFD). The identification of

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possible associative effects between US or AS and HQR on OMD and NDFD was also an objective of the experiments, and was determined as a significant difference between observed and calculated digestibilities of the diets. Calculated percent nutrient digestibilities were obtained by the following relationship:

$$CPND = \frac{(A \times B) + (C \times D)}{E} \times 100$$

where

CPND = Calculated percent nutrient digestibility
A = Nutrient intake from straw
B = Observed nutrient digestibility in 100 percent straw diet
C = Nutrient intake form HQR
D = Observed nutrient digestibility in 100 percent HQR diet
E = Total nutrient intake

Materials and Methods

Thirty-five and twenty-eight wether lambs (50 lb) were housed in individual pens and randomly assigned to seven treatments in two separate experiments (five and four lambs/treatment for experiments 1 and 2, respectively; Table 1).

In experiment 1, US was blended with either ALF or DEHY, while AS was used in experiment 2. Straws and ALF were ground through a 1.5 inch screen. Lambs were fed once a day, ad libitum, and supplemented daily with 45 g of mineral-vitamin supplement shown in Table 1. Lambs on the 100 percent US diet also received 5 g of urea/day. Individual feed refusals were recorded and sub-sampled daily. After a 15-day adaptation period, individual collection of total feces was achieved by means of bags during a 7-day period in experiment 1 and a 5-day period in experiment 2. Animals were weighed at the beginning and end of each period. Representative samples of feed, feed refusals and feces were analyzed for dry matter, ash and NDF. Data were analyzed by analysis of variance with a test made for linear and quadratic effects on OM intake, OMD and NDFD.

Results and Discussion

Substitution of ALF or DEHY for both types of straws resulted in an increase ($P<.01$) in OM intake (Figure 1) and organic matter digestibility (Figure 2). The NDFD was linearly increased ($P<.01$) with the progressive inclusion of HQR in US based diets, but it was linearly decreased ($P<.01$) in AS based diets. This was due to the marked increase in NDFD caused by ammoniation and the relatively low NDFD of 0:100 AS:HQR diet (Figure 2). Ammoniation of wheat straw also improved its OM intake and digestibility (Figures 1 and 2).

Different associative effects were observed between wheat straw and HQR depending on type of straw and HQR used. For the US:HQR diets, the combination of US with HQR resulted in a decrease in OMD and a negative associative effect on NDFD of the whole diets. On the other hand, with AS:ALF diets, positive associative effects were observed for OMD and NDFD. Substitution for AS with DEHY resulted in negative associative effects on OMD and NDFD of the whole diet (Table 2).

Calculated metabolizable energy (ME) intake increased as the level of substitution of HQR increased in the diet with US:HQR diets. The ME intake was not sufficient to meet maintenance ME requirements of lambs

Table 1. Formulation and composition of diets.

	Dietary treatment													
	Experiment 1							Experiment 2						
	US:ALF				US:DEHY			AS:ALF				AS:DEHY		
	100: 0[a]	67: 33	33: 67	0: 100	67: 33	33: 67	0: 100	100: 0	67: 33	33: 67	0: 100	67: 33	33: 67	0: 100
Ingredients (% as fed basis)														
US	100	67	33	--	67	33	--	--	--	--	--	--	--	--
AS	--	--	--	--	--	--	--	100	67	33	--	67	33	--
ALF	--	33	67	100	--	--	--	--	33	67	100	--	--	--
DEHY	--	--	--	--	33	67	100	--	--	--	--	33	67	100
Vit & Min[b] supplement	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Composition (% DM basis)														
Organic matter	93.6	93.5	93.3	93.2	92.0	90.3	88.7	95.8	94.7	93.7	92.6	93.9	91.8	89.9
Crude protein	4.3	8.9	13.5	18.1	8.8	13.3	17.8	11.4	13.8	16.3	18.7	14.6	17.8	21.0
Neutral detergent fiber	83.2	71.4	59.3	47.5	72.5	61.4	50.7	77.6	69.3	60.7	52.4	66.8	55.7	44.9

[a] 100% US treatment received 5 g of urea daily.

[b] Supplement level and composition: 45 g/head/day, molasses 20.25 g, dicalcium phosphate 18.18 g, trace mineralized salt 2.0 g, potassium sulfate 4.46 g, plus vitamins A, D and E to supply 970, 21 and .05 IU/head/day, respectively.

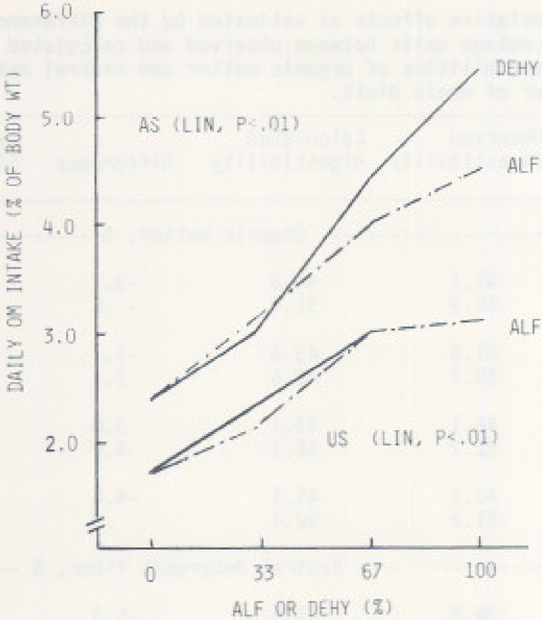

Figure 1. Effects of addition of ALF or DEHY to wheat straw diets when fed ad libitum on daily organic matter (OM) intake (% of body wt).

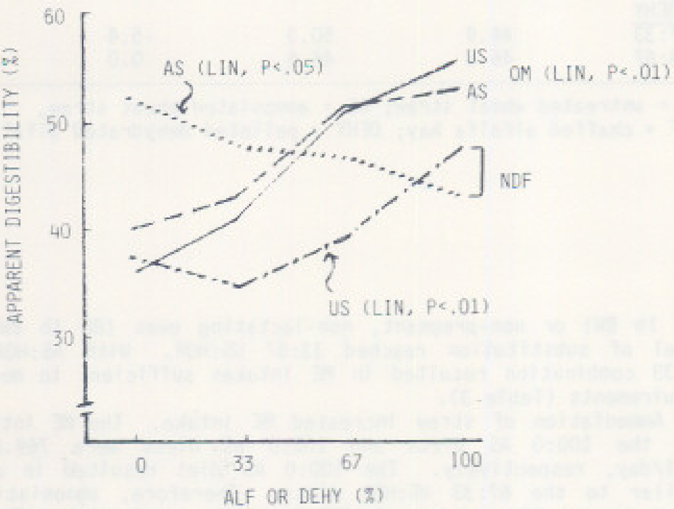

Figure 2. Effect of addition of ALF or DEHY to straw diets when fed ad libitum on OMD and NDFD (%).

Table 2. Associative effects as estimated by the differences in percentage units between observed and calculated digestibilities of organic matter and neutral detergent fiber of whole diets.

Treatment[a]	Observed digestibility	Calculated digestibility	Difference	Level of Significance
	------- Organic matter, % -------			
US/ALF				
67:33	41.1	44.8	-3.7	NS
33:67	50.9	51.4	- .5	NS
US/DEHY				
67:33	41.9	43.6	-1.7	NS
33:67	50.7	49.6	1.1	NS
AS/ALF				
67:33	46.1	43.1	3.0	NS
33:67	51.2	46.3	4.9	.02
AS/DEHY				
67:33	40.5	45.1	-4.6	.02
33:67	51.2	50.4	.8	NS
	------- Neutral detergent fiber, % -------			
US/ALF				
67:33	36.2	41.5	-5.3	.10
33:67	39.1	44.2	-5.1	NS
US/DEHY				
67:33	33.6	40.0	-6.4	.05
33:67	40.3	41.4	-1.1	NS
AS/ALF				
67:33	52.1	48.9	3.2	NS
33:67	48.6	44.9	3.7	.08
AS/DEHY				
67:33	44.9	50.3	-5.4	.01
33:67	46.6	46.6	0.0	NS

[a]US = untreated wheat straw; AS = ammoniated wheat straw, ALF = chaffed alfalfa hay; DEHY = pelleted dehydrated alfalfa.

(55 lb BW) or non-pregnant, non-lactating ewes (80 lb BW), until the level of substitution reached 33:67 US:HQR. With AS:HQR diets, the 67:33 combination resulted in ME intakes sufficient to meet the above requirements (Table 3).

Ammoniation of straw increased ME intake. The ME intake of lambs fed the 100:0 AS diets and 100:0 US diets were 769.6 and 442.2 Kcal/day, respectively. The 100:0 AS diet resulted in an ME intake similar to the 67:33 US:HQR diets. Therefore, ammoniation of wheat straw spared 33 percent of HQR from the total diet. The economical implication of this saving needs to be considered by each producer using prices for his available feedstuffs.

Table 3. Potential to meet metabolizable energy requirements for maintenance (MEMT) for lambs or ewes, with observed intakes of calculated ME(MEIn), under different wheat straw/high quality roughages diets.

Diet[a]	ME In (Kcal/day)	ME In/ME Mt[b] 55 lb lamb	80 lb ewe
US/ALF			
100:0	442.2	.41	.37
67:33	726.6	.67	.61
33:67	1300.2	1.21	1.09
0:100	1541.6	1.43	1.29
US/DEHY			
67:33	786.3	.73	.66
33:67	1371.9	1.28	1.15
0:100	1486.6	1.38	1.24
AS/ALF			
100:0	769.6	.72	.64
67:33	1190.2	1.11	1.00
33:67	1864.2	1.73	1.56
0:100	2103.2	1.95	1.76
AS/DEHY			
67:33	1058.8	.98	.89
33:67	2313.5	2.15	1.94
0:100	3209.8	2.98	2.69

[a]US = untreated wheat straw; AS = ammoniated wheat straw; ALF = chaffed alfalfa hay; DEHY = dehydrated alfalfa pellets.

[b]Ratio = calculated ME intake/ME maintenance requirement , 55 lb lamb = 1075.5; 80 lb ewe = 1195.0 Kcal/day.

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ENERGY SUPPLEMENTATION OF UNTREATED AND AMMONIATED WHEAT STRAW DIETS FOR SHEEP

Zorrilla-Rios, J.[1], G.W. Horn[2], R.W. McNew[3] and K.B. Poling[4]

Story in Brief

Sixteen yearling lambs (84 lb) housed in metabolism cages were used to study the effect of ammoniation of wheat straw and energy supplementation as 0, 10 or 20 g of whole shelled corn per kg of metabolic body weight/day on voluntary intake of untreated or ammoniated wheat straw, apparent digestibility of total dietary dry matter, organic matter, neutral detergent fiber and nitrogen, retention of nitrogen, ruminal ammonia-nitrogen concentrations and pH. Sheep consuming untreated straw diets were supplemented with 15 g of urea/head/day.

Ammoniation increased (P<.01) intake of straw organic matter and total dietary organic matter apparent digestibility but the apparent digestibility of dietary nitrogen decreased (P<.01). There was a tendency to reduced nitrogen retention with ammoniation. Energy supplementation resulted in a linear increase (P<.01) in daily intake of digestible organic matter and nitrogen and the retention of nitrogen.

The beneficial effect observed in sheep consuming diets based on straw plus nonprotein nitrogen, in terms of total digestible organic matter intake and retention of nitrogen with the supplementation of energy in the form of whole shelled corn, emphasizes the nature of the first limiting nutrient in such type of regimes.

(Key Words: Wheat Straw, Ammoniation, Energy Supplementation, Digestibility, Nitrogen Retention.)

Introduction

Ammoniation of low quality roughages increases voluntary intake and improves the apparent digestibility of organic matter. The net benefit obtained from the added nitrogen with regard to meeting the crude protein requirements of ruminant livestock is still a subject of research.

The faster ruminal availability of nitrogen than energy in ammoniated straw diets may not be optimal for microbial utilization of the increased nitrogen. Supplementation with a source of energy that would match ruminal nitrogen release may improve microbial fermentation and therefore, diet utilization.

The objective of the present experiment was to obtain additional information relative to nutritive value of the added nitrogen of ammoniated straw, and to evaluate the effect of using whole shelled corn as a source of energy in low quality roughage-nonprotein nitrogen diets.

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[4]Animal Care Supervisor

Materials and Methods

An experiment was conducted with sixteen rumen fistulated yearling lambs (average weight 60 lb), housed in metabolism pens, to study the effects of ammoniation of wheat straw and level of energy supplementation in the form of whole shelled corn (WSC), on voluntary intake of untreated (US) or ammoniated wheat straw (AS), total intake of dietary nutrients, apparent digestibility, nitrogen balance, and rate of passage of ruminal particulate matter, pH and ammonia nitrogen concentration (NH_3-N). Wheat straw was ammoniated with 35 g NH_3/kg of straw dry matter by the stack method. Supplementary WSC was fed to lambs receiving US and AS at levels of 0, 10 or 20 g per day per kilogram of metabolic body weight ($kg^{.75}$). Untreated straw based diets were supplemented with 15 g urea/head.d^{-1}. All animals received a supplement of trace minerals and salt during the trial and were dosed via intramuscular injection, with vitamins A, D and E at the beginning of the experiment. Feed was offered once a day and refusals weighed every morning. Daily output of total feces and urine were measured for each lamb during three consecutive periods of 7 days each, each period preceded by 15-20 days during which voluntary intake of straw was recorded. At the end of each period, samples of rumen fluid were obtained at 0, 1, 2, 4, 8 and 12 h after feeding for pH and NH_3-N measurements. Rate of passage and mean retention time (MRT) of ruminal particulate matter were measured each period by means of a pulse dose of Yb-labeled straw followed by fecal sampling at 36, 48, 60 and 72 h post-dosing.

Results and Discussion

Effects of Ammoniation

Ammoniation of wheat straw resulted in a 33 and 9 percent increase in straw OM intake and total diet OM digestibility, respectively ($P<.01$; Table 1). Ammoniation of straw had no effect on apparent digestibility of total fiber (NDF) of the diet, and decreased in 29 percent the apparent digestibility of total dietary N ($P<.01$). The net effect of the above factors was a 41 percent increase in total digestible organic matter intake/$kg^{.75}$ (TDOMI; $P<.01$), but N balance/$kg^{.75}$ was only 85.5 percent of that observed in the untreated straw plus urea diets, though not significantly different. The reduced apparent digestibility of nitrogen by lambs fed the AS diets may have resulted from increased microbial fermentation in the caecum of a more potentially digestible straw OM that escaped rumen fermentation. The reduction in MRT of ruminal particulate matter of AS diets supports this suggestion. Therefore, more nitrogen from the ammonia pool in the caecum may have been incorporated into caecal microorganisms, most of which will pass undigested in the feces. Indeed, fecal nitrogen output was significantly increased (2.3 times, $P<.01$) in lambs consuming AS diets, while urinary nitrogen output was similar among US and AS. This increased caecal fermentation and the resultant loss of nitrogen may adversely effect the nitrogen economy of ruminants fed ammoniated roughages.

Rumen pH values were always above 6, regardless of the type of straw, level of energy supplementation or time of sampling after feeding (Table 2). Therefore, microbial activity apparently was not impaired at any time by an unfavorable pH in the rumen.

Table 1. Daily intake and apparent digestibility of nutrients and nitrogen balance in sheep fed untreated (US) or ammoniated wheat straw (AS), supplemented with different levels of whole shelled corn (WSC).

	Wheat straw							Level of significance			
	Untreated (US)			Ammoniated (AS)			Std	US vs		WSC	
WSC[1]:	0	10	20	0	10	20	Error	AS	WSC	LIN	QUAD
Daily intake (g):											
Straw OM	555	555	444	736	728	609	27.4	.01	.01	.01	.04
Total diet OM	590	709	728	750	861	870	27.0	.01	.01	.01	.05
Total diet N	10.1	11.3	12.8	13.5	15.8	16.4	.64	.01	.01	.01	NS
Total diet apparent digestibility (%):											
OM	53.9	59.5	62.1	58.7	62.6	63.7	1.1	.01	.01	.01	NS
NDF	53.2	50.9	42.0	52.5	53.2	45.2	2.3	NS	.01	.01	.08
N	73.3	70.1	70.1	51.9	54.3	56.7	1.6	--[2]	--	--	--
Daily intake of digestible nutrients ($g/kg^{.75}$):											
OM	22.09	29.72	32.49	31.19	38.48	39.78	1.24	.01	.01	.01	.03
N	.519	.562	.644	.500	.626	.664	.033	NS	.01	.01	NS
N balance	.145	.202	.276	.124	.221	.333	.035	NS	.01	.01	NS

[1] Supplementary whole shelled corn: 0, 10, 20 g $DM/kg^{.75}$.
[2] Significant interaction type of straw * linear effect from grain supplementation ($P<.03$).
NS = Not significant ($P>.10$).

Table 2. Post feeding pattern in rumen pH and ammonia nitrogen concentrations (mg NH_3-N/dl), in sheep consuming untreated (US) or ammoniated (AS) wheat straw, supplemented with whole shelled corn (WSC)(n=6).

		Type of straw							Level Sig.	
		Untreated (US)			Ammoniated (AS)				US vs AS	WSC Lin
Hr	Variable WSC[1]:	0	10	20	0	10	20	SE		
0	pH	6.8	6.9	6.9	6.9	6.9	6.9	.05	NS	NS
	NH_3-N	7.43	5.81	4.61	6.95	7.51	6.24	.56	.04	.01
1	pH	7.0	7.0	7.0	6.7	6.7	6.7	.05	.01	NS
	NH_3-N	31.8	34.8	26.8	24.6	25.1	19.4	4.1	.01	NS
2	pH	6.9	6.8	6.9	6.6	6.5	6.5	.07	.01	NS
	NH_3-N	39.4	36.3	27.5	29.8	25.6	22.3	3.4	.01	.01
4	pH	6.8	6.5	6.4	6.6	6.3	6.3	.08	.03	.01
	NH_3-N	36.7	18.0	19.0	23.9	17.0	14.8	2.3	.01	.01
8	pH	6.4	6.2	6.4	6.2	6.2	6.2	.10	NS	.04
	NH_3-N	17.7	5.1	1.8	9.6	8.2	5.8	1.8	NS	.01
12	pH	6.5	6.5	6.2	6.5	6.4	6.2	.08	NS	.01
	NH_3-N	8.8	6.5	3.6	9.6	7.9	6.6	1.4	NS	.01

[1] Whole shelled corn supplementation = 0, 10 or 20 g DM/kg$^{.75}$.d^{-1}.

During the first four hours after feeding, rumen NH_3-N concentrations in lambs fed AS diets was lower as compared to US fed lambs (P<.01). At 8 and 12 h postfeeding, the differences were nonsignificant (P>.10). For both types of straw diets, NH_3-N increased after feeding and reached maximum concentrations at 2 h postfeeding (Table 2). In most instances, NH_3-N was above 5 mg/dl, a concentration considered adequate for growth of ruminal microorganisms.

Effects of Energy Supplementation

Supplementation (Table 1) with WSC resulted in a net increase in TDOMI (g/kg$^{.75}$) of 34 and 47 percent for US and AS, respectively, at the low level of supplementation, and of 23 and 28 percent at the higher level as compared with unsupplemented diets. Intake of AS and US straw OM was maintained with the low level of WSC supplementation but reduced by 17 and 20 percent, respectively, at the higher level of WSC supplementation (quadratic response, $P<.04$). A linear interaction ($P<.03$) was found for apparent digestibility of dietary N between type of straw and level of WSC supplementation with an increase for AS diets.

Nitrogen balance (g N/kg$^{.75}$) of lambs fed US diets was increased linearly ($P<.01$) due to supplementation with WSC by 39 and 178 percent, and by 90 and 169 percent for AS diets. This marked increase in nitrogen retention as a result of WSC supplementation supports the concept of energy being the first limiting nutrient in low quality roughage diets (Zorrilla-Rios et al., 1984). Therefore, to achieve an efficient utilization of the increased crude protein of ammoniated low quality roughages, it is required that the supplemental energy will become available to the rumen microflora as synchronously as possible with the nitrogen.

In both types of straw, except for the first hour after feeding, ruminal NH_3-N concentration decreased linearly ($P<.01$) with the increase in energy. No consistent interaction ($P>.10$) between type of straw and level of energy supplementation was found (Table 2). The consistent lower levels of ruminal NH_3-N observed with AS as compared to US plus urea diets at all sampling times after feeding, suggests a greater uptake of nitrogen by the rumen microflora, and therefore a more efficient utilization of N at the rumen level. The reduction in ruminal NH_3-N found as the level of WSC supplementation increased with both types of straws supports the concept of energy being the first limiting nutrient for an efficient utilization of dietary nitrogen at the rumen level. The further reduction observed in ruminal NH_3 in the AS diets, emphasizes a greater benefit to be expected in terms of proximal microbial fermentation, when AS diets are supplemented with energy.

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CRUDE PROTEIN SPARING EFFECT OF AMMONIATED WHEAT STRAW FOR GROWING STEERS

Zorrilla-Rios, J.[1], W.A. Phillips[2], G.W. Horn[3] and M.A. Worthington[4]

Story in Brief

Thirty-two Beefmaster x Hereford-Angus crossbred steers (634 lb) were individually fed for 90 days with untreated wheat straw (US) plus corn-soybean meal (SBM) mix to supply 70 (trt 1), 80 (trt 2) or 100 (trt 3) percent of estimated crude protein requirements for a daily gain of 1.0 lb. A fourth treatment consisted of ammoniated straw (4.4 g NH_3/kg straw) supplemented with corn only (trt 4), and fed at a similar dry matter intake as the US treatments. Daily gains (ADG) of steers fed US was linearly increased (P<.01) as SBM supplementation increased, with ADG for trt 4 (AS + corn) being no different than that of steers fed US and the highest level of SBM (trt 3). The crude protein sparing effect with ammoniated wheat straw was comparable to 1.3 lb of SBM. Results are discussed in terms of animal performance and concentrations of ruminal and blood metabolites.

(Key Words: Ammoniation, Wheat Straw, Protein Value, Steers.)

Introduction

Substantial work has focused on changes in chemical composition, animal performance and overall digestibility of ammoniated crop residues, in particular wheat straw based rations (Horton, 1978). Various levels of supplementation, usually with some source of conventional protein and less frequently, energy (Streeter et al., 1983) have been included in the diet. Estimates of the potential sparing effect of dietary protein as a result of the increased nitrogen content of ammoniated residues is poorly documented in the literature.

The objective of the present study was to estimate the nutritional value of the nitrogen added to wheat straw by ammoniation, in terms of animal performance and rumen and blood metabolites measurements. Soybean meal was used as the reference nitrogen source.

Materials and Methods

Thirty-two Beefmaster x Hereford-Angus crossbred steers (634 lb) of a common cow herd were individually allocated according to weight to eight blocks of four animals each. Steers within each block were randomly assigned to the four treatments. Three treatments consisted of untreated wheat straw (US), supplemented with soybean meal (SBM) to supply 70 (trt 1), 80 (trt 2) or 100 (trt 3) percent of crude protein requirements for a daily gain of 1 lb. Treatment 4 was ammoniated wheat straw (AS) with no SBM, offered at a similar dry matter (DM)

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intake as that for the US treatments. Ground corn was fed at a level of 6.2 to 7.7 lb/head/day to all steers to meet net energy requirements for the desired level of performance. Minerals and vitamins were included in the supplement to satisfy NRC (1970) requirements for Ca, P, S, Mg, K and vitamins A, D, and E. Straw was ammoniated by the stack method (Sundstol et al., 1978; 4.4 percent NH_3 of as-fed straw). Individual daily intakes of straw were calculated by weekly recording of refusals. Initial and final body weights were recorded after withholding feed and water for 18 hours. All steers were fed a maintenance level of alfalfa hay for five days prior to the final shrink. Samples of rumen fluid (stomach tube) and blood plasma (jugular vein) were obtained from each animal at 2, 4 and 8 h after feed had been offered. Rumen fluid was analyzed for pH, ammonia nitrogen concentration (NH_3-N, mg/dl) and total volatile fatty acids (TVFA, mmoles/liter). Blood plasma samples were analyzed for total protein (TP, g/dl) and urea (BU/dl).

Results and Discussion

Results on intakes and animal performance are summarized in Table 1. Total DM intake was similar among treatments, while N intake of steers fed US increased linearly ($P<.01$) with increasing intakes of SBM. The proportion of total DM intake as straw DM and daily gains of steers increased in a linear fashion ($P<.01$) with higher SBM-nitrogen intakes. Average daily gain for trt 4 (AS) was not different from that of trt 3 (US + 1.3 lb/head.day^{-1} of SBM). Therefore, the differences in ADG among treatments can be interpreted as a response to increased intake of N. Increasing the N content of US by ammoniation (4.2 to 11.0 percent), had a sparing effect of 1.3 lb of SBM (50 percent CP, dry matter basis) for 634 lb steers gaining at a rate of 1 lb/day.

Table 1. Animal performance of steers fed untreated wheat straw (US) and increasing amounts of soybean meal (SBM) or ammoniated wheat straw (AS).

Treatments:	1	2	3	4	SBM linearity	
Straw type:	US	US	US	AS	(level of	
SBM, lb/head/day:	0	.385	1.3	0	significance)	SEM
Total intake, lb/day						
Dry matter	13.9	14.5	14.7	14.7	NS	.2
Straw DM	7.1	7.6	7.9	7.8	Not tested	--
Corn DM	5.6	5.3	4.5	5.7	Not tested	--
Crude protein	1.17	1.38	1.69	2.10	.01	.02
DM intake, % BW	2.09	2.16	2.16	2.16	NS	.03
Straw DM/total, %	51.0	52.6	53.7	53.5	.01	.57
Average daily gain, lb	.616	.722	.970	.990	.01	.04

Rumen fermentation measurements are shown in Table 2. Time after feeding resulted in a linear reduction ($P<.01$) in ruminal pH and the acetic/propionic acid ratio (Ac/Pr). Total VFA concentrations increased ($P<.01$) with time after feeding. In general, ruminal pH could

Table 2. Effect of ammoniation of wheat straw and soybean meal supplementation on blood plasma urea and ruminal fermentation measurements at different hours after feeding.

Hours after feeding	Treatments				Rumen fluid[3]			
	Straw type[1]	SBM ($lb/h.d^{-1}$)	OBS[2]	Blood urea (mg/dl)	pH	NH_3-N (mg/dl)	TVA (mMoles/L)	Ac/Pr
2	US	0	8	3.07[a][4]	6.98	2.71[a]	60.9	4.5
	US	.385	8	8.38[b]	7.00	5.02[b]	55.3	4.3
	US	1.3	7	15.77[c]	7.05	10.88[d]	64.3	4.6
	AS	0	8	5.79[ab]	7.03	8.74[c]	59.4	4.7
	SE			.33	.06	.65	3.0	.27
4	US	0	8	5.94[a]	6.88	2.25[a]	67.0	4.0
	US	.385	8	14.21[b]	6.86	2.49[a]	65.7	3.9
	US	1.3	7	25.79[c]	6.93	9.01[b]	75.6	3.8
	AS	0	8	13.45[b]	6.91	9.00[b]	72.2	4.4
	SE			.82	.05	1.01	3.4	.31
8	US	0	8	1.93[a]	6.64	.91[a]	73.3[ab]	2.9
	US	.385	8	3.63[ab]	6.58	1.98[a]	73.0[ab]	3.8
	US	1.3	7	9.70[c]	6.45	6.80[b]	81.0[b]	3.0
	AS	0	8	4.05[b]	6.72	2.50[a]	69.6[a]	4.3
	SE			.21	.09	.80	3.4	.56

[1]Straw type: US = untreated; AS = ammoniated.
[2]OBS = Number of observations.
[3]NH_3-N = ammonia nitrogen; TVFA = total volatile fatty acids; Ac/Pr = Acetic/Propionic.
[4]Means in a column for each hour with different superscripts are different at: a,b,c,d, P<.01.

be considered adequate for microbial activity under high roughage dietary regimes. Treatments had no effect on ruminal pH or Ac/Pr (Table 2). Total VFA concentrations were increased in trt 3 (P<.01), while trt 4 was similar to trt 1 and trt 2. Ruminal NH_3-N was influenced by treatments and time after feeding. Treatment 3 showed the highest levels (P<.01). Blood plasma total protein concentrations were not influenced by treatment, nor post-feeding interval (range 7.19 to 7.47 g/dl). Blood urea increased linearly (P<.01) with the inclusion of SBM; AS values resembled those of the medium level of SBM supplementation (trt 2). The lower rumen NH_3-N and BU concentrations observed in the AS diets (trt 4) as compared to the highest level of SBM supplementation to US diet (trt 3) may reflect a greater uptake of nitrogen by ruminal bacteria. By this mechanism, the nitrogen added to the ammoniated straw becomes of nutritional value to the host animal. The degree to which conventional protein can be spared by ammoniation will depend to some extent on other nutritional and physiological factors that may influence ruminal microbial activity. Nevertheless, under conditions where no energy or mineral deficiencies are apparent, it may be considered that for growing steers gaining at a rate of 1 lb/day, no supplementary nitrogen from conventional sources of protein are required if ammoniated wheat straw represents 50 percent of the total daily dry matter intake.

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COMPARISON OF EXTERNAL MARKERS FOR ESTIMATING FECAL OUTPUT OF CATTLE GRAZING WHEAT PASTURE

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Story in Brief

Fecal output (FO) of steers grazing immature and mature wheat forage were obtained by total collection and marker dilution using three external markers: Cobalt EDTA solution, Chromium oxide powder and Ytterbium-labeled wheat forage. Percent recovery of markers varied from 86 to 97 percent for Cobalt (Co), after correction for an assumed 5 percent absorption, and from 99 to 106 percent for Chromium (Cr) and Ytterbium (Yb). Diurnal variation in fecal marker concentrations was much higher for Co, while Cr and Yb concentrations of fecal grab samples were much less variable. Fecal outputs estimated from Cr and Yb markers were in good agreement with FO obtained by total collection, while Co overestimated FO. Use of Cr resulted in estimated FO that were the least variable, while those obtained with Co exhibited the greatest amount of variability.

Key Words: Fecal Output, Markers, Grazing, Wheat Pasture, Steers.

Introduction

Estimates of forage intake of grazing ruminants are of primary importance in predicting animal performance and in planning supplementation programs. Daily forage intake can be calculated from measurements of fecal output and digestibility of the consumed forage by the following relationship:

$$\text{Intake} = \text{Fecal Output}/(1\text{-Digestibility})$$

Several methods are available to determine fecal output. Among these, the direct measurement of total fecal excretion during the feeding cycle is considered the most reliable approach, though not entirely free of biases. Nevertheless, the amount of labor required and the relative stress imposed on the animals, among other considerations, are factors that limit collection of total feces. The accuracy and reliability of external markers to estimate fecal output needs verification under each managerial situation. The objective of this study was to investigate the usefulness of three external markers to estimate fecal output as compared with total collection of feces from steers grazing wheat pasture. Also, specific factors influencing the results, such as percentage marker recovery, postdosing fluctuations in fecal marker concentrations, and their interaction with the experimental conditions (stage of wheat forage maturity) were considered.

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Materials and Methods

Total daily fecal output (FO) of eight ruminally cannulated grazed a single paddock of wheat pasture (var. TAM-105) from March 7 to March 27 (immature stage) and April 22 to May 14 (mature stage), with forage dry matter availabilities of 1642 and 1565 lb/acre, respectively. Three external markers were investigated: Yb-labeled wheat forage (Yb-WF), cobalt EDTA solution (CoEDTA) and chromium (Cr_2O_3 powder administered in gelatin capsules). All markers were administered to steers by ruminal dosing twice daily (12 hours apart) for eight days prior to sampling. Fecal grab samples(GS) were obtained once for each animal at each of the following hours after the am dosing: 0, 3, 4, 6, 9 and 12. Total FO was measured with collection bags over a 4-day period with bags being replaced every 24 hours. Fecal marker concentrations were determined by atomic absorption spectrophotometry. Estimates of daily output from GS were calculated for each of the markers. The uncorrected FO from the GS samples was estimated by the following equation:

UFGS = marker dose/marker concentration in feces

With this approach it is assumed that the daily dosage of marker is completely recovered in feces of the same 24 hour period. Total fecal outputs and corresponding marker concentrations were used to calculate the percentage recovery of each marker (R). Estimated fecal outputs from GS were adjusted for recovery of markers by:

CFGS = dose of marker x R/marker concentration in feces

Extent of postdosing fluctuation in fecal marker concentrations was investigated by comparing GS to samples of total fecal collections (TFC).

Results and Discussion

Data obtained with Yb during the grazing of immature wheat forage were inconsistent and samples are being reanalyzed. Therefore, these results were not available at the time of preparation of this report.

Recovery of Markers From Total Fecal Collections

Recovery of markers from total fecal collections are listed in Table 1. Recovery of Co is presented as observed and after corrected for an assumed 5 percent absorption along the gastrointestinal tract. Regardless of the way it is expressed, cobalt recovery was lower ($P<.01$) than those for Cr and Yb. Stage of wheat forage maturity influenced recovery of markers (interaction $P<.05$).

Comparison of Marker Concentrations in Fecal Grab Samples (GS) and Samples of Total Fecal Collections (TFC)

The concentration of Cr in GS at 3 and 9 (immature stage) and 9 h (mature stage) postdosing were different ($P<.05$) from the concentrations in TFC (Figures 1 and 2). Significant differences were detected for Yb (mature stage) at 0, 3 and 4 h postdosing ($P<.02$).

Table 1. Recovery of markers from total fecal collections of steers grazing immature and mature wheat forage.

Stage of maturity	n	Percent recovery			SE
		Co[1]	Cr[1]	Yb[1]	
Immature	32	81.0(85.3)[ac2]	99.2[be]	NA[3]	2.26
Mature	32	91.9(96.7)[ad]	106.2[bf]	105.8[b]	2.17
SE		.028	.028	----	

[1]Co = CoEDTA, Cr = Cr_2O_3 powder, Yb = Yb-labeled wheat forage.
[2]Observed values (corrected values for an assumed 5 percent absorption of Co from the gastrointestinal tract).
[3]Not available.
[a,b]Means in a row with different superscripts are different (P<.01).
[c,d]Means in columns with different superscripts are different (P<.01).
[e,f]Means in columns with different superscripts are different (P<.04).

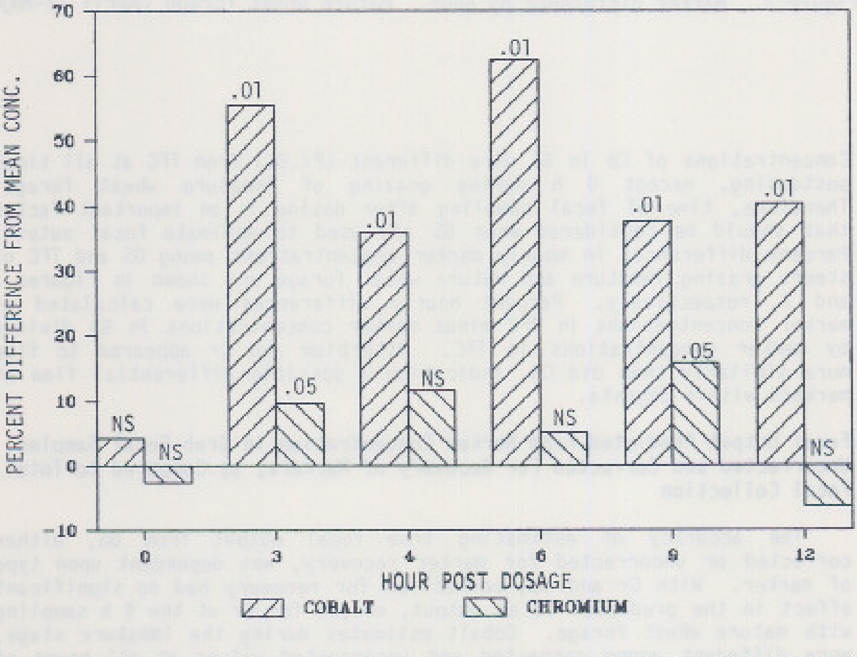

Figure 1. Marker difference by hour. Immature wheat forage (March 7-27).

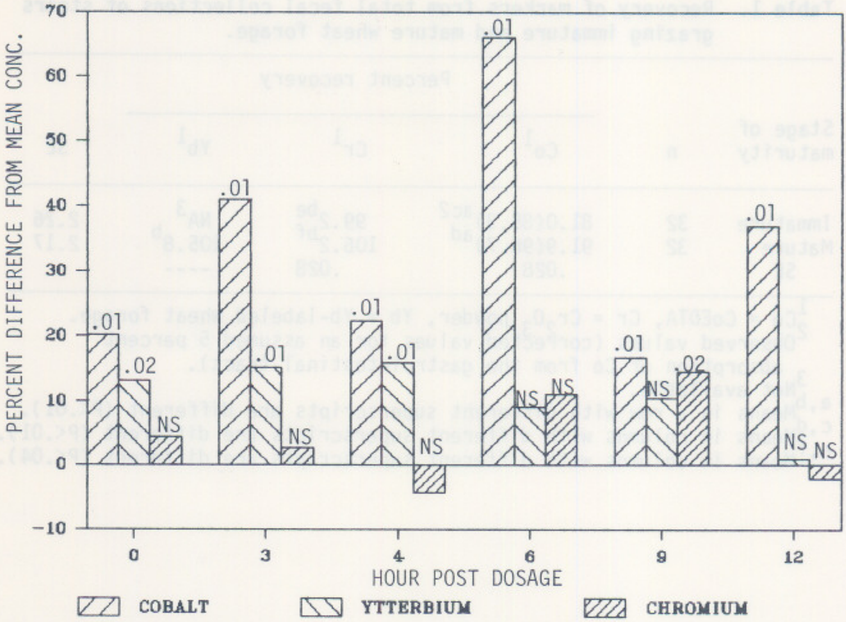

Figure 2. Marker difference by hour. Mature wheat forage (April 22-May 14).

Concentrations of Co in GS were different (P<.01) from TFC at all times postdosing, except 0 h during grazing of immature wheat forage. Therefore, time of fecal sampling after dosing is an important factor that should be considered when GS are used to estimate fecal output. Percent differences in hourly marker concentrations among GS and TFC of steers grazing immature and mature wheat forage are shown in Figures 1 and 2, respectively. Percent hourly differences were calculated as marker concentrations in TFC minus marker concentrations in GS divided by marker concentrations in TFC. Ytterbium and Cr appeared to flow more similarly than did Co, indicating a possible differential flow of markers within digesta.

Fecal Output Predicted From Marker Concentration in Grab Fecal Samples Uncorrected and Corrected For Recovery of Markers, as Compared to Total Fecal Collection

The accuracy of estimating true fecal output from GS, either corrected or uncorrected for marker recovery, was dependent upon type of marker. With Cr and Yb, correction for recovery had no significant effect in the predicted fecal output, except for Cr at the 9 h sampling with mature wheat forage. Cobalt estimates during the immature stage, were different among corrected and uncorrected values at all hours of sampling, except hour 4. No difference was observed for Co estimates with mature forage. The close 100 percent recovery of Yb and Cr in

Table 2. Fecal output prediction from grab fecal samples using three different markers vs total collection of feces as influenced by stage of maturity of wheat forage and adjustment for recovery of marker (kg/hd/day) (LS means, n = 8).

		Stage of maturity[1]			
		Immature		Mature	
Hour	Marker[2]	Uncorrected	Corrected	Uncorrected	Corrected
0	Co	2.73[bc]	2.35[d]	3.42[b]	3.31[b]
	Cr	2.07	2.05	2.46	2.64
	Yb	NA[3]	NA	2.63	2.78[b]
	True	2.06[a]		2.38[a]	
3	Co	6.69[bc]	5.77[bd]	5.08[b]	4.81[b]
	Cr	2.32	2.30	2.33	2.47
	Yb	NA	NA	2.67	2.82
	True	2.06[a]		2.38[a]	
4	Co	5.36[b]	4.62[b]	3.60[b]	3.48[b]
	Cr	2.21	2.20	2.18	2.31
	Yb	NA	NA	2.69	2.85
	True	2.06[a]		2.38[a]	
6	Co	8.44[b]	7.27[b]	8.23[b]	7.96[b]
	Cr	2.28	2.26	2.65	2.81
	Yb	NA	NA	2.53	2.67
	True	2.06[a]		2.35[a]	
9	Co	4.37[bc]	3.77[bd]	3.39[b]	3.28[b]
	Cr	2.50[b]	2.48[b]	2.68	2.84[b]
	Yb	NA	NA	2.54	2.69
	True	2.06[a]		2.31[a]	
12	Co	4.88[a]	4.20[b]	4.82[b]	4.66[b]
	Cr	1.97	1.96	2.25	2.38
	Yb	NA	NA	2.31	2.44
	True	2.06[a]		2.38[a]	
24 h Mean					
	Co	5.44[bc]	4.69[bd]	4.70[b]	4.55[b]
	Cr	2.21	2.20	2.42	2.56
	Yb	NA	NA	2.56	2.71
	True	2.06[a]		2.38[a]	

[1] Immature = March 7-27; Mature = April 22-May 14.
[2] Co = CoEDTA solution; Cr = Cr_2O_3 powder; Yb = Yb-labeled wheat forage.
[3] NA = not available.
Means are different from true values = a,b (P<.05).
Corrected vs uncorrected means are different: c,d (P<.05).

feces caused correction for recovery to have no effect on the predictions of fecal output. Comparisons of true fecal output obtained by total collection and fecal output estimated from GS are presented as uncorrected and corrected values (Table 2). An indication of variability within each method of measurement of FO was considered. This was derived from the uncorrected total sum of squares obtained in the analysis (General Linear Model) of the differences among fecal output estimated by the dilution marker technique as compared with total fecal collections. Fecal output estimated with Cr had the smallest variation followed by Yb while those obtained with Co exhibiting the greatest variation.

In conclusion, these data confirm sources of variation and their implications with regard to obtaining estimates of fecal output of cattle grazing wheat pasture. The need to validate both choice of marker and its time of sampling after dosing is also demonstrated. Failure to do this may result in biased estimates of FO. Chromium oxide powder and Yb-WF gave comparable estimates of FO, while Co-EDTA gave highly variable estimates of FO.

CHROMIUM OR YTTERBIUM AS SINGLE MARKERS FOR ESTIMATING DUODENAL DIGESTA FLOW OF STEERS GRAZING WHEAT PASTURE

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Story in Brief

Duodenal digesta flow was estimated by reference to chromium (Cr_2O_3 powder) or ytterbium ($YbCl_3 \cdot 6H_2O$) labeled wheat forage, from samples obtained from eight steers (average body weight 1000 lbs) equipped with rumen and duodenal cannulae (T-type). Measurements were made over 2 periods during which the steers grazed immature and mature wheat forage. Effects of lasalocid supplementation (treatment) on duodenal flow of digesta during each stage of wheat forage maturity were also measured. Estimates of duodenal digesta flow were affected by marker, with significant two and three way interactions detected among marker and stage of maturity and marker, stage of maturity and treatment, respectively ($P<.10$). Measurements obtained in reference to ytterbium had lower coefficients of variation, accounted for a larger proportion of the total variation, resulted in a higher observed significance levels for main effect differences and resulted in significant interaction between stage of maturity and lasalocid supplementation ($P<.10$). Based on the selected criteria, Yb-labeled forage appears to be more effective than chromium as a single, particulate marker for measurement of duodenal digesta flow of steers grazing wheat pasture.

[Key Words: Chromium, Ytterbium, Digesta flow, Wheat pasture, Steers.]

Introduction

The accuracy of using chromium (Cr_2O_3 powder) as an external marker in combination with spot sampling of digesta to estimate flow of digesta along the gastro-intestinal tract of ruminants, has been a frequent and controversial topic of discussion. The primary concern is the apparent independent flow of chromium in relation to either the particulate or liquid phase of digesta. The rare earth ytterbium, as its salt $YbCl_3 \cdot 6H_2O$, has been used as an external particulate marker when bound to wheat forage (Mader et al., 1984). Under these conditions, Yb may more closely mimic the flow of particulate digesta than chromium. The objective of this study was to compare relative differences among estimated duodenal flow of nutrients obtained by using chromium oxide powder or ytterbium labeled wheat forage markers in steers grazing wheat pasture. In order to examine the ability of the markers to identify treatment differences, effects of stage of maturity of the wheat pasture and lasalocid supplementation on flow of nutrients were measured.

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Materials and Methods

Eight ruminally and duodenally (T-type) cannulated Hereford steers (approximately 1000 lbs. body weight) were allowed to graze a single paddock of wheat forage. Measurements of duodenal digesta flows were undertaken during the immature (March 7-27) and mature (April 22-May 14) stages of wheat forage maturity. Hand clipped wheat forage samples representative of each stage of maturity were labeled with $YbCl_3 6 \cdot H_2O$ by the immersion procedure described by Mader et al. (1984). Each steer received intraruminal dosages of known amounts of Yb-labeled wheat forage and Cr_2O_3 powder in gelatin capsules twice daily at 7:00 am and 7:00 pm. A total of six duodenal samples were collected at 4 h intervals beginning 10 days after dosing of markers was initiated. Samples were composited by weight over sampling times for subsequent analysis. Wheat forage and duodenal samples were freeze-dried, and together with Yb-labeled forage and Cr_2O_3, analyzed for marker concentrations utilizing atomic absorption spectophotometry. Nitrogen content of forage and duodenal samples was determined by the macro-Kjeldahl technique. Daily flow of digesta and nutrients to the duodenum was calculated assuming 100 percent recovery for each marker as follows:

$$\text{Duodenal Flow of Digesta} = \frac{\text{Daily Dose of Marker}}{\text{Marker Concentration in Duodenal Digesta}}$$

$$\text{Duodenal Nutrient Flow} = \text{Duodenal Flow of Digesta} \times \text{Nutrient Concentration of Duodenal Digesta}$$

The criteria used to compare estimates obtained from each marker were: (1) Coefficient of variation (C.V.); (2) Total amount of experimental variation accounted by the model (coefficient of determination, R^2); (3) Observed significance levels of difference among least square means of the two main effects; (4) Detection of interactions among the two main effects.

Results and Discussion

Least square means for flow of nutrients to the duodenum in reference to ytterbium and chromium are shown in table 1. Sources of variation and level of significance for the measurements are presented in table 2. While the marker by treatment (lasalocid) interaction was not significant, the two and three way interactions of marker by period and marker by period by treatment, respectively, for flow of OM and N to the duodenum were significant ($P<.10$). The presence of these interactions suggests a true difference between the measurements obtained in reference to chromium or ytterbium.

Even though the absence of absolute measurements makes interpretation of the data obtained with the two markers difficult, the criteria in table 2 should aid decisions relative to the appropriateness of the two markers. Measurements obtained from Yb-labeled wheat forage had a low C.V. and accounted for a greater proportion of the total variation (R^2), except for the flow of N to the duodenum (table 2). A higher level of significance for differences among main effect means was obtained for measurements in reference to ytterbium as compared with

Table 1. Ytterbium (Yb) vs chromium (Cr) as a single marker to estimate flow of nutrients to the duodenum of steers grazing wheat forage at two stages of maturity, with and without lasalocid supplementation (LS means; n=4).

			Duodenal Flow			
			Organic Matter		Nitrogen	
Stage of Maturity	Lasalocid (Mg/head/d)	Marker	lb/day	% intake	g/day	% intake
Immature	0	Yb	5.43[a]	30.9[a]	180[ab]	47.3[a]
		Cr	7.75[b]	44.1[b]	257[c]	67.5[b]
	300	Yb	5.57[a]	33.2[a]	190[b]	52.4[a]
		Cr	9.35[c]	55.7[c]	319[d]	87.9[c]
Mature	0	Yb	7.17[b]	44.9[b]	163[a]	84.7[c]
		Cr	9.23[c]	57.8[c]	209[c]	108.8[d]
	300	Yb	7.45[b]	55.4[c]	171[ab]	106.1[d]
		Cr	9.12[c]	68.0[d]	211[c]	131.1[e]
SE			.359	2.3	9.5	4.2

[a,b,c,d,e]Means in a column with different superscripts are different P<.10.

chromium, with the exception of N flow to the duodenum at both stages of maturity (table 2). The stage of maturity by lasalocid interaction for flow of nutrients to the duodenum relative to intake was significant (P<.10) when measured in reference to ytterbium (table 2).

In summary, based on the selected criteria, Yb-labeled wheat forage appears to be more effective than chromium as a single, particulate marker for measurement of duodenal digesta flow of steers grazing wheat pasture.

Table 2. Sources and amount of variation and level of significance obtained for differences among least square means of flow of nutrients to the duodenum, as estimated from ytterbium (Yb) or chromium (Cr) as single markers (n=4).

		Duodenal Flow			
		Organic Matter		Nitrogen	
Item	Marker	lb/day	% intake	g/day	% intake
C.V.[1]	Yb	9.22	9.99	8.53	10.85
	Cr	13.84	15.09	14.21	17.88
R-sq[2]	Yb	.89	.94	.75	.96
	Cr	.56	.76	.82	.84
TRT[3]	Yb	.51	.02	.26	.02
	Cr	.27	.05	.12	.06
PER[4]	Yb	.01	.01	.05	.01
	Cr	.35	.03	.01	.01

[1]C.V. = Coefficient of variation.
[2]R-sq = Coefficient of determination.
[3]TRT = With or without lasalocid.
[4]PER = Immature vs mature forage.

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EFFECT OF LASALOCID AND STAGE OF MATURITY OF WHEAT FORAGE ON RUMINAL FERMENTATION OF STEERS GRAZING WHEAT PASTURE

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Story in Brief

The effect of supplementing the ionophore, lasalocid, and stage of maturity of wheat forage on ruminal fermentation of steers grazing wheat forage was studied in eight rumen fistulated steers. Lasalocid supplementation reduced ($P<.08$) the acetate:propionate ratio but had no effect on total volatile fatty acid concentrations, ruminal pH or concentrations of ammonia-nitrogen. Lasalocid seemed to have no influence on the extent of deamination of wheat forage protein in the rumen.

Ruminal ammonia nitrogen, total volatile fatty acids and butyric acid concentrations were higher in steers grazing the immature wheat forage as compared with mature forage. Ruminal pH of steers was lower for steers grazing the immature wheat forage. The data indicate that wheat forage organic matter and protein are extensively degraded in the rumen. Lasalocid may increase weight gains of stocker cattle on wheat pasture by mechanisms other than shifting the amounts of acetic and propionic acid produced in the rumen.

Key Words: Wheat Pasture, Stage Maturity, Lasalocid, Rumen Fermentation, Steers.

Introduction

Wheat forage is a high quality forage. The crude protein content and dry matter digestibility of wheat forage will commonly range, respectively, from 25 to 30 percent and 65 to 80 percent. Little data is available relative to the extent of ruminal digestion of the nutrients of wheat forage at different stages of maturity.

Reduced ruminal proteolysis of plant protein by cattle supplemented with monensin has been reported (Poos et al., 1979). Therefore, amounts of nonammonia nitrogen reaching the small intestine might be increased. Similar information is not available for cattle grazing wheat pasture at different stages of maturity and supplemented with ionophores.

The objective of this study was to obtain information on ruminal fermentation of steers grazing wheat pasture as influenced by stage of forage maturity and lasalocid supplementation.

Materials and Methods

During the period of March through May 1984, eight rumen fistulated Hereford steers (average body weight 1000 lb) grazed a single paddock of wheat forage (var. TAM-105) with free access to a commercial salt

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block. Four steers were ruminally dosed twice a day (0700 and 1900), 300 mg/head.d^{-1} of lasalocid. The other four steers remained as controls. During each of two distinct stages of maturity of wheat forage, immature (March 7-27) and mature (April 22-May 14), rumen samples from all steers were obtained once at 1000 h, 3 h after the am dose, corresponding to 27 and 67 days after the dosing of lasalocid started. Strained rumen fluid was used for measurement of pH, ammonia-nitrogen concentrations (NH_3-N) by direct distillation of acidified strained rumen fluid over MgO, and volatile fatty acids (VFA) concentrations by standard chromatograph analysis. Samples of wheat forage grazed at each stage of maturity were obtained by hand clipping and were freeze-dried for further analysis. Total nitrogen was determined by the Kjeldahl method; soluble N by Kjeldahl analysis of the filtrate obtained after extraction of wheat forage in a buffer (Ohio buffer, pH 6.5) solution, for 1 h at 39 C. In vitro dry matter digestibility (IVDMD) measurements were conducted by incubation of wheat forage for 48 h in buffered rumen fluid obtained from the same steers grazing wheat pasture, followed by a further 48 h exposure to HCl-pepsin digestion.

Results and Discussion

Chemical composition of wheat forage for each stage of maturity is listed in Table 1. Soluble N in buffer solution was 27.0 and 34.0 percent of total N for the immature and mature wheat forage, respectively. Advance maturity in wheat forage reduced the concentration of total N and soluble N by 44 and 39 percent, respectively, while IVDMD decreased 13 percent. Measurements of rumen fermentation are shown in Table 2.

Table 1. Chemical composition of wheat forage (var. TAM-105) at two stages of maturity.

Nutrient	Stage of maturity[1] Immature	Mature
Observations	3	4
Dry matter, %	24.3	22.7
Organic matter, % of DM	92.5	93.7
Nitrogen, %		
Total	4.39	2.03
Soluble	1.184	.691
Non-protein	.438	.201
Ratios		
Soluble N/total N	27.0	34.0
NPN/total N	10.0	9.9
In vitro dry matter digestibility, %	75.6	66.4
Forage in offer, lb/acre	1642	1565

[1] Immature: March 7-27; Mature: April 22-May 14.

Table 2. Effect of stage of maturity of wheat forage and lasalocid supplementation on ruminal fermentation of steers.

Variable	Maturity Stage		SE	Lasalocid (mg/head.d^{-1})		SE	Level of Significance	
	Immature	Mature		0	300		Maturity	Lasalocid
Observations	8	8		8	8			
pH	6.06	6.36	.11	6.15	6.28	.11	.10	NS
Ammonia-N (mg/dl)	43.0	19.8	2.6	27.5	35.3	2.6	.01	NS
Volatile fatty acids								
Total (mMoles/L)	146.2	113.0	6.76	127.82	131.39	6.76	.01	NS
Individual (Molar, %)								
Acetate (Ac)	60.35	66.83	.69	64.84	62.34	.69	.01	.08
Propionate (Pr)	20.78	20.00	.47	19.89	20.89	.47	NS	NS
Butyrate	12.75	8.97	.44	10.48	11.23	.44	.01	NS
Valerate	1.79	1.07	.07	1.35	1.51	.07	.01	NS
Isobutyrate	1.96	1.40	.04	1.58	1.78	.04	.01	.08
Isovalerate	2.37	1.66	.08	1.85	2.19	.08	.01	.04
Ac/Pr	2.92	3.36	.10	3.27	3.01	.10	.02	.08

NS = Not significant (P>.10).

Maturity of wheat forage influenced ($P<.05$) all rumen measurements, except for pH and propionate concentrations (Table 2). Ruminal pH during the grazing of immature wheat forage might be borderline for optimum cellulolytic activity at certain periods of the feeding cycle.

The high ruminal NH_3-N, total VFA and branched-chain fatty acid concentrations observed at both stages of maturity of wheat forage, are indicative of the high ruminal degradability of wheat forage organic matter and protein, particularly when immature. Observations on the extent and rate of in situ disappearance of wheat forage dry matter and nitrogen at both stages of maturity further support this observation (Zorrilla-Rios et al., 1985).

Lasalocid supplementation decreased ruminal concentrations of acetate ($P<.08$), and increased the concentrations of isobutyrate and isovalerate ($P<.08$ and $P<.04$, respectively). Although no effect of lasalocid on ruminal propionate concentrations was observed, the acetate:propionate ratio was decreased ($P<.08$). Ruminal ammonia nitrogen concentrations were not significantly ($P>.10$) affected by lasalocid supplementation, a response that cast doubt on a possible inhibitory proteolytic effect of lasalocid within the rumen, on wheat forage protein.

The beneficial effect of lasalocid on weight gains of stocker cattle grazing wheat forage supplemented with lasalocid reported by Horn et al. (1984), may be due to effects other than a significant shift in the amounts of acetic and propionic acid produced in the rumen.

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IN SITU DISAPPEARANCE OF DRY MATTER AND NITROGEN OF WHEAT FORAGE, CORN GLUTEN MEAL, COTTONSEED MEAL AND SOYBEAN MEAL IN STEERS GRAZING WHEAT FORAGE AT TWO STAGES OF MATURITY

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Story in Brief

Eight rumen fistulated Hereford steers (average body weight, 1000 lb), were used to measure the extent of ruminal digestion and kinetics of dry matter and nitrogen from wheat forage, and three conventional plant protein supplements (soybean meal, cottonseed meal and corn gluten meal) in the rumen of steers grazing wheat forage at two stages of maturity (immature and mature).

Extent of dry matter and nitrogen disappearance during 24 h of in situ ruminal incubation was, respectively, 145 and 33 percent higher (P<.01) for immature wheat forage than for mature forage. Wheat forage nitrogen existed kinetically as two distinct pools with different rates of disappearance over time (P<.01; 3-24 h, 13.0 percent/h and 24-48 h, 2.2 percent/h for immature; P<.01; 3-12 h, 28.0 percent/h and 12-48 h, 2.8 percent/h for mature). By 48 h of incubation, 95 and 84 percent of the initial N from the immature and mature forage had disappeared in situ indicating that wheat forage nitrogen degradation within the rumen is dependent largely upon its retention time in the rumen. The extent and rate of ruminal nitrogen disappearance was lower for corn gluten meal than for cottonseed and soybean meals. Because of the rapid and extensive ruminal degradation of wheat forage protein, post-ruminal protein supply for growth of stocker cattle on wheat pasture may be limiting and weight gains of stocker cattle on wheat pasture might be increased by supplementation with feeds of low ruminal protein degradation.

(Key Words: In Situ, Nitrogen Disappearance, Wheat Pasture, Oilseed Supplements, Cattle.)

Introduction

Extent and kinetics of dietary dry matter and nitrogen disappearance within the rumen of animals grazing forages needs to be examined to properly supplement with nutrients and to select the best protein source for supplementation.

Wheat forage has a high nutritive value, often containing over 20 percent protein and 75 percent digestible organic matter on a dry matter basis. A substantial amount of information is available concerning the cultural and managerial aspects of grazing wheat pasture (Horn, 1984). But information on digestion and utilization of wheat forage within the animal is lacking. The objectives of the present study were to: 1) determine the extent and rate of disappearance of wheat forage dry matter and nitrogen within the rumen of cattle grazing

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wheat forage at two stages of maturity and 2) estimate ruminal disappearance of nitrogen from three conventional plant protein supplements known to differ considerably in their ruminal availability of nitrogen under different dietary regimes. The plant protein supplements were corn gluten meal (CGM), cottonseed meal (CSM) and soybean meal (SBM).

Materials and Methods

During the spring of 1984 (March to May), eight rumen fistulated steers (average body weight 1000 lb) grazed a single paddock of wheat forage (var. TAM-105) and had free access to a commercial salt block. At the immature stage (March 7 to March 27), wheat forage dry matter (DM) available was 1642 lb/acre versus 1565 lb/acre at the mature stage of growth (April 22 to May 14). Samples of wheat forage during both stages of maturity were hand clipped and cut to an average particle length of 1 1/2 inches. Subsamples (20 g fresh basis) were placed in duplicate nylon bags and incubated in the rumen of each animal for 3, 6, 12, 24 and 48 h. Extent of disappearance of dry matter and nitrogen at each incubation time was estimated as the difference between initial and final dry weight or nitrogen content, respectively. Rates of ruminal dry matter and nitrogen disappearance were calculated as the slopes obtained by regressing the natural log of the percentage of residual dry matter or nitrogen against incubation time and with later slopes peeled from earlier slopes when the regression was obviously curvilinear. Time required for half the material in the pool described by the fractional rate of disappearance (slope) to be degraded ($T_{1/2}$, hours) was obtained by the equation: $T_{1/2}$ (h) = 2 ln/slope. Representative samples of wheat forage for each stage of maturity were freeze-dried for dry matter determination and subsequently analyzed for ash and total and soluble nitrogen. Approximately 10 g samples of CGM, CSM and SBM were also incubated in situ simultaneously with the wheat forage, and treated in the same manner, except that the longest incubation time was 24 h and subsamples for analysis were oven-dried.

Results and Discussion

Chemical composition of wheat forage at both stages of maturity is presented in Table 1. Stage of maturity of the wheat forage had a significant effect ($P<.01$) on the extent of in situ disappearance of wheat forage DM and N (Table 2). In the immature stage, 77 and 90 percent of the initial DM and N had disappeared after 24 h of incubation. These values were 145 and 33 percent higher, respectively, than for mature wheat forage. These differences were declined to 38 and 13 percent, respectively, at 48 h of incubation.

Visual examination of the plots of the natural log of the percent N remaining at each h of incubation on time revealed that two distinct pools were present. Statistical analysis of the slopes obtained between 3 and 24 h of incubation and 24 and 48 h for the immature wheat forage, and between 3 and 12, and 12 and 48 h for mature wheat forage, indicated that rate of disappearance differed ($P<.01$) between these two time intervals (Table 3; Figures 1 and 2). Two distinct pools were present. For nitrogen in immature wheat forage, one highly soluble pool of 75 percent of total N disappeared at a rate of 13 percent/h. A second pool of 15 percent of total N had a lower ($P<.01$) rate of dis-

Table 1. **Chemical composition of wheat forage (var. TAM-105) during the immature (March 7 to March 27) and mature (April 22 to May 14) stage of growth (percent).**

Nutrient	Stage of maturity Immature	Mature
Observations	3	4
Dry matter	24.3	22.7
Organic matter	92.5	93.7
Nitrogen (N)		
Total	4.39	2.03
Soluble	1.184	.691
Nonprotein	.438	.201
Ratios		
Soluble N/total N	27.0	34.0
NPN/total N	10.0	9.9
In vitro dry matter digestibility, %	75.6	66.4
Forage available, (lb/acre)	1642	1565

Table 2. **Wheat forage extent of in situ dry matter (DM) and nitrogen (N) disappearance in steers grazing wheat forage at two stages of maturity (percent of initial).**

Stage of maturity[a]	Hours of incubation 3 DM	3 N	6 DM	6 N	12 DM	12 N	24 DM	24 N	48 DM	48 N
Immature	32.6	32.1	43.3	54.1	57.1	71.8	76.9	90.1	88.8	95.0
Mature	13.3	26.8	17.0	38.0	25.7	59.7	31.4	67.7	64.2	84.3
SE	.9	1.9	1.0	1.4	1.4	2.0	1.6	2.7	1.1	1.5

[a]Stage of maturity differed (P<.01) at all hours of incubation for dry matter and nitrogen.

appearance (2.2 percent/h). Both nitrogen pool were almost completely available with 90 percent of total N disappearing by 24 h of incubation.

In mature wheat forage, the more soluble N pool with 52 percent of total N disappeared at a rate of 28.1 percent/h, while the second pool, at 59 percent of total N, had a rate of disappearance of 2.8 percent/h. Extent of total nitrogen disappearance at 24 h was only 68 percent.

Table 3. Kinetics of wheat forage nitrogen disappearance from in situ ruminal measurements in steers grazing wheat forage at two stages of maturity.

Measurement	Stage of maturity: Immature 3-24 h	Immature 24-48 h	Mature 3-12 h	Mature 12-48 h
Rate of N disappearance (%/h)	13.0[a]	2.2[b]	28.1[a]	2.8[b]
Time for half of N to disappear, (h)	5.3[a]	31.6[b]	2.5[a]	24.8[b]
N pool size at 0 h (% of total N)[c]	75.2	15.6	52.2	58.7

[ab]Row means within same stage of maturity with different superscripts, are different ($P<.01$).
[c]Estimated from the intercepts of each slope.

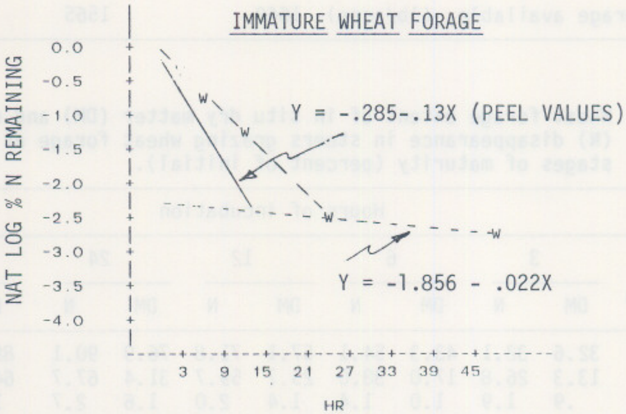

Figure 1. Description of the rate of in situ disappearance of two nitrogen pools identified in immature wheat forage.

Overall ruminal degradation of forage protein, particularly for the immature wheat forage, was very high. This means that the extent of ruminal digestion of wheat forage nitrogen will ultimately depend on its ruminal retention time. Therefore, cattle grazing immature wheat forage may have a low supply of bypass protein and might be greatly dependent on protein of microbial origin to meet their amino acid needs. For high levels of production, total true protein and/or specific amino acids available for absorption from the intestine might limit performance and supplemental protein with a high ruminal bypass may be useful.

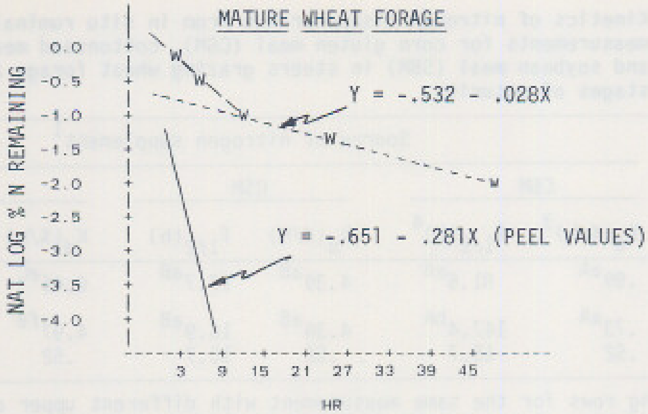

Figure 2. Description of the rate of in situ disappearance of two nitrogen pools identified in mature wheat forage.

In situ ruminal disappearance of nitrogen from plant protein supplements incubated for various times in the rumen is shown in Table 4. Extent of N disappearance at all times of incubation was the lowest for CGM while SBM had the highest disappearance with CSM being intermediate. Two pools of nitrogen were not detected with these feeds, but extent of disappearance at 24 hours appeared slightly greater in the rumen of steers receiving immature than those receiving mature forage for SBM and CSM. Nitrogen from SBM had the fastest rate of disappearance (6.45 percent/h, $P<.01$), CGM had the lowest (.89 percent/h) and CSM was intermediate (4.39 percent/h; Table 5).

Table 4. Extent of nitrogen disappearance in situ of corn gluten meal (CGM), cottonseed meal (CSM) and soybean meal (SBM) in steers grazing wheat forage at two stages of maturity (percent of initial).

Stage of maturity	Substrate	Hours of incubation: 3	6	12	24
Immature	CGM	16.9	19.8	24.1	31.2
	CSM	35.7	42.6	55.5	73.2
	SBM	32.9	44.0	58.6	81.4
Mature	CGM	17.3	19.0	20.7	28.6
	CSM	28.5	31.7	50.7	69.9
	SBM	26.7	30.5	41.8	67.2
SE		1.9	1.4	2.0	2.7

Table 5. Kinetics of nitrogen disappearance from in situ ruminal measurements for corn gluten meal (CGM), cottonseed meal (CSM) and soybean meal (SBM) in steers grazing wheat forage at two stages of maturity.

	Source of nitrogen supplement[1]					
	CGM		CSM		SBM	
Stage of[2] maturity	K_d(%/h)[3]	$T_{1/2}$(h)[4]	K_d(%/h)	$T_{1/2}$(h)	K_d(%/h)	$T_{1/2}$(h)
Immature	.89^{aA}	81.6^{aA}	4.39^{aB}	17.7^{aB}	6.45^{eC}	11.5^{aB}
Mature	.73^{aA}	147.4^{bA}	4.39^{aB}	16.9^{aB}	4.97^{fB}	21.9^{aB}
SE	.52	15.7	.52	15.7	.52	15.7

[1]Means along rows for the same measurement with different upper case superscripts are significantly different at P<.01.
[2]Means in each column with different lower case superscripts, are significantly different at: a,b P<.01; e,f P<.10.
[3]Rate of N disappearance (kd, %/h).
[4]$T_{1/2}$ is time for half of N to disappear (h).

Time for half of the nitrogen to disappear within the rumen was therefore lowest for SBM and highest for CGM. Data indicate that ruminal degradation of CGM nitrogen is much lower than either CSM or SBM which may make CGM more useful as a feedstuff to supplement protein for cattle grazing wheat pasture if supplemental amino acids are needed. The effect of these nitrogen sources on animal performance remains to be investigated. Greater benefit would be expected with immature than mature forages and with younger, rapidly growing cattle with higher protein requirements and limited capacity to consume wet feeds.

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EFFECT OF STAGE OF MATURITY OF WHEAT PASTURE AND LASALOCID SUPPLEMENTATION ON INTAKE, SITE AND EXTENT OF NUTRIENT DIGESTION BY STEERS

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Story in Brief

Effects of stage of maturity of wheat forage (immature and mature) and lasalocid supplementation (0 vs 300 mg/h·d) on site and extent of digestion of nutrients were studied with eight steers fitted with rumen and duodenal cannulae. Increasing forage maturity and lasalocid supplementation shifted the site of digestion of consumed organic matter and nitrogen toward the post-ruminal tract. Lasalocid increased the post-ruminal utilization organic matter and nitrogen reaching the duodenum by 32 and 11 percent, respectively (P<.01).

Key Words: Wheat Pasture, Maturity, Lasalocid, Intake, Site of Digestion, Steers.

Introduction

Efficient utilization of grazed forage is dependent on an understanding of the agronomic and animal processes involved and their interaction. Very little of the available information on grazing wheat pasture deals with the process of digestion of wheat forage within the gastrointestinal tract of ruminant livestock. This data is essential for improving the utilization of nutrients of grazed wheat pasture and for identification of sound supplementation strategies.

The ionophore, lasalocid, has been found to increase daily gains of stocker cattle grazing wheat pasture (Horn et al., 1984). Additional data relative to its mode of action are needed.

Materials and Methods

Experimental animals, treatments and conditions under which measurements were obtained have been described elsewhere in this research report (Vogel et al, 1985; Andersen et al., 1985). Measurements of fecal output by total collection during four consecutive days were obtained from steers grazing immature (March 7-27) and mature (April 22-May 14) wheat forage, which corresponded to approximately 20 and 67 days after initiation of lasalocid supplementation. Forage samples for in vitro dry matter digestibility (IVDMD), organic matter (OM) and total and soluble nitrogen (TN and SN, respectively) determinations were obtained by hand clipping wheat forage of each stage of maturity. Forage samples were freeze-dried for later analyses.

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Intake of forage dry matter (DM) was calculated as follows:

$$\text{Forage DM intake} = \frac{\text{Fecal output}}{1 - \text{IVDMD}}$$

Daily intake of OM and TN were calculated from forage composition and forage DM intake. Total tract apparent digestibility of OM and TN (OMD and TND, respectively) was calculated by the following expression:

$$\text{Total Tract Apparent digestibility of nutrient} = \frac{\text{Nutrient intake - nutrient in feces}}{\text{Nutrient intake}}$$

Estimates of digesta flow to the duodenum were obtained using ytterbium labeled wheat forage (Yb-WF) as a single marker.

Results and Discussion

Chemical composition, IVDMD and amounts of available forage during the grazing of immature and mature wheat forage is shown in Table 1. A reduction of 54 percent in the total N concentration of mature wheat forage was accompanied by an unexpected increase of 26 percent in the proportion of soluble nitrogen. No explanation for this observation is apparent at this time. With increasing forage maturity, more nitrogen would be expected to be part of the insoluble true protein and cell wall fractions. More detailed chemical analysis of the nitrogen fractions of wheat forage at different stages of maturity together with composition of structural and soluble carbohydrates is pending analysis.

Table 1. Chemical composition of wheat forage (var. TAM-105) during the immature (March 7 to March 27) and mature (April 22 to May 14) stage of growth (percent).

Nutrient	Stage of maturity	
	Immature	Mature
Observations	3	4
Dry matter	24.3	22.7
Organic matter	92.5	93.7
Nitrogen (N)		
Total	4.39	2.03
Soluble	1.184	.691
Nonprotein	.438	.201
Ratios		
Soluble N/total N	27.0	34.0
NPN/total N	10.0	9.9
In vitro dry matter digestibility, %	75.6	66.4
Forage available, (lb/acre)	1642	1565

Because of differences in forage intake, comparisons among treatments for the extent of nutrient disappearance in the rumen and flow of nutrients to the duodenum have been expressed as a percentage of total nutrient intake. Extent of disappearance of nutrients postruminally were calculated as the difference between duodenal flow and fecal output and have also been expressed as a percentage of nutrient flow to the duodenum.

Significant interactions ($P<.10$) between the two main effects (stage of maturity and lasalocid supplementation) were observed for total tract apparent digestibility of OM and N, the percentage of OM and N intake truly digested in the rumen, percentage of N intake reaching the duodenum and the postruminal digestion of OM and N (Table 2).

Daily intakes of OM and N by steers decreased ($P<.01$), respectively with increasing stage of wheat forage maturity from 17.2 to 14.7 and from .818 to .388 lb. Lasalocid supplementation decreased ($P<.08$) OM and N intakes, respectively, from 16.8 to 15.1 and from .629 to .577 lb/day.

Apparent digestibility of OM and N was decreased by 12 percent ($P<.05$) with increasing maturity of wheat forage. Lasalocid supplementation did not affect apparent digestibility of OM and N of immature wheat forage, but decreased ($P<.05$) apparent digestibility of both nutrients of mature wheat forage by 5 percent.

True ruminal digestion of dietary OM and N was decreased ($P<.05$) by 19 and 25 percent, respectively, with increasing maturity of wheat forage. Lasalocid supplementation of steers grazing immature wheat forage did not affect true ruminal digestibility of OM and N, but decreased ($P<.05$) true ruminal digestibility of OM and N by 14.4 and 30 percent, respectively, during grazing of mature wheat forage. With regard to the amount and nature of the nitrogen flowing to the duodenum, the main effects observed were on the quantity and proportion of microbial nitrogen to total N flow. Both measurements increased ($P<.05$) during the grazing of mature wheat forage. The proportion of forage N that was undegraded in the rumen, expressed as a percentage of total N flowing to the duodenum, was decreased ($P<.05$) by 13.6 percent with increasing forage maturity. The percentage of consumed wheat forage N that reached the duodenum was increased by 82 percent ($P<.05$) during grazing of mature wheat forage. Lasalocid supplementation increased by 9 percent ($P<.05$) the actual amount of wheat forage N bypassing the rumen at both stages of forage maturity. When this dietary bypass N was expressed as a percentage of wheat forage N intake, lasalocid increased ($P<.05$) the ratio by 52 percent only during the grazing of mature wheat forage.

The amount of microbial N flowing to the duodenum as a proportion of the quantity of dietary OM truly digested in the rumen (microbial efficiency) was increased by 81 percent ($P<.05$) during the grazing of mature wheat forage. Lasalocid increased microbial efficiency by 35.5 percent only during grazing of mature forage. Stage of maturity had no effect on the relative postruminal digestion of OM and N, while lasalocid supplementation increased ($P<.05$) both measurements by 63 and 17 percent, respectively during the mature stage only.

These estimates of daily intake of digestible organic matter per kg of body weight for immature wheat forage (13-14 g DOMI/kg BW) are similar to values reported by Losada et al. (1982) for cattle grazing ryegrass (13-18 g DOMI/kg BW). In contrast, the flows of nonammonia N (NAN) to the duodenum/kg DOMI for immature wheat forage of this study are much lower than values reported for ryegrass (13-14 vs 27-41 g NAN/kg DOMI, respectively). Differences in type of animals, forage and methodology among experiments may have influenced these comparisons. Nevertheless, these data suggest a possible shortage of the amount of nonammonia N available for absorption from the small intestine, and perhaps some limitations in the total intake of OM (energy) for high

Table 2. Effect of stage of maturity and lasalocid supplementation on site of digestion and flow of nutrients in steers grazing wheat pasture. (Least square means, n=4).

	Stage of maturity					Level of Significance	
	Immature		Mature				
Lasalocid, mg/h·d	0	300	0	300	SE	Maturity	Lasalocid
Intakes, lb/d							
Organic matter	17.6[b][1]	16.8[b]	16.0[b]	13.4[a]	.64	.01	.04
Nitrogen	.836[b]	.800[b]	.422[a]	.354[a]	.02	.01	.08
Total tract apparent digestibility (%)							
Organic matter	82.6[c]	81.9[c]	73.1[b]	69.5[a]	.35	IA[2]	IA
Nitrogen	82.1[c]	82.3[c]	72.9[b]	69.3[a]	.60	IA	IA
True rumen digestion/intake (%)							
Organic matter	79.7[c]	78.2[c]	64.6[b]	55.3[a]	1.5	IA	IA
Nitrogen	73.8[c]	70.6[c]	52.2[b]	36.6[a]	2.1	IA	IA
Duodenal flow of nitrogen							
Total, g/d	152.8	161.6	162.6	170.8	7.2	NS	NS
Nonammonia, g/d	89.4	90.6	106.3	101.9	9.5	NS	NS
NAN/total, %	58.7	56.3	65.2	60.3	4.2	NS	NS
Microbial, g/d	53.2[a]	54.8[ab]	70.8[b]	68.7[ab]	6.3	.05	NS
Microbial/total, %	34.7[a]	33.9[a]	43.6[b]	39.8[ab]	2.6	.03	NS
Dietary, g/d	99.6[ab]	106.8[b]	91.8[a]	102.1[b]	3.4	NS	.05
Dietary/total, %	65.3[b]	66.1[b]	56.4[a]	60.2[ab]	2.6	.03	NS
Dietary/intake, %	26.2[a]	29.4[a]	47.8[b]	63.4[c]	2.1	IA	IA
Microbial efficiency[3]	8.4[a]	9.2[a]	15.2[b]	20.6[c]	1.8	.01	NS
Postruminal digestion/duodenal flow, %							
Organic matter	41.1[ab]	47.7[b]	31.2[a]	50.8[b]	4.7	IA	IA
Nitrogen	62.4[a]	65.7[a]	63.6[a]	74.2[b]	2.8	IA	IA

[1] Means in the same row with different superscripts differ (P<.10).
[2] Significant stage of maturity by lasalocid supplementation interaction (P<.10).
[3] Microbial efficiency in g microbial N per kg of OM truly digested in the rumen.

levels of performance of growing cattle grazing wheat forage, particularly during the immature stage of forage growth.

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THE INFLUENCE OF POSTPARTUM NUTRITION AND WEANING AGE OF CALVES ON COW BODY CONDITION, ESTRUS, CONCEPTION RATE AND CALF PERFORMANCE OF FALL-CALVING BEEF COWS

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Story in Brief

Data from a four-year study were collected on 104 fall-calving beef cows, ranging from 2-8 years of age, to determine the influence of postpartum nutrition on cow and calf performance. The cows were fed either a Moderate (5 lb cottonseed meal/hd/day) or a Low (no supplemental protein) level of nutrition from calving (October 1) to the start of the breeding season (January 1). All cows were fed the Moderate level from the start of the 63 day breeding season until warm season grasses began to grow (April 30).

Moderate cows lost less body weight and were able to remain in acceptable body condition to the start of the breeding season. As a result, Moderate cows had a 4.7 percent higher return to estrus (97.7 vs 93.0 percent), exhibited postpartum estrus 15 days earlier (52.1 vs 67.1 days) and had a 14.9 percent higher conception rate (94.9 vs 80.0 percent) than Low cows. The added supplement provided Moderate cows from calving to the start of the breeding season amounted to $56.00 per cow.

Calves nursing Moderate cows to 210 days were 15 lb heavier than calves nursing Low cows (631 vs 612 lb). The additional weight was insufficient to compensate for the greater supplement costs unless pounds of calf weaned per cow exposed to the bull were considered.

Weaning and selling calves at 9-10 months of age rather than 7 months resulted in 199 lb additional selling weight or $77.09 per calf. Calves remaining on their dams for 285 days were 66 lb heavier and $42.24 more valuable than calves weaned at 210 days and run as stockers on native pasture for 75 days. Cows weaning calves at 285 days were lighter in weight and thinner in condition at 285 days postpartum than cows weaning their calves at 210 days; however, body condition was still acceptable.

(Key Words: Postpartum Nutrition, Estrus, Conception, Weaning Age, Fall-Calving)

Introduction

Two of the most important traits in any cow-calf operation are the reproductive performance of the cows and the weaning weights of their calves. Since these traits are the keys to profitability, cows and calves must be managed to optimize these economically important traits. Previous research has shown that the level of nutrition prior to calving primarily influences when a cow will return to estrus, while postpartum

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nutrition primarily influences conception rate. As a result of summer grazing, fall-calving cows are typically in better nutritional condition prior to calving than spring-calving cows. However, if available forage is low and inadequate winter supplementation is provided, the postpartum nutritional level of fall-calving cows may be quite low. Little is known about the combined effects of condition at calving and postpartum nutritional level on the reproductive performance of fall-calving cows, especially when the availability and quality of forage is decreased. While it may be possible to increase weaning weights of calves by extending the suckling period to 9-10 months, the effect on cow condition and reproductive performance is not clearly understood.

The purpose of this study was to determine the influence of level of nutrition from calving to breeding and weaning age of calves on cow body weight, cow body condition, postpartum interval to first estrus, conception rate and calf performance of fall-calving beef cows.

Materials and Methods

Data from a four-year study were collected on 104 fall-calving Angus x Hereford cows, ranging in age from 2 to 8 years, at the Southwestern Livestock and Forage Research Station. The forage on the research station, classified in excellent condition, is predominantly little bluestem (Andropogon scorporius) with a carrying capacity of approximately 7 acres per cow-calf unit on a year-long basis. The range forage is normally dormant from early November (first frost) to late April.

Two postpartum nutritional levels were evaluated. Moderate cows were maintained on native pasture at a stocking rate of one cow-calf unit per 12 acres and were supplemented with cottonseed meal (41 percent CP) at the rate of 2 lb prior to calving and 4 to 5 lb postcalving per head per day until warm season grasses began to grow (April 30). Available forage was abundant and the additional winter supplementation was deemed adequate to maintain fall-calving cows in good breeding condition (body condition score 5.5 to 6.0).

To mimic an overstocked, short forage supply situation with little, if any, winter supplementation prior to the breeding season, the Low cows were maintained on native pasture at a stocking rate of approximately one cow-calf unit per two acres and received no supplemental protein prior to the start of the breeding season.

At the start of the breeding season (January 1), all cows were maintained at a stocking rate of one cow-calf unit per 12 acres and received 5 lb of cottonseed meal per head daily to April 30. Throughout the study, all cows were fed three times per week [(daily allowance x 7) - 3)]. After April 30, all cows grazed common pasture through weaning.

From calving to the start of the breeding season, teaser bulls with chin ball markers and visual observation were used to detect estrus. During the breeding season (January 1 to March 3), the cows were divided into four breeding groups on the basis of postpartum nutrition level and weaning age of the calf. All cows were purchased bred to Charolais and Hereford bulls. Cows were exposed to Beefmaster bulls in year 1 and 2, Charolais bulls in year 3 and Limousin bulls in year 4. The bulls were rotated among pastures every two weeks. Cows were observed for breeding activity twice daily and herd bulls were equipped with chin-ball markers to assist in determination of breeding dates.

Individual cow weights and body condition scores were taken after a 12-hour shrink every two weeks from September 1 to March 3 (end of the breeding season) and monthly from March 3 to September 1. The condition scores were based on a scale of 1 (very thin) to 9 (very fat).

All calves were weighed and eartagged within 24 hours after birth. The calves remained with their dams on native pasture until weaning and did not receive creep feed. Calf weights were obtained after a 6-hour shrink every two weeks until the end of the breeding season and monthly thereafter. To determine the effect of weaning age on calf and cow performance, calves were weaned from their dams at 210 or 285 days of age (+7 days). Weaning occurred every two weeks from April 1 to September 4. Assignments to weaning age within postpartum nutritional level were made on the basis of calving date to equalize the effects within treatment groups. The age-corrected weaning weights were adjusted for age of dam by Beef Improvement Federation Guidelines and all heifer calves were corrected to a steer equivalent by multiplying by 1.05. Calves weaned at 210 days were fed a high roughage weaning ration (ad-libitum) for two weeks to reduce weight loss associated with the stress of weaning. After the two-week period, the weaned calves were placed on native pasture similar to that grazed by the nursing calves and received no additional feed. Steer calves were implanted with Ralgro in February and reimplanted in June.

Results and Discussion

Cow weight and condition

At calving, cows assigned to both nutritional levels had nearly identical body weights and condition scores (Table 1). Moderate cows

TABLE 1. The effect of postpartum nutrition on cow weights, weight change and body condition scores from calving to end of breeding season.

	Postpartum Nutrition Level	
	Moderate	Low
No. of cows	214	200
Initial wt., post calving	1020	1021
Wt., start of breeding season	977	937
Wt., end of breeding season	886	866
Wt. change		
Initial to start of breeding	-43	-84
Initial to end of breeding	-134	-155
Condition score		
Initial	5.9	5.8
Start of breeding	5.5	4.9
End of breeding	5.3	4.9

lost 4.2 percent of their initial postcalving weight and 0.4 body condition score unit from calving until the start of the breeding season. Even though abundant forage was available, the TDN content of the forage plus the TDN content of the cottonseed meal was inadequate to meet the TDN requirement of 1000 lb. lactating mature beef cows, resulting in body weight and condition loss. However, the Moderate cows were still in good breeding condition (5.5) entering the breeding season. The reduced nutrient supply to the Low cows resulting from overstocking and no winter supplementation prior to the breeding season resulted in double the weight loss (8.2 percent of postcalving weight) and double the body condition losses (0.9 condition score) of the Moderate cows. Therefore, the Low cows entered the breeding season with a condition score (4.9) below the recommended level for good breeding performance.

Abundant forage plus 5 lb of cottonseed meal during the breeding season were insufficient to maintain the weight of either treatment group; however, the additional winter supplement fed the Low cows during breeding helped maintain their body condition. Nevertheless, the Low cows were still lighter in weight and thinner in body condition at the end of the breeding season than the Moderate cows.

With the advent of warm season grass growth in April and May, all cows were able to regain considerable weight and condition to weaning. By 210 days postpartum, Moderate and Low cows were similar in weight and condition (Table 2). The weight and condition score patterns continued to 285 days postpartum regardless of weaning age of calves. However, cows weaning calves at 285 days postpartum were still acceptable in weight and condition. It should be noted that these were fall-calving cows and the additional 75 days encompassed the peak nutritional period of the native forage. Under a spring-calving regime, an additional 75

TABLE 2. The effect of postpartum nutrition and weaning age on cow weights and body condition scores at 210 and 285 days postpartum.

	Postpartum Nutrition Levels	
Days Postpartum	Moderate	Low
210 days		
Weight	940	935
Condition score	5.4	5.3
285 days		
Calves weaned at 210 days		
Weight	1147	1114
Condition score	6.7	6.6
Calves weaned at 285 days		
Weight	1069	1082
Condition score	6.0	5.9

days would result in weaning during December, January and February, the poorest months in terms of nutritive value of the forage.

Reproductive Performance

The effect of postpartum nutrition level on the reproductive performance of cows is presented in Table 3. Moderate cows had a 4.7 percent higher return to estrus and exhibited estrus 15 days sooner than Low cows. As a result of fewer cows actually cycling, a longer postpartum interval to first estrus and a 63 day breeding season, Low cows had 14.9 percent fewer cows exposed to the bull that actually conceived. In addition, only 83.9 percent of the Low cows actually serviced by a bull settled as compared to 96.2 percent for the Moderate cows. Therefore, the low postpartum nutritional level prior to the breeding season apparently had an adverse effect on conception rate.

TABLE 3. The effect of postpartum nutrition on the reproductive performance of fall-calving cows.

	Postpartum Nutrition Levels	
	Moderate	Low
No. of cows	214	200
No. exhibiting estrus	209	186
Days postpartum to first estrus	52.1	67.1
No. of cows bred	203	160
Percent cows exposed actually bred	94.9	80.0
Percent cows serviced that settled	96.2	83.9

Calf Performance

Calves suckling Moderate cows were 15 and 19 lb heavier than calves suckling Low cows at 210 and 285 days, respectively (Table 4). The Moderate cows were fed protein supplement from calving to the start of the breeding season (January 1), while the Low cows received none. This increased supplementation cost \$56.00 (560 lb x \$0.10/lb) for the Moderate cows. The additional 15 lb at 210 days for the Moderate calves was worth \$11.25 (15 x \$0.75/lb). Therefore, the additional weight was insufficient to make up the difference in protein cost. However, if conception rate is considered (Table 3), the Moderate calves were 81 lb heavier (441 vs 360 lb) per cow exposed to the bull. The market price for 300 - 500 lb feeder steers at Oklahoma City from April to July (approximately 210 days) for the past four years has averaged \$75/cwt. This 81 lb difference amounts to a \$60.75 advantage to the Moderate calves. The added cost of supplementing Moderate cows is offset by the added revenue received as a result of differences in pounds of calf weaned per cow exposed to the bull.

Delaying weaning of fall-born calves until 285 days of age to take advantage of the high quality summer forage resulted in an average of 199 lb additional selling weight than weaning and selling at 210 days.

Since the average weight of calves at 210 days was 457 lb, the gross return for calves weaned and sold at 210 days was $342.75. The average weight of calves weaned at 285 days was 656 lb. The market price for 500 - 700 lb feeder steers at Oklahoma City from July to September (approximately 285 days) for the past four years has averaged $64/cwt. Therefore, the gross return for calves weaned at 285 days was $419.84. Delaying weaning by 75 days increased gross calf revenue by $77.09 without adding any expense or detrimental effects on the cows.

TABLE 4. The effect of dam's postpartum nutrition and weaning age on adjusted calf weights.

	No.	Adjusted 210 day wt.	Adjusted 285 day wt.
Dam's postpartum nutrition			
Moderate	214	465	631
Low	200	450	612
Weaning age			
Weaned at 210 days	214	454	590
Weaned at 285 days	200	461	656

Calves weaned at 285 days were 66 lb heavier than calves weaned at 210 days and grazed as stockers on native pasture for 75 days. The reduction in stress at weaning plus the additional milk of the dam resulted in an added daily gain of 0.9 lb. This management practice alone resulted in an increased revenue of $42.24.

While extending the suckling period by 75 days did result in lower body weight and body condition scores of the dams, their weight and body condition were still acceptable. Therefore, delaying weaning under a fall-calving regime may be an important management practice to increase the profitability of the cow-calf program providing that the additional forage consumed by the calves does not hamper the weight and condition gain of the cows during the summer grazing period and does not limit the availability of forage the coming year.

THE INFLUENCE OF BODY CONDITION SCORE ON WINTER WEIGHT AND CONDITION LOSSES BY SPRING CALVING COWS

J.J. Wagner[1], K.S. Lusby[2] and J. Rakestraw[1]

Story in Brief

The effect of condition score (CS) on winter weight and condition change was studied using 64 Hereford and Angus cows bred to calve in the spring of 1984. Cows ranged in CS from 4 to 7 units at the start of the trial, grazed together in two common pastures of native tallgrass range and were individually fed 3 lb/head/day of soybean meal from mid-November until calving and 4 lb/head/day of soybean meal from calving through May. During winter, cows lost a mean of 93.4 lb and .94 units CS. Fat cows tended to lose more weight (P<.10) and lost more condition (P<.001) than thin cows (24.22 lb and 1.06 units per unit CS). The utility of manipulating body condition during winter under Oklahoma range conditions appears limited.

(Key Words: Body Condition Score, Weight:Height Ratio, Urea Water Space, Carcass Composition, Beef Cows.)

Introduction

The cost of maintaining the cow herd is often the major expense limiting the efficiency of beef production. Up to 91% of the total energy consumed by a cow may be partitioned toward maintenance. Even a small savings in maintenance may dramatically improve net returns per cow.

The influence of body condition on maintenance energy requirements is poorly understood. Previous research indicated that fat cows of the same lean body mass had lower maintenance costs than thin cows. These authors concluded that a cow must be kept in fat condition for 10 years in order to realize a savings in maintenance costs.

The objective of this research was to study the effect of body condition on winter weight and condition loss by spring calving Hereford cows.

Materials and Methods

Sixty-four Hereford and Angus cows (904 lb, CS = 5.5 units), bred to calve in the spring of 1984 were stratified by breed, weight, CS and expected calving date and assigned to three feeding regimes in August of 1983. From August through mid-November, 22 cows were group fed 2.2 lb/head/day of soybean meal, 21 were group fed .9 lb/head/day of soybean meal, and the remaining cows were fed no supplemental protein. By November, CS ranged from 4 to 7 units. All cows were individually fed 3.16 lb/head/day of soybean meal from mid-November until calving (March) and 4.0 lb/head/day of soybean meal from calving through May.

From August through mid-November, each group of cows grazed similar

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pastures (220 acres) of native tallgrass range in North Central Oklahoma. From mid-November through May all cows grazed together in two common pastures (440 acres). The predominant forage species were little bluestem (Andropogan scoparius), big bluestem (Andropogan gerardii), switchgrass (Panicum virgatum) and Indian grass (Sorghastrum nutans). Large round bales of prairie hay were offered ad libitum on days when snow or ice covered native grass. Cows were weighed and assigned CS after an overnight withdrawal of feed and water initially, and at 28 day intervals throughout the trial.

Results and Discussion

The effects of cow condition on winter (November 15, 1983 to May 25, 1984) weight and condition change were analyzed by regressing winter weight (Table 1) and condition (Table 2) change on cow breed, December cow weight and CS, calving date, calf birth weight and calf sex. Cow breed, December weight, calf sex and calf birth weight did not significantly influence winter weight loss (93.4 lb) by spring calving cows. Cows calving early in the season lost more weight (P<.015) than cows calving late in the season (1.28 lb/day). Cows which were fat when entering the winter tended to lose more weight (P<.10) during the winter than cows entering the winter thin (24.22 lb/unit CS). Winter CS losses by spring calving cows (.94 units) were not influenced by cow breed or calving date. Cows nursing bull or steer calves tended to lose .394 or .312 units more condition (P<.10) than cows nursing heifer calves. Cows that gave birth to heavier calves tended to lose more condition (P<.10) than those giving birth to lighter calves (.015 units CS per pound birth weight). Cows with more condition in December lost significantly more condition (P<.001) than thinner conditioned cows (1.062 units per unit CS).

Table 1. Regressions of winter (November 15, 1983 to May 25, 1984) weight change on cow breed, December cow weight, December condition, calving date, calf birth weight and calf sex.

Variable		Regression Coefficient	P[a]	Standard Error
Intercept		29.71	.765	98.175
Breed of cow:	Angus	3.77	.873	23.548
	Hereford	0.00		
Sex of calf:	bull	-18.45	.373	20.535
	steer	-21.71	.407	25.965
	heifer	0.00		
December weight, lb		-0.11	.617	.229
December CS[b], units		-24.22	.099	14.443
Calving date, days		1.28	.015	.511
Calf birth weight, lb		-0.95	.638	2.021

[a]Probability of a greater T for the hypothesis, H_0: parameter = 0.
[b]Condition score.

Wagner et al. (1984) demonstrated that cow weight and condition can be efficiently increased prior to winter. Spring calving cows gained

2.4 lbs for each pound of soybean meal consumed. The results of this study may be interpreted to suggest that cows with more condition entering the winter lose more weight and condition during winter than thin cows when supplemented alike.

It appears that under Oklahoma range conditions, the utility of manipulating body fatness in order to realize a savings in maintenance costs is limited. Perhaps body weight and condition are more readily maintained under production systems utilizing higher quality harvested forages.

Table 2. Regressions of winter (November 15, 1983 to May 25, 1984) condition change on cow breed, December cow weight, December condition, calving date, calf birth weight and calf sex.

Variable		Regression Coefficient	P[a]	Standard Error
Intercept		3.710	.001	.847
Breed of cow:	Angus	0.075	.714	.203
	Hereford	0.000		
Sex of calf:	bull	-0.394	.030	.177
	steer	-0.312	.169	.224
	heifer	0.000		
December weight, lb		0.003	.001	.001
December CS[b], units		-1.062	.001	.125
Calving date, days		0.001	.880	.004
Calf birth weight, lb		-0.015	.065	.008

[a]Probability of a greater T for the hypothesis, H_o: parameter = 0.
[b]Condition score.

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RELATIONSHIP BETWEEN BODY CONDITION SCORE AND DAILY METABOLIZABLE ENERGY REQUIREMENT OF MATURE, NONPREGNANT, NONLACTATING HEREFORD COWS DURING WINTER

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Story in Brief

Thirty-five cows in 1982-83 and 36 cows in 1983-84 were utilized in a comparative slaughter trial to investigate the effects of carcass composition on winter metabolizable energy (ME) requirements for maintenance. Prior to initiation of the study, all cows were randomly assigned to one of three feeding regimes to either lose, maintain or gain weight and condition. By the start of the trials, live weight (LW) ranged from 606 to 1311 lb and condition score (CS) ranged from 2 to 8 units (1 = very thin, 9 = very fat). In December of each year, 12 cows representing the entire range of CS were slaughtered. Regression equations based on CS and LW were developed from the initial slaughter groups to predict the initial composition of the remaining cows. Remaining cows were individually fed differing amounts of a complete diet (1.13 mcal ME per pound dry matter) in drylot for an average of 115 days. Daily feed intakes were adjusted each week to maintain live weight throughout the winter. In March, all cows were slaughtered and carcass composition was determined. Data were analyzed by fitting the model, ME intake = k^{-1} (carcass energy change) + $f(CS)LW^{.75}$, where k = efficiency of ME use for carcass energy change, LW = kilograms live weight and f(CS) = function of condition score. The expression, $.1028 + .0234(CS) - .0025(CS)^2$, accounted for 41% of the variation in ME (mcal) for maintenance per kilogram $LW^{.75}$. These data suggest that cows in thin (CS = 3) condition and cows in fat (CS = 7) condition require 4.4 and 8.9% less ME per kilogram metabolic weight, respectively than cows in moderate (CS = 5) condition. Daily ME requirements for 950 lb cows with CS = 3, 5 or 7 were 14.2, 14.9 or 13.6 mcal, respectively.

(Key Words: Carcass Composition, Metabolizable Energy, Beef Cows.)

Introduction

In recent years, improving the efficiency of beef production has received increased emphasis. Tremendous improvement in understanding and predicting the performance of feedlot cattle has been achieved with the application of modern ration formulation programs such as the California Net Energy system.

Current National Research Council feeding standards compute energy requirements for beef cattle factorially. Energy expenditures for maintenance, tissue gain, and in the case of cows, pregnancy and lactation are summed and their total is considered to equal the requirement.

Cow size, as determined by cow weight, is the major factor determining energy expenditures for maintenance. The NE_m requirement for pen-

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ned cattle in nonstressful environments with minimal activity is estimated by the expression 77 kcal$\cdot W^{.75}$, where W is body weight in kilograms. Energy requirements for maintenance can be adjusted for differences in environmental temperature, humidity and wind velocity. Previous research has demonstrated variations in maintenance requirements due to breed, season of the year, previous plane of nutrition and body composition as related to feed intake and stage of production.

The objectives of this research were: 1) to evaluate the relationship between body condition score and winter maintenance energy expenditures in mature Hereford cows and 2) to develop equations based on weight and/or body condition score representing energy requirements for maintenance.

Materials and Methods

Thirty-five cows in 1982 and 36 cows in 1983 were randomly assigned to one of three feeding regimes to either lose, maintain or gain weight and condition. By November in year 1 and October in year 2, live weight (LW) ranged from 606 to 1311 lb and CS ranged from 2 to 8 units. In December of each year, 12 cows representing the entire range of CS were slaughtered. Regression equations were developed from the initial slaughter groups to predict the initial composition of the remaining cows. Remaining cows were individually fed a complete diet (Table 1) in drylot for an average of 114 days in year 1 and 115 days in year 2. Daily feed intakes were adjusted each week to maintain LW throughout the winter. In March, all cows were slaughtered and final composition was determined.

Daily weather data were obtained during each winter from the Oklahoma State University Agronomy Weather Station. Average daily temperature, rainfall and snow were computed for each week of the feeding trial. The effects of temperature and precipitation on metabolizable energy required for maintenance were examined.

Table 1. Composition of diet fed to cows.

Ingredient	Int. feed no.	Percentage[a]
Rolled corn	4-02-931	39.5
Alfalfa pellets	1-00-023	36.0
Cottonseed hulls	1-01-599	21.7
Cane molasses	4-04-696	2.5
Salt		.3
Dry matter, %		90.2
Crude protein		12.0
Metabolizable energy[b]		1.13

[a]Dry matter basis.
[b]Mcal/lb dry matter.

Results and Discussion

Throughout year 1 (Table 2), cows gained a mean of 3.7 lb LW and .2 units CS while cows in year 2 (Table 3) gained a mean of 9.7 lb LW and

Table 2. Data used to estimate maintenance requirements of cows fed during year one.

Item	Mean	Standard Deviation
Live weight, lb		
Initial	872.6	138.68
Final	876.3	143.90
Condition score, units		
Initial	5.0	1.33
Final	5.2	1.18
Carcass energy, mcal		
Initial[a]	378.7	177.1
Final	458.0	174.7
Carcass fat, lb		
Initial[a]	52.0	34.56
Final	64.1	35.07
Carcass protein, lb		
Initial[a]	59.9	8.27
Final	72.5	11.81
Daily energy intake, mcal	13.4	1.64

[a]Estimated using equations developed from initial kill data.

Table 3. Data used to estimate maintenance requirements of cows fed during year two.

Item	Mean	Standard Deviation
Live weight, lb		
Initial	859.6	159.79
Final	869.3	159.44
Condition score, units		
Initial	5.0	1.59
Final	5.1	1.47
Carcass energy, mcal		
Initial[a]	381.2	207.5
Final	423.8	198.0
Carcass fat, lb		
Initial[a]	52.5	39.69
Final	59.1	39.03
Carcass protein, lb		
Initial[a]	61.7	17.50
Final	67.4	13.33
Daily energy intake, mcal	14.5	1.77

[a]Estimated using equations developed from initial kill data.

.1 units CS. Cows in year 1 consumed from 10.24 to 16.77 mcal/day and gained a mean of 12.1 lb carcass fat, 12.6 lb carcass protein and 79 mcal carcass energy while cows in year 2 consumed from 10.14 to 17.76 mcal·day and gained a mean of 6.6 lb carcass fat, 5.7 lb carcass protein and 43 mcal carcass energy. Average daily ME intake was 13.4 mcal in year 1 and 14.5 mcal in year 2. The ME required for maintenance was estimated by solving the following multiple regression equation for zero energy retention, ME intake = $k^{-1}\cdot$retained energy + f(CS)·$LW^{.75}$, where k = the efficiency of ME utilization for carcass energy change and f(CS) = function of CS and LW = kilograms live weight.

In year 1, daily maintenance energy requirement (zero energy retention) was best fit by the equation: ME (mcal) = (.0308 + .0474 CS - .0046 CS^2)$LW^{.75}$ (Table 4). Daily carcass energy change and the quad-

Table 4. Regression of metabolizable energy intake on energy retained and condition score.

Year	Equation[e]	Sy·x	R^2
1	ME intake[a] = .0308(±.0664)+.8056(±.5945)ECH[b] +.0474(±.0262)CS[c]-.0046(±.0024)CS^2	.0153	.29*
2	ME intake = .1324(±.0264)+.9728(±.5858)ECH +.0151(±.0114)CS-.0017(±.0012)CS^2	.0093	.34**
Both[d]	ME intake = .1028(±.0286)+.9181(±.4078)ECH +.0234(±.0116)CS-.0025(±.0011)CS^2	.0115	.41***

[a]Daily metabolizable energy intake, mcal per kg live weight $^{.75}$.
[b]Daily tissue energy change, mcal per kg live weight $^{.75}$.
[c]Condition score, units.
[d]Model includes year as a class variable.
[e]Regression coefficients ± standard error.
*P<.10.
**P<.05.
***P<.0001.

ratic function of CS accounted for 29% of the variation in ME intake per kilogram $LW^{.75}$. In year 2, 34% of the variation in ME intake per kilogram $LW^{.75}$ was explained by daily carcass energy change and the quadratic function of CS (Table 4). Daily maintenance energy requirement was estimated by the expression: ME (mcal) = $(.1324 + .0151\ CS - .0017\ CS^2) \cdot LW^{.75}$.

Figure 1 shows the relationship between Mcal $ME \cdot (W^{.75})^{-1}$ required for maintenance and CS for years 1 and 2. Energy required for maintenance averaged 12% higher in year 2 than year 1. The winter of 1983-84 was more severe than the winter of 1982-83. Average daily temperature ranged from -1.4 to 10.7°C in year 1 and from -11.8 to 11.2°C in year 2. When data from both years were combined, the regression, ME intake per kilogram $LW^{.75} = \beta_0 + \beta_1(CS) + \beta_2(CS)^2$, was nonsignificant ($P<.18$) and only accounted for 11% of the observed variation in maintenance. When year was included as a class variable, the expression, $.1028 + .0234\ (CS) - .0025(CS)^2$ accounted for 41% of the variation in maintenance per kilogram $LW^{.75}$ (Table 4).

Equating the first derivative of the maintenance function of CS, $.0234 - .005\ CS$, to zero and solving for CS indicates that maximum mcal $ME \cdot (LW^{.75})^{-1}$ occurs at CS = 4.68. Cows in thin condition (CS = 3) required 95.6% of the maximum mcal $ME \cdot (LW^{.75})^{-1}$ while cows in fat condition (CS = 7) required 91.1% of the maximum mcal $ME \cdot (W^{.75})^{-1}$.

The effects of environment on daily metabolizable energy required for maintenance were evaluated by fitting the model, ME intake = $k^{-1} \cdot$LW change each week + [f(CS) + f(ENV)] $LW^{.75}$, where k = the efficiency of LW change, f(CS) = the maintenance function of CS and f(ENV) = the function of average daily temperature and precipitation for each week. The interactions between environment and CS were also examined. The full model accounted for 41.2% of the variation in ME intake per kilogram $LW^{.75}$. Rainfall, snow, CS x rain and CS x snow were not significant ($P>.10$) sources of variation in ME intake per kilogram $LW^{.75}$ and were removed from the model. The reduced model (Table 5) explained

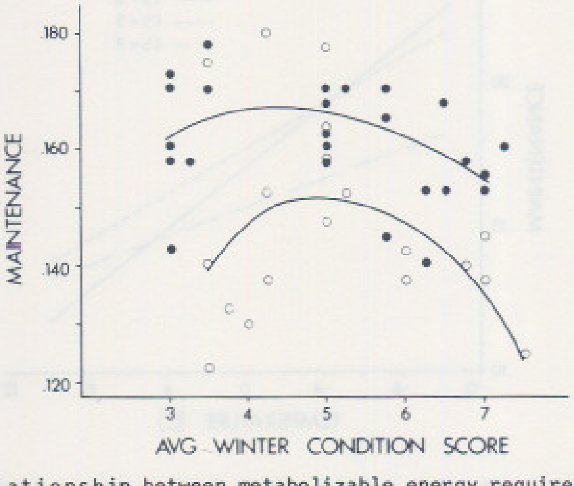

Figure 1. Relationship between metabolizable energy required for maintenance per kilogram body weight$^{.75}$ and average condition score during winter.

Table 5. Regression of daily metabolizable energy intake per kilogram live weight$^{.75}$ on live weight change per kilogram live weight$^{.75}$ and the maintenance function of condition score and on the function of environment.

Variable	Regression Coefficient	P[a]	Standard Error
Intercept	.1151	.0001	.0199
Weight change[b]	.3127	.0001	.0581
Condition score, units	.0295	.0004	.0082
Condition score^2	-.0034	.0001	.0008
Temperature, °C	-.0076	.0001	.0008
CS x temperature[c]	.0007	.0001	.0002

[a]Probability of a greater T for the hypothesis, H_o: parameter = 0.
[b]Kilograms·(live weight$^{.75}$)$^{-1}$.
[c]Condition score x temperature interaction, units·°C.

39.7% of the variation in maintenance. The influence of temperature and the interaction between temperature and CS were highly significant (P<.0001) indicating that the effect of temperature on ME required for maintenance was dependent on CS. The interaction between average daily temperature for the week and CS is illustrated in Figure 2. For each °C decrease in average temperature, ME required per kilogram LW$^{.75}$ for maintenance was increased .0055, .0039 and .0025 mcal for cows with CS 3, 5 and 7 units, respectively. These data indicate that the effect of temperature on ME required for maintenance may be greater for thin cows than for cows in moderate or fat conditions.

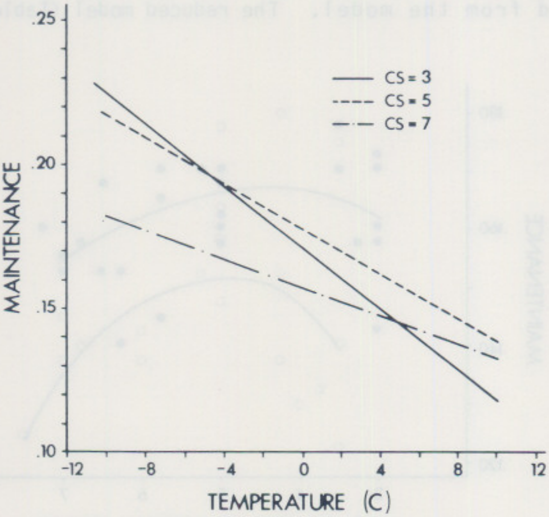

Figure 2. Relationship between metabolizable energy (mcal) required for maintenance per kilogram body weight$^{.75}$ and average weekly temperature for cows of condition score 3, 5 and 7 units.

Regression coefficients for CS (.0295±.0082) and CS^2 (-.0034± .0008) appeared similar to the regression coefficients reported earlier for CS (.0234±.0116) and CS^2 (.0025±.0011) when year was included in the model as a class variable. This indicates that most of the variation associated with year could be attributed to differences in environmental temperature.

Discussion

Data reported in this study suggest that cows in fatter body condition (CS = 7 units) and cows in thin condition (CS = 3 units) have lower ME requirements per kilogram body weight than cows with a moderate degree of fat (CS = 5 units). Maintaining the cow herd, especially during winter, is often regarded as the most important expense limiting the efficiency of beef production. Consequently, even a small savings in maintenance could improve net returns per cow.

Daily metabolizable energy requirements of nonpregnant, nonlactating cows for maintenance during winter are shown in Table 6. Frame score 3, condition score 3 Hereford cattle would weigh approximately 750 lbs and require 11.9 mcal ME for maintenance. The same cow at CS 5 would weigh 850 lbs and would require 13.7 mcal ME. At CS 7, this cow would weigh 1050 lbs and would require 14.4 mcal ME.

The utility of manipulating body fatness in an attempt to reduce maintenance costs is limited. Fat cows weigh more than thin cows of the same frame size. For cows of given breeding and type, fattening increases weight and additional energy is required to maintain this added weight. Perhaps in northern climates the insulatory benefits of additional fat may overcome the cost of maintaining additional weight. A 14.0% savings in feed costs, primarily due to lower LW, could be realized by maintaining cows in thin condition. The relationship between reproduction and cow weight and condition is well established. At present, it is not feasible to keep cows in thin condition and maintain satisfactory reproductive performance. If factors initiating estrus and maintaining pregnancy could be identified and managed to promote satisfactory reproduction under adverse conditions, maintaining cows in thin condition may become a viable option for cattlemen.

Table 6. Daily metabolizable energy required for maintenance by cows of various weights and condition scores.

	Body Condition Score				
Cow Weight (lb)	3	4	5	6	7
750	11.9	12.4	12.5	12.1	11.4
850	13.1	13.6	13.7	13.3	12.5
950	14.2	14.8	14.9	14.5	13.6
1050	15.3	15.9	16.0	15.6	14.4
1150	16.4	17.1	17.2	16.7	15.7

The results obtained from the current study are most useful as a tool to help budget feed requirements more precisely. Maintenance requirements per unit metabolic weight are not static and vary with environmental conditions, plane of nutrition, genotype, physiological status and carcass composition. Daily metabolizable energy (mcal) required by mature, nonpregnant, nonlactating Hereford cows during winter were best described by the expression, $[.1028 + .0234(CS) - .0025(CS)^2]LW^{.75}$ (LW = kg live weight).

BODY CONDITION SCORE, LIVE WEIGHT AND WEIGHT:HEIGHT RATIO AS ESTIMATORS OF CARCASS COMPOSITION IN NONPREGNANT, NONLACTATING, MATURE HEREFORD COWS

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Story in Brief

Body condition score (CS), live weight (LW) and weight:height ratio (WTHT) were evaluated and compared as estimators of carcass composition in beef cows. Seventy-one mature, nonpregnant, nonlactating Hereford cows ranging in LW, CS and WTHT from 606 to 1311 lbs, 2.0 to 8.0 units and 12.82 to 25.86 lb/inch of height, respectively, were slaughtered. Live weight, CS or WTHT predicted total carcass energy (mcal; r^2 = .81, .85 or .83), carcass fat (lb; r^2 = .78, .82 or .80), carcass protein (lb; r^2 = .71, .74 or .70) and carcass water (lb; r^2 = .78, .71 or .77) with similar accuracy, respectively. When composition was expressed on a per unit weight basis, condition score was superior to live weight or weight:height ratio as a predictor of energy/lb of hot carcass weight, energy/lb live weight, and percent fat in the carcass (r^2 = .82 vs .60 and .64, .83 vs .58 and .62, and .82 vs .64 and .68, respectively). Correlation coefficients between predictor variables and percent water or percent protein in the hot carcass were low and regression equations developed to predict percent water or percent protein were of limited value. These data indicate that CS was the more useful predictor of carcass composition in mature cows.

(Key Words: Body Condition, Weight:Height Ratio, Carcass Composition, Beef Cows.)

Introduction

The relationship between weight, body condition and reproduction in beef cows has been well established. For many years animal scientists and producers have been searching for accurate, precise and nondestructive methods to estimate carcass energy stores in beef cows for research and management. Objective techniques range in sophistication from simple measurements of live weight (LW) to complex double isotope dilution procedures. In addition, a number of subjective scoring systems have been developed to describe body condition. Relatively few attempts have been made to quantify these scoring systems.

The objective of this research was to evaluate and compare condition score (CS), LW, and weight:height ratio (WTHT) as estimators of carcass composition in mature, nonpregnant, nonlactating Hereford cows.

Materials and Methods

Seventy-one mature, nonpregnant, nonlactating Hereford cows were

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slaughtered as part of a regression study investigating the effects of carcass composition on energy requirements for maintenance during the winter. Prior to slaughter and after an overnight (16h) withdrawal of feed and water, each cow was weighed and evaluated visually and by palpation and assigned a body condition score (Table 1) by two independent observers. Hip height (HPHT) was determined on all cows prior to the initiation of the trial. WTHT was computed by dividing LW(lb) by HPHT(in).

Cows were slaughtered at a commercial slaughter plant. Hot carcass weight (HCW) was measured. Kidney, heart and pelvic fat were removed, weighed and sampled within 30 min of death. Carcasses were cooled for two days and the right side of each carcass was delivered to the Oklahoma State University meat laboratory where the chemical composition of the edible carcass tissue was determined.

Dry matter was determined by drying duplicate samples for 48 h at 212°F in a vacuum oven. Dry samples were weighed and extracted with ethyl ether (B.P. 95°F) in a Soxhlet apparatus for 48 h (AOAC, 1975). Ash content was estimated by combusting the remaining residue at 1112°F for 8 h. Total nitrogen was determined on duplicate samples by the Kjeldahl procedure (AOAC, 1975). Percent protein was calculated as Kjeldahl nitrogen x 6.25.

Total carcass energy (TMCAL, mcal) was estimated by the equation: TMCAL = carcass fat (FAT, lb)*4.26 mcal/lb + carcass protein (PRO, lb)*2.54 mcal/lb (NRC, 1984). Kidney, heart and pelvic fat was includ-

Table 1. Condition scoring system.

Score	Description
1 --	Severely emaciated. All ribs and bone structure easily visible and physically weak. Animals have difficulty standing or walking. No external fat present by sight or touch.
2 --	Emaciated. Similar to 1, but not weakened.
3 --	Very thin. No palpable or visible fat on ribs or brisket. Individual muscles in the hind quarter are easily visible and spinus processes are very apparent.
4 --	Thin. Ribs and pin bones are easily visible and fat is not apparent by palpation on ribs or pin bones. Individual muscles in the hind quarter are apparent.
5 --	Moderate. Ribs are less apparent than in a 4 and have less than 1/2 cm of fat on them. Last 2-3 ribs can be felt easily. No fat in the brisket. At least 1 cm of fat can be palpated on pinbones. Individual muscles in hind quarter are not apparent.
6 --	Good. Smooth appearance throughout. Some fat deposition in brisket. Individual ribs are not visible. About 1 cm of fat on the pin bones and on the last 2-3 ribs.
7 --	Very good. Brisket is full, tailhead and pin bones have protruding deposits of fat on them. Back appears square due to fat. Indentation over spinal cord due to fat on each side. One to two cm of fat on last 2-3 ribs.
8 --	Obese. Back is very square. Brisket is distended with fat. Large protruding deposits of fat on tailhead and pin bones. Neck is thick. Three to four cm of fat on last 2-3 ribs. Large indentation over spinal cord.
9 --	Very obese. Description of 8 taken to greater extremes.

ed in the calculation of FAT. Carcass energy content per pound HCW (ECCW) and per pound LW (ECLW) was computed by dividing TMCAL by HCW or LW, respectively. Proportion FAT (FATPR), PRO (PROPR) and carcass water (WATPR) were computed by dividing FAT, PRO and carcass water (WAT) respectively, by HCW. Contribution of carcass bone to carcass fat, protein and water was not accounted for.

Results and Discussion

The mean and standard deviation of each of the variables in the data set are summarized in Table 2. Cows varied widely in LW (606 to 1311 lbs) and CS (2.0 to 8.0 units). Hip height and WTHT ranged from 43.75 to 50.75 inches and from 12.82 to 25.86 lb/inch of height, respectively.

Simple correlation coefficients between LW, CS, WTHT, HPHT and estimates of composition are displayed in Table 3. These data were obtained from cows utilized in a study in which large ranges in body condition and LW were created prior to the initiation of the trial. Increasing the range of these data may increase the magnitude of correlation coefficients.

The measurements of LW, CS or WTHT show a similar degree of association with TMCAL (r = .90, .92 and .91), FAT (r = .88, .91 and .90), PRO (r = .84, .86 and .84) and WAT (r = .88, .84 and .88), respectively. When energy and fat are expressed on a percentage basis, however, CS (r = .90, .91 and .91) appeared to be more closely related to ECCW, ECLW and FATPR respectively, than LW (r = .76, .76 and .80) or WTHT (r = .80, .77 and .83).

The correlation between WTHT and LW in this study was greater than .98. Consequently, the degree of relationship between WTHT or LW and the other variables measured is likely to be similar. Correlation coefficients between HPHT and other variables were low (r = .30, .19, .14, .28, .19, .36, -.03, .38 and -.17 for TMCAL, ECCW, ECLW, FAT, FATPR,

Table 2. Summary of slaughter data used to generate correlation coefficients and prediction equations.

Item	Mean	Standard Deviation
Live weight, lb	877.4	146.57
Condition score, units	5.1	1.45
Hip height, in	47.8	8.05
Weight:height, lb/in	18.5	2.86
Carcass fat, lb	59.9	40.18
Carcass protein, lb	67.4	14.08
Carcass water, lb	249.0	45.05
Hot carcass weight, lb	472.5	101.87
Total carcass energy, mcal	426.7	202.15
Carcass energy/lb HCW[a]	.86	.25
Carcass energy/lb LW[b]	.45	.15
Carcass fat, %	11.7	5.83
Carcass protein, %	14.3	1.48
Carcass water, %	53.1	3.63

[a]Hot carcass weight.
[b]Live weight.

Table 3. Correlation coefficients between live weight, condition score, hip height, weight:height ratio and estimates of carcass composition[a].

	TMCAL	ECCW	ECLW	FAT	FATPR	PRO	PROPR	WAT	WATPR
LW	.90	.76	.76	.88	.80	.84	-.08[b]	.88	-.43
CS	.92	.90	.91	.91	.91	.86	.07[b]	.84	-.40
HPHT	.30	.19[b]	.14[b]	.28	.19[b]	.36	-.03[b]	.38	-.17[b]
WTHT	.91	.80	.77	.90	.83	.84	-.08[b]	.88	-.44

[a] LW = live weight; CS = condition score; HPHT = hip height; WTHT = weight:height ratio; TMCAL = total carcass energy; ECCW = TMCAL x lb^{-1} hot carcass weight; ECLW = TMCAL x lb^{-1} LW; FAT = carcass fat; FATPR = percentage carcass fat; PRO = carcass protein; PROPR = percentage carcass protein; WAT = carcass water; WATPR = percentage carcass water.
[b] Probability >.05.

PRO, PROPR, WAT and WATPR, respectively). There appeared to be little relationship between PROPR and LW, CS, HPHT or WTHT (r = nearly zero).

Equations for predicting carcass energy from LW, CS and WTHT are shown in Table 4. When carcass energy was expressed on an absolute basis (TMCAL), CS, LW and WTHT predicted carcass energy with a similar degree of accuracy (r^2 = .85, .81 and .83, respectively). However, when carcass energy was expressed on a per unit weight basis, CS accounted for more of the variations in ECCW and ECLW (r^2 = .82 and .83) than LW (r^2 = .60 and .58) or WTHT (r^2 = .64 and .62).

Equations for estimating carcass fat from LW, CS or WTHS are shown in Table 5. When carcass fat was expressed on a total pounds basis, CS, LW and WTHT predicted FAT with similar accuracy (r^2 = .82, .78 and .80, respectively). When carcass fat is expressed as a percentage of hot carcass weight, CS accounted for more variation in FATPR than LW or WTHT (r^2 = .82 vs. .64 and .68, respectively).

Table 4. Equations for estimating carcass energy from live weight, condition score or weight:height ratio.

Equations		Sy·x[a]	R^2
TMCAL[b]	= -221.5 + 128.19 CS[c]	79.14	.85*
	= -661.5 + 1.24 LW[d]	89.06	.81*
	= -756.7 + 64.49 WTHT[e]	85.16	.83*
ECCW[f]	= .067 + .1572 CS	.242	.82*
	= -.313 + .0013 LW	.355	.60*
	= -.441 + .0710 WTHT	.338	.64*
ECLW[g]	= -.024 + .0971 CS	.143	.83*
	= -.241 + .0008 LW	.223	.58*
	= -.319 + .0428 WTHT	.213	.62*

[a]Standard error of the regression.
[b]Total carcass energy, mcal.
[c]Condition score, units.
[d]Live weight, lb.
[e]Weight:height ratio, lb/in.
[f]Mcal/lb carcass.
[g]Mcal/lb live weight.
*P<.001.

Table 5. Equations for estimating carcass fat from live weight, condition score or weight:height ratio.

Equations		Sy·x[a]	R^2
FAT[b]	= -66.96 + 25.093 CS[c]	7.72	.82*
	= -152.91 + .243 LW[d]	8.56	.78*
	= -172.22 + 12.650 WTHT[e]	8.14	.80*
FATPR[f]	= -6.75 + 3.645 CS	2.46	.82*
	= -16.30 + .032 LW	3.52	.64*
	= -19.34 + 1.690 WTHT	3.32	.68*

[a]Standard error of the regression.
[b]Total carcass fat, lb.
[c]Condition score, units.
[d]Live weight, lb.
[e]Weight:height ratio, lb/in.
[f]Percent fat in hot carcass.
*P<.001.

Discussion

The close relationship between CS and the estimates of carcass energy and composition indicates that CS can be used to estimate carcass composition in cows. When estimates of carcass components are expressed on an absolute basis (lb or mcal), LW and CS predict composition with about equal accuracy. However, when carcass components are expressed on a percentage basis, CS is superior to LW as a predictor of composition. Although subjective in nature, CS offers sufficient accuracy for many research and management situations. Data from this study indicate that 76% of the variation in LW, 85% of the variation in carcass energy and 82% of the variation in carcass fat was explained by condition score.

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EFFECT OF LATE SPRING AND SUMMER PROTEIN SUPPLEMENTATION WITH AND WITHOUT LASALOCID ON LACTATING BEEF COWS

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Story in Brief

The feeding of low levels of protein supplement with and without lasalocid during late spring and summer was compared to a conventional program where animals grazed native range without any supplementation. Seventy-two lactating Angus, Hereford, and Hereford X Angus cows were allotted to three supplemental protein treatments: (I) control (supplemented with 4 lb SBM/day from 2-4 weeks postcalving to April 27, 1984, and no supplement thereafter); (II) protein (supplemented with 4 lb SBM/day from 2-4 weeks postcalving to April 27, 1984, and 1 lb SBM/day until July 16, 1984); and (III) protein plus lasalocid (same as the protein treatment with the addition of 300 mg/hd/day lasalocid). During late spring and summer, cows fed protein or protein + lasalocid gained more ($P<.05$) weight and condition than control cows (91.19 lb, .58 units, and 86.32 lb, .57 units, -vs- 62.25 lb, .26 units). Protein plus lasalocid cows tended to produce slightly more milk (13.11 lbs -vs- 10.94 lb and 10.84 lbs for control and protein groups, respectively). Calf weaning weights were similar for all treatments (429 lbs, 418 lbs, and 435 lbs for the control, protein and protein plus lasalocid, respectively). Feeding low levels of protein in late spring and summer effectively increased cow weight and body condition but did not increase milk production, calf weaning weight or pregnancy rate. No advantage was seen from feeding 300 mg/hd/day lasalocid over protein supplementation alone. Approximately 2.9 lbs of SBM were required for each lb of added cow weight.

(Key Words: Protein Supplements, Lasalocid, Beef Cattle.)

Introduction

The months of May and June typically coincide with the beginning of the spring breeding season when an adequate level of nutrition is essential to insure a short postpartum interval to the onset of estrus. Typically, oilseed meal-based protein supplements are fed to spring calving cows grazing dormant winter range from mid-November until late April when spring forage becomes available. A supplementation program into May and June that would efficiently increase cow weight and condition during this period might increase rebreeding enough to offset the cost of the supplement. Additional benefits could be greater milk production, increased weaning weights and better cow body condition in late summer and fall when forage quality is declining.

Lasalocid, a polyether ionophore, improves average daily gain and feed efficiency in feedlot and stocker cattle. Recent work at the Oklahoma Agricultural Experiment Station (Wagner et al., 1984) suggests a possible increase in weight gain when lasalocid was added to a protein

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supplement fed to cows at the rate of 200 mg/day from August to April. This amount is typically fed to stocker calves that weigh considerably less than mature beef cows.

The objectives of this study were: (1) to determine the effects of feeding 300 mg of lasalocid from 2-4 weeks post calving to mid-July on cow weight and condition change; and (2) to determine the effects of feeding a low level of supplemental protein with 0 or 300 mg of lasalocid from the time winter supplementation normally ceases (mid to late April) through May and June, on cow weight and condition change, conception rates, milk production, and calf performance of spring calving Hereford and Angus cows.

Materials and Methods

Seventy-two lactating Angus, Hereford, and Angus X Hereford cows, ranging in age from 4-10 years, bred to calve from late February to mid-April, were blocked and assigned to three treatments based on breed, calving date, weight and body condition score. Actual assignment to treatments was made at each weighing when cows were 2-4 weeks postcalving (Table 1). Each cow was fed 4 lb of soybean meal after calving. Treatments were (I) control, 4 lb SBM/hd/day from 2-4 weeks postcalving to April 27, 1984, and no supplement thereafter; (II) same as treatment I, except that 1 lb SBM/hd/day was fed from April 27 to July 16; and (III) same as treatment II with 300 mg of lasalocid/hd/day fed from 2-4 weeks postcalving to July 16. All cows and their calves were maintained in a single pasture. Cows were gathered on Monday, Wednesday and Friday mornings and fed the prescribed supplement individually in covered stalls. Supplement amounts were prorated for 3 times/week feeding. Control cows were gathered along with treatments II and III during the May to July 16 phase of the trial.

Table 1. Supplementation schedule.

Time Period	Supplement Intake[a]		
	Control	Protein	Prot/Lasalocid[b]
Trial start[c] to April 27	4.0	4.0	4.0
April 28 to July 17	0.0	1.0	1.0

[a]Pounds/head/day.
[b]300 mg lasalocid/head/day.
[c]Trial start = 2-4 weeks postcalving.

Cow weights and body condition scores were measured after overnight withdrawal from feed and water at 14 day intervals. Milk production was estimated for a 24 hour period on May 1, June 5 and July 17, using the weigh-suckle-weigh procedure.

A 60-day breeding season began on May 20, 1984. Cows that were at least 60 days postpartum at the start of the breeding season were synchronized with prostaglandin at the beginning of the breeding season and artificially inseminated at the synchronized estrus. Chin-ball equipped breeding bulls were then run with the cows for the remainder of the breeding season. Pregnancy status was determined by rectal palpation on

October 11, 1984.

Blood samples were obtained weekly via the tail vein from May 25 until July 13. An anticoagulant was added to each sample and the samples were cooled in an ice bath. Samples were centrifuged and plasma decanted and stored at -10°C until glucose was quantified colorimetrically.

Rumen samples were obtained from a sample of cows within each treatment 24 hours after their last supplementation. Samples were taken via stomach tube, pH recorded, and then stored to be later analyzed for acetate, proprionate, and butyrate concentration by gas chromatography.

Results and Discussion

Cow weight and body condition changes during the trial are shown in Table 2. From May 8 to July 17, cows receiving protein supplement gained more (P<.05) weight and body condition than unsupplemented control cows (104 and .71 units, -vs- 76.03 and .33 units, respectively). No difference was seen due to the addition of lasalocid to the protein supplement.

Table 2. Cow weight change, condition change, and conception rates.

	Treatment[a]		
	Control	Protein	Prot/Lasalocid[b]
Number of cows	24	24	24
Time period:			
Trial start to May 8:			
Weight change, lbs	-13.77	-13.55	-12.25
Condition change[b]	-.07	-.13	.03
May 8 to July 17:			
Weight change, lbs	76.03[c]	104.74[d]	98.58[d]
Condition change	.33[c]	.71[d]	.54[cd]
Trial start to July 17:			
Weight change, lbs	62.25[c]	91.19[d]	86.32[d]
Condition change	.26[c]	.58[d]	.57[d]
Conception rate, %	87.5	79.0	83.3

[a]Least squares means adjusted for cow breed, initial weight, initial condition and calving date.
[b]Condition change in units (1=very thin, 9=very fat).
[cd]Means in same row with different superscripts differ (P<.04).

Milk production estimates and calf performance are presented in Table 3. Cows fed the protein plus lasalocid supplement had slightly (nonsignificant) greater milk production at each time measured. Calf weaning weights did not differ between treatments (429, 418 and 435 for treatments I, II and III, respectively).

Pregnancy rates are presented in Table 2. Treatments did not affect pregnancy rates which were 87.5, 79.0 and 83.3% for treatments I, II and III, respectively. Intervals from calving to conception will be calculated from calving dates in 1985.

Concentrations of glucose in plasma are summarized in Figure 1.

Table 3. Cow milk production and calf performance.

	Treatment		
	Control	Protein	Prot/Lasalocid[b]
Number of cows	24	24	24
Milk production[a]:			
May 1	10.54	9.50	12.60
June 5	10.20	10.95	13.23
July 17	12.11	12.06	13.50
Average	10.94	10.84	13.11
Ave. daily gain, calves[b]:			
Birth to May 8	1.64[cd]	1.55[c]	1.76[d]
May 8 to July 17	1.96	1.84	1.94
Birth to July 17	1.65[cd]	1.56[c]	1.77[d]
Birth to October 2	1.94	1.86	1.98
Adjusted weaning weight, calves[b]:			
Oct 2	429	418	435

[a]Least squares means, expressed in pounds, and adjusted for breed of cow, breed of calf, initial weight, initial condition and calving date.
[b]Least squares means, expressed in pounds, and adjusted for breed of cow, calf age, calf sex, initial cow weight and initial cow condition.
[cd]Means in same row with different superscript differ (P<.05).

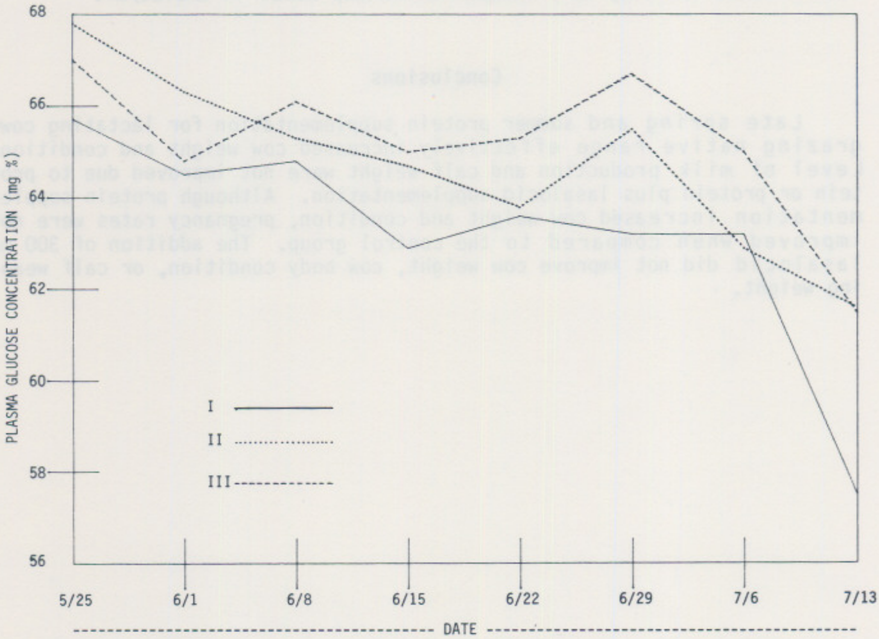

Figure 1. Plasma glucose concentrations (mg %) for Control (I), Protein (II) and Protein/Lasalocid (III) treatments.

Polynomial response curves were fit to plasma glucose concentrations and tests of heterogeneity of regression coefficients were used to determine treatment effects. Concentrations of glucose in plasma were not influenced by treatment. Glucose averaged 67 mg% for all cows on May 25 and concentrations decreased slightly until July 13.

Rumen volatile fatty acid concentrations and pH from samples taken 24 hours after the last supplemental feeding were similar between treatments (Table 4). The lasalocid fed cows had a slightly lower acetate to proprionate ratio (8.25 -vs- 8.57 and 8.07 for the control, protein and protein plus lasalocid groups, respectively).

Table 4. June 19 rumen volatile fatty acid concentration[a] and pH.

	Treatment		
	Control	Protein	Prot/Lasalocid[b]
Number of cows sampled	13	15	11
Total VFA's	66.57	76.28	59.36
Acetate	53.14	61.93	47.54
Proprionate	6.93	7.01	5.91
Butyrate	5.72	6.20	4.99
Acetate/Proprionate	8.25	8.57	8.07
pH	7.15	7.24	7.34

[a]Rumen volatile fatty acid concentration expressed in umoles/ml.

Conclusions

Late spring and summer protein supplementation for lactating cows grazing native range effectively increased cow weight and condition. Level of milk production and calf weight were not improved due to protein or protein plus lasalocid supplementation. Although protein supplementation increased cow weight and condition, pregnancy rates were not improved when compared to the control group. The addition of 300 mg lasalocid did not improve cow weight, cow body condition, or calf weaning weight.

INTAKE AND DIGESTIBILITY OF LOW QUALITY NATIVE GRASS HAY BY BEEF COWS FED INCREASING QUANTITIES OF CORN GRAIN

C.C. Chase, Jr.[1] and C.A. Hibberd[2]

Story in Brief

Supplements providing 0, 2, 4 or 6 lb ground corn/d were fed to sixteen beef cattle (12 Hereford cows, 4 mature ruminally cannulated heifers) maintained on native grass hay (4.2 percent CP) to determine the effect of corn feeding on utilization of low quality forage. Corn supplementation decreased hay intake, especially when 4 or 6 lb corn was fed. Feeding 4 or 6 lb corn/d decreased (P<.05) hay digestibility from 33.7 percent (no corn) to 23.2 percent (6 lb corn/d). Digestible dry matter intake (DDMI) was unaffected (P<.05) when 0, 4 or 6 lb corn was fed although 2 lb corn/d increased (P<.05) DDMI compared to 4 or 6 lb corn/d. Feeding grain-based supplements that provide more than 2 lb grain/d appears to decrease forage intake and seriously hinder forage utilization.

Introduction

Beef cows wintered on native range are commonly supplemented with small quantities (1-2 lb) of a high protein cube (40 percent). Under some circumstances such as inadequate forage supply or high nutrient requirements (cold weather), feeding larger quantities of a high energy, low protein cube may be justified. Previous research suggests that feeding high energy supplements composed of high starch cereal grains such as corn may decrease forage utilization. Starchy supplements appear to decrease forage digestibility which may result in decreased forage intake. Little research, however, indicates the amount of corn that can be fed or the extent to which forage intake and digestibility are depressed. Thus, the objective of this experiment was to determine the effect of feeding increasing quantities of supplemental corn on digestibility and intake of low quality native grass hay by beef cows.

Materials and Methods

Twelve Hereford cows (873 lb) and four ruminally cannulated Hereford x Angus heifers (724 lb) were blocked by weight into four groups and utilized in four simultaneous 4 x 4 Latin squares. Four isonitrogenous supplements providing 0, 2, 4 or 6 lb of ground corn were fed daily (table 1). These supplements supplied from .1 (0 lb corn/d) to 4.2 lb (6 lb corn/d) starch/d. Native grass hay (4.2 percent CP, 52.6 percent ADF) harvested in mid-November was coarsely chopped through a 2 in screen and offered free choice daily to all animals.

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Table 1. Supplement intake and nutrient supply (DM basis).

	Corn			
	0	2	4	6
Daily intake, lb				
Corn, ground	0	1.9	3.8	5.8
Cottonseed meal	1.3	.9	.4	0
Mineral premix[a]	.3	.3	.3	.3
Total	1.6	3.1	4.5	6.1
Nutrient supply, lb/d				
Crude protein	.57	.60	.60	.54
Starch[b]	.1	1.3	2.6	4.2
TDN[b]	1.0	2.4	3.7	5.2

[a]Mineral premix contained 63.4% dicalcium phosphate, 15.1% potassium chloride, 20.9% trace mineralized salt and .6% Vitamin A (20,000 IU/d).
[b]Estimated.

After 10 days of adaptation in each period, fecal samples were collected twice daily (0800 and 2000 h) on days 11 through 14. Supplement and native grass hay, offered and refused, were weighed and sampled daily. All samples were composited by animal, dried and ground through a 1 mm screen prior to analysis. Acid-insoluble ash was used as an indigestible marker to determine dry matter (DM) and acid detergent fiber (ADF) digestibility. Hay digestibility was estimated by difference assuming a supplement digestibility of 80 percent. The data were subjected to least squares analysis and differences between means detected with Tukey's HSD test.

Results and Discussion

Feeding 0 or 2 lb of corn/d had no significant effect on hay intake (table 2, figure 1). When corn supplementation was increased to 4 or 6 lb, hay intake decreased ($P<.05$) by 5.1 and 8.1 lb, respectively, when compared to no corn. Feeding 6 lb corn/d decreased hay intake from 2.3 (no corn) to 1.3 percent of body weight. Similarly, hay digestibility was not different ($P>.05$) when 0 or 2 lb of corn were fed. Consumption of 4 or 6 lb of corn/d decreased ($P<.05$) hay digestibility by as much as 31 percent. Acid detergent fiber digestibilities mimicked estimated hay digestibility. Much of the decrease in hay intake observed with grain feeding is probably due to the observed depression in fiber digestion.

Apparent dry matter digestibility (DMD) increased as corn intake increased, a reflection of the high digestibility of corn grain. Greater increases in DMD might be expected when feeding corn; however, the depression in hay digestibility negated some of the beneficial effects of corn feeding. Digestible dry matter intake [DDMI = (hay + supplement) x DMD] was similar for 0, 4 or 6 lb of corn/d (figure 1). Feeding 2 lb of corn increased ($P<.05$) DDMI when compared to higher quantities of corn. Although DDMI is a very crude estimator of energy intake, the energy status of cows fed 4 or 6 lb corn/d was probably little, if any, better than cows receiving 2 lb corn/d. This observation emphasizes the importance of forage digestibility as a major contributor to the energy intake of grazing cattle.

Table 2. Daily intake and digestibility of hay and supplements.

Item	Corn lbs/day 0	2	4	6	SE
Hay intake, lb	19.2[a]	18.0[a]	14.1[b]	11.1[c]	.62
Hay intake, % body wt	2.3	2.2	1.7	1.3	---
Hay digestibility, %	33.7[a]	33.5[a]	24.6[b]	23.2[b]	1.41
Acid detergent fiber digestibility, %	33.6[a]	33.2[a]	27.2[b]	25.9[b]	1.18
Dry matter intake, lb	20.8[ab]	21.1[a]	18.6[bc]	17.2[bc]	.62
Apparent dry matter digestibility, %	37.4[b]	40.8[ab]	39.3[b]	44.2[a]	1.08
Digestible dry matter intake, lb	7.7[ab]	8.6[a]	7.3[b]	7.5[b]	.26

[abc]Means with different superscripts differ (P<.05).

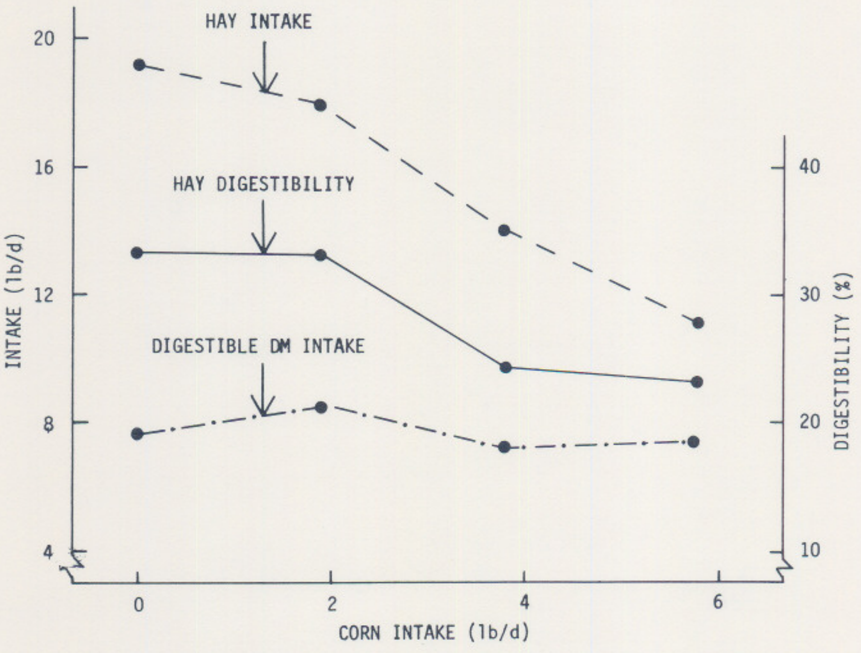

Figure 1. Hay intake (---), digestibility (——) and digestible dry matter intake (-·-·-) of beef cows fed increasing quantities of corn.

This study suggests that feeding more than 2 lb corn/d will dramatically depress digestibility (31 percent decrease) and intake (39 percent decrease) of low quality native grass hay. Although minor depressions were noted (P>.05), feeding 2 lb corn/d had little effect on hay utilization. Consequently, feeding large quantities of corn-based supplements in an attempt to enhance the energy status of beef cows grazing native range may not be successful. Because forage intake was depressed, feeding high grain supplements provides a management tool to spare available forage. The utilization of consumed forage under these circumstances, however, was very inefficient (23.2 percent hay digestibility). Alternate high energy, low starch supplements may allow better forage utilization when forage supplies are low or cattle requirements are high.

FEEDING FREQUENCY OF HIGH GRAIN SUPPLEMENTS WITH LOW QUALITY NATIVE GRASS HAY

C.C. Chase, Jr.[1] and C.A. Hibberd[2]

Story in Brief

Two levels of a corn-based supplement were fed daily or on alternate days (2 x daily amount) to 12 Hereford cows and 4 Hereford x Angus heifers maintained on coarsely chopped native grass hay (5.0 percent CP) to determine the effect of feeding frequency of grain supplements on forage utilization. Feeding frequency did not influence hay ($P<.62$) or dry matter ($P<.62$) intake. Alternate day feeding tended to depress both hay ($P<.22$) and dry matter ($P<.20$) digestibility. Digestible dry matter intake was decreased ($P<.03$) by .5 lb by alternate day feeding. Alternate day feeding of high grain supplements appears to alter rumen environment to a greater extent than daily feeding. If grain-based supplements are to be fed, small quantities (less than 2 lb) provided on a daily basis may minimize deleterious effects on forage utilization.

Introduction

Infrequent feeding (2 or 3 feedings/week) of high protein supplements to wintering beef cows has been shown to maintain performance as effectively as daily feeding. Certainly, feeding high grain supplements on alternate days would also be an appealing production practice. There is little data, however, on the effect of infrequent feeding of grain-based supplements on forage utilization. Daily feeding of more than 2 lb of corn has been shown to decrease forage digestibility and intake. Continuous feeding of high starch supplements may produce a rumen environment deleterious to forage digestion. Feeding twice the daily allowance on alternate days may decrease this effect on days when no grain is fed, allowing better overall forage utilization. Thus, the objective of this study was to determine the effect of daily or alternate day feeding of corn-based supplements on digestibility and intake of low quality native grass hay by beef cows.

Materials and Methods

Twelve Hereford cows (876 lb) were blocked by weight into three groups. Four ruminally cannulated Angus x Hereford heifers (754 lb) comprised a fourth group. The four groups were utilized in four simultaneous 4 x 4 Latin squares with treatments arranged in a 2 x 2 factorial design. Two isonitrogenous corn based supplements (levels) provided either 1.8 or 3.8 lb corn/d (table 1). Supplements were fed daily or on alternate days (2 x daily amount). Thus, 1.8 lb of corn was fed daily (Low-daily) or twice that amount (3.6 lb) fed on alternate days (Low-alternate) while 3.8 lb was fed daily (High-daily) or 7.6 lb on alternate days (High-alternate, table 2). All cows were offered free choice

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Table 1. Supplement intake and nutrient supply (DM basis).

Item	Corn level Low	Corn level High
Average daily intake,lb		
Corn, ground	1.8	3.8
Cottonseed meal	.9	.4
Mineral premix[a]	.3	.3
Total	3.0	4.5
Average nutrient supply,lb/d		
Crude protein	.56	.55
Starch	1.2	2.6
TDN[b]	2.3	3.7

[a]Mineral premix contained 63.4% dicalcium phosphate, 15.1% potassium chloride, 20% trace mineralized salt and .6% Vitamin A (20,000 IU/d).
[b]Estimated.

Table 2. Supplementation schedule.

Schedule	Day 1	2	3	4	...	13	14
	Corn intake,lb/d						
Low-daily	1.8	1.8	1.8	1.8		1.8	1.8
Low-alternate	3.6	---	3.6	---		3.6	---
High-daily	3.8	3.8	3.8	3.8		3.8	3.8
High-alternate	7.6	---	7.6	---		7.6	---

coarsely chopped (2 in screen) low quality native grass hay (5.0 percent CP, 46.2 percent ADF).

Each 14 day period included eight days for diet adaptation and six days of fecal sampling twice daily (0800 and 2000 h). Supplement and hay, offered and refused, were weighed and sampled daily. All samples were composited by animal, dried and ground through a 1 mm screen before analysis. Dry matter and acid detergent fiber digestibility were estimated using acid-insoluble ash as an indigestible marker. Hay digestibility, assuming supplement digestibility of 80 percent, was estimated by difference. The data were subjected to least squares analysis. Because the Level x Frequency interaction was not significant (P = .19 or greater) for any variable, simple effect means were averaged and main effect means presented.

Results and Discussion

Level of Feeding

Supplements providing a daily average of 3.8 lb corn decreased (P<.0001) hay intake from 21.1 to 19.3 lb/d (table 3). Much of the depression in hay intake is attributable to decreased hay (P<.02) and acid detergent fiber (P<.009) digestibilities. Although less severe than in previous studies, digestible dry matter intake was slightly decreased by feeding 3.8 lb corn/d. Certainly, the additional corn did not improve the digestible dry matter intake of the cows as might be expected.

Table 3. Daily intake and digestibility of hay and supplements.

Item	Level			Frequency		
	Low	High	P[a]	Daily	Alternate	P[a]
Hay intake, lb	21.1	19.3	.0001	20.3	20.1	.62
Hay digestibility, %	47.8	44.8	.02	47.0	45.6	.22
Acid detergent fiber digestibility, %	42.3	39.0	.009	41.3	40.1	.32
Dry matter intake, lb	24.2	23.8	.29	24.0	23.9	.62
Apparent Dry matter digestibility, %	52.0	51.8	.83	52.5	51.2	.20
Digestible dry matter intake, lb	12.5	12.3	.33	12.7	12.2	.03

[a]Probability.

Feeding Frequency

Feeding frequency had no effect (P<.62) on hay intake (table 3). Although not significant, alternate day feeding tended to decrease acid detergent fiber and hay digestibility. Apparent dry matter digestibility was also depressed (P<.20) by alternate day feeding resulting in reduced (P< .03) digestible dry matter intake.

Feeding large quantities of grain on alternate days appears to create a ruminal environment that is more deleterious to forage digestion than daily feeding (figure 1). These conditions apparently carry over into the second (no grain feeding) day. The resulting depression in apparent dry matter digestibility produced a small but significant decrease in digestible dry matter intake. A .5 lb depression in digestible dry matter intake, however, may not be large enough to justify the added expense of daily supplementation.

This study suggests that the most efficient method of providing grain supplements to cows wintered on low quality native grass is in small quantities fed frequently. Unfortunately, daily supplement feeding results in interrupted grazing patterns, unequal supplement consumption and increased labor. Perhaps self-feeding grain supplements with the use of intake regulators such as salt would allow frequent consumption with minimal labor inputs.

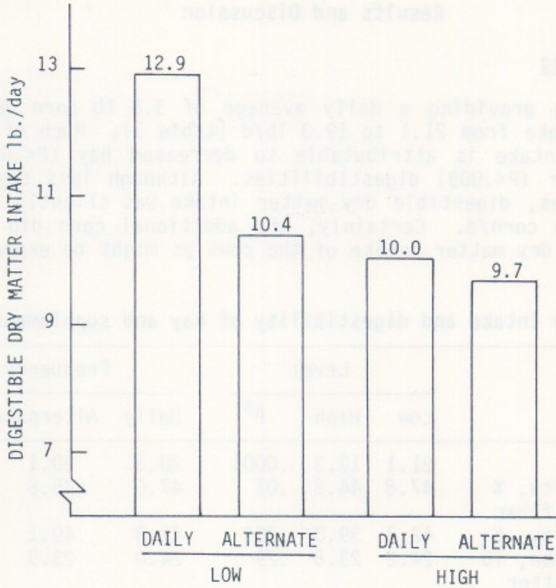

Figure 1. Effect of feeding frequency on digestible dry matter intake.

CORN GLUTEN FEED OR A CONVENTIONAL PROTEIN CUBE FOR STOCKERS ON SUMMER NATIVE RANGE

F.T. McCollum[1], D.R. Gill[2] and R.L. Ball[3]

Story in Brief

Crossbred beef steers (avg initial wt = 616 lb) grazing tallgrass rangeland, received either no supplement, 7 lb/hd/wk of a 38 percent CP cube (38 percent) or 14 lb/hd/wk of a 19 percent CP cube containing corn gluten feed (CGF). During the 62-day feeding trial (7/20/84 to 9/20/84), unsupplemented steers gained 66 lb/hd, 38 percent steers gained 85 lb/hd and CGF steers gained 65 lb/hd. These results suggest that CGF-protein is not a viable supplement for stockers on summer native range.

(Key words: stocker cattle, summer supplements, corn gluten feed)

Introduction

Past studies at OSU (Lusby and Horn, 1983) demonstrated the benefits of feeding high protein supplements to stocker cattle on summer native range. These studies generally show a supplement conversion rate of 2.0 to 2.5 lb supplement/lb added gain when 6 to 8 lb supplement/hd/wk are fed during the late summer grazing season (mid-July to late September). Recently, several by-product feeds have become relatively inexpensive due to import restrictions in Europe. Corn gluten feed, a by-product of the corn milling industry, is one such feedstuff. CGF contains 23 to 25 percent crude protein. The relatively low protein cost ($/lb of protein) of CGF would make a 20 percent protein supplement, based on the by-product, competitive with conventional natural protein supplements. However, little is known about CGF as a supplement for medium-to-low quality forages.

Materials and Methods

On July 20, 52 head of crossbred beef steers (avg initial wt = 616 lb) were weighed, allocated to one of three supplement treatments and then placed on one of three native pastures at the Pawhuska Research Station. The steers had been on another grazing study since April, 1984. The supplement groups were 1) control - no supplement 2) 7 lb per head per week of a commercial 38 percent CP cube and 3) 14 lb per head per week of a 19 percent CP supplement containing corn gluten feed as the primary protein source (table 1). Prorated amounts of the supplements were fed three times weekly during the 62-day trial. The treatment groups were kept in separate pastures throughout the trial and pastures were rotated every 10 to 14 days to help remove any effects of location or pasture. The cattle were weighed off pasture on September 20. Both the initial and final weights were taken in the morning following a 12 to 16 hour period without feed or water.

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Table 1. Composition of supplements.

Ingredient, %	19%[1] cube	38%[1] cube
Corn gluten feed	76.45	---
Wheat midds	10.00	---
Soybean meal	---	43.00
Cottonseed meal	---	47.00
Dicalcium phosphate	.50	1.00
Molasses	6.97	5.00
Fat	1.00	---
Vitamin A	.08	.16
Binder	5.00	3.84

[1] Produced by A&M feeds, Stillwater, OK.

During the trial one steer died and two steers developed eye problems which reduced performance; therefore, only 49 steers were used in statistical analyses. Analysis of variance and a protected LSD were used to separate treatment means. Least squares procedures were used to adjust for missing values.

Results and Discussion

During the 62-day trial, unsupplemented steers gained 1.06 lb/day for a total gain of 66 lb/head (table 2). Feeding 1 lb daily of the commercial 38 percent CP cube boosted total gain 20 lb/head and ADG about .33 lb/day. Supplement conversion (3.0 lb suppl/lb added gain) was less efficient than noted in previous studies by Lusby and Horn (1983) and Gill et al. (1984). The corn gluten feed (CGF) based cube had no influence on steer performance. Gains were similar to the unsupplemented steers despite a supplemental protein intake similar to the 38 percent CP group. The lack of response to CGF cannot be explained at this time. The form of supplemental crude protein in CGF may have influenced steer response. Data from Van Soest (1984) indicates that in excess of 50 percent of CGF crude protein is present as nonprotein nitrogen. As a rule, NPN supplements (urea-based or biuret-based) are not as beneficial as natural protein supplements for ruminants consuming low-to-medium quality forages. Research is currently underway to define the influences of CGF supplements on digestion and utilization of low-to-medium quality prairie hays.

In summary, supplementation with 38 percent CP cubes increased late summer gains 20 lb/head over unsupplemented controls. In contrast, CGF steers were supplemented at the same protein level as the 38 percent group but gained no more weight than the controls. These results suggest that CGF has no value as a supplement for stockers grazing native range during late summer. However, more research is needed before any definite conclusions can be made.

Table 2. Weights and performance of steers receiving no supplement or a commercial 38% CP cube or a 19% CP corn gluten feed cube.

	Control	38% cube	19% cube	Sig. Level
No. steers	15	18	16	
Weekly supplement, lb/hd/wk	0	7	14	
Initial wt, lb (7/20/84)	614	618	616	
Final wt, lb (8/20/84)	680[a]	704[b]	681[a]	P<.05
62-day gain, lb/hd	66[a]	86[b]	65[a]	P<.05
ADG, lb/hd/day	1.06[a]	1.39[b]	1.05[a]	P<.05
Supplement conversion, lb suppl./lb added gain	---	2.6/1	1/0	

Literature Cited

Gill, D.R. et al. 1984. The effect of protein supplement on late summer gains of stocker cattle grazed on native bluestem range. OAES MP-116, pp. 144-146.

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Van Soest, P.J. 1984. A commentary on nitrogen solubility. Feed Management 35(5):59.

WINTER PROTEIN SUPPLEMENTS FOR STOCKERS ON NATIVE RANGE

F.T. McCollum[1], D.R. Gill[2] and R.L. Ball[3]

Story in Brief

One hundred eleven crossbred beef steers averaging 491 lb were fed one of three winter supplements from November 11, 1983, until April 17, 1984. Supplements were 1) 14 lb/hd/wk of a 42 percent CP cube (HP) 2) 16 lb/hd/wk of a 23 percent CP cube (LP) and 3) 16 lb/hd/wk of a 23 percent cube containing .05 percent sarsaponin (LPS). During the winter, HP steers gained 5 lb/hd while the LP and LPS groups lost 8 and 34 lb/hd, respectively. From April 17 to July 20, cattle were grazed on native range unsupplemented; gains were 229, 243 and 243 lb/hd for the HP, LP and LPS groups, respectively. As generally noted, despite differences coming out of the winter period, steers compensated and there were no differences in group weights on July 20.

(Key words: stocker cattle, winter, protein supplements, rangelands)

Introduction

Winter nutrition of stocker cattle on native range is of interest since feeder cattle prices are generally lower in late fall than in the spring months. However, the expense of maintaining the cattle through the winter with little or no weight gain can make a dry-winter program unattractive. Besides interest on borrowed capital, supplemental feeds are the primary costs of these programs. Thus, any method of improving winter performance or reducing feed costs for maintenance would be of value to the cattleman.

Sarsaponins are a group of naturally occurring steroid saponins of the yucca plant and have been suggested to enhance rumen fermentation. On high concentrate diets, performance responses most often occur when dietary protein is marginal. In dairy cows, both ruminal and total nitrogen and organic matter digestibilities were increased by supplementing a 50 percent concentrated diet with sarsaponin (Goetsch and Owens, 1984). Total tract fiber digestibility also tended to be higher on the sarsaponin diet. Other work has shown that certain fractions of sarsaponins have urease-inhibiting properties (Goodall, personal communication). Since dry wintered stockers exist on diets with marginal protein, rely on nitrogen recycled to the rumen as urea and could also benefit from enhanced organic matter, fiber and nitrogen digestion, the following study was conducted to monitor the influences of sarsaponin in a low-protein supplement on winter steer performance.

Materials and Methods

On November 11, 1983, 111 head of crossbred beef steers averaging 491 lb were weighed and allocated to one of the three winter feeding treatments. The steers were assembled by a cooperator and delivered to the Pawhuska Research Station after an initial receiving period. The

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three winter feeding treatments were 1) 14 lb/hd/wk of a 42 percent CP cube (HP) 2) 16 lb/hd/wk of a 23 percent CP cube (LP) or 3) 16 lb/hd/wk of the 23 percent CP cube containing .05 percent sarsaponin (LPS). Composition of the supplements are shown in table 1. The treatment groups were pastured separately on three native tallgrass pastures. Pastures were rotated bi-weekly to remove any effect of location or pasture. Salt, mineral and fresh water were available free choice. The cattle were weighed off trial on April 17, 1984, and subsequently allocated to grazing management treatments for the summer. Steer weights were measured again on July 20 to determine if winter performance influenced early summer gains on pasture. All weights (November, April and July) were taken in the morning after a 12 to 16 hour overnight period without feed or water. Supplement influences on winter weight gain and subsequent summer gains were analyzed by analysis of variance. A protected LSD was utilized to separate treatment means.

Table 1. Supplement composition, as-fed basis.

	Supplement		
Ingredient, %	HP	LP	LPS
Soybean meal	50.00	20.00	20.00
Cottonseed meal	48.89	20.00	20.00
Corn, ground	---	42.14	42.14
Alfalfa, ground	---	15.00	15.00
Vitamin A	.11	.11	.11
Dicalcium phosphate	1.00	2.70	2.70
Sevarin	---	---	.06

Results and Discussion

The winter of 1983-84 was characterized by periods of extremely harsh, cold weather with subzero chill factors occurring for several days at a time. This unusually cold weather undoubtedly had an influence on steer gains recorded in this trial. Winter weight gain ranged from -102 to +65 lb for all 111 head. The range of weight losses noted within each treatment group were similar; however, the mean weight gains (losses) varied between treatments. The HP group gained 5 lb/hd over the winter while the LP group lost 8 lb/hd. Adding sarsaponin to the LP cube reduced weight gains ($P<.05$). From previous work with other types of diets, one might have expected sarsaponin to moderate differences between the HP and LP treatments. The reduction in weight gain may be related to the urease-inhibiting properties of the sarsaponin. Ruminants on diets with marginal and/or deficient protein contents depend upon nitrogen which is conserved and recycled into the rumen as urea. If ruminal urease activity was inhibited then ruminal forage digestion, forage intake and total nutrient supply to the animal may have been reduced.

The previous winter, another group of steers gained 50 lb/hd from January 4 to April 14 (Gill et al., 1984). Those cattle had received either 9 lb/hd/wk of a 38 percent cube or 13 lb/hd/wk of a 25 percent CP cube. From these results, 1.25 lb/hd (9 lb/hd/wk) was suggested as a minimum supplementation level for 500 lb steers on dormant winter range.

The disparity between the current trial and the previous year complicate any feeding recommendations. Generally, 2 lb/hd/day of a 40 percent CP supplement would be expected to produce 0 to .5 lb/day gain (Gill, personal communication). Despite differences in winter gain, steers in the current study compensated and by July 20 there were no statistical differences in steer weights (table 2).

Table 2. Winter and summer performance of steers receiving high protein, low protein or low protein plus sarsaponin during dry winter phase.

	HP	LP	LPS
No. of steers	37	37	37
Weekly supplement, lb/hd/wk	14	16	16
Initial weight, lb (11/11/83)	490	489	496
Final weight, lb (4/17/84)	495[a]	481[ab]	462[b]
Winter gain, lb/hd	5[a]	-8[b]	-34[c]
Summer weight, lb (7/20/84)	724	724	705
Early summer gain, lb/hd	229[d]	243[e]	243[e]

[a,b,c]Means with different superscripts are different (P<.05).
[d,e]Means with different superscripts are different (P<.10).

In summary, winter gains were lower than expected for the rates of supplementation. Severe cold weather may have reduced performance below the anticipated level. Addition of sarsaponin reduced steer performance significantly. This influence may have resulted from inefficient utilization of recycled nitrogen. Unfortunately, a 42 percent CP + sarsaponin cube could not be tested due to limited pasture space.

Literature Cited

Goetsch, A.L. and F.N. Owens. 1984. Sarasponin and site of digestion and passage rates in dairy cows. OAES MP-116, pp. 79-82.

THE EFFECT OF MASS-MEDICATION, LASALOCID OR DECOQUINATE, AND MEDICAL TREATMENT ON THE GAINS AND HEALTH OF NEWLY-ARRIVED STOCKER AND FEEDER CATTLE

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Story in Brief

Eleven loads of newly-received steer and bull calves and yearlings (1047 head) averaging 474 pounds were divided into two groups; one received routine processing on arrival, and the other received the routine processing plus long-acting oxytetracycline and sustained release sulfadimethoxine. Morbidity was reduced (P<.05) from 33.5 percent in the non-mass medication cattle to 14.7 percent in those receiving mass-medication at processing. The 524 head of non-mass medicated cattle had 1179 sick pen days, while the 523 mass-medicated cattle had 424 sick pen days, a reduction (P<.05) from 2.25 to 0.81 sick days per head. Average daily gains of the mass medicated cattle were significantly higher than those not receiving mass-medication (1.57 vs 1.45 lb/day). The above cattle were fed supplements containing no drugs, lasalocid (150 mg/head/day) or decoquinate (100 mg/head/day). Daily gains were not significantly altered by feed treatments (1.52, 1.56, and 1.47 lb/day, respectively). Sick cattle in the group not mass medicated at processing were assigned to one of four treatments: (1) negative control, (2) RO5-0037, an experimental drug, (3) oxytetracycline and sulfamethazine boluses, or (4) amoxicillin. Recovery rate was 91% for RO5-0037, 85% for oxytetracycline and sulfamethazine, and 47% for amoxicillin. Responses of 70% to the first treatment is considered excellent in previous studies. The negative controls (animals not administered antimicrobials on signs of sickness) were sick for more (P<.05) days than either of the treated groups and death losses were higher (4.7 vs 2.9% of the sick cattle).

(Key Words: Lasalocid, Decoquinate, Bovine Respiratory Complex, Newly-Arrived Cattle.)

Introduction

Between 2 and 5 percent of newly-received stocker cattle received in Oklahoma die of stress related diseases, primarily the Bovine Respiratory Disease (BRD) complex, shortly after shipping. Morbidity ranges from 0 to 100 percent, with an average probably between 25 and 30 percent. Cattlemen receiving stressed cattle must be prepared with a complete health program to prevent excessive death loss and decreased performance. Most cattleman and their veterinarians follow programs similar to the one outlined in OSU RP-9104 0481, treating sick animals as they are detected. Another approach is to mass-medicate all animals on arrival based on the premise that a high percentage of the cattle will get sick shortly after arrival and that sickness is not easily identified on arrival.

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Bristol (1969) showed that if treatment was started early, most of the approved antimicrobial drugs were very effective, but if treatment was delayed the response to antimicrobial drugs could be very poor. Early attempts to reduce the incidence of BRD by the injecting a single antibiotic at the point of origin before shipping were not successful (Addis et al., 1973). But more recently developed long acting oxytetracycline and sustained release sulfonamides can provide more prolonged medication and have shown promise when administered at processing time (Lofgreen, 1983; Swafford et al., 1983).

Materials and Methods

All eleven loads of cattle used in this study were assembled by order buyers with the majority coming from auction barns in the southeastern United States and trucked to Pawhuska, Oklahoma. Newly-received cattle were weighed individually off the truck and ear tagged. The ear tag number pre-assigned the medical treatment if the animal became sick. Cattle were poured with famphur systemic insecticide and randomly assigned by pen to mass-medication (MM) or non-mass medication (NMM) groups. Following weighing and tagging, cattle were placed in one of nine pens of 20 to 25 animals in each pen. Water and native bluestem grass hay were provided free choice. On the morning following arrival, cattle were processed by pen as follows:

1. Body temperature and time were recorded.
2. Cattle were vaccinated with IBR-PI_3 (IM MLV) vaccine, Leptospira pomona bacterin, and 4 Way Clostridia bacterin (Cl. chauvoei, septicum, novyi, sordellii)
3. Branded.
4. Dewormed with levamisole gel.
5. Cattle in the MM group received an injection of long-acting oxytetracycline[a] (10 mg/lb) and sustained release sulfadimethoxine boluses[b] (label dosage).
6. Sick cattle received antibiotic treatment if clinical signs of illness were detected or if body temperature exceeded 104° F (non-mass medicated cattle).
7. Hospital card was initiated (NMM).
8. Animals from the NMM group which were not sick and all MM cattle (sick or well) were returned to their home pen. Sick animals from the NMM group were placed in the hospital pen.

By processing only one pen at a time, cattle were seldom out of their pen for more than 35 minutes. Consequently, body temperatures should be more useful to identify sick animals. As soon as cattle were placed in their pens, they had ad libitum access to prairie hay and were offered a pelletted feed supplement (Table 1) at a rate of two lb/hd/day for the first 21 days and one lb/hd/day during days 22-28. The supplements contained (1) no added drugs, (2) lasalocid[c] (75 mg/lb), and (3) decoquinate[d] (50 mg/lb). Three hospital pens were maintained so that sick animals received their assigned feed while out of their

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[a] LA-200®, Pfizer, Inc., New York, NY 10017.
[b] Albon-SR®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.
[c] Bovatec®, Hoffman-LaRoche, Inc., Nutley, NJ 07110.
[d] Deccox®, Rhone-Poulenc, Inc., Monmouth Junction, NJ 08852.

home pen.

Mass-medication was assigned at random to either 4 or 5 pens in each trial. In each trial, each feed medication was fed to at least one pen. Numbers of pens assigned to treatment were balanced between trials. Non-mass medicated cattle were placed in the remainder of the nine pens. Mass-medication was administered at processing time and cattle were returned to their home pen even if the cattle were detected as sick at that time. If the mass-medicated cattle were detected sick 24 hours or more after processing they were removed from their home pen and treated with the second drug in the sequence of antibiotics (Table 2).

Table 1. Composition of feed supplement.

Ingredient	Percent
Soybean Meal	88.9
Salt	3.0
Vitamin A-30000 IU / Gram	.22
Premix[a]	.18
Cottonseed Meal	5.0
Dicalcium Phosphate	2.75

[a] to provide: 0 for control, 75 mg. lasalocid per pound, or 50 mg. decoquinate per pound.

The medication schedule assigned to non-mass medicated cattle were (A) no treatment (negative controls), (B) a sequence of antimicrobial drugs (Table 2), or (C) an experimental potentiated sulfa (RO5-0037[e]). Cattle treated by schedule B were treated with the first drug in the sequence. If body temperature dropped 2°F or to less than 104°F, or clinically improved within 24 hours, the first drug was continued for at least two more days. If no improvement was apparent after 24 hours, the next drug in the sequence was used and the process was repeated until improvement was detected as outlined in OSU RP-9104 0481. In trials 3, 4, and 5, treatments 1 and 3 were reversed in order so that the first treatment was amoxicillin. Cattle treated by schedule C were administered RO5-0037 boluses orally at 30 mg/lb on day one and 15 mg/lb on days 2-5, regardless of response to therapy. If additional treatment was required at the end of the 5 day treatment with RO5-0037, they were started on the second drug in the sequence (Table 2).

After processing, cattle were checked twice daily for signs of illness. If an animal was sick it was taken to the processing area where its body temperature was taken and a severity of illness score (slight, moderate or severe) was assigned. If the body temperature was over 104°F or if the animal exhibited clinical signs, it was considered sick and treated.

At the end of the 28 day trial, the cattle were held overnight without feed or water, weighed the following morning and, when necessary, castrated and horns were tipped. They were then returned to their owner.

Results in this study are reported as least square means. This

[e]Primor®, Hoffmann-LaRoche, Inc., Nutley, NJ 07110.

technique corrects for variations due to the trial (origin and possibly the time of year), truck (origin), treatment interactions, and unequal sample sizes. Models for the variables studied (gains, sick days and morbidity) originally included truck, feed treatment, mass vs non-mass medication and all two way interactions and were adjusted for initial weight. The final models for each variable included only those interactions having probabilities less than 0.20. Initial weight was also only included if its probability was less than 0.20.

Table 2. Sequence of drugs used for treatment of BRD.

Treatment No 1:	OXYTETRACYCLINE (Biomycin-C®) subcutanously - 5 mg/lb. Plus SULFAMETHAZINE BOLUSES (Sulmet® - 15 gm) 1 bolus/150 lb on day 1. One bolus/300 lb on subsequent days.
Treatment No 2:[1]	ERYTHROMYCIN (Gallamycin®) deep in the muscles - 10 mg/lb
Treatment No 3:[1]	AMOXICILLIN (Amoxi-ject®) subcutanously 5 mg/lb.
Treatment No 4:[1]	Procaine Penicillin G subcutanously - 30,000 IU/lb.
Treatment No 5:[1]	TYLAN 200 - 10 mg/lb.
Treatment No 6:[1]	SPECTINOMYCIN (Spectam®) - 5 mg/lb.

[1] Some of the antimicrobial drugs used in this study were used for extra-label purpose or at extra-label dosages and require a veterinarian-client-patient relationship before use.

For statistical analysis on all cattle, the model for average daily gain included truck, feed treatment, medical treatment, truck-medical treatment interaction, and was adjusted for initial weight. The model for sick days included truck, feed treatment, medical treatment, truck-feed treatment interaction, and truck-medical treatment interaction. The model for morbidity was the same as that for sick days except that an adjustment for initial weight was included. Those cattle in trial 4, truck 1 were not included in the analysis for sick days and morbidity because of an error in allocation to feed treatment.

For statistical analysis of the sick cattle, the model for average daily gain included truck, feed treatment, sick treatment, and was adjusted for initial weight. The model for re-pulls and morbidity were the same except initial weight was not included. Mass vs. non-mass medication was not included in these models because it caused too many empty cells.

Data on feed intakes and efficiencies were analyzed using pens as the experimental unit since feed records were kept on a pen basis. The model for feed intake included trial, medical treatment, feed treatment, and trial-feed treatment interaction. The model for feed efficiency was the same except a correction for initial pen weight was also included.

All cattle dying during this trial were submitted to the Oklahoma Animal Disease Diagnostic Laboratory for gross and histological examination, virus isolation, bacterial culture and antibiotic sensitivity testing.

Results and Discussion

Gains were significantly affected by truck (Table 3). Initial weight on trial also affected gains (P<0.0001)with lighter calves gaining at a faster rate than the heavier calves, the opposite of what was expected. Cattle buyers apparently were purchasing older, heavier, lower quality calves to reduce the purchase price per pound.

The administration of mass-medication reduced (P<.0001) sick days (2.25 vs 0.81) and morbidity (33.5% vs 14.7%). Gains in the 28 day receiving period were significantly increased (P<.01) by mass-medication (1.57 vs 1.45 lb/day). These reductions in morbidity, hospital pen days and improvements in gain are consistent with results from other research stations. The effect of feed treatment, while not significant, was most apparent in the cattle that were sick.

Table 3. Rate of gain, sick days and morbidity--all cattle.

Item, Origin & Date			No.[b]	In Wt	Daily Gain[a]	Sick Days[a]	Morbidity[a]
Trial 1							
Truck 1	FL	9/15/83	101	429	2.25[h]	2.25[f]	37.2[f]
Trial 2							
Truck 1	OK	10/20/83	95	439	1.90[g]	0.59[cd]	9.6[c]
Truck 2	FL	10/20/83	92	484	1.47[ef]	0.91[d]	20.5[d]
Trial 3							
Truck 1	OK	12/1/83	104	438	2.15[h]	1.63[e]	28.9[e]
Truck 2	OK	12/8/83	88	440	1.63[f]	0.20[c]	3.3[c]
Trial 4							
Truck 1	TN	1/10/84	93	491	1.58[ef]	----	----
Truck 2	TN	1/12/84	99	482	1.40[e]	4.06[g]	49.9[g]
Trial 5							
Truck 1	AK	2/18/84	79	532	1.07[d]	1.58[e]	27.8[def]
Truck 2	AK	2/24/84	90	538	0.83[c]	3.93[g]	59.8[h]
Trial 6							
Truck 1	MO	3/21/84	101	471	1.13[d]	0.11[c]	3.3[c]
Truck 2	MO	3/28/84	105	487	1.20[d]	0.05[c]	1.7[c]
Medical Treatment							
No Mass			524		1.45[c]	2.25[c]	33.5[c]
Mass-Medication			523		1.57[d]	0.81[d]	14.7[d]
Feed Treatment							
Control			343		1.52		
Lasalocid			348		1.56		
Decoquinate			356		1.45		

[a] Gain, Sick Days and Morbidity expressed as LSMEAN.
[b] Original number of calves on trial.
[c-h] Means with different superscripts differ (P<0.05).

Gains by the sick cattle (Table 4) were not significantly affected by any of the feed treatments, however, cattle receiving either lasalocid or decoquinate tended to gain faster. Sick cattle receiving treatment for sickness (schedule B or C) had higher gains than sick cattle receiving no treatment (schedule A, $P<0.0037$), and were sick for significantly fewer days.

Sick days in the sick cattle were reduced when supplements contained lasalocid or decoquinate ($P<0.0762$). Decoquinate tended to reduce sick days more than lasalocid. Sick treatment had a significant effect on sick days, with those cattle receiving treatment having fewer sick days than the negative control cattle. Death loss in the negative treatment cattle was 4.7% of those getting sick, compared to 2.9% of those becoming sick in the group that received medical treatment when ill.

Table 4. Rates of gain, sick days and re-pulls--sick cattle.

Item	Number	Daily Gain[a]	Sick Days[a]	% Re-Pulls[a]
Feed Treatment				
Control	82	0.95	6.48	13
Lasalocid	83	1.12	6.22	17
Decoquinate	88	1.21	5.42	2
Effect Of Sick Treatment				
Negative Control	43	0.84	7.56[d]	
Conventional	63	1.25	5.31[c]	7
RO5-0037[b]	68	1.28	6.01[c]	17
Mass-conventional	79	1.02	5.28[c]	15

[a] Gain, Sick Days and Re-Pulls expressed as LSMEAN.
[b] Protocol requires at least a 5 day treatment.
[c,d] Means with different superscripts differ ($P<0.05$).

Table 5. Feed intakes and feed efficiencies.

Item	Number of Pens	Feed Intakes, lb/day[a]	Feed/Gain[a]
Trial 1	6	12.13[b]	7.16[b]
Trial 2	9	13.36[c]	8.69[b]
Trial 3	9	16.05[e]	9.62[b]
Trial 4	9	13.50[c]	9.02[b]
Trial 5	9	14.60[d]	16.74[c]
Trial 6	9	15.57[e]	13.45[d]
Feed Treatment			
Control	17	14.35	11.52
Lasalocid	17	14.32	10.55
Decoquinate	17	13.94	10.27
Medical Treatment			
No Mass	26	14.68[b]	11.64[b]
Mass	25	13.72[c]	9.92[c]

[a] Feed Intakes, Feed Efficiencies expressed as LSMEAN.
[b,c,d,e] Means with different superscripts differ ($P<0.05$).

Feed intakes and feed efficiencies (Table 5) were significantly affected by the trial and the administration of mass-medication. Mass-medication reduced (P<.01) feed intakes from 14.7 to 13.7 lbs per day. Mass-medication improved (P<.04) feed efficiencies (11.6 vs 9.9 lb feed per lb gain).

Ten head died in the study, three of which died of causes not related to the experimental treatments. Post-mortem findings are presented in Table 6.

Table 6. Post-mortem findings.

Trial No./Calf No.	Cause of Death	No. of Days on Trial
1-710	Acute fibrinonecrotic pneumonia	4
2-65	Bovine respiratory disease syndrome (P. hemolytica)	13
2-85[a]	Chronic necrotizing and purulent arthritis with secondary lung abscessation (P. hemolytica and C. pyogenes)	29
4-47	Fibrinous pneumonia (P. hemolytica)	6
4-103	Acute fibrinopurulent pneumonia (P. hemolytica)	13
4-136	Bovine respiratory disease syndrome	15
4-163	Bovine respiratory disease syndrome (P. hemolytica)	15
4-100[a]	Castration hemorrhage	29
5-71	Acute fibrinous pneumonia (P. hemolytica)	10
6-145[a]	Bloat and peritonitis	20

[a] Died of causes not related to diseases being studied.
Death loss rate for the project this season was: overall .76%, mass-medication 0.76, and non-mass medication .76%

The economics of mass-medicating cattle depends on the cost and success of conventional treatment, availability of labor, ability to detect sick cattle early, and on the health status of cattle received. Mass medication at processing usually is not economical for fresh local cattle which experience peak illness at a later time (7-14 days after arrival). Mass medication should reduce labor and drug costs, and increase performance for long-haul, stale, or otherwise stressed calves.

The use of a coccidiostat in the diet or the drinking water for newly arrived shipped cattle has proven more beneficial in previous years at Pawhuska and in field trials reported elsewhere in this research report. No clinical coccidiosis was detected in any cattle during this study. Nevertheless, a coccidiostat should be included in the receiving ration for stale, stressed, or even local sale barn calves as subclinical coccidiosis even without clinical appearance can reduce performance.

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INTENSIVE EARLY STOCKING VS. SUMMER-LONG STOCKING PROGRAMS FOR STOCKER CATTLE ON CROSS TIMBERS RANGELAND

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Story in Brief

One hundred-seventy four head of crossbred beef steers (avg wt = 475 lb) were divided into two replications of two grazing management programs. Steers were grazed at double normal stocking density (steers/ac) for 84 days (4/27 to 7/20; IES) or at normal density for 146 days (4/27 to 9/20; SLS) during the summer of 1984. Average 84 day gains were 207 lb/steer for IES and 209 lb/steer for SLS. Total summer gain for SLS was 293 lb/steer. Cost and return analyses yielded profits of $28.10/head for IES cattle and $26.74/head for SLS cattle. Since twice as many steers were grazed on IES, profit would have increased 110 percent under this program.

(Key words: grazing management, stocker cattle, economics, rangeland)

Introduction

Intensive early stocking (IES) is an adaptation of seasonal suitability grazing and involves grazing range areas by growing animals during the period of high forage quality. The intent of an IES program is to maximize gain/acre without reducing individual animal performance; this is accomplished by stocking heavily during the period when forage quality is high (Smith and Owensby, 1978). "Heavy" stocking is implemented by increasing stock density (animals/acre) rather than stocking rate (animals days/acre).

For the past several years, researchers have studied IES on both shortgrass and tallgrass ranges in Kansas (Smith and Owensby, 1978; Launchbaugh et al., 1983). These studies have shown that IES can increase gain/acre, maintain or improve range condition and increase profitability of the stocker operation. These and other benefits should make IES attractive to Oklahoma stocker operators but few have adapted this grazing management program. The following results are from the first year of a four year study to compare IES and SLS program for stockers on the Cross Timbers range type.

Materials and Methods

In 1984, four pastures on the Pawhuska Research Station were randomly assigned to either intensive-early stocking (IES) or summer-long stocking (SLS). The pastures are comprised of a mosaic of savannah and prairie sites. Proper stocking rates (animal unit days/ac) for each pasture were estimated from SCS soil surveys, visual appraisal of pasture condition and experience of the station herdsman. After yearlong stock-

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ing rates had been established for each pasture, stocking density (animal units/ac) was adjusted to achieve the proper stocking rate under IES and SLS.

On April 27, 174 head of crossbred beef steers averaging 475 lb/hd were weighed and allocated to one of the four treatment pastures. One hundred sixteen head and 58 head were assigned to IES and SLS, respectively. Steers had free access to minerals and ponded water at all times during the summer. Protein supplement (1 lb/hd/day) was fed to SLS cattle during the last 62 days of the summer. All cattle were weighed on the morning of July 20 and SLS cattle were weighed again on the morning of September 20. Weights were taken after a 12 to 16 hour overnight period without feed or water.

Cost-and-return analyses were based on gain data from the steers, market information from the Oklahoma City National Stockyards and the following assumptions: cattle were purchased in March and put through a 28-day receiving program (2 percent death loss, $14/head feed costs, $7/head medical costs), interest rates were 14 percent, pasture lease was $40 per 153 steer days and protein supplement was $200/ton. In addition, costs for labor and implanting were included.

Results and Discussion

Grazing at double stock density had no apparent effect on steer performance during the first 84 days of the summer season (table 1). Average gains were 207 and 209 lb/hd on IES and SLS, respectively. Lower gains on pasture 2 may indicate that stocking rate was over estimated. Despite pasture differences, gains were very acceptable. Adjusting for differences in stocking density, we find that for every pound of gain produced on SLS, IES produced 1.98 lb of gain (206.5 x 2/208.5). Hence, SLS steers would have had to maintain their early summer rate of gain in order to equalize total summer gain between grazing programs. Instead, SLS cattle, supplemented with protein, only gained 85 lb/hd during late summer yielding a total summer gain of 293 lb/hd. If no supplement had been fed, gain would have been 20 to 25 lb less than reported in table 1. Summarizing performance data, IES did not reduce early summer gains but, instead produced 1.41 lb gain for each 1 lb of gain on the conventional summer long program.

Breakeven prices for IES and SLS were $60.06/cwt and $58.31/cwt, respectively (table 2). At the end of the IES period, feeder prices were $64.18/cwt for 680 lb steers and yielded an estimated $28.10 profit/head. Likewise, 770 lb cattle were bringing $61.80/cwt at the end of the SLS program and estimated profits were $26.74/head. Therefore, IES increased net returns 110 percent since twice as many cattle were pastured on this program. For purposes of comparison, cattle without late summer protein supplements would have returned about $22.00/head or 82 percent of SLS with protein and only 39 percent of IES returns.

The increased profitability of IES lies in the optimal use of allowable grazing days on a given pasture. Simplistically, during early summer, approximately two thirds of the potential summer gain is paying for all fixed costs plus one half of rent, labor and interest. During late summer, approximately one third of the potential summer gain is paying for one half of rent, labor and interest and all of the supplementation costs. In the current study, cost of gain was $.345/lb for the first 84

Table 1. **Weights and gains of steers.**

	Pasture	Init wt	7/20 wt	Gain to 7/20	9/20 wt	Gain 7/20 to 9/20	Gain 146 days	Adj[1] gain
Intensive early stocking								
84 days	1	474	689	215	--	--	--	
	2	475	673	198	--	--	--	
	mean	475	681	207	--	--	--	413
Season-long stocking								
146 days	3	472	684	212	764	80		
	4	480	685	205	774	89		
	mean	476	685	209	768	85	293	293

[1]Adjusted gain = gains adjusted for differences in stocking density. For every 1 steer on SLS, 2 steers were on IES. Thus, Adj gain for IES = 84 day gain x 2 and Adj gain for SLS = 146 day gain x 1.

Table 2. Cost-and return analyses for IES and SLS grazing.

	Stocking scheme	
	Season-long 4/27-9/20	Intensive-early 4/27-7/20
Initial wt, lb/hd	475	475
Initial value, $/cwt	71.23	71.23
Initial value, $/hd	338.34	338.34
Final wt, lb/hd	768	681
Final value, $/cwt	61.80	64.18
Final value, $/hd	474.63	437.71
Gross return, $/hd	136.29	99.37
Cash costs, $/hd	109.55	71.27
Breakeven, $/cwt	60.06	58.31
Net return, $/hd	26.74	28.10
Adjusted net return, $1/hd	26.74	56.20

[1]Adjusted for differences in stocking density
IES Adj net return = IES net return/head x 2
SLS Adj net return = SLS net return/head x 1

days and $.45/lb for the final 62 days. These results suggest that by stocking heavily for shorter periods of time one can increase gain/acre, maintain lower costs of gain and increase profit potential. The study will continue for three more years so that a variety of climatic and market conditions should be encountered.

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EFFECT OF LASALOCID ON PERFORMANCE, RUMINAL FERMENTATION AND FORAGE INTAKE OF WHEAT PASTURE STOCKER CATTLE

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Story in Brief

Twenty-seven fall-weaned Hereford heifers that averaged 460 lb in year 1 (1982-83), and twenty-seven Hereford and Hereford x Angus heifers that averaged 488 lb in year 2 (1983-84), were blocked by initial weight (year 1), initial weight within breed (year 2), and were randomly allotted to three treatments. The heifers grazed a common wheat pasture for 100 days in year 1, and 101 days in year 2 and were individually fed a supplement supplying either 0, 100 or 200 mg lasalocid/head/day. Daily weight gains of heifers were increased .25 lb (2.51 vs 2.26) by the highest level of lasalocid. Digestibility of wheat forage and forage intake were not influenced by either level of lasalocid.

(Key Words: Stocker Cattle, Wheat Pasture, Lasalocid.)

Introduction

Supplementation programs for stocker cattle grazing winter wheat pasture offer a means of increasing daily gains and efficiency of forage utilization. Lasalocid, an ionophore, was recently cleared by the Food and Drug Administration for increased rate of weight gain in pasture cattle. However, little information is available on the effect of lasalocid on stocker cattle grazing winter wheat pasture. Results of a two year study to determine effects of lasalocid on weight gains, ruminal fermentation, and forage intake of stocker cattle grazing winter wheat pasture are reported herein.

Materials and Methods

Twenty-seven fall-weaned Hereford heifers that averaged 460 lb in year 1 (1982-83), and twenty-seven Hereford and Hereford x Angus heifers that averaged 488 lb in year 2 (1983-84) were blocked by initial weight in year 1, and initial weight within breeds in year 2, and allotted to three treatments. Treatments consisted of 0, 100 and 200 mg lasalocid/head/day. Heifers grazed a common wheat pasture for 100 and 101 days in years 1 and 2, respectively. The heifers were fed in individual feeding stalls 6 days/week, 2.33 lb supplement that was prorated to supply 0, 100 or 200 mg lasalocid/head/day. Ground corn was used as the carrier feed in year 1. In year 2, supplements consisted of (percent as fed): ground corn, 75 percent; cottonseed hulls, 10 percent; ground alfalfa hay, 8 percent; liquid molasses, 7 percent; and the desired amount of lasalocid. Supplements were fed in pelleted form (3/16 inch pellet).

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Initial, intermediate and final weights were measured each year following a 15 to 17 h drylot shrink without feed or water.

Wheat forage intake and digestibility of dry matter (DMD) and organic matter (OMD) were measured once during each of the 2 trials. Heifers were bolused with gelatin capsules that contained 4 g of chromic oxide twice daily (0800 and 1600 h) during 6-day preliminary and 5-day fecal collection periods. Fecal samples were taken from the rectum at the time of bolusing, dried, and were composited across sampling times for each heifer. Fecal outputs were calculated by the chromium dilution technique while forage DMD and OMD were determined using indigestible neutral detergent fiber (INDF) as an internal indigestible marker. The INDF concentrations of fecal and hand-clipped forage samples were determined as neutral detergent fiber remaining after a 144-h in vitro incubation with 40 ml of buffered rumen fluid.

At the end of each forage intake trial, rumen fluid samples were collected by stomach tube from 7 heifers per treatment. Samples were obtained 4 h after feeding the lasalocid supplements. Heifers grazed wheat pasture after consuming the supplements until rumen fluid samples were obtained. Ruminal fluid pH was measured with a pH meter and glass electrode. Ammonia and volatile fatty acid concentrations were measured by the magnesium oxide distillation method and by gas chromatography, respectively.

Results and Discussion

Effects of lasalocid on heifer performance are shown in Table 1. During the first 57 days of year 1, daily gains of heifers that received 200 mg lasalocid/day were greater than gains of heifers that received 0 or 100 mg lasalocid/day. However, differences among treatments were not significant (P>.05). During the last 43 days, daily gains of heifers that received 200 mg lasalocid/day were greater (P<.05) than those that received 0 or 100 mg lasalocid/day. Daily gains of heifers fed 200 mg lasalocid/day for the entire 100-day grazing period of year 1 were .23 to .26 lb greater (P<.05) than gains of heifers fed 0 or 100 mg lasalocid/day.

In year 2, increasing levels of lasalocid tended to increase daily gains of heifers over the entire grazing period. However, differences among treatments were not significant (P>.05).

Effects of lasalocid on weight gains of heifers in both years are shown at the bottom of Table 1. The year by treatment interaction was not significant (P>.15). Daily gains of heifers fed 200 mg lasalocid/day were .25 lb greater (P<.05) than those of heifers fed 0 or 100 mg lasalocid/day.

Forage Intake Trials

Effects of increasing levels of lasalocid on fecal outputs, DMD, OMD and intake of wheat forage by heifers are shown in Table 2. Data were pooled across years. Year x treatment interaction was not significant (P>.15) for any of the measurements. Forage DM and OM digestibilities were similar for heifers fed 0, 100 and 200 mg lasalocid/day. Forage DM intakes were unusually high. However, fecal ash concentrations were also high (7.0 to 15.0 percent) suggesting that the heifers consumed a considerable amount of soil with the forage. Because insoluble ash appears as a cell wall component in the NDF procedure, fecal NDF concentrations expressed as a percent of fecal DM) would have

Table 1. Effect of lasalocid on daily weight gains (lb) of heifers grazing wheat pasture.

		Mg lasalocid/head/day			
		0	100	200	
Year 1					SE(N=7)
No. of heifers		7	9	9	
Mean initial weight, lb		460^{a}	462^{a}	459^{a}	
Grazing Interval	Days				
12/28/82-2/24/83	57	1.5^{a}	1.54^{a}	1.71^{a}	.076
2/25/83-4/8/83	43	2.17^{a}	2.03^{a}	2.42^{b}	.081
12/28/82-4/8/83	100	1.76^{a}	1.73^{a}	1.99^{b}	.069
Year 2					SE(N=8)
No. of heifers		8	8	9	
Mean initial weight, lb		491^{a}	497^{a}	484^{a}	
Grazing Interval	Days				
1/13/84-2/27/84	45	2.25^{a}	2.54^{a}	2.56^{a}	.123
2/28/84-4/24/84	56	2.75^{a}	2.79^{a}	3.07^{a}	.117
1/13/84-4/24/84	101	2.51^{a}	2.68^{a}	2.85^{a}	.113
Years 1 and 2					SE(N=15)
No. of heifers		15	17	18	
Mean initial weight, lb		477^{a}	478^{a}	472^{a}	
Average daily gain^{c}, lb		2.26^{a}	2.26^{a}	2.51^{b}	.067

[a,b]Means in rows with no or different superscripts are different ($P \leq .05$).
[c]100- and 101-day grazing intervals of years 1 and 2, respectively.

Table 2. Effect of lasalocid on fecal output, digestibility of forage dry matter (DM) and organic matter (OM), and forage intake of heifers grazing wheat pasture[a].

	Mg lasalocid/head/day			
Item	0	100	200	SE
No. of heifers	16	17	18	
Fecal output, % of body wt				
DM	.66	.64	.68	.023
OM	.59	.58	.61	.021
Forage digestibility, %				
DM	84.78	84.25	83.83	.370
OM	82.26	81.42	81.27	.449
Forage intake, % of body wt				
DM	4.40	4.13	4.23	.187
OM	3.36	3.12	3.33	.141

[a]Pooled data of years 1 and 2. Differences among treatment means are not significant ($P > .05$).

Table 3. Effect of lasalocid on ruminal fermentation.

	Year 1				Year 2				
	Mg lasalocid/head/day				Mg lasalocid/head/day				OSL[a]
	0	100	200	SE	0	100	200	SE	year x trt
No. of heifers	6	7	7		7	7	7		
pH	6.9[d]	6.9[d]	6.6[e]	.07	7.2[d]	7.1[d]	7.0[d]	.14	.49
Ammonia (mg/100 ml)	10.57[d]	15.22[e]	17.81[e]	1.71	8.32[d]	11.95[d]	11.66[d]	1.44	.40
Total[b] VFA,mmole/liter	96.95[d]	109.35[d]	128.58[e]	8.90	74.54[d]	83.74[d]	77.82[d]	9.45	.21
VFA molar proportions[c]									
Acetic	56.6[d]	58.1[d]	56.6[d]	.89	59.8[d]	59.0[d]	60.0[d]	.93	.08
Propionic	20.7[d]	20.1[d]	18.9[d]	.62	21.0[d]	21.7[d]	21.7[d]	.57	.09
Isobutyric	1.9[d]	1.9[d]	2.2[d]	.18	1.3[d]	1.3[d]	1.3[d]	.07	.33
Butyric	16.3[d]	14.9[d]	17.4[d]	.86	14.8[d]	15.6[d]	13.4[d]	.84	.02
Isovaleric	2.9[d]	2.9[d]	2.8[d]	.23	1.2[d]	1.4[d]	1.7[e]	.13	.20
Valeric	1.6[d]	1.8[d]	2.1[d]	.24	2.0[d]	1.9[d]	1.8[d]	.15	.27
Acetic:propionic ratio	2.7[d]	2.9[d]	3.0[d]	.11	2.9[d]	2.7[d]	2.8[d]	.10	.17

[a]Observed Significance Level.
[b]Acetic, propionic, isobutyric, butyric, isovaleric and valeric acids.
[c]VFA molar proportions (moles/100 moles).
[d,e]Means in rows within year with different superscripts are different ($P<.05$).

been biased upwards. Thus, forage DM intakes would be biased upwards. Estimates of forage OM intakes would not be biased by high fecal ash concentrations. Intakes of forage OM were not, however, affected (P>.05) by either level of lasalocid.

Ruminal Fermentation Measurements

Ruminal fluid pH, ammonia and VFA concentrations of the heifers are shown in Table 3. Rumen fermentation data are presented by year since year x treatment interaction was significant (P<.10) for molar proportions of acetic, propionic and butyric acids.

In year 1, 200 mg lasalocid reduced rumen pH (P<.05). A similar, nonsignificant (P>.05) trend was observed for rumen pH in year 2. Rumen ammonia concentrations were increased (P<.05) by both levels of lasalocid in year 1. A somewhat similar trend for rumen ammonia concentrations was observed in year 2, but treatment means were not different (P>.05).

Consistent general trends were not observed with regard to effects of lasalocid on total VFA concentrations, molar proportions of individual acids and acetic:propionic acid ratios. Total VFA concentrations of heifers fed 200 mg lasalocid were increased (P<.05) in year 1. This effect was not observed in year 2. Neither level of lasalocid affected (P>.05) the molar proportions of acetic, propionic or butyric acids, or the acetic:propionic acid ratio in ruminal fluid samples. Isovaleric acid concentrations of heifers of year 2 were increased (P<.05) with increasing level of lasalocid.

This study indicates that 200 mg lasalocid/day is effective in increasing weight gains of stocker cattle on wheat pasture. The mechanism(s) by which weight gains were increased needs further study. Alterations by lasalocid of site of digestion of forage OM and flow of forage protein to the post-ruminal tract may be involved.

USE OF SILAGE IN WHEAT PASTURE AND BERMUDAGRASS STOCKER PROGRAMS

G.J. Vogel[1], W.A. Phillips[2], G.W. Horn[3] and M.A. Worthington[4]

Story in Brief

Ninety-six fall-weaned steers averaging 425 lb were placed on wheat pasture and subsequently bermudagrass. Steers of treatment 1 received no silage, while those of treatments 2, 3 and 4 had ad libitum access to sorghum silage on pasture. Initial stocking densities on wheat pasture were 2.25, 2.25, 1.69 and 1.12 acres per steer and .8, .8, .56 and .38 acres per steer for treatments 1 through 4, respectively, on bermudagrass. Mean intakes of silage dry matter (DM) by steers on wheat pasture were 1.46, 1.64 and 2.40 lb DM for treatments 2, 3 and 4, respectively. Silage was fed on bermudagrass only when amounts of bermudagrass became limiting. Silage was fed for 6 and 99 days with mean DM intakes of 8.14 and 6.67 lb per head per day for treatments 3 and 4. Daily gains of steers on wheat pasture and bermudagrass were not different (P>.05) among treatments. Use of supplemental silage in wheat pasture and bermudagrass stocker programs allowed stocking densities to be doubled and gains of cattle to be maintained during periods of inadequate forage availability.

(Key Words: Wheat Pasture, Bermudagrass, Stocker Cattle, Silage.)

Introduction

Rate of weight gain of stocker cattle is of primary importance to the stocker cattle operator. Gains of cattle grazing wheat pasture and bermudagrass are potentially good. However, these gains may be depressed because of inadequate amounts of available forage. In addition, performance of cattle on wheat pasture may be limited because of snow and(or) ice cover. A sound supplementation program using silage might alleviate these problems. The silage could serve as a substitute during periods of bad weather or serve to stretch existing forage supplies during periods of inadequate growth. Therefore, a study was initiated in the fall of 1981 to investigate the effects of silage supplementation on performance of stocker cattle on wheat pasture and bermudagrass. The primary objective of the study was to attempt to add stability to the existing forage supply by using silage. The data herein represent the third year of the study. Data from years 1 and 2 were reported by Ford et al. (1983) and Phillips et al. (1984).

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Materials and Methods

Wheat Pasture

Twenty-four Hereford, 40 Hereford x Angus and 32 Limousin cross steers averaging 425 lb were randomly allotted (within breed by weight) into 2 blocks of 48 steers, with each block consisting of 4 treatments. Treatment 1 served as the control and received no silage, while steers of treatments 2, 3 and 4 had ad libitum access to sorghum silage on pasture. Stocking densities were 2.25, 2.25, 1.69 and 1.12 acres per steer for treatments 1 through 4. On December 7, initial availabilities of forage DM were 875, 1112, 674 and 600 lb/hd for treatments 1 through 4. Because of the large amounts of forage that were initially available to the steers, silage supplementation began on January 9 and continued through March 19 (68 days). The silage had a mean dry matter, crude protein and in vivo dry matter digestibility of 24.7 percent, 9.5 percent of DM and 53.4 percent, respectively. During days of snow and ice cover, steers of treatment 1 received old world bluestem hay. Approximately 6.7 lb/hd/day were fed for 9 days.

During the wheat pasture grazeout period (March 21 to May 23), steers of all treatments were combined within blocks and allowed .6 acres/steer. During the grazeout period, no supplemental silage was fed. Forage availability was estimated throughout the wheat pasture grazing period by hand clipping 3 one-half square meter plots at selected times to coincide with major changes in climatic conditions.

Bermudagrass

The same steers used for the wheat pasture phase were subsequently grazed on bermudagrass. All steers remained in their assigned treatments from the wheat phase. Initial stocking rates for treatments 1 through 4 were .8, .8, .56 and .38 acres of bermudagrass per steer.

During the bermudagrass phase (May 23 to September 11), steers in each treatment followed a rotational grazing system in which each pasture was divided by electric fencing into two paddocks. Cattle grazed a single paddock until the bermudagrass became limiting and then were subsequently rotated between paddocks until the forage supply of both paddocks became low. At this point steers were given access to both paddocks. The objective of the rotational grazing was to keep the available forage between 1 to 4 inches tall. If the available forage of ungrazed pastures became too abundant and the cattle could not maintain the pasture, the ungrazed pastures were mowed and baled as hay.

Silage was fed to steers in each treatment only when the available forage became limiting. Silage was fed to steers in treatments 3 and 4 for 6 and 99 days, respectively. Bermudagrass never became limiting in treatment 2. Hence, no silage was fed.

All pastures were fertilized with 50 lb of nitrogen (as urea) on May 8, June 18, and August 8. Additionally, all pastures were mowed following the initial grazing to remove senescent cool season annual grasses.

Results and Discussion

Wheat Pasture

Silage dry matter intakes of steers and forage availabilities are presented in Figures 1 and 2. During the week of January 12, silage

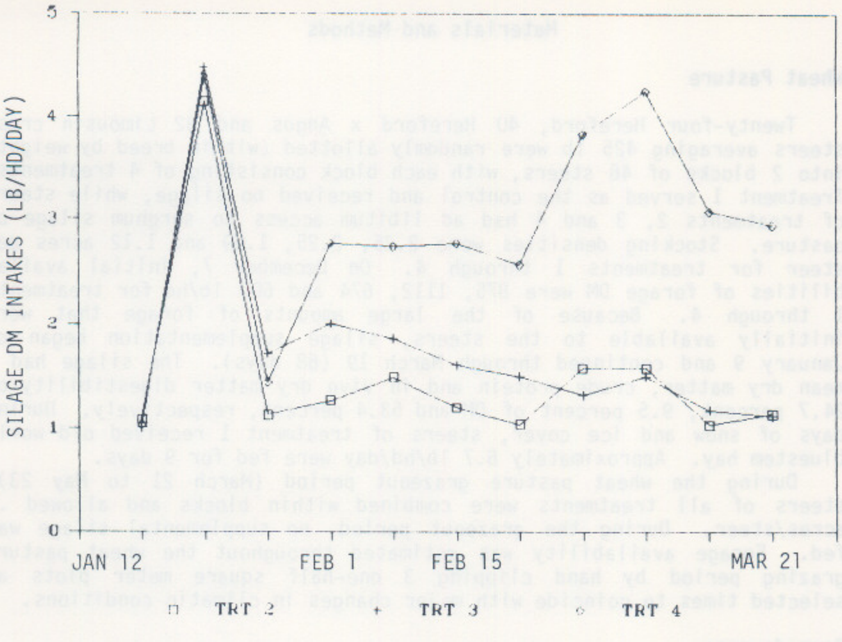

Figure 1. Silage DM intakes of steers grazing wheat pasture.

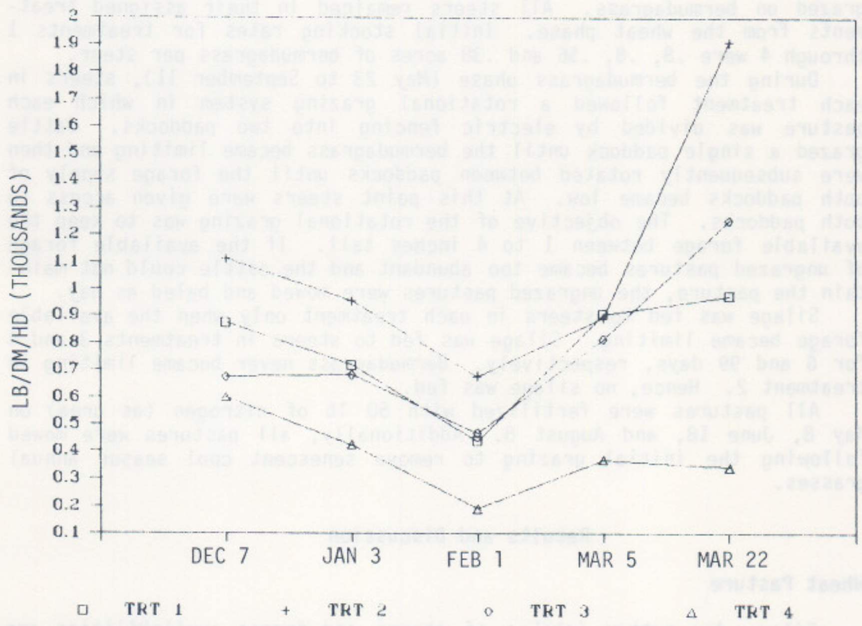

Figure 2. Availabilities of wheat forage.

consumption of steers of all treatments increased rapidly due to snow cover of wheat forage. Silage intake subsequently decreased as the snow melted. Because of extremely cold weather during the study, forage growth was depressed. Available forage for treatment 4 was lowest on February 1 when forage availability was 190 lb DM/hd (Figure 2). Steers of treatment 4 compensated by increasing silage consumption. Silage intakes of steers of treatments 2 and 3 were similar, reflecting the similarities in forage availability. Silage DM consumption ranged from .93 to 4.91 lb DM/hd/day for steers of both treatments 2 and 3 (Figure 1).

Average daily gains (Table 1) of steers of all treatments were similar, indicating that supplemental silage will maintain gains of stocker cattle on wheat pasture during periods of inadequate forage growth. Additionally, gains of steers of all treatments were not different (P>.05) during the grazeout period.

Table 1. Mean initial body weights and daily gains of steers on wheat pasture and bermudagrass.

	Treatment			
	1	2	3	4
No. of steers	24	24	24	24
Wheat pasture				
Initial wt, lb	427	428	419	426
Daily gains, lb				
12/7/83-3/21/84(105 days)	2.09[a]	2.37[a]	2.55[a]	2.33[a]
3/21/84-5/23/84(61 days) (grazeout period)	2.41[a]	2.27[a]	2.17[a]	2.56[a]
Bermudagrass				
Initial wt, lb	794	814	819	826
Daily gains, lb				
5/23/84-9/11/84(112 days)	1.23[a]	1.36[a]	1.44[a]	1.37[a]
Wheat pasture and Bermudagrass (278 days)	1.82[a]	1.94[a]	2.02[a]	1.99[a]

[a]Means are not different (P>.05).

Bermudagrass

Silage DM intakes of steers on bermudagrass are shown in Figure 3. Silage was fed only when amounts of bermudagrass became limiting and could not withstand grazing pressures. Silage was fed for 6 days (September 6 to September 10) and 99 days (June 4 to September 10) for steers of treatments 3 and 4, respectively. Bermudagrass never became limiting for steers in treatment 2. Hence, no silage was offered. Silage intakes increased steadily for steers of treatment 4 from 5.0 (July 9) to 13.8 lb/hd/day (September 10) as the amount of available bermudagrass decreased. Daily gains of steers of all treatments during both periods were similar (Table 1). Gains of cattle at the higher stocking densities were maintained with supplemental silage when available forage became limiting.

Results from this year indicate the use of supplemental silage will allow stocking densities to be increased on wheat pasture and bermudagrass without decreasing cattle performance as amounts of available

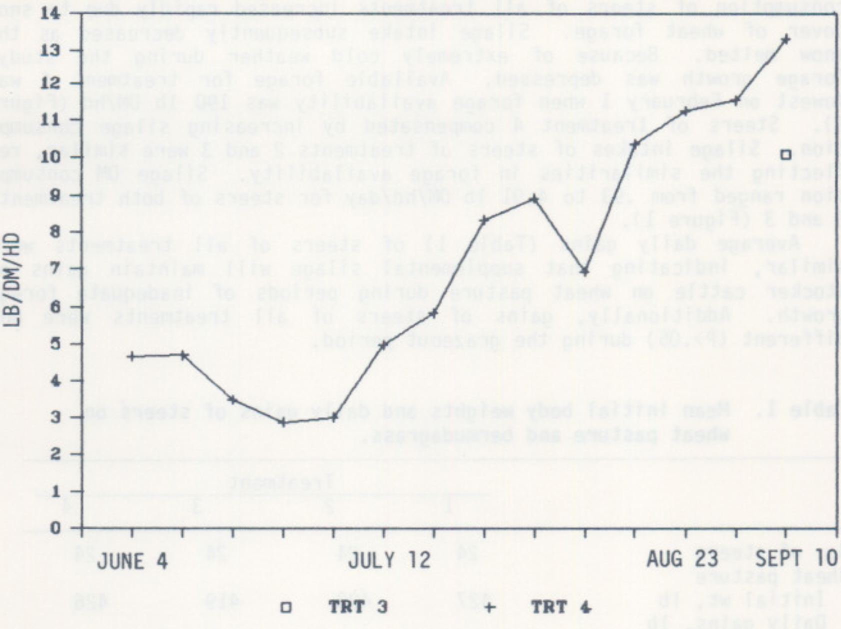

Figure 3. Silage DM intakes of steers grazing bermudagrass.

forage decrease for stocker cattle of the higher stocking densities. An economic analysis will be conducted upon completion of this project.

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RESPONSE OF FALL BORN CALVES TO SYNOVEX®C IMPLANTS AND REIMPLANTS

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Story in Brief

Two trials, involving 469 steer and heifer calves, were conducted to evaluate the practices of implanting or reimplanting suckling fall born calves with Synovex®C implants. Calves having an average initial weight of 148 lb were randomly allocated within sex and location to remain either as nonimplanted controls or to receive a Synovex®C implant in the late fall, in the spring, or in both fall and spring. Nonimplanted calves in Trial 1 gained 1.26 lb/day during the winter months, and Synovex®C implants improved growth rate by 7% to 1.34 lb/day ($P<.05$). Average daily gain (ADG) of calves during the winter months of Trial 2 was only .45 lb/day, and was not affected by implanting with Synovex®C. ADG of calves during the spring and summer was improved an average of 4.3 to 10% ($P<.05$) by Synovex®C in both trials regardless of when they were implanted. ADG of calves over the entire 8-month trials was 1.46 lb/day for nonimplanted calves and was improved ($P<.01$) to 1.55, 1.55 and 1.56 lb/day for calves on the two single implant and reimplant schedules, respectively. Implanted calves gained an average of 23 lb more than nonimplanted calves during the study.

(Key Words: Synovex®C Implants, Suckling Calves, Growth Promotion.)

Introduction

Research with Synovex® implants has demonstrated that a 4-pellet implant containing 10 mg of estradiol benzoate and 100 mg of progesterone is both safe and effective for improving growth rates of suckling steer and heifer calves (Spires et al., 1983; FDA, 1983). All efficacy trials supporting those claims, however, were conducted using spring calves in which cows and calves were grazing pastures of sufficient quality to maintain minimum ADG of calves above 1.4 lb/day at all times during the study (Spires et al., 1983; Gill et al., 1984). Rearing of fall calves constitutes a different situation than rearing of spring calves, since poor pastures decrease available dietary energy to the suckling calf at a time when cold environmental temperatures increase the maintenance energy requirement. Consequently, gains of suckling calves on winter pastures typically are lower than on spring pastures and the benefits of implanting with Synovex®C under those conditions have not been established. Furthermore, effects of early calfhood implanting upon growth rate of the calf several months later also is a subject on which little information is available.

This study was conducted to monitor the performance until weaning of fall calves which were implanted with Synovex®C, either in the fall, the spring, or both the fall and spring, and to compare those gains with calves that remained nonimplanted throughout the entire study.

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Materials and Methods

Four hundred sixty-nine suckling calves, having an average initial weight of 148 lbs, were selected for two trials. One hundred thirty-eight steer and 155 heifer Hereford calves were used for Trial 1 near Claremore, Oklahoma, while 82 steer and 94 heifer Hereford and Hereford X Angus cross calves were used for Trial 2 at Mill Creek, Oklahoma. Calves were pastured with their dams on native bluestem range throughout the study. The forage was dormant from the start of the trials until the beginning of the growing season, about May 1. Calves were individually identified by eartags and were randomly assigned, within sex, to one of the following four treatments: (1) control-control, no implants throughout the study; (2) Synovex-control, implanted only on the first day of the study; (3) control-Synovex, nonimplanted during the first period of the study but received an implant just prior to green grass; and (4) Synovex-Synovex, implanted both at the beginning of the trial and reimplanted just prior to green grass. The start, reimplant, and end dates were November 30, April 17, and July 25, respectively, in Trial 1, while the same dates for Trial 2 were December 8, April 5 and August 15.

Synovex®C implants were placed in the top central one-third of the ear. All calves were weighed on the first day of the study and received blackleg vaccinations. All bull calves were castrated at that time. Calves were reweighed at the reimplant dates and again at the end of the trials. ADG of each calf was calculated for both the first and second periods and for the total trial. Data were analyzed by analysis of variance (GLM, SAS, 1979) and treatment means were compared by Duncan's Multiple Range Test in the event that a treatment effect ($P<.05$) was detected.

Results

Performance of calves between the two locations was different (Table 1, $P<.0001$). Calves in Trial 2 were larger than in Trial 1 at the start of the study, but calves in Trial 1 gained faster in both the winter and summer months so that the average weights of calves at reimplanting and weaning were larger in Trial 1 than in Trial 2. Steers and heifers gained at a similar rate during the winter months, but steer calves gained slightly faster than heifer calves (2.20 -vs- 2.10 lb/day across all treatments) when green grass was available ($P<.01$). No interactions between locations, sex and implant treatments were detected, indicating that both sexes tended to respond similarly to implants at both of the trial locations (Table 1).

In Trial 1, nonimplanted calves gained 1.26 lb/day during the winter months, and Synovex®C implants improved ADG approximately 7% to 1.34 lb/day (Table 2, $P<.05$). However, during the winter months in Trial 2, ADG of all calves was less than .5 lb/day, and no differences in growth rates of implanted -vs- nonimplanted calves were observed (Table 3). Consequently, the combined results for both studies illustrate a trend toward improved ADG of implanted calves during the winter months (Table 4), but the lack of response in the slower gaining calves in Trial 2 precluded statistical significance.

The combined analysis revealed that ADG of calves in the summer months was increased by Synovex®C implants regardless of when the calves had been implanted (Table 4) and the same observation was apparent in both of the individual trials (Tables 2 and 3). Calves which remained nonimplanted throughout the entire study gained 2.04 lb/day

Table 1. Analysis of variance of average daily gain[a] of calves implanted or reimplanted with Synovex®C.

Source of Variation	df	Prob F for Average Daily Gain Period 1	Period 2	Cumulative
Location	1	.0001	.0001	.0001
Treatment	3	.2191	.0009	.0080
Location x treatment	3	.4103	.6552	.5610
Sex	1	.5379	.0070[b]	.1560
Location x sex	1	.7837	.4712	.9458
Treatment x sex	3	.6817	.8249	.5594
Location x treatment x sex	3	.1652	.4123	.0792
Error	468	--	--	--

[a]Error mean square was used as the error term to compute all F-ratios.
[b]Steers gained faster than heifers during Period 2.

Table 2. Performance of calves implanted with Synovex®C at the Ingersol Ranch (Trial 1).

Variable	Control-Control	Synovex®C-Control	Control Synovex®C	Synovex®C-Synovex®C	SE
Number of calves	75	75	70	73	--
Initial wt, lb	141	139	133	137	4
Reimplant wt, lb	315	322	305	328	8
Period 1 ADG*, lb	1.26^{ab}	1.32^{ab}	1.24^{a}	1.37^{b}	.04
Final wt, lb	524	547	533	544	10
Period 2 ADG, lb	2.12^{a}	2.29^{b}	2.31^{b}	2.20^{ab}	.05
Overall ADG, lb^{c}	1.62^{a}	1.72^{b}	1.69^{ab}	1.72^{b}	.03
% increase		6.2	4.3	6.2	

[ab]Means with different superscripts differ ($P<.05$).
[c]Length of trial was 139 days for Period 1 and 99 days for Period 2.
*ADG of calves implanted with Synovex®C during Period 1 was 1.34 lb/day compared with 1.25 lb/day for nonimplanted calves ($P<.05$).

Table 3. Performance of calves implanted with Synovex®C at the Daube Ranch (Trial 2).

Variable	Control-Control	Synovex®C-Control	Control Synovex®C	Synovex®C-Synovex®C	SE
Number of calves	45	44	52	45	--
Initial wt, lb	165	165	164	162	8
Reimplant wt, lb	215	214	220	218	7
Period 1 ADG, lb	.43	.41	.47	.47	.03
Final wt, lb	467	480	495	489	11
Period 2 ADG, lb	1.91^{a}	2.02^{ab}	2.09^{b}	2.05^{b}	.04
Overall ADG, lb^{c}	1.20^{a}	1.26^{ab}	1.32^{b}	1.30^{b}	.03
Percent increase		5.0	10.0	8.3	

[ab]Means with different superscripts differ ($P<.05$).
[c]Length of trial was 119 days in Period 1 and 132 days in Period 2.

Table 4. Performance of calves implanted with Synovex®C in the two trials combined.

Variable	Control-Control	Synovex®C-Control	Control Synovex®C	Synovex®C-Synovex®C	SE
Number of calves	120	119	112	118	--
Initial wt, lb	150	148	145	147	4
Reimplant wt, lb	278	282	273	286	5
ADG, winter, lb	.95	.98	.95	1.03	.03
Final wt, lb	502	522	519	523	7
ADG, summer, lb	2.04[a]	2.19[b]	2.23[b]	2.14[b]	.03
Overall ADG, lb[c]	1.46[a]	1.55[b]	1.55[b]	1.56[b]	.02
Percent increase		6.2	6.2	6.8	

[ab]Means with different superscripts differ (P<.01).
[c]Weighted average length of the two trials was 131 days for Period 1 and 110 days for Period 2.

during the last 110 days of the trial (Table 4). ADG of calves which were implanted with Synovex®C only at the beginning of the trial was 2.19 lb/day, while ADG of calves implanted during the last 110 days and those implanted both at the beginning and middle of the study were 2.23 and 2.14 lb/day, respectively. Summer gains of calves which were implanted either at the start of the study, the middle of the study, or at both times were greater than gains of calves that remained nonimplanted (P<.01), but no differences in ADG of calves among any of the three implanting schedules were observed.

ADG of calves calculated over the entire study also was increased by Synovex®C regardless of the time of implanting. ADG of calves implanted either at the beginning of the study or at the midpoint was 1.55 lb/day compared to 1.46 lb/day for calves which were not implanted (Table 4, P<.01). Reimplanted calves also gained faster than nonimplanted controls (1.56 lb/day, P<.01), but no benefit of reimplanting compared with a single implant either at the beginning or middle of the study was observed.

Discussion

The growth rate of suckling fall calves implanted with Synovex®C averaged 6 to 7% faster than nonimplanted calves. Consequently, the final weaning weights, adjusted for equal starting weights, averaged 22 lbs heavier for calves implanted once during the trial and 24 lbs heavier for calves which were reimplanted with Synovex®C. This 6 to 7% improvement in performance of fall calves agrees closely with the percentage increases previously observed when Synovex®C and other anabolic implants have been used in trials with spring calves (Basarab et al., 1984; Gill et al., 1984; Lamm and Greathouse, 1984; Lewis et al., 1978; Simms, 1984; Spires et al., 1983).

This study helped to allay some of our primary concerns regarding the use of growth promoting implants in suckling calves pastured on dry winter pastures. It has been reported that the estrogenic implants (Synovex®S, zeranol, and formerly DES) increase the concentration of thyroxin in plasma by increasing its secretion from the thyroid gland

(Gopinath and Kitts, 1982; Kahl et al., 1978). In addition, slight increases in heart rate, fasting urinary nitrogen excretion and fasting heat production also have been observed in cattle fed or implanted with DES and implanted with Synovex®S which suggest that the estrogenic implants slightly increase maintenance energy requirements (Rumsey et al., 1973; Rumsey et al., 1980; Tyrell et al., 1975). Early research also indicted that animals fed a submaintenance diet lost weight more rapidly if DES was included (Oltjen et al., 1973). More recently, Rumsey and Hammond (1984) demonstrated a typical 22% increase in ADG of feedlot steers implanted with Synovex®S and fed ad libitum, but they were unable to detect a response to Synovex®S in steers fed a restricted energy diet which supported an ADG of only 1.9 lb/day. Consequently, one of the major concerns in designing this trial was the prospect that performance of calves over winter might actually be depressed if maintenance energy requirements were increased by the Synovex®C implants.

Fortunately, no depression in growth rate of implanted calves over the winter was observed. ADG of nonimplanted calves in Trial 2 was only .45 lb/day during the winter months and average growth rate of calves implanted with Synovex®C during that period also remained at the same rate or .45 lb/day. Calves on better pastures and gaining 1.26 lb/day during the winter in Trial 1, however, benefited from Synovex®C during that time period. Consequently, maintenance energy requirements were not increased by Synovex®C implants to an extent that their use was contraindicated over the winter months. In previous studies conducted to identify the optimum steroid combination and optimum dose for suckling calves, it was found that the 8-pellet Synovex®H implants were not as effective as a half dose of the same estradiol benzoate-testosterone propionate formulation in calves gaining less than 1 lb/day (Spires et al., 1983). Likewise, the same tendency also was true when the 8-pellet Synovex®S implant was compared with the 4-pellet Synovex®C. Those observations also support the hypothesis that the growth promoting implants may tend to increase maintenance energy requirements and, consequently, was a major reason that a 4-pellet -vs- an 8-pellet Synovex implant was developed for suckling calves.

The extended effectiveness into the spring and summer months of the Synovex®C implant in calves implanted only in the fall was not really expected. Overall ADG throughout the trials, which averaged 241 days, did not differ among any of the implant treatments, regardless of when the implants were administered. Furthermore, performance during the average 110 days in the spring-summer period of these trials was improved more than 7% ($P<.01$) by implanting calves during the preceding winter, 131 days before the spring-summer period began. Rumsey et al (1984) recently reported that approximately 75% of the original doses of both progesterone and estradiol were absorbed by 60 days and 85% by 120 days in growing-finishing steers implanted with Synovex®S. Those observations seem somewhat inconsistent with out observation that a larger improvement in the performance of suckling calves was observed during the period from 131 to 241 days after implanting than from 1 to 131 days. Greathead (1984) recently reviewed studies with zeranol implants and concluded that the response may be large and of relatively short duration in rapidly growing cattle on high levels of energy intake. However, smaller improvements in growth rate, but occurring over a longer duration, are more typically observed in cattle gaining less than about 1.5 lb/day. Observations we have made in studies with Synovex®C also tend to support that hypothesis (H.R. Spires, et al., unpublished observations). However, any differences in absorption, tissue distribution and/or metabolism and elimination of the implant materials, which may explain those different responses, have not been elucidated.

Observations that a positive response from Synovex®C can be realized regardless of whether fall calves are implanted in the fall or the spring gives cow-calf producers considerable flexibility in implementing an implant program.

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SALT-LIMITED CREEP FEED FOR NURSING CALVES

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Story in Brief

Seventy-two spring-born nursing calves were allotted to Control (no creep) or Creep-fed cottonseed meal in a creep feeder with salt added to limit intake to about 1 lb/head/day from July 17 to October 2. Thirty eight fall-born calves were similarly allotted to Control (no creep) or Creep-fed treatments and fed from June 1 to August 3. Spring-born calves and their dams grazed native range near Stillwater while fall-born calves and their dams grazed bermudagrass pastures near Muskogee. Spring-born calves consumed an average of .88 lb of cottonseed meal/head/day and gained .32 lb/day faster (P<.01) than Control calves. Fall-born calves ate an average of .68 lb of cottonseed meal/head/day and gained .3 lb/day faster (P<.01) than Control calves. The percent salt required to limit intake to about 1 lb/head/day was 10% for fall calves and 15% for spring calves. At a cottonseed meal cost of $.10/lb, the cost of added gain for fall-born calves was $.23/lb and $.28/lb for spring-born calves.

(Key Words: Salt-Limited, Protein, Creep Feed, Beef Cattle.)

Introduction

Creep feeds for nursing calves have traditionally consisted of grain mixtures fed free-choice. Daily intakes typically reach 6-8 lbs/head/day with conversions of creep to added gain between 5:1 and 15:1. The high costs of mixed rations and the poor feed conversions have seldom made creep feeding feasible for commercial cow-calf operations. Research has shown that supplementing relatively small amounts of high protein feeds to stocker cattle grazing native grass or bermudagrass from mid- to late summer increases forage intake and digestibility and results in efficient conversions of supplement to added gain. If nursing calves would respond to protein supplementation as efficiently as stocker calves, limit-fed high protein creep feeds might offer a method of profitably increasing weaning weights in commercial cow-calf operations.

Materials and Methods

Trial 1

Thirty-eight fall-born Simmental crossbred calves nursing Hereford x Angus cows were used to study the effects of a salt-limited cottonseed meal creep on the rate and efficiency of calf gain. This trial was conducted at the Eastern Research Station near Muskogee in eastern Okla-

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homa. Forage consisted of bermudagrass that was 8-10 inches tall at the start of the study. Calves were allotted by sex, birthdate and age of dam on June 1 to two treatment groups; (1) Control, grazing with no creep feed, and (2) Creep Feed, to receive free-choice salt-limited cottonseed meal at a rate of about 1 lb/head/day. Creep was provided in a whirlwind mineral feeder equipped with a rubber pan that could hold approximately 50 lb of cottonseed meal and salt. A small creep feeding area was constructed with portable panels and a creep gate allowing access only to calves. Initial mixtures consisted of 5% salt and 95% cottonseed meal with a small amount of hay to entice the cattle into the creep feeding area. Creep intake was measured three times each week and the percent of salt was increased as necessary to maintain cottonseed meal intake at about 1 lb/head/day. The trial lasted from June 1 to August 3 when calves were weaned at about 10 months of age. Calves were weighed after overnight withdrawal from feed and water.

Trial 2

Seventy-two Hereford, Angus and Hereford X Angus calves nursing Hereford and Angus cows were used. Procedures were similar to Trial 1 with the following exceptions. Calves were born between late February and mid-April. Cows and calves grazed native range near Stillwater in North Central Oklahoma. Allotment to treatment groups was based on calf birth date and breed of dam. The study began on July 17 and ended on October 2 when the calves were weaned.

Table 1. Gain and efficiency of calves fed salt-limited creep on bermudagrass pastures.

	Control	Creep-fed	Prob.
Number of calves	18	20	
Initial weight, June 1 (lb)	437	442	
Daily gain, 63 days (lb)	1.24	1.54	P<.01
Lb creep/lb added gain		2.27	
Cow weight, June 1 (lb)	931	903	
Cow weight change, 63 days (lb)	53	70	

Table 2. Gain and efficiency of calves fed salt-limited creep on native grass pastures.

	Control	Creep-fed	Prob.
Number of calves	36	36	
Initial weight, July 17 (lb)	247	261	
Daily gain, 76 days (lb)	1.60	1.92	P<.01
Lb creep/lb added gain		2.79	
Cow weight, July 17 (lb)	942	950	
Cow weight change, 76 days (lb)	116	115	
Cow condition score, July 17[a]	5.2	5.4	
Cow condition change, 76 days	+.6	+.4	

[a]1=very thin, 9=very fat.

Results and Discussion

Trial 1

The calves were 7-9 months of age at the start of creep feeding and averaged 440 lbs in weight (Table 1). Creep-fed calves gained 1.54 lb/head/day compared to 1.24 for Control calves ($P<.01$). Creep consumption ranged from .25 to 1.55 lb/head/day and averaged .68 lb/head/day for the 63 day trial period. Two weeks were required for the calves to begin consuming the creep, and then the desired cottonseed meal intake was sustained by adjusting the salt content to between 5 and 10%. A level of 15% salt reduced intake below the 1 lb/head/day level. Creep-fed calves had slicker haircoats and appeared thriftier than Control calves. This difference in appearance is consistent with observations of stocker cattle fed protein supplements during the summer. Weight changes were similar for dams of Control and Creep-fed calves.

Trial 2

The calves used in Trial 2 were younger (4-6 months old) and lighter (254 lbs) than the fall-born calves used in Trial 1. The native grass pastures had not been grazed during the summer prior to the creep feeding study and contained ample forage. The creep feeding area was established under a shade tree close to a stock pond in a 160 acre pasture. A period of about 10 days was required for daily cottonseed meal consumption to reach the desired 1 lb/head/day. A salt level of 15% was adequate to maintain the desired intake of cottonseed meal. Creep-fed calves gained .32 lb/head/day more than Control calves ($P<.01$) with a conversion of 2.79 lb cottonseed meal/lb of added gain. Differences in animal appearance was obvious, similar to results of Trial 1.

No differences in weight or condition change were noted among dams of Control and Creep-fed calves. This observation is consistent with other studies that have shown no effect of creep feeding on milk intake of calves.

The efficient conversion of cottonseed meal to added gain seen in both trials strongly suggests that forage intake and/or digestibility was increased. At a cottonseed meal cost of $.10/lb, the cost of added gain would have been about $.23 for calves in Trial 1 and $.28 for calves in Trial 2.

As in all programs dependent on forage intake responses, a protein-based creep feeding program assumes that adequate forage is available. Aside from the low cost of added gain, a salt-limited high protein creep feeding program has the advantage of reducing the amount of creep feed that must be handled. It is likely that the addition of growth promotives such as Rumensin could further improve the efficiency of creep feed conversion to added gain. It is also probable that the addition of Rumensin will permit a reduction in the amount of salt needed to limit intake. This comparison is planned for future studies at OSU.

EFFECT OF PROTEIN SUPPLEMENTATION ON STOCKERS GRAZING NATIVE GRASS IN SOUTHEASTERN OKLAHOMA

Jim Cantrell[1], Gerald Bryan[1] and K.S. Lusby[2]

Story in Brief

A cooperative field trial was conducted to determine the effect of supplemental protein on the performance of calves grazing native grass on reclaimed timber land in southeastern Oklahoma. Forty calves were assigned to either a control group receiving no supplement, or a supplemented group which received 1.07 lbs/day of soybean meal cubes (44% CP) per day (2.5 lbs/head fed Monday, Wednesday and Friday). For the 56 day trial period in late summer, the supplemented calves gained .49 lbs/day more than control calves (1.32 lbs/day -vs- .83 lbs/day, respectively). The results of this trial indicate that protein supplementation can significantly increase gain of stocker calves grazing native grass in southeastern Oklahoma.

(Key Words: Protein, Stocker Cattle, Brushland.)

Introduction

Several studies have been conducted in central and north-central Oklahoma to determine the effectiveness of protein supplementation in improving the gains of stocker calves grazing native grass pastures. The harvesting of timber and the use of herbicides to remove forest cover have released a substantial amount of land to forage production. Much of this land is too rough to plant improved forages, and consequently is typically covered by native grasses released after removal of the forest canopy. The objective of this field trial was to determine if protein supplementation would economically increase gains of stockers grazing native grasses grown on reclaimed forest land.

Materials and Methods

Forty Angus and Angus X exotic crossbred steers, approximately 10 months old, were assigned to either a control or a supplemented treatment group. The supplemented group received 1.07 lb/head/day of soybean meal cubes and were fed 2.5 lbs/head on Monday, Wednesday and Friday. Both treatment groups had access to a free choice salt/mineral mix.

This trial was conducted on the Kerr Foundation Ranch in southeastern Oklahoma, and utilized 160 acres of land that had been treated four years earlier with Graslan® herbicide. This tract was divided into two pastures of 80 acres each, and stocked at a rate of four acres per calf. Pastures were rotated at the intermediate weigh period to reduce any pasture effects.

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Results and Discussion

The results of this trial are in agreement with similar trials conducted in other sections of Oklahoma (Lusby et al., 1982; Lusby and Horn, 1983). Feeding small amounts of high protein supplement resulted in a significant improvement in stocker performance (Table 1). This trial was conducted August 16 to October 11, and as the season progressed the control calves showed a dramatic drop in performance. This drop in performance was partially offset by the use of the high protein supplementation. The apparent feed conversion of the protein supplement was 2.0 lbs of feed per pound of added gain. At a cost of $0.10/lb of protein supplement, the cost of added gain (feed alone) would be about $0.20/lb of gain. This conversion would be very economical for producers with stockers on this type of forage. These results could have application to producers who purchase stocker calves during the summer months when prices frequently are low. These calves could then be held with acceptable rates of gain until cool season forages such as small grains or fescue are ready to be grazed in the fall.

Table 1. Performance of steers grazing reclaimed native range and fed protein supplements.

	Treatments	
	Control	Supplement
Number steers	20	20
Initial wt, lb (8/16)	494	489
Gain, lb/day (total)		
8/16 to 9/18, 33 days, lbs	1.41 (46)^{a}	1.73 (57)^{b}
9/18 to 10/11, 23 days, lbs	.01 (.28)^{a}	.75 (17)^{b}
18/16 to 10/11, 56 days, lbs	.83 (47)^{a}	1.32 (74)^{b}

^{ab}Means with different superscript letters differ (P<.05).

Literature Cited

Lusby, K.S. et al. 1982. Energy -vs- protein supplementation of steers grazing native range in late summer and early fall. OSU MP-112:36.

Lusby, K.S. and G.W. Horn. 1983. Energy -vs- protein supplementation of steers grazing native range in late summer. OSU MP-114:209.

EFFECT OF DIFFERENT MANAGEMENT PRACTICES ON WEIGHT GAINS OF STOCKER CALVES GRAZING BERMUDAGRASS

Jim Cantrell[1], Gerald Bryan[1] and K.S. Lusby[2]

Story in Brief

A cooperative field trial was conducted at the Kerr Foundation Ranch to determine the effectiveness of different management practices in improving gains of stocker calves grazing bermudagrass. One hundred forty-one calves averaging 442 lbs were separated into three groups and were grazed on bermudagrass with no supplement (control), received one lb of protein supplement/head/day (supplement), or were assigned to a pasture that was managed to maintain high quality forage (rotation). For the 57 day trial conducted in late summer, supplemented calves gained 0.3 lbs/day faster than unsupplemented calves and 0.15 lbs/day faster than calves of the rotation group (1.25, 1.10 and .95 lbs/day for supplemented, rotation and control groups, respectively). The results of this trial indicate that protein supplementation will improve gain of stocker calves grazing mature bermudagrass, but may not be economical if pastures are maintained in a state of high quality.

(Key Words: Pasture Rotation, Beef Cattle, Bermudagrass.)

Introduction

Summer stockers or fall-born calves are typically grazed on bermudagrass in much of eastern Oklahoma. Although bermudagrass can tolerate very heavy grazing pressure, daily gains are often disappointing. Research with native grass indicates a very favorable response to protein supplementation and this response may also apply to bermudagrass. In addition, work in Louisiana, Texas and Oklahoma indicates that with very heavy stocking rates and high fertilization, bermudagrass can produce impressive gains per head and per acre. This trial was designed to compare the effects of protein supplementation, and a more intensive pasture management system to a traditional bermudagrass grazing program.

Experimental Procedure

One hundred forty-one Angus, Angus X exotic, and Angus X Brahman calves, approximately 10 months old, were assigned to one of three treatments. Forty calves were assigned to a control group (no supplement), forty calves to a supplemented group (1.0 lb soybean meal cubes per head per day, fed 2.5 lbs/head on Monday and Friday and 2.0 lbs/head on Wednesday) and 61 calves to a pasture management group (rotation group) where high quality forage was maintained. All three pastures were approximately 25 acres in size with forage consisting predominantly of bermudagrass with a small amount of ladino clover. The stocking rate was 1.5 calves/acre for both the control and supplement groups, and 2.5 calves/acre for the rotation group.

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The control and supplement pastures were fertilized with 300 lbs/acre of 17-0-31 on June 7, 1984 and with 150 lbs/acre of 34-0-0 on July 18. The rotation pasture was fertilized with 300 lbs of 17-17-17 on June 7, and with 150 lbs of 34-0-0 on July 18. All the pastures had been cut for hay three to four weeks prior to onset of the trial, and were in good to excellent grazing condition.

The rotation treatment was designed to maintain the forage in a high quality state by keeping the grass grazed to a short, rapidly growing condition. This management was accomplished by subdividing the rotation pasture into three smaller pastures with electric fence and then rotating the calves among the three small pastures. Any excess forage was clipped to maintain quality. The rotation dates were based on visual appraisal of forage quality and quantity, and not on a strict time schedule.

The control and supplemental groups were also rotated between pastures at two week intervals to reduce pasture effects. All cattle were held off water and feed overnight before each weighing.

Results and Discussion

Results of this trial are shown in Table 1. All three pastures involved in this study had been cut for hay three to four weeks before the start of the study, and the similar gains for the first weight period indicate that all pastures were of comparable quality.

When quality of bermudagrass is adequate to support a daily gain of 1.86 lb/day without supplementation (control group), there is apparently no advantage for protein supplementation. During the second 28 days of the study, the apparent forage quality dropped substantially in all pastures. This decrease in quality is probably a combination of factors--increased height and maturity of the forage in addition to seasonal factors. This decrease in forage quality was partially offset by feeding supplemental protein. The more intense management of the pasture rotation treatment also appeared to improve gain, although gain differences between the control and rotation groups were not significant. It should be pointed out that the trial was carried out during a serious drought, and consequently all forage was probably lower than normal in quality.

Table 1. Weight gains of calves grazing bermuda pasture.

	Control[1]	Supplement[2]	Rotation[3]
Number calves	40	40	61
Initial wt, lb	438	440	446
Gain/day, lb, (total)			
8/16-9/14 (28 days)	1.86 (52)^{a}	1.89 (53)^{a}	1.82 (52)^{a}
9/14-10/12 (29 days)	.08 (2.2)^{a}	.62 (18)^{b}	.37 (10.7)^{ab}
8/16-10/12 (57 days)	.95 (54.4)^{a}	1.25 (71.4)^{b}	1.10 (62.5)^{ab}

^{ab}Means with different superscripts differ (P<.05).
[1]Bermuda + no supplement.
[2]Bermuda + 1.0 lb soybean meal/day (three times/week).
[3]1.5 times the stocking rate of control and supplement pastures, rotated through three pastures with no supplement.

The results of this trial indicate that the response to protein supplementation by stockers grazing bermudagrass in late summer is highly dependent in forage quality. Apparent feed conversion was 3.3 lbs soybean meal per pound of gain in the supplemented group over the controls. Although the rotation group did not gain significantly faster than the control group, the pasture rotation did appear to improve gains over the control pasture. Protein supplementation may be a more viable option than intensive rotation for some producers because less fencing is required and a greater stock pile of forage can be accumulated. These results indicate that protein supplementation of stockers grazing bermudagrass in late summer is beneficial and economical if stocking rates are traditional, and forage quality is low. If the forage is maintained in a short, fast growing condition, supplementation may not be economical.

Literature Cited

Lusby, K.S. et al. 1982. Energy -vs- protein supplementation of steers grazing native range in late summer and early fall. OSU MP-112:36.

Lusby, K.S. and G.W. Horn. 1983. Energy -vs- protein supplementation of steers grazing native range in late summer. OSU MP-114:209.

DECCOX-MINERAL FEEDING STUDIES--OKMULGEE COUNTY, OKLAHOMA

K.C. Barnes[1], K.S. Lusby[2], Fred Still[3]
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Story in Brief

Two trials with 100 heifers each were conducted to determine the effectiveness of Deccox (decoquinate), a coccidiostat, on sickness and weight gain of newly-arrived stocker cattle. Studies were conducted from November to February on a ranch near Okmulgee, Oklahoma. Deccox-fed heifers gained about .5 lb/day faster ($P<.01$) and had less sickenss than Control heifers. Some bloody stools, indicating coccidiosis, were noted for Control heifers in both trials.

(Key Words: Deccox, Coccidiosis, Beef Cattle.)

Introduction

Coccidiosis is a common occurance among newly arrived cattle on Oklahoma cattle operations. The infection causes economic losses from death loss, high labor and treatment costs and poor performance of some cattle following recovery. Chronic infections may occur in all seasons of the year but are more frequently seen during the fall and winter. There is some evidence that sub-clinical levels of coccidiosis can reduce performance as well as increase susceptibility to other diseases. It is often difficult to administer anticoccidial agents to cattle that are not normally fed supplemental feed or maintained at locations where treatment through feed or water is possible. In these circumstances, administration of an anticoccidial drug through self-fed mineral mixes might be an efficient and economical means of protecting cattle from both clinical and sub-clinical coccidiosis. The following trials were conducted to study the effectiveness of Deccox when self-fed in a mineral mix during the receiving period on the performance and health of newly arrived stocker calves.

Materials and Methods

Two field trials were conducted in Okmulgee County, Oklahoma, approximately 35 miles south of Tulsa in East Central Oklahoma. Cattle and land were provided by Mr. Fred Still and the studies were supervised by Kent Barnes, Area Livestock Specialist, located in Muskogee and Don Taylor, Okmulgee County Extension Director.

Trial 1

One hundred and one heifers were purchased from auction barns and local ranches and were received in four groups over a 2 week period on November 21, November 24, November 29 and December 6, 1983. Average

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weight was 394 pounds. Each load was randomly split into two treatments, Deccox or Control. Heifers were individually weighed when received, midway through the trial and again at the end of the trial, about 58 days from the start. All heifers were vaccinated for IBR-PI3 (IM), Lepto, Blackleg (3-way), wormed with tramisol, treated with systemic grubicide and implanted with ralgro. Each heifer was branded, ear notched, and number tagged for identification. Cattle with horns were tipped.

Heifers were confined by treatment in receiving traps about 10 acres in size and fed ad libitum low quality grass hay and 2 pounds of a 38% protein supplement. The feeding program was designed to minimize purchased feed and provide for daily gains in the .5 to .75 lbs/head/day range. Heifers were observed daily and pulled for treatment when depression, respiratory distress, scouring or other obvious clinical signs were noted. Treatment regimes recommended by the consulting veterinarian were followed.

A commercial mineral mix (Table 1) was offered to all cattle throughout the length of the trial in whirlwind feeders equipped with rubber pans. Deccox was hand mixed into one mineral mix (1.5 lbs. of 6% Deccox premix per 50 lb of mineral) to deliver at least 23 mg. of decoquinate/100 lb of body weight if anticipated intake occured (.2 to .3 lb/head/day).

Table 1. Ingredient composition of mineral mix.

Ingredient	lb/ton batch	Percent
Dicalcium phosphate	650	32.5
Salt	300	15.0
Limestone	250	12.5
Corn, ground	300	15.0
Cottonseed meal	300	15.0
Alfalfa pellets, ground	100	5.0
Molasses	100	5.0
Vitamin and trace mineral premix	10	10 lb/ton
Vitamin A, D and E	2	2 lb/ton

To test the consistency of mixing, mineral samples were collected during the course of the study and analysed for decoquinate at Hess and Clark Analytical Lab, Walland, Ohio. Mineral intake was measured weekly with cottonseed meal added (5-20%) and feeder locations adjusted when needed to induce adequate intake of mineral.

Trial 2

One hundred heifers were purchased from auction barns and received in four groups over a 4 week period on December 10, December 31, January 1 and January 7, 1983-1984. Average weight was 383 pounds. Experimental procedure was the same as in Trial 1 except for a period of 5 days in mid-January. Extreme cold with snow and ice was encountered during the first few days that this group of calves was assembled. Ice had to be chopped on watering ponds and the calves probably consumed minimal water. As a result of weather conditions and/or animal preference, mineral consumption by both Control and Deccox calves was inadequate. In order to insure adequate Deccox intake, Deccox was hand mixed with cottonseed meal into the protein supplement and fed in addition to the medicated mineral.

Results and Discussion

Trial 1

Results are shown in Table 2. Mineral consumption averaged 1.94 oz./head/day and calculated Deccox consumption averaged 92 mg/head/day during the trial. Mineral consumption varied with daily intakes of Deccox ranging from 38 mg up to 166 mg. Laboratory analyses showed that actual Deccox concentrations in mineral mixes exceeded the calculated amount in every sample taken.

Table 2. Performance of heifers in Trial 1.

	Control	Deccox
Number of Heifers	50	51
Start weight, lbs.	388	400
Daily gain, 1st. period (32 days)	.73	.80
Daily gain, 2nd. period (26 days)	-.14[a]	.78[b]
Daily gain, total period (58 days)	.34[a]	.79[b]
Final weight	408	446
Sick pulls, %[c]	54	38
Repulled, %	60	10
Sick pulls with scours, %	100	10
Dead, %	0	0

[ab]Means differ ($P<.01$)
[c]One sick pull signifies that a calf was removed for treatment and treated until deemed well.

Daily gains were similar for both Control and Deccox heifers (.73 vs .80 lbs./day) during the first 32 days of the study, which would have mostly taken place in December. However, during the final 26 days, Deccox heifers gained .78 lbs./day compared to -.14 lbs./day for Control heifers ($P< .01$) For the entire 58 day period, Control heifers gained .34 lb/day compared to .79 lb/day for Heifers receiving Deccox ($P< .01$). The increased weight gain for the Deccox-fed heifers was readily apparent in the physical appearance of the calves.

More Control heifers were pulled for treatment than Deccox heifers (54% vs 38%) and more Control heifers had to be repulled at a later date for additional treatment (60% vs 10%). The primary reason for sickness in both groups of heifers was respiratory disease. Clinical coccidiosis did not appear to be a major problem with either group of heifers although some bloody stools were noticed in the Control group. It is interesting to note that 100% of the Control heifers that had to be treated for sickness showed scouring compared to 10% for Deccox heifers. Since the diet for the heifers was 2 lbs. of a soybean meal-cottonseed meal pellet and free choice medium to low quality grass hay, there is little reason to suspect that the diet could have been responsible for any scouring. The increased weight gain and the reduced incidence of scouring seen with heifers fed Deccox and the presence of some bloody stools in the Control group suggests that subclinical coccidiosis may have been a problem in these heifers. No death loss was seen in Trial 1. The pronounced difference in gains between treatments during the second period suggests that some stress was affecting the heifers and the extreme cold weather encountered in late December and early January may have been enough additional stress to retard performance of the Control group.

Trial 2

As was stated in the Materials and Methods section, heifers in this trial were received during a period of extreme cold and it was not possible to achieve adequate Deccox intake through the mineral mix. Palatability of the drug did not appear to be the problem because Control mineral mix was not consumed either. For a 5 day period, additional drug was administered in cottonseed meal blended with the regular protein supplement. After this 5 day period the drug was again fed with the mineral mix. Medicated mineral was available throughout the trial, and consumption averaged 1.66 oz./head/day. Calculated Deccox intake averaged 86 mg./head/day but ranged from 0 to 135 mg./head/day at weekly measurements.

Mineral delivery of any product must be monitored closely with preparations made for altering the palatability of the mineral mix to either increase or reduce intake and to use some other delivery system if adequate mineral intake is not possible. The emergency delivery system used in this study was a small supply of sacked cottonseed meal that could be hand mixed with the drug and substituted for a portion of the regular protein supplement.

Cattle performance is shown in Table 3. During the approximately 57 day trial period, Control heifers lost .03 lbs/day compared to a gain of .57 lbs./day for Deccox heifers ($P < .01$). In contrast to Trial 1, a

Table 3. Performance of heifers in Trial 2.

	Control	Deccox
Number of Heifers	49	51
Start weight, lbs.	397	379
Daily gain, 1st period (29 days)	.09[a]	.66[b]
Daily gain, 2nd period (28 days)	-.15[a]	.47[b]
Daily gain, total period	-.03[a]	.57[b]
Final weight	396	412
Sick pulls, %[c]	65	16
Repulled, %	30	60
Sick pulls with scours, %	100	100
No. dead	2	1

[ab]Means differ ($P<.01$)
[c]One sick pull signifies that a calf was removed for treatment and treated until deemed well.

highly significant gain advantage was seen for Deccox heifers during the first half of the trial as well as during the second half. Gains for Control heifers were poor (.09 lbs./head/day) for the first 29 days of the study and weight loss was seen during the final 28 days (-.15 lbs./head/day). Heifers receiving Deccox gained .66 lbs./day for the first 29 days and .47 lbs. for the final 28 days.

Clinical coccidiosis was noted in the Control group. As was the case in Trial 1, more Control heifers than Deccox heifers were pulled for treatment (65% vs 16%) although scours was noted in most of the sick heifers from both groups. More Deccox heifers had to be repulled for treatment than Control heifers although the low number of sick heifers in the Deccox group limits interpretation about the relationship between coccidiostat and retreatment of sick cattle in this trial. It is likely that some heifers may not have received sufficient drug during the first few days of the study because of previously noted difficulties with mineral intake during the early part of Trial 2. Two heifers died in the Control group compared to one in the Deccox group. The low mortality in comparison to the high morbidity (sickness) rate, especially in the Control group was a reflection of the excellent treatment received. This level of morbidity would likely result in a higher death rate in many circumstances.

Conclusions

Mineral mixes may be used to deliver Deccox to newly arrived cattle providing the intake is carefully monitored and preparations are made for altering the palatibility of the mineral mix and for delivering the drug though some other feed source if mineral intake is not adequate. In a total of 4 trials at this ranch, 2 in the spring and the 2 winter trials reported here, mineral consumption was adequate in 3 of the 4 studies.

A significant gain response was seen in both winter trials as well as a reduction in the number of cattle treated for sickness. Clinical coccidiosis was seen in both studies and the degree of scouring noted suggested that subclinical coccidiosis could have been a problem. Coccidiosis is very common in the fall and early winter in stressed calves. Prevention of the disease with coccidiostats is an obvious recommendation and mineral delivery of coccidiostats may be an additional management tool in situations where the feeding program limits the number of feeds that can be stored and fed. Consumption must be monitored, however, and alternate feeding plans available.

EFFECTS OF FEEDING DECCOX IN GROWING RATIONS FOR STOCKER HEIFERS

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Story in Brief

A field trial was conducted on a ranch in Noble County in north central Oklahoma. Ninety-eight heifer calves, purchased in a western Arkansas auction, were shipped to the ranch on October 11, 1984 and allotted to the study on October 13. Heifers were maintained in drylot pens and full-fed wheat hay and crabgrass hay for 56 days. All heifers were fed 2 lb of 38 percent cottonseed meal-based pellets per day with half the heifers receiving 100 mg of Deccox in their supplement. Heifers fed Deccox gained 1.34 lb/day compared to 1.06 lb/day for control heifers (P<.01). One case of clinical coccidiosis was seen in control heifers. These data suggest that these newly received calves were affected by sub--clinical coccidiosis enough to reduce performance.

(Key Words: Deccox, Coccidiosis, Stocker Calves.)

Introduction

Coccidiosis is a common health problem among newly arrived stocker calves in Oklahoma. Clinical cases with signs of bloody scours and death loss cause obvious economic losses. However, recent research suggests that coccidiosis may reduce performance in some cattle without causing the most apparent clinical signs of the disease. Because Deccox (Decoquinate) is an effective coccidiostat that should not have any other growth promotive effects, feeding Deccox during the receiving and growing phase should provide evidence of the effects of subclinical coccidiosis in cattle.

Materials and Methods

A 56-day field trial was conducted on a ranch in Noble county near Perry in north central Oklahoma. Ninety-eight heifer calves weighing about 340 lb were purchased in a western Arkansas auction and trucked to the ranch on October 11, 1984. The heifers were vaccinated for IBR, PI-3, Haemophylus somnus, Pasteurella hemolytica-multicida, Lepto and 5-way Clostridia. All heifers were injected with Ivermectin and implanted with Synovex®H. Hay was provided free choice to all heifers in round bale feeders and 2 lb/head/day of cottonseed meal was fed in feed troughs. Hay consisted of high quality wheat and crabgrass hay for the first 28 days and lower quality wheat hay for the last 28 days of the study.

On October 13, all heifers were randomly allotted to either Control or Deccox treatments. Deccox was administered through the cottonseed meal pellets at the rate of 50 mg/lb or 100 mg/head/day in 2 lb of

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[4]County Extension Director

supplement. All heifers were individually identified with a color coded and numbered ear tag at the time of allotment to treatments. Thirteen heifers had been pulled for sickness at the time of arrival and processing and were allotted to treatment groups while in the sick pen. All weights were unshrunk weights taken immediately after moving cattle from their pens to the scales. Heifers were maintained in adjacent drylot pens throughout the study.

Heifers were observed daily and pulled for treatment when signs of sickness such as anorexia and depression were noted. Rectal temperatures were taken on all calves pulled for sickness. Sick calves were treated with antibiotics prescribed by the consulting veterinarian. The veterinarian was called to examine calves not responding to treatments and to evaluate severe cases.

Results and Discussion

During the first 28 days of the trial, calves fed Deccox in their cottonseed meal supplement gained 1.53 lb/day (Table 1) compared to 1.24 lb/day for control calves ($P<.05$). Control calves appeared to have slightly rougher haircoats and showed more loose stools than calves fed Deccox during the first 28 days in drylot. One case of clinical coccidiosis in a Control heifer was diagnosed by the consulting veterinarian on the tenth day of the trial. This heifer showed bloody scours, extreme incoordination and weakness. After treatment with Amprolium and antibiotics, the heifer recovered. Weather was generally mild during this period with limited rainfall.

Table 1. Performance and health of heifers fed Deccox for 56 days following arrival.

	Control	Deccox	Prob.
Number heifers	49	49	
Initial weight	352	342	
Daily gain, lb/day			
1st 28 days	1.24	1.53	P<.05
2nd 28 days	.88	1.17	P<.01
56 days	1.06	1.34	P<.01
Number dead	0	0	
Number treated at processing	7	6	
Sick days/calf pulled	3	3	
Number treated after Deccox feeding began	24	17	
Sick days/calf pulled	5.5	5.9	

During the second 28 days of feeding, calves fed Deccox again gained faster than control calves (1.17 lb/day vs .88 lb/day, $P<.01$). Approximately 5 inches of snow fell during this period. At the time of the final weighing, about 70 percent of the control cattle showed some signs of loose stools although no blood was apparent in their feces. No Deccox-fed calves were observed to show any scouring. The fact that feed related scouring would not be expected with a diet of low quality wheat hay and 2 lb/day of cottonseed meal, and that no scouring was observed in the Deccox group, suggests that some other factor was involved. These data suggest that these heifers were affected with subclinical coccidiosis severely enough to reduce weight gain without causing clinical signs of coccidiosis. No heifers died during the trial. Slightly more Control calves required treatment for sickness than Deccox--fed calves although there was no apparent effect of treatment on the number of days each calf was sick. Respiratory illness was the most common sign among calves pulled for treatment.

For the entire 56 day trial, calves fed Deccox gained 1.34 lb/day compared to 1.06 lb/day for Control calves (P<.01). Deccox-fed heifers gained a total of 15.7 lb more than Control heifers during the trial. At a value of $58 per hundred, the added gain would be worth $9.09 per heifer. The cost of the drug will be between 2 and 5 cents per head per day depending on the source. Deccox is normally recommended for feeding the first 28 days after arrival. It was fed for 56 days in this study to estimate effects of controlling coccidiosis on performance of growing calves. Typically, a growth promotive feed additive would be used after the first 28 days. This study, along with others in Oklahoma (Barnes et al., 1984a and b), suggest that feeding a coccidiostat in growing and receiving rations can improve gains, particularly in the fall and spring months and in locations with a history of coccidiosis.

Literature Cited

Barnes, K.C. et al. 1984. Deccox-mineral feeding studies--Okmulgee County, Oklahoma. OSU MP-116:130.

Barnes, K.C. et al. 1984. Performance of newly-arrived stocker cattle fed Decoquinate. J. Anim. Sci. 59:382 (abstr.).

THE EFFECT OF RESPIRATORY SYNCYTIAL VIRUS VACCINE ON HEALTH AND PERFORMANCE OF NEWLY-ARRIVED STOCKER CATTLE

R.A. Smith[1], R.B. Hicks[2], D.R. Gill[3], and R.L. Ball[4]

Story in Brief

One-hundred forty one newly-received steer and bull calves and yearlings averaging 475 lb were divided into two groups. Eighty-one received routine processing upon arrival, and 60 received routine processing plus respiratory syncytial virus (RSV) vaccine. Vaccination with RSV vaccine decreased daily gain (1.61 vs 1.35 lb/head). Morbidity was 66% for the RSV vaccine group which was higher ($P<.05$) than for the controls (47%). Sick days also were higher in the RSV vaccine group (6.8 vs 4.3 days/animal). Death loss also tended to be higher in the vaccinated groups (13.3 vs 2.5%). In this study, the use of RSV vaccine was detrimental to health and performance of newly-received stressed calves in this 28 day receiving period.

(Key Words: RSV, BRD, Newly-received cattle, Shipping fever

Introduction

Respiratory syncytial virus (RSV) has been detected in respiratory infections of cattle with severe clinical and pathological features (Rosenquist, 1974) and recent work has suggested that RSV may be associated with the Acute Respiratory Distress Syndrome of calves. Antibody surveys have shown that the virus is common in cattle populations. A modified live virus vaccine was recently introduced onto the market for use in cattle. As part of ongoing stressed cattle and shipping fever research, calves were randomly selected from three loads of cattle to study the effect of RSV vaccine on the health and performance of newly arrived stocker and feeder calves.

Materials and Methods

All cattle were purchased by order buyers from auction markets in Tennessee or Alabama and shipped by truck to the Pawhuska, Oklahoma Research Station. Newly-received cattle were weighed individually off the truck, ear tagged and treated with Lysoff®[a]. Following weighing and tagging cattle were placed in pens of 20 to 25 animals each depending on the number of cattle received. For this study, animals from three different truckloads were used in trials starting on August 18, 1984, October 11, 1985 and November 14, 1984. Water and native bluestem grass hay were available free choice. The morning following arrival, the cattle were processed as follows:

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[a]Cutter Laboratories, Shawnee Mission, KS 66201.

1. Body temperature and time were recorded.
2. All cattle were vaccinated with IBR-PI_3 (MLV) IM, Leptospira pomona bacterin and Clostridia chauvoei, septicum, novyi and sordellii bacterin.
3. Sixty head were vaccinated with respiratory syncytial virus vaccine[b] and 81 head served as unvaccinated controls.
4. One-half the cattle were dewormed with ivermectin[c], the other half in each vaccination group served as controls as part of a deworming trial superimposed on this study.
5. Calves were started on antibiotic treatment if clinical signs of illness were detected or if body temperature exceeded 104°F except for the one-third of the calves which received no treatment if they became sick.
6. For sick calves, a hospital card was initiated and the calf was placed in a hospital pen.

Bluestem hay was available at all times and a supplement (Table 1) was offered at a rate of 2 lb/head/day for the first 21 days and 1 lb/head/day during days 22-28.

Table 1. Composition of feed supplement.

Ingredient	Percent
Soybean meal	88.9
Salt	3.0
Vitamin A-30000 IU/gm	.22
Premix[a]	.18
Cottonseed meal	5.0
Dicalcium phosphate	2.75

[a]To provide 75 mg lasalocid per pound.

After processing, cattle were checked twice daily for signs of illness. If an animal was suspected to be sick, it was taken to the processing area where its body temperature was determined and a severity of illness score (slight, moderate or severe) was assigned. If the body temperature exceeded 104°F the animal was considered sick. The animal could also be classified as sick based on clinical signs.

Medical treatment for sick animals was determined by the ear tag number which was applied at random on arrival. Treatment schedules were (A) no treatment (negative controls), (B) a sequence of antimicrobial drugs listed in Table 2 or (C) an experimental potentiated sulfa (RO5-0037[d]) substituted for Treatment 1 in Table 2. Thirteen control cattle and seven in the RSV vaccine group were randomly assigned to treatment schedule A. Cattle treated by schedules B and C were initially treated with the first drug in the sequence. If body temperature dropped 2°F or to less than 104°F, or clinical signs were improved within 24 hours, the first drug was continued for at least

[b]Bovine Respiratory Syncytial Vaccine (serial number 57), Norden Laboratories, Lincoln, NE.
[c]Ivomec®, MSD Agvet, Rahway, NJ 07065
[d]Primor®, Hoffmann-LaRoche, Inc., Nutley, NJ 07110.

another two consecutive days. If no improvement was apparent within 24 hours, the next drug in the sequence was applied and the procedure repeated until improvement was detected (procedure outlined in OSU RP-9104-04/81). Cattle treated by schedule C received R05-0037 boluses orally (30 mg/lb on day one and 15 mg/lb/day thereafter.

At the end of the 28 day trial, the cattle were held overnight without feed or water, weighed the following morning and, when necessary, cattle were castrated and horns were tipped. Cattle were then returned to the owner.

All cattle dying during this study were admitted to the Oklahoma Animal Disease Diagnostic Laboratory for gross and histological examination, virus isolation, bacterial culture and antibiotic sensitivity testing.

Table 2. Sequence of drugs used for treatment of BRD.

Treatment No. 1:	OXYTETRACYCLINE (Biomycin-C®) subcutanously - 5 mg/lb. Plus SULFAMETHAZINE BOLUSES (Sulmet® - 15 gm) 1 bolus/150 lb on day 1. One bolus/300 lb on subsequent days.
Treatment No 2:[1]	ERYTHROMYCIN (GALLAMYCIN®) deep in the muscles - 10 mg/lb.
Treatment No 3:[1]	SPECTINOMYCIN (Spectam®) 5mg/lb IM.
Treatment No 4:[1]	PROCAINE PENICILLIN G - Subcutanously - 30,000 IU/lb.
Treatment No 5:[1]	TYLAN 200 - 10 mg/lb IM.

[1]Some of the antimicrobial drugs used in this study were used for extra-label purpose or at extra-label dosages and require a veterinarian-client-patient relationship before use.

Results and Discussion

Least square means are presented in Table 3. Average daily gains (ADG) during the 28 day receiving period were 1.61 lb/day for the controls and 1.35 lb/day for those vaccinated with RSV vaccine. Data from cattle that died during the study were not used to calculate gains. Morbidity was high in both groups, but greater ($P<0.05$) in the group vaccinated with RSV vaccine (66 vs 47%). Number of repulls (cattle that had to be treated more than once for respiratory disease) were higher in the RSV vaccinated group and death loss tended to be increased with the RSV vaccine group (13.33% compared to 2.47%). The death loss percentage among cattle that were treated when they became ill by treatment schedule B or C was 5% in the RSV vaccinated group and 0% in the unvaccinated controls.

Table 3. Effect of RSV vaccine on morbidity, mortality and performance of stressed calves.

	Controls (81 head)	RSV Vaccine (60 head)	Vaccine Effect (%)
Average daily gain, lb	1.61	1.35	-16
Morbidity, %	47.	66.	+59
Repulls, %	26.	37.	----
Sick days	4.3	6.8	+40
Total mortality, %	2.5	13.3	+540
Percent mortality excluding treatment schedule A cattle	0.	5.	----

Under the conditions of this study, health and performance of newly-arrived calves were impaired by treatment with respiratory syncytial virus vaccine. This vaccine offered no economic advantage in processing of stressed calves in this study.

Literature Cited

Rosenquinst, B.D. 1974. Isolation of respiratory syncytial virus from calves with acute respiratory disease. J. Infect. Dis. 130:177-182.

THE EFFECT OF COMPUDOSE AND FINAPLIX ALONE AND IN COMBINATION ON GROWTH OF FEEDLOT STEERS

R.B. Hicks[1], D.R. Gill[2], L.H. Carroll[3], J.J. Martin[4] and C.A. Strasia[5]

Story in Brief

One-hundred-twenty yearling steers were divided into five treatments as follows: (1) no implant, (2) Compudose on day 1, (3) Trenbolone acetate (TBA) on days 1 and 63, (4) Compudose on day 1 and TBA on days 1 and 63, and (5) Compudose and TBA on day 1.

Daily gains and feed efficiencies were improved for the steers receiving a combination of Compudose and TBA. Compudose plus a single TBA implant improved gains 8.6 percent and feed efficiency 4.6 percent on a carcass basis. Compudose plus two TBA implants improved daily gain 7.6 percent and feed efficiency 3.9 percent on a carcass basis. Gain and feed efficiency were improved 4.3 and 1.0 percent by Compudose alone on a carcass basis. The TBA implants alone reduced gain and efficiency 7.3 and 3.9 percent, respectively on a carcass basis. Dressing percentages and marbling tended to be lower for steers receiving TBA implants.

(Key Words: Feedlot Steers, TBA, Compudose, Growth Promotants.)

Introduction

Estrogenic anabolic implants have been used to increase rate of gain and improve feed efficiency in feedlot cattle in the U.S. for many years. One such implant is Compudose. The use of the androgenic steroid trenbolone acetate (TBA) to improve beef cattle performance has been reported in European literature. It has been suggested that the growth response to TBA is additive to that produced by estrogens. The objective of this study was to evaluate the effect of Compudose and Finaplix (200 mg TBA) alone and in combination on growth and carcass characteristics of feedlot steers.

Materials and Methods

One-hundred-twenty crossbred steers of predominantly one-half Brahman breeding were weighed on trial at Goodwell, Oklahoma on April 25, 1984. These steers had been grazed as a single group on winter wheat pasture near Purcell, Oklahoma since October 1983. They were implanted on January 4, 1984 with Ralgro (36 mg zeranol) and had received no additional implants prior to the initiation of this study.

The steers were weighed twice on day 1 of the trial, and had an average initial weight of 762 lbs. They were blocked by weight and breed type into three groups of 40 head each. Each block was further divided into five pens of eight head each with the five treatments being

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randomly assigned within each block. The treatments were (1) control, (2) Compudose on day 1, (3) TBA on days 1 and 63, (4) Compudose on day 1 and TBA on days 1 and 63, and (5) Compudose and TBA on day 1.

The Compudose implants were placed subcutaneously in the posterior surface of the left ear. The TBA implants were placed subcutaneously in the posterior surface of the right ear. Second TBA implants administered on day 63 were also placed in the right ear.

A complete concentrate ration consisting of whole shelled corn, cottonseed hulls and pelleted supplement was fed for the full 126 day trial (Table 1). Dehydrated alfalfa pellets and cottonseed hulls were used to dilute the ration to 60 percent concentrate for starting the cattle on feed, these were decreased in 5 steps until the cattle were on the final ration at 28 days on feed. Steers were weighed full on days 28, 56, 84, 112 and 126. They were weighed twice on day 126. On days 56 and 112 each animal was evaluated for male characteristics in the head, neck and shoulder areas.

Steers were trucked 70 miles to Booker, Texas on day 127 of the trial (August 30, 1984) for slaughter and carcass data was obtained. In addition, each carcass was evaluated for masculinity traits. Live weights are reported on a full basis while gains and feed efficiencies were calculated using a 4 percent shrink. Gains and feed efficiencies for the total trial were calculated from hot carcass weights assuming a dressing percentage of 62, and are indicated as "0-slaughter" in Table 2.

Table 1. Ration composition, dry matter basis[a].

Ingredient	Ration 1[b]	Ration 2
Corn, whole shelled, %	51.85	86.85
Cottonseed hulls, %	15.00	5.00
Alfalfa, dehydrated, %	25.00	-----
Pelleted supplement,%	8.15	8.15
	Supplement Composition, % of DM	
Soybean meal	3.84	
Cottonseed meal	2.05	
Calcium carbonate	1.00	
Urea	0.45	
Salt	0.30	
Molasses	0.28	
Potassium Chloride	0.20	
Vitamin A-30	0.02	
Trace mineral	0.01	

[a]Calculated to contain 11.65% crude protein, .60% potassium, .42% calcium and .33% phosphorus.
[b]Starting ration only.

Results and Discussion

Performance and carcass data are presented in Table 2. Steers

Table 2. Performance and carcass data.

	Treatment*				
	Control	E_2B, day 1	TBA days, 1 & 63	E_2B, day 1; TBA, days 1 & 63	E_2B, day 1; TBA, day 1
Weights, lb					
Initial	762	762	762	761	762
126 days	1156^{b}	1170^{ab}	1150^{b}	1205^{a}	1204^{a}
Daily gain, lb					
0-126 days	2.76^{b}	2.87^{ab}	2.72^{b}	3.14^{a}	3.12^{a}
0-slaughter	3.03^{ab}	3.16^{a}	2.81^{b}	3.26^{a}	3.29^{a}
Daily feed, lb					
0-126	17.7	18.3	17.0	18.23	18.3
Feed/gain					
0-126	6.41^{a}	6.36^{a}	6.28^{ab}	5.82^{c}	5.86^{bc}
0-slaughter	5.84^{ab}	5.78^{ab}	6.07^{a}	5.61^{ab}	5.57^{b}
Carcass weight, lb	709^{ab}	719^{a}	691^{b}	727^{a}	730^{a}
Dressing percent	61.3	61.5	60.1	60.3	60.6
Liver abscesses,					
Incidence, %	0	8.3	8.3	4.2	0
Severity[e]	0	.17	.13	.04	0
Rib eye area, sq in	12.8	12.7	12.3	13.0	12.7
KHP, %	2.10	2.19	1.85	2.10	2.10
Fat thickness, in.	0.40	0.46	0.41	0.48	0.47
Marbling score[d]	12.5	12.4	11.6	11.8	11.7
Cutability, %	50.9	50.4	50.8	50.4	50.3
Yield grade	2.5	2.8	2.6	2.7	2.8
Federal grade[f]	11.1	11.2	10.5	10.8	10.4

*E_2B= Compudose 200 (Estradiol control release implant).
TBA= Finaplix (Trenbolone acetate).
abc Means in a row with different superscripts differ ($P<.05$).
d 11=average slight; 12=slight plus.
e 0 = one; 1 = small size; 2 = many or moderate sized abscess.
f Average Good = 10; Good Plus = 11.

implanted with Compudose had significantly higher daily gains (carcass weight basis) than steers receiving TBA alone. Improvements in rate of carcass adjusted gain with these implants were 8.6 percent for Compudose plus a single TBA implant, 7.6 percent for Compudose plus two TBA implants and 4.3 percent for Compudose alone. TBA alone decreased gains 7.3 percent on a carcass basis. On a live weight basis, steers receiving both Compudose and TBA implants had significantly higher gains than the controls and steers receiving TBA alone. Gains reported on a live weight basis were higher for steers receiving Compudose plus two TBA implants. Compudose alone or in combination with TBA increased feed intake 3.4 percent, whereas TBA alone decreased feed intake 4.0 percent.

Steers receiving Compudose and a single TBA implant had a significantly improved feed efficiency (carcass weight basis) compared to TBA alone. Improvements in efficiency of feed use reported on a carcass weight basis were 4.6 percent (Compudose plus one TBA implant), 3.9 percent (Compudose plus two TBA implants) and 1.0 percent (Compudose alone). TBA alone reduced efficiency of feed use 3.9 percent on a carcass weight basis, whereas TBA alone improved efficiency 2.0 percent on a live weight basis.

Carcass weight differences correspond with differences in rate of gain discussed above. Dressing percentages and marbling scores tended to be lower for steers implanted with TBA. Only five steers had liver abscesses in the trial. No differences in masculinity traits were observed on a live basis or carcass basis.

The combination of Compudose and TBA implants in this study increased daily gains and improved efficiency of feed use for feedlot cattle over either implant alone. (Caution!! TBA implants are not approved for use alone or in combination with other implants in the Unites States at the time this report is being written.)

EFFECTS OF MGA®, TYLOSIN, LASALOCID AND MONENSIN FED IN COMBINATION ON THE PERFORMANCE OF FEEDLOT HEIFERS

J. J. Martin[1], C.A. Strasia[2], D. R. Gill[3] and R. B. Hicks[4]

Story in Brief

Additives in the following combinations were tested for a 110 day feeding test: 1, MGA; 2, tylosin; 3, lasalocid; 4, MGA + tylosin; 5, MGA + lasalocid; 6, lasalocid + tylosin; 7, MGA + lasalocid + tylosin; and 8, MGA + monensin + tylosin. If the averages for treatments 1 and 2 (MGA or tylosin only) are used as the reference point then carcass adjusted feed efficiencies were improved 6% for lasalocid only (3), 10% for MGA + tylosin (4), 8% for MGA + lasalocid (5), 1% for lasalocid + tylosin (6), 6% for MGA + lasalocid + tylosin (7), and 15% for MGA + monensin + tylosin (8). The data from this test will be most meaningful when pooled with tests of the same design conducted at the same time at other universities. Only the combination of MGA + monensin + tylosin had significantly improved feed efficiency over MGA alone.

None of the additives or combinations had any effect on carcass measurements or liver abscesses. The fact that all test cattle were fed decoquinate for the first 28 days of the 64 day warm up period before the test additives were administered may have affected the results.

(Key Words: Feedlot Heifers, MGA, Lasalocid, Monensin, Tylosin.)

INTRODUCTION

A major problem which greatly reduces the efficiency of beef production is the lack of safety-efficacy clearances by the FDA for a number of proven effective feed additives. The lack of necessary clearances often prevents cattlemen from using two or more proven effective additives at the same time in the diet. This study is a part of a number of studies conducted to obtain clearances which ultimately will allow cattle feeders to feed combinations of Monensin + Tylosin + MGA, or lasalocid + Tylosin + MGA at the same time. The feeding of combinations of proven safe and effective feed additives which in most cases are both complimentary and additive to one another can greatly improve the efficiency of beef production. Since modes of action of MGA, tylosin and the ionophores are different, administration of them in either two or three-way combinations should result in improved performance of feedlot heifers over that achieved with any additive fed singly. Two of these drugs, MGA and tylosin, have unique non-overlapping claims not shared with monensin or lasalocid. Therefore, these two drugs will contribute separate added claims to either of the ionophores utilized in three-way combinations. Because of MGA's estrus suppressing activity approval to administer this drug in two and/or three way combination with other feed additives will be of considerable benefit to the feedlot heifer industry.

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[2]Area Specialized Agent [3]Professor [4]Graduate Assistant

Experimental Procedure

A group of 192 heifers were selected for uniformity from a larger group purchased at sale barns in south central Oklahoma. At preprocessing, the heifers were pregnancy checked and heifers detected pregnant were not used. The test heifers were then injected with 5 ml Lutalyse® and shipped to Goodwell, Oklahoma for feeding. The heifers were placed on a high silage ration containing decoquinate to provide 150 mg per head per day for the first 28 days. The heifers then were placed on additive-free starter ration and gradually moved up to the concentrate level of the test ration. They were held on the final additive-free ration until at least 50% of the animals had been observed cycling. In total, the heifers were fed 64 days before the test additives were added to the diets. At this time the heifers were palpated to further demonstrate that the heifers were in fact cycling. The animals were then stratified into three weight groups and randomly allocated to eight experimental feed groups consisting of three pens each.

Table 1. Treatment designation.

1. MGA 0.5mg/hd/day
2. Tylosin 10 g/ton of complete feed
3. Lasalocid 30 g/ton of complete feed.
4. MGA (0.5mg)-tylosin (10 g)
5. MGA (0.5mg)-lasalocid (30g)
6. Lasalocid (30g)-tylosin (10g)
7. MGA (0.5mg)-lasalocid (30g)-tylosin (10g)
8. MGA (0.5mg)-monensin (30g)-tylosin (10g)

Special supplements containing the additives were added each day at feeding time so that MGA could be administered at a rate of 0.5 mg/head/day, while tylosin, lasalocid, and monensin were administered at specific concentrations per ton as indicated in Table 2.

Heifer weights were recorded following a 12 hour withdrawal from feed and water and were weighed at 28 day intervals. Final weights were taken after a 48 hour drug withdrawal. The animals were transported approximately 75 miles to Booker, Texas for slaughter and collection of routine carcass information, including liver abscess data. Data from 8 heifers were excluded from the trial because of apparent errors in the data collected at the packing plant. One heifer was injured in weighing and was slaughtered at Panhandle State University. The net energy equations were used to calculate feed consumed by the nine animals and these data were deleted from the analysis.

Results and Discussion

The design of this experiment dictated that open cycling heifers were to be used for the test. It was presumed that the heifers were both old and big enough to be cycling at time of purchase. However, they had to be held on feed for 64 days before these criteria could be met. As a result the pay to pay performance of these cattle greatly exceeded the performance in the trial summary. Because this design was dictated by the requirements of the FDA and a limitation in facilities

Table 2. Diet composition and additive concentrations.

Ingredient	Percent	
Corn Silage	4.00	
Whole Shelled Corn	85.98	
Supplement	5.02	
Limestone		1.00
Salt		.30
Urea		.45
Soybean Meal		2.08
Vitamin A-30000		.02
Cottonseed Meal		1.00
Cane Molasses		.17
Additive Carrier[a]	5.00	
Ground Corn + additives		2.50
Soybean Meal		2.50

[a]Additive Carrier pellets contained:

Additive	Theory	Assay
MGA[b]	3000 mg. per ton	2860
Tylosin[c]	600 gr. per ton	598
Lasalocid[c]	1800 gr. per ton	1583
Monensin[c]	1800 gr. per ton	1690
Blank no additives[d]		

[b]MGA carrier fed at a rate of 0.33 lb/head/day (0.5 mg).
[c]Fed at a rate of 1.85% of ration dry matter to provide 30 grams per 90% dry matter basis ton of lasalocid or monensin, or to provide tylosin at 10 grams.
[d]Added at feeding time so that total additive carrier equals 5% of the ration dry matter.

and funding no negative control could be included. The reader of this report should use these data with those of 4 or 5 other experimental locations which conducted the similar tests using the same protocol. The level of MGA fed gave complete estrus suppression, and appeared to be additive with tylosin and the two ionophores.

The results of this test are presented in Table 3. The grading as indicated by the marbling scores on these light weight heifers was outstanding with only 2 animals not reaching the choice or better grade.

Table 3. The effect of treatment on heifer performance.

Item	Treatment Number							
	1	2	3	4	5	6	7	8
Number of Heifers	22	23	21	23	24	23	24	23
Starting wt	677	672	672	672	672	667	674	678
Final wt	924	909	932	936	936	904	930	952
ADG, live	2.25	2.15	2.36	2.40	2.40	2.16	2.33	2.50
Feed intake	15.77$_{a}$	14.45$_{a}$	14.97	14.92	14.79	14.48	14.76	14.55
Feed/gain, live	7.01^{a}	6.71^{a}	6.33^{ab}	6.25^{ab}	6.17^{ab}	6.79^{a}	6.32^{ab}	5.84^{b}
ADG, carcass^{c}	2.42$_{a}$	2.26	2.50	2.59	2.50	2.30	2.45	2.67
Feed/gain, carcass^{c}	6.50^{a}	6.40^{ab}	6.07^{ab}	5.80^{ab}	5.92^{ab}	6.39^{ab}	6.05^{ab}	5.45^{b}
Dress, %	63.42	63.03	63.18	63.54	62.88	63.28	63.03	63.37
Fat Thickness, in	.37	.36	.36	.40	.35	.38	.40	.36
Ribeye Area, in	11.43	11.86	12.09	12.09	11.70	11.88	11.72	12.03
Marbling score^{d}	15.63	15.13	14.72	13.88	14.96	15.41	14.42	14.06
Cutability %	51.07	51.70	51.58	51.33	51.28	51.54	51.21	51.40
Liver abscesses^{e}	.42	.08			.33			

^{ab}Means in a row with different superscripts differ (P<.05).
^{c}Adjusted live weight calculated by dividing hot carcass weight by 0.62.
^{d}12 = slight plus, 13 = small minus, 14 = average small, 15 = small plus, 16 = modest minus.
^{e}0 = none, 1 = small, 2 = 2 or more small, 3 = extensive.

COMPARISON OF IONOPHORES FOR FEEDLOT HEIFERS: LASALOCID A.M. PLUS OXYTETRACYCLINE P.M. -VS- CONTINUOUS MONENSIN-TYLOSIN

C.A. Strasia[1] and L.J. Jordan[2]

Story in Brief

Forty-eight yearling heifers which had been in the feedyard for 60 days and had been receiving monensin (300 mg/hd/day) plus tylosin (90 mg/hd/day) were fed 96 days on an 88% concentrate ration (NE_g = 1.25 mcal/kg) with (1) monensin (300 mg/hd/day) plus tylosin (90 mg/hd/day) or with (2) lasalocid (300 mg/hd/day) fed A.M. plus oxytetracycline (75 mg/hd/day) fed P.M. Supplements were top dressed on the ration at each feeding. Feed intake was 4.7% greater, average daily gain was 4.8% higher, and feed efficiency 4.7% better in the monensin-tylosin treatment. Hot carcass weights, fat thickness over the rib, marbling scores and kidney-heart and pelvic fat were 1.9, 2.2, 5.8, and 4.9 percent, respectively, higher for the monensin-tylosin cattle. Dressing percent, rib eye area and yield grade were .20, 1.0 and 8.9 percent greater, respectively, in the lasalocid A.M. and oxytetracycline P.M. treatment.

Animals may be crossed over from one ionophore to another without any significant performance changes (i.e. monensin-tylosin to lasalocid A.M.-oxytetracycline P.M.).

(Key Words: Feedlot Heifers, Monensin, Lasalocid, Oxytetracycline, Tylosin.)

Introduction

The two ionophores, currently approved for use in beef cattle, monensin (Rumensin®) and lasalocid (Bovatec®), are extensively fed to feedlot cattle to improve efficiency of feed utilization. It has been demonstrated that several antibiotics are effective in reducing the incidence of liver abscess in feedlot cattle. Two of these antibiotics are oxytetracycline (Terramycin) and tylosin (Tylan). To date, only tylosin is cleared for use with an ionophore, and only with monensin. The combination of two drugs, such as ionophore and antibiotic, requires a voluminous documentation of efficacy prior to being cleared for use by the Food and Drug Administration. Consequently, two methods may be used to deliver an oral antibiotic for liver abscess control when an ionophore is used in the ration which has no combination clearance: (1) a high therapeutic level fed a few days each month, or (2) A.M.-P.M. continuous low level where all the ionophore is fed A.M. and all the antibiotic fed P.M. The objective of this study was to determine the efficacy and feasibility of A.M.-P.M. lasalocid + oxytetracycline versus the combination monensin-tylosin supplementation program.

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Materials and Methods

Forty-eight crossbred heifers were individually weighed, identified with ear tags and randomly allocated to two treatment and six pens on June 14, 1983. This design allowed each treatment to be replicated three times. The heifers had been in the L&W Feedyard, Follett, Texas since April 22, 1983 and had received routine feedlot vaccinations and implants, and had been managed on the standard feedlot nutritional program which included use of monensin-tylosin in the rations (Table 1).

The initial shrunk weight of the heifers on June 14, 1983 was 701 lb. The heifers were receiving the finishing ration upon initiation of the study and continued receiving this ration until completion of the study on day 96. Full weights were taken on days 28, 56, 84 and 96, and were subjected to a 4% pencil shrink for reporting purposes.

The purpose of the study was to test the efficacy of a monensin-tylosin (300 mg + 90 mg) feeding regime versus a lasalocid A.M. - oxytetracycline P.M. (300 mg-75 mg) feeding program.

The heifers were trucked 42 miles to Booker, Texas for slaughter. Gains and feed efficiencies for the total trial were calculated from hot carcass weights assuming a dressing percentage of 62. Performance and carcass data were compared using analysis of variance (Steel and Torrie, 1960).

Table 1. Diet consumption, dry matter basis.[a]

Ingredient	Percentage
Corn, steam flaked	83.10
Alfalfa, ground	10.58
Wheat mids	1.13
Calcium carbonate	1.09
Meat meal	.80
Urea	.90
Sunflower meal	.80
Salt	.64
Cottonseed meal	.48
Potassium chloride	.18
Ammonium sulfate	.16
Dicalcium phosphate	.12
Premix[b]	.01

[a] To provide 12.5 percent crude protein, .65 percent calcium, .39 percent phosphorus, .68 percent potassium, and 1.25 mcal/kg dry matter (NE_g).

[b] Pelleted supplement composed 7.9 percent of the ration dry matter. The supplement for treatment 1 was formulated to supply 30 g/ton Rumensin per ton of air dry feed and 90 mg tylosin/head/day.

Results and Discussion

Prior to the start of this study the animals were receiving a standard feedlot finishing ration indicated in Table 1 which contained monensin + tylosin. The ration was contained monensin + tylosin at a level of 300 mgs + 90 mgs per head per day, respectively. The animals receiving the monensin-tylosin treatment continued receiving this ration. The pens receiving the lasalocid-A.M.-oxytetracycline-P.M. were immediately crossed over to this feeding regime. Feed delivery to the pens was by mixer truck. The supplements were top dressed on the ration to assure that the proper amount of supplement was delivered to each pen. Feedlot performance data are shown in (Table 2).

Average daily gain, daily feed intake and feed conversion was enhanced by 5.0, 0.5, and 4.9 percent, respectively, by the monensin-tylosin treatment. This same pattern has been observed in steers fed intermittent high levels of antibiotics (Gill et. al., 1984). One of the problem areas with A.M.-P.M. feeding of additives is that more than half the ration is fed in the A.M. whereas only half the supplement is apportioned at this time. In the typical custom feedlot situation, this may be a problem that is logistically insurmountable.

Table 2. Gains and feed efficiencies of heifers on different ionophore antibiotic feeding regimes.

	Treatments	
	Monensin + Tylosin	Lasalocid A.M. Oxytetracycline P.M.
Heifers, number	24	23
Weights, lbs[a]		
Initial	704[d]	700[d]
28 days	785[d]	782[d]
56 days	870[d]	859[d]
84 days	937[d]	915[d]
96 days, live	959[d]	935[d]
96 days, carcass	1005[d]	986[d]
Daily gains, lbs		
0-28 days	2.80[d]	2.82[d]
28-56 days	2.91[d]	2.77[d]
56-84 days	2.77[d]	2.55[d]
84-96 days	2.66[d]	2.45[d]
96 days, carcass	3.13[d]	2.98[d]
Daily feed, lb[b]		
0-28 days	21.72[d]	21.54[d]
28-56 days	20.14[d]	20.44[d]
56-84 days	25.01[d]	24.30[d]
84-96 days	17.91[d]	18.40[d]
0-96 days	21.74[d]	21.63[d]
Feed/gain[b]		
0-28 days	7.49[d]	7.38[d]
28-56 days	6.61[d]	7.41[d]
56-84 days	10.52[d]	12.16[d]
84-96 days	9.59[d]	10.69[d]
0-96 days	6.92[d]	7.26[d]
Metabolizable Energy, mcal/kg	3.11[d]	3.02[d]

[a]Interval weights are reported after a 4% shrink; weights for the test are based on hot carcass weight with 62 dressing percentage.
[b]All consumption data on an as fed basis. (Ration dry matter = 87%).
[c]Feed/gain for the trial is expressed on a 100% dry matter basis.
[de]Means within a row with different superscripts differ (P<.05).

Table 3. Carcass measurements for heifers on different ionophore antibiotic feeding regimes.

Parameters	Treatments	
	Monensin + Tylosin	Lasalocid A.M. Oxytetracycline P.M.
Carcass weight	623[a]	611[a]
Dress percent	61.9[a]	62.0[a]
Liver abscess incidence, %	4.2[a]	0[a]
Rib eye area, square inches	11.88[a]	12.00[a]
Sq. In./CWT	1.90[a]	1.96[a]
Kidney-heart-pelvic fat, %	2.33[a]	2.22[a]
Fat thickness, in.	.46[a]	.45[a]
Marbling[c]	15.66[a]	14.79[a]
Yield grade	2.68[a]	2.46[a]

[ab]Means within a row with different superscripts differ (P<.05).
[c]14=small; 15=small plus; 16=moderate minus.

There were no significant differences in the carcass parameters measured (P<.05). Hot carcass weights, fat thickness and marbling score were 1.9, 2.2 and 5.8 percent, respectively, higher for the monensin-tylosin cattle. Dressing percent, rib eye area and yield grade were .16, 1.0 and 8.9 percent, respectively, improved in the lasalocid A.M.-oxytetracycline P.M. treatment. One small liver abscess was noted in the study and occurred in the monensin-tylosin treatment. The 4 percent rate in this treatment and zero level in the lasalocid-oxytetracycline treatment is substantially below industry averages of condemned livers due to abscess (Foster and Woods, 1970).

Animals may be successfully crossed over from an ionophore-antibiotic combination to an A.M.-P.M. ionophore-antibiotic feeding regime with no significant differences in performance or carcass characteristics.

The supplement for treatment 2 was formulated to supply lasalocid at 30 g/ton and oxytetracycline at 75 mg/hd/day.

Literature Cited

Foster, L. and W. Woods. 1970. Liver loss in finishing cattle. Nebraska Beef Cattle Report EC 70:218.

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COMPARISON OF SALINOMYCIN TO OTHER IONOPHORES FOR FEEDLOT STEERS

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Story in Brief

One hundred thirty-seven yearling steers were fed whole shelled corn diets (1) without additives, (2) with salinomycin (10 g/ton of feed), (3) with lasalocid (30 g/ton of feed) or (4) with monensin (25 g/ton of feed) plus tylosin (10 g/ton of feed). Feed intake was reduced by 4.2% with salinomycin, 1.3% with lasalocid and 6.0% with monensin-tylosin. Rate of gain was increased with salinomycin (5.0%) and with lasalocid (5.3%), and monensin-tylosin decreased gains 2.5% on a carcass basis. Efficiency of gain was increased by salinomycin (8.7%), lasalocid (5.4%) and monensin-tylosin (2.4%) on a carcass basis. Dressing percentages were higher for those steers fed salinomycin. Fat thickness tended to be lower with an ionophore in the diet and cutability higher.

(Key Words: Feedlot Steers, Salinomycin, Lasalocid, Monensin, Tylosin.)

Introduction

Feed additives of a class called ionophores have proven to increase efficiency of feed use by feedlot cattle. Monensin, lasalocid and salinomycin are three ionophores. Monensin is widely fed today. Salinomycin appears promising based on earlier studies (Owens and Gill, 1982; Ferrell et al., 1983; Martin et al., 1984) and approval by the FDA for feeding to feedlot cattle is expected shortly. In these studies, salinomycin improved gains from 7 to 18.6% and feed efficiencies from 5.2 to 9.6%. This trial was conducted to further evaluate salinomycin and to compare the effects of salinomycin, lasalocid and monensin-tylosin on the performance of finishing cattle.

Materials and Methods

One hundred forty yearling crossbred steers were purchased from Oklahoma auction barns and assembled at a backgrounding operation in Purcell, Oklahoma. On arrival at this facility, the steers were ear tagged and received IBR, PI_3, BVD, Lepto, clostridial, and pasturella haemolytica (live) vaccines. After assembly the cattle were trucked to Stillwater, Oklahoma on December 9, 1983. On arrival they were held in drylot for two weeks. On December 26, the steers were weighed and divided into five weight groups (average initial weight of 723 lb). Steers within each weight group were allocated to one of four pens (seven head per pen) and the four feed treatments were randomly allotted to pens within a weight group. Cottonseed hulls, alfalfa pellets and whole corn comprised 92.9% of the ration with the percentage hulls and alfalfa pellets in the ration decreasing sequentially from 40 to 30 to 20 to 10 and 6% over a three week period (Tables 1 and 2). Drug assays agreed well with proposed drug concentrations (Table 3). Steers received the 40%

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roughage diet for three days, 30% for five days, 20% for 7 days, 10% for 6 days, and 6% for the remainder of the trial. Steers were weighed full at the start of the trial and on days 28, 56, 84 and 112. The steers were switched to an additive-free diet on day 112 of the trial and fed this ration for nine days. The steers were trucked to Emporia, Kansas

Table 1. Diet composition, dry matter basis[a].

Ingredient	Ration Sequence 1	2	3	4	5
			%		
Corn, whole shelled	52.88	62.88	72.88	82.88	86.88
Cottonseed hulls	15.00	10.00	10.00	5.00	4.00
Alfalfa, dehy-pellets	25.00	20.00	10.00	5.00	2.00
Pelleted supplement	7.12	7.12	7.12	7.12	7.12

[a]To provide 11.94% protein, .46% calcium, .33% phosphorus, .52% potassium and 1500 I.U. vitamin A per pound of ration dry matter.

on day 121 of the trial for slaughter and carcass evaluation. Two steers died during the trial and one steer was removed from the trial for causes not related to the experimental treatments. Weights are reported on a full basis while the total trial gain and efficiency (day 112) were calculated using a 4% pencil shrink. Gains and feed efficiencies for the total 121 day trial were calculated from hot carcass weights assuming a dressing percentage of 62.

Table 2. Pellet composition, dry matter basis[a].

Ingredient	Percent
Soybean meal	3.15
Cottonseed meal	2.00
Calcium carbonate	1.00
Urea	.40
Cane molasses	.25
Salt	.30
Trace mineral	.01
Vitamin A - 30	.01
Drug premix	
Total	7.12

[a]Pellet supplement for specific treatments contained .2367% Salinomycin 30, .3140% Bovatec 68, or .3017% Rumensin 60 plus .1775% Tylan 40.

Results and Discussion

Daily gains were influenced little by the addition of ionophores to the diet (Table 4). During the first half of the trial, gains tended to be higher with added ionophores, whereas in the latter half of the feeding period the control steers had the highest gains. Changes in gains adjusted to an equal carcass basis with these additives were: +5, +5.3 and -2.5% for salinomycin, lasalocid and monensin-tylosin, respectively. Feed intakes generally decreased with an added ionophore. Salinomycin decreased feed intake 3.9%. This is in contrast with previous studies at OSU (Owens and Gill, 1982; Ferrell et al., 1983; Martin et al., 1984) in which it increased feed intakes by 2.0, 1.4 and 7.4%. Feed intake did not increase with time on feed but was similar for the first and second half of the trial despite the increase in body weight.

The presence of an ionophore in the diet slightly improved feed efficiencies on a carcass weight adjusted basis (8.7, 5.4 and 2.4% for salinomycin, lasalocid and monensin-tylosin, respectively). Those steers fed salinomycin were significantly more efficient than the control steers (P<0.05) but other differences were not significant

Table 3. Drug assay results[a].

Diet	Theory Level, g/ton	Assayed, g/ton
Salinomycin	142	143.7
Lasalocid	427	447.5
Monensin	362	373.1
Tylosin	142	122.4

[a]Assayed for A.H. Robbins Company.

Table 4. Performance data.

Item	Control	Salinomycin	Lasalocid	Monensin-Tylosin
Weight, lb				
Initial	731	729	715	716
28 days	855	859	858	838
56 days	959	972	962	945
84 days	1055	1062	1056	1045
112 days	1127	1130	1118	1107
Daily gains, lb				
0-56 days	4.07	4.34	4.40	4.10
57-112 days	3.00	2.81	2.80	2.88
0-112 days	3.13	3.18	3.20	3.10
0-slaughter[c]	3.23	3.39	3.40	3.15
Daily feed, lb				
0-56 days	20.6	20.0	20.7	19.4
57-112 days	21.1	19.7	20.4	19.8
0-112 days	20.8	20.0	20.6	19.6
0-slaughter	20.5	19.7	20.4	19.4
Feed/gain				
0-56 days	6.11	5.50	5.60	5.81
57-112 days	7.34	7.31	7.69	7.31
0-112 days	6.66	6.29	6.44	6.33
0-slaughter[c]	6.35[a]	5.80[b]	6.01[ab]	6.20[ab]

[a,b]Means in a row with different superscripts differ (P<.05).

[c]Based on carcass weight divided by .62, an assumed dressing percentage.

statistically. The improvement in efficiency with salinomycin compares favorably with those observed in earlier trials at OSU (5.5, 5.2, and 9.6% improvements).

Carcass weights (Table 5) were higher for those steers that had higher rates of gain. Dressing percentages were significantly higher for those steers fed salinomycin or lasalocid as compared to the monensin-tylosin cattle (P<0.05). About 14% of the steers had liver abscesses and one steer had liver flukes. None of the steers fed monensin-tylan had liver abscesses, suggesting that tylan prevented this disorder. Steers receiving ionophores had greater cutability and a more desirable yield grade.

Results of this trial correspond well with previous benefits noted with salinomycin in earlier trials at OSU (Table 6). Averaged across these trials, rate of gain increased 10% and efficiency of feed use increased 7.7% with the addition of salinomycin to the diet.

Table 5. Carcass characteristics.

Item	Control	Salinomycin	Lasalocid	Monensin-Tylosin
Carcass wt, lb	695	706	698	680
Dressing percent	61.7^{ab}	62.5^{a}	62.5^{a}	61.4^{b}
Liver abscesses				
Incidence, %	22.9^{a}	12.4^{ab}	20.0^{ab}	0.0^{b}
Severity[d]	0.48	0.25	0.40	0.00
Rib eye area	12.5	13.0	12.8	12.9
KHP, %	1.41^{b}	1.55^{ab}	1.65^{ab}	1.76^{a}
Fat thickness, in.	0.47^{a}	0.44^{ab}	0.39^{b}	0.39^{b}
Marbling score[e]	12.4	12.0	12.5	12.0
Cutability, %	50.6	51.1	51.3	51.4
Yield	2.6	2.4	2.4	2.3
Percent choice	534	48	52	40

[a,b,c]Means in a row with different superscript differ (P<.05).
[d] 1=abscess of small size; 2=many abscesses or one of moderately large size.
[e] 11=average slight; 12=slight plus.

Table 6. Effects of Salinomycin feeding in trials at Oklahoma State.

	Effects (%)			
Reference	Daily Gain	Feed Intake	Feed/ Gain	Steers/ Treatment
Owens and Gill, 1982	8.0	2.0	5.5	28
Ferrell et al., 1983	7.0	1.4	5.2	14
Martin et al., 1984	18.6	7.4	9.6	32
This trial	5.0	-3.9	8.7	35
Weighted average	10.0	1.6	7.7	

Literature Cited

Ferrell, M.C. et al. 1983. Salinomycin levels for feedlot steers and heifers. OSU MP-114:45.

Martin, J.J. et al. 1984. Comparison of ionophores for feedlot steers. OSU MP-116:266.

Owens, F.N. and D.R. Gill. 1982. Salinomycin levels for feedlot steers. OSU MP-112:131.

WHEAT TO CORN RATIOS FOR FEEDLOT CATTLE

J.J. Martin[1], C.A. Strasia[2], F.N. Owens[2] and D.R. Gill[3]

Story in Brief

One hundred fifty black and black baldy implanted yearling steers were fed cracked grain diets containing (1) 50% corn and 50% wheat (50W), (2) 25% corn and 75% wheat (75W) or (3) 100% wheat (100W). Diets contained monensin (30 g/ton of feed) and tylosin (90 mg/hd/d) and 12% roughage of which 7% was cottonseed hulls, 2.5% was alfalfa pellets and 2.5% was in the supplement.

Feed consumption, rate of gain, shrunk live weight, carcass adjusted gain, hot carcass weight and marbling score all favored the 50W diet. Daily feed intake was depressed by 7.6% or about 1.7 pounds per head by 75W and 100W diets. Daily gains for cattle fed 50W, 75W and 100W diets were 3.23, 3.09 and 3.09 pounds (live basis) or 3.44, 3.32 and 3.22 pounds (carcass weight adjusted basis). Fat thickness and yield grades slightly favored steers fed 75W and 100W diets. Efficiency of feed use was best for the 75W diet (6.13 vs 6.44 and 6.39 pounds of feed per pound of gain for 75W vs 50W and 100W diets). Metabolizable energy value was between 3 and 14% greater (mean 8.4%) for wheat than corn depending on level of substitution in the diet.

(Key words: Wheat, Corn, Energy value, Steers.)

Introduction

In the past, hard red winter wheat was never fed as more than one-third of the grain in diets for finishing steers. Bloat and acidosis became prevalent at higher levels of wheat incorporation. With the advent of ionophores, problems with bloat and acidosis decreased (Bartley et al., 1983). Hence, when attractively priced, wheat would be ideal as the only grain in the diet and in 1984 there was a resurgence in the use of wheat in diets for finishing cattle. Level of roughage in wheat diets may be important. Gill et al. (1981) with corn-based diets indicated that rate and efficiency of gain are improved as roughage levels are reduced to 12% or below though type of grain, method of processing and type of roughage may make other levels more desirable. The 12% level of roughage will still provides some margin of safety while providing sufficient energy for rapid and efficient gains. This trial was conducted to (1) test the feasibility of feeding wheat as 100% of the grain portion of the diet, (2) determine the relative energy values of cracked wheat and corn grains for feedlot steers and (3) test the effects of a elevated wheat levels on feedlot performance, liver abscesses and carcass characteristics of steers.

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[2]Area Extension Livestock Specialist, Guymon, OK [3]Professor

Materials and Methods

One hundred fifty black and black baldy yearling steers, some of which were crossed with exotic breeds and had been pastured together on wheat near Alva, OK were trucked 185 miles to Panhandle State University, Goodwell, OK on May 17, 1984. On arrival, all steers received routine feedlot vaccinations, were ear tagged and received a Synovex-S® implant. A second Synovex-S® implant was administered 56 days later.

Steers had an average shrunk weight initially of 711 pounds. They were blocked by weight into two groups (674 and 749 lb means) and randomly allocated within block to three treatments. A total of 6 pens (2 per treatment) with 25 steers per pen were used in this experiment. Composition of the finishing diets is shown in Table 1. Animals were gradually switched from the initial diet (50% roughage) to their finishing diet (12% roughage) during the first 56 days of the study. Animals were weighed after trucking (shrunk) initially and on full feed on days 28, 56, 84 and 126 with a pencil shrunk of 4% applied to calculate shrunk weights and weight gains.

After feeding for 126 days, cattle were trucked for slaughter at National Beef, Liberal, KS and data on hot carcass weight, marbling score, preliminary yield grade, fat thickness at the 12th rib, and liver abscess incidence were obtained. Treatment means for performance and carcass characteristics were compared by Analysis of Variance (Steel and Torrie, 1960).

Table 1. Diet composition, dry matter basis.

	Percentage Wheat		
	50%(50W)	75%(75W)	100%(100W)
Ingredients			
Wheat, cracked	40.7	61.1	81.4
Corn, cracked	40.7	20.4	0
Cottonseed hulls	7.00	7.00	7.00
Alfalfa pellets	2.55	2.55	2.55
Molasses	4.00	5.00	5.00
Supplement[a]	5.00	4.00	4.00
Calculated composition, % of dry matter			
Crude protein, %	11.8	12.6	13.6
Calcium, %	.438	.383	.381
Phosphorus, %	.336	.334	.371
Potassium, %	.776	.874	.932
NE_m, mcal/100 lb	90.8	90.6	91.0
NE_g, mcal/100 lb	56.6	57.2	57.8
ME, mcal/kg	2.93	2.97	2.97

[a]Supplements, formulated to provide Monensin, (30 mg/hd/d) and Tylosin, (90 mg/hd/d) in the total diet contained (%): Alfalfa meal, 59.7; cottonseed meal, 10.4; $CaCO_3$, 15.6; urea, 7.68; salt, 5.76; Monensin 60, .47; Vitamin A 30, .23; and Tylosin 40, .23 percent.

Results and Discussion

Daily gains favored cattle fed the 50W diet (Table 2). Daily gain tended to decrease linearly as percentage of wheat in the diet increased. Steers fed 100W gained less rapidly (P<.05) than steers fed other diets during 56 to 84 days on feed.
Feed consumption tended to be lower as wheat became more than 50% of the grain in the diet. But feed efficiency was improved by replacing corn by wheat in the diet with 75W producing the lowest feed intake and best efficiency. Part of this effect may be due to energy (starch) digestibility of the wheat being higher than for corn though the higher level of protein in the higher wheat diets (Table 1) may be involved as well.

Table 2. Animal performance with various wheat levels.

	Wheat, percentage		
	50	75	100
Animals	50	50	50
Pens	2	2	2
Period daily gain, lbs			
0-28 days	3.42	3.32	3.50
29-56	3.17	2.91	3.34
57-84	3.31[a]	3.22[a]	2.76[b]
85-126	3.07	2.95	2.85
Cumulative daily gain, lbs			
0-56	3.30	3.12	3.42
57-84, live basis	3.12	3.01	2.77
0-126, live basis	3.23	3.09	3.09
0-126, carcass basis	3.44	3.32	3.22
Period daily feed, lbs			
0-28 days	17.42	16.08	16.20
29-56	21.72	19.49	19.34
57-84	23.75	21.80	22.19
85-126	24.60	22.90	23.27
Cumulative daily feed, lbs			
0-56	19.57	17.79	17.78
57-84	23.91	22.14	22.51
0-126	22.17	20.38	20.59
Period feed/gain ratio			
0-28, live basis	5.09	4.84	4.62
29-56, live basis	6.85	6.69	5.79
57-84, live basis	7.17	6.77	8.03
85-126, live basis	8.01	7.76	8.16
Cumulative feed/gain ratio			
0-56, live basis	5.93	5.70	5.19
57-84, live basis	7.67	7.35	8.12
0-126, carcass basis	6.44	6.13	6.39
Calculated Metabolizable Energy			
mcal/kg diet dry matter	2.60	2.69	2.64

[ab]Means within a row with different superscripts differ (P<.05).

Animals with lower initial weights had lower feed intakes, higher rates of gain and more favorable feed efficiency than animals with heavier initial weights (Table 3). This difference could be due to being on an earlier part of the growth curve or to genetic or background differences in the two weight groups. Feed intake continued to increase throughout the feeding trial for lighter steers but intake plateaued for heavier steers near the end of the trial. Intake and efficiency differences match patterns often observed in commercial feedlots.

Table 3. Effects of initial weight grouping on performance and efficiency.

	Starting weight, lb.	
	674	749
Animals	75	75
Cumulative daily gain, lbs		
0-56, live basis	3.28	3.28
57-126, live basis	2.87	3.07
0-126, carcass basis	3.35	3.31
Period daily feed, lbs		
0-28	16.27	16.86
29-56	19.70	20.67
57-84	21.76	23.40
85-126	23.06	24.11
Cumulative daily feed, lbs		
0-56	17.98	18.77
57-84	22.22	23.48
0-126	20.52	21.58
Period feed/gain ratio		
0-28, live basis	4.39	5.40
29-56, live basis	6.88	6.06
57-84, live basis	6.63	8.01
85-126, live basis	8.63	7.44
Cumulative feed/gain ratio		
0-56, live basis	5.48	5.72
57-84, live basis	7.74	7.65
0-126, carcass basis	6.12	6.51
Calculated Metabolizable Energy		
mcal/kg diet dry matter	2.56	2.66

Most carcass measurement including adjusted gain, hot carcass weight, marbling score and dressing percentage tended to favor steers fed the 50W diet (Table 4). Since the treatment differences in fat thickness and other carcasses measurements were small, the slightly lowered marbling score with the 100W diet may be due to random biological variation.

The incidence of liver abscesses were all high for diets containing the antibiotic tylosin. Incidence of abscesses tended to greater with higher levels of wheat in the diet though the difference was not significant (P>.05). The incidence of liver abscesses was typical of that found in the feedlot industry though higher than most previous

Table 4. Effects of different wheat levels on animal performance and carcass characteristics.

	Wheat, percentage		
	50	75	100
Dressing percentage	63.5	63.6	62.9
Live weight, lbs	1119.1	1101.6	1102.4
Gain/head, live, lbs	407.2	389.2	389.4
Gain/hd, 62% carcass adjusted	434.6	418.5	406.8
Carcass weight, lbs	710.5	701.2	693.8
Marbling score[a]	12.8	12.7	11.8
Yield grade	3.22	3.13	3.13
Fat thickness, inches[b]	.48	.45	.45
Liver abscesses, % of cattle	16	32	22
Cost of gain, $/cwt	54.28	50.68	49.68

[a] 11 = good plus; 12 = choice minus.
[b] Measured at the 12th rib.

studies from the Goodwell station with small pens of cattle and corn or milo based diets.

The metabolizable energy values for the total diet tended to favor the diets containing more wheat. The first increment of cracked wheat added to the 50W diet to increase the percentage of wheat to 75% calculates to have a value 114% that of cracked corn. In contrast, wheat added to the 50W diet to increase wheat to 100% of the diet had a value 103% that of cracked corn for an overall mean advantage for wheat over corn of about 8% for the total ration or about 10% for the wheat alone considering that 81% of the ration dry matter is grain. This advantage for wheat conflicts with tabular values (NRC, 1984) which indicate that dry corn grain has about 102% the metabolizable energy value of wheat. Differences in grain processing and varieties as well as feeding conditions (roughage level and source) may be responsible for this discrepancy. Metabolizable energy values all were about 12% lower than expected from composition of the finishing diet (Table 1). This is probably due to the 56-day period which was needed to adapt cattle to the 88% concentrate diets.

Based on the price of corn grain ($6.61) and wheat ($5.83) when this trial was conducted, the feed cost of gain favored diets higher in wheat. Since wheat at 75% of the grain in the diet gave the highest efficiency, little economic advantage to feeding more than 75% wheat was apparent.

Diets containing up to 100% of their grain from rolled wheat were well utilized by growing steers at a roughage level of 12%. For prevention of metabolic disorders, which appear more frequently with wheat than corn or milo diets, wheat diets should contain an ionophore plus a liver-abscess preventing antibiotic. Good bunk management can make high wheat diets work in the feedlot though the optimal level for wheat feeding may be less than 100%.

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POTASSIUM LEVELS AND DIGESTIBILITIES IN FEEDLOT STEERS

B.E. Doran[1], A.L. Goetsch[2], and F.N. Owens[3]

Story in Brief

Effect of potassium (K) level on site and extent of digestion was investigated with four cannulated steers receiving a 90 percent concentrate rolled corn diet with 10 percent cottonseed hulls as a roughage source. Four levels of potassium [.48 (control), .64, .79, and .95 percent of diet dry matter] with supplemental potassium from potassium chloride were fed in a 4 x 4 latin square design experiment. Ruminal, duodenal, and fecal pH were not significantly different (P>.05). Ruminal ammonia nitrogen concentration was greatest for the .95K diet. Ruminal organic matter (OM), starch, and nitrogen digestibilities did not differ significantly (P>.05), but tended to be greatest for the .95K diet (70.3, 83.1, and 54.8 percent), lowest for the .79K diet (62.0, 76.6, and 42.2 percent), and intermediate for the .48K and .64K diets. Post ruminal digestibilities of organic matter, starch and nitrogen tended to be the greatest at the .79K level. Although fluid dilution and particulate passage rates were not significantly affected by K level, the overall correlation of ruminal liquid (CoEDTA) with solids (Yb-labeled corn) passage rates was positive (r=.46; P<.07). Ruminal starch digestion was inversely related to fluid dilution rate (r=-.36; P<.18) and to particulate passage rate (r=-.65; P<.01). Microbial efficiency was maximized at the .79K level (16.4 percent) and was lowest at the .95K level of supplementation (12.2 percent). Statistical analysis revealed a significant cubic effect (P<.02) of K on microbial efficiency being greatest with .79 percent K in the diet.

[Key Words: Feedlot, Potassium Chloride, Steers, Site of Digestion, Passage Rate.]

Introduction

Early research indicated that potassium (K) levels of .5-.6 percent in the ration dry matter was adequate for rapid weight gains in finishing steers (Roberts and St. Omer, 1965). Currently, K recommendations for growing and finishing steers range from .5-.7 percent ration dry matter, with a suggested value of .65 percent (NRC, 1984). Because most concentrate feeds are below this percentage, K supplementation of high concentrate rations is a common practice.

Previous trials at Oklahoma State University suggest that with increased K supplementation levels, feedlot performance may be increased. Limited research suggests K supplementation might benefit the animal in several ways: 1) through maintenance of a desirable moisture content of the rumen fluid for bacterial fermentation (Ward, 1966); 2) by enhancing ruminal digestion, particularly of fiber (Zinn et al., 1983); 3) through buffering since K may be converted to $KHCO_3$ in the rumen (Zinn and Owens, 1983); 4) by stabilizing feed intake (Zinn et al., 1981);

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and 5) through increasing water intake and water turnover rate (Ward, 1966). The objectives of this study were to examine the influence of various KCl supplementation levels on the site and extent of digestion and on ruminal passage rates.

Materials and Methods

Four dairy steers (254 lb) fitted with ruminal and duodenal cannulas were used in a 4 x 4 latin square design experiment to study site and extent of digestion of a high concentrate, complete, mixed diet. The control diet (C) had no supplemental K (Table 1), but was calculated to contain .48 percent K. Potassium chloride replaced rolled corn in the test diets to produce test diets which contained .64, .79, and .95 percent K on a DM basis. All diets contained chromic oxide as an indigestible marker at .3 percent above the total ration. Steers were fed twice daily at 0800 and 2000 hr, and daily DM intake was 2.25 percent of body weight.

Table 1. Complete mixed diet compositions.

Ingredient	Percent of Dry Matter
Corn Dent #2, Rolled	80.54
Cottonseed Hulls	10.36
Soybean Meal, Solvent process	4.03
Cottonseed Meal, Solvent process	2.01
Calcium Carbonate	1.00
Salt	.30
Urea	.56
Cane Molasses	.25
Trace Minerals	.01
Vitamin A-30	.01
Rumensin, 60 gram per pound	.02
Tylan, 10 gram per pound	.04
Corn grain	.87-.0
Potassium chloride[a]	.0-.87
Chromic oxide	.3

[a]To provide .64, .79, and .95 percent dietary potassium from added potassium chloride (.29, .58, and .87 percent).

Periods lasted 14 days with sampling on days 13 and 14. One-hundred grams of ytterbium labeled corn was added to each diet at 2000 hr on day 11 to estimate particulate passage. A fluid marker (CoEDTA) was intraruminally dosed prior to the morning feeding on day 13. Rumen samples were obtained via cannula on day 13 before dosing and 1, 3, 6, 9, and 12 hr post feeding. Samples from the duodenum and rectum were obtained 39, 45, 51, 57, 66, 72, 78, and 84 hr after feeding ytterbium-labeled corn. Feed samples were collected on days 11-14. Feed, ruminal fluid, duodenal, and rectal samples were subjected to all or part of the following analyses: pH, dry matter (DM), Kjeldahl nitrogen (N), ammonia-N (NH_3-N), nucleic acid-N (NAN), ash, starch, chromium, ytterbium, and cobalt.

Results and Discussion

Mean ruminal, duodenal, and fecal pH (Table 2) did not differ significantly (P>.05) with increasing K supplementation levels. However, fecal pH tended to be higher with K levels of .64 percent or greater. In this trial ruminal and fecal pH in all treatments was higher than expected for a 90 percent concentrate ration. However, this may be related to modest feed intake level which should reduce the incidence of subacute and acute digestive disturbances. Duodenal pH was similar to other reports in which similar concentrate levels were fed. Since pH was not increased with added KCl, increased buffering capacity of ruminal contents seems unlikely.

Table 2. Mean digestive tract measurements.

Item	Diet			
	.48%K	.64%K	.79%K	.95%K
Ruminal pH	6.22	6.17	6.24	6.21
Duodenal pH	2.33	2.39	2.33	2.34
Fecal pH	6.30	6.47	6.54	6.45
Ruminal ammonia-N, mg/dl	3.5[b]	3.8[ab]	3.7[ab]	5.6[a]
Ruminal fluid				
Dilution rate, %/h	4.14	5.15	4.61	6.00
Volume, liter	12.7	10.8	12.0	10.5
Particulate passage rate, %/h	4.32	3.37	3.80	4.03

[a,b]Means in a row with different superscripts differ (P<.05).

Ruminal ammonia-N (Table 2) was greater (P<.05) for steers receiving .95 than those fed .48 percent K. This may be due to increased ruminal N degradation or reduced use of ammonia-N for synthesis of microbial protein. Microbial N (MN) entering the duodenum tended to be greater for the .48K and .79K (23.2 and 23.4 g/day) than with the .64K and .95K diets (20.7 and 21.0 g/day). Also ruminal fluid dilution rates tended to be lower with the .48K and .79K diets (Table 2). Ruminal fluid volumes were not significantly different (P>.05). Rumen volume and ruminal fluid dilution rate were inversely related (r=-.88; P<.0001); rumen volume and particulate passage rate also were inversely related (r=-.45; P<.08). Urinary excretion of K may have increased water intake and rumen fluid dilution rate, but this was not measured in this study. Water intake and urine excretion volume usually are directly related to K intake. Ruminal liquid and solids passage rates were correlated positively (r=.46; P<.07).

Table 3. Site and extent of digestion of diets varying in percent potassium.

Item[c]	Diet				Contrast[d]
	.48%K	.64%K	.79%K	.95%K	
Organic matter, %					
Ruminal	67.9	66.9	62.0	70.3	-
Post ruminal (apparent)	14.5	18.7	22.4	15.7	-
Total tract	82.4	85.6	84.4	86.0	-
Starch, %					
Ruminal	82.4	80.7	76.6	83.1	-
Post ruminal	13.1	16.7	19.8	13.9	-
Total tract	95.5	97.4	96.4	97.1	-
Nitrogen, %					
Intake, g/d	46.1	45.3	46.1	46.2	-
Duodenal, g/d					
Total, g/d	50.6	48.9	53.0	45.2	-
Microbial, g/d	23.2	20.7	23.4	21.0	-
Feed, g/d	23.9	24.9	25.7	20.8	-
Total tract digestibility, %	71.0	74.0	72.3	75.1	-
Microbial efficiency, g MN/kg organic matter fermented	13.8[ab]	12.4[b]	16.4[a]	12.2[b]	C

[ab]Means in a row with different superscripts differ (P<.05).
[c]Digestion measures, % of intake.
[d]Indicative of linear (L), quadratic (Q), and or cubic (C) effect (P<.05).

Although dietary level of K had no significant (P>.05) impact on ruminal organic matter digestibility, ruminal organic matter (OM) digestion coefficients (Table 3) tended to be higher for the .95K ration (70.3 percent) and lower for the .79K diet (62.0 percent). Zinn (1983) found enhanced ruminal OM digestion with increased K supplementation, particularly with rations containing more fiber. Ruminal OM digestibility and particulate passage rate were negatively correlated (r=-.64; P<.01). Rumen fluid dilution rate also was inversely related to ruminal OM digestion (r=-.31; P<.24).

Post ruminal OM digestion did not differ significantly (P>.05) with K level of the diet. At the .79K level, post ruminal OM digestion tended to be greatest. This may be due to compensation for decreased ruminal OM digestion with this diet. Total tract OM digestion did not differ significantly (P>.05) but total tract OM digestion tended to increase with increasing dietary K in agreement with previous potassium trials (Zinn and Axe, 1983).

Ruminal and total tract N digestibility (Table 3) was not significantly different (P>.05) but tended to be greatest with .95K supplementation. A negative correlation (r=-.52; P<.04) existed between particulate passage rate and ruminal N digestibility.

Statistical analysis revealed a significant cubic effect (P<.02) with microbial efficiency tending to decrease as levels of K in the diet increased. Microbial efficiency was higher at .79 K than at the .95 K level (P<.05). Elevated liquid and particulate passage rates may inhibit the efficiency of microbial growth and decrease flow of MN from the rumen if time of fermentation is inadequate for maximum microbial colonization. However, ruminal OM digestibility and microbial efficiency were negatively correlated (r=-.95; P<.0001). Relative rates of 1) microbial dilution, 2) feed removal, 3) fermentation rate and capacity, and 4) lag time for fermentation are needed to assess the total effect of altered dilution rates on microbial output from the rumen (Goetsch and Owens, 1984). Lower dilution and particulate passage rates may enhance the proportion of duodenal chyme which is microbial protein but decrease microbial efficiency. This may be due to marker problems or reflect ruminal flow conditions more optimal for efficient microbial growth. Ward (1966) has also proposed that potassium increases the osmotic pressure of the rumen fluid and functions to maintain a desirable moisture content in the rumen fluid which could increase bacterial fermentation.

Ruminal starch digestion (Table 3) did not differ (P>.05) with K level but was 7 percent greater for the .95K diet than the .79K diet. Incorporation of starch into microbial protein might be involved. Post-ruminal starch digestion inversely related to ruminal starch digestion. Whether this was due to increased digestion in the small intestine or increased fermentation of starch in the small intestine plus colon was not determined in this study. Total tract starch digestion paralleled total tract OM digestion. Ruminal starch digestion was negatively correlated with fluid dilution rate (r=-.63; P<.18) and with particulate passage rate (r=-.65, P<.01); particulate passage rate was also inversely related to total starch digestion (r=-.63; P<.01).

Results from this trial indicate that a moderate level of K supplementation (.79 percent K diet dry matter) tended to increase icrobial efficiency (P<.02). However, total tract OM, starch, and N digestibilities did not differ significantly. K supplementation to the .95K level shifted greater OM, starch, and nitrogen digestibility to the rumen and tended to reduce microbial efficiency. A moderate K level (.79 percent) shifted starch and N digestibility to the post ruminal tract and maximized microbial efficiency. Further research is needed to determine the optimum K supplementation to maximize microbial efficiency and extent of digestion. The relationship of potassium intake to water intake, particulate passage rate, rumen fluid dilution rate, and water turnover rate ust be examined to understand the physiological importance of the K level in the diet.

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STARCH DIGESTION BY FEEDLOT CATTLE: INFLUENCE OF ROUGHAGE AND INTAKE LEVEL AND PARTICLE SIZE

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Story in Brief

Three steers were fed an 80 percent concentrate diet at 1.5 or 2 percent of body weight or a 60 percent concentrate diet a 2 percent of body weight. Cottonseed hulls were added to decrease the concentrate level. Addition of cottonseed hulls to the diet increased starch digestion in the total tract by about 3 percent and reduced the amount of starch found in fecal particles over 2000 microns in diameter. Starch digestion in the rumen tended to decrease with added cottonseed hulls. Of the starch found in the feces, over 85 percent was in particles exceeding 2000 microns in diameter. Starch particles greater than 2000 microns in diameter escaped intestinal digestion while particles under 1000 microns in diameter were extensively digested in the rumen. Particles between 1000 and 2000 microns tended to escape ruminal digestion and disappear most extensively in the intestines. Particle size reduction by grain processing will increase extent of starch digestion in the total tract, especially in the rumen. Accelerating rate of passage of processed grain or addition of certain roughages like cottonseed hulls should shift site of digestion to the intestines and may improve energetic efficiency.

(Key Words: Starch Digestion, Particle Size, Feed Intake, Roughage Level.)

Introduction

Extent of digestion of dietary starch is usually much higher in swine, poultry and sheep than in feedlot cattle (>99 percent versus 85 to 98 percent). Various factors such as low enzyme activity or limited absorptive capacity have been proposed to be responsible. Steam flaking will increase extent of starch digestion and this response has generally been attributed to gelatinization of the starch. But fine grinding also can increase extent of starch digestion. Smaller particles expose more surface area both to microbial attack in the rumen and large intestine and to enzymatic action in the small intestine. Passage rate of particles from the rumen can be influenced by particle size. Particles of forage greater than 1200 microns (1.2 millimeters) in diameter seldom leave the rumen while forage particles less than 100 microns (.1 millimeter) tend to be flushed along with fluids from the rumen. Density also influences passage rate, with very dense or very light particles being retained in the rumen for a longer times and continued digestion. Hence, particle size can alter site and extent of digestion.

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Feed particle size can be reduced by 1) mechanical processing prior to feeding, 2) chewing of feeds during eating and rumination and 3) microbial fermentation which weakens the physical structure and combined with ruminal contractions will gradually reduce particle size. Previous studies (Zinn and Owens, 1983) suggest that at higher feed intake levels, ruminal digestion of organic matter is reduced. In another study (Teeter and Owens, 1981), addition of cottonseed hulls to a whole corn grain diet increased extent of starch digestion. Both of these observations might be related to extent of particle size reduction in the rumen due to decreased fermentation time or to increased chewing or rumination of the grain. The objective of this study was to check the influence of feed intake level and cottonseed hull addition to the diet on particle sizes at the start and end of the small intestine and in feces and on starch digestion of a high concentrate diet fed to growing steers.

Materials and Methods

Three steers (250 kg) equipped with "T" cannulas in the proximal duodenum and distal ileum were used in a 3 by 3 Latin square experiment to measure the influence of level of feed intake on starch digestion, N metabolism and particle size distribution at the start (duodenum) and end (ileum) of the small intestine and in feces. The basal rolled corn diet (Table 1) was fed twice daily (0800 and 2000) at a daily level equal to 1.5 or 2 percent of body weight or at 1.5 percent of body weight with .5 percent of body weight added from cottonseed hulls.

Table 1. Concentrate composition.

Ingredient	Percentage (as fed)
Rolled corn	65.7
Cottonseed hulls	20.0
Soybean meal	10.0
Cane molasses	3.0
Limestone	0.5
Trace mineralized salt	0.5
Chromic oxide	0.3

Experimental periods lasted 11 days with digesta samples collected the final 3 days of each period. During the collection period, samples were obtained simultaneously from the duodenum, ileum and rectum at 2, 6 and 10 hours postfeeding with a minimum of 12 h between sampling times. Chromic oxide was used as a digesta marker. Rumen samples were obtained for measurement of pH and NH_3 and isolation of ruminal bacteria by differential centrifugation 2 h post-feeding after digesta samples had been collected on the final day of each period. Samples of feed, duodenal digesta, ileal digesta and feces were separated into particle sizes by flushing the sample with 25 C water though standard screen sieves with mesh sizes of 4000, 2000, 1000, 500, 250 and 125 microns.

Dry matter content of feed, digesta and feces were determined through oven drying at 65 C. Dried samples were ground and subjected to all or part of the following analyses: Kjeldahl nitrogen, ammonia N, acid detergent fiber, chromium, starch, ash and purines.

Results and Discussion

The effects of intake and roughage level on digestive tract measurements are presented in Table 2. Higher intake of the high concentrate diet decreased ruminal pH but did not alter other measurements. Added cottonseed hulls tended to increase fecal pH and dry matter content of duodenal, ileal and fecal samples. Ruminal ammonia concentrations were all quite low considering that concentrate dry matter contained 13.6 percent crude protein.

Table 2. Digestive tract measurements.

Intake level	1.5	2.0	2.0
Concentrate level, %	80	80	60
Ruminal pH	6.17	5.98	6.15
Ruminal NH_3, mg/dl	2.14	2.53	2.25
Duodenal pH	2.20	2.17	2.13
Duodenal dry matter, %	4.9	7.4	6.8
Ileal pH	7.53	7.58	7.59
Ileal dry matter, %	10.3	12.5	14.4
Fecal pH	6.29	6.23	6.44
Fecal dry matter, %	19.3	22.8	22.8

Site and extent of digestion of organic matter, starch and nitrogen are presented in Table 3. Increased feed intake increased flow of organic matter to the duodenum and ileum and decreased extent of ruminal digestion of organic matter. In this study, increasing feed intake did not increase flow of starch to the duodenum in agreement with results of Zinn and Owens (1983). Total tract starch digestion was not reduced, as might be expected with higher feed intakes. With an even higher feed intake or ad libitum access to feed of feedlot cattle, extent of chewing may be reduced which would increase particle size in the rumen and possibly depress both ruminal and total tract starch digestion. Adding cottonseed hulls to this cracked corn diet shifted site of starch digestion from the rumen to the small intestine and also tended to increase total tract starch digestibility. Small intestinal digestibility tended to be low but was not reduced by added cottonseed hulls. These results support the earlier work of Teeter et al (1981) where cottonseed hulls increased the extent of starch digestion. Previously, this was thought to be due to greater rumination and increased digestion in the rumen, not in the small intestine as suggested from the present study. Total tract digestion of dry matter, starch and N were all lower than anticipated with the basal diet.

To determine the influence of particle size on site and extent of starch digestion, feed, duodenal, ileal and fecal samples were sieved and starch content of subsamples measured (Table 4). Most of the starch in all samples had a particle size greater than 2000 microns.

Table 3. Site and extent of digestion.

Intake level	1.5	2.0	2.0
Concentrate level, %	80	80	60
Organic matter			
Intake, g	2923	3907	3936
Duodenal, g	786	1240	1297
Ileal, g	574	662	666
Fecal, g	668	661	624
Digestibility, %			
Total tract	77.2	82.4	84.6
Ruminal			
Apparent	73.5	68.9	66.6
True	81.4	78.0	74.9
Starch			
Intake, g	904	1208	925
Duodenal, g	130	105	159
Ileal, g	70	76	54
Fecal, g	61	61	25
Digestibility, %			
Total tract	93.3	94.5	97.4
Ruminal	86.0	90.9	82.2
Small intestine	6.2	2.7	11.7
Large intestine	1.0	0.9	3.5
Digesta ash percent			
Duodenum	11.9	11.7	13.0
Ileum	9.7	10.9	11.4
Feces	5.9	7.7	7.4

Table 4. Passage of starch in particles of various size.

Measurement site	Feed	Duodenum	Ileum	Feces
Particle size, microns	----------	g starch daily	----------	
>4000	246	21.1	0.6	13.8
2000-4000	542	27.3	15.5	27.2
1000-2000	137	13.8	13.4	0.9
500-1000	499	0.4	2.6	2.7
250-500	24	1.3	1.3	0.8
125-250	12	0.0	0.3	0.3

Passage of large particles conflicts with the concept developed from forage diets that few particles greater than 1200 microns in diameter leave the rumen. The high density of grain particles and absence of a ruminal mat to filter and trap coarse particles may be responsible for the more extensive passage of large particles with a high concentrate diet.

From the amount of starch of each particle size at various points in the digestive tract, digestion of each particle size was calculated (Table 5) even though particle may be reduced in size during rumination or digestion. Sampling through T-cannulas will reduce recovery of very large or whole corn kernels, but with the smaller particles, digesta samples should be representative.

Table 5. Disappearance of starch from particles of various sizes.

Digestion site	Rumen	Small plus Large intestine	Total tract
Particle size, microns	--------- Percent digested ---------		
>4000	91.4	34.6	94.3
>2000	95.0	0.4	95.0
>1000	89.9	93.5	99.3
>500	99.9	-575.0	99.5
>250	94.6	38.4	96.6
>125	100.0	----	97.5

Generally the smaller the grain particle, the more extensively it was digested in the rumen and in the total digestive tract. Extent of starch digestion in the rumen appeared lower for particles between 1000 and 2000 microns than smaller particles which would be more rapidly digested and larger particles which may be retained in the rumen for further digestion. Galyean et al. (1981) illustrated that the rate of ruminal disappearance from dacron bags suspended in the rumen was much greater for small than large particles but possible differences in rate of passage prevented extrapolation of that work to extent of ruminal digestion. These results show that extent of ruminal digestion of cracked corn is low for larger particles. The fact that fine grinding and steam flaking increase extent of digestion in the rumen and total tract partially reflect surface area for fermentation. Extent of digestion of starch in the small intestine and renewed fermentation in the large intestine did not react in a similar fashion to size of particles entering those points. Over 89 percent of fecal starch was in particles exceeding 2000 microns or one-tenth of an inch in diameter. With added CSH in the diet, very little starch was found to exceed 2000 microns as observed previously by Teeter (1981) with whole corn diets.

The prevalence of large particles containing starch in duodenal, ileal and fecal samples leads to the suggestion that particle size is a major factor limiting digestion of starch in both the rumen and the intestines. Though larger particles escape digestion in the rumen more extensively than small particles, large particles pass through the intestines largely intact. Further study of particle sizes of digesta samples is needed to examine the optimal particle size to escape the rumen but not escape digestion in the small intestine.

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SARSAPONIN LEVEL AND DIGESTION WITH HIGH CONCENTRATE DIETS

A.L. Goetsch[1], F.N. Owens[2] and B.E. Brown[3]

Story in Brief

Three dairy steers (196 lb) were fed 92 percent concentrate rolled milo based diets, at 2.5 percent of body weight to provide 0, 300 or 500 mg sarsaponin (S). All diets contained 200 mg Rumensin per head per day. Ruminal fluid passage rate increased while volume decreased with addition of S. Ruminal organic matter digestion decreased while postruminal disappearance of organic matter increased as level of dietary S increased. Duodenal flows of both total N and nitrogen of feed origin were elevated by dietary S. Likewise, disappearance of feed nitrogen in the rumen decreased while nitrogen disappearance in the small intestine increased linearly with increasing dietary S level. In this study, sarsaponin shifted protein digestion of high concentrate, rolled milo based diet from the rumen to the intestines which could increase performance under certain feeding conditions.

Key Words: Sarsaponin, Digestion, Rumen, Protein Bypass.

Introduction

For lightweight feedlot animals, increasing ruminal protein bypass may be of benefit. Sarsaponin has been suggested to increase bypass of protein in moderately high concentrate feedlot diets (Zinn et al., 1983). However, with 50 percent concentrate rations, S tended to increase ruminal organic matter digestion (Goetsch and Owens, 1984). This trial investigated effects of S on digestion of a high concentrate, rolled milo diet, containing Rumensin.

Materials and Methods

Three cannulated dairy steer calves (196 lb) were fed the basal diet (Table 1) at 2.5 percent of body weight (dry matter basis) plus a special premix. Premixes were formulated and fed to supply daily to each animal: 200 mg Rumensin[4] (C), 200 mg Rumensin and 300 mg sarsaponin[5] (300) or 200 mg Rumensin and 500 mg sarsaponin (500). Periods lasted 21 days with sampling of feeds, duodenal and fecal materials on days 19 through 21. Digesta markers (CoEDTA, Yb-labeled forage) were used to determine passage rates. Samples were subjected to all or part of the following analyses: ammonia-nitrogen (NH_3-N), markers, dry matter, ash, nitrogen (N), starch, chromium, acid detergent fiber (ADF) and nucleic acid-N.

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Table 1. Basal diet composition.

Ingredient	% of dry matter
Rolled milo	86.49
Cottonseed hulls	5.00
Chopped alfalfa	3.00
Cane molasses	2.00
Ammonium sulfate	.10
Potassium chloride	.10
Urea	.90
Dicalcium phosphate	.66
Limestone	.95
Trace mineralized salt	.50
Chromic oxide	.30

Results and Discussion

Ruminal NH_3-N concentration decreased linearly with increasing S level at 11 hours postfeeding (8.6, 7.5 and 5.9 mg NH_3-N/dl for C, 300 and 500 steers, respectively). It has been suggested that S depresses ruminal urease activity. Urea influx from the blood into the rumen would be expected to be highest at later periods in the feeding cycle. These data support the concept that S affects ruminal wall transfer of urea, possibly through slowing urea hydrolysis and thereby reducing the concentration gradient of urea between the rumen lumen and bloodstream.

Increasing S linearly increased ruminal fluid passage rate and decreased volume markedly (Table 2). Fluid passage rate and ruminal volume were negatively related (r=-.90). Particulate passage rate was tended to increase with addition of S to the diet (Table 2).

Table 2. Digesta kinetics.

Item	Treatment 0	300	500
Ruminal fluid dilution rate, %/h	6.7	7.6	9.7
Ruminal fluid volume, liters	29.2	21.1	18.6
Particulate passage rate, %/h	4.6	6.4	5.6

Organic matter (OM) digestion linearly decreased in the rumen and increased in the small intestine with increasing S (Table 3). Hindgut OM digestion tended to decrease with increasing S so that total tract OM digestion was similar for all treatments. Ruminal fluid dilution rate may be a reflection of altered ruminal OM digestion. With high concentrate diets in which ruminal fill does not limit intake, changes in transient volume of undigested material in the rumen could affect dilution rate. As digestion was decreased with S, undigested material might stimulate greater ruminal motility, accelerate ruminal passage rate and decrease ruminal fluid volume. Soluble fluid markers used to estimate fluid dilution rate, however, describe kinetics of total

Table 3. Digestion measures.

Item	Treatment 0	300	500
Organic matter digestion, % of intake			
Ruminal, true	57.9	51.3	45.9
Small intestinal	10.5	16.1	28.4
Hindgut	8.2	5.6	0
Total	76.6	73.0	74.2
Starch digestion, % of intake			
Ruminal	69.4	69.6	58.5
Small intestinal	11.2	11.2	27.9
Hindgut	5.6	4.3	-1.0
Total	86.2	85.2	85.4
Total acid detergent fiber digestion, % of intake	23.5	30.7	31.7
Nitrogen, g/day			
Intake	44.9	44.8	45.0
Duodenal			
Total	40.9	55.0	58.7
Microbial	26.2	25.9	24.0
Feed	11.6	25.7	31.4
Ammonia	3.0	3.4	3.4
Fecal	9.0	12.6	10.9
Microbial efficiency, g microbial nitrogen/kg organic matter fermented	22.1	24.1	26.7

ruminal liquids and do not partition fluid into the amounts associated with particles or free in the rumen.

Ruminal starch digestion tended to be lowest and small intestinal starch disappearance tended to be greatest for 500 diet (Table 3). Total tract digestion of ADF tended to be greater for 300 and 500 diets (Table 3).

Entry of total N and feed N into the duodenum increased linearly with increasing S (Table 3) similar to a previous report by Zinn et al. (1983). Ruminal fluid dilution rate was related to duodenal passage of N. Ruminal and small intestinal N disappearance varied linearly with S level and microbial efficiency tended to increase with increasing S level. The decrease in ruminal OM digestion increased microbial efficiency and protein bypass may be due to the large reduction (36 percent) in rumen volume with 500 S. Sarsaponin shifted site of N disappearance in the presence of an ionophore. Hence, sarsaponin must act differently from or in addition to the ionophore used in this study. However, in feeding studies an interaction between Sarsaponin and ionophores might be detected as both could improve protein status of cattle but alter ruminal volume or passage in opposite directions.

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DUODENAL DOSES OF CASEIN OR GLUCOSE AND RUMINAL FLUID PASSAGE RATE

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Story in Brief

To study the impact of supply of protein to the small intestine on passage of material from the rumen, two dairy calves (364 lb) were fed an 80 percent concentrate diet at 1.8 percent of body weight and were dosed with hydrolyzed casein or glucose into the duodenum twice daily. Ruminal fluid dilution rate outflow and volume were slightly greater with glucose administration to the duodenum.

Key Words: Protein, Ruminal Passage Rate, Rumen Volume.

Introduction

In an earlier report (Goetsch et al., 1985) protein supplementation of a marginal protein diet decreased ruminal digestion of the dietary protein. Such an effect could be due to changes either in the rumen directly or by postruminal feedback to the rumen. Perhaps, increasing the amino acid supply to the small intestine could speed flow of digesta from the rumen. This study was designed to examine the effect of duodenal administration of casein hydrolysate or glucose on ruminal fluid kinetics.

Materials and Methods

In this pilot study, two dairy steer calves (364 lb) were used in a crossover design with two 14 day periods. Steers were fed an 80 percent concentrate diet (Table 1) twice daily at 12 hour intervals at a level of 1.8 percent of body weight. The diet contained 11.1 percent crude protein on a dry matter basis.

Table 1. Diet composition.

Ingredient	% of dry matter
Ground corn	75.0
Prairie hay	20.0
Urea	1.6
Dicalcium phosphate	.5
Limestone	.94
Molasses	1.96

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Steers were dosed with casein hydrolysate or glucose solutions two hours before each meal. Each dose consisted of 65 or 70 ml volume of fluid. With casein hydrolysate, this provided additional crude protein equal to 10 percent of the daily N intake or about 33 grams of casein. The amount of glucose was equal in weight of dry matter. Ruminal samples were obtained at various times after dosing a water soluble marker. Fluid passage rate, volume and outflow rate were calculated from concentration of this marker in rumen samples.

Results and Discussion

Ruminal fluid dilution rate, volume and outflow were 14, 21 and 38 percent greater with duodenal doses of glucose than of casein (Table 2). The diet should have been adequate to support ruminal fermentation though lower than needed for a rapid growth rate. Based on the earlier study, we had reasoned that an improved amino acid status in the intestine might have an influence on ruminal function via hormonal or neural paths and increase ruminal motility or emptying. Results from this study were opposite to that expected and suggest that the added amino acid supply to the small intestine slowed flow of liquid from the rumen or that glucose administration increased flow.

Table 2. Ruminal fluid kinetics.

Item	Treatment	
	Casein	Glucose
Fluid passage rate, %/h	8.48	9.65
Rumen volume, liters	18.53	22.33
Rumen outflow, liter/h	1.57	2.16

An increased energy to protein ratio in duodenal digesta from infused glucose may have signaled the rumen to enhance fluid passage from the rumen in order to 1) increase the amount of protein from feed which would escape from ruminal destruction, 2) increase ruminal outflow of microbial protein or 3) increase rumen microbial efficiency. Each of these could increase protein supply and depress the ratio of energy to protein in duodenal digesta. Conversely, infused casein hydrolysate would depress the energy:protein ratio in the intestines and could signal the rumen to hold materials longer. With high grain diets, particle size may limit intestinal utilization of starch. A longer ruminal retention time usually increases the quantity of energy liberated in the rumen and in the total digestive tract. Ruminal volume and passage rates may be controlled to regulate site of digestion of energy and protein. These results warrant further exploration of the influences of body energy:protein status on rumen function and suggest that bypassed nutrients might be employed commercially to influence retention time and site of digestion by ruminant animals.

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ILEAL ANTIBIOTIC ADMINISTRATION AND DIETARY PROTEIN LEVEL FOR BEEF HEIFERS FED ROUGHAGE DIETS

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Story in Brief

Four beef heifers were fed prairie hay diets with a low (L) or a high (H) level of crude protein (9 or 12.5 percent), and received daily doses into the ileum of either antibiotics (A) in salt solution or the salt solution (S) without antibiotics. Antibiotic infusion tended to increase ruminal ammonia-nitrogen concentration with the high protein diet but to decrease it with the low protein diet. Digestion of organic matter, acid detergent fiber and starch in the rumen tended to be lower in animals receiving antibiotics. Passage of nonammonia-N to the duodenum was equal to 128, 142, 92 and 104 percent of N intake for LS, LA, HS and HA treatments indicating that antibiotics tended to increase the amount of recycled N which was utilized in the rumen. Antibiotic infusion tended to speed passage of fluid from the rumen and to increase volume of digesta in the large intestine.

Key Words: Digestion, Antibiotic, Protein Level, Infusion.

Introduction

Gastrointestinal tract fill may limit intake of forage-fed ruminants. Since the rumen represents the major contributing organ to gut fill, signals originating at the rumen may regulate intake of grazing cattle. Removal of feed particles from the rumen, either by digestion or passage, relieves ruminal distention. Since all undigested residues must pass out of the rumen, certain signals originating from digesta in the postruminal tract ultimately could control rumen emptying.

The contribution of fermentation in the hindgut to total digestion has received limited attention. Microbial activity in the cecum and proximal colon may influence both digestion and passage rate and either liberate ammonia for recycling to the rumen or capture ammonia for excretion in feces. With a low protein-high fiber diet such as low quality native range grass, ruminal fermentation becomes quite dependent on N recycling and methods to increase recycling could be useful.

By dosing antibiotic into the end of the small intestine, fermentation in the large intestine should be reduced. This could reduce the demand for ammonia in the large intestine. Postruminal antibiotics would have different effects from fed antibiotics, as dietary antibiotics can have direct effects on microbes in the rumen or may be absorbed and have systemic effects. The antibiotic used in this study was not absorbed so it should have no systemic effects. With coating technology, protected antibiotics could be developed to be released past the rumen. Value and effects of post-ruminal antibiotics with various feeding conditions remain to be determined. This study

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investigated the effects of antibiotic doses into the ileum and of dietary protein level on site of digestion and passage rate in beef heifers fed a roughage diet.

Materials and Methods

Four beef heifers (569 lb) in a Latin square experiment were fed diets shown in Table 1. The unabsorbed antibiotic or the wash salt solution were dosed via cannula at 0600 each day in each of the four 14-day periods. Corn labeled with ytterbium and cobalt EDTA were used to measure ruminal and post-ruminal passage rates. Specific dosing, sampling and analytical procedures were described previously (Goetsch and Owens, 1984).

Table 1. Diet compositions.

	Diet	
Ingredient, % of dry matter	L	H
Chopped prairie hay	81.3	81.3
Ground corn	8.5	----
Cane molasses	.4	.4
Soybean meal	9.0	17.5
Trace mineralized salt	.5	.5
Chromic oxide	.3	.3

Results

Ruminal ammonia-N (NH_3-N) was greater with the high protein diet at 2, 6 ($P<.05$) and 10 h ($P>.05$) after feeding (Table 2). NH_3-N tended to decrease with antibiotic infusion with the L diet, but to increase with the H diet. This could be due either to changes in the extent of ruminal fermentation and ammonia release or capture or to changes in the amount of ammonia recycled to the rumen.

Table 2. Ruminal ammonia-nitrogen concentrations.

Time after	Treatment[1]				Diet		Infusion	
feeding, h	LS	LA	HS	HA	L	H	S	A
2	5.81[a]	5.24[a]	8.85[b]	10.12[b]	5.53[a]	9.48[b]	7.33	7.68
6	2.91[ab]	.86[b]	4.21[a]	5.04[a]	1.89[a]	4.62[b]	3.56	2.95
10	5.20	3.00	4.10	6.99	4.10	5.55	4.65	4.99

[1]Treatments include diet (L = 9% crude protein; H = 12.5% crude protein) and ileal antibiotic infusion (S = none; A = antibiotic).
[a,b]Means in a row within treatment, infusion or diet headings differ ($P<.05$).

Protein level had little effect on extent ruminal digestion of organic matter (OM), but ileal antibiotic infusion tended to depress OM disappearance in the rumen (Table 3). Hindgut OM digestion compensated and tended to be greater with antibiotic addition. Disappearance of OM in the hindgut as a percent of OM exiting the ileum was 20.3, 27.1, 22.2 and 29.5 percent for LS, LA, HS and HA treatments, respectively. Hence, the ileal antibiotic did not reduce hindgut or total tract digestion.

Protein level had little effect on acid detergent fiber (ADF) digestion but antibiotic infusion reduced ($P<.08$) ruminal ADF digestion. Again, postruminal digestion compensated for this difference. Ruminal microbial efficiency tended to increase with antibiotic doses, increasing as ruminal OM fermentation decreased. Ruminal passage of particles was related to microbial efficiency (MOEFF), passage of microbial N through the duodenum, and ruminal OM digestion ($r=.61$, .55 and -.52, respectively).

Increasing the protein level tended to decrease ($P<.08$) ruminal starch digestion in the rumen but to increase starch digestion in the total tract. Such a change in site of digestion should increase energetic efficiency. Ileal infusion of antibiotic had a similar effect on site of starch digestion, reducing ($P<.12$) starch digestion in the rumen and increasing ($P<.06$) starch digestion in the hindgut.

Passage of nonammonia-N to the duodenum was equal to 128, 142, 92 and 104 percent of N intake for LS, LA, HS and HA treatments, respectively. An interaction ($P<.10$) between infusion and diet was observed for small intestinal N disappearance (Table 3) in which antibiotics tended to increase disappearance of N from the small intestine at the low protein level but decrease it with the higher protein diet. Amount of microbial N (MN) in feces, estimated from purine concentration, tended to be greater ($P<.10$) with the lower protein diet and represented 36, 34, 22 and 28 percent of total non-ammonia N in feces for LS, LA, HS and HA diets, respectively. Total tract N digestibility corrected for nondietary N, tended to increase with antibiotic infusion with the higher protein diet. Total tract N digestibility, not corrected for nondietary N, was higher with the higher protein level.

Antibiotic infusion tended to reduce passage rate of fluid from the rumen (Table 4), but ruminal fluid passage rate and ruminal volume were inversely related ($r=-.60$). An interaction between antibiotic infusion and protein level ($P<.19$) on ruminal volume and passage rate of fluid through the hindgut approached significance with antibiotic infusion increasing ruminal volume and decreasing passage rate of fluid from the large intestine only with the higher protein diet. The first kinetic component of passage rate of particles from the rumen (k_1) estimated from ileal samples was reduced ($P<.08$) with antibiotic infusion. An increase in ruminal or hindgut volume with antibiotic infusion cause this difference. Passage rate (k_1) for ruminal particles estimated from samples from the ileum differed from k_1 estimated from fecal samples in this trial, but the two were related ($r=.59$).

Discussion

Since the antibiotic was infused into the small intestine and not into the rumen and this antibiotic is not absorbed, effects on ruminal digestion were surprisingly large. These must be due to alterations hormone levels or in nutrient recycling to the rumen which alter ruminal volume or passage rate through the upper digestive tract. The

Table 3. Digestion measures.

Item	Treatment				Diet[c]		Infusion[c]	
	LS	LA	HS	HA	L	H	S	A
Organic matter digestion, % of intake								
Ruminal, true	53.4	47.6	51.5	49.4	50.5	50.4	52.4	48.5
Small intestinal	4.3	4.3	6.3	3.6	4.3	4.9	5.3	3.9
Hindgut	10.0	14.4	9.5	14.5	12.2	12.0	9.8	14.4
Total	67.7	66.2	67.2	67.4	67.0	67.3	67.5	66.8
Acid detergent fiber digestion, % of intake								
Ruminal	60.1	56.0	60.1	58.3	58.0	59.2	60.1	57.2
Postruminal	1.6	4.2	2.0	4.1	2.9	3.0	1.8	4.2
Total	61.6	60.2	62.1	62.4	60.9	62.3	61.9	61.3
Nitrogen disappearance, % of intake								
Ruminal	58.8	38.9	59.9	58.0	48.9	58.9	59.4	48.6
Small intestinal	9.3	32.5	20.0	17.0				
Hindgut	8.2	1.9	-3.1	5.9	5.1	1.4	2.5	3.9
Total, corrected for nonfeed constituents	76.3	73.4	76.8	80.9				
Total, uncorrected for nonfeed constituents	62.5	59.0	70.0	73.2				
Nitrogen passage to the duodenum, g/day								
Total	79.3	88.0	80.6	91.0	83.6	85.8	79.9	89.5
Microbial	49.9	46.7	41.8	49.8	48.3	45.8	45.9	48.3
Feed	23.7	35.2	32.0	33.5	29.4	32.7	27.8	34.3
Ammonia	5.8	6.1	6.7	7.8	5.9[a]	7.2[b]	6.2	6.9
Microbial efficiency, g microbial nitrogen/kg organic matter fermented	26.3	31.4	23.3	28.7	28.9	26.0	24.8	30.1

Treatments include diet (L = 9% crude protein; H = 12.5% crude protein) and ileal antibiotic infusion (S = none; A = antibiotic).

[ab]Means in a row within treatment, infusion or diet headings with different superscripts differ (P<.05).

[c]Omitted means denote an interaction between infusion and diet (P<.10).

reduction in ruminal digestion with antibiotic infusion with the 9 percent protein diet may be due to the reduction in ruminal ammonia concentration. Ammonia concentration in the rumen was related to disappearance of N in the rumen (r=.44; P<.09). As level of ruminal ammonia increased even above 5 mg/100 ml, extent of organic matter digestion in the rumen has increased (Weakley and Owens, 1983). Starch and ADF digestion in the hindgut compensated for depressed ruminal digestion suggesting that ammonia concentration limited fermentation in the rumen before it limited fermentation in the large intestine.

Table 4. Passage of digesta and volume estimates.

Digesta phase	Sampling site	Item	Treatment LS	Treatment LA	Treatment HS	Treatment HA	Diet L	Diet H	Infusion S	Infusion A
Fluid	Rumen	Ruminal passage rate, %/h	6.2	5.6	7.7	5.4	5.9	6.6	7.0	5.4
		Ruminal volume, l	63.8	57.7	47.0	57.5	60.7	52.2	55.4	57.6
	Rectum	Hindgut passage rate, %/h	26.3	25.3	30.0	21.4	25.8	25.7	28.2	23.4
Particulate	Ileum	k_1, %/h	10.2	7.3	10.5	9.4	8.7	10.0	10.3	8.4
		k_2, %/h	2.9	3.1	2.0	2.2	3.0	2.1	2.1	2.7
	Rectum	k_1, %/h	8.2	5.8	5.7	6.3	7.0	6.0	6.9	6.1
		k_2, %/h	2.2	2.7	2.6	2.6	2.5	2.6	2.4	2.7

Treatments include diet (L = 9% crude protein; H = 12.5% crude protein) and ileal antibiotic infusion (S = none; A = antibiotic).

Hindgut starch disappearance increased (r=.66) as ruminal ammonia increased. This relationship between ruminal ammonia and hindgut digestion of starch and fiber is probably due to increased ruminal escape of fermentable substrate and passage to the hindgut for digestion.

Ruminal OM digestion increased as particle passage rate decreased. This suggests that the time needed for particle size reduction probably did not delay passage of particles from the rumen. When particles in the rumen disintegrate slowly, the relationship between ruminal digestion and passage rate will be positive. As passage rate of particles from the rumen (k_2) increased, OM digestion in the total tract decreased (r=-.49; P<.06) as well. With this prairie hay diet, extent of digestion in the rumen and the total tract were both limited by digestion of cell walls which occurs primarily in the rumen.

ADF digestion in the rumen increased as passage rate of particles from the rumen decreased (r=-.38; P<.15). In contrast, ADF digestion decreased as rate of FLUID passage from the rumen decreased (r=.46; P<.07). No explanation for this relationship is apparent. Usually fluid and particle passage rates vary together. Increased rumination should increase both fluid passage and extent of ADF digestion. Possibly changes in the relative volumes of fluid and particles in the rumen or passage of fluid imbibed in undegraded forage particles are responsible. Decreased water intake can increase digestibility of certain forages like wheat pasture.

In this trial, microbial efficiency (MOEFF) increased as passage rate of particles increased. Increased efficiency would be expected when microbes leave the rumen more rapidly since the idling time and energy cost for microbes will decrease. In a previous experiment with concentrate diets (Goetsch and Owens, 1984) no relationship of MOEFF to particle passage rate was detected. The relationship of MOEFF to passage rate may be stronger with roughage than concentrate diets, since 1) with concentrate feeds, less ruminal action is needed to prepare particles for ruminal exit and 2) microbes may associate more intimately with roughage than concentrate particles. Nonammonia-N passage to the duodenum, expressed as a percent of N consumed, was higher for the lower protein diet and increased with antibiotic infusion. This may reflect differences in ruminal ammonia concentration since ammonia absorption from the rumen increases as its concentration increases.

Assuming that ileal digesta contained 10 percent dry matter, hindgut volumes were 12.4, 15.0, 10.6, and 17.0 ml/kg of body weight, representing 4.5, 5.1, 5.3, and 6.9 percent of the estimated ruminal fluid volume for LS, LA, HS and HA treatments, respectively. Thus, large intestinal plus cecal volume increased with antibiotic infusion whether expressed on a body weight basis or relative to ruminal volume. Antibiotic-fed or germ-free nonruminants usually have a larger cecal or large intestinal volume than animals with their normal microbial population in the intestine. Enlargement of the hindgut may be due to presence of undigested osmotic compounds which pull water into the intestine, to entry of greater amounts of digesta or to reduced gut motility or gut wall thickness. The increase in hindgut volume with antibiotic infusion can explain the lower passage rate for fluid through the hindgut.

Results indicate that antibiotic doses into the intestine increases volume of the large intestine. These changes can affect rumen function through altering recycling of N to the rumen and thereby change site of digestion. Hence, interactions between antibiotic effectiveness and protein level and concentrate level should be expected. Additional mechanisms (hormonal, neural) which influence volume of and passage rate from various sections of the digestive tract need further study.

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EFFECTS OF BODY WEIGHT, FRAME SIZE AND PREVIOUS RATE OF GAIN ON THE ENERGY CONTENT OF GAIN OF STEERS

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Story in Brief

The energy concentration or composition of gain is an important variable in beef cattle feeding systems. The National Research Council (NRC, 19766 and 1984) use equations based on body weight, rate of gain, frame size and calf or compensating yearling designation to predict this value. A recently developed dynamic computer growth model (Oltjen, 1983) also makes this estimate. The factors affecting energy concentration of gain in the NRC system and the computer model are compared in this study. The results from the computer model agree with the NRC (1984) system regarding body weight and frame size unlike NRC estimates, model estimates of composition of gain for calves and compensating yearlings converge as body weight increases. In this model, energy composition of gain is more sensitive to rate of gain than the NRC equations are.

(Keywords: growth model, body composition, net energy)

Introduction

Predicting gain of beef cattle not only requires some estimate of energy available for gain, but also an estimate of the energy concentration of that gain, so that the retained energy may be converted to the more familiar weight gain. Conversely, when the weight gain of cattle is known, a prediction of the composition of that gain also requires an estimate of the energy concentration of gain. Feeding standards make an estimate of this concentration for several different conditions; however, more recent computer models of animal growth allow this to be estimated directly. The objective of this paper is to compare estimates of the energy concentration of empty body weight gain of beef steers for the National Research Council (NRC, 1976 and 1984) feeding standards and for the dynamic model of beef cattle growth of Oltjen (1983).

Materials and Methods

Equations for the energy content of gain of implanted steers as given by the NRC (1976 and 1984) is shown in Table 1, assuming empty body weight gain is 95.6% of live weight (shrunk) gain (NRC, 1984).

Energy content of gain for the Oltjen (1983) model was calculated using NRC (1984) net energy values for desired rates of gain, and then iterating on feed intake each day to achieve that rate of gain throughout the feeding period. Because the model predicts both empty body fat and protein accretion, the energy concentration in the gain is the energy in the protein and fat gain divided by the rate of empty body

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weight gain. Medium frame implanted calves and compensating yearlings were started at 200 and 300 kg live weight with condition scores (1, extremely thin - 10, extremely fat) of 5 and 3, respectively; large frame cattle were 20% heavier.

Table 1. Energy concentration of empty body weight gain (EBG, kg) for steers of different type and body weight (BW, kg).

Steer type	Energy in gain (Mcal/kg)	Source
All	$(.05515+.00748*EBG)\ BW^{.75}$	NRC (1976)
Medium frame calves	$.0635\ EBG^{.097}BW^{.75}$	NRC (1984)
Medium frame yearlings	$.0562\ EBG^{.097}BW^{.75}$	"
Large frame calves	$.0562\ EBG^{.097}BW^{.75}$	"
Large frame yearlings	$.0498\ EBG^{.097}BW^{.75}$	"

Results and Discussion

Energy value of gain increases from about 3 to 6 Mcal/kg as body weight increases from 200 to about 500 kg when rate of gain is held constant at a kg/d (figure 1). The former NRC (1976) did not differentiate between frame size and age (calf or compensting yearling), and its estimate is nearest to the more recent NRC (1984) value for medium frame calves (MC). Medium frame compensating yearlings (MY) and large frame calves (LC) have corresponding lines which reflect less energy in gain than for the medium frame calves, but greater than for large frame compensating yearlings (LY). In figure 2, body weight is held constant but gain is allowed to vary. The same sort of comparison between the two NRC publications and between frame size and age or previous nutrition as in figure 1 may be made, with similar magnitude of effects. The variation in the energy value of gain, however is less for rate of gain (figure 2) than for body weight (figure 1).

Using the Oltjen (1983) model to compare the effect of body weight on the energy value of gain, energy in gain increases from about 3 to 66 Mcal/kg as body weight increases from 200 to about 500 kg (figure 3). Frame size effects are similar to the NRC (1976), with large frame cattle about 1 Mcal/kg lower at similar body weights. However, the lines for compensating yearlings, although starting at nearly the same point as the NRC, do not remain below the calf lines as body weight increases. Instead they converge as the animal becomes larger, suggesting a similar composition of gain later in a feeding period.

A direct comparison of the NRC equations and Oltjen (1983) model is made in figures 4 and 5 for medium frame steers. NRC (1984) calves have energy concentrations of gain above all other lines (figure 4), but the lines for NRC (1984) compensting yearlings is within .2 Mcal/kg of the model's calf line throught and the model's compensating yearling line between about 350 and 500 kg body weight. Whether calves' gain consists of more fat at all weights than genetically similar cattle which have experienced a period of restricted nutrition should be investigated. The dynamic model used here contradicts this hypothesis and the slightly higher line for the compensating yearlings at greater body weight causes

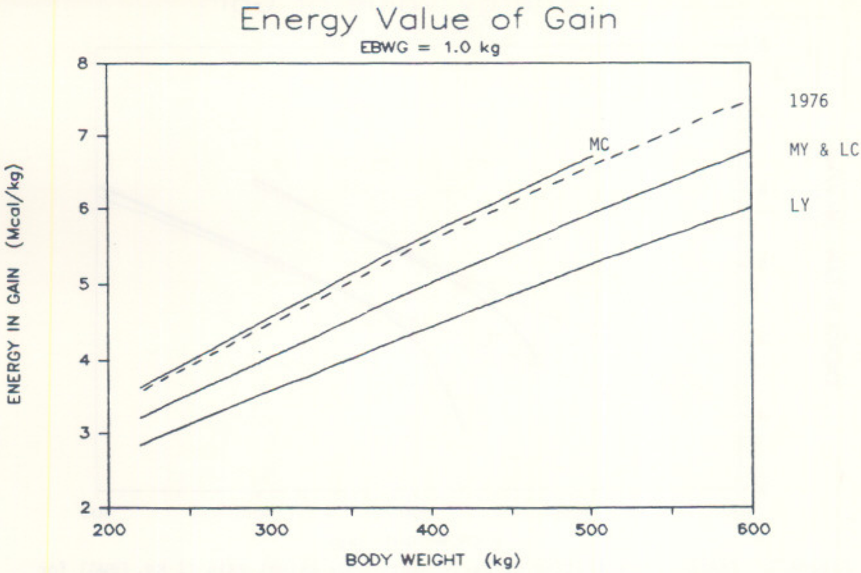

Figure 1. Energy concentration of daily empty body weight gain (1 kg, EBWG) for steers of different body weight: 1976 - NRC (1976); MC - medium frame calves, MY - medium framecompensating yearlings, LC - large frame calves and LY - large frame compensating yearlings from NRC (1984).

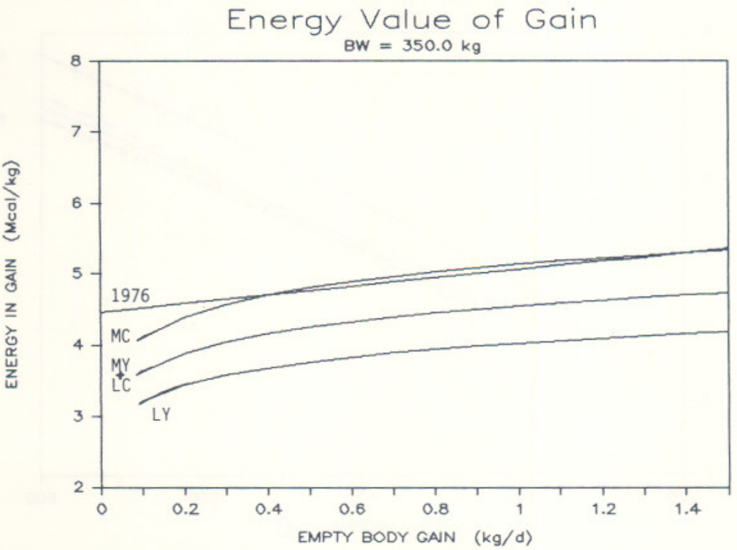

Figure 2. Energy concentration of different empty body weight gain for steers of 350 kg body weight: 1976 - NRC (1976); MC - medium frame calves, MY - medium frame compensating yearlings, LC - large frame calves and LY - large frame compensating yearlings from NRC (1984).

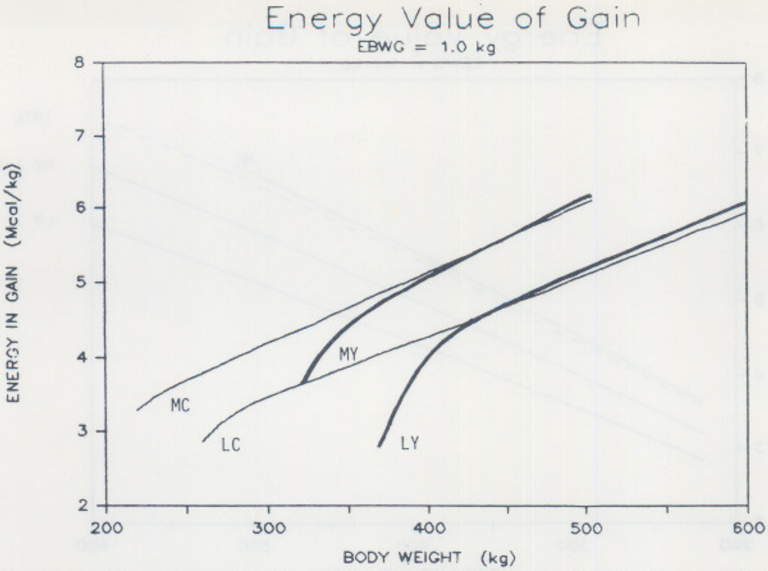

Figure 3. Energy concentration of daily empty body weight gain (1 kg, EBWG) for steers of different body weight: MC- medium frame calves, MY- medium frame compensating yearlings, LC - large frame calves and LY - large frame compensating yearlings from Oltjen (1983).

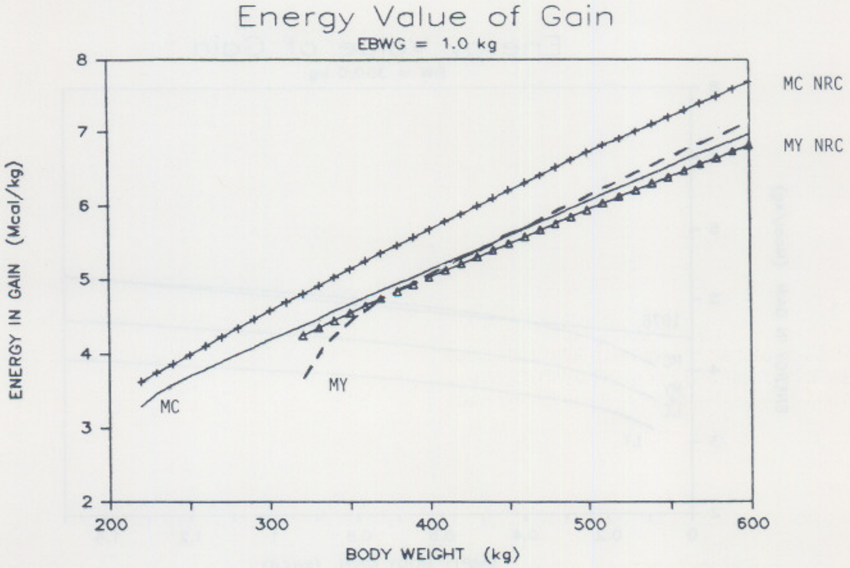

Figure 4. Energy concentration of daily empty body weight gain (1 kg, EBWG) for steers of different body weight: MC NRC - medium frame calves and MY NRC - medium frame compensating yearlings from NRC (1984), MC - medium frame calves and MY - medium frame compensating yearlings from Oltjen (1983).

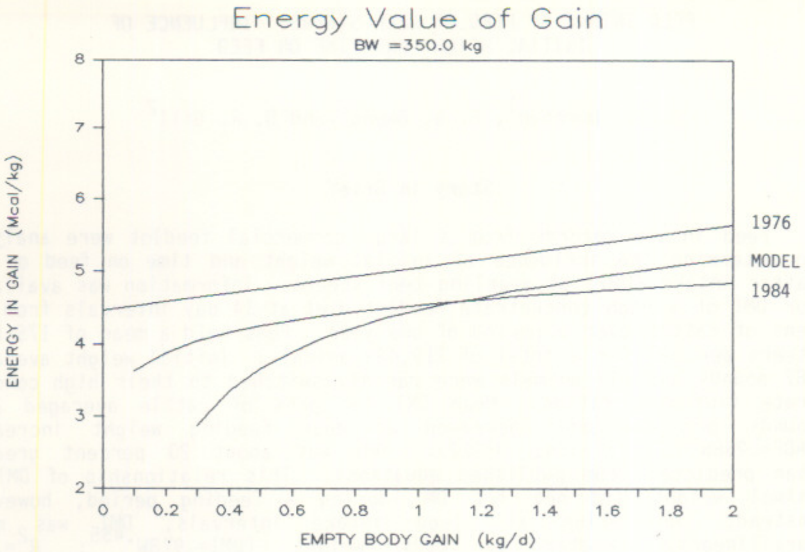

Figure 5. Energy concentration of different empty body weight gain for medium frame yearling steers of 350 kg body weight: 1976 - NRC (1976), 1984 - NRC (1984) and MODEL - Oltjen (1983).

compositional differences to narrow as the animals grow.

In figure 5 the effect of rate of gain for yearlings weighing 350 kg is compared. As shown previously, the former NRC (1976) equation estimates higher values than NRC (1984). The lines for the more recent NRC and the Oltjen (1983) model intersect at about 1.1 kg/d gain, with the model being more sensitive to gain. Corresponding compositions of gain (% fat) for the NRC (1976), NRC (1984) and the model are 43, 37 and 30 for .5 kg/day; 47, 41 and 40 for 1.0 kg/d; and 51, 43 and 45 for 1.5 kg/d empty body gain, respectively.

In conclusion, the effects of body weight and frame size on energy content of gain of beef steers are similar for the Oltjen (1983) model and the NRC (1984). Model estimates for both yearlings and calves are more similar to NRC compensating yearling estimates, with NRC calf energy content of gain particularly greater at increased body weight. However, the Oltjen (1983) model is more sensitive to rate of gain than the NRC (1976 and 1984) equations.

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FEED INTAKE BY FEEDLOT BEEF STEERS: INFLUENCE OF INITIAL WEIGHT AND TIME ON FEED

J. H. Thornton[1], F. N. Owens[2] and D. R. Gill[2]

Story in Brief

Feed intake records from a large commercial feedlot were analyzed to determine the influence of initial weight and time on feed on dry matter intake (DMI) by yearling beef steers. Information was available for DMI of a high concentrate feedlot diet at 14 day intervals from 675 pens of cattle over a period of one year. Pens held a mean of 175 beef steers per pen for a total of 119,482 animals. Initial weight averaged 687 pounds and all animals were rapidly switched to their high concentrate finishing ration. Mean DMI for pens of cattle averaged 21.5 pounds per day and increased as mean feeding weight increased ($ADF=.258W^{.656}$; $R^2=.54$; N=212). DMI was about 20 percent greater than predicted from published equations. This relationship of DMI to animal weight did not fit DMI during a feeding period, however. Instead, considering all feed intake intervals, DMI was more curvilinearly related to body weight ($DMI=.978W^{.455}$; $R^2=.30$; N=3896). Mean DMI increased about 1.5 pounds per hundred pound increase in starting weight. The feed intake curves consisted of three different segments with intake during the first 14 days on feed being proportional to body weight ($DMI=.0214W^{1.02}$), an intake plateau from day 28 to day 140 followed by a slight decrease as steers reached slaughter weight. Since the observed shape of the DMI curve during the feeding period differs from that used to calculate nutrient requirements, requirements during different parts of the finishing period need to be reconsidered and recalculated.

(Key words: Feed intake, Dry matter intake, Starting weight, Time on feed.)

Introduction

Performance of feedlot steers can be predicted quite accurately when net energy content of the diet and feed intake are known. Net energy values can be estimated from tables of feed composition, but less information is available to predict feed intake. Equations to predict feed intake have been advanced by several workers (Table 1). Most of these equations were developed from AVERAGE feed intakes from feeding trials and AVERAGE feeding weight and relate intake to metabolic body size (body weight to the three-quarter power). This means that intake would increase continually as steers gain weight. Such is not the case based on field experience of cattlemen. Instead, feed intake during a feeding period first increases and later declines with time on feed. Three of the equations predict this rise and decline in intake, but two predict a gradual rise and fall while the third predicts a relatively flat plateau during the feeding period.

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Table 1. Dry matter intake equations for feedlot cattle[a].

Gill (1979)

$$DMI,\ lb = (.08968+.0000498INWT+.00498FG)W^{.75} - ((WT-500)/210.8)^2;$$ with feeder grade (FG) between 1 and 10, usually near 5.

ARC (1980)

$$DMI,\ lb = W^{.75}(.1423-.0129ME);$$

Goodrich & Meiske (1981)

$$DMI,\ lb = 3.39+.1249W^{.75}-1.571ME;$$

Owens & Gill (1982)

$$DMI,\ lb = -11.21+.0636W-.0000325W^2+.0039(INWT-610);$$

NRC (1984)

$$DMI,\ lb = W^{.75}(.1819NE_m-.056NE_m^{\ 2}-.0239);$$

Plegge et al. (1984) for mean intake

$$DMI,\ lb = -16.87+.0063MW+.0000085MW^2+20.73ME-4.187ME^2;$$

Plegge et al. (1984) for intake during a feeding trial

$$DMI,\ lb = -95.21-.004INWT+.0000136INWT^2+81.22RELWT-45.89RELWT^2+53.9ME-9.696ME^2;$$

Fox & Black (1984)

$$DMI,\ lb = W^{.75}(.11 \text{ to } .12 \text{ depending on } W)[1+(.03(1.27-NE_g))]$$

[a]Terms include DMI, daily dry matter intake; W, shrunk weight in pounds; INWT, starting shrunk weight in pounds; ME, metabolizable energy in mcal/kg feed dry matter; MW, mean shrunk weight for the feeding trial; NE_m, net energy for maintenance in mcal/kg feed dry matter; RELWT, current shrunk weight as a fraction of slaughter weight; NE_g, net energy for gain in mcal/kg feed dry matter.

Since feed intake is the basis on which both nutrient requirements and gain and profit are predicted, the shape of the feed intake equation needs to be defined. The objective of this study was to determine the pattern of the feed intake of commercially fed yearling steers and the impact of starting weight on feed intake.

Materials and Methods

Daily pen records from a large feedlot in Western Kansas were analyzed to determine the impact of various factors on feed intake of finishing cattle. Mean DMI for sequential 14 day intervals of 246 feedyard pens were obtained from feeding records from December 1981 until November 1982. This represented 675 different sets of non-dairy steers including primarily steers of British breeding, usually crossbred and a small percent of steers with some Brahman breeding. Most cattle were yearlings or older when placed on feed and were fed for 98 to 168 days. For analysis, pens with less than 50 head were removed to reduce variation, so that the mean number of animals in each pen was 175 (range of 50 over 500; standard deviation = 82). Hence, intakes for the year represented values from a total of 119,482 cattle. A mean of 18 observa-

Table 2. General information on beef steers.

Item	Mean	Standard deviation
Pens	675	
Cattle/pen	175	82
Total cattle	119,482	
Pen-period observations	3897	
Weights		
Initial	687	80
112 days	1029	79
ADG	2.97	
Bullers, %	2.8	2.7
Hospital, %	1.4	3.0
Dead, %	.7	1.2
Dry Matter Intake		
Across all pens		
0-14 days	17.4	3.0
15-28 days	21.8	2.7
29-42 days	21.9	2.1
43-56 days	22.1	2.0
57-70 days	22.3	2.0
71-84 days	22.4	2.1
85-98 days	22.3	2.1
99-112 days	21.9	1.9
113-126 days	20.9	1.6
129-140 days	19.7	1.6
Within the same set of cattle		
0-112 days	21.5	1.9

tions were available per pen for a total of 3897 period-pen observations. Further information on the sets of cattle are presented in Table 2.

Data available for each set of cattle included starting feedlot weight (weight on arrival into the feedyard typically after trucking at least 24 hours), sex, breed, number of cattle in the pen, number in the hospital pen for all reasons, deaths per pen for all reasons and number of animals removed due to riding by other animals (bullers), projected current weight which was updated daily based on initial weight, feed intake and NE_m plus NE_g content of the diet. No information on origin, length of haul or backgrounding of cattle was available. All cattle were dipped at the start, received routine medical attention and growth-stimulating ear implants. During the first 28 days on feed, level of roughage in the diet was decreased stepwise from about 40 percent to the 14 percent of the finishing diet. This diet was fed thereafter. The high energy diet consisted primarily of high moisture harvested corn grain, corn silage, chopped alfalfa hay and soybean meal or urea. Monensin was included between 20 and 25 g per ton of feed. On a dry basis, the diet contained 3.18 mcal ME per kg or 2.18 mcal NE_m per kg throughout the year. For statistical analysis and comparisons, components included initial weight, days on feed and current weights. To calculate mean weights and DMI for a pen of cattle, data from the first 112 days of feeding were averaged.

Results and Discussion

Mean DMI for 212 pens of steers for 112 days or longer were calculated from intakes at 14 day intervals are plotted in Figure 1. Mean feed intake increased as mean weight increased. This is similar to most feed intake equations which have been developed (Table 1). Generally, feed intake has been expressed relative to body weight raised to a power or exponent, usually .75. Mean feed intake in this study was related to mean body weight during the feeding period taken to the .656 ($\pm$ .044; R^2=.54) power as drawn in Figure 1. This power changed with time on feed, however. The power function best matching feed intake during individual 14 day intervals ranged from a low of .47 at feeding intervals beyond 56 days on feed to 1.02 during the first 14 days on feed. This means that the relationship of DMI to body weight changes during the feeding period.

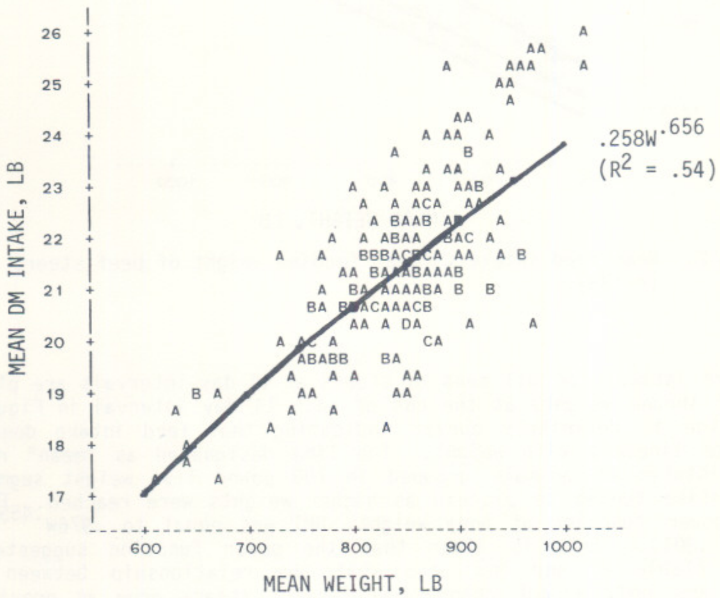

Figure 1. Mean weight vs feed intake (n=188).

Measured mean feed intakes are compared with predicted mean intake values from equations of the ARC (1980), NRC (1984) and Plegge et al. (1984) data from Minnesota in Figure 2. Since these equations incorporate values for energy content of the diet, those for the finishing diet (3.18 mcal ME or 2.18 mcal NE_m per kg feed dry matter) were used. Measured mean feed intakes exceeded predicted feed intakes by 20 to 30 percent though all equations predict intake at zero when weight is zero. This discrepancy may be due to differences in environment or in background of the cattle. Further, the predicted reduction in feed intake for higher energy diets in various equations may exceed that observed with implanted, monensin-fed yearling beef steers. Few equations were developed for cattle rapidly adapted to a diet this high in energy.

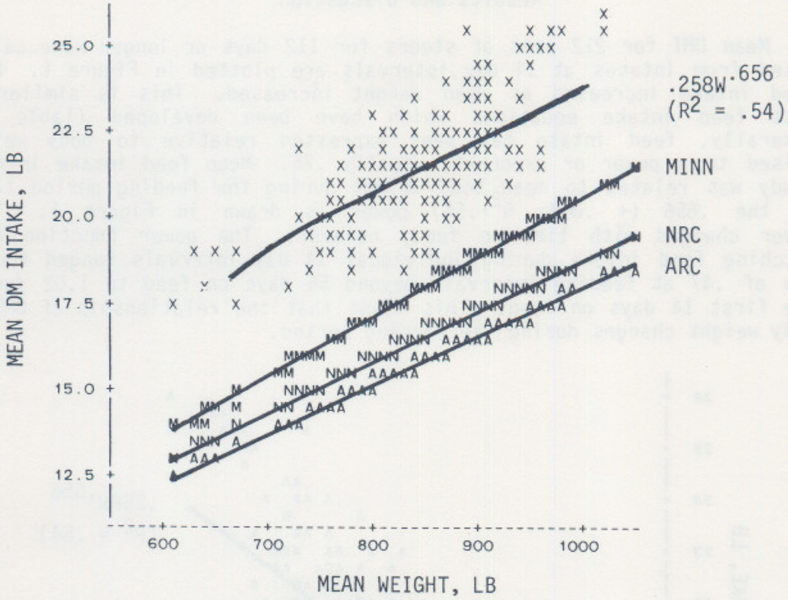

Figure 2. Mean feed intake vs mean feeding weight of beef steers (n=188).

Feed intakes for all pens of steers at 14 day intervals are plotted against shrunk weights at the end of each 14 day interval in Figure 3. This line is definitely curved indicating that feed intake does not increase linearly with weight. The line designated as "mean" represents intakes of animals grouped in 100 pound live weight segments. Feed intake tended to plateau as higher weights were reached. Fitted to a power function of body weight, DMI was equal to $.976W^{.455 \pm .011}$ (R^2 = .301). This is lower than the power function suggested by others (Table 2) and indicates that the relationship between feed intake and body weight changes as feedlot steers grow as previously suggested by Gill (1979), Owens and Gill (1982), Plegge et al. (1984) and Fox and Black (1984). A lot of variation remains, however, as individual letters represent the number of pens of cattle at each point (A=1; B=2; Z=26 or more). The low initial point on the "mean" line represents either lighter starting weights or earlier periods of feeding. To subdivide these effects, feed intake was plotted against starting weight (Figure 4). Feed intake definitely increased as starting weight increased, with daily feed intake increasing about 1.5 pounds for every increase in starting weight of 100 pounds.

The overall curve (Figure 3) was averaged across pens and initial weights. Intakes of individual pens might differ from this curve. To look at DMI with individual pens of cattle without being confounded by differences in initial weight, data from 5 pens which had starting weights which were similar to each other (685 to 688 pounds) and near to the mean starting weight for all cattle were plotted (Figure 5). Feed intake was lowest for virtually all pens during the first 14 days

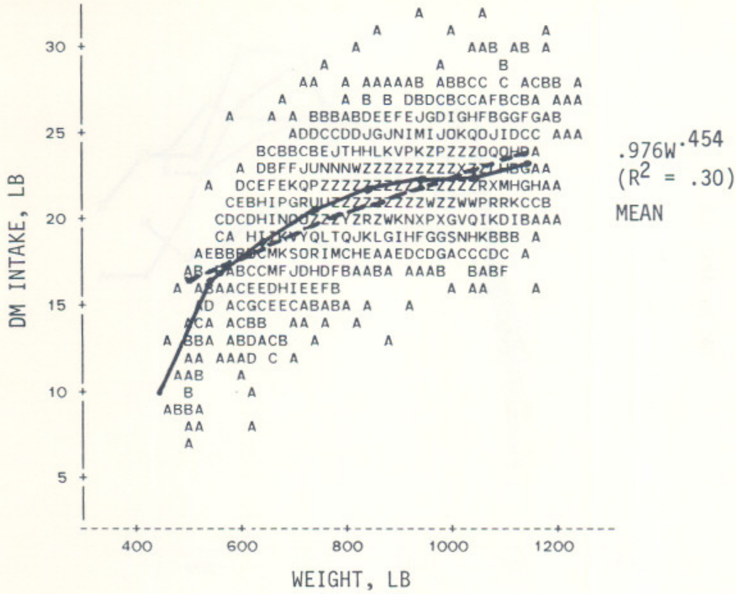

Figure 3. Feed intake and steer weight at 14-day intervals (n=3896).

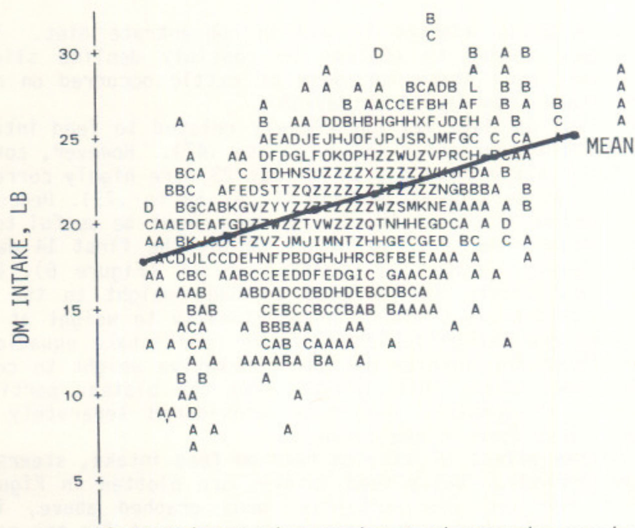

Figure 4. Feed intake vs initial weight.

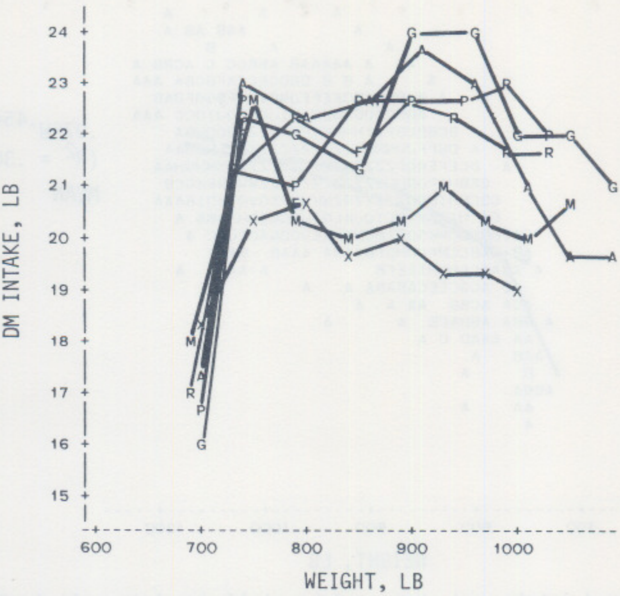

Figure 5. Feed intakes by selected pens of steers (685-688 lb) initial weight.

when animals were being adapted to a high concentrate diet. Thereafter, feed intake tended to plateau or possibly decline slightly. Often, the maximum feed intake for pens of cattle occurred on day 28 (the mean feed intake from day 14 to day 28).

Intake the first 14 days was not closely related to feed intake at day 56 or for periods thereafter (R^2 = .37 to .47). However, correlations between feed intake from day 14 to day 28 were highly correlated with feed intakes at subsequent periods (R^2 = .53 to .73). Hence, intake during the third to the sixth week on feed might be useful to predict subsequent feed intake. Feed intake during the first 14 days on feed was most closely related to starting weight (Figure 6). During this interval, feed intake was related to body weight to the first power. Feed intake increased almost proportionally to weight at which the steers entered the feedyard. Some of the feed intake equations in the literature adjust for initial weight or relative weight to correct for this difference. Since this differs from the plateau portion of the intake curve, it probably should be considered separately as a component of the total feed intake curve.

To determine the effect of time on feed on feed intake, steers were grouped by time periods. Daily feed intakes are plotted in Figure 7. As was apparent for the few individual pens graphed above, intake reached a plateau at 28 days and remained at that point for the next 96 days. Thereafter, intake tended to decline slightly as steers reached slaughter weights. The shape of these curves do not coincide with the shape of the feed intake curve suggested previously by Owens and Gill (1982) or by Plegge et al. (1984) who determined that intake continued to increase to a peak when cattle reached 88 percent of slaughter

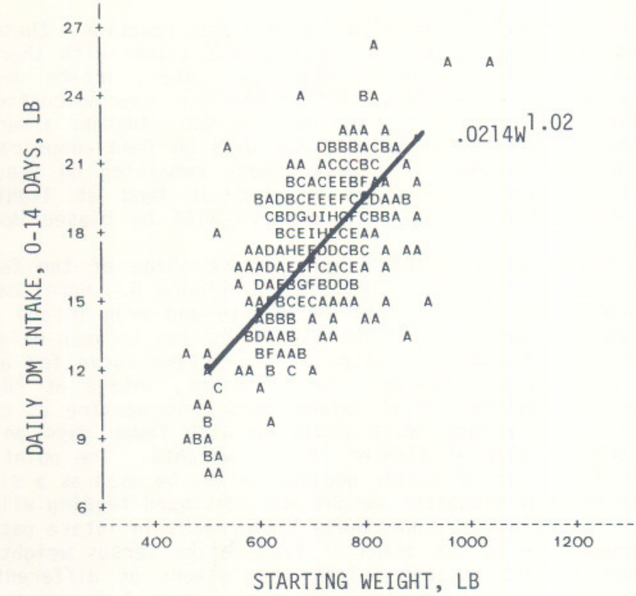

Figure 6. Intake vs weight first two weeks on feed (n=445).

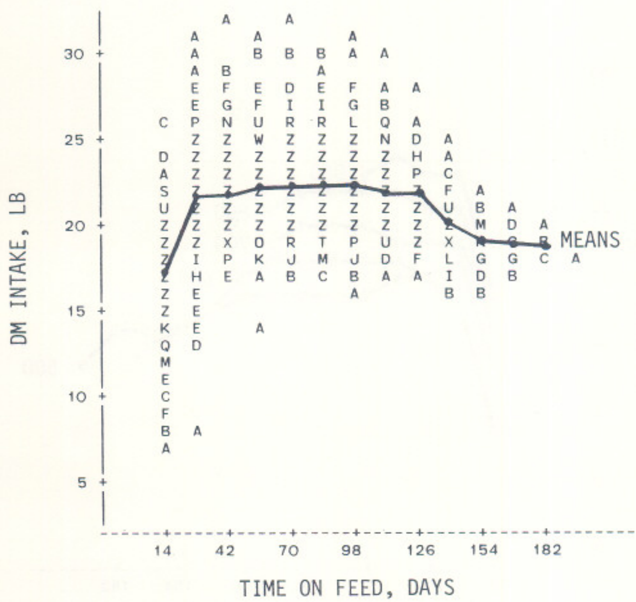

Figure 7. Feed intake vs time on feed (n=3896).

weight. In contrast to previous prediction equation, these feedlot records indicate that intake is considerably higher with shorter times on feed and rapidly reaches a plateau. Later, intake declines as steers reached market weight. Differences in energy content of the diet, cattle background or age may be involved. Another alternative is that initial weights, final weights and days on feed complicate interpretation of the curves. The only steers remaining on feed for 140 days or longer are those which started on feed at light initial weights. Hence, the average intake curve will be biased downward at that point.

The influence of starting weight on the shape of the feed intake curve with time on feed is illustrated in Figure 8. Here, cattle have been grouped by 100 pound weight increments and mean intake at 14 day intervals was plotted. Little overlap in intakes between weight groups is apparent, but the overall shape of the intake curve for all weight groups is surprisingly similar. In all cases, intake at 28 days was near or at the maximum. Feed intake tended to decline as cattle approached slaughter weight which would be with fewer days on feed for cattle at heavier than at lighter initial weights. The point at which feed intake for a pen of cattle declines might be used as a signal that cattle have reached slaughter weight and continued feeding will be less economical. To illustrate how these differences in intake pattern give a curved appearance to the graph of feed intake versus weight, intakes were plotted against current weights for steers of different initial weights in Figure 9. The overall curve of Figure 3 is can be ascribed to lower feed intakes of cattle during the first period on feed as well as lower feed intakes of cattle started at lighter weights. Means here, however, suggest that at heavier initial weights, feed intake may not plateau but continue to increase gradually as such cattle gain weight.

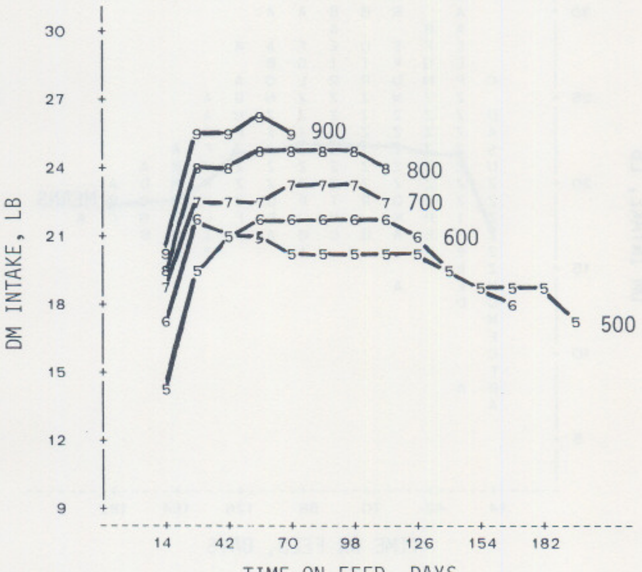

Figure 8. Feed intake vs time on feed for steers with different initial weights.

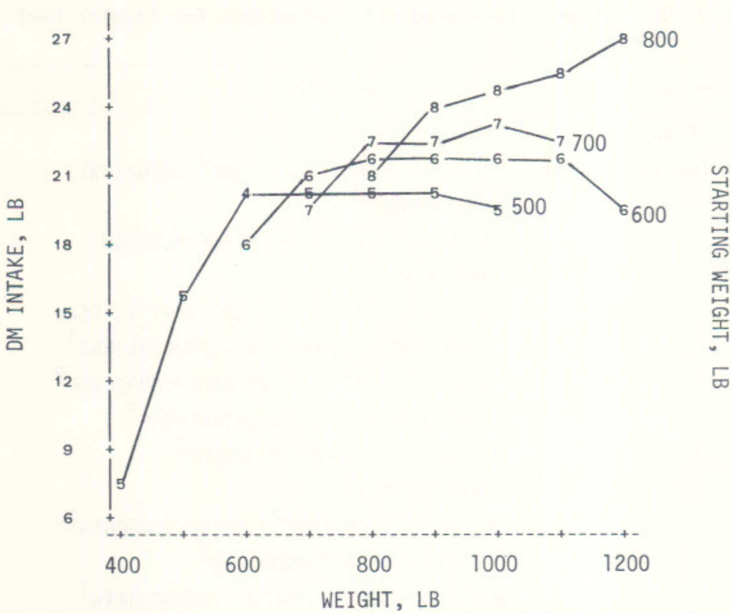

Figure 9. Feed intake vs weight for steers with different starting weights.

Based on these data, the feed intake curve for cattle moved to a high concentrate diet rapidly appears to consist of three segments. During the first 14 days, when cattle are moved through diets containing sequentially less roughage, feed intake is proportional to body weight. During the next 84 to 140 days, feed intake plateaus or gradually creeps upward at a level proportional to starting weight. After 84 days for heavier cattle or 140 days for lighter starting weight cattle, feed intake will decline slightly. Equations relating feed intake during the feeding period are presented in Table 3. Input variables chosen were those which could be appraised easily. Variables known at the time cattle are delivered such as initial weight and days on feed would be preferable for prediction purposes. Variables were chosen by stepwise regression procedures and were included only when significant at a probability level of 20 percent and when addition improved the precision of prediction. Percent of finished (market) weight was not included as a variable since the time of marketing is dictated by many factors in addition to carcass fat.

Weight gains and nutrient requirements can be predicted from these feed intakes and body weights. Formulas provided by NRC (1984) permit requirements to be calculated at various rates of gain providing feed intake is specified. When contrasted with requirements predicted from NRC (1984), predictions from these intake curves indicate that the protein needed, expressed as a percentage of the diet, is lower than predicted by NRC (1984) for cattle at lighter weights. However, the requirement for protein does not decrease as steeply as predicted by NRC since feed intake does not increase with time on feed as the NRC equation projects.

Table 3. Dry matter intake prediction equations for feedlot beef steers[a].

Time period	Equation	R^2
First 14 days	$DMI=.0214W^{1.02}$	.54
Total feeding period	$DMI=3.91+.259DOF-.0027DOF^2+.0162INWT$ $+.0000083DOF^3$	.50
	$DMI=4.36+.207DOF-.00286DOF^2+.0164W$ $.0000095DOF^3$	.55
	$DMI=-3.04-.175INWT+.000235INWT^2+.196W$ $-.000196WT^2+.00000007W^3-.0000001INWT^3$	.39
	$DMI=4.73+.0177INWT+.0716DOF+.00024DOF^2$ $+.0001DOF*INWT-.0000016INWT*DOF^2$	.47
After 14 DOF	$DMI=15.27+.042DOF-.00028DOF^2$ $+.0000113INWT^2$	.38
	$DMI=-2.81-.00051DOF^2+.0655W-.000061W^2$ $+.0000013DOF^3+.000000024W^3$	.47
	$DMI=1.22+.109W-.00012W^2+.000000044W^3$ $-.0729INWT+.000112INWT^2-.000000048INWT^3$	.36
	$DMI=10.27+.0106INWT+.0000059INWT^2$ $+.0528DOF-.00000053INWT*DOF^2$	.39

[a]Terms include DMI, daily dry matter intake in pounds; W, shrunk weight in pounds; INWT, starting shrunk weight in pounds; DOF, days on feed.

Since feed intake can vary with breed, sex, season, initial weight and environmental conditions, diets can be tailored to meet specific conditions providing the impact of these factors can be measured. In addition, seasonal effects on feed intake of feedlot cattle in various regions of the US need to be studied to more accurately estimate requirements and the economics of cattle feeding of various types and backgrounds.

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FEED INTAKE BY FEEDLOT CATTLE: INFLUENCE OF BREED AND SEX

F. N. Owens[1], J. H. Thornton[2] and S. R. Arp[3]

Story in Brief

Records from a large commercial feedlot were analyzed to determine the feed intake and health differences attributable to sex and breed type. Feed intakes adjusted for differences in live weight averaged 10 percent greater for Holstein steers than beef steers but intake of beef heifers was equal to that of beef steers. Incidence of bullers and death losses was greater for Holstein than beef steers though a seasonal effect on incidence of bullers and on death losses was apparent. These peaked during midwinter and were lowest during midsummer suggesting that day length may be involved.

(Key words: Sex, Feedlot, Feed intake, Animal health.)

Introduction

Cattle fed in feedlot of the Great Plains vary in type and sex with economic conditions. Certain types are more desirable at specific cattle prices. Greater feed intakes are usually expected for steers than heifers and for Holstein than beef-bred steers (Plegge et al., 1984; Fox and Black, 1984). However, effects of sex and breed on feed intake with various times on feed and on incidence of riding (bullers), hospitalizations and death losses have not been reported. The objective of this report was to determine the influence of breed type and sex on feedlot performance and health.

Materials and Methods

The feedlot conditions and records screened in this report have been described in a companion paper (Owens et al., 1985). Records included information from 745 different sets of cattle (3 sets of cattle per pen during the year) of which 22 were for Holstein steers, 48 were non-dairy heifers and 675 were non-dairy steers of British, British crossbred and (a limited number) Brahman crossbred cattle. Most cattle were yearlings or long yearlings when placed on feed and were fed for 98 to 168 days. Intakes for the year represented values from a total of 132,393 cattle. A mean of 18 observations were available per pen for a total of 4316 period-pen observations. Data from pens with less than 50 cattle were removed prior to analysis. Further information on the sets of cattle are presented in table 1.

Data available for each set of cattle included starting feedlot weight (weight on arrival into the feedyard typically after trucking at least 24 hours), sex, breed, number of cattle in the pen, number in the hospital pen for all reasons, deaths per pen for all reasons, number of

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animals removed due to riding by other animals (bullers), and projected current weight. This weight was calculated and updated daily based on initial weight, feed intake and calculated energy contents (net energy for maintenance and gain) of the diet. No information on origin, length of haul or backgrounding of cattle was available.

For statistical analysis, the dry matter intake, percent bullers, hospitalized and dead were classed for means comparison by sex (beef heifers vs beef steers) and breed (Holstein steers vs beef steers), by initial weight and by days on feed.

Results and Discussion

In Table 1, feed intakes for steers and heifers are presented for various lengths of time on feed. Holstein steers ate more feed than beef steers (25.1 vs 21.4 pounds of dry matter per day) with a mean difference of 3.7 pounds or 17% during each period.

TABLE 1. General information on cattle subdivided by type.

Variable	Beef steers Mean	Beef steers SD	Beef heifer Mean	Beef heifer SD	Holstein steer Mean	Holstein steer SD
Pens	675		48		22	
Cattle/pen	175	81	104	51	101	33
Total cattle	119,482		5012		2056	
Pen-period records	3897		289		130	
Weights						
Initial	687	80	622	61	757	78
112 days	1029	79	916	68	1136	78
ADG	2.97		2.63		3.35	
Bullers, %	2.8	2.7	.1	.4	3.6	3.7
Hospital, %	1.4	3.0	1.3	2.2	1.3	1.8
Dead, %	.7	1.2	.6	1.1	1.2	1.6
Dry matter intake across all pens of cattle						
0-14 days	17.4	3.0	17.1	2.3	22.2	2.7
15-28 days	21.8	2.7	21.5	2.2	25.7	2.1
29-42 days	21.9	2.1	21.3	1.7	25.0	1.5
43-56 days	22.1	2.1	21.6	2.2	25.7	1.7
57-70 days	22.3	2.1	21.8	2.2	26.0	1.4
81-84 days	22.4	2.1	21.6	2.4	26.0	1.6
85-98 days	22.4	2.1	21.4	1.8	25.7	1.5
99-112 days	21.9	1.9	21.4	1.7	25.0	1.1
113-126 days	20.9	1.6	20.2	.9	24.1	1.1
129-140 days	19.7	1.6	18.8	1.5	22.8	1.7

The difference was largest from 14 to 28 days on feed which was near the peak feed intake for the all cattle (Figure 1). During the first two to three weeks, diets were increased in concentrate level. For beef steers and heifers, dry matter intake was almost constant from 14 days to 112 days on feed. For dairy steers, daily intake tended to decline after 98 days on feed. Despite large differences in intake between pens of cattle, feed intake within each pen was surprisingly

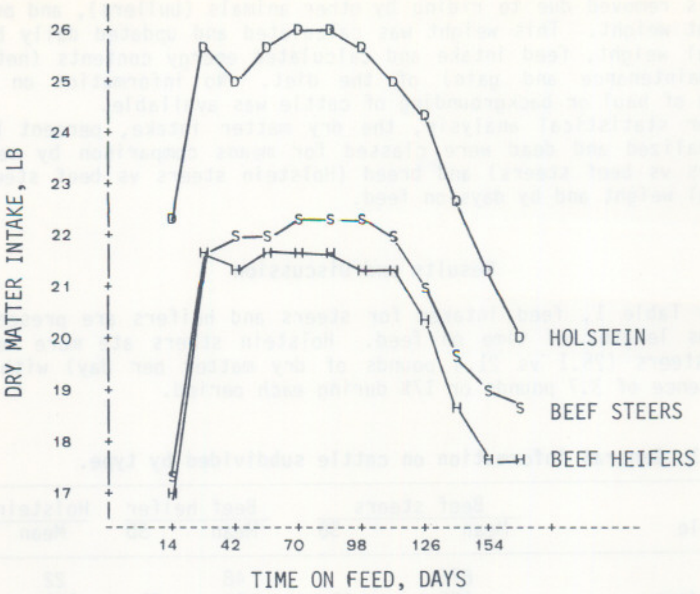

Figure 1. Influence of time on feed on feed intake of feedlot cattle.

constant, usually varying by no more than .5 pounds of dry matter per head from one 14-day period to the next. Feed intake of a subsequent period could be predicted reasonably well (r = .80) by feed intake the previous period. Hence, intakes did not fluctuate and compensate over time, but pens with high intakes remained high.

Overall, feed intake of beef steers exceeded feed intake of heifers by 2.8 percent (21.4 vs 20.8 lb). Feed intake for heifers tended to peak at 28 days and decline thereafter while with beef and Holstein steers, intake peaked after about 70 days on feed. The decline was steeper for Holstein than beef steers or heifers. The time point at which intake declined tended to be earlier (fewer feeding days) for heifers than for steers.

These differences in feed intake due to sex and breed may be associated with differences in weight of cattle initially and during the feeding period even though most equations estimating feed intake do not include initial weight as a variable. Starting weights were much higher for Holstein than beef steers, and higher for steers than heifers during all months of feeding (Figure 2). Note that few Holstein steers were fed during the summer months. As feed intake is greater for Holstein steers than beef steers, a seasonal effect on feed intake would be expected in this feedlot due to the prevalence of Holstein steers on feed during certain seasons. Adjusting for this difference in weight during the feeding period might pull feed intake estimates for breeds and sexes together.

Intakes at various weights during the feeding period are presented in Figure 3. Feed intake by heifers and steers were very similar when compared at a similar live weight. Since mature weight of steers should exceed that of heifers, the similar feed intake of the two

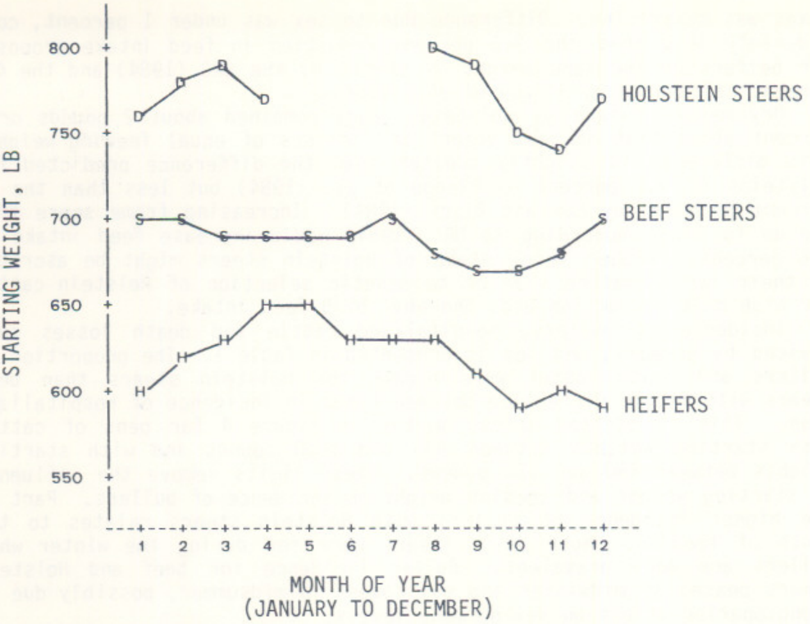

Figure 2. Influence of season on starting weights.

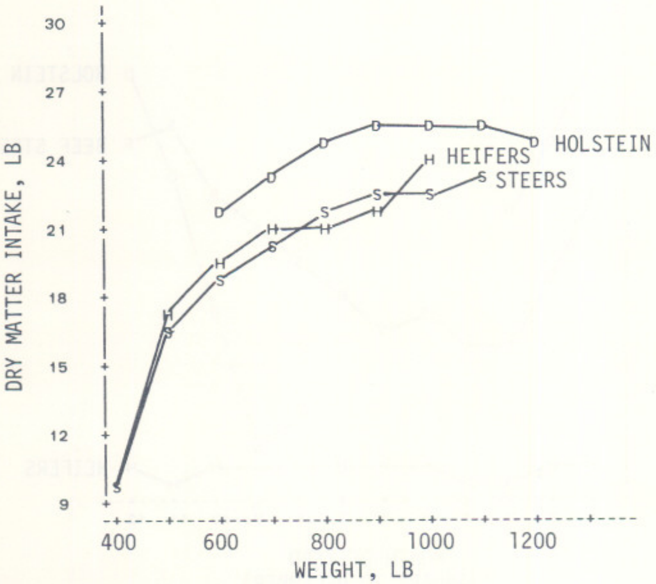

Figure 3. Influence of weight on feed intake.

sexes was surprising. Difference due to sex was under 1 percent, considerably less than the 3.3 percent reduction in feed intake proposed for heifers of the same weight as steers by the NRC (1984) and the 4.7 percent calculated by Plegge et al. (1984).

Dry matter intake by Holstein steers remained about 2 pounds or 9 percent above that of beef steers and heifers of equal feeding weight. This difference is slightly greater than the difference predicted for Holsteins of 8.2 percent by Plegge et al. (1984) but less than the 17 percent proposed by Fox and Black (1984). Increasing frame score from medium to large according to NRC (1984) would increase feed intake by 5.6 percent. Higher feed intake of Holstein steers might be ascribed to their larger mature size or to genetic selection of Holstein cattle for high milk production and, thereby, high feed intake.

Incidence of bullers, hospitalized cattle and death losses subdivided by breeding and sex is presented in Table 1. The proportion of bullers and death losses were higher for Holstein steers than beef steers with little difference between types in incidence of hospitalization. This is plotted across months in Figure 4 for pens of cattle with starting weights between 900 and 1000 pounds and with starting weights between 650 and 750 pounds. These limits remove the influence of starting weight and feedlot weight on incidence of bullers. Part of the higher incidence of bullers with Holstein steers relates to the month of feeding. Most dairy steers were fed during the winter when bullers are more prevalent. Buller incidence for beef and Holstein steers peaked in midwinter and was lowest in midsummer, possibly due to a photoperiod effect on sex hormone levels.

Death losses also tended to be highest during the fall, especially for steers, and lowest during the summer. This is plotted in Figure 5 for the same pens of cattle as used above. No explanation for this

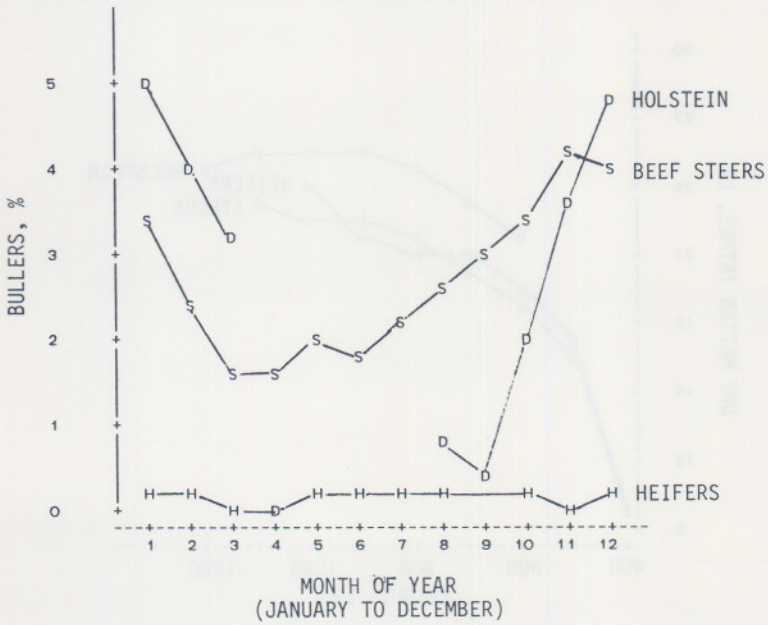

Figure 4. Influence of season on incidence of bullers.

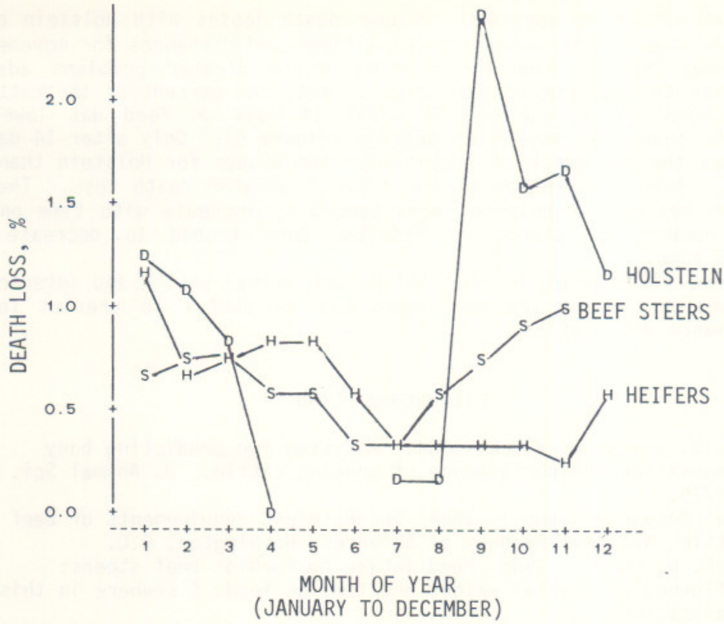

Figure 5. Influence of season on death loss.

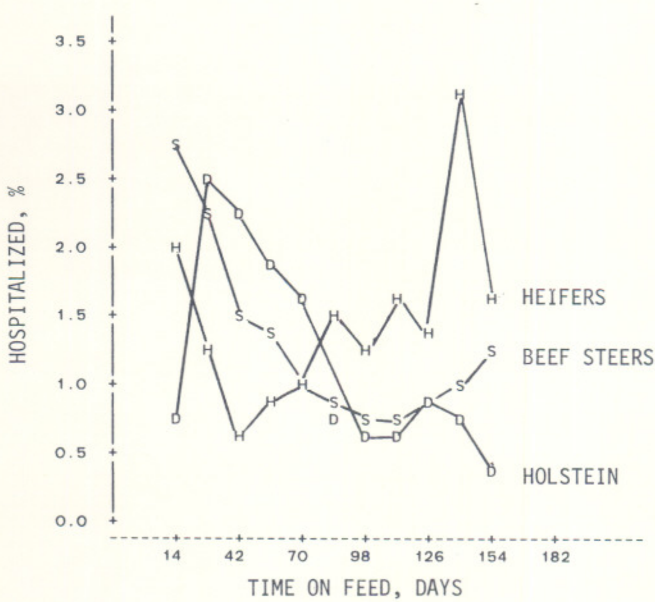

Figure 6. Influence of time on feed on percentage of cattle in hospital pens.

seasonal effect is apparent. Higher death losses with Holstein cattle might be due to the longer trucking times and distances for movement to the Great Plains area for feeding or to greater problems adapting Holsteins to high concentrate diets. Yet, the percent of the cattle in a pen hospitalized during the first 14 days on feed was lower for Holstein than beef steers or heifers (Figure 6). Only after 14 days on feed was the incidence of hospitalization higher for Holstein than beef steers. This corresponds to the time of greater death loss. The percent of heifers in hospital pens tended to increase with time on feed while numbers of steers in hospital pens tended to decrease with feeding time.

These differences in feed intake and animal health and interactions with season due to sex and breed can be useful to predict feedlot performance and profits.

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THE EFFECT OF THE RATIO OF DRY ROLLED CORN TO HIGH MOISTURE HARVESTED SORGHUM GRAIN ON THE SITE AND EXTENT OF ORGANIC MATTER DIGESTION IN HEIFERS[1]

M.N. Streeter[2], D.G. Wagner[3], C.A. Hibberd[4] and M.R. Putnam[5]

Story in Brief

Dry rolled corn (DRC) and high moisture harvested sorghum grain (HMS) were blended in a variety of ratios (100 percent DRC, 75:25, 50:50, 25:75, 100 percent HMS) to determine the effect of blending on site and extent of organic matter digestion. Five blends were fed (two percent of body weight) in a 5 x 5 Latin square using five Hereford-Angus heifers (693 lb) equipped with ruminal, duodenal and ileal T-type cannulae. Total tract organic matter disgestibility decreased linearly as corn was replaced with high moisture sorghum. Ruminal and large intestinal organic matter disappearance tended to decrease in a linear manner as greater amounts of high moisture sorghum was added to the grain mix. Small intestinal organic matter disappearance was not influenced by altering the ratio of corn to high moisture sorghum. The factors causing depression of ruminal organic matter disappearance may be responsible for decreasing large intestinal and total tract digestion. Based on ruminal, large intestinal and total tract OM digestion it appears that small amounts of high moisture sorghum grain blended with large amounts of dry rolled corn may be more advantageous than the reverse condition.

Introduction

The use of high moisture grains has become more common over the last ten years. High moisture sorghum is typically harvested at 25 to 30 percent moisture and stored in a ground or rolled form to facilitate packing. Blending of dry and high moisture grains does occur, but the specific ratio of dry to high moisture grain is usually determined by the supply of each. Little work has been conducted blending dry coarsely rolled corn and high moisture sorghum grain in a variety of ratios. Even less work has been conducted to determine the effects of such blends on the site and extent of organic matter digestion in feedlot cattle. Therefore, this study was conducted to determine the effect of blending dry coarsely rolled corn and high moisture sorghum grain on the site and extent of organic matter digestion and also to determine if any associative affects occur between DRC and HMS.

Materials and Methods

Five rations, listed in Table 1, were created using coarsely ground corn and commercially obtained HMS (70 percent toluene DM). The ratios

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[1]Authors wish to express appreciation to Lowan Feeders for furnishing high moisture harvested sorghum.
[2]Graduate Student [3]Professor [4]Assistant Professor [5]Associate Professor, College of Veterinary Medicine, Auburn, Univ.

Table 1. Ration compositions of experimental diets.

Ingredient	A 100% DRC	B 75:25	C 50:50	D 25:75	E 100% HMS
High moisture sorghum grain	---	20.8	41.8	62.7	83.8
Dry corn	83.2	62.6	41.8	20.9	---
Cottonseed hulls	8.0	8.0	8.0	8.0	8.0
Soybean meal	5.2	5.2	5.2	5.2	5.2
Urea	1.0	.87	.76	.65	.53
Supplement					
Dicalcium phosphate	.44	.44	.44	.44	.44
Calcium carbonate	.93	.93	.93	.93	.93
Potassium chloride	.57	.57	.57	.57	.57
Sodium sulfate	.17	.14	.13	.11	.09
Chromic oxide	.20	.20	.20	.20	.20
Trace mineral salt	.25	.25	.25	.25	.25
Vitamin A	2200 IU/kg				

of the grains in each diet, on a dry matter basis were as follows: ration A 100 percent DRC, ration B 75 percent DRC:25 percent HMS, ration C 50 percent DRC:50 percent HMS, ration D 25 percent DRC:75 percent HMS, ration E 100 percent HMS. Analysis of initial grain samples indicated that urea could not be used as the only nitrogen supplement. Therefore, soybean meal was added at equal levels to all diets and urea was used in an attempt to make diets isonitrogenous.

Rations were fed to five Hereford-Angus heifers (693 lb), fitted with ruminal, duodenal and ileal T-type cannulae to allow determination of site and extent of organic matter digestion. Heifers and rations were arranged in a 5 x 5 Latin square and fed twice daily at two percent (DM basis) of initial body weight. Experimental periods lasted 10 days with days 1 through 7 serving for diet adaptation and days 8 through 10 serving for sample collection, performed at 1000, 1400 and 1800 hours. Digesta samples were composited across day and time within each period. Feed samples were ground through a 1 mm screen in a Udy mill using dry ice to facilitate grinding and stored frozen prior to analysis. Digesta samples were dried using a lyophilizer prior to grinding through a 1 mm screen in a Udy mill and analysis. Grain, feed and digesta samples were analyzed for all or part of the following: dry matter, starch (glucose polymers), crude protein and ash. Organic matter digestibility was determined by chromic oxide ratios. Orthogonal polynomials determined if the relationship between organic matter digestion and increasing the percent corn in the ration was linear or not.

Results and Discussion

The chemical composition of the grains and diets used is listed in Table 2. Starch content of the blends tended to reflect the higher starch content of HMS (84.0 percent) versus DRC (78.5 percent). Crude protein content of HMS was slightly higher than that of corn, but does not explain the variation observed in the complete feeds. Ash content of HMS and corn were nearly identical; however, ash content of the

Table 2. Chemical characteristics of grains and feeds.

Item	A 100% DRC	B 75:25	C 50:50	D 25:75	E 100% HMS
Feed					
Starch	66.53	65.69	65.80	66.54	71.05
Crude protein[a]	12.84	13.99	13.37	13.42	12.92
Ash[b]	4.04	4.55	4.40	4.41	4.65
ADF[b]	10.87	8.53	7.80	8.51	8.53
Grain					
Starch	78.54				84.01
Crude protein	9.50				9.82
Ash	1.33				1.32

[a]Quadratic polynomial (P<.05).
[b]Quartic polynomial (P<.05).

complete feeds showed considerably greater variation. Diet A (100 percent DRC) had the lowest ash value (4.04 percent) while diet E (100 percent HMS) had the greatest ash value (4.65 percent). Diet A (100 percent DRC) had the greatest acid detergent fiber content and diet C (50 percent DRC:50 percent HMS) the lowest, while diets B, D and E were intermediate.

Organic matter (OM) intake (Table 3) tended to increase as greater amounts of HMS were added to the grain mix; however, the difference in intake between the highest and lowest values was only 103 g/day. Ruminal OM disappearance corrected for microbial OM and expressed as a percent of OM intake tended to decrease in a linear manner (P<.10) as greater amounts of HMS were added to the grain mix (100 percent DRC 70.2 percent vs 100 percent HMS 64.8 percent). When ruminal OM disappearance was expressed as a percent of total tract digestion and diet A was ignored, values tended to increase with the exclusion of corn (86.5 percent for B vs 89.0 percent for E). Organic matter disappearance in the small intestine was relatively low and constant across all treatments, with the mean value being 34.1 percent of entry. Organic matter disappearance in the small intestine, expressed as a percent of total tract digestion, tended to respond quarticly (P<.20). Disappearance of OM through the ileum expressed as a percent of intake showed no trend across diets. However, within diets containing both HMS and corn (B, C and D), increasing amounts of HMS appeared to depress ileal OM disappearance. Ileal OM disapperance (percent of total tract) tended to increase as corn was removed from the grain mix, reflecting a greater importance of pre-ileal digestion as HMS increased in the diets (Figure 1). Large intestinal OM disappearance (percent of entry) tended to decrease linearly (P<.10) as corn levels were reduced (100 percent corn 25.7 percent vs. 100 percent HMS 7.9 percent). Total tract OM digestibility decreased (P<.05) lineraly as HMS was substituted for corn (100 percent corn 80.0 percent vs. 100 percent HMS 73.0 percent). Ruminal and large intestinal organic matter fermentation tend to reflect the same affects of adding greater amounts of HMS to the grain mix, indicating that the same factors causing reduced ruminal OM digestion may have a similar effect in the large intestine. The small intestine appears to be unaffected by treatment at these levels of intake, with

Table 3. Site and extent of organic matter digestion of DRC-HMS blends.

Item	A 100 % DRC	B 75:25	C 50:50	D 25:75	E 100 % HMS
OM Intake (g/day)	5966	5927	6011	6040	6032
Ruminal disappearance					
% of Intake (c)[ac]	70.2	68.6	69.3	66.2	64.8
% of total tract (c)[a]	88.1	86.5	87.4	88.8	89.0
% of intake (u)[c]	62.8	60.6	61.2	57.6	56.4
% of total tract (u)	78.6	76.5	77.3	77.3	77.5
OM disappearance SI					
% of entry (u)	34.7	40.3	32.0	33.5	32.0
% of total tract (u)[d]	15.7	19.4	15.9	19.0	19.0
OM disappearance Ileal					
% of Intake	72.6	76.4	74.3	71.3	70.7
% of total tract	92.0	95.4	93.2	96.8	96.6
OM disappearance LI					
% of entry[c]	25.7	19.1	21.2	5.9	7.9
% of total tract	8.0	4.6	6.8	3.2	3.4
Total tract OM dig.[b]	80.0	79.6	79.5	74.6	73.0

[a]Ruminal OM disappearance corrected for microbial OM.
[b]Linear polynomial (P<.05).
[c]Linear polynomial (P<.10).
[d]Quartic polynomial (<.20).

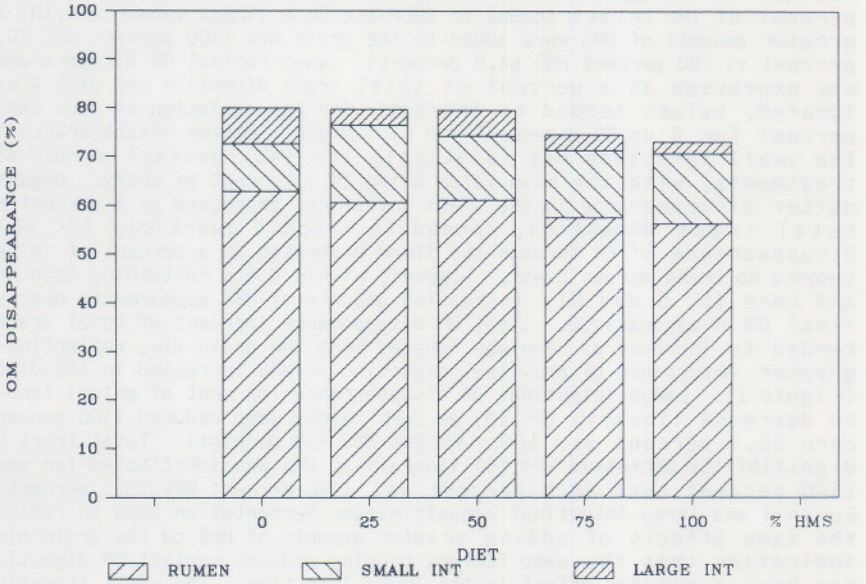

Figure 1. Site and extent of organic matter digestion of DRC-HMS blends (ruminal digestion uncorrected for microbial OM).

disappearance (percent of entry) values being rather low and similar on all diets. Increasing feed intake may increase the importance of small intestinal digestion; however, a large portion of the diet organic matter would be starch and the digestive capacity of the organ may soon be exceeded. Rates of passage were not determined and differences in flow rates may play an important role in creating the trends observed.

Associative effects may have occurred in the small intestine (percent of total tract); however, no associative effects were observed in other segments of the digestive tract, assuming that associative effects of DRC and HMS would result in a non-linear increase or decrease in OM disappearance or digestion. Based on ruminal and total tract OM digestion values, there is some suggestion that high levels of DRC and low levels of HMS may be more advantageous than the reverse condition. Protein may have limited organic matter accessibility within the HMS resulting in decreased total tract digestion. The same differences may or may not be expected with dry rolled and high moisture sorghum blends.

Blends do appear to alter the importance of ruminal and large intestinal fermentation and may cause differences in animal performance.

EFFECT OF SORGHUM GRAIN VARIETY ON THE SITE AND EXTENT OF NITROGEN DIGESTION IN HEIFERS

M.N. Streeter[1], C.A. Hibberd[2], D.G. Wagner[3] and M.R. Putnam[4]

Story in Brief

Dwarf Redlan, 1133, Darset and millrun sorghum grain varieties were dry rolled and fed in a high grain ration with all supplemental nitrogen coming from urea to determine the effect of variety on site and extent of nitrogen digestion. Dwarf Redlan is a low tannin, waxy endospermed sorghum. 1133 is a waxy high tannin-bird resistant type, while Darset is a normal endosperm, high tannin-bird resistant type. Millrun was purchased commercially through the OSU feedmill. The four sorghum varieties were fed (two percent of body weight) in a 4 x 4 Latin square using four Hereford-Angus heifers (506 lb) equipped with ruminal, duodenal and ileal cannulae. Total tract nitrogen digestion was higher for non-bird resistant types, Dwarf Redlan (69.0 percent) and millrun (63.8 percent) than bird resistant types, 1133 (54.0 percent) and Darset (47.8 percent). Ruminal feed nitrogen disappearance was highest for Dwarf Redlan (51.7 percent) and lowest for 1133 (27.9 percent), with millrun (42.2 percent) and Darset (35.4 percent) being intermediate. For all varieties, nitrogen disappearance was nearly complete by the ileum. Waxy type grains tended to have improved nitrogen digestion post ruminally when compared within bird resistant or non-bird resistant groupings. Sorghum grain variety does appear to alter both site and extent of nitrogen digestion in beef heifers and may result in variation in animal performance.

Introduction

Sorghum grain is an ever increasingly important feed grain in the Great Plains region. Constantly decreasing water supplies in combination with increasing water demands increase the importance of sorghum grain research and utilization for feedlot cattle. Sorghum grain, although less popular than corn due to the increased processing required, is drought resistant. Unlike corn, sorghum varieties vary greatly in physical and chemical composition. Variation between varieties leads to inconsistent and often lower animal performance. Sorghum grain protein degradation is probably of greater importance than is corn protein degradation, because sorghum starch is encapsulated in protein. Digestion of protein has been suggested as a limiting factor in starch availability. Therefore, the following study was conducted to determine the relationship of four sorghum grain varieties to the site and extent of protein digestion in heifers.

Materials and Methods

Three varieties of sorghum grain, Dwarf Redlan (Dwf), 1133 and

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Darset (Dar) were grown under dryland conditions at the Perkins Agronomy Experiment Station. A fourth variety, millrum (MR), was purchased commercially through the OSU feedmill. Origin of MR was unknown, but appeared to be representative of that commonly purchased on a commercial basis. Observable physical characteristics of the varieties are listed in Table 1.

Table 1. Descriptive characteristics of sorghum grains.

			Endosperm		
Sorghum Variety	Abbreviation	Pericarp color	Color	Starch type	Testa Layer[a]
1133	1133	brown	yellow	waxy	present
Darset	Dar	brown	white	normal	present
Dwarf Redlan	Dwf	red	white	waxy	absent
Millrun	MR	mixed	non-descript	normal	absent

[a]Presence of a testa layer indicative of high tannin content and bird resistance.

Each grain variety was dry rolled and incorporated at the same level of dry matter into an 88.8 percent sorghum grain ration (Table 2). Complete mixed diets were stored at room temperature until fed. Rations were fed to four Hereford-Angus heifers (506 lb) fitted with ruminal, duodenal and ileal T-type cannulae to allow determination of the site and extent of protein digestion. Heifers and rations were arranged in a 4 x 4 Latin square design. Heifers were fed equal portions twice daily to total two percent (DM basis) of initial body weight. Experimental periods lasted 10 days with days 1 through 7 serving for diet adaptation and days 8 through 10 for digesta sampling, performed at 1000, 1400 and 1800 hours. Ruminal fluid was collected on day 10 of each period. Digesta and ruminal samples were composited across time and day within each period. Digesta samples were dried using a lyoiphilizer and ground through a 1 mm screen in a Udy mill prior to analysis. Ruminal fluid was acidified by adding 3.3 ml of 36N H_2SO_4 per 1000 ml of fluid and frozen prior to analysis. Ruminal fluid was also collected at 1400 hours during periods two and four and used to determine bacterial nitrogen reaching the small intestine.

Grain, feed, ruminal and digesta samples were analyzed for all or part of the following: dry mater, ash, tannin (catechin equivalents), ammonia-nitrogen, RNA-nitrogen (total purines) and crude protein-nitrogen. Protein digestibility was determined by RNA and chromic oxide ratios. Differences between means were detected by orthogonal contrasts. Contrast BR compared bird resistant to non-bird resistant varieties. Contrast Dwf compared Dwarf Redland to millrun, and 1133 compared 1133 to Darset.

Results and Discussion

The crude protein content of bird resistant grain varieties tended to be higher than non-bird resistant varieties (Table 3). Varieties with waxy endosperm (Dwf and 1133) were more similar to each other than

Table 2. Ration composition of experimental diets (dry matter basis).

Ingredient	%
Sorghum grain	88.78
Cottonseed hulls	7.22
Supplement	
Urea	1.20
Dicalcium phosphate	.44
Calcium carbonate	.93
Potassium chloride	.57
Sodium sultate	.36
Chromic oxide	.20
Vitamin A	2200 IU/kg

were varieties with normal endosperm (Dar and MR). Millrun was considerably lower in crude protein content (10.3%) than all other varieties. Tannin contents of the grains reflect brown seed coats and the presence of a testa layer. Bird resistent varieties (1133 and Dar) contained more tannin (P<.05) than did non-bird resistant varieties (Dwf and MR). Darset (1.44 cat.eq.) also tended to contain greater amounts of tannin than 1133 (1.19). Crude protein and tannin content of the complete mixed feeds tended to reflect differences observed for the grains.

Table 3. Chemical characteristics of sorghum grains and complete feeds (dry matter).

	1133	Darset	Dwarf Redlan	Millrun	SE
Grain					
Crude protein %[abc]	12.0	13.2	12.4	10.3	.1
Tannin (cat eq/g)[a]	1.19	1.44	0.00	0.00	.07
Feed					
Crude protein %[abc]	13.5	14.4	14.3	12.1	.2
Tannin (cat eq/g)[ac]	1.24	1.54	0.02	0.02	.05

[a]Bird resistant varieties vs non-bird resistant varieties (P<.05).
[b]Dwarf Redlan vs Millrun (P<.05).
[c]1133 vs Darset (P<.05).

All differences observed in nitrogen digestion between grain varieties were between bird resistant and non-bird resistant varieties (Table 4). However, within each bird resistant or non-bird resistant group, trends are present that may become increasingly important as feed intake increased. Nitrogen intake was not equal for all diets. Greater nitrogen intakes occurred when heifers were fed Dwarf Redlan (103.5 g/d) and Darset (103.2 g/d) versus 1133 (96.7 g/d) and millrun (87.0 g/d), due primarily to higher protein contents of Dwf and Dar grains. Crude protein intake was below NRC recommemded levels for 500 pound heifers for the MR diet. With all diets there was a net gain in the amount of nitrogen reaching the duodenum above nitrogen intake levels. A gain in nitrogen through the rumen may be a reflection of inadequate nitrogen intake and increased nitrogen recycling to the rumen. Low rumen ammonia concentrations across all diets may also reflect inadequate nitrogen for maximum microbial growth. The extent of feed nitrogen disappearance in the rumen was greatest for Dwarf Redlan (51.7 percent) and lowest for 1133 (27.9 percent), with millrun (42.2 percent) and Darset (35.4 percent) being intermediate. Bird resistant varieties (1133 and Dar) had lower ruminal nitrogen disappearance than non-bird resistant varieties (Dwf and MR). The rumen was the major site of nitrogen degradation for Dwf (76.4 percent), Dar (75.2 percent) and MR (72.6 percent) and tended to be of less importance for 1133 (54.7 percent). Microbial efficiencies did not vary greatly between varieties.

Table 4. Site and extent of nitrogen digestion of sorghum varieties.

Item	1133	Darset	Dwarf Redlan	Millrun
N-Intake g/day	96.7	103.2	103.5	87.0
Non-Urea-N Intake g/day	71.7	78.2	78.2	61.8
Ruminal N disappearance:				
Ruminal NH_3 g/dl	3.42	4.47	3.74	4.55
Nitrogen appearing at duodenum, g/day[a]	118.6	119.8	105.5	98.7
Nitrogen disappearance in rumen:				
Feed-N g/day	26.9	36.6	53.6	40.2
Feed-N, % of intake	27.9	35.4	51.7	46.2
Feed N, % of total tract	54.7	75.2	76.4	72.6
Microbial efficiency g Microbial N/kgOM fermented	20.5	21.7	21.1	20.3
Non-NH_3 nitrogen disappearance in small intestine				
g/day	69.8	57.6	62.8	62.6
%	61.6	49.8	62.7	66.8
Non-NH_3 nitrogen disappearance through ileum				
% of Intake[a]	55.0	46.2	64.4	63.8
% of total tract	103.1	97.1	93.6	100.2
Total tract N digestibility %[a]	54.0	47.8	69.0	63.8

[a]Bird resistants vs non-bird resistants ($P<.05$).

Non-ammonia nitrogen disappearance in the small intestine tended to be higher for non-bird resistant than bird resistant varieties. Within bird resistant varieties, the extent of non-ammonia nitrogen disappearance in the small intestine tended to be greater in heifers fed 1133 than Dar (61.6 percent vs 49.8 percent). Non-ammonia nitrogen disappearance through the ileum (percent of intake) suggests that greater amounts of nitrogen disappear with non-bird resistant versus bird resistant sorghum grain varieties. Within each group, waxy varieties (Dwf and 1133) tended to have greater disappearance through the ileum than normal varieties (MR and Dar). Non-ammonia nitrogen disappearance through the ileum (percent of total tract) was nearly equal to or in two cases greater than total tract digestibility, indicating that nitrogen digestion was almost complete at the ileum. Total tract non-ammonia nitrogen digestion was greatest for MR (69.8 percent) and Dwf (69.0 percent), the non-bird resistant varieties, and lowest for 1133 (54.0 percent) and Dar (42.8 percent), the bird resistant varieties. As was the case in the small intestine, varieties within each group with waxy endosperm, Dwf (69.0 percent) and 1133 (54.0 percent), tended to have greater non-ammonia nitrogen digestibilities than normal endosperm varieties, MR (63.8 percent) and Dar (47.8 percent).

Differences observed between bird resistant and non-bird resistant varieties may be caused by tannin, present in bird resistant varieties, binding to feed and endogenous protein making the feed nitrogen less available and possibly making proteinatious enzymes less active. The bird resistant characteristic may also result in decreased protein solubility. Waxy varieties may have greater nitrogen digestibility due to increased protein solubility. Bird resistant varieties may have reduced ruminal feed nitrogen disappearance due to tannin binding of feed protein or through inhibition of ruminal microbes by tannin. Rates of passage may differ between varieties resulting in depressed nitrogen digestibility for bird resistant types. However, passage measurements were not made in this study and statements about passage rates are speculative.

The site and extent of nitrogen digestibility of the four sorghum grain varieties tested are different. These differences would be expected to result in animal performance differences at these levels of feed intake. At higher levels of feed intake (more typical in feedlot situations) larger differences in digestibility and animal performance would be expected. Further research is needed to determine more clearly the effects of the bird resistant characteristic and of condensed tannins on nitrogen digestion in feedlot cattle.

EFFICACY OF BIO-COX, 3-NITRO-10 AND BACIFERM-50 COMBINATIONS FED TO BROILER CHICKENS IN A FLOOR PEN STUDY

M.O. Smith[1] and R.G. Teeter[2]

Story in Brief

A combination of an ionophore (bio-cox), a coccidiostat (3-nitro-10) and an antibiotic (baciferm-50) was administered in the feed to 4800 commercial broiler chicks during a 46 day floor pen trial. Day old chicks were placed in two forty-pen houses which had previously been occupied by other chickens. Body weight gain and feed efficiency was improved when the drugs were fed in combination. Males gained 19% more than females and showed a greater response to the higher drug combinations. Mortality was not affected by drug treatment.

[Key Words: Ionophore, Coccidiostat, Antibiotics, Gain, Mortality.]

Introduction

Antibiotics are widely used in the broiler industry to reduce the incidence of common debilitating diseases and to improve growth rate and feed efficiency. The growth-promoting effects of antibiotics in poultry is concerned with decreasing the magnitude of the "environmental disease level", by inhibiting the growth of nutrient-destroying organisms and those that produce excessive amounts of toxic nitrogenous wastes, while concomitantly improving the availability or absorption of certain nutrients.

Ionophores are commonly used as coccidiosats in poultry rations and like antibiotics, have been credited with increases in growth and feed efficiency. Low level continuous feeding of antibiotics or ionophores have been used to effectively control the low disease levels found in good poultry operations. A combination of an ionophore and antibiotic, with the required FDA clearance, could possibly improve performance over that observed with administration of either drug independently. Three drugs Bio-cox, 3-nitro-10 and baciferm-50 have been successfully used in improving the performance of broiler chicks when administered singly, but to date, no documented combinations of these three have been used.

This study was conducted to evaluate the efficacy of the combination of bio-cox, 3-nitro-10 and baciferm-50 in broiler chickens raised on deep litter.

Materials and Methods

Forty-eight hundred commercial day-old broiler chicks were randomly allotted to eight pens in two houses (30 males and 30 females per pen). To ensure the proper environmental disease level, this trial followed a previous feeding study with no clean-up between groups. A starter mash was fed for the first 28 days of age and a finishing ration was fed from

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[1]Graduate Assistant [2]Associate Professor

28 to 46 days (Table 1). Treatment designations are shown in Table 2. Each dead bird was weighed and recorded and the weight used to adjust for feed efficiency. Data collection and measurement included body weight gain, feed consumption for 46 days, mortality and adjusted feed efficiency.

Table 1. Starter and finisher rations[a].

Ingredient	Starter %	Finisher %
Ground Corn	52.8	69.76
Soybean Meal	39.0	25.0
Fat	4.0	2.0
Dicalcium Phosphate	2.35	1.75
Calcium Phosphate	.9	.6
Vitamin Mix	.4	.4
Salt	.3	.3
dl-Methionine	.15	.09
Trace Mineral	.1	.1
	100	100

[a] .4% ground polyethylene was added to the basal ration with all drug mixtures substituted for polyethylene.

Table 2. Experimental treatments.

Treatment	Bio-Cox[a] (g/ton)	3-Nitro-10[b] (g/ton)	Baciferm-50[c] (g/ton)
1	60	0	0
2	60	22.7	0
3	60	34.1	0
4	60	45.4	0
5	60	0	50
6	60	22.7	50
7	60	34.1	50
8	60	45.4	50

[abc] International Minerals and Chemical Corporation, Terre Haute, Indiana 47808.

Results and Discussion

Body weight gain, feed efficiency and percent ortality at forty-six days of age is presented in Table 3. Birds administered Bio-cox (Treatment 1) alone gained significantly less weight than those

Table 3. Body weight gain, feed efficiency and percent mortality of 46-day old birds.

Treatment No.	Body Weight Gain(g)	Feed/Gain	Mortality(%)
1	1513^{g}	2.02	1.84
2	1536^{f}	1.95	2.08
3	1617^{c}	1.83	2.76
4	1595^{d}	1.86	1.76
5	1582^{e}	1.87	1.20
6	1584^{de}	1.86	1.59
7	1705^{a}	1.73	2.43
8	1634^{b}	1.75	2.21

[abcdefg]Means in column having different superscripts differ (P<.05).

given biocox in combination with 3-nitro-10 or baciferm-50. The combination of biocox, baciferm-50 and 3-nitro-10 at the 34.1 g/ton level (Treatment 7) produced significantly greater gains than all other treatment. Feed efficiency paralleled body weight gain with the tendency being for birds given the combination of all three additives at the higher levels of 3-nitro-10 to be more efficient. Percent mortality was unaffected by drug treatment.

Examining the body weight gains of males and females independently (Table 4) revealed that males gained 19% more weight than females. The gain response to the feed additives was more pronounced in the females where the combination of biocox, baciferm-50 and 3-nitro-10 at the two highest levels (Treatments 7 and 8) was greater (P<.05) than any other combination.

Table 4. Body weight gain of male and female birds at 46 days of age.

Treatment No.	Body Weight Gain(g) Males	Body Weight Gain(g) Females
1	1644^{g}	1382^{e}
2	1651^{g}	1420^{d}
3	1770^{c}	1463^{c}
4	1730^{d}	1459^{c}
5	1693^{f}	1470^{bc}
6	1718^{e}	1463^{c}
7	1895^{a}	1513^{a}
8	1786^{b}	1482^{b}

[abcdefg]Means in columns having different superscripts differ (P<.05).

These results indicate that with the required FDA clearance, the drug combination of biocox, 3-nitro-10 and baciferm-50 has potential for improving gain and feed efficiency of broiler chickens reared on deep litter.

ALOE VERA BY-PRODUCTS AS POTENTIAL ENERGY SOURCES

R.G. Teeter[1]

Story in Brief

Two experiments were conducted to evaluate the potential energy value of 4 Aloe Vera by-products. The addition of by-product to broiler rations did not impact body weight gain, but generally depressed feed efficiency. In vitro dry matter disappearance of the by-products was high averaging 90% disappearance while solubility averaged 29% suggesting a significant microbial fermentation.

[Key Words: Aloe Vera, By-Products, Poultry, Ruminants.]

Introduction

Thousands of tons of Aloe Vera by-products are produced in Oklahoma annually. These products are normally discarded after the juice is squeezed out of the leaves. However, the remaining residue may contain useable energy for livestock classes. The following study was conducted to estimate the energy value of 4 Aloe Vera by-products.

Materials and Methods

To estimate the feeding value for animals with limited microbial digestion, the chick was utilized as the experimental model. Arbor Acres x Vantress broiler chicks were weighed and allotted to ten treatment groups at random such that each group was replicated 3 times with 12 chicks per replicate. Birds were housed in electrically heated batteries for the duration of the two week experiment. All additions to the basal diet (Table 1) were made by dilution to the desired level. Feed and water were available continuously. Bird body weight gain and feed consumption were tallied at the end of the two week feeding period.

To estimate the feeding value of the by-products in animals with extensive fermentation processes, in vitro dry matter disappearance was determined.

Results and Discussion

Body weight gain, feed consumption and feed efficiency are summarized in table 2. In this study, no significant impact of by-products upon body weight gain was detected. Birds were able to increase diet consumption to offset the decline in nutrient density which apparently accompanied by-product addition. Feed efficiency declined linearly

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Table 1. Treatments.

1	Poultry Ration
2	Ao1 + .3% pulp with aloin
3	Ao1 + 1% pulp with aloin
4	Ao1 + 3% pulp with aloin
5	Ao1 + .3% pulp
6	Ao1 + 1% pulp
7	Ao1 + 3% pulp
8	Ao1 + 5% waste leaves cooked
9	Ao1 + 10% waste leaves cooked
10	Ao1 + 5% waste leaves uncooked
11	Ao1 + 10% waste leaves uncooked

*All by-products were dried prior to evaluation to reduce the possibility of mold growth. Dietary additions are on a dry matter basis.

Table 2. Average Live Body Weight, Gain, Feed Consumption, Feed Efficiency and Feed Efficiency Corrected By-Product Consumption.

Treatment	Gain (g)	Feed Consumption (g)	Gain/Feed	Gain/Adj Feed[1]
1	61	111	.55[a]	.55
2	55	110	.50[ab]	.50
3	56	110	.51[ab]	.51
4	54	113	.48[b]	.49
5	59	104	.57[a]	.57
6	55	107	.51[ab]	.52
7	55	108	.50[ab]	.53
8	54	105	.51[ab]	.54
9	55	109	.50[ab]	.56
10	54	109	.50[ab]	.52
11	56	112	.50[ab]	.56

[1]Feed efficiency corrected for by-product consumption.

[2]Means within a column with unlike superscripts significantly diff. (P<.05).

(P<.05) with increasing levels of by-product. The by-products examined have a poor feeding value for poultry and other animals with limited microbial digestion capacity. Toxicity of the products at the levels examined appears slight though rations containing high levels of aloin may be of concern.

The in vitro disappearance values are shown in table 3. Contrary to the poultry experiment, data collected from this phase of the study

Table 3. In vitro dry matter digestibility of 4 cosmetic specialities aloe vera by-products.

	Digestibility (%)
pulp with aloin	94.6^{a}
pulp without aloin	88.6^{ab}
cooked waste leaves	88.9^{ab}
uncooked waste leaves	85.9^{b}

^{ab}Means with unlike superscripts significantly differ (P<.05).

Table 4. In vitro dry matter solubility of 4 cosmetic specialities aloe vera by-products.

	Solubility (%)
pulp with aloin	20.7^{b}
pulp without aloin	50.2^{a}
cooked waste leaves	25.0^{b}
uncooked waste leaves	19.4^{b}

^{ab}Means with unlike superscripts significantly differ (P<.05).

Table 5. By-product composition (dry matter basis).

	pulp with aloin	pulp	cooked leaves	uncooked leaves
Dry Matter	1.6	3.8	9.7	4.4
Crude Protein	4.0	5.7	7.3	4.8
Acid Detergent Fiber	46.7	23.8	39.1	49.4
Neutral Detergent Fiber	31.4	19.6	34.0	34.0
Ash	15.0	14.9	12.6	13.1

Means within a row with unlike superscripts significantly differ (P<.05).

are encouraging as disappearance averaged 90%. This would imply that the products would be extensively fermented by microorganisms in the ruminants digestive tract. A second study conducted to characterize digestible constitutents through solubility (Table 4) indicated that solubility was low for all the by-products except pulp without aloin suggesting that the in vitro values do indeed represent, at least in part, a significant microbial digestion. By-product analysis (Table 5) indicates that principle constituents are fibrous components and that protein is quite low. Ruminants fed the product exclusively would not perform well. However, it should be possible to benefit from the by-products fermentable energy content.

One concern regarding the utilization of the by-products is the high moisture content. Drying the products prior to feeding would most likely not be cost effective. Alternatives include feeding the material fresh or ensiling prior to feeding.

EVALUATION OF SALINOMYCIN FOR IONOPHORE ACTIVITY IN BROILER CHICKENS

M.O. Smith[1] and R.G. Teeter[2]

Story in Brief

Two experiments were conducted to determine if the toxic effect of feeding high salinomycin levels could be overcome through potassium supplementation. Rations contained soybean meal, fish meal or casein as the protein source to achieve basal potassium concentrations of .96, .75 and .2% respectively. Salinomycin levels evaluated in the first experiment included 60 and 75 g per ton with levels of 100 and 200 g per ton evaluated in the second. Salinomycin depressed weight gain only at the 200 g per ton level. Potassium supplementation failed to enhance weight gain.

[Key Words: Ionophore, Potassium, Salinomycin.]

Introduction

Including salinomycin, a known ionophore, in broiler rations at 70 g/ton is frequently efficacous. However, when Salinomycin dietary levels exceed 100 g/ton, growth depressions may be noted. Ionophores are known to interact with nutrients in the diet; noticeably the electrolytes, sodium, potassium and chloride. The ion carriers facilitate the passage of mineral ions through biological membranes and in some instances exhibit selectivity. Austic and Smith (1980) have shown that Salinomycin facilitates entry of sodium into animal cells with gradual intracellular potassium depletion. This suggests that Salinomycin related growth depressions may be related to broiler potassium status. Cervantes et al., (1982) reported a significant interaction between the ionophore monesin and diets containing soy or fish meal as the major protein source. Potassium supplementation increased growth rate of chicks fed the low K fish meal diet but had no effect on the high K soybean meal based ration.

The purpose of this study was to evaluate the impact of salinomycin upon broiler growth rate in rations containing varying amounts of potassium.

Materials and Methods

Two experiments were conducted to evaluate Salinomycin for ionophore activity. In the first experiment, one week old Arbor Acre x Vantress broiler chicks were weighed and allotted to 24 experimental groups at random such that each group was replicated 4 times with 10 chicks per replicate. Birds were housed in electrically heated starter batteries under continuous lighting for the duration of the 3 week growth study. Rations (Table 1) and water were available for *ad libitum* consumption. Treatments within each ration type included:

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Basal
Basal + 60 g Salinomycin/ton
Basal + 60 g Salinomycin/ton + 0.2% K
Basal + 60 g Salinomycin/ton + 0.4% K
Basal + 75 g Salinomycin/ton
Basal + 75 g Salinomycin/ton + 0.2% K
Basal + 75 g Salinomycin/ton + 0.4% K
Basal + 0.2% K

All diets contained 0.3% sodium.

Table 1. Composition of basal diets for experiment 1.

	Protein Source		
Ingredients	Soybean Meal	Fish Meal	Casein
	-------------------% -------------------		
Ground Corn	49.1	61.54	55.3
Soybean Meal	39.8	8.50	---
Fish Meal	---	20.0	---
Casein	---	---	18.5
Fat	5.0	5.0	5.0
Dicalcium Phosphate	3.20	---	3.64
Calcium Phosphate	1.23	1.03	.67
Salt	.48	.47	.61
Vitamin Mix	.40	.40	.30
Trace Mineral	.10	.10	.10
D-L Methionine	.24	.10	---
Polyethylene	.45	2.86	15.43
L-Arginine	---	---	.45
	100	100	100

In experiment two, Salinomycin levels were increased to 100 g and 200 g per ton with the potassium supplement level at .25% (Table 2). The basal ration contained .96% K. Body weight gain and feed consumption were measured.

Results and Discussion

Results for the first experiment are displayed in tables 3-5. Adding 60 or 75 g salinomycin to rations containing .96, .75 or .2% K did not effect (P>.1) live gain. Potassium addition to the basal rations, averaged across ration type, enhanced (P<.05) body weight gain by a mean of 8.6%. However, addition of K to rations containing salinomycin, averaged across ration typed, depressed weight gain (P<.05) by a mean of 11.3%.

Table 2. Composition of basal diet for experiment 2.

Ingredient	%
Ground Corn	54.85
Soybean Meal	38.0
Alfalfa	3.0
Dicalcium Phosphate	2.35
Calcium Phosphate	.9
Vitamin Mix	.4
Salt	.3
Trace Mineral	.1
D-L Methionine	.1
	100

Table 3. Body weight gain, feed consumption and feed efficiency of birds on a soybean meal ration.

			60 g Salinomycin per ton			75 g Salinomycin per ton		
Potassium (%)	0	.2	0	.2	.4	0	.2	.4
Gain (g)	443[ab]	487[a]	410[bc]	341[d]	403[bc]	426[abc]	374[cd]	399[bc]
Feed (g)	779	789	679	696	763	762	708	736
Gain/Feed	.57[ab]	.61[a]	.60[a]	.49[b]	.53[ab]	.56[ab]	.53[ab]	.54[ab]

[abcd]Means in rows with unlike superscripts differ ($P<.05$).

Table 4. Body weight gain, feed consumption and feed efficiency of birds on a fish meal diet.

			60 g Salinomycin per ton			75 g Salinomycin per ton		
Potassium (%)	0	.2	0	.2	.4	0	.2	.4
Grain (g)	436[a]	446[a]	453[a]	368[d]	378[cd]	437[a]	390[abcd]	414[abc]
Feed (g)	731	763	819	701	730	784	709	754
Gain/Feed	.59	.58	.55	.52	.52	.56	.55	.55

[abcd]Means in rows with unlike superscripts differ ($P<.05$).

Table 5. Body weight gain, feed consumption and feed efficiency of birds on a casein diet.

			60 g Salinomycin per ton			75 g Salinomycin per ton		
Potassium (%)	0	.2	0	.2	.4	0	.2	.4
Gain (g)	281^{abc}	324^{a}	300^{ab}	285^{abc}	261^{bc}	286^{abc}	276^{abc}	234^{c}
Feed (g)	574	620	631	630	630	622	615	617
Gain/Feed	$.49^{a}$	$.52^{a}$	$.47^{a}$	$.45^{a}$	$.41^{ab}$	$.46^{a}$	$.45^{a}$	$.38^{b}$

[abcd]Means in rows with unlike superscripts differ (P<.05).

Birds fed the diet (.2% K) containing casein as the major protein source (Table 5) gained significantly less weight than those on either soybean meal or fish meal suggesting that palatability may have been a problem. The casein ration met or exceeded all known nutrient requirements. If salinomycin impacts the K requirement of the growing broiler, the effect should be maximized here as the diet provided just .2% K. Salinomycin failed to impact growth rate, however, supplementing the ration with K resulted in a linear (P<.01) decline in growth.

The second experiment was conducted to evaluate salinomycin-potassium effects in the corn-soybean meal based ration at higher salinomycin levels. Salinomycin depressed weight gain by 2.3 and 24.6% for the 100 and 200 g per ton inclusion levels respectively. Adding .25% K to the ration increase weight gain 4.5% in birds fed the control ration but was without numerical effect with salinomycin treatments. Additional work is needed to adequately understand this area.

Table 6. Body weight gain, feed consumption and feed efficiency of birds in experiment 2.

	Salinomycin (g/ton)			Salinomycin (g/ton) + .25% K		
	0	100	200	0	100	200
Gain (g)	175	171	132	183	173	133
Feed (g)	371	377	362	397	374	372
Gain/Feed	$.47^{a}$	$.45^{a}$	$.37^{ab}$	$.46^{a}$	$.45^{a}$	$.35^{b}$

[ab]Means in row with unlike superscripts differ (P<.05).

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ILEAL CANNULATION OF THE NEONATAL PIG WITH A SIMPLE T-CANNULA

W. R. Walker[1], G. L. Morgan[2] and C. V. Maxwell[3]

Story in Brief

A cannula and surgical procedure suitable for ileal cannulation of pre-weaned pigs were devised. Cannulas were installed in pigs at 18 days of age to study digestion immediately following weaning. The lightweight, durable T-cannula provided adequate ileal samples from pigs fed both semi-purified and practical diets. The screw cap and collar provided adjustment for growth and simplified maintenance and collection. Cannulas provided repeated ileal samples from pigs up to 135 lb at which time cannulas were nonsurgically removed from the conscious pig and replaced with larger cannulas for subsequent studies.

(Key Words: Swine, Neonatal Pig, Ileal Cannulation, T-Cannula)

Introduction

In order to maximize production efficiency, further understanding is needed concerning nutrient availability in pigs during all phases of production. Ileal sampling to estimate pre-ileal bioavailability is the method of choice for determining availability of nutrients in the pig since modifications of nitrogen and essential amino acids by microbial organisms in the cecum and small intestine of pigs makes availability calculation based on fecal samples questionable. Digestion and absorption of most nutrients is essentially complete in the small intestine and nitrogen and amino acids that disappear from the hindgut are of little or no value to the pig.

The neonatal pig at weaning is subjected to extreme changes in diet and digestive capacity is rapidly developing. Since these conditions limit the pigs ability to adapt to dietary changes and result in reduced gain and efficiency , the effect of diet on nutrient availability may be more critical in neonatal pigs than in older growing-finishing swine. Several ileal cannulation techniques have been described using T-cannulas for collecting intestinal samples in growing-finishing pigs, but no such techniques have been reported for the neonatal pig. The cannula for the young pig must be small enough to fit within the lumen of the small intestine yet have a large enough internal diameter to allow suitable digesta flow through the cannula. In addition, the cannula must be designed to minimize protrusion beyond the body wall since restraint, which is the typical means of protecting a cannula, is impractical in the neonatal pig.

This paper describes a lightweight, ileal T-cannula which allowed repeated sample collection in early weaned pigs.

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[1]Graduate Assistant [2]Associate Professor [3]Professor

Materials and Methods

Cannula Design

The cannula for ileal cannulation of 18 day old pigs (figure 1) was constructed of a rigid lightweight yet extremely durable plastic (Delrin 600). The cannula was milled from a solid stock bar of Delrin. One end of this bar was machine cut to form the cannula body which was then threaded externally (25 threads/in). This body was machine cut on two opposite sides leaving an ovoid shaped body with two flat smooth sides and threaded ends. The bar was then centrally drilled through its entire length to provide an ovoid shaped barrel for digesta passage during collection. The large diameter end of the bar was hand tooled to provide the flanged end with a concave inner surface to conform to the shape of the small intestine.

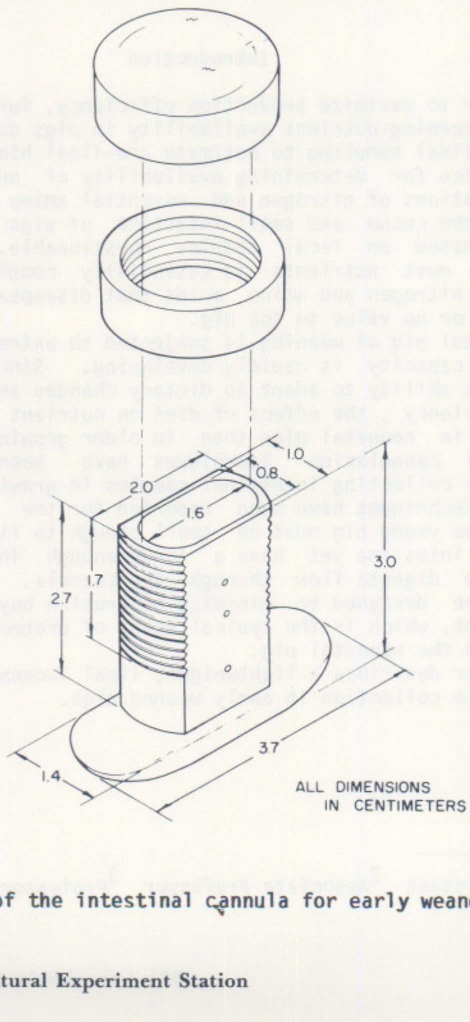

Figure 1. Design of the intestinal cannula for early weaned pigs.

To secure the cannula in place against the body of the pig, a lucite collar was constructed and threaded internally to match the threads on the body of the cannula. The collar secured the cannula in place and allowed adjustment to compensate for thickening or swelling of the body wall. A cap, also made of lucite, was designed in a similar fashion to fit the collar to prevent leakage during periods between sample collection.

Surgical Procedure

Yorkshire gilt pigs weighing 10 to 12 lb were removed from the litter approximately 1 hour prior to surgery. Halothane anesthesia was administered via face mask and maintained with an endotracheal tube. The pigs were placed on their left side on padded cotton towels provided for warmth. The right flank was shaved with surgical clippers and prepped with a surgical scrub.

An incision was made in the right abdominal wall through which the cecum was located and exteriorized and the ileo-cecal ligament identified. A section of ileum near the anterior attachment of the ileo-cecal ligament was isolated and packed off with saline saturated cotton gauze. A purse-string suture approximating the circumference of the body of the cannula was placed in the surface of the ileum and a longitudinal incision of minimal length to accommodate the flange of the cannula was made in the center of the purse-string. With gentle manipulation and the use of thumb forceps the cannula was inserted into the lumen of the ileum and the purse-string was tightened around the base of the cannula body. Two simple interrupted sutures were placed across the ileum at the anterior and posterior borders of the body of the cannula.

A stab incision was made through the right body wall above and behind the original incision. The length of the stab incision was sufficient to barely accommodate the body of the cannula thus avoiding the necessity of skin sutures in this incision. The cannula was then brought up through the stab incision. It is essential that the cannula not be rotated and that the proximal end of the ileum remain ventral and the posterior end remain dorsal to allow gravity to facilitate sample collection.

The original incision site was closed with a continuous interlocking pattern of sutures in the muscle layers and an interrupted pattern in the skin. After closing, a topical antibiotic spray was applied to the two incisions sites. The cannula collar was placed on the body of the cannula and tightened until the internal flange and ileum were pulled snugly against the internal peritoneal surface of the body wall. Care should be taken to avoid getting the collar so tight as to cause restriction of peripheral circulation in the area surrounding the cannula. The cap was then screwed tightly on the top of the cannula to prevent leakage of intestinal contents. In the final step, cotton gauze was placed over the cannula and surgical area and an adhesive bandage wrapped over the gauze and around the abdomen of the pig. This wrap provided protection of the incision site and cannula from trauma or foreign material and from other pigs in the litter during the recovery period. Care should be taken with male pigs to avoid enclosing the prepuce in the adhesive wrap.

Post Surgical Care

Immediately following surgery the pigs were returned to the litter and remained with the dam for a 7 day recovery period. To avoid injury, from the sow or other pigs in the litter, the cannulated pigs were closely observed for 2 to 3 hours after surgery or until the effects of the anesthesia were no longer evident. Following surgery, procaine penicillin was administered twice daily for 5 days at a dose of 9,000 IU/lb body weight.

In addition to the milk provided by the dam, the pigs were allowed continuous access to an 18% crude protein starter diet in creep feeders and water was available at all times from nipple waters. The adhesive wrap was changed when necessary. In general, this was necessary only when the wrap was loosened by other pigs in the litter. The recovery period was generally uneventful and skin sutures were removed approximately 10 days postsurgery. Pigs were weaned and moved to individual metabolism crates 7 days postsurgery and digestibility studies began following a 2 day adjustment period.

Results and Discussion

This cannula has been installed in 6 pigs at 18 days of age weighing between 10 and 12 lb. All pigs completely recovered within 7 to 10 days postsurgery as evidenced by a lack of inflammation around the surgical area and normal appetite and growth. Following weaning at 25 days of age, the adhesive wrap was removed and the cannula was left unprotected. Pigs were housed in smooth sided metabolism crates to minimize trauma caused by catching the cannulas on the sides of the crate. Crates were located in an environmentally controlled feeding room. Five of the 6 pigs were used in a 5 week digestion study starting when pigs were 27 days of age. During this time all pigs were fed semi-purified cornstarch based diets. Samples were collected from the cannulas by removing the cap and unscrewing the collar until the outside edge was flush with the end of the body of the cannula. A small plastic bag was then attached over the collar and around the body of the cannula to collect digesta. This procedure could be performed within the metabolism crate with the unrestrained pig. After the 5 week trial, all 6 pigs were fed an 18% crude protein corn-soybean meal starter diet until they reached about 55 lb at which time the diet was switched to a 16% crude protein growing diet until the cannulas were removed. Samples were collected from all pigs periodically during this time to insure that function of the cannula was maintained. When pigs reached approximately 75 lb live weight, the cannulas were removed from 3 of the pigs in the unanesthetized state by hand manipulation of the cannula until the cannula was dislodged. A larger, flexible cannula was inserted into the fistula immediately following removal of the small rigid cannula. The larger T-cannula were maintained for subsequent trials as the pigs grew larger. The remaining 3 pigs with rigid cannulas as well as the 3 with flexible cannulas were maintained with periodic collections until they reached a weight of about 135 lb at which time all cannulas were nonsurgically removed.

Other cannula designs were also tested in this age and weight of pig. Cannulas made of flexible tubing large enough for sample collection resulted in intestinal blockage, frequent loss of cannula or were too large to fit within the lumen of the small intestine. Thin walled stainless steel cannulas could not be threaded and therefore provided no practical means of securing the cannula in place or of adjusting the cannula for changes in body wall thickness. Stainless steel cannulas thick walled enough to be threaded were too heavy and difficult to maintain in the pig. Initial cannulas were designed with two circular openings, one for intestinal blockage with an inflatable catheter and the other for digesta collection, but the diameter of the openings with this system proved to be too small to allow suitable cannula flow in pigs fed semi-purified diets.

The cannula described in this paper was small, lightweight but sturdy enough to use in digestion studies with neonatal pigs. This cannula does not protrude excessively from the body of the pig and avoided certain problems encountered such as cannula loss and intestinal blockage previously encountered with other types of cannulas in neonatal pigs. Collections can be accomplished by one person on unrestrained pigs. The cannula was large enough to provide sufficient sample flow for routine analysis from pigs fed either semi-purified or practical diets. The screw on cap and collar allowed adjustment for changes in body wall thickness that accompanies pig growth and provided a method to easily attach bags to collect digesta.

EFFECT OF PROTEIN SOURCE ON NUTRIENT DIGESTIBILITY IN EARLY WEANED PIGS

W. R. Walker[1], C. V. Maxwell[2], F. N. Owens[2] and D. S. Buchanan[3]

Story in Brief

Practical diets with supplemental protein from either calcium caseinate (CAS), isolated soybean protein (ISP), ethanol extracted soybean protein (ESOY) or soybean meal (SBM) were fed to 72 Yorkshire boar pigs weaned at 21 days to determine dry matter (DM), starch, nitrogen (N) and amino acid (AA) digestibility. Diets contained 1.01 to 1.03% lysine on a dry matter basis. Digestibilities were determined from fecal samples collected after 3 weeks of feeding the experimental diets. Digestibilities of DM ($P<.05$), lysine ($P<.05$), valine ($P<.05$), methionine ($P<.01$) and proline ($P<.01$) were greater for pigs fed the CAS diet than for pigs fed any of the soybean protein diets. The average apparent digestibilities for the essential amino acids (EAA) were 86.8, 82.4, 84.1 and 80.2% and for lysine were 86.2, 82.8, 83.8 and 80.1% for the CAS, ISP, ESOY and SBM diets, respectively.

(Key Words: Swine, Early Weaned Pig, Amino Acid Digestibility)

Introduction

Performance of young pigs weaned between 1 and 28 days of age is usually better when starter diets contain protein from milk than from soybean meal, soy flour or isolated soybean protein. The reasons for the milk protein superiority have not been determined. Older pigs perform equally well with protein from milk or soybean products, so an age factor must be involved.

Various treatments of SBM (alkali or acid treatment) as well as supplementation of corn-soybean meal rations, with AA and digestive enzymes in an attempt to improve the utilization of soybean protein by the early weaned pig have met with only limited success. Ethanol extraction of soy flour has been shown to prevent intestinal disorders of calves fed milk replacers containing heated soy flour but this has not been tested with early weaned pigs.

Differences observed in the rate and efficiency of gain of early weaned pigs fed either milk or soybean protein diets may be due to differences in the bioavailability of the essential amino acids (EAA) from these protein sources. Several studies have shown that the requirement for lysine (the limiting AA in common grain-SBM diets) for the 11-22 lb pig fed a grain-SBM diet is considerably higher than the .95% currently recommended by NRC (1979). Therefore, diets formulated to meet the minimum requirements for lysine as recommended by NRC (1979) may be deficient in lysine and small differences in the availability of lysine could cause large differences in pig performance. Current information on AA availability for young pigs is limited.

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This study was conducted to determine the effect of source of protein and method of processing of soybean protein upon DM, N, AA and starch digestibility for pigs weaned at 21 days of age.

Materials and Methods

Seventy-two Yorkshire boar pigs were used to study the effect of dietary protein source on nutrient availability. Twelve pigs in each of 6 replicates were weaned at approximately 21 days of age and randomly allotted within litter to one of the four dietary treatments providing a total of 18 pigs per treatment with a mean initial weight of 12 lb. One milk and 3 soybean protein sources were used to formulate practical diets (Table 1) which met NRC (1979) requirements for the 11-22 lb pig.

TABLE 1. Composition of Diets.

Ingredient	Diets[a,b] CAS	ISP	ESOY	SBM
	%			
Corn (IFN 4-02-935)	87.14	83.17	77.87	69.99
Calcium caseinate[c]	9.74			
Isolated soy protein[d]		13.39		
Ethanol extracted soy protein			18.69	
Soybean meal (IFN 5-04-604)				26.67
Calcium carbonate (IFN 6-01-069)	0.87	1.21	1.15	1.19
Dicalcium phosphate (IFN 6-01-080)	1.35	1.33	1.39	1.25
Vitamin, TM premix[f]	.35	.35	.35	.35
Salt (IFN 6-14-013)	.30	.30	.30	.30
ASP-250[g]	.25	.25	.25	.25
	100	100	100	100

[a]As fed basis, calculated to contain .80% Ca and .60% P.
[b]CAS: calcium caseinate diet;ISP: isolated soybean protein diet; ESOY: ethanol extracted soybean protein diet;SBM: soybean meal diet.
[c]Ultra supreme calcium caseinate, Erie Casein Co. Inc., Erie, IL.
[d]Soybean protein grade II, United States Biochemical Corp., Cleveland, OH.
[e]Promocaf, Central Soy, Fort Wayne, IN.
[f]Supplied 4,000,000 IU vitamin A, 3,000,000 IU vitamin D, 4 g riboflavin, 20 g pantothentic acid, 30 g niacin, 800 g choline chloride, 15 mg vitamin B_{12}, 10,000 IU vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.
[g]Each pound of ASP-250 contained 20 g Chlortetracycline, 20 g sulfamethizine and 10 g penicillin.

Protein sources were calcium caseinate (CAS), isolated soybean protein (ISP), ethanol extracted soybean protein (ESOY) and 44% crude protein solvent extracted soybean meal (SBM). Protein sources were substituted for corn on a lysine basis to provide .95% lysine as fed. All other amino acids exceeded NRC (1979) requirements and crude protein ranged from 17 to 19% among diets. Pigs were housed in individual 2.0 by 3.3 foot metal pens in an environmentally controlled feeding room maintained between 80 and 90 F. Pigs had ad libitum access to feed and water throughout the trial. Pigs remained on trial for 35 days with weights and feed intakes recorded weekly. During the third week of each replicate, chromic oxide, added to each diet at the rate of .25%, served as an indigestible marker for calculating nutrient digestibility. A fresh fecal sample was collected from each pig on the last day of the 3rd week of each replicate. Samples were lyophilyzed and ground prior to determination of DM, starch, N and AA content in both feed and feces. Amino acid concentrations were determined from acid hydrolysates by ion exchange chromatography using a Beckman model 121 automatic amino acid analyzer. Acid hydrolysis was conducted under nitrogen reflux in 6N HCl for 24 h.

Results and Discussion

The protein and amino acid composition of diets is shown in table 2. Crude protein as well as the essential amino acids (EAA) arginine, phenylalanine and threonine were highest in the soybean diets while methionine and valine were highest in the CAS diet. The remainder of the EAA were similar among all diets.

The performance data including feed intake, rate and efficiency of gain have been reported previously (Walker et al., 1984). The apparent digestibility of DM was highest in pigs fed the CAS diet averaging 2.7, 3.4 and 5.2 percentage units higher ($P<.05$) than for pigs fed the ISP, ESOY and SBM diets, respectively (table 3). The apparent digestibility of DM by pigs fed the ISP diet was similar to that observed for pigs fed the ESOY diet but higher ($P<.01$) than that observed for pigs fed the SBM diet. Dry matter digestibility was similar ($P>.1$) in pigs fed the ESOY and SBM diets. Differences in DM digestibility between pigs fed the CAS and ISP diets were due primarily to differences in N availability since the digestibilities for starch were similar among all dietary treatments ranging from a low of 98.3% in pigs fed the SBM diet to a high of 99.0% in pigs fed the CAS diet. Greater DM digestibility for ISP and ESOY than SBM may be due to the removal of complex indigestible carbohydrates during the isolation and extraction procedures.

Apparent digestibility of N differed among dietary treatments ($P<.1$) and was highest in pigs fed the CAS diet and lowest in pigs fed the SBM diet (table 3). The difference in N digestibility between pigs fed the CAS and ISP diets (3.1 percentage units) was similar to the difference in DM digestibility (2.7 percentage units) for these same protein sources. Apparent digestibility was higher for methionine ($P<.01$), lysine ($P<.05$) and valine ($P<.05$) in pigs fed the CAS diet than for pigs fed any of the soybean protein diets (table 3). The apparent digestibility of methionine and lysine was similar among pigs fed all of the soybean protein sources while digestibility of valine was higher ($P<.05$) in pigs fed the ESOY diet than in pigs fed the SBM. Other EAA for which differences among dietary treatments were observed ($P<.1$) were isoleucine and leucine.

TABLE 2. Protein and amino acid composition of diets.

Item	Diet[a,b] CAS	ISP	ESOY	SBM
Crude protein, %	17.9	19.9	19.5	19.1
Amino acids, %				
Essential				
Arginine	.78	1.31	1.30	1.24
Histidine	.51	.52	.51	.50
Isoleucine	.78	.85	.82	.80
Leucine	1.87	1.90	1.85	1.77
Lysine	1.03	1.02	1.02	1.01
Methionine	.46	.37	.34	.36
Phenylalanine	.88	1.00	.97	.94
Threonine	.72	.75	.76	.76
Valine	1.01	.95	.92	.90
Nonessential				
Alanine	.87	1.07	1.05	1.02
Aspartic acid	1.28	1.96	1.94	1.91
Cystine	.23	.40	.42	.40
Glutamic acid	3.51	3.61	3.51	3.40
Glycine	.51	.81	.81	.81
Proline	1.73	1.28	1.27	1.21
Serine	.93	1.00	1.00	.97
Tyrosine	.87	.79	.77	.77

[a]Dry matter basis.
[b]For explanation of diet code names, see table 1, footnote b.

The apparent digestibility of these AA appeared to be higher in pigs fed the CAS diet than in pigs fed any of the soybean protein diets with the greatest differences in digestibility being between the CAS and SBM diets. Differences in apparent digestibility were not observed (P>.1) for the remaining EAA, but, except for arginine, digestibility was higher for all of these AA in pigs fed the CAS diet than by those fed any of the soybean protein diets. Differences in the digestibility among dietary treatments for the nonessential AA were observed only for proline (P<.01) and tyrosine (P<.1) for which digestibility was highest in pigs fed the CAS diet and lowest in pigs fed the SBM diet. The apparent digestibility of the remaining nonessential AA was similar among all dietary treatments. These diets were formulated to meet the NRC (1979) requirement for lysine (.95%) for the 11-22 lb pig. This lysine level is below the level of lysine (1.15 - 1.20%) reported to provide maximum rate and efficiency of gain for young pigs fed grain-SBM diets. Since lysine digestibility was higher for CAS than for the soybean proteins, better performance would be expected.

TABLE 3. Apparent digestibility of DM, starch, N and AA measured over the total digestive tract in 42 day old pigs.

Item	Diet[a]				
	CAS	ISP	ESOY	SBM	SE
Pigs per treatment, no[b]	17.0	18.0	17.0	17.0	
Dry matter, %	87.6^{d}	84.9^{e}	84.2^{ef}	82.4^{f}	.8
Starch, %	99.0	98.5	98.6	98.3	.3
Nitrogen, %[c]	83.7	80.6	80.8	76.2	1.1
Amino acids, %					
Essential					
Arginine	88.4	90.6	91.1	88.1	.6
Histidine	89.7	86.8	88.4	86.0	.8
Isoleucine[c]	86.1	81.0	82.6	77.6	1.2
Leucine[c]	88.4	82.2	85.0	80.9	1.2
Lysine	86.3^{d}	82.8^{e}	83.8^{e}	80.1^{e}	.9
Methionine	87.7^{g}	79.6^{h}	81.0^{h}	78.9^{h}	1.2
Phenylalanine	86.5	82.6	83.8	78.5	1.1
Threonine	82.4	77.2	80.0	75.6	1.2
Valine	85.6^{d}	78.8^{ef}	81.1^{e}	75.7^{f}	1.2
Average	86.8	82.4	84.1	80.2	
Nonessential					
Alanine	78.9	75.3	78.4	73.5	1.5
Aspartic acid	81.5	85.0	86.0	82.1	.9
Cystine	95.3	96.0	97.8	95.2	.8
Glutamic acid	90.4	87.7	89.1	86.0	.8
Glycine	75.0	78.6	80.4	75.3	1.2
Proline	93.2^{g}	87.7^{h}	88.2^{h}	84.2^{i}	.9
Serine	87.5	84.4	85.9	81.3	1.0
Tyrosine[c]	88.1	82.4	83.5	79.0	1.1
Average	86.2	84.6	86.2	82.1	

[a] For explanation of diet code names, see table 1, footnote b.
[b] One pig on the CAS diet died from causes unrelated to dietary treatment. One pig was removed from each of the ESOY and SBM diets for prolonged feed refusal.
[c] Treatment effect ($P<.1$).
[def] Means in the same row with different superscripts differ $P<.05$.
[ghi] Means in the same row with different superscripts differ $P<.01$.

Results of this study as previously reported (Walker, 1984) indicate that faster growth and a higher gain to feed ratio can be achieved during the first 2 weeks postweaning in pigs weaned at 3 weeks of age when casein is substituted for soybean protein but gain and efficiency was equal for the two protein sources after the 2nd week postweaning. These differences in performance may be accounted for by the differences observed in nutrient digestibility especially for the EAA lysine and methionine.

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EFFECT OF PROTEIN SOURCE ON ILLEAL AVAILABILITY IN EARLY WEANED PIGS

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Story in Brief

Two 5 X 5 Latin square designed trials were conducted using either five 4 week old gilts or five 200 lb barrows fitted with simple ileal T-cannulas to determine the effect of protein source and age of pig upon protein and amino acid availability. The apparent availability of nitrogen (N) and amino acids (AA) in pigs fed hydrolyzed casein (HCAS), calcium caseinate (CAS), isolated soybean protein (ISP), ethanol extracted soybean protein (ESOY) and soybean meal (SBM) were determined at the ileum in 4 to 9 week old pigs and at both the ileum and over the total digestive tract in finishing pigs. The pigs were fed semi-purified diets formulated to contain 22% protein. The apparent availability of N and essential amino acids (EAA) at the terminal ileum in both early weaned and finishing pigs and over the total digestive tract of finishing pigs was higher (P<.01) in pigs fed HCAS, CAS, ISP and ESOY than in those fed SBM. For the early weaned pig, the apparent availability of N and AA was generally higher for the casein protein sources than for the soybean protein sources. In addition, the apparent availability of N and all AA except cystine and glycine significantly increased with increasing age of the young pigs. The apparent pre-ileal availability of lysine, threonine and methionine for early weaned pigs fed SBM was 69.3, 69.3 and 59.3%, respectively. The apparent pre-ileal availability was lower in the young pigs with an average availability for the EAA of 91.3, 89.5, 85.8, 85.2 and 70.5% compared to 95.3, 93.1, 93.4, 92.7 and 80.6% for the older pigs fed HCAS, CAS, ISP, ESOY and SBM, respectively. Apparent availability values over the total digestive tract were higher than values estimated in samples obtained at the ileum in the finishing pigs indicating a net disappearance of N and AA in the hindgut.

(Key Words: Swine, Early Weaned Pig, Amino Acid Availability)

Introduction

Although weaning as early as 18 days can be an economic advantage, many swine producers experience postweaning problems with this management practice. The reduced performance accompanying early weaning is associated with a reduced feed intake and little or no weight gain. Early weaned pigs also experience a longer postweaning growth depression and higher mortality rate than those weaned later.

Several studies have reported inferior performance in early weaned pigs fed soybean protein diets compared to those fed milk protein diets. Our studies (Walker et al., 1984) have demonstrated that the effect of protein source on performance is more evident during the first 2 weeks postweaning than during the subsequent 3 week period when pigs were weaned at 3 weeks of age. The fact that the neonatal pig is subjected

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to extreme diet changes during a period when digestive capacity is undergoing rapid development may account for the higher sensitivity to dietary protein sources observed in early weaned pigs compared to that normally seen in older pigs.

Protein sources have been shown to vary not only in AA content but also in availability when measured at either the ileum or in fecal samples of growing-finishing pigs. However, studies in the early weaned pig where the effect of protein source may be even greater have not been conducted. Furthermore, it is common practice to formulate diets to barely meet the requirement for the most limiting AA. Recent studies have shown that the requirement for lysine, the first limiting AA for maximum growth in typical grain-soybean diets, may be much higher than the current NRC recommendation for pigs weighing from 11 to 22 lb. Pigs fed diets containing lysine levels below the requirement for maximum gain and efficiency of gain would be responsive to small decreases in amino acid availability.

This study was conducted to determine the apparent biological availability of dry matter (DM), starch, N and individual AA in milk and soybean proteins fed to ileally cannulated early weaned pigs and to compare these values to those of finishing pigs fed the same diets.

Materials and Methods

Five Yorkshire gilt pigs were surgically fitted with simple T-cannulas located in the distal ileum near the ileocecal junction. Pigs were removed from the sow at 18 days of age at which time the cannulas were surgically installed. Immediately following surgery pigs were returned to the sow where they remained with the rest of the litter for a 7 day recovery period. Creep feed and water were available to pigs at all times during the recovery period. After recovery the pigs were moved to an environmentally controlled feeding room where they were housed in individual elevated metal pens measuring 2.0 by 3.3 ft. Temperature in the feeding room was maintained between 80 and 90 F for the duration of the trial. After a 2 day adjustment period, the pigs were started on a 5 X 5 Latin square designed trial at 27 days of age.

Dietary treatments consisted of two milk and three soybean protein sources in semi-purified cornstarch-cerelose based diets (Table 1). Protein sources included hydrolyzed casein (HCAS), calcium caseinate (CAS), isolated soybean protein (ISP), ethanol extracted soybean protein (ESOY) and 44% crude protein solvent extracted soybean meal (SBM). Twenty-two percent crude protein diets were formulated to exceed the NRC (1979) requirement for crude protein for the 10 - 22 lb pig by 10% such that no single AA would be limiting. Chromic oxide was added as an indigestible marker for availability determinations. Each pig was fed a measured quantity of feed twice daily at 8:00 a.m. and 8:00 p.m. and allowed continuous access to the feed for a 1 hour period after which all uneaten feed was removed. To increase intake, dry diets were mixed with an equal portion of water and fed as a gruel. All uneaten and wasted feed was collected, dried and weighed so daily feed intake for each pig could be monitored. Water was available from cup waterers at all times.

Each of the five 7-day experimental periods consisted of a 4-day adjustment period followed by a 3-day collection period. Ileal samples were collected continuously on each collection day, beginning one hour after the morning feeding and continuing until either 1.75 oz of wet sample was collected for each pig or until feeding time of the evening meal. Samples were collected in plastic bags suspended from the cannula. Bags containing sample were changed at a maximum of 1 hour intervals. Ileal samples collected over the 3 collection days of each period were composited by treatment prior to lyophilyzation and grinding for laboratory analysis.

TABLE 1. Composition of Diets.

	Diet (as fed basis)[a]				
Ingredient	HCAS	CAS	ISP	ESOY	SBM
Corn starch	30.82	31.35	30.48	25.93	18.91
Cerelose	30.82	31.35	30.48	25.93	18.91
Acid hydrolysed casein[b]	25.43				
Calcium caseinate[c]		25.43			
Isolated soy protein[d]			26.11		
Ethanol extracted soy protein[e]				35.25	
Soybean meal					49.64
Solka floc	5.00	5.00	5.00	5.00	5.00
Corn oil	4.00	4.00	4.00	4.00	4.00
Calcium carbonate	.70		.79	.78	.90
Dicalcium phosphate	1.73	1.73	2.00	1.97	1.50
Vitamin, TM premix[f]	.35	.35	.35	.35	.35
Salt	.30	.30	.30	.30	.30
ASP 250[g]	.25	.25	.25	.25	.25
Chromic oxide	.25	.25	.25	.25	.25
DL-tryptophan	.35				
	100	100	100	100	100

[a]HCAS: acid hydrolyzed casein diet; CAS: calcium caseinate diet; ISP: isolated soybean protein diet; ESOY: ethanol extracted soybean protein diet; SBM: soybean meal diet.
[b]Acid hydrolyzed casein, type 1, Sigma Chemical Co. St. Louis, MO.
[c]Ultra supreme calcium caseinate, Erie Casein Co. Inc., Erie, IL.
[d]Soybean protein grade II, United States Biochemical Corp., Cleveland, OH.
[e]Promocaf, Central Soy, Fort Wayne, IN.
[f]Supplied 4,000,000 IU vitamin A, 3,000,000 IU vitamin D, 4 g riboflavin, 20 g pantothentic acid, 30 g niacin, 800 g choline chloride, 15 mg vitamin B_{12}, 10,000 IU vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.
[g]Each pound of ASP-250 contained 20 g Chlortetracycline, 20 g sulfamethizine and 10 g penicillin.

Dry matter, starch, N and AA content of both feed and ileal samples were determined. Amino acid concentration was determined from acid hydrolysates by ion exchange chromatography using a Beckman model 121 automatic AA analyzer. Acid hydrolysis was conducted under nitrogen reflux in 6N HCl for 24 hours.

A second study was conducted using five Yorkshire barrows averaging 200 lb liveweight with simple T-cannulas constructed of pliable tygon tubing surgically installed in the ileum of the small intestine. The experiment consisted of a 5 X 5 Latin square arrangement of treatments using the same diets (table 1) as those fed the neonatal pigs, with the exception of a .1% reduction in the amount of vitamin trace mineral premix. Each pig was fed 2.2 lb of unwetted feed twice daily at 8:00 a.m. and 8:00 p.m. with water available from nipple waterers at all times. These pigs were housed in an environmentally controlled feeding room in individual crates (2.0 by 5.3 ft) for the duration of the trial. Each of the five 7-day experimental periods consisted of a 4-day adjustment period followed by ileal collections on the 5th and 7th day of each period. Ileal samples were collected continuously on each collection day beginning 1 hour after the morning feeding and continuing until either 7.0 oz of wet sample was collected for each pig or until feeding of the evening meal. In addition, a fresh fecal grab sample was collected from each pig on both the 5th and 7th day of each period for fecal availability determination. All samples were collected, stored and analyzed in a similar manner as described for the early weaned pig study. Fifth and 7th day ileal samples within each period were composited by treatment prior to laboratory analysis while 5th and 7th day fecal samples were analyzed separately.

Results and Discussion

Early weaned pigs.

Protein and AA composition of the complete diets are shown in table 2. The two casein protein diets were similar in lysine and threonine content but higher in methoinine content than the 3 soybean protein sources. These are the AA that tend to be most limiting in diets that are commonly fed to early weaned pigs and, therefore, are of the most interest.

The apparent pre-ileal availability of DM, starch, N and individual AA in the various protein sources is shown in table 3. The apparent pre-ileal DM availability in pigs fed HCAS, CAS, ISP and ESOY was higher (P<.05) than in those fed SBM while DM availability in pigs fed CAS and ISP was higher (P<.05) than those fed ESOY. These differences, at least to some extent, reflect differences in dietary crude fiber content. The availability of starch exceeded 95% and was similar for all protein sources except in pigs fed HCAS when starch availability was slightly reduced.

The apparent pre-ileal availability of N, the EAA and the nonessential AA (NEAA), with the exception of cystine and glycine, was lower (P<.05) in pigs fed SBM than in those fed all other protein sources. The average apparent pre-ileal availability of the EAA in pigs fed SBM was 70.5% compared to 91.3, 89.5, 85.8, and 85.2% for those fed HCAS, CAS, ISP and ESOY, respectively. The apparent pre-ileal availability of both lysine and threonine was higher (P<.05) in pigs fed HCAS than in those fed ISP or ESOY while the availability of these AA was intermediate in pigs fed CAS. The apparent pre-ileal availability of methionine was similar in pigs fed HCAS, CAS, ISP or ESOY. For the remainder of the EAA, effects similar to those reported for lysine and threonine were evident for histidine, isoleucine, leucine and valine while effects similar to those reported for methionine were evident for arginine and phenylalanine. Although differences were not always significant, there was a trend for higher apparent availabilities in the casein protein sources when compared to the soybean protein sources. In addition, when CAS was compared to the average of the soybean proteins the apparent pre-ileal availability was higher (P<.05) for CAS in each of the EAA with the exception of arginine. The low value reported for the average apparent pre-ileal availability of the EAA in SBM (70.5%) is not surprising since the digestive capacity of this age pig is undergoing rapid development. In addition, the presence of proteolytic enzyme inhibitors in SBM is likely to have a greater effect in young pigs than that normally apparent in older growing-finishing pigs.

TABLE 2. Protein and amino acid composition of diets.

Item	Diet[a,b]			
	CAS	ISP	ESOY	SBM
Crude protein, %	17.9	19.9	19.5	19.1
Amino acids, %				
Essential				
Arginine	.78	1.31	1.30	1.24
Histidine	.51	.52	.51	.50
Isoleucine	.78	.85	.82	.80
Leucine	1.87	1.90	1.85	1.77
Lysine	1.03	1.02	1.02	1.01
Methionine	.46	.37	.34	.36
Phenylalanine	.88	1.00	.97	.94
Threonine	.72	.75	.76	.76
Valine	1.01	.95	.92	.90
Nonessential				
Alanine	.87	1.07	1.05	1.02
Aspartic acid	1.28	1.96	1.94	1.91
Cystine	.23	.40	.42	.40
Glutamic acid	3.51	3.61	3.51	3.40
Glycine	.51	.81	.81	.81
Proline	1.73	1.28	1.27	1.21
Serine	.93	1.00	1.00	.97
Tyrosine	.87	.79	.77	.77

[a]Dry matter basis
[b]For explanation of diet code names, see table 1, footnote b.

A linear increase over time (P<.05) was observed for the apparent pre-ileal availability of N, all of the EAA and the NEAA with the exception of cystine and glutamic acid (Table 4). Increasing availability with increasing age has been observed for several nutrients in young animals.

TABLE 3. Apparent pre-ileal availabilities of DM, starch, N and AA in milk and soybean protein sources in early weaned pigs.[a]

	Diet[b]					
Item	HCAS	CAS	ISP	ESOY	SBM	SE
Dry matter, %[c]	80.7^{de}	85.4^{d}	83.0^{d}	77.0^{e}	65.0	1.6
Starch, %	94.5^{e}	98.7^{d}	98.5^{d}	98.8^{d}	97.3^{de}	.9
Nitrogen, %[c]	86.0	84.5	81.8	83.4	68.4	2.1
Amino acids, %						
Essential						
Arginine[c]	88.8	86.7	90.9	90.5	77.8	1.6
Histidine[c]	89.5^{d}	89.2^{de}	84.4^{de}	83.9^{e}	70.3	1.8
Isoleucine[c]	93.6^{d}	89.6^{de}	87.7^{de}	87.2^{e}	73.3	2.1
Leucine[c]	93.3^{d}	92.8^{de}	86.9^{de}	86.0^{e}	72.2	2.3
Lysine[c]	92.0^{d}	89.6^{de}	84.1^{e}	85.0^{e}	69.3	2.2
Methionine[c]	93.8	92.8	85.9	82.6	59.3	4.8
Phenylalanine[c]	86.4	89.3	86.5	86.2	71.8	2.2
Threonine[c]	90.5^{d}	85.3^{de}	80.4^{e}	81.2^{e}	69.3	2.0
Valine[c]	94.1^{d}	90.4^{de}	85.0^{e}	84.1^{e}	71.2	2.2
Avg	91.3	89.5	85.8	85.2	70.5	
Nonessential						
Alanine[c]	90.9^{d}	82.9^{e}	83.1^{e}	83.2^{e}	68.5	1.9
Aspartic acid[c]	87.4	86.9	89.0	88.7	76.4	1.6
Cystine	100.0^{d}	100.0^{d}	70.0^{e}	77.5^{f}	64.0^{e}	2.4
Glutamic acid[c]	90.1	90.9	89.5	89.1	77.2	2.2
Glycine[c]	78.5^{d}	72.1^{d}	76.9^{d}	76.7^{d}	64.5^{e}	2.3
Proline[c]	96.5^{d}	94.3^{d}	85.7^{e}	85.8^{e}	73.5	1.9
Serine[c]	93.6^{d}	86.2^{e}	87.2^{e}	86.7	74.7	1.9
Tryosine[c]	90.2	94.0	88.4	88.3	74.6	2.1
Avg	90.9	88.4	83.7	84.5	71.7	

[a] Values are means of five observations.
[b] For explanation of diet code names, see table 1, footnote a.
[c] SBM differs from other diets P<.05.
[def] Means in the same row with different superscripts differ P<.05.

Pigs fed diets limiting in EAA would be responsive to small differences in AA availability. Recent studies have shown that the lysine requirement for the 11 to 22 lb pig is higher than the .95% currently recommended by NRC. Therefore, the differences in availability observed in this study may account for reduced growth and efficiency observed in pigs fed soybean protein diets compared to those fed CAS diets during the first 2 weeks postweaning in pigs weaned at 3 weeks of age and fed these same protein sources in practical diets formulated to meet minimum NRC requirements for lysine (Walker et al., 1984).

TABLE 4. Effect of time on apparent pre-ileal amino acid availability in early weaned pigs.[a]

Item	Week 1	2	3	4	5	
Dry matter, %	77.7	75.5	79.9	79.4	78.6	1.6
Nitrogen, %[c]	78.9	75.9	81.5	85.8	81.8	2.1
Amino acids, %						
Essential						
Arginine[b]	81.8	84.2	87.7	91.7	89.4	1.6
Histidine[c]	81.1	79.2	83.8	88.2	85.1	1.8
Isoleucine[b]	83.0	81.6	86.4	92.0	88.3	2.1
Leucine[c]	82.7	82.1	86.2	91.6	88.6	2.3
Lysine[b]	81.3	77.4	84.6	89.8	87.0	2.2
Methionine[c]	78.2	74.6	83.7	91.6	87.0	4.8
Phenylalanine[b]	80.5	79.7	84.3	88.7	86.9	2.2
Threonine[b]	78.1	75.8	82.1	86.9	83.9	2.0
Valine[c]	82.2	79.7	85.0	90.7	87.2	2.2
Nonessential						
Alanine[b]	78.5	76.2	81.5	87.9	84.4	1.9
Aspartic acid[b]	82.5	82.3	86.7	89.7	87.3	1.6
Cystine	83.3	78.9	77.7	89.2	82.3	2.4
Glutamic acid	85.1	84.4	87.8	92.0	87.5	2.2
Glycine[b]	69.1	68.4	76.3	81.0	73.9	2.3
Proline[c]	85.0	83.0	87.3	91.8	88.9	1.8
Serine[c]	83.3	80.5	86.8	90.8	87.0	1.9
Tryosine[c]	84.8	83.0	87.2	91.2	89.3	2.1

[a]Values are means of five observations.
[b]Linear effect P<.01.
[c]Linear effect P<.05.

Finishing pigs.

Significant differences were not observed between values obtained from fecal samples collected on either the 5th or 7th day of each period and, therefore, these values were averaged and analyzed as a single sample. The apparent availability of DM and starch at both the terminal ileum and over the total digestive tract is shown in table 5. The apparent DM availability was similar at the terminal ileum in pigs fed HCAS, CAS and ISP and over the total digestive tract in pigs fed HCAS, CAS, ISP and ESOY. The apparent DM availability was lower (P<.01) in pigs fed SBM than in pigs fed all other protein sources at both sites and was lower at the terminal ileum (P<.01) in pigs fed ESOY than for those fed HCAS, CAS and ISP. Dry matter disappearance from the hindgut ranged from 21.8% for SBM to 3.2% for HCAS which may be a reflection of the higher crude fiber content of SBM and the high digestibility of nutrients in HCAS. Starch availability was similar for all protein sources and approached 100% when estimated at both the terminal ileum and over the total digestive tract.

The apparent pre-ileal availability of N and all EAA was lower (P<.05) in pigs fed SBM than for those fed HCAS, CAS, ISP and ESOY (table 6). The apparent pre-ileal availability of lysine and threonine was similar for pigs fed HCAS, CAS, ISP and ESOY while that of methionine was higher (P<.05) for pigs fed HCAS than those fed either ISP or ESOY with those fed CAS being intermediate. Similar trends were evident for the remainder of the EAA and the NEAA. The average apparent pre-ileal availability was 95.3, 93.1, 93.4, 92.7 and 80.6% for the EAA and 93.2, 88.4, 88.8, 91.0 and 75%, for the NEAA in pigs fed HCAS, CAS, ISP, ESOY and SBM, respectively. These values are all higher than those observed in the early weaned pig.

TABLE 5. Apparent availabilities of dry matter and starch at the end of the small intestine and over the total tract of finishing pigs.[a]

	Diet[b]					
Item	HCAS	CAS	ISP	ESOY	SBM	SE
Dry matter, %						
Terminal ileum	88.5[d]	85.6[d]	85.7[d]	76.1[e]	61.0[f]	1.1
Total tract	91.7[d]	91.3[d]	90.3[d]	90.5[d]	82.8[e]	.5
Difference[c]	3.2	5.7	4.6	14.4	21.8	
Starch, %						
Terminal ileum	99.8	99.8	99.9	99.9	99.6	.1
Total tract	99.9	99.9	99.8	100.0	99.6	.1
Difference[c]	.1	-.1	.1	.1		

[a]Values are means of five observations.
[b]For explaination of diet code names, see table 1, footnote a.
[c]Differences obtained by subtraction of ileal availabilities from total tract availabilities.
[def]Means in the same row with different superscripts differ P<.01.

The apparent availability of the EAA measured over the entire digestive tract averaged 97.3%, 96.8%, 95.3%, 95.4% and 85.9% in pigs fed HCAS, CAS, ISP, ESOY and SBM, respectively (table 7). The apparent availability of the EAA and N over the entire tract was higher (P<.05) in pigs fed HCAS, CAS, ISP and ESOY than in those fed SBM. In addition, the availability of lysine over the entire tract was higher (P<.05) in pigs fed CAS (97.7%) than in those fed ISP (96.2%) or ESOY (95.7%) and higher (P<.05) in pigs fed HCAS (97.2%) than in those fed ESOY.

Similarly, the fecal availability of threonine was higher (P<.05) in pigs fed CAS (95.4%) than in those fed ISP (93.8%) or ESOY (93.7%) while availability was similar in pigs fed HCAS (95.0%). The fecal availability of methionine was higher ($P<.05$) in pigs fed CAS (97.7%) and HCAS (97.6%) than in those fed ISP (93.1%) or ESOY (94.7%). Similar patterns were observed for the remainder of the EAA and the NEAA. The low apparent fecal availability for AA may be due to the low apparent availability of DM in the small intestine (61%), as was previously mentioned. This would provide more energy substrate to the hindgut than would normally be expected to occur with this type diet which in turn would result in an increase of microbial AA in the feces and consequently lower fecal availability estimates.

TABLE 6. Apparent ileal availability of nitrogen and amino acids in milk and soybean protein sources in finishing pigs[a].

	Diet[b]					
Item	HCAS	CAS	ISP	ESOY	SBM	SE
Nitrogen, %[c]	92.3^{d}	88.1^{e}	90.6^{de}	89.7^{de}	79.5	1.2
Amino acids, %						
Essential						
Arginine[c]	94.7^{de}	93.1^{e}	97.0^{d}	96.1^{d}	87.3	.8
Histidine[c]	92.3	95.1	94.4	92.8	79.8	1.1
Isoleucine[c]	96.3^{d}	91.3^{e}	93.1^{e}	93.8^{de}	82.4	.9
Leucine[c]	96.7^{d}	95.4^{de}	93.3^{e}	93.3^{e}	81.8	1.0
Lysine[c]	96.7	96.3	95.4	94.3	81.8	1.2
Methionine[c]	97.7^{d}	95.8^{de}	93.8^{e}	94.2^{e}	86.1	1.0
Phenylalanine[c]	94.3	95.4	94.7	93.4	82.6	.9
Threonine[c]	92.4	84.9	87.4	85.8	67.5	2.7
Valine[c]	96.4^{d}	90.5^{e}	91.7^{de}	90.7^{e}	76.1	1.5
Average	95.3	93.1	93.4	92.7	80.6	
Nonessential						
Alanine[c]	94.6^{d}	85.0^{e}	90.5^{d}	90.1^{de}	75.2	1.8
Aspartic acid[c]	92.2	90.2	93.4	93.4	79.8	1.2
Cystine	100.0^{d}	100.0^{d}	84.5^{e}	86.4^{e}	78.8^{e}	8.5
Glutamic acid[c]	89.6^{e}	91.9^{de}	95.5^{d}	95.2^{d}	80.6	1.6
Glycine	82.5^{d}	75.5^{de}	87.0^{d}	85.3^{d}	64.1^{e}	4.5
Proline[c]	97.1	93.1	93.2	91.0	76.3	2.4
Serine	94.9^{d}	81.0^{e}	92.9^{d}	91.2^{d}	75.7^{e}	1.8
Tyrosine[c]	96.5	97.0	96.7	95.7	84.4	.8
Average	93.2	88.4	88.8	91.0	75.0	

[a]Values are means of five observations.
[b]For explaination of diet code names, see table 1, footnote a.
[c]SBM differs from other diets ($P<.01$).
[de]Means in the same row with different superscripts differ $P<.05$.

TABLE 7. Apparent fecal availabilities of nitrogen and amino acids in milk and soybean protein sources in finishing pigs.[a]

	Diet[b]					
Item	HCAS	CAS	ISP	ESOY	SBM	SE
Nitrogen, %[c]	95.5	95.4	94.4	94.8	87.5	.4
Amino acids, %						
Essential						
Arginine	96.2[d]	96.5[d]	97.9c	97.8[c]	91.3[e]	.3
Histdine	96.6[c]	97.6[c]	96.6[c]	96.7[c]	88.7[d]	.4
Isoleucine	96.6[c]	95.4[c]	95.1[c]	95.0[c]	84.4[d]	.5
Leucine	96.8[c]	97.0[c]	94.9[d]	95.4[d]	84.8[e]	.3
Lysine	97.2[cd]	97.7[c]	96.2[de]	95.7[e]	85.5[f]	.4
Methionine	97.6[c]	97.7[c]	93.1[d]	94.7[d]	88.1[e]	.7
Phenylalanine	94.8[c]	97.3[d]	95.6[d]	95.7[d]	85.6[e]	.4
Threonine	95.0[cd]	95.4[c]	93.8[d]	93.7[d]	81.4[e]	.5
Valine	97.3[c]	96.4[c]	94.6[d]	94.6[d]	83.5[e]	.5
Avg	97.3	96.8	95.3	95.4	85.9	
Nonessential						
Alanine	94.5[c]	93.0[c]	93.4[c]	92.9[c]	79.9[d]	.6
Aspartic acid	94.0[d]	95.5[cd]	97.1[c]	96.7[c]	87.4[e]	.5
Cystine	100.0[c]	100.0[c]	94.1[d]	95.3[d]	89.9[e]	1.2
Glutamic acid	97.9[c]	97.5[c]	98.0[c]	97.7[c]	90.7[d]	.4
Glycine	91.6[de]	90.8[e]	94.6[c]	94.2[d]	82.5[f]	.9
Proline	98.8[c]	98.5[c]	96.9[d]	96.8[d]	89.0[e]	.3
Serine	96.2[c]	94.2[c]	96.1[c]	95.9[c]	86.9[e]	.7
Tyrosine	96.7[d]	98.1[c]	96.1[d]	95.6[d]	86.3[e]	.4
Avg	96.1	96.0	95.8	95.6	86.6	

[a]Values are means of five observations.
[b]For explanation of diet code names, see table 1, footnote a.
[cdef]Means in the same row with different superscripts differ P<.05.

Most of the apparent fecal availability estimates were larger than ileal availability estimates indicating a net disappearance of N and AA from the hindgut. Since these pigs were fed cornstarch based diets that were all highly available (greater than 99% starch availability at the terminal ileum) a net disappearance of N and AA in the hindgut would be expected.

In general, the availability of N and AA in pigs fed SBM was lower than for those fed the other dietary protein sources. This may reflect differences in proteolytic enzyme inhibitors or carbohydrate complexes within the dietary protein source and may account for the inferior growth and efficiency observed for early weaned pigs fed SBM diets compared to those fed milk protein diets. The apparent ileal availability of N and AA was higher for the older finishing pigs than for the early weaned pigs and the EAA averaged 4.0, 3.6, 7.1, 7.5 and 10.1 percentage units higher availability for pigs fed HCAS, CAS, ISP, ESOY and SBM, respectively. These differences in availability should be considered when formulating diets for young pigs especially when using SBM as a supplemental protein source and formulating diets to meet minimum NRC requirements for lysine.

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EFFECT OF PROTEIN SOURCE (SOYBEAN VERSUS WHEY) UPON SERUM CHOLESTEROL LEVELS OF THE PIG

S.A. Norton[1], C.G. Beames, Jr.[2] and C.V. Maxwell[3]

Story in Brief

Four Yorkshire barrows were used in a Latin square experiment to determine the effect of whey versus soybean protein on blood cholesterol in pigs. Diets were fed without or with .5% supplemental cholesterol. When soybean protein was replaced by whey with no supplemental cholesterol, there was a slight but nonsignificant increase in blood cholesterol. Added dietary cholesterol increased serum cholesterol, but when soybean protein was replaced by whey in diets containing .5% cholesterol, serum cholesterol was significantly reduced. A protein source by cholesterol interaction was noted. In swine fed a high cholesterol diet, whey is more hypocholesteremic than soy protein.

Key Words: (Serum Cholesterol, Dietary Cholesterol, Whey, Soy Protein)

Introduction

Previous biomedical investigations have demonstrated a correlation between the incidence of atherosclerosis, diet, and serum cholesterol levels. Researchers have shown that serum cholesterol levels can be elevated by adding high levels of chemically isolated cholesterol, and by varying the ratio of polyunsaturated to saturated fats.

Other dietary nutrients may also influence levels of serum cholesterol and the incidence of atherosclerosis. Specifically, milk and milk products have been suggested to exacerbate hypercholesteremic (increasing blood cholesterol) effects by increasing both fat and animal protein intake Dietschy, et al.,1978). Recently, however, several reports have indicated that certain components of whole, skim, fermented and unfermented milk products may be hypocholesteremic (decreasing blood cholesterol) (Kritchevsky et al., 1979; Mann, 1977; Richardson, 1978).

The hypocholesteremic effects of milk and milk products have not been monitored in swine extensively. Declines in both total and HDL-cholesterol have been observed in pigs fed large amounts of whey, but only slight depressions in serum triglyceride titers were apparent. The exact mechanism of this response in swine to whey feeding, and the nature of the interaction of whey with other dietary components remains unknown. A clearer understanding of the hypocholesteremic effect of whey is particularly important since it conflicts with the general attitude that animal proteins are hypercholesteremic relative to vegetable proteins. This study was conducted to further investigate the influence of dietary protein source (whey versus soybean meal) and dietary cholesterol on serum cholesterol levels in the pig.

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[1]Graduate Assistant [2]Professor [3]Professor

Materials and Methods

Four Yorkshire barrows weighing approximately 60 kg were utilized in a 4 X 4 Latin square design with a 2 X 2 factorial arrangement of diets. Each pig was surgically fitted with an indwelling jugular catheter to accomodate daily blood collection and randomly assigned to one of four diets (Table 1). Diets consisted of 11.3% soybean meal + 0% cholesterol (Diet1), 11.3% soybean meal + .5% cholesterol (Diet 2), 40% dried whey + 0% cholesterol (Diet 3), and 40% whey and .5% cholesterol (Diet 4). Whey or soybean meal was provided as the supplemental protein source in corn-soy based diets formulated to supply .62% lysine. Each experimental period lasted 14-d followed by a 7-d interim during which a basal diet was fed to allow serum cholesterol levels to stabilize before the initiation of the next period. In addition, at the start of each period pigs were weighed to readjust feed intake to 2.8% of bodyweight. Water was available ad libitum.

At 0700 h each day a 10 ml whole blood sample was drawn and the cannulas immediately flushed with 10 ml of 2.8% sodium citrate in .9% saline. Blood samples were allowed to clot at approximately 4 C for 3 hours after which time the serum was extracted from the sample by centrifugation at 3000 x g for 20 min. Serum was stored at -20 C until total cholesterol analyses were performed.

Table 1. Percent composition of basal and experimental diets.

Item	Basal	Diet 1	Diet 2	Diet 3	Diet 4
Corn, ground	75.60	74.45	73.95	46.40	45.90
Whey, dried	0.00	0.00	0.00	40.00	40.00
Soybean Meal	21.15	11.30	11.30	0.00	0.00
Animal Fat	0.00	8.00	8.00	8.00	8.00
Meat and Bone Meal	0.00	5.00	5.00	5.00	5.00
Dicalcium Phosphate	1.50	.55	.55	0.00	0.00
Cholesterol[a]	0.00	0.00	.50	0.00	.50
Salt	.50	.35	.35	.35	.35
Vitamin-TM Premix	.50	.25	.25	.25	.25
Calcium Carbonate	.75	.10	.10	0.00	0.00
COMPOSITION					
Dry Matter	87.65	89.57	89.66	92.02	91.83
Crude Protein	15.96	14.04	14.00	11.40	11.36
Ether Extract	2.53	9.95	9.02	9.17	9.52
Lysine	.79	.62	.62	.62	.62
Calcium	.69	.71	.71	.90	.90
Phosphorus	.63	.63	.63	.68	.68

[a] Sigma Chemical Co., USP Grade

Results and Discussion

Mean serum cholesterol concentrations across all sampling days for four experimental diets are presented in Table 2. Serum cholesterol values were low but similar in pigs fed diets without supplemental

Table 2. Serum cholesterol concentrations as influenced by basal and experimental diets.

Diet Description	N	Serum Cholesterol [a,b]
Diet 1		
Control w/o Cholesterol	16	86.62[c]
Diet 2		
Control w/ Cholesterol	16	158.36[d]
Diet 3		
Whey w/o Cholesterol	16	89.70[c]
Diet 4		
Whey w/ Cholesterol	16	135.02[e]

[a] Values expressed as mg/dl.

[b] Standard error of mean for all values +/- 2.46.

[c,d,e] Means in the same column with different superscripts differ (P<.0001).

dietary cholesterol. Adding .5% cholesterol (diets 2 and 4) increased serum cholesterol levels (P<.0001). However, response to added cholesterol differed with protein source (P<.0001). Serum cholesterol was approximately 15% lower with whey than with soybean meal as a source of dietary protein (diet 4 versus diet 2). This response indicates that whey had a hypocholesteremic effect only when the diet contained .5% supplemental cholesterol.

The response of serum cholesterol over time on each test diet is presented in Figure 1. Serum cholesterol of pigs offered diet 1 and 3 increased slightly and linearly (P<.0001) from day 0 to 4 with only a small fluctuation between 85 and 95 mg/dl for the remainder of the 14-d period. The slight increases observed between days 0 and 4 may represent an adaptation to the switch from the lowfat basal ration (% ether extract = 2.8%) to the higher fat content of experimental diets (% ether extract = 9.28%).

Among pigs fed the soy with added cholesterol (diet 2), serum cholesterol exhibited a quadratic increase (P<.0001) to approximately 200 mg/dl at day 11 after which levels decreased and stabilized at 185 mg/dl for the duration of the period. A similar quadratic increase (P<.0001) in serum cholesterol was observed for pigs fed the whey protein diet with added cholesterol (diet 4), except that the increase was more gradual.

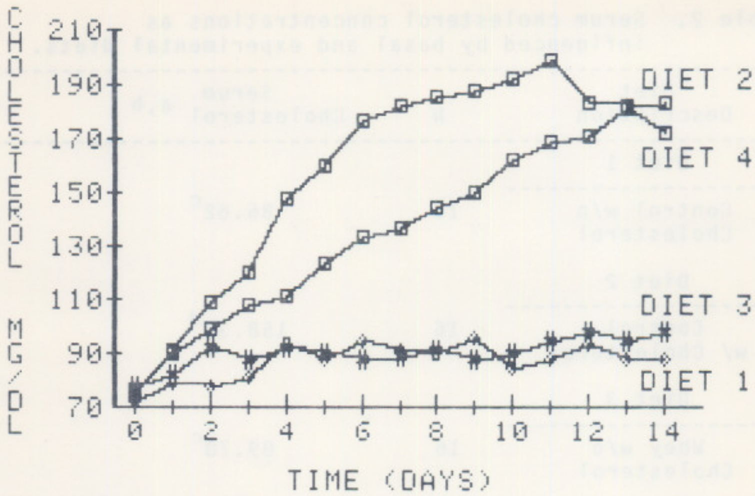

Figure 1. Response of serum cholesterol over time to experimental and basal diets.

The results of this trial indicate that dietary whey protein reduces the increase in serum cholesterol in pigs fed a high cholesterol diet. This supports the position that milk and milk products do contain a hypocholesteremic factor(s). Since blood levels had not fully stabilized by day 14, longer-term studies are needed to determine the effects under steady state conditions. The mechanism whereby this effect occurs still remains to be elucidated. Since the human diet varies in composition from day to day, and milk and milk products have hypocholesteremic effects with variable diets, past criticism of milk products should be reevaluated.

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THE EFFECT OF WHEAT VS. CORN ON PERFORMANCE IN TWO LINES OF GROWING-FINISHING SWINE

Charles Maxwell[1], Dave Buchanan[2], Bill Luce[1], Ron Bates[3], and Rex Vencl[4]

Story in Brief

Three feeding trials with a total of 570 growing-finishing pigs were conducted to compare corn vs wheat as a feedstuff for swine using rations formulated on an equal lysine basis. Average daily gain, average daily feed intake, feed efficiency and backfat were similar in pigs fed either the wheat or corn diet although some differences in response between a rapid growth line and a slow growth line were observed for average daily gain. This study suggests that when proper formulation procedures are used, wheat is comparable with corn as a feedstuff for growing and finishing swine.

(Key Words: Wheat, Growing-Finishing Swine, Performance)

Introduction

Although wheat has been the grain source in swine rations which would produce the least cost gains at times during the past several years, swine producers have been reluctant to feed wheat because of previous unsatisfactory experiences or because of an unfamiliarity with feeding wheat. Producers who do choose to feed wheat will commonly limit the amount of wheat in swine rations to no more than half of the grain portion of the ration.

One of the potential problems encountered with wheat feeding is improper ration formulation. To take advantage of the higher levels of protein and amino acids in wheat, standard rations must be reformulated specifically for feeding wheat. Wheat-soybean meal rations formulated from standard growing or finishing ration and substituting wheat for either corn or milo will result in overfeeding both protein and the limiting amino acids. Conversely, formulating wheat rations to contain crude protein levels similar to those commonly used in milo or corn rations will result in a lysine deficiency and reduced performance. These trials were conducted to compare performance of growing-finishing swine fed wheat or corn based diets formulated on an equal lysine basis.

Materials and Methods

This trial was conducted at the Livestock and Forage Research Laboratory at El Reno and consisted of 570 pigs in 31 pens over three seasons. All pigs were housed in a feeding unit with indoor concrete floors and pens equipped with self-feeders and waterers. Pigs from a line selected for rapid growth and a line selected for slow growth were randomly allotted within line to two treatments (Table 1). All diets were formulated to contain 0.75% lysine during the growing period (42 - 121 lb) and 0.62% lysine during the finishing period (121 - 222 lb).

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The two treatments consisted of either a corn-soybean meal diet or a hard red winter wheat-soybean meal diet.

TABLE 1. Composition of experimental rations.

	% Composition (as-fed)			
	Grower		Finisher	
Ingredient	Corn	Wheat	Corn	Wheat
Corn, yellow	77.12		82.65	
Wheat, hard red winter		81.00		86.80
Soybean meal (44%)	19.03	15.37	14.06	10.15
Dicalcium phosphate	1.84	1.46	1.68	1.25
Calcium carbonate	0.76	0.92	0.76	0.95
Salt	0.50	0.50	0.50	0.50
Vitamin trace mineral mix[a]	0.25	0.25	0.25	0.25
Tylan 10	0.50	0.50	0.10	0.10
Total	100.00	100.00	100.00	100.00
Calculated Analysis				
% Protein	15.16	16.64	13.46	15.06
% Lysine	0.75	0.75	0.62	0.62
% Met + Cys	0.53	0.48	0.49	0.44
% Threonine	0.60	0.59	0.52	0.51
% Calcium	0.75	0.75	0.70	0.70
% Phosphorus	0.65	0.65	0.60	0.60

[a]Supplied 4,000,000 IU vitamin A, 300,000 IU vitamin D, 4 g riboflavin, 20 g pantothenic acid, 30 g niacin, 800 g choline chloride, 15 mg vitamin B_{12}, 10,000 IU vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.

Results and Discussion

During the growing period (42 - 121 lb, Table 2), pigs from the rapid growth line grew 2% faster when fed the wheat diet but pigs from the slow growth line grew faster (4.4%) when fed the corn diet. Although treatment differences were not significant for either line, this inconsistent response between lines resulted in a line by treatment interaction (P<.01). Average daily feed intake followed a pattern similar to that observed for average daily gain, although neither treatment effects nor the interaction was significant. Feed efficiency was similar for both corn and wheat fed pigs within each line. As expected, pigs from the rapid growth line grew more rapidly and had a higher feed intake than pigs from the slow growth line. The results of this summary of three trials is similar to observations over a single trial (Maxwell et al., 1983) and suggest that hard red winter wheat is comparable with corn as a feedstuff for the growing pigs when diets are formulated on an equivalent lysine basis.

TABLE 2. Treatment means of two lines of pigs fed either wheat or corn during the growing period.

	Treatments			
	Rapid Growth Line		Slow Growth Line	
Item	Corn	Wheat	Corn	Wheat
Pigs per treatment, no	167	156	116	131
Pens per treatment, no	11	10	8	9
Avg initial wt, lb	47.5	45.0	35.1	38.9
Avg final wt, lb	123.9	122.8	118.9	115.2
Avg daily gain, lb[ab]	1.50	1.53	1.42	1.36
Avg daily feed intake, lb[a]	3.99	4.03	3.79	3.62
Feed per lb gain, lb	2.67	2.67	2.73	2.72

[a]Line effect (P<.001).
[b]Line by treatment interaction (P<.01).

During the finishing period (121 - 222 lb; Table 3), pigs fed corn grew slightly faster than pigs fed wheat in both the rapid growth line and the slow growth line although differences were not significant and resulted in only a 2.8% overall improvement in gain. Since this difference in gain was greater in the slow growth line (6.2%) than in the rapid growth line (0.5%), a line by treatment interaction (P<.08) was observed. Similarly, average daily feed intake averaged over both lines was only slightly higher (2.2%) for pigs fed the corn diet than those fed the wheat diet. Feed efficiency was similar for pigs fed the corn or wheat diet when summarized over both lines (3.44 vs 3.42 lbs of feed per lb of gain, respectively). Backfat was not affected by dietary treatment in this study. Pigs from the rapid growth line grew more rapidly, had a higher feed intake and were more efficient than pigs from the slow growth line. This summary of results of three feeding trials suggest that pigs perform similarly when fed corn or hard red winter wheat during the finishing period although there is some indication that slower growing pigs may have more of a tendency to prefer corn over wheat than faster growing pigs.

TABLE 3. Treatment means of two lines of pigs fed wheat or corn during the finishing period.

	Treatments			
	Rapid Growth Line		Slow Growth Line	
Item	Corn	Wheat	Corn	Wheat
Pigs per treatment, no	167	155	114	130
Pens per treatment, no	11	10	8	9
Avg initial wt, lb	123.9	122.8	118.9	115.2
Avg final wt, lb	224.8	224.3	220.3	215.0
Avg daily gain, lb[ab]	1.95	1.94	1.70	1.60
Avg daily feed intake, lb[a]	6.52	6.35	5.36	5.28
Feed per lb gain, lb[c]	3.31	3.36	3.56	3.49
Backfat, in	1.04	1.03	0.97	0.99

[a]Line effect (P<.001).
[b]Line by treatment interaction (P<.08).
[c]Line by effect (P<.05).

Literature Cited

Maxwell, C.V. et al. 1983. Ok. Agr. Exp. Sta. Rpt. Mp. 114:152.

AMINO ACID SUPPLEMENTATION OF WHEAT DIETS FOR GROWING-FINISHING SWINE

C.V. Maxwell[1], D.S. Buchanan[2], R.O. Bates[3], F.N. Owens[1],
W.G. Luce[1] and Rex Vencl[4]

Story in Brief

To determine the effect of replacing a portion of the soybean meal in wheat rations with lysine with or without added threonine on performance, 348 growing-finishing pigs were fed wheat-soybean meal diets. Substituting only lysine for soybean meal reduced daily gains and efficiency of feed use. Addition of threonine together with lysine improved daily gain in the growing period but not in the finishing period. Gains by pigs fed wheat plus lysine and threonine were equal to those fed the control wheat-soybean meal diet for slow growth line pigs but not for those from a rapid growth line. Following lysine, threonine limited feed intake and gain from wheat diets for growing pigs but not for finishing pigs.

Introduction

Portions of the soybean meal used to supplement diets of sorghum or corn grain for swine can be replaced by addition of limiting amino acids. Levels of the primary amino acids which may limit growth (lysine, sulfur amino acids, tryptophan and threonine) are higher in wheat than in corn or milo grains, but research information to determine the feasibility of replacing a portion of the soybean meal in wheat diets with semipurified amino acids is not available. All the limiting amino acids are available in sufficient quantities to supplement though cost is currently quite high. Amounts required to supplement wheat diets are considerably less than needed for corn or sorghum grain diets. This study was conducted to determine the effect of replacing half or all of the supplemental soybean meal in wheat diets with lysine or with lysine plus threonine on performance of growing-finishing swine.

Materials and Methods

This trial was conducted at the Livestock and Forage Resarch Laboratory at El Reno, Oklahoma. A total of 348 pigs in 22 indoor pens equipped with self-feeders and waterers were fed the test diets. Pigs came from groups genetically selected for slow growth or rapid growth and were randomly allotted within growth line to the three dietary treatments (table 1). All diets contained 0.75 percent lysine from wheat plus soybean meal or lysine during the growing phase (42-116 lb) and 0.62 percent lysine during the finishing (116-217 lb) phase. The three treatments consisted of: (1) a wheat-soybean meal diet; (2) wheat supplemented with lysine but formulated to supply only the required amount of threonine which was calculated to be the second limiting amino acid or (3) diet 2 plus threonine at 120% of the NRC (1979) requirement.

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[1]Professor [2]Associate Professor [3]Graduate Assistant [4]Herdsman

TABLE 1. Composition of experimental rations.

Item	Grower Diets 1 wheat	2 wheat + lys	3 wheat + lys + thr	Finisher Diets 1 wheat	2 wheat + lys	3 wheat + lys + thr
	-----------% Composition (as-fed)-----------					
Wheat, hard red winter	81.00	89.00	88.92	86.80	96.53	96.45
Soybean meal (44%)	14.37	7.00	7.00	10.15	0.00	0.00
Dicalcium phosphate	1.46	1.60	1.60	1.25	1.38	1.38
Calcium carbonate	0.92	0.90	0.90	0.95	0.92	0.92
Salt	0.50	0.50	0.50	0.50	0.50	0.50
Vit TM mix[a]	0.25	0.25	0.25	0.25	0.25	0.25
Lysine hydrochloride	0.00	0.25	0.25	0.00	0.32	0.32
Threonine	0.00	0.00	0.08	0.00	0.00	0.08
Tylan 10	0.50	0.50	0.50	0.10	0.10	0.10
Calculated analysis						
% Protein	16.64	13.94	13.93	15.06	12.06	12.06
% Lysine	0.75	0.75	0.75	0.62	0.62	0.62
% Met + cys	0.48	0.41	0.41	0.44	0.35	0.35
% Threonine	0.59	0.46	0.54	0.51	0.37	0.44
% Calcium	0.75	0.75	0.75	0.70	0.70	0.70
% Phosphorus	0.65	0.65	0.65	0.60	0.60	0.60

[a]Supplied 4,000,000 IU vitamin A, 3,000,000 IU vitamin D, 4 g riboflavin, 20 g pahtothenic acid, 30 g niacin, 800 g choline chloride, 15 mg vitamin B_{12}, 10,000 IU vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.

These levels of amino acids (.32 and .40% of the diet) replaced 7.4% (over half) and 10.1% (all) of the soybean meal in the diet during the growing phase and the finishing phase, respectively.

Results and Discussion

A block (growth rate selection line) by treatment interaction for average daily gain and average daily feed intake was detected, so results are presented within line of selection (table 2). During the growing period, pigs fed the wheat-soybean meal diet (treatment 1) grew faster (P<.01) than pigs fed the wheat-lysine diet (treatment 2). Lysine substitution for soybean meal reduced growth rate by 22.0 and 12.9 % for the rapid growth and for the slow growth line, respectively. Addition of threonine (treatment 3) to the wheat-lysine diet (treatment 2) increased gain (P<.01) by 16.4 for pigs from the rapid growth line and by 14.8% for pigs from the slow growth line. Compared to growth rates of pigs fed the wheat-soybean meal diet (treatment 1), growth rate with the wheat-lysine-threonine diet (treatment 3) remained low (P<.01) for pigs from the rapid growth line. In contrast, gains from treatments 1 and 3 were equal for pigs from the slow growth line. This differential response to supplemental amino acids between the rapid and slow growth lines caused a selection line by treatment interaction (P<.001) and indicates that amino acid requirements as a percentage of the diet change as potential growth rate changes.

TABLE 2. The effect of level of soybean meal and amino acids on gain and feed intake in two lines of growing-finishing swine fed wheat based diets.

	Rapid Growth Line Treatments			Slow Growth Line Treatments		
	1 wheat + soy	2 wheat + lys	3 wheat + lys + thr	1 wheat + soy	2 wheat + lys	3 wheat + lys + thr
Pigs per treatment, no	60	55	41	61	58	62
Pens per treatment, no	4	3	3	4	4	4
Growing period (42-116 lb)						
Avg daily gain, lb[ab]	1.64[c]	1.28[d]	1.49[e]	1.32[c]	1.15[d]	1.32[c]
Avg daily feed intake, lb	4.24[f]	3.82[g]	4.08[fg]	3.42[f]	3.41[f]	3.78[g]
Finishing period (116-217 lb)						
Avg daily gain, lb[ab]	2.17[c]	1.85[d]	1.85[d]	1.60[f]	1.51[g]	1.54[fg]
Avg daily feed intake, lb	6.64[c]	6.21[cd]	5.88[d]	5.00	5.06	5.07

[a]Growth rate line by treatment interaction (P<.0001).
[b]Growth rate line effect (P<.0001).
[cde]Means in the same row with a different superscript within line differ (P<.01).
[fg]Means in the same row with a different superscript within line differ (P<.1).

Feed intake during the growing period also responded differently to supplementation in the two growth rate lines. For pigs from the rapid growth line, feed intake was highest for pigs fed the wheat-soybean meal diet (treatment 1) and lower (P<.10) for pigs fed the wheat-lysine diet (treatment 2) with intake of the wheat-lysine-threonine diet (treatment 3) being intermediate. In contrast, feed intake of pigs from the slow growth line was equal for the wheat-soybean meal (treatment 1) and wheat-lysine (treatment 2) diet but tended to increase (P<.1) with added threonine (treatment 3). Most of the added gain can be explained by the additional feed consumed. These data suggest that threonine limited feed intake and gain of pigs fed a wheat-lysine diet calculated to meet the threonine requirement. Possibly lysine supply for the rapid growth line limited response to added threonine. Effects of threonine on growth hormone release also could differ between pigs selected for slow versus rapid growth. Responses in feed intake but not in gain could indicate that threonine, not lysine, was the first limiting amino acid in wheat diets for pigs from the slow growth line.

TABLE 3. The effect of level of soybean meal and amino acids on feed efficiency and backfat in two lines of growing-finishing swine fed wheat based diets.

Item	Treatments 1 wheat	2 wheat + lys	3 wheat + lys + thr
Pigs per treatment, no	122	118	108
Pens per treatment, no	8	7	7
Growing period (42-116 lb)			
Feed per lb gain, lb	2.70^{ae}	3.01^{bf}	2.88^{abf}
Finishing period (116-217 lb)			
Feed per lb gain, lb	3.35^{ce}	3.61^{df}	3.40^{cde}
Growing-finishing period (42-217 lb)			
Backfat, in	1.14^{e}	1.12^{e}	1.11^{f}

[ab]Means in the same row with different superscripts differ (P<.01).
[cd]Means in the same row with different superscripts differ (P<.05).
[ef]Means in the same row with different superscripts differ (P<.1).

During the finishing period (116-217 lb), pigs selected for rapid growth again gained more rapidly than those selected for slow growth (P<.0001). The wheat-soybean meal diet (treatment 1) produced more rapid gains than the wheat-lysine diet for pigs from the rapid (P<.01) and from the slow (P<.10) growth line. The addition of threonine failed to improve performance in pigs from either selection line. Differences in growth rate between pigs fed the wheat-soybean meal diet and those fed the wheat-lysine diet was much greater for pigs from in the rapid growth line than for pigs in the slow growth line which resulted in the selection line by treatment interaction (P<.001). Responses could suggest that some amino acid other than lysine or threonine was limiting growth rate or feed intake with these wheat diets and that threonine may be limiting for slowly but not rapidly growing pigs. Feed intake during the finishing period was lower (P<.01) for pigs from the rapid growth line with the wheat-lysine-threonine diet (treatment 3) than with the wheat-soybean meal diet (treatment 1). Since the addition of threonine did not produce a growth rate or feed intake response, these data support the suggestion that threonine was not the amino acid limiting growth in finishing swine fed a wheat-lysine diet or that a combination of amino acids was limiting.

No interaction between growth rate line and diet was detected for feed efficiency so trial means are presented in table 3. Feed efficiency was poorer for the wheat-lysine than the wheat-soybean meal diet in both the growing (P<.01) and finishing (P<.05) periods. Feed efficiency was improved slightly by adding threonine to the wheat-lysine diet for both growing and finishing pigs. Feed efficiency tended to be poorer for pigs fed the wheat-lysine-threonine diet than for pigs fed the wheat-soybean meal diet during the growing period (P<.10) but not during the finishing period. Backfat tended to be lower for pigs fed amino acid supplemented diets. These data suggest that supplementing wheat diets with threonine and lysine to meet the NRC (1979) threonine requirement will restore feed efficiency during the finishing, but notduring the growing period. The observation that feed efficiency of finishing swine was improved by addition of both lysine and threonine is inconsistent with the observation that average daily gain was not improved in either line by adding threonine to the wheat-lysine diet.

Literature Cited

NRC. 1979. Nutrient Requirements of Swine. National Academy of Sciences. National Research Council, Washington, DC.

WITHIN HERD VARIATION FOR FEEDLOT PROFIT

J. W. Oltjen[1] and D. R. Gill[2]

Cattle feeders have long since recognized that cattle within a pen vary tremendously in their profit potential. This observation appears true within a relatively homogenous group of cattle, even for those originating from the same herd. Although factors affecting this variation may be genetic and environmental, our interest has been in relating easily measured individual traits with subsequent feedlot profits.

A preliminary data set containing individual birth date, weaning weight, off-pasture (feedlot-in) weight, feedlot check (75 day on feed) weight, carcass weight, yield and grade data was collected for 148 Charolais x (Hereford-Angus) steers from one herd fed in a Panhandle feedlot. Feed intake was estimated based on National Research Council equations for gain. Financial data were feedlot-in price, $61/cwt; carcass price, $93/cwt-GOOD and $103/cwt- CHOICE; and $182/ton feed dry matter (includes all miscellaneous costs). Greater weaning weight, pasture daily gain and feedlot-in weight were associated with less profit; increased feedlot gain, quality and yield grade, and early feedlot gain were associated with more profit (table 1). Quality grade had the greatest effect on profit due to a $10/cwt differential between good and choice carcasses. When this effect was removed statistically, a remaining change in profit was -$12 per 100 lb weaning weight, -$18 per 100 lb off pasture weight, -$15 per lb prefeedlot (pasture) daily gain, -$1 per unit yield grade, +$10 per lb feedlot daily gain and +$6 per lb 75 day feedlot daily gain.

Table 1. Relationship of feedlot profit with various traits[a].

Item	Correlation (r)	Effect[b] ($/unit change)
Weaning weight	-.17*	- .12
Weaning age	+.03	
Weaning weight/day age	-.15	
Pasture daily gain	-.22**	-15.28
Off pasture weight	-.34**	- .18
Feedlot daily gain	+.25**	+ 9.70
Feedlot intake	+.12	
Final weight/day age	+.01	
Final weight	+.00	
Final age	+.03	
Quality grade	+.77**	+27.64
Yield grade	+.32**	- 1.19
75 day feedlot weight	+.20*	+ 6.25

[a]Weight (lb); time (D); quality grade (Choice=10, choice-=9, etc.).
[b]After adjustment for quality grade effect.
*P<.05, **P<.01.

[1]Assistant Professor [2]Professor

FEEDING WHEAT TO DAIRY COWS

L. J. Bush[1], M. Faldet[2], and G. D. Adams[3]

In Oklahoma, an abundant supply of wheat is generally available for livestock feeding. At times, the price is competitive with that of other feed grains used as an energy source in dairy rations. When this is the situation, wheat can be used to advantage in formulating high energy rations for lactating dairy cows; however, the limits on the extent to which other grains can be replaced by wheat in dairy rations have not been well defined. Much of the earlier work on the subject was conducted using cows producing considerably less milk and fed much less concentrates than is common in the industry today. Also, there is a lack of information concerning the feasibility of using wheat as a major component of a complete mixed ration where silage is the only forage.

A feeding trial is underway to compare the performance of lactating cows fed concentrate mixtures containing different amounts of wheat included in a complete ration with sorghum silage as the only forage. The concentrate mixtures contain 0, 40, and 60 % wheat, with the latter level representing the highest percent that can be used and still maintain protein, fiber and energy content of the total ration at an acceptable level. The rations were calculated to be isocaloric and isonitrogenous with wheat replacing some soybean meal as well as corn.

The rations consist of 55 % concentrates and 45 % forage on a dry basis. The respective rations are fed to individual cows in three portions at 8-hour intervals. A total of 21 cows in their second or greater lactation are being used in a switchback trial with three periods of 4 wks each. Measurement criteria are: milk yield and composition, feed intake, incidence of off-feed, weight change, body condition change, concentration of blood plasma urea, rumen pH, lactic acid and volatile fatty acids.

Data from the last two weeks of each period will be used for comparisons among treatments. To date, feed intake by cows fed the three rations appears to be similar. Also, no serious off-feed conditions or apparent digestive disturbances have been observed.

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[1]Professor [2]Graduate Assistant [3]Instructor

DEVELOPMENT OF RESTRUCTURED BEEF PRODUCTS

J.R. Busboom[1], H.G. Dolezal[2], J.J. Guenther[3], and F.K. Ray[4]

The chuck comprises over 25% of the beef carcass and because of it's inherent lack of tenderness, cuts from the chuck are used primarily for roasts and/or hamburger. U.S. consumers generally desire more steaks and fewer roasts. The preference for steaks is relfected in the price differential between steaks and roasts. Current lifestyles indicate that this preference will continue since in many families both husband and wife are employed outside the household. Therefore products such as steaks that can be prepared quickly, conveniently and in individual portions will be in demand.

Restructuring of chuck muscles is a manufacturing process that imparts to chuck meat desirable palatability characteristics. Currently available restructured products lack palatability characteristics necessary to merit success in the market place. Therefore, research is being conducted to improve consumer acceptability of currently available restructured beef products, such as chunked and formed beef steaks, and also to develop a new restructured beef product made from muscles of the chuck and other low to intermediate value cuts. The new product will more closely resemble intact muscle cuts of meat in such characteristics as appearance, palatability, texture and "bite" than do conventional restructured products. Technology for manufacturing the new product will involve removal of individual muscles from the low value wholesale cuts of beef and reorientation of the muscles to achieve the desired effect. Appropriate equipment has been obtained and placed in operation. Consumer response to experimental products has been extremely favorable. The products have received comments such as "very good flavor", "very tender" and "steak-like texture".

Individual chuck muscles are being characterized to ascertain their suitability for inclusion in restructured products. Twenty chucks varying in quality (U.S. Choice vs U.S. Good) and yield (U.S. 2 vs U.S. 3) grade will be physically separated into fat, individual muscles and bone. Eighteen muscles from each chuck will be analyzed for weight, chemical composition, connective tissue, shear resistance, fiber diameter, oxidative enzyme activity and binding strength.

In addition, experiments are planned to:

1. Compare new products with conventional restructured products and intact muscle using trained and consumer taste panels.
2. Evaluate the effects of type and quantity of added binding materials on functional and sensory characteristics of the product.
3. Determine the most efficient method for extraction of binding protein.
4. Determine the effects of long term modified atomosphere storage on product stability.

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[1]Research Associate, [2]Assistant Professor, Animal Science, [3]Professor, Animal Science, [4]Associate Professor, Animal Science.

EFFECTS OF DIFFERENT LEVELS OF CORN GLUTEN FEED IN RATIONS FOR BEEF CATTLE

Rajiha Younis[1] and Don Wagner[2]

Corn gluten feed (CGF) is by-product of wet-milling corn in the manufacture of corn starch or syrup. On the average this product contains about 22.0% crude protein, 2.0% ether extract and 9.0% crude fiber. Some studies with species other than ruminants, such as swine and poultry, have demonstrated that CGF might be satisfactory to replace a part of the protein supplement although CGF generally is low in protein quality. Possible replacement with CGF in ruminant rations has received little study, especially with forage based diets. Therefore, there is a need for research to establish the limits and value of corn gluten feed in rations for grazing beef cattle.

Past OSU research has shown supplementation with soybean meal to produce very positive and economical responses in daily gain in stocker cattle. Moreover, intake and digestibility of forage were improved substantially by soybean meal when stocker cattle were fed medium quality prairie hay. The objective of this study, therefore, is to determine the effects of replacing soybean meal supplements with different levels of CGF when beef cattle heifers are fed a basal diet of medium quality prairie hay (harvested in early to mid July). Fifteen heifers will be fed five different protein supplements in a replicated 5 x 5 Latin square design trial. Hay will be labeled with markers of chromium oxide and Ytterbium to estimate digestion parameters and rate of passage.

The next stage of the study will involve a feeding trial using five heifers with ruminal and duodenal cannulae. Animals will be fed rations as in trial 1 to estimate the rate of disappearance of CGF from dacron bags placed in the rumen and to measure the protein bypass to the duodenum by using a dual marker system.

This study should provide information on the potential usefulness and preferable level of CGF in supplements for grazing beef cattle such as stockers and perhaps beef cows.

[1]Graduate Student [2]Professor

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Studies at the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma, were conducted in cooperation with USDA-ARS Texas-Oklahoma Area. Several studies were part of regional research projects.

The following is a listing of those who contributed to the research program of the Animal Science Department during the preceding year.

A. H. ROBBINS, INC., Richmond, VA
AMERICAN CYANAMID CO., Wayne, NJ
BOOKER CUSTOM PACK, Booker, TX
CANADIAN VALLEY MEAT COMPANY, Oklahoma City, OK
COBA SELECT SIRES, INC., Tyler, TX
COOPERATIVE STATE RESEARCH SERVICE, Washington, D.C.
CORNETT PACKING CO., Oklahoma City, OK
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OKLAHOMA PORK COMMISSION, DePew, OK
OKLAHOMA SWINE BREEDERS ASSOC., Stillwater, OK
OKLAHOMA WHEAT COMMISSION, Oklahoma City, OK
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Leaford Thornbrough, Sayre, OK

College of Veterinary Medicine (Medicine & Surgery)
Lionel Dawson
Lawrence E. Rice

College of Arts and Sciences (Statistics Department)
P. Larry Claypool
Ronald W. McNew

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p. iii. Authors and page number for second article under Foods and Carcass Evaluation are incorrect. This listing should be **"Effect of Electrical Treatment on the Diffusion of Nitrate Ions into Porcine Muscle ... A.M.S. Alam, J.J. Guenther, P.L. Claypool and K.K. Novotny ... 31".**

p. 292. The equations given in the third paragraph are incorrect. These should read as follows:

"For yearlings, NE_m (Mcal/day) = $.0390\ W^{.75}$;

For yearling steers, NE_g (Mcal/day) =
$(.0122\ ADG + .000717\ ADG^2)\ W^{.75}$;

For yearling heifers, NE_g (Mcal/day) =
$(.0130\ ADG + .00133\ ADG^2)\ W^{.75}$;"