Oklahoma State University

DEPARTMENT OF ANIMAL SCIENCE
COLLEGE OF AGRICULTURE

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To: Clientele in Animal Agriculture

Re: 1988 Animal Science Research Report

The Animal Science Department is proud to bring you this 1988 report of our research activities for the past year. One of our priority goals is to provide new information to clientele as quickly as possible. This report is very important in achieving that goal.

Always there is change. We will likely see more changes during the remainder of this century than in any comparable period in history. Animal agriculture will change, in reaction to many forces. The biotechnology revolution and the knowledge explosion will bring vast changes, largely inconceivable today, to Animal Agriculture in the next decade.

Changes also continue in the Animal Science Department at Oklahoma State University. We are filling vacant positions with new faculty members who will bring new skills. We are adding new, more sophisticated equipment. We are upgrading some of our facilities. We are seeking more "outside" funds. We are using new techniques, not only in research, but in the dissemination of knowledge through teaching and extension.

These changes must occur if we are to insure that Oklahoma's Animal Agriculture progresses and becomes more efficient and competitive.

As always, we appreciate your reactions and input to help guide our efforts.

Yours truly,

Robert Totusek, P.A.S.
Head, Animal Science Department

RT/csw

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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.

Purpose for Publication

The information given in this publication is for educational 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

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PRODUCTIVITY OF THREE-, FOUR- AND FIVE-YEAR-OLD CROSSBRED COWS WITH 0, 1/4 AND 1/2 BRAHMAN BREEDING IN SPRING VERSUS FALL CALVING SYSTEMS

M.N. McCarter[1], D.S. Buchanan[2], R.R. Frahm[3] and J.W. Castree[4]

Story in Brief

Productivity of three-, four- and five-year old crossbred cows with 0, 1/4 and 1/2 Brahman breeding was evaluated using 372 records on spring-calving cows and 372 records on fall-calving cows collected over a three year period. No significant interaction between crossbred cow group and season of calving was found for any calf trait examined. Season of calving had a stronger influence on the percentage of cows exposed that weaned a calf than did cow group, as values ranged from 78.2% for the Angus x Hereford cows to 89.6% for the Brahman x Angus cows and spring-calving cows averaged 98.1% compared with only 71.4% of the fall-calving cows. Adjusted weaning weight tended to increase as proportion Brahman increased, with cows out of Hereford dams tending to wean heavier calves than cows out of Angus dams with the same proportion Brahman breeding. The difference between preweaning growth was significant for the two seasons as spring calves outgained fall calves by .23 pounds per day; however, since the spring calves were weaned at an average of 205-days of age and the fall calves were weaned at an average of 240-days of age, adjusted weaning weights were not different for the two groups. These data indicate, based on reproductive rate, that spring calving is more advantagous than fall calving. In both seasons, productivity tended to increase as proportion Brahman increased.

(Key words: Crossbreeding, Beef Cattle, Brahman, Cow Productivity, Genotype x Environment Interaction).

Introduction

Crossbreeding is one of the major management techniques available for producers attempting to increase efficiency of commercial beef production. However, different environments may have varying effects on different crossbred types due to genotype by environment interactions. Evaluation of this genotype (crossbred cow group) by environment (season of calving) interaction is the purpose of a study currently being conducted by the Oklahoma Agricultural Experiment Station. In order to evaluate possible interactions between crossbred cow type and season of calving, this project was designed to use crossbred cows with different proportions of Brahman, Angus and Hereford breeding, managed in spring and fall calving systems. The objective of this portion of the study was to determine the effects of crossbred cow group, season of calving and the interaction between cow group and season of calving on the productivity of three-, four- and five-year-old females.

The traits analyzed were percentage of cows exposed weaning a calf, percentage of cows requiring assistance at birth, birth weight,

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preweaning average daily gain, weaning weight, weaning hip height, weaning conformation score and condition score, and average cow weight.

Experimental Procedure

Females for this project were produced by assigning Angus and Hereford cows at random to spring- and fall- calving groups. These cows were mated to Angus, Hereford, Brahman, Brahman x Angus and Brahman x Hereford sires to produce calves with 0 Brahman breeding (Hereford x Angus and Angus x Hereford), 1/4 Brahman breeding (1/4 Brahman-1/4 Hereford-1/2 Angus and 1/4 Brahman-1/4 Angus-1/2 Hereford) and 1/2 Brahman (Brahman x Angus and Brahman x Hereford). The same trio of bulls of each sire breed were used for both the spring and fall groups in the same year with a different set of bulls used each of the three foundation years of this project. The mating system, origin of foundation breeding stock and the growth performance of crossbred calves with 0, 1/4 and 1/2 Brahman breeding were reported by Bolton et al. (1986). Milk production results were presented by McCarter et al. (1987a) and productivity of these cows as two-year-olds was reported by McCarter et al. (1987b). Cows were maintained on native tallgrass and bermudagrass pastures at the Southwestern Livestock and Forage Reseach Laboratory, El Reno, OK. Cows were synchronized and bred to Limousin bulls by artificial insemination twice, if a second time was necessary. Following artificial insemination, cows were placed in breeding pastures with Limousin bulls for a total breeding period of 75 days. Spring-calving cows were bred to calve from February through April and fall-calving cows were bred to calve from September to November.

Calf birth weights were obtained within 24 hours of birth. Calving difficulty scores were assigned by the herdsman using a scale of 1 to 6 (1=no difficulty, 2=little difficulty, 3=moderate difficulty, 4=major difficulty, 5=caesarian section and 6=abnormal presentation). Calves remained with their dams on native tallgrass and bermudagrass pastures without creep feed. Spring-born and fall-born calves were weaned at an average age of 205 and 240 days, respectively. Fall-born calves were weaned at an older age than spring-born calves, a practice typical of Oklahoma beef production. Calf weight, hip height, condition and conformation scores were determined at weaning. Cows were weighed at breeding and at weaning. These two weights were averaged to obtain average cow weight. Reproduction, birth and weaning data were collected over a three-year period on 372 spring-calving and 372 fall-calving cows. The breakdown of the number of records by cow type, season and age of dam used in this analysis is presented in Table 1. The data were analyzed by least-squares procedures to determine the effect of crossbred cow type, season of birth and the interaction between cow type and season of birth.

Results and Discussion

Effects of the age of the dam at calving were not found to be significant for any trait presented here.

The percentage of cows exposed to bulls that weaned a calf was significantly influenced by crossbred cow group and season of calving, however no evidence of an interaction between these two effects was found. Thus, the least-squares means for each cow type and for each season are presented in Table 2. The three groups of cows from Angus

Table 1. Number of records used in analysis.

Breed group[a]	Age and Season					
	Three		Four		Five	
	Spring	Fall	Spring	Fall	Spring	Fall
0 Brahman:						
HA	24	23	17	17	8	11
AH	8	14	8	14	3	7
1/4 Brahman:						
1/4B:1/4H:1/2A	44	40	32	27	20	16
1/4B:1/4A:1/2H	34	27	23	20	14	12
1/2 Brahman:						
BA	40	39	23	26	9	17
BH	31	27	25	22	9	13

[a]A=Angus, H=Hereford, B=Brahman.

Table 2: Percentage of cows exposed to breeding that weaned a calf.

Comparison	Percentage weaned
Breed group[a]	
HA	86.4[bd]
AH	78.2[c]
1/4B:1/4H:1/2A	85.7[bd]
1/4B:1/4A:1/2H	82.0[cd]
BA	89.6[b]
BH	86.8[bd]
Season	
Spring	98.1[e]
Fall	71.4[f]

[a]H=Hereford, A=Angus and B=Brahman.
[bcdef]Values in same group not sharing a common superscript are different ($P < .05$).

dams and the Brahman x Hereford (BH) cows weaned significantly more calves than did the Angus x Hereford (AH) and Brahman-Angus x Hereford (BAH) cows. Of the Hereford x Angus (HA), Brahman-Hereford x Angus (BHA), Brahman x Angus (BA) and BH cows, approximately 85% of those cows exposed weaned a calf compared with 82% weaned by BAH and 78.2% weaned by AH cows. Of those cows exposed in the spring-calving group, 98.1% weaned a calf. This is significantly higher than that of the fall-calving group of which only 71.4% weaned a calf.

For all calf traits examined, there was no significant interaction between cow group and season of calving. Therefore, least-squares means were calculated for cow groups averaged over the two calving seasons and for calving season averaged over cow groups. Calving difficulty was measured as the percentage of cows requiring assistance and receiving a calving difficulty score of 3, 4 or 5. Due to the small number requiring assistance (5%), no significant differences were found between the cow groups or between calving seasons.

Least-squares means for birth weight, preweaning average daily gain and adjusted weaning weight are presented in Table 3. Calves from BA cows were significantly lighter (73.9 lb) than those from all other breed groups which ranged from 78.9 to 82.4 lb. Spring-born calves (87.5 lb) were significantly heavier than fall-born calves (72.3 lb).

Preweaning average daily gain (ADG) and weaning weight (Table 3) for calves from the two groups of 0 Brahman cows was significantly (P<.05) less than for calves from the other cow groups. Preweaning average daily gain was similar for the two groups of 1/4 Brahman cows and for the two groups of 1/2 Brahman cows with calves from 1/2 Brahman cows significantly (P<.05) outgaining calves from 1/4 Brahman cows. Weaning weight results were similar to ADG results with the exception of no significant difference between calves from BAH and BA cows. Spring-born calves were significantly (P<.05) faster gaining (.23 lb/day) than fall-born calves; however, due to the different ages of the two groups at weaning no significant difference was found between the weaning weights of the two groups.

Least-squares means for conformation score, which reflects amount of muscling, condition score and weaning hip height are presented in Table 4. Calves from 0 Brahman cows, while not significantly different from calves out of BHA and BA dams, were lightest muscled receiving significantly lower scores than did calves from BAH and BH cows. No significant differences existed between calves from BHA, BAH and BA cows. Calves from BH dams received the highest conformation scores. No

Table 3: **Least-squares means for birth weight, preweaning average daily gain and adjusted weaning weight.**

Comparison	Birth weight lb	Preweaning ADG lb/day	Adjusted weaning weight, lb[a]
Breed group:			
HA	82.4[b]	1.71[b]	462.4[b]
AH	81.9[b]	1.73[b]	467.4[b]
1/4B:1/4H:1/2A	80.2[b]	1.87[c]	495.2[c]
1/4B:1/4A:1/2H	82.3[b]	1.92[c]	506.9[cd]
BA	73.9[c]	1.97[de]	511.7[de]
BH	78.9[b]	2.01[d]	525.9[e]
Season:			
Spring	87.5[f]	1.981[f]	488.9[f]
Fall	72.3[f]	1.754[g]	500.9[f]

[a]205-day and 240-day weights, respectively, for spring-born and fall-born calves. Weights are adjusted for sex of calf.

[bcde]Breed groups means for a trait not sharing a common superscript are different (P<.05).

[fg]Season means for a trait not sharing a common superscript are different (P<.05).

Table 4: Least-squares means for conformation score, condition score and adjusted hip height.

Comparison	Conformation score[a]	Condition score[b]	Hip height in.[c]
Breed group:			
HA	13.2[d]	5.46[e]	46.3[d]
AH	13.1[d]	5.40[e]	47.0[de]
1/4B:1/4H:1/2A	13.4[de]	5.62[d]	47.6[e]
1/4B:1/4A:1/2H	13.5[ef]	5.59[d]	47.1[de]
BA	13.4[de]	5.54[d]	47.6[e]
BH	13.7[f]	5.79[f]	48.6[f]
Season:			
Spring	13.3[g]	5.59[g]	44.1[g]
Fall	13.5[g]	5.54[g]	50.6[h]

[a]Conformation score: 12=low choice, 12=average choice and 14=high choice.
[b]Condition score: 1=thin, 5=average and 9=fat.
[c]Hip heights adjusted to 205 and 240 days of age, respectively, for spring- and fall-born calves.
[def]Breed group means for a trait not sharing a common superscript are different (P<.05).
[gh]Season means for a trait not sharing a common superscript are different (P<.05).

significant difference was found between spring-born and fall-born calves.

Condition scores (Table 4) were similar for calves out of 0 Brahman cows. Calves from AH cows received significantly (P<.05) lower scores than calves from 1/4 and 1/2 Brahman cows. Condition scores for spring and fall calves were not significantly different.

Adjusted weaning hip height of calves (Table 4) were similar for calves out of AH, HA and BA cow with calves out of HA dams being significantly (P <.05) shorter at weaning than calves out of BHA and BH cows. Spring-born calves were significantly (P<.05) shorter (6.49 in.) than fall-born calves; however, part of this difference may be attributed to the fall-calves being an average of 35 days older at weaning.

Average cow weight (Table 5) was not significantly influenced by the cow group by season interaction. All cow groups had similar average weights with the exception BH cows weighing significantly (P<.05) more (80.2 lb) than BHA cows. Fall-calving cows were significantly (P<.05) heavier (154 lb) than spring-calving cows. This difference in weights can probably be attributed to the times at which the cows were weighed and the relationship between time of weighing and the availability and quality of forage. Age of dam was a significant effect on average cow weight as five-year-old cows were signivficantly (P<.05) lighter than three- and four-year-old cows, 87.1 and 97.4 lb, respectively.

In summary, percentage of cows exposed weaning a calf indicated that it was more difficult to manage fall-calving cows than spring-

Table 5: Least-squares means for average cow weight[a].

Comparison	Average cow wt. (lb)
Breed group:	
HA	969.7[bc]
AH	960.0[bc]
1/4B:1/4H:1/2A	915.3[b]
1/4B:1/4A:1/2H	916.9[bc]
BA	980.4[bc]
BH	995.5[c]
Season:	
Spring	879.3[d]
Fall	1033.3[e]
Age of Dam:	
3	981.9[f]
4	992.2[f]
5	894.8[g]

[a]Average of weight at breeding and weight of weaning.
[bc]Breed group means not sharing a common superscript are different (P<.05).
[de]Season means not sharing a common superscript are different (P<.05).
[fg]Age of dam means not sharing a common superscript are different (P<.05).

calving cows to calve at regular intervals. Progeny performance, in general, tended to increase as proportion Brahman breeding increased. Within each of the three levels of Brahman breeding, those cows with Hereford dams tended to raise larger calves than did cows with Angus dams. However, these differences were seldom significant. Preweaning average daily gain was different for calves in the two seasons; however, weaning weight was not affected by season due to the longer preweaning period for fall calves. Calves in the fall group were also taller at weaning than spring-calves; however, this difference is again probably due to the different weaning ages of the two groups.

Literature Cited

Bolton, R.C. et al. 1986. Performance of 0, 1/4 and 1/2 Brahman crossbred calves in spring and fall calving systems. Okla. Agr. Exp. Sta. MP-118:21.

McCarter, M.N. et al. 1987. Milk production of crossbred cows with 0, 1/4 and 1/2 Brahman breeding in spring and fall calving systems. Okla. Agr. Exp. Sta. MP-119:1.

McCarter, M.N. et al. 1987. Productivity of two-year-old crossbred cows with 0, 1/4 and 1/2 Brahman breeding in spring versus fall calving systems. Okla. Agr. Exp. Sta. MP-119:6.

LIMOUSIN vs SALERS AS A TERMINAL SIRE: BIRTH AND WEANING CHARACTERISTICS

E.D. Tinker[1], D.S. Buchanan[2], R.R. Frahm[3] and L.W. Knori[4]

Story in Brief

Limousin and Salers sires were evaluated for use as terminal cross sires to produce calves to weaning. Twelve different sires of each breed were used over a two-year period (six sires per breed per year) to produce 335 calves. Calves were born in the spring and raised by their dams, without creep feed, on native and bermuda grass pastures. Weaning occurred at an average age of 205 days, and calves were weighed and scored for conformation and condition at that time. Birth weights of calves were similar for the two sire breeds, averaging 82.3 lbs, and calves were born with very little difficulty. Daily gain from birth to weaning, 205-day adjusted weaning weight and weaning condition score were similar for the two sire breeds, with averages of 2.23 lbs/day, 539 lbs and 5.8 (5=average), respectively. Limousin-sired calves had slightly higher weaning conformation scores (13.5 vs 13.2, 13=average choice). These preliminary results indicate the Salers breed is as useful as the Limousin breed as a terminal sire for producing calves to weaning age.

(Key Words: Crossbreeding, Terminal Sire, Limousin, Salers)

Introduction

The economic climate in the cow-calf industry necessitates that producers become as efficient as possible. One method of increasing efficiency is utilization of specialized breeding programs. Inclusion of a "terminal sire" breed into a breeding program will increase the growth rate of calves, thus providing more pounds at sale time, although heifers may not be as desirable as replacements.

Selection of an appropriate sire breed to use as a terminal sire is an important step when using such a system. Many new breeds have been introduced into North America in recent years, with little information available on how they can best be used in a breeding program. Some of these may have merit as a terminal sire breed. The purpose of this study was to compare calves from Salers bulls, one of the recent breed introductions, with calves from Limousin bulls, a breed known for its usefulness as a terminal sire.

Materials and Methods

Two different cow herds were used in this study. Calves born in 1986 were from 11-, 12- and 13-year-old cows of eight different breed groups: 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. Due to their age, these cows were sold following

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weaning. The 1987-born calves were produced by 4-, 5- and 6-year-old cows comprising six breed groups: Hereford x Angus, Angus x Hereford, Brahman x Angus, Brahman x Hereford, 1/4 Brahman:1/4 Hereford:1/2 Angus and 1/4 Brahman:1/4 Angus:1/2 Hereford.

Bulls used in the study were selected by the North American Limousin Foundation and the American Salers Association, with semen donated by the owners of the bulls. Six different bulls of each breed were used in each breeding season, for a total of twelve bulls from each breed. Cows were randomly assigned to bulls, with semen from each bull inseminated into approximately the same number of cows from each crossbred group and age.

Calves were born primarily from February to April at the Lake Carl Blackwell Research Range west of Stillwater. All calves were weighed, tagged, dehorned and bulls were castrated within 24 hours of birth. Calving difficulty scores (1=no difficulty, 2=little difficulty, 5=caesarean) were assigned by the herdsmen. Calves received no creep feed and were raised by their dams on native and bermuda grass pastures. When calves averaged 205 days of age they were weaned, weighed and scored for conformation (muscling; 13=average choice, 14=high choice) and condition (fatness; 1=thin, 5=average, 9=fat).

Results and Discussion

A total of 335 calves were born in the two years of the study. Sire breed means were averaged over years, crossbred dam groups and sexes. Birth weights of the calves were very similar for the two sire breeds (83.1 lbs for Limousin and 81.5 lbs for Salers), and calves were born with very little difficulty. Daily gains from birth to weaning

Table 1. Crossbred calves sired by Limousin and Salers bulls.

	Breed of sire[a]	
Trait	Limousin	Salers
Number of animals	172	163
Birth weight, lb	83.1	81.5
Calving difficulty score[b]	1.02	1.03
Preweaning ADG, lb/day	2.23	2.23
205-day weaning weight, lb[c]	540	538
Weaning conformation score[cde]	13.5	13.2
Weaning condition score[cf]	5.9	5.8

[a]Least squares means with adjustments for years, crossbred dam groups and sexes.
[b]Calving difficulty: 1=no difficulty, 2=little difficulty.
[c]Traits adjusted for age of calf.
[d]Conformation score equivalents: 13=average choice, 14=high choice.
[e]Average scores of sire breeds significantly different ($P<.05$).
[f]Condition score equivalents: 1=very thin, 5=average to 9=very fat.

averaged 2.23 lbs/day for calves sired by both breeds, so 205-day adjusted weaning weights were also similar (540 lbs for Limousin-sired calves and 538 lbs for Salers-sired calves). Condition scores of calves at weaning were comparable (5.9 and 5.8 for Limousin-sired and Salers-sired calves, respectively), but calves from Limousin sires had slightly higher conformation scores (13.5 vs 13.2).

These results provide preliminary indication that the Salers breed tsuseful as a terminal sire as the Limousin breed when considering birth and weaning traits. Continuing research with these sire breeds will provide more data for a better comparison of the two breeds and will also furnish information on feedlot and carcass characteristics of cattle produced during this study.

AN EVALUATION OF RAPID VERSUS SLOW GROWING LINES OF PIGS

A.C. Clutter[1], M.D. Woltmann[2], D.S Buchanan[3] and R. Vencl[4]

Story in Brief

Lines of pigs that differ in their genetic potential for growth were developed through selection of sires to produce a base generation and four subsequent generations of selection for either rapid (RGL) or slow (SGL) postweaning gain. The RGL pigs grew faster and more efficiently than SGL pigs, but were also fatter at 220 lbs. Differences in the reproductive performance of the RGL and SGL were not consistent, but suggested that selection for gain may affect litter traits. These lines that are genetically different in their growth potential provide unique material for studying the biology underlying the growth process in pigs. Further selection for rapid growth has begun under either restricted or ad libitum intake in an attempt to better identify animals that are more efficient at converting feed to lean tissue.

(Key Words: Swine, Selection, Gain, Backfat, Feed Efficiency)

Introduction

Improving the efficiency of pork production results in greater profit to the producer through lower cost per unit of finished output. Postweaning growth rate is an important component in determining efficiency of the pork production system and previous studies have shown that selection is an effective way to improve genetic potential for growth in pigs. A study was begun to determine the effects of selection for growth rate on other production traits such as feed intake, lean tissue growth, lean tissue feed efficiency, litter size and litter gain. The study has recently been expanded to evaluate the relationship between appetite and lean tissue growth. Included in this report are results from four generations of selection for either rapid or slow postweaning gain and a discussion of how these lines of pigs are being further used to better understand the phenomenon of growth in swine.

Materials and Methods

Lines of pigs were established from litters born during 1981 at the Southwest Livestock and Forage Research Station. A rapid growth line (RGL) was derived from pigs sired by high indexing Duroc boars and out of gilts sired by high indexing Hampshire boars. A slow growth line (SGL) was established from pigs sired by low indexing Duroc boars and out of gilts sired by low indexing Hampshire boars. Duroc and Hamshire boars were purchased in breed pairs from various performance test stations with one of each pair having achieved a high index value and the other a low index value. The index used to rank them was consistent

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[4]Herdsman

across test stations and breeds and put heavy emphasis on postweaning growth.

Once the RGL and SGL were established, they were further separated in their growth potential by four generations of selection among boars for rapid or slow gain during the postweaning period from 9 weeks of age to 230 pounds. Selection in each line was replicated with spring and fall farrowing seasons. Each line has been maintained with eight boars and 50 gilts each farrowing season. Litter size and individual pig weight were measured at birth, 21 and 42 days. Measurements at birth included all fully-formed pigs. Creep feed was provided at 21 days and weaning was at 42 days. Pigs were penned following weaning in groups of 14 to 18 and fed ad libitum. Average daily gain and pen feed efficiency of barrows and gilts from these lines was measured during a growing phase (9 weeks of age to a pen average of 120 lb) and a finishing phase (end of growing phase to 220 lb), and backfat thickness was measured with an ultrasonic probe at 220 lb. Results are for litters reflecting the initial selection of Duroc and Hampshire boars to form the base generation and four subsequent generations of selection among boars for postweaning gain. An early characterization of these lines following their initiation was reported by Buchanan et al. (1984).

Results and Discussion

Continued selection for rapid or slow postweaning growth has brought about further divergence in growth rate of the two lines. It is apparent that barrows and gilts from the RGL grew faster ($P<.01$) than those from the SGL during both the growing and finishing phases of each season (Table 1). On an overall basis, RGL pigs grew .29 lbs per day faster than SGL pigs in both the spring and fall farrowing groups. Pigs from the RGL were also fatter ($P<.01$) coming off test than pigs from the SGL. The RGL pigs were more efficient in their overall postweaning growth ($P<.01$) than SGL pigs, even though RGL pigs consumed more feed per day. It appears that differences in daily feed intake contributed to the differences in growth rate that have been acheived, but that the increased growth rate of the RGL was great enough to offset increased intake and provide a greater overall efficiency.

Differences in the reproductive performance of the RGL and SGL have not been consistent across farrowing season. In the spring season, size of SGL litters tended to be larger than that of RGL litters at birth, 21 days and 42 days (Table 2). These differences in litter size were probably also reflected in differences in average pig weight; pigs from the SGL had lower ($P<.05$) average weights than pigs from the RGL throughout the pre-weaning period. In the fall season, however, litter size at birth, 21 days and 42 days was greater ($P<.01$) in the RGL than the SGL. Differences in litter sizes of fall-born pigs were not consistently reflected in average pig weights. This interaction between line and farrowing season for litter traits has been observed following each of the last three cycles of selection. While the reason for this interaction is not clear, it appears selection for postweaning growth rate may have some effect on litter traits.

The increases in feed intake and backfat thickness that have accompanied increased gain in the RGL raise questions concerning the relationship between an animal's appetite and how efficiently it can convert what it eats into lean tissue. Selection for increased gain under some environment other than that of ad libitum intake may better identify animals that are superior for lean growth efficiency.

Table 1. Average daily gain, feed efficiency and backfat thickness of barrows and gilts from lines selected for rapid or slow growth.

			Average daily gain (lb/day)[d]			Feed efficiency (lb feed/lb gain)[ef]			Backfat thickness
Line	Season	N[a]	Grower[b]	Finisher[c]	Overall	Grower	Finisher	Overall	(in.)[g]
RGL	Spring	322	1.56	1.82	1.68	2.82	3.50	3.22	1.24
SGL	Spring	278	1.35	1.43	1.39	2.86	3.83	3.41	1.20
RGL	Fall	286	1.54	1.98	1.76	2.73	3.40	3.11	1.26
SGL	Fall	245	1.34	1.61	1.47	2.81	3.50	3.20	1.22

[a]Number of pigs.
[b]Period before pens averaged 120 lbs.
[c]Period after pens averaged 120 lbs.
[d]Average daily gain of RGL and SGL differed significantly ($P<.01$) in all phases of both seasons.
[e]Based on pen intake and gain.
[f]Feed efficiency of RGL and SGL differed significantly ($P<.05$) on an overall basis in both seasons and during the finisher phase of the spring season.
[g]Backfat thickness of RGL and SGL differed significantly ($P<.01$) in both seasons.

Table 2. Summary of litter traits for lines selected for rapid or slow growth.

Line	Season	N[a]	Litter size[b]			Average pig weight (lbs)[c]		
			Birth	21 days	42 days	Birth	21 days	42 days
RGL	Spring	48	9.77	8.52	8.29	3.62	12.90	27.85
SGL	Spring	48	10.23	8.81	8.63	3.06	11.66	23.77
RGL	Fall	47	10.32	8.68	8.43	3.26	10.94	23.50
SGL	Fall	45	9.02	7.53	7.24	3.24	11.42	23.33

[a]Number of litters.
[b]Litter size means for RGL and SGL differed significantly (P<.01) only for the fall season.
[c]Average pig weight means for RGL and SGL differed significantly (P<.05) only for the spring season.

Consequently, the RGL has been subdivided and selection for rapid postweaning growth begun under both ad libitum intake and where intake is limited to 82% that of predicted ad libitum. The initial data reflecting the first generation of selection under these selection environments have just recently been evaluated and results thus far are inconclusive.

Animals from the RGL and SGL provide unique material for studying the underlying biology that actually defines the complex process of growth in the pig. A study has begun to obtain profiles of hormones and other physiological growth factors in the two lines of pigs that may contribute to differences in their genetic potential for growth. These lines may also be useful in determining the response of animals with varying growth potential to treatment with some of the growth factors being suggested for use in today's industry.

Literature Cited

Buchanan, D.S. et al. 1984. Characteristics of rapid and slow growing lines of pigs. Okla. Agr. Exp. Sta. MP-116:1.

LITTER SIZE, BIRTH WEIGHT AND WEANING WEIGHT IN DORSET, FINNISH LANDRACE OR BOOROOLA MERINO SIRED LAMBS

L.G. Burditt[1], M.T. Zavy[2], D.S. Buchanan[3]

Story in Brief

Rambouillet ewes (n=242) were exposed to sires of one of three breeds: Dorset, Finnish Landrace or Booroola Merino. These matings resulted in 343 crossbred progeny. Breed of sire had a significant effect on the 70 day weights of the lambs but not on litter size, birth weight or survival to 70 days. Mean performance for litter size, birth weight, survival to weaning and 70 day weight for Dorset, Finn and Booroola sired lambs, respectively, were: 1.68, 1.76, 1.68 lambs; 9.94, 9.44, 9.43 lbs; 74, 79, 71%; 38.17, 41.63, 34.38 lbs. These results indicate that the Booroola Merino, while contributing a gene for prolificacy, will produce lambs that have relatively slow growth rate.

(Key Words: Sheep, Booroola Merino, Finnish Landrace, Litter Size, Growth Performance)

Introduction

Increased litter size is probably the most sought after goal in the sheep industry. In recent years the discovery of the Booroola strain of Merino in Australia has sparked renewed interest in this topic. The increase in litter size of the Booroola Merino over control Merino ewes is remarkable (2.9 vs .7 lambs). This increase is apparently caused by a single gene called the fecundity gene (F gene) much like the classical horned vs polled gene in cattle.

Proper evaluation of this breed requires comparison to a highly fecund breed which derives its fecundity by more typical quantitative gene action. The Finnish Landrace is a readily available highly fecund breed for which there is a large amount of research. Comparison to a breed, such as the Dorset, which is a frequent contributor to crossbred ewe flocks is also useful. With these thoughts in mind, a project was initiated to compare the productivity and reproductive biology of the Booroola Merino, Finn and Dorset Breeds. This report summarizes the initial performance to weaning of the crossbred lambs.

Materials and Methods

Rambouillet ewes (n=242), located at the Forage and Livestock Research Laboratory, El Reno, Oklahoma, were randomly assigned to one of three sire breed groups (i.e. Dorset, Finnish Landrace or Booroola Merino). Beginning September 15, and continuing for 60 days, the ewes were placed with fertility tested rams which were either Finnish Landrace (Finn), Dorset or Booroola Merino. Ram fertility had been evaluated by semen volume, sperm motility and sperm concentration. The Booroola Merino rams were progeny tested homozygous carriers of the

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Fecundity gene (FF). They were obtained from the US Meat Animal Research Center (MARC) in Clay Center, Nebraska. US MARC also furnished the Finn rams which were used in the study. Dorset rams were obtained from a purebred breeder in the El Reno area. All ewes were condition scored 6 weeks prior to breeding (using a 1 to 5 scoring system: 1=emaciated, 5=obese).

Ewes were handled as one large flock during the gestation period in order to reduce any variation due to their location during the winter. At lambing, ewes were placed in smaller lambing pastures. Ewes lambed primarily unassisted and the lamb numbers reflected by this study are based on the number of fully-formed fetuses for each ewe.

Results and Discussion

The breed of sire was not significant either for total number of lambs or number of lambs born alive. Breed did not have a significant effect on birth weight, however, the lambs sired by Dorset rams tended to be heavier than either the Finn- or Booroola Merino-sired lambs (Table 1). Similarly, breed of sire did not have a significant effect on survival of the lambs to weaning (70 days), but Finn-sired lambs tended to have the best survival rate followed by the Dorset-sired lambs. Weaning weight was affected by breed of sire ($P<.01$). Finn-sired lambs were the heaviest (41.63 lb) followed by Dorset (38.17 lb) and Booroola Merino (34.38 lb) (Table 2).

Individual sire had a significant effect on birth weight ($P<.05$) and weaning weight ($P<.01$). Litter size had a significant effect on birth weight ($P<.01$), survival to weaning ($P<.05$) and weaning weight ($P<.01$) of the lambs. The lambs' ability to survive from birth to weaning was significantly affected by the body condition of the ewe at the time of breeding ($P<.01$). Ewe condition score also tended to have an effect on the birth weight of the offspring ($P<.1$).

This study suggests that, among these three breeds, differences are minimal for birth and early post-natal characteristics (i.e. litter size, birth weight and survival to weaning). However, at weaning the Finn-sired lambs were the heaviest followed by the Dorset-sired lambs.

Table 1. Least squares means for birth characteristics in Dorset-, Finn-and Booroola Merino-sired lambs[a].

Breed of Sire	Total Born	Born alive	Birth weight
Dorset	1.65(35)	1.42(35)	9.94(51)
Finn	1.59(115)	1.40(115)	9.07(169)
Booroola Merino	1.65(92)	1.38(92)	9.05(136)
Standard Error	0.217	0.086	0.447

[a]Number of animals is shown following each mean.

Table 2. Least squares means for weaning characteristics in Dorset-, Finn- and Booroola Merino-sired lambs[a].

Breed of sire	Survival to weaning	Adjusted weaning weight[b]
Dorset	0.740(51)	38.17(47)
Finn	0.788(169)	41.63(156)
Booroola Merino	0.707(136)	34.38(124)
Standard Error	0.073	1.699

[a]Number of animals is shown following each mean.
[b]Breed of sire was a significant source of variation for adjusted weaning weight.

The lambs sired by Booroola Merino rams were significantly lower in body weight at 70 days than either the Finn or Dorset sired lambs. Other research indicates that the lighter body weight results from typical Merino performance and was not caused directly by the presence of the F gene. This report is from the first year of a long-term study of these breeds. The ewe lambs from this portion of the study will be incorporated into the breeding program in order to evaluate F_1 reproductive performance and investigate reproductive biology in sheep.

IMMUNIZATION OF HEIFERS AGAINST LUTEINIZING HORMONE RELEASING HORMONE DELAYS PUBERTY AND CAUSES ANESTRUS

R.P. Wettemann[1] and J.W. Castree[2]

Story in Brief

Ten prepubertal Angus x Hereford heifers at 13 months of age were immunized against luteinizing hormone releasing hormone (LHRH) to determine the long term effects of immunization and booster injections against LHRH on ovarian cycles. Half of the heifers were immunized against human albumin conjugates of LHRH and the other heifers were controls. Booster immunizations were given on days 42, 175, and 322 after the initial treatment. The onset of puberty was delayed an average of 11 weeks in immunized compared with control heifers. Booster immunization of treated heifers after cycles had been initiated caused the cessation of estrous cycles for about two months.

(Key Words: Anestrus, Heifers, LH, LHRH, Puberty.)

Introduction

The hypothalamus secretes LHRH which controls synthesis and release of luteinizing hormone (LH) by the pituitary. Secretion of LH is necessary for ovarian growth, puberty, and normal estrous cycles. Regulation of the pituitary gland has been studied by isolation of the gland by pituitary stalk section and hypothalamic lesions in many species. When these methods are used to separate the pituitary from the hypothalamus, many endocrine functions are disrupted. We have attempted to develop an immunological barrier to remove the secretion of LH from the control of the hypothalamus. In addition this technique may be useful to prevent pregnancy in stocker heifers.

The purpose of this experiment was to evaluate the effect of immunization of heifers against LHRH on the onset of puberty and ovarian function.

Materials and Methods

Ten prepubertal Angus x Hereford heifers at 13 months of age were used. Half of the heifers were immunized against LHRH conjugated to human serum albumin and the others were controls. The conjugate (2 mg) was emulsified in Freund's complete adjuvant and injected at five intradermal and five subcutaneous locations in the mammary gland. The prepubertal heifers were about 13 months of age when immunized (week 0).

On week 6, a booster immunization with incomplete adjuvant was given. Second and third booster immunizations were given on weeks 25 and 46. Blood plasma was obtained weekly for 14 months and progesterone was quantified to access ovarian luteal activity (OLA). Antisera titers to LHRH were determined at selected times.

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Results and Discussion

The interval from the initial immunizations until the onset of OLA was delayed 11 weeks in the immunized heifers (Table 1). Control heifers had OLA by 9.6 ± 1.4 weeks after the start of treatment and immunized heifers averaged 20.8 ± 2.4 weeks until OLA.

Antisera titer was evaluated at week 17. All immunized heifers had titers against LHRH (Table 1). The antisera titer was related to the length of time puberty was delayed. For instance, heifer 333 had the lowest antisera titer and the earliest puberty.

Figure 1 depicts concentrations of progesterone in a control heifer. Progesterone was first greater than 1 ng/ml on week 7, and the heifer continued to have normal ovarian cycles. Figure 2 depicts

Table 1. Ovarian luteal activity and antisera titer in heifers immunized against LHRH-HSA.

Heifer No	Treatment	Weeks to OLA	Binding of ^{125}I LHRH to antisera (%)[a]
75	I	16	16
302	I	25	24
333	I	14	6
338	I	25	32
342	I	24	17
X±SE	I	20.8±2.4	19±4
331	C	6	3
341	C	7	3
376	C	13	3
385	C	12	3
826	C	10	3
X±SE	C	9.6±1.4	3±0

[a] Antisera titer on week 17.

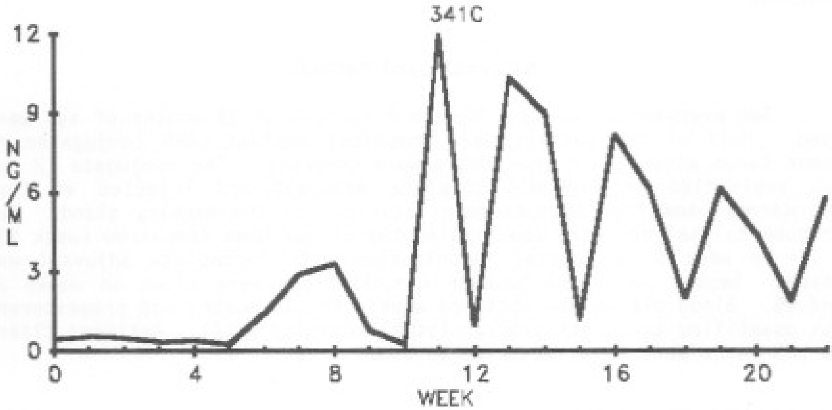

Figure 1. Concentrations of progesterone in plasma of a control heifer before and after puberty. Treatment was initiated on week 0.

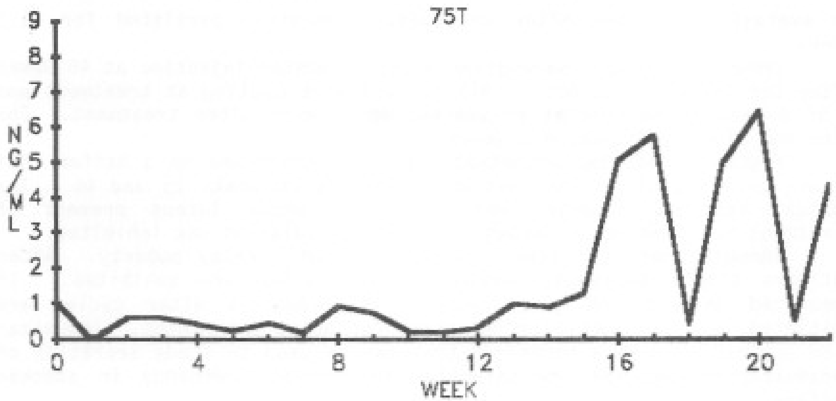

Figure 2. Concentrations of progesterone in plasma of a heifer with delayed puberty after immunization against LHRH. Treatment was initiated on week 0.

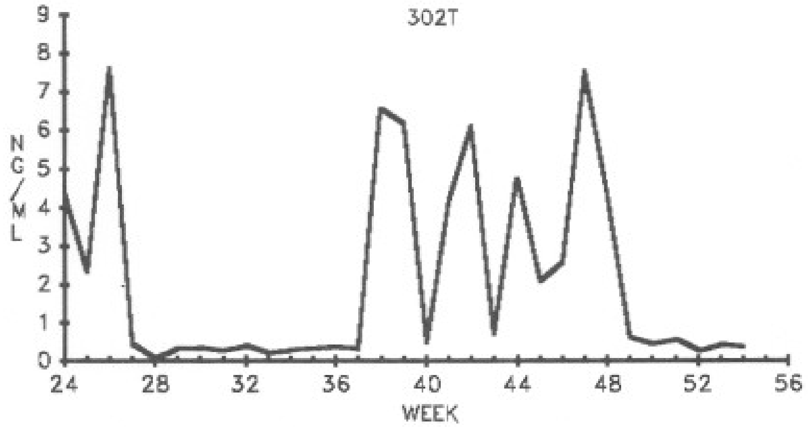

Figure 3. Concentrations of progesterone in plasma of a heifer immunized against LHRH at week 0. After puberty, booster immunizations against LHRH were given on weeks 25 and 46.

concentrations of progesterone in a heifer immunized against LHRH. Progesterone was less than 1 ng/ml until 16 weeks. Puberty was delayed for an average of 11 weeks in treated heifers. After OLA started, normal cycles continued.

Immunized heifers were given a second booster with incomplete adjuvant at 25 weeks after the initial treatment. All heifers exhibited normal OLA cycles at treatment. Three of the five heifers ceased OLA at an average of 1 week after treatment. Anestrus persisted for 11.3 weeks.

Immunized heifers were given a third booster injection at 46 weeks after the initial treatment. All heifers were cycling at treatment and 4 of 5 became anestrus at an average of 3 weeks after treatment. The duration of anestrus was 8.2 weeks.

Figure 3 depicts concentrations of progesterone in a heifer that became anestrus after the booster injections on weeks 25 and 46. The typical response observed was that the corpus luteum present at treatment had a normal lifespan but further ovulation was inhibited.

Immunization of heifers against LHRH will delay puberty. After antisera titers decrease, normal estrous cycles are exhibited. If immunized heifers are given booster immunizations after cycles are initiated, ovarian luteal cycles cease for about two months. Immunization against LHRH is a technique that can be used to study secretion of gonadotropins and has the potential to prevent pregnancy in stocker heifers.

EFFECTS OF BODY CONDITION AND OVARIECTOMY ON SECRETION OF LUTEINIZING HORMONE IN BEEF COWS

M.W. Richards[1], R.P. Wettemann[2] and S.D. Welty[3]

Story in Brief

Five nonpregnant, nonlactating, Hereford cows were fed to maintain body weight, body condition, and normal estrous cycles and ten were fed a restricted diet to lose weight and body condition until they became anestrus. Five of the anestrous cows were randomly allotted to be ovariectomized via flank incision and the other five to remain intact. All maintain cows were ovariectomized. Blood was collected frequently for 4 h on days -1, +1, +2, +3, +4, +5 and +10 (day 0 = day of ovariectomy) and luteinizing hormone (LH) was quantified. Concentrations of LH were determined in daily samples collected on days -1 through +10. Concentrations of LH increased in maintain ovariectomized cows when compared with restricted ovariectomized and restricted intact cows, whereas concentrations of LH were similar for restricted ovariectomized and intact cows. The number of LH pulses was similar for maintain and restricted cows. We conclude that secretion of LH is greater, before and after ovariectomy, in cows with moderate body condition compared to secretion in thin cows and the control of LH release from the anterior pituitary is independent of ovarian control in thin anestrous cows.

(Key Words: Beef Cow, Body Condition, Nutrition, LH, Ovariectomy.)

Introduction

Luteinizing hormone (LH) is one of the primary hormones that controls reproduction in farm animals. Anestrus occurs when cows lose weight and have a body condition of about 3.5 (Richards et al., 1986). Nutritional anestrus is probably caused by reduced secretion of LH from the pituitary gland. Increases in both LH pulse frequency and amplitude occur after removal of the ovaries in cows with good body condition. Underfeeding appears to increase the sensitivity of the brain and/or the pituitary to the effects of estradiol in cows.

The objectives of this study were to determine if removal of the ovaries causes an increase in concentrations of LH in nutritionally anestrous beef cows and to examine the relationship between body energy reserves and the secretion of LH in ovariectomized cows.

Materials and Methods

Fifteen nonpregnant, nonlactating, Hereford cows with moderate to good body condition (BCS = 5.2 ±. 3) were used in this study. Two people independently assessed BCS using the system where 1 = emaciated and 9 = obese (Wagner et al., 1985). All cows exhibited normal estrous cycles at the initiation of the study. Five cows were randomly allotted

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to maintain (M) their initial body weight (BW) and BCS and the remaining ten cows were fed a restricted (R) diet (approximately 2 kg of prairie hay per day in a drylot) for approximately 26 wk until they became anestrus (absence of ovarian luteal activity). Within the R group, 5 cows were assigned to be ovariectomized (OVX) and the other 5 cows were left intact (INT). All M cows were ovariectomized.

Body weights and BCS were recorded monthly until R cows became anestrus. Concentrations of progesterone in blood samples were used to determine absence of ovarian luteal activity. All cows were given 2 injections (i.m.) of prostaglandin $F_{2\alpha}$ (25 mg) 11 d apart to synchronize estrus in the cows exhibiting normal cycles. On days 3 to 5 after estrus, cannulae were nonsurgically inserted into jugular veins and cows were confined to metabolism stalls. Two days later, 5 R (R-OVX) and 5 M (M-OVX) cows were ovariectomized through flank incisions. The number and size of all follicles on the surface of the ovary that were 2 mm or greater in diameter were recorded. Follicles were classified as small (< 3.9 mm), medium (4.0 - 7.9 mm) or large (< 8.0 mm). Total and dry ovarian weights, follicular fluid weights and corpora lutea weights were determined.

At 0800 h, on days -1, +1, +2, +3, +4, +5, and +10 (day 0 = day of ovariectomy), blood was collected at 10 min intervals for 4 h. Concentrations of LH in frequent samples were quantified by radioimmunoassays.

Results and Discussion

Restricted cows lost BW and BCS and became anestrus after approximately 26 wk on the restricted diet (Table 1). Body weight and BCS were maintained for M cows and they exhibited normal estrous cycles until ovariectomy. At ovariectomy, R cows were 98 kg lighter and had a 3 unit reduction in BCS ($P<.01$) compared with M cows.

Concentrations of progesterone in the plasma of M cows averaged 2.5 ± .5 ng/ml on the day of ovariectomy (day 5-7 after estrus) and declined to less than 1.0 ng/ml within 72 h after ovariectomy. By contrast, concentrations of progesterone in the blood of R cows averaged .6 ± .1 ng/ml on the day of ovariectomy and averaged less than 1.0 ng/ml throughout the study.

Maintain cows had heavier total ($P<.01$) and dry ($P<.10$) ovarian weights than did R cows (Table 2). There were no CL present on the ovaries from any of the R cows and one M cow that exhibited estrus did not have a CL. These results are in agreement with previous studies

Table 1. Effect of restricted nutrient intake on weight change and body condition score (BCS).

	Body weight (kg)[a]		BCS[a]	
Time	Maintain	Restricted	Maintain	Restricted
Initiation of treatment	453±9	460±6	5.3±.4	5.1±.2
Ovariectomy	438±19[b]	340±6[c]	5.7±.1[b]	2.7±.2[c]

[a]Weight and BCS of 1 cow from each treatment were not available at initiation of the study.

[b,c]Means in the same row within a trait with different superscripts differ ($P<.01$).

Table 2. Ovarian characteristics of cows fed maintenance or restricted diets.

Criteria[a]	Diet		
	Maintenance	Restricted	SEM
Total ovarian weight, g	8.92[b]	5.86[c]	.74
Dry ovarian weight, g	1.24[d]	.92[e]	.13
Dry ovarian weight, %	15.00	16.00	1.00
Corpus luteum weight, g	.87[f]	.00[g]	.29
Follicular fluid weight, g	1.15	.86	.13
No. small follicles (<3.9 mm)	3.90	2.00	.84
No. medium follicles (4.0 to 7.9 mm)	.90	1.10	.33
No. large follicles (>8.0 mm)	.30	.10	.13

[a]Values are a total for both ovaries.
[b,c]Means not having a common superscript differ (P<.01).
[d,e]Means not having a common superscript differ (P<.10).
[f,g]Means not having a common superscript differ (P<.05).

which demonstrated that cows fed diets with reduced energy had lighter ovaries than those fed adequately. Neither follicular fluid weight nor percentage dry ovarian weight were significantly different between M and R cows. However, M cows tended (P<.12) to have more small follicles than R cows. The numbers of medium and large follicles were similar for M and R cows. These results demonstrate that when a cow's body energy reserves are depleted cyclic ovarian function ceases.

Average daily concentrations of LH increased linearly (P<.01) in M cows after ovariectomy; however, R cows did not exhibit an increase in serum LH after their ovaries were removed (Figure 1). Pulse frequency of LH secretion was not influenced by ovariectomy and averaged .89, .71 and .71 ± .26 pulses per 4 h for M-OVX, R-OVX and R-INT cows, respectively. Results from studies using dairy cows indicated that pulse frequency increased by as much as 3-fold within the first four days after ovariectomy. In addition, ovariectomized beef heifers fed a diet low in energy had fewer pulses of LH per 6 h than those fed a diet with adequate energy.

Pulse amplitude of LH was greater for M-OVX than R-INT cows at all times evaluated. Restricted-OVX cows had less LH pulse amplitude on days +2, +4 and +5 after ovariectomy when compared with M-OVX cows. Our results suggest that the brain and pituitary of cows that have adequate body energy reserves and normal estrous cycles prior to ovariectomy are capable of secreting greater quantities of LH once the negative feedback is removed when compared with thin anestrous cows. These results agree with other studies that indicated that when dairy cows in a negative energy balance were ovariectomized 4 d after parturition they had reduced LH pulse frequency and amplitude and reduced mean LH concentrations when compared with cows that were cyclic prior to ovariectomy.

Since ovariectomy did not alter concentrations of LH in R cows, reduced body energy reserves suppress LH secretion by a mechanism which is independent of ovarian steroid or other hormonal feedback. This supports the concept that, although ovarian secretions inhibit LH secretion, reduced nutrient intake has a direct effect on the brain and its related structures.

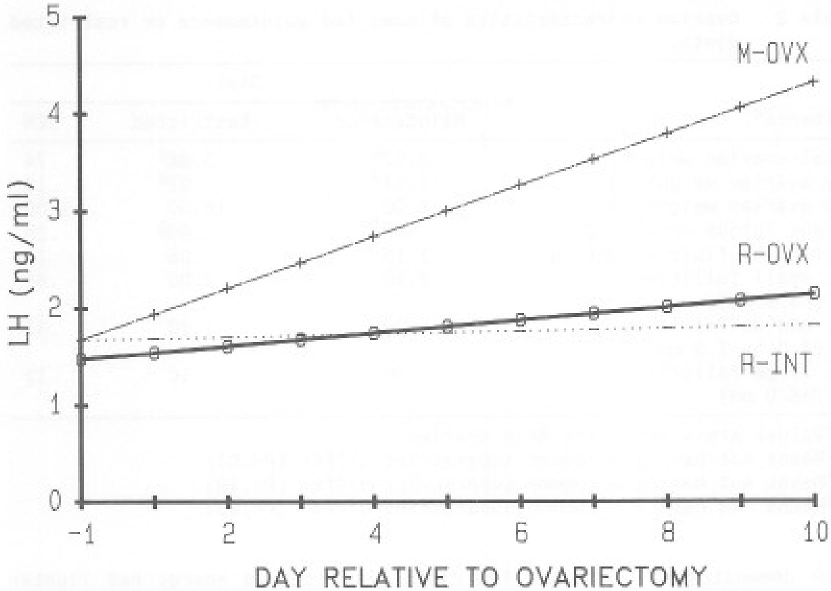

Figure 1. Concentration of LH in daily blood samples from cows fed a maintenance diet and ovariectomized (M-OVX), a restricted diet and OVX (R-OVX), or a restricted diet and left intact (R-INT).

In conclusion, our results suggest that body energy reserves and/or presence or absence of normal estrous cycles prior to ovariectomy alter LH secretion in beef cows. Cows with reduced body energy reserves secrete less LH than those with adequate amounts of body energy reserves. Since ovariectomized thin cows do not have an increase in LH secretion after removal of their ovaries, signals from body energy reserves are independent of the ovary and may directly influence brain and/or pituitary regulation of secretion of LH in beef cows.

Literature Cited

Richards, M.W. et al. 1986. Effect of restricted intake on cyclic ovarian activity and estrus in Hereford cows. Okla. Agr. Exp. Sta. MP-118:308.

Wagner, J.J. et al. 1985. Body condition score, live weight and weight:height ratio as estimators of carcass composition in nonpregnant, nonlactating, mature Hereford cows. Okla. Agr. Exp. Sta. MP-117:196.

PLASMA CONSTITUENTS AND OVARIAN FUNCTION OF BEEF COWS TREATED WITH GROWTH HORMONE-RELEASING FACTOR

R.P. Wettemann[1], M.W. Richards[2], R.J. Rasby[2], J.C. Garmendia[2] and T.F. Mowles[3]

Story in Brief

Hereford and Hereford x Angus cows were used to evaluate the effects of growth hormone releasing factor (GRF) on postpartum performance. Cows were infused with GRF or saline 3 times daily on days 25 to 45 post partum. Treatment with GRF increased growth hormone and non-esterified fatty acids in the blood, and feed intake was increased. Secretion of luteinizing hormone was not altered by treatment. Treatment of lactating anestrous cows for 21 days did not influence calf growth or the interval to the onset of ovarian luteal activity.

(Key Words: Anestrus, Beef Cow, GRF, Growth Hormone, Postpartum.)

Introduction

Treatment of cattle with growth hormone-releasing factor (GRF) increases concentrations of growth hormone (GH) in serum. Treatment of lactating dairy cows with bovine growth hormone increases milk yield and changes in blood and milk lipids indicate mobilization of adipose tissue reserves.

If nutrient intake is inadequate and body energy reserves are depleted, the interval from calving to the first estrus is extended in beef cattle. Body energy reserve at calving is an important factor that influences subsequent pregnancy rate. Secretion of LH is a limiting factor to the initiation of postpartum estrous cycles. Infusion of lactating beef cows with glucose will decrease concentrations of non-esterified fatty acids (NEFA) in plasma and increase luteinizing hormone (LH) secretion.

Growth hormone may partition dietary energy in dairy cows between body tissue, milk, heat, methane, feces and urine. Postpartum beef cows have less potential for milk production than dairy cows and alterations in energy metabolism may provide nutrients to enhance secretion of LH and stimulate ovarian function. The objectives of this experiment were to determine the effect of three times daily infusion of postpartum beef cows with GRF on concentrations of glucose and NEFA in plasma, LH and insulin in serum, and ovarian function.

Materials and Methods

Ten mature anestrous Hereford cows at 25 ± 2 d post partum were used to determine the effect of treatment with GRF on blood constituents and ovarian function. Cows received rations during the last 90 d of gestation so that body weights and body condition scores (BCS; 1 = emaciated, 9 = obese) were 881 ± 44 pounds and 4.9 ± .2, respectively,

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[1]Regents Professor [2]Graduate Assistant [3]Scientist

at parturition. During the first 85 d after calving, cows were fed cotton seed meal (41% CP) in addition to grass pasture to permit weight gain (about 0.4 kg/day). Cows were cohabited with androgenized cows with chinball markers and concentrations of progesterone in plasma collected each week were used to select anestrous cows.

On day 22 post partum, cows and calves were removed from range pasture and pairs were maintained in individual pens in a building. Daily intake of a 12% protein ration, supplied ad libitum, was determined. On day 25 post partum, a cannula was inserted into the jugular vein of each cow. Cows were blocked by calving date and received either human GRF (hGRF-(1-29)-NH_2; 3 μg/kg) or saline, intravenously, at 0800, 1400 and 2000 h daily through day 45 post partum. Blood samples were obtained daily at 0800 and 0830 and at 10 m intervals for 8 h on day 42 post partum.

Estimates of 24-h milk production were made by the calf-weight-change technique before (day 23 post partum) and during (day 44 post partum) treatment.

On day 46 post partum, cows were returned to pasture and cohabited with fertile bulls until at least 90 d post partum. Progesterone was quantified in weekly blood samples between 46 and 85 d post partum to assess ovarian luteal activity. Pregnancy rate was determined at 90 d post breeding and day of conception was calculated by subtraction of 280 d from the subsequent parturition. An LH pulse was defined as any value greater than 2 standard deviations above the mean for a cow. Basal LH was determined by averaging all LH values < 2 ng/ml.

Results and Discussion

Body weights were similar for control and GRF treated cows at the start of treatment. Weight gains and BCS changes during treatment were similar for cows on both treatments. Cows gained an average of 0.29 kg/d. Feed intake was greater ($P<.05$) for GRF treated (17.2 ± .4) than for control cows (15.7 ± .4 kg/d).

Concentrations of GH in serum were increased by infusion with GRF. Concentrations of GH increased ($P<.001$) from .6 ± .6 ng/ml before infusion to 15.8 ± .6 ng/ml at 30 m after GRF infusion.

Milk production and the change in milk production during treatment were not significantly influenced by treatment. Similarly, average daily gain of the calves and weaning weights were not altered by GRF treatment. Average daily gain of the calves was correlated with milk production of the dam ($r = .74$; $P<.05$) and feed intake of the dam (.68; $P<.05$).

There was a treatment x day effect on concentrations of NEFA in plasma (Figure 1). During the first 9 days of treatment, NEFA's in plasma were greater in GRF treated than control cows. However, after day 10, concentrations were similar in GRF treated and control cows.

Concentrations of glucose in plasma were influenced by day of treatment (Figure 2; $P<.05$). Although not significant ($P<.12$), there was a tendency for a treatment x day effect on glucose in plasma. Concentrations of glucose tended to be greater in GRF treated than in control cows during days 10 through 21 of treatment. The average concentration of glucose in a cow for the 21 d period was correlated with average daily gain of the calf ($r = .76$; $P<.01$). Concentrations of insulin in serum were influenced by day ($P<.001$), but were not affected by treatment.

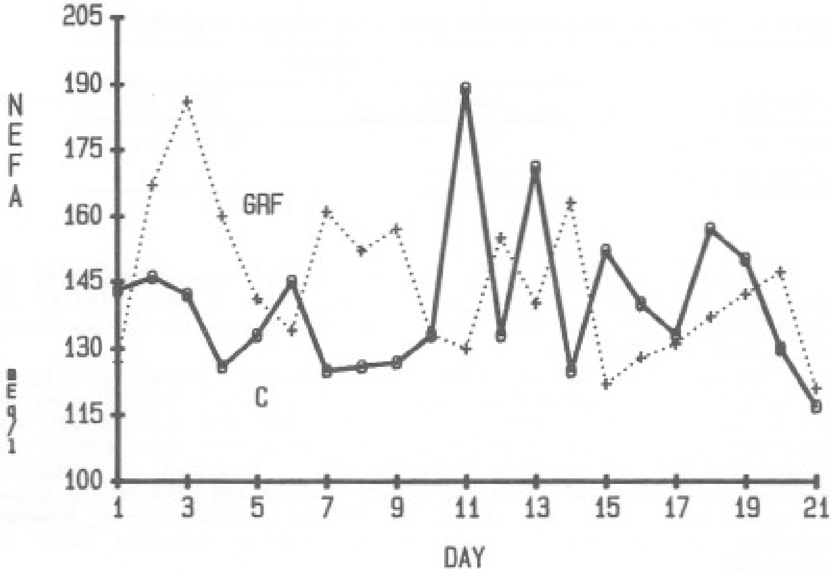

Figure 1. Concentrations of non-esterified (NEFA) in the plasma of control beef cows and cows treated with GRF three times daily after calving. The first day of treatment (Day 1) was 25 ± 2 d post partum.

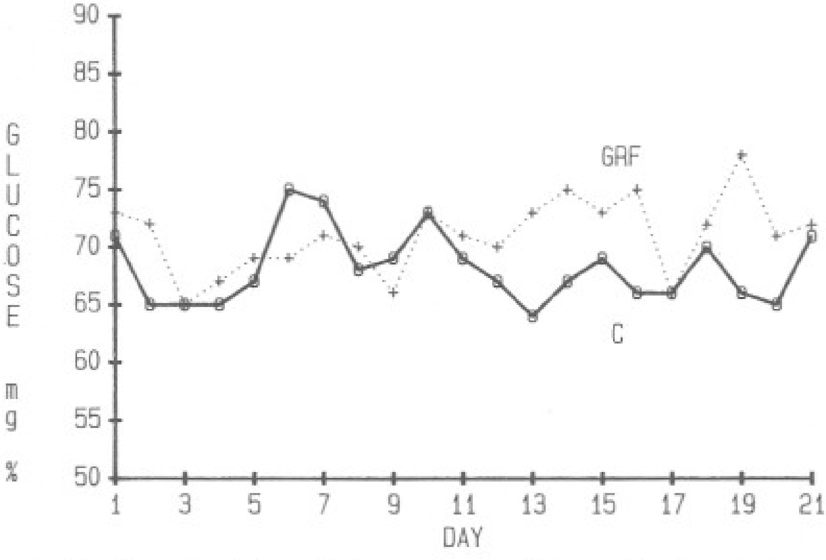

Figure 2. Concentrations of glucose in the plasma of control beef cows and cows treated with GRF three times daily after calving. The first day of treatment (Day 1) was 25 ± 2 d post partum.

Table 1. **Serum LH in postpartum beef cows treated with GRF.**

Criteria	Treatment	
	Control	GRF
Basal LH, ng/ml	.97 ± .16	.86 ± .11
Pulses per 8 h	2.0 ± .6	2.0 ± .4

Secretion of LH on day 18 of treatment was not influenced by GRF treatment (Table 1). Basal concentrations of LH were similar for control and GRF treated cows, and cows on both treatments had an average of 2 pulses of LH per 8 h.

The number of days until the onset of ovarian luteal activity was not affected by treatment and averaged 70 ± 6 for control cows and 73 ± 5 for GRF cows. Four of 5 control cows and 3 of 5 GRF cows conceived and the days from calving to conception were similar for control and GRF treated cows, respectively. Treatment of postpartum anestrous cows with GRF increased growth hormone and NEFA in the blood, increased feed intake, and tended to increase plasma glucose, however, secretion of LH, milk production and ovarian function were not influenced.

THE EFFECTS OF MGA[1] FED PRIOR TO NATURAL SERVICE ON REBREEDING PERFORMANCE OF POSTPARTUM BEEF COWS

G. E. Selk[2], K. C. Barnes[3], and J. Flusche[4]

Story in Brief

Fifty-two mature Brangus cows were allotted into two groups to examine the effects of short term feeding of melengestrol acetate on postpartum reproduction of beef cows. The treatment group (n = 27) received 1 mg melengestrol acetate in supplemental pelleted feed for 10 days prior to the breeding season. The control group (n = 25) received similar supplementation with no melengestrol acetate added. Two fertility tested bulls were placed with each group for the three months breeding season. Cows records were grouped by month of calving in 1986 for analysis of treatment effect on calving interval and percentage calf crop. Among cows calving in March, treatment cows had increased calf crop percentage and decreased calving intervals compared to control cows. Similar, non-significant trends were evident for cows calving in February and April. Cows that calved in February could be expected to have returned to estrus by the start of the breeding season. Cows that calved in March and later were more susceptible to the effects of the synthetic progesterone, melengestrol acetate.

(Key words: MGA, beef cows, postpartum reproduction, natural service)

Introduction

Beef cow-calf producers can profit in many ways by shortening the time period between the date the first calf is born and the date the last calf arrives. Among the benefits gained from a shorter calving season are: more uniform calf-crops; heavier calves at weaning time; more convenient, herd nutrition and herd health management; and better planning of labor needs. Reducing the calving interval (days from parturition in one year to the next) could aid in shortening breeding seasons by moving late calving cows forward to give birth with the remainder of the herd.

Melengestrol acetate (MGA), when fed to beef heifers for periods of 2 weeks, has been shown to induce estrus in some cattle (Selk, et al. 1987) and tends to synchronize estrus in cycling females, upon removal from the diet. Therefore an experiment was conducted to determine the effect of short term MGA feeding to naturally bred postpartum beef cows on calf crop percentage, uniformity of calving time, and calving interval.

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Materials and Methods

Fifty-two mature lactating Brangus cows were divided into two groups with 27 cow-calf pairs and 25 cow-calf pairs in each of two 160 acre bermuda grass pastures. Two pounds/head/day of pelleted grain (14% C.P.) were fed to each group starting on April 25. (A three day period of acclimation to the feed was used to insure uniform consumption by the cows). On April 28, MGA-treated cows began to receive 1 mg/day of MGA (melengestrol acetate) at the rate of .5 mg per pound of pelleted feed. Control cows received two pounds of the pelleted grain per day throughout the trial. On May 8, feeding was terminated for both groups. At this time, the cows averaged 60 days postpartum and ranged from 96 days to 1 day postpartum.

On May 8, all cows were individually assigned a body condition score. The body condition scoring system used a 1 through 9 scale with 1 = emaciated and 9 = very obese. At this time, two bulls were placed in each pasture (approximate cow/bull ratio = 13:1). The bulls had previously passed a breeding soundness examination and were left in the breeding pastures for 90 days. Dicalcium phosphate and salt were available free choice and all cows were exposed to dust bags/and or backrubbers for external parasite control. All cows were pregnancy checked and length of pregnancy estimated on October 10 by a veterinarian. Non-pregnant cows were culled from the herd. Calving dates in the spring of 1987 were recorded. From these comparisons of 1986 and 1987 calving dates, the effects of MGA feeding on calving interval were evaluated.

Treatment effects on pregnancy rates, 1987 calving dates, and calving intervals were tested by analysis of variance. Treatment effects on pregnancy rates and calving intervals were examined by month in which the 1986 calf was born. These tests also were conducted by analysis of variance of those cows calving in those individual months.

Results and Discussion

Upon preliminary analysis, the 1986 calving date was found to be the major source of variation accounting for the differences in calving interval and pregnancy. Therefore, an analysis of the cows calving within each calendar month in 1986 was performed. Table 1 summarizes the calving dates, calving intervals, and pregnancy percentages for MGA-fed and control cows by month in which they calved.

Figure 1 illustrates the treatment effects on pregnancy rates and figure 2 represents the treatment effects on calving interval of cows calving in February, March, April, and May, respectively. Those cows that calved in February averaged more than 80 days postpartum at the start of the breeding season, therefore both treatment and control cows had ample opportunity to return to estrus by the time of first exposure to the bulls. Consequently any estrus induction effect of the MGA supplementation would be negated, as all of the cows would be expected to have returned to estrus by the breeding season.

The March-calving cows, however, were 56 days and 50 days postpartum for control and treatment cows, respectively, when the breeding season began. Fewer of these cows would be expected to have returned to estrus by the first of the breeding season. Even with this limited number of cows, there was a greater ($p < .01$) percentage of cows that became pregnant (100 vs 63) and a reduction ($p < .05$) in average calving interval (356 vs 377) for cows fed MGA compared to control cows.

Table 1. Mean 1986 and 1987 calving dates, mean calving intervals, pregnancy rates, and pre-breeding body condition scores (BCS) of MGA-fed (MGA) and control (C) cows by month in which 1986 calving occurred.

Month of Calving	(Treatment)	No. of cows	BCS	Mean* 1986 calving date	Mean* 1987 calving date	Mean Calving interval (days)	% Pregnant in 1987
Febr.							
	(MGA)	9	5.5	2-16±2.5	3-12±6.2	389	100
	(C)	14	5.3	2-11±1.8	3-13±6.4	394	93
Mar.							
	(MGA)	9	5.0	3-19±2.8	3-11±3.8	356[a]	100[a]
	(C)	8	5.4	3-13±3.7	3-24±6.9	377[b]	63[b]
Apr.							
	(MGA)	7	5.1	4-16±4.8	3-26±6.8	339	71
	(C)	3	5.5	4-17±7.0	4-2 ----	350	33
May							
	(MGA)	2	5.2	5- 7±0.0	4-20 ---	348	50
	(C)	0	---	-------	--------	---	--
All							
	(MGA)	27	5.2	3-17±5.5	3-16±3.9	364	89
	(C)	25	5.3	3- 1±4.8	3-17±5.5	386	76

*Means ± Standard errors

abMeasurements for cows calving within the same month are different ($p < .05$)

Treatment and control cows calving during April had identical averages of 21 days post partum at the start of the breeding season. Although the trends for increased pregnancy rates and decreased calving intervals were similar to March-calving cows, no significant differences were found. The April cows and those calving in May would not be expected to be as responsive to a synthetic progesterone as cows that were longer in days postpartum.

Previously reported research has provided mixed results as to the effectiveness of the feeding of MGA to the postpartum beef cow. Beal and Good, (1986) reported that MGA-prostaglandin treatments consistently induced estrus in 50% of anestrous beef cows. In contrast, Boyd, et al. (1986) noted that low percentages of postpartum lactating beef cows fed MGA for seven days were induced to begin estrus. The current study

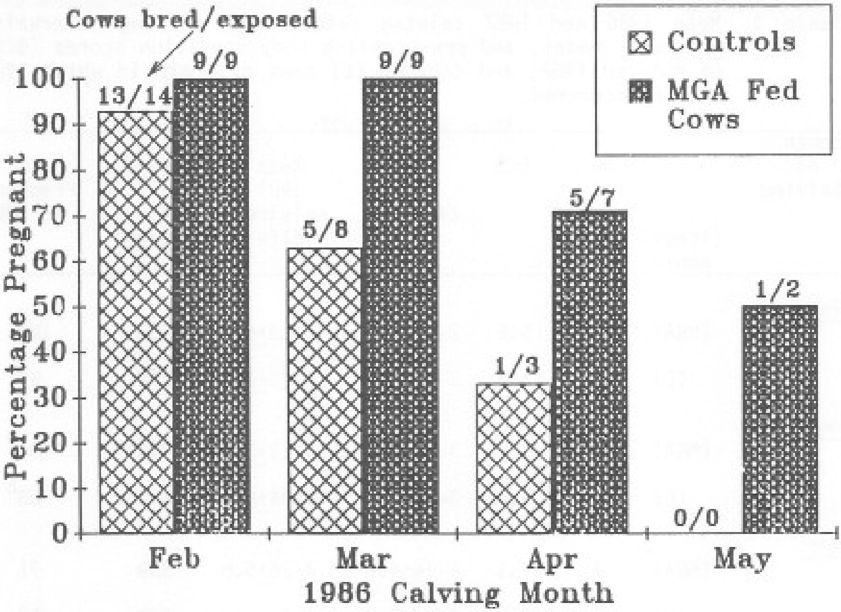

Figure 1. Percentage of cows that became pregnant during 1986 breeding season for MGA-fed and control cows graphed by month in which 1986 calving occurred.

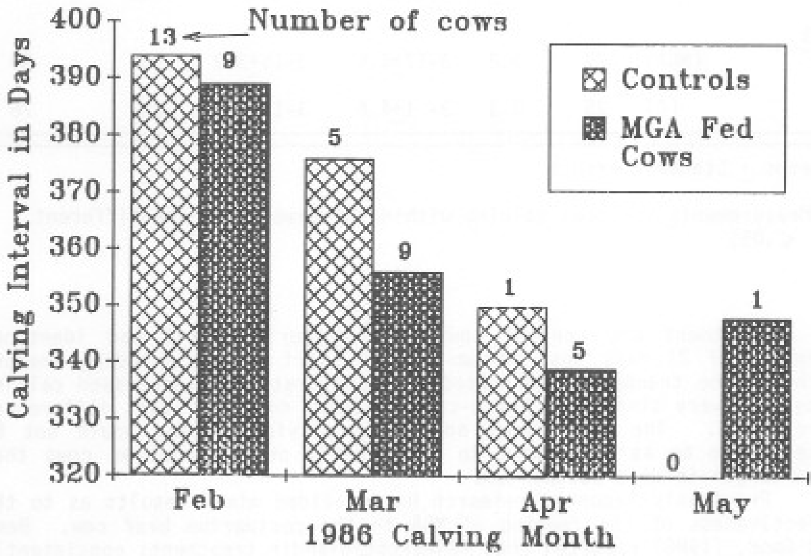

Figure 2. Year to year calving intervals (in days) for MGA-fed and control cows graphed by month in which 1986 calving occurred.

suggests that synthetic progestins may be more effective at inducing estrus in cows that are approximately 50 days postpartum and nearing the time of normal onset of ovarian activity. Any induction of estrus by feeding a synthetic progestin may be partiallly offset by the apparent reduction in fertility noted in first estrus after withdrawal of the drug (Beal, et al. 1988). More research is needed to better understand the estrus induction response caused by synthetic progestins and the subsequent effect on fertility and overall pregnancy rate.

Literature Cited

Beal, W. E. and G. A. Good. 1986. Synchronization of estrus in postpartum beef cows with melengestrol acetate and prostaglandin F_{2a}. J. Anim. Sci. 63:343.

Beal, W. E., J. R. Chenault, M. L. Day, and L. R. Corah. 1988. Variation in conception rates following synchronization of estrus with melengestrol acetate and prostaglandin F_{2a}. J. Anim. Sci. 66:599.

Boyd, G. W., D. J. Patterson, L. R. Corah, and J. R. Brethour. 1986. Effects of MGA and PGF on estrus induction and synchronization in cows and heifers. Cattleman's Day 1986; Report of Progress 494:42. Kansas State Univ., Manhattan.

Selk, G. E., C. A. McPeake, and R. P. Wettemann. 1987. Inducing estrus in beef replacement heifers with MGA. Animal Science Research Report; MP-119:59. Oklahoma State Univ., Stillwater.

ESTRUS SYNCHRONIZATION OF CATTLE USING ELEVEN DAY OR FOURTEEN DAY PROSTAGLANDIN PROTOCOLS

G.E. Selk[1], M.S. Fink[2] and C.A. McPeake[3]

Story in Brief

Forty-two beef replacement heifers were used to compare synchronization regimes. Two injections of prostaglandin F2a were given at 11 day or 14 day intervals. Heifers were observed twice daily for standing heat and were inseminated 12 hours after they were first observed in standing estrus. Estrous detection and artificial insemination were continued for another 45 days and used to determine the percentage of heifers that returned to estrus after the initial insemination. No difference in mean days to time of insemination, synchrony of insemination time, or in first service non-return rate was found. A fourteen day protocol of two prostaglandin injections should be expected to give similar estrous synchronization and conception rates to that found with the more commonly used eleven day system.

(Key words: Beef heifers, synchronization, prostaglandin)

Introduction

One of the primary methods of estrous synchronization available for beef producers is use of prostaglandin injections. Recent developments in endocrinology have revealed a series of hormone-like substances called prostaglandins (or prostaglandin analogs) that are highly effective in synchronizing estrus under certain conditions. They act by causing the corpus luteum to regress, thereby allowing the cow to begin a new estrous cycle. For this to be accomplished the following conditions must be met: 1) the cow must be cycling and 2) the cow must have a functional corpus luteum (between days 5 and 18 of the cycle). Prostaglandins do not cause non-cycling cows to come into heat. Their only function is to cause regression of a functional corpus luteum.

When management has been good, prostaglandins have greatly reduced the labor and expense of A.I. The period of time during which estrus must be detected is greatly reduced or eliminated entirely depending on the management system adapted. Three basic schemes have been used.

1. Two injections are given, 11 days apart. Any cyclic cow not having a corpus luteum (CL) that can be regressed by prostaglandin at the time the first injection is given, should have a CL at the time of the second injection, 11 days later. Cows are either bred upon detection of estrus or at 75 to 80 hours after the 2nd injection regardless of estrus.

Some experienced inseminators breed potential problem cows twice -- once at 72 hours after prostaglandin and again at 96 hours after the injection. This will increase labor and semen costs but has been shown to be effective with some problem breeders.

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[1]Assistant Professor [2]Beef Herdsman [3]Associate Professor

2. Cattle are detected in estrus and inseminated for at least 4 days and on the morning of the 5th day all cattle not detected in estrus or inseminated are injected. Breeding continues according to estrus for another 4 or 5 days.

3. Prostaglandin is injected and cows are inseminated at detected estrus for about 5 days. Cows in the first 5 days of their cycle at the time of injection will not be synchronized.

The choice of system depends on costs, labor, facilities and the amount of time the cattleman wants to devote to breeding. Success requires a cow herd with a close calving interval, good nutrition, good facilities, good semen, a good inseminator and good heat detection, if heat detection is used.

In the application of the first scheme, some producers choose to change the protocol from 11 days to a few days fewer or more between injections. Off-farm employment and impending bad weather are both possible reasons for changing the 11 day system to 14 days between injections. This allows for both injections to be given on the same day of the week to fit more conveniently into work schedules. A producer may want to avoid giving the second injection during or just before a severe winter storm and choose to wait three more days for better weather. With these possible scenarios in mind, a study was conducted to compare the estrus synchronization properties of two prostaglandin injections given 11 days apart versus two injections given 14 days apart. Cattle that receive the injections 14 days apart will have more mature corpora lutea to regress at the second treatment that may improve the effectiveness of the synchronization program.

Materials and Methods

Forty-two replacement beef heifers (of six different breeds) were blocked into two groups for synchronization of estrus. Twenty-one heifers (Treatment group) were injected with 25 mg of prostaglandin F2a (Lutalyse)[4] on April 10. The Control heifers (n = 21) were given an injection of prostaglandin F2a on April 13. All heifers were given a second injection of the prostaglandin on April 24. Consequently, the Treatment heifers were given two injections 14 days apart. All heifers were observed for signs of estrus twice each day for six days following the last injection. Estrous observations were conducted in early morning (7:00am) and at dusk (7:00pm). Only heifers that responded with observable estrus within 6 days after the second injection were included in the study. Any heifer observed in standing estrus was artificially inseminated at the next estrus observation period (approximately 12 hours later). The times of inseminations were recorded as AM or PM breedings and are shown graphically in figure 1. For example a heifer that was inseminated on the morning of the third day after the injection would be listed as 3.0 days, where as a heifer inseminated in the evening on the same day would be recorded as 3.5 days after the second injection. All heifers were observed for estrus for 45 days after the second injection of prostaglandin. Those that did not return to estrus in this time period were assumed to have conceived. Conception was verified by subsequent calving.

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[4]Product of Upjohn Co., Kalamazoo, Michigan.

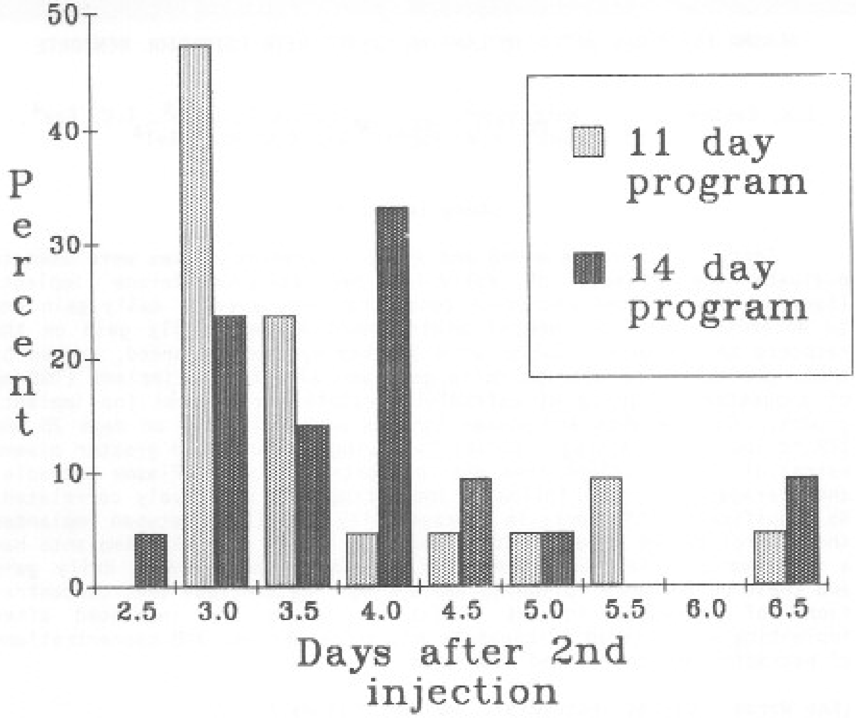

Figure 1. Percentage of heifers inseminated at half day intervals following a second injection of PGF2a that was given 11 or 14 days after a previous injection.

PLASMA ESTRADIOL AFTER IMPLANTING CALVES WITH ESTRADIOL BENZOATE

J.W. Castree[1], R.P. Wettemann[2], K.S. Lusby[3], E.R. Cole[4], T.C. Fox[4], M.A. Kimbrough[4], K.W. Kugler[4] and B.G. McDaniel[4]

Story in Brief

Forty fall-born Hereford and Angus x Hereford calves were used to evaluate the effects of estradiol benzoate-progesterone implants (Synovex-C) on plasma estradiol concentrations, average daily gain and to determine the influence of pretreatment average daily gain on the response to implants. Calves were blocked by sex and breed, ranked by their preimplanting average daily gain and allotted to implant (100 mg of progesterone, 10 mg of estradiol benzoate) or control (no implant) groups. Calf weights and plasma samples were collected on days 28 and 108 following implanting. Calves receiving implants had greater plasma estradiol concentrations than did the control calves. Plasma estradiol and average daily gain following implanting were positively correlated. No significant differences in average daily gain (ADG) between implanted and control calves were detected, however, calves receiving implants had a positive correlation between their preimplanting average daily gain and their performance following implanting. We conclude that concentrations of estradiol in the plasma of calves are increased after implanting with estradiol benzoate and progesterone, and concentrations of estradiol are correlated with gain.

(Key Words: Calves, Estradiol, Implant, Plasma.)

Introduction

The use of anabolic steroids as growth promoters is a profitable management practice. The growth rate of fall-born suckling steer and heifer calves implanted with estradiol benzoate and progesterone was increased by 6 to 7% over nonimplanted calves (Gill et al., 1986). The objectives of this study were to determine the effects of implanting calves with estradiol benzoate and progesterone on plasma estradiol concentrations, and to evaluate the influence of pretreatment ADG on the response to implanting.

Materials and Methods

Forty fall-born Hereford and Angus x Hereford calves were used in this study. Calves were blocked by sex and breed and ranked according to their 84 day pretreatment ADG then equally assigned to either a non-implanted control or implanted group. Control calves had an average initial weight of 233 lbs and a pretreatment ADG of 0.84 lbs/day. Implanted calves weighed 232 lbs at the time of implanting with a pretreatment ADG of 0.88 lbs/day. Throughout the trial all calves remained with their dams, who were maintained on native range and protein supplement.

[1]Graduate Assistant [2]Regents Professor [3]Professor [4]Student

Implanted calves were implanted once with Synovex-C containing 100 mg progesterone and 10 mg estradiol benzoate under the skin on the convex surface of the ear. Calf weights were recorded at the time of implanting and on days 28, 42, and 108 following treatment. Blood samples were taken from calves by venipuncture on days 28 and 108 following treatment. Oxalic acid was added to blood samples to prevent clotting and samples were immediately cooled in ice. Blood samples were centrifuged and the plasma was analyzed for estradiol concentrations by radioimmunoassay.

Results and Discussion

Plasma estradiol concentrations and average daily gains of the implanted and control calves are summarized in Table 1. Sex by treatment interactions were not detected, so data for heifer and steer calves were averaged. The implanted calves had a greater concentration of estradiol in plasma than control calves on day 28 following treatment ($P<.01$). This increase in plasma estradiol in implanted calves compared with control calves was also evident 108 days following treatment ($P<.09$). Concentrations of estradiol were correlated with ADG ($r=0.40$, $P<.1$) during the first 42 days following treatment in calves receiving implants.

Table 1. Influence of implanting on ADG and plasma estradiol.

	ADG (lbs)[e]		Plasma Estradiol (ng/ml)	
Treatment	Pre-implanting (84 Days)	Post-implanting (42 Days)	Day 28 after implanting	Day 108 after implanting
Implant	0.88	0.61	14.06[a]	8.26[c]
Control	0.84	0.54	7.04[b]	6.29[d]

[a,b]Means in the same column with different superscripts differ ($P<.01$).
[c,d]Means in the same column with different superscripts differ ($P<.09$).
[e]No differences ($P<.05$) were noted in ADG.

Average daily gain was not significantly influenced by implanting, however, gain tended to be greater in implanted calves. The ADG of implanted calves during the 111 day pretreatment period was correlated positively with gain during the 108 days following implanting ($r=.53$, $P<.05$).

Calves were divided into two groups; those that gained more than or less than .85 lbs per day before implanting. The response to implanting was not influenced by preimplanting ADG. During the first six weeks after treatment, implanting improved ADG by .08 lbs per day in slow gaining calves and by .09 lbs per day in faster gaining calves.

We conclude that implanting calves with estradiol benzoate and progesterone increases plasma estradiol concentrations and growth rate is correlated with concentrations of estradiol in the plasma of implanted calves.

Literature Cited

Gill, D.R. et al. 1986. Response of fall-born calves to progesterone-estradiol benzoate implants and reimplants. J. Anim. Sci. 62:37.

KINETICS OF RUMINAL DISAPPEARANCE OF WHEAT FORAGE NITROGEN IN STEERS GRAZING WHEAT PASTURE OF TWO STAGES OF MATURITY

G.J. Vogel[1], M.A. Andersen[1] and G.W. Horn[2]

Story in Brief

Experiments were conducted to measure the kinetics of in situ ruminal disappearance of nitrogen of wheat forage at two stages of forage maturity. In each of three years, 8 multi-cannulated steers were used in a split plot design in which steers grazed wheat pasture during the immature and mature stages of growth. Wheat forage nitrogen existed kinetically as two distinct nitrogen pools. In immature wheat forage, 73.9% of total nitrogen disappeared at a fractional rate of 17.5 %/hr which was greater than the second nitrogen pool (26.1% of total nitrogen) that disappeared at 3.1 %/hr. With advanced forage maturity, less nitrogen was present in the rapidly disappearing pool (55%). Extent of ruminal nitrogen disappearance (%) was greater for immature (69.6) than mature (56.8) wheat forage. These data indicate that wheat forage protein is very rapidly degraded in the rumen, and that large quantities of dietary N may not reach the small intestine because of loss of protein. Performance of rapidly growing cattle on wheat pasture may be improved by feeding protein supplements of low ruminal degradability.

(Key Words: Wheat Forage, Nitrogen Disappearance, Rumen Degradability.)

Introduction

Wheat and other small grain forages are high quality forages commonly containing 24 to 30% crude protein. Rate of degradation of forage protein in the rumen affects microbial protein synthesis and therefore the amount of protein which flows to the small intestine. Recent research (Lee, 1985; Horn et al., 1987) has demonstrated a beneficial response from supplementation of stocker cattle on wheat pasture with "high bypass" protein supplements. Very limited information is available on rate of ruminal degradation of wheat forage protein. Therefore, the objective of this research was to determine the kinetics of ruminal disappearance of wheat forage nitrogen in stocker cattle grazing wheat pasture of two stages of forage maturity.

Experimental Procedure

In each of three years, 8 multi-cannulated Hereford and Hereford x Angus steers were used in a split plot design with two grazing periods. The mean weight of the steers was 1267 $\pm$ 24 lb, 978 $\pm$ 29 lb and 1153 $\pm$ 30 lb in year 1 (1985), year 2 (1986) and year 3 (1987), respectively. Grazing periods represented the period of rapid spring

[1]Graduate Assistant [2]Professor

growth (immature, March 8 to March 20) and the "grazeout" period (mature, April 18 to May 4) on wheat pasture. As a part of other experiments relative to site and extent of digestion of wheat forage, steers were randomly allotted to two treatments each year. In year 1 (1985) steers received either 0 or 300 mg of lasalocid daily. In years 2 and 3 steers received either a corn-based (control) or a 16 to 20% crude protein (CP) supplement that contained 18 to 25% meat meal.

Duplicate dacron bags containing approximately 10 g of fresh hand-clipped wheat forage cut to an average particle length of 1 inch were incubated in situ in the rumen of each steer for 4, 8, 12, 18, 24, 36, 48 and 60 hr during the last three days of each grazing period. In years 2 and 3, the 18 and 60 hr incubation times were deleted. Residual contents in the bags were analyzed for nitrogen (N) by the Kjeldahl procedure. Estimates of N disappearance were analyzed using the "curve peeling" technique of Shipley and Clark (1972). A "break point" (i.e., the point where the contribution from the more rapidly disappearing pool becomes insignificant) was determined by visual inspection of plots of the natural logarithm of the percent N remaining vs time. Break points of 24 and 12 hr incubation were used for the immature and mature forages, respectively. After the break point was determined, the slope (K_2) and intercept (A_2) for the more slowly degraded pool were determined by linear regression of the natural logarithm of the percent N remaining vs time. The contribution of this pool to the earlier data points was then subtracted and the slope (K_1) and intercept (A_1) of the more rapidly disappearing pool were then determined by linear regression. Nitrogen pool sizes were estimated from the anti-logarithm of the intercepts and were set equal to one (i.e., $A_1+A_2=1$). The time required for one-half of the N to disappear from each pool was estimated as .693/rate of N disappearance (i.e., slope).

Ruminal N disappearance (RD) of wheat forage was estimated using the equation of Broderick and Craig (1980) where:

$$RD = ((A_1*K_1)/(K_p+K_1)) + ((A_2*K_2)/(K_p+K_2))$$ where

K_p represents rate of passage obtained from the concurrent site and extent of digestion trials using ytterbium-labeled wheat forage.

In each grazing period, rumen fluid samples were obtained approximately 3 hours after supplements were offered and the steers were returned to pasture. Samples were subsequently analyzed for ammonia by the MgO distillation procedure. Triplicate hand clipped wheat forage samples were also taken to characterize forage composition. Clipped forage samples were immediately frozen by suspension over liquid nitrogen, and were subsequently lyophilized and analyzed for total N by the Kjeldahl procedure, non-protein N (NPN) by sodium tungstate precipitation and soluble N following a 1 hour incubation in the mineral mixture (2% v/v; pH = 6.5) of the "Ohio" in vitro fermentation media (Johnson, 1969). In vitro dry matter digestibility (IVDMD) was also determined.

Results and Discussion

The chemical composition of the grazed wheat forage is shown in table 1. Differences in forage maturity were reflected in differences in crude protein and IVDMD. With increasing forage maturity mean crude protein content decreased by 85% (23.7 vs 12.7%) while IVDMD decreased by 12.4% (79.1 vs 70.3%). These differences were most likely due to the decreased proportion of leaf-to-stem and the increased content of

Table 1. Chemical composition of grazed wheat forage during the immature and mature stages of forage growth.

	Year 1		Year 2		Year 3		
Forage maturity:	Immature	Mature	Immature	Mature	Immature	Mature	SEM[a]
Dry matter (DM), %	23.30	27.06	24.76	28.32	27.68	24.85	.51
Soluble carbohydrate, % of DM	31.48	34.70	15.87	19.65	30.24	21.43	1.98
Crude protein, % of DM	24.44	13.19	27.19	11.38	19.31	13.75	1.39
Nitrogen, % of DM							
Total N	3.91	2.11	4.35	1.82	3.09	2.20	.22
Soluble N	1.42	.98	1.71	.79	1.50	.76	.08
NPN[b]	.45	.32	.66	.37	.28	.37	.03
Soluble N, % of total N	36.19	46.29	39.22	43.70	48.52	34.22	1.19
NPN, % of total N	11.39	15.17	15.14	19.44	8.89	17.16	1.28
IVDMD[c]	76.19	65.67	76.40	64.43	84.69	80.92	1.90

[a]Standard error of the mean.
[b]Non-protein nitrogen.
[c]In vitro dry matter digestibility.

structural carbohydrates which are normally observed with advancing forage maturity. Soluble N (% of DM) decreased with advancing forage maturity and comprised from 1.42 to 1.71 and from .76 to .98% for the immature and mature forages, respectively. Nonprotein nitrogen (NPN) followed a similar trend and comprised from .28 to .66% and from .32 to .37% of DM, respectively. When these values were expressed as a percent of total N, approximately 36 to 48% of total N was soluble and NPN accounted for 9 to 19% of total N. In general, losses of N from the rumen would be expected to increase with increasing amounts of soluble N.

The main effect due to treatment (i.e., lasalocid or protein supplementation) was not significant (P>.25) in any of the three experiments for the in situ data. Therefore, the data were pooled across treatments. Visual examination of the data of figures 1 and 2 and significant (P<.05) lack of fit tests revealed that two distinct N pools were present in wheat forage. In immature wheat forage, different rates of N disappearance were obtained between 4 and 24 hr and 24 and 60 hr while in mature wheat forage, different rates of disappearance were obtained between 4 and 12 hr and 12 and 60 hr. For immature wheat forage, 73.9% of total N disappeared at a fractional rate of 17.5 %/hr which was greater (P<.05) than the second N pool (26.1% of total N) which disappeared at the rate of 3.1 %/hr (table 2). With increasing forage maturity, there was a shift in the size of each N pool. In mature wheat forage the rapidly disappearing pool decreased to approxi-

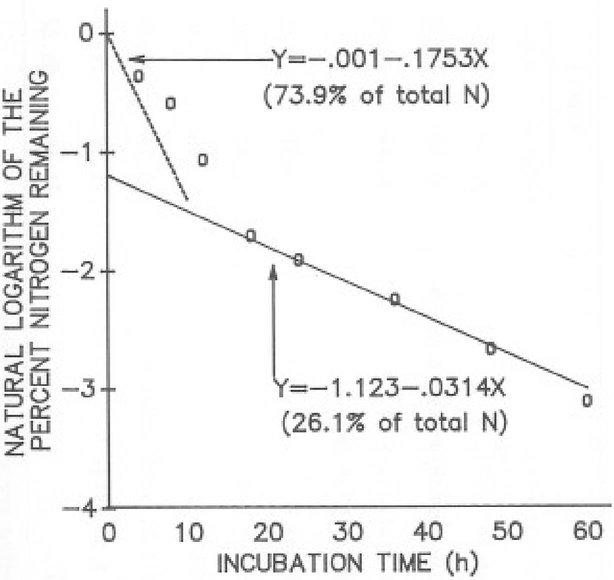

Figure 1. In situ nitrogen disappearance (O) of two nitrogen pools in immature wheat forage.

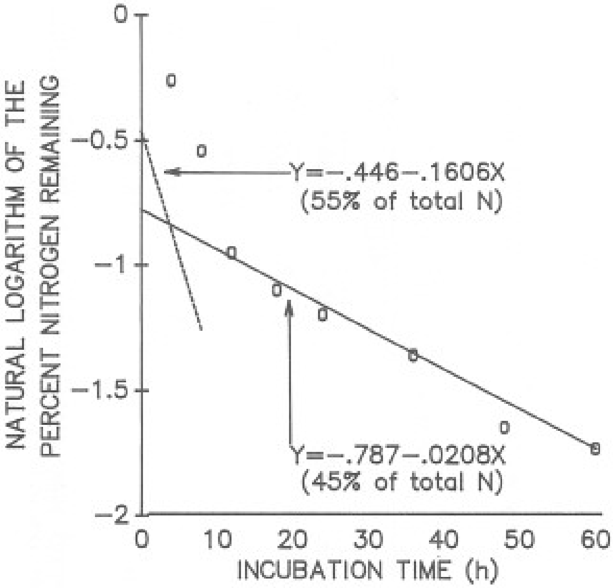

Figure 2. In situ nitrogen disappearance (O) of two nitrogen pools in mature wheat forage.

mately 55% of total N. However, this pool was still larger (P<.10) than the less soluble N pool. Nevertheless, the fractional rate of disappearance for the more rapidly disappearing pool in mature wheat forage was 8-fold greater (P<.05; 16.1 vs 2.1 %/hr). Similar results have been reported by Zorrilla-Rios et al. (1985a) who reported that 50 to 75% of wheat forage N disappeared at rates of 13 to 28 %/hr.

Estimates of ruminal N disappearance indicated that approximately 69.6% of the N present in immature forage was degraded ruminally (table 2) while ruminal disappearance decreased (P<.05) to 56.8% with advanced maturity. Similar values were reported by Zorrillo-Rios et al. (1985b) who reported that true rumen N disappearance was 72.2 and 44.6% for immature and mature wheat forage, respectively.

Ruminal ammonia concentrations of steers are presented for each year in table 3. Rumen ammonia concentrations were highly variable and ranged from 65.44 to 7.40 mg/dl. The value for immature forage of year 1 is atypically high, and an explanation for the value is not apparent. Except for year 3, ammonia concentrations decreased (P<.05) with advancing maturity.

These data indicate that wheat forage protein is very rapidly degraded in the rumen, and that large quantities of dietary N may not reach the small intestine because of loss of ammonia-N from the rumen that is not incorporated into microbial protein. Performance of rapidly growing cattle on wheat pasture may be improved by feeding protein supplements of low ruminal degradability which may compensate for the N lost from the forage during fermentation.

Table 2. Kinetics of nitrogen disappearance and in situ ruminal degradability of wheat forage in steers grazing wheat pasture of two stages of maturity.

	Stage of forage maturity					
	Immature			Mature		
Item	4-24 h	24-60 h	SEM[a]	4-12 h	24-60 h	SEM[a]
Rate of N disappearance, %/hr	17.53[b]	3.14[c]	1.01	16.06[b]	2.08[c]	1.38
N pool size, %	73.87[b]	26.13[c]	2.23	55.21[d]	44.79[e]	4.22
Half-life of N pool, hr	4.48[b]	25.63[c]	1.87	6.16[b]	40.33[c]	2.56
Ruminal degradability of N, %		69.57[f]			56.75[g]	1.93

[a]Standard error of the mean.
[b,c,d,e]Means in the same row within forage maturity with different superscipts differ: bc (P<.05); de (P<.10).
[f,g]Means in the same row with different superscripts differ (P<.05).

Table 3. Rumen ammonia concentrations (mg/dl) in steers grazing wheat pasture of two stages of maturity.

Item	Forage maturity		
	Immature	Mature	SEM[a]
Year 1	65.94^{b}	10.21^{c}	1.77
Year 2	29.64^{b}	7.40^{c}	2.60
Year 3	19.95^{c}	36.10^{b}	3.59
Mean	37.17^{b}	18.24^{c}	1.64

[a]Standard error of the mean.
[a,b]Means in the same row with different superscripts differ ($P<.05$).

Literature Cited

Broderick, G.A. and W.M. Craig. 1980. Effect of heat treatment on ruminal degradation and escape, and intestinal digestibility of cottonseed meal protein. J. Nutr. 110:2381.

Horn, G.W. et al. 1987. Effect of inclusion of high protein feedstuffs in supplements on stocker cattle performance on wheat pasture. Oklahoma. Agr. Exp. Sta. Res. Rep. MP-119:222.

Johnson, R.R. 1969. Techniques and Procedures in Animal Science Research. p. 175.

Lee, R.W. 1985. Bypass protein supplementation for cattle grazing wheat pasture. Kansas Cattle Feeders Day. Report of Progress 474. p. 7.

Shipley, R.A. and R.E. Clark. 1972. Methods for In Vivo Kinetics. pp 21-44. Academic Press, NY.

Zorrilla-Rios, J. et al. 1985a. In situ disappearance of dry matter and nitrogen of wheat forage, corn gluten meal, cottonseed meal and soybean meal in steers grazing wheat pasture at two stages of forage maturity. Oklahoma Agr. Exp. Sta. Res. Rep. MP-117:169.

Zorrilla-Rios, J. et al. 1985b. Effect of stage of maturity of wheat pasture and lasalocid supplementation on intake, site and extent of nutrient digestion by steers. Oklahoma Agr. Exp. Sta. Res. Rep. MP-117:175.

THE EFFECT OF ADVANCING SEASON ON FORAGE DIGESTION AND RUMINAL FERMENTATION IN CATTLE GRAZING ON TALLGRASS PRAIRIE

R.R. Campbell[1] and F.T. McCollum[2]

Story in Brief

Fistulated beef steers grazing native tallgrass prairie were used to monitor diet quality and ruminal digestion during four trials in the 1986 grazing season (May-September). Diet crude protein decreased from 12.23% in mid-May to 7.53% in late September. Acid detergent fiber and neutral detergent fiber ranged from 42.92 to 47.6% and from 74.48 to 81.22%, respectively. Potential dry matter disappearance and nitrogen disappearance decreased from 74.5 and 57.6% in mid-May to 72.6 and 39.1% in late September. The combined effects of reduced dietary protein and reduced nitrogen disappearance lowered ruminally digestible protein from 8.10% in mid-May to 2.74% in September. Ruminal ammonia concentration (mg/100ml) ranged from 7.09 in mid May to 2.18 in late September. However, cotton string digestibility did not vary significantly among trials suggesting that the decline in ruminal digestibility of grazed forage associated with advancing season is due to indigestible forage constituents rather than ammonia deficiencies in the rumen.
(Keywords: forage quality, digestion, fermentation, rangeland)

Introduction

The influence of advancing season on growth and nutritive value of range plants in relation to daily requirements of grazing animals is well noted. However, information concerning the relationship between diet quality, ruminal environment and nutrient utilization in grazing cattle is limited. A more complete understanding of these relationships will aid the development of nutrition and grazing management programs that will improve the efficiency of livestock production from these areas.

In 1986, a two year study was initiated to investigate the seasonal changes in diet quality, forage intake and nutrient utilization that occur on tallgrass prairie in central Oklahoma. A portion of this study is discussed in this report.

Methods and Procedures

Cattle were grazed on moderately-stocked native range located 12 miles WSW of Stillwater. Range condition on the area was high fair-low excellent and the vegetation was dominated by big bluestem, little bluestem and switchgrass.

Four 7-day trials were conducted: mid-May(May), late June(LJune), mid-August (MAug) and late September (LSept) of 1986. Diet samples were obtained from esophageally fistulated steers the first two days of each trial and during two interim periods: early June (EJune) and early September (ESept). Masticate samples were dried in a forced air oven at 50C, ground through a 2mm screen and stored for analysis of crude

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protein (CP), neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Six ruminally cannulated beef steers composed of Angus X Hereford and Limousin X Hereford breeding were used to monitor ruminal fermentation. Ruminal fluid was collected at 0800, 1400 and 2000 hours on day 6, and 0200 hours on day 7 of each trial. Fluid was strained through cheesecloth, acidified and immediately frozen in plastic whirlpaks.

Ruminal dry matter (DMD) and nitrogen disappearance was estimated by suspending duplicate dacron bags containing 2g (as-is) esophageal masticate in the rumen for intervals of 72, 48, 36, 24 and 12 hours. Duplicate bags containing .5g of cotton string were also incubated for 72, 48, 36 and 24 hour to monitor ruminal cellulose disappearance. All bags were removed from the rumen simultaneously, washed with water until effluent ran clear and were dried at 55C for 48 hours. Residual forage was removed from the bags and analyzed for dry matter and kjeldahl nitrogen (N). Strings were removed from bags, washed clean, placed in foil pans, dried at 105C and weighed to determine disappearance.

Results and Discussion

Diet protein declined from 12.24% in MMay to 8.47% in LJune and stabilized around 7.6% throughout the remainder of the grazing season (Table 1). Cell wall constituents in the diets increased from MMay to EJune and again from LJune to MAug.

In situ dry matter disappearance reflected changes in the less digestible fiber fraction, acid detergent fiber, that occurred during the summer (Tables 1 and 2). The primary differences occurred at incubation times greater than 36 hours. May and June diets were more digestible at 48 and 72 hours than either August or September diets. Assuming that digestibility approximates TDN content, energy availability in diets dropped approximately 20% from MMay to LSept.

TABLE 1. Diet components.

	TRIAL					
Component	Mid May*	Early June**	Late June*	Mid Aug*	Early Sept**	Late Sept*
Crude Protein	12.24^a	9.86^b	8.47^c	7.63^c	7.79^c	7.53^c
Acid Detergent	42.92	45.81	43.81	44.91	47.01	47.60
Neutral Detergent	76.23^a	78.34^b	78.59^b	81.21^c	81.22^c	74.48^a

^{a,b,c}Means within row with different subscripts differ significantly (P<.05).

* Diets samples taken during ruminal digestion trials.

**Diet samples taken during interim periods do not correspond with ruminal digestion trials.

TABLE 2. In situ dry matter disappearance, %.

	TRIAL			
Hours of Incubation	Mid May	Late June	Mid Aug	Late Sept
12	30.22	29.35	33.60	30.66
24	47.97[a]	48.28[a]	44.14[ab]	38.09[b]
36	53.69	59.23	55.27	48.88
48	67.56[a]	66.39[a]	61.93[a]	54.92[b]
72	74.50[a]	75.09[a]	69.37[b]	57.61[c]

[a,b,c]Means within row with different subscripts differ significantly ($P<.05$).

Nitrogen disappearance followed a trend similar to forage DMD (Table 3). Potentially digestible nitrogen ranged from 72.6% in MMay to 39.1% in LSept. Combining values for diet protein with values for 48 hour nitrogen disappearance (Tables 1 and 3), estimated levels of digestible protein were 8.10% in MMay, 5.11% in LJune, 4.62% in MAug and 2.74% in LSept.

Ruminal ammonia concentrations, when averaged over time of day, were significantly lower in LSept than in earlier periods (Figure 1). Previous research has suggested that ruminal microbes require between 2 and 5 mg NH_3-N/100 ml rumen fluid. Levels in the current study varied across this range but there were no differences in ruminal cotton string disappearance (Table 4). This suggests that ruminal fiber digestion was limited by structural changes in the dietary fiber rather than an ammonia deficiency in the rumen.

Table 3. In situ nitrogen disappearance, %.

	TRIAL			
Hours of Incubation	Mid May	Late June	Mid Aug	Late Sept
12	18.65[a]	24.21[b]	35.11[c]	21.13[ab]
24	42.28[a]	38.79[a]	40.84[a]	17.08[b]
36	48.85[a]	52.71[a]	53.07[a]	31.82[b]
48	66.18[a]	60.29[a]	60.57[a]	36.42[b]
72	72.59[a]	72.12[a]	64.98[b]	39.10[c]

[a,b,c]Means within row with different subscripts differ significantly ($P<.05$).

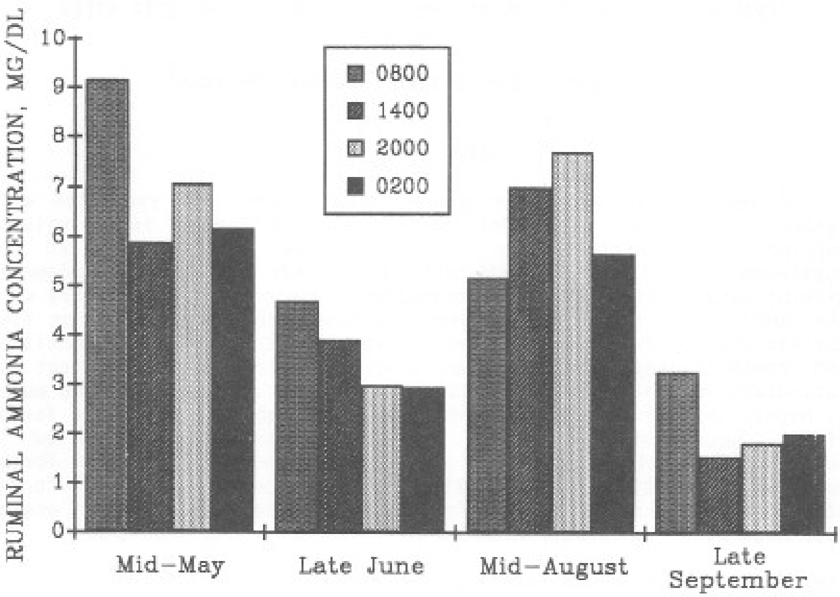

Figure 1. Ruminal ammonia concentration, mm/100 ml.

TABLE 4. In situ cellulose disappearance, %.

Hours of Incubation	TRIAL			
	Mid May	Late June	Mid Aug	Late Sept
24	17.70	20.19	18.71	19.34
36	32.14	37.27	39.73	38.67
48	52.05	53.14	49.43	62.49
72	84.27	81.84	76.13	85.28

In previous OSU studies, feeding high protein supplement in July, August and September improved weight gain .3-.4 lb/day. Our preliminary results suggest that improved gains result from correcting a protein deficiency for the steers rather than correcting a ruminal ammonia deficiency. Further analysis will evaluate a second year of data including the relationship between nitrogen intake and protein available in the small intestine.

EVALUATION OF A FEED INTAKE MODEL FOR THE GRAZING BEEF STEER

J.C. Hyer[1], J.W. Oltjen[2] and M.L. Galyean[3]

Story in Brief

A feed intake model for grazing beef steers was evaluated with respect to changes in model parameters and forage input values. Supplementation effects on forage intake were quantified by supplementing all forage diets with 2.2 pounds of a corn supplement. Without supplements, systematic underprediction of the model occurs with low quality forages and subsequent overprediction is observed on high quality diets. Model behavior was insensitive to microbial composition and growth parameters. Intake was sensitive to changes in nutrient use parameters for fiber and insensitive to protein and starch. The model is highly sensitive to the amount of non-degradable fiber in the forage diet. Supplementation of the forage diet with energy resulted in substitution ratios consistent with literature results. As forage quality increased, greater substitution of concentrate for the forage occurs. The model correctly predicts the effects of energy supplementation on forage intake.

(Key Words: Feed Intake, Grazing Beef Steer)

Introduction

Several approaches to predict feed intake of feedlot cattle have been successfully developed (Plegge and Goodrich, 1987). Most approaches for pen-fed cattle have used regression relationships and applied adjustment factors to predict results. The lack of knowledge of the plant-animal interface has resulted in a deficiency in the literature regarding models that can be used to predict intake of grazing cattle. For grazing cattle, animal factors such as body weight, physiological state and ruminal fill interact with forage quality to determine feed intake. Because of the extensive variation associated with forage type and quality, most regression relationships can only be applied to the forage condition for which they were developed. Previous work by the authors described the primary equations and conceptual basis of a mathematical model to predict feed intake of the grazing beef steer (Hyer et al., 1988).

If a mechanistic model is to be used with confidence, it must meet two criteria: it must accurately predict animal response (i.e. feed intake) and appropriately represent the biology of the function being studied (i.e. supplementation effects on fermentation in the rumen). The objective of this work was to evaluate the feed intake model for the grazing steer and determine if model behavior is in agreement with validated biological concepts which influence intake.

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Materials and Methods

Parameters of a dynamic feed intake model (Hyer et al., 1988) for grazing cattle were estimated using 42 data points representing a broad range of forage composition (Table 1). Criteria used to select reference data points included complete forage quality information and ad libitum grazed intake measurements. Twenty-four of the data points were native grasses, 4 wheat pasture, and 12 perennial ryegrass. Sensitivity analysis of rate constants, model parameters and forage input values was accomplished using the simplex fitting procedure described by Nelder and Mead (1965). Literature values were used to determine the range of analysis for each parameter estimate and nutrient input. Supplementation of each of the reference data points was accomplished using rolled corn (1 kg) as an energy supplement.

Results and Discussion

A plot of the predicted versus observed intake and the fitted regression line is illustrated in Figure 1. The relationship between residual intake (observed-predicted) and the dietary non-degradable fiber, DNBH, indicates that systematic underprediction occurs on lower quality diets and overprediction is apparent with higher quality forages (Figure 2).

Sensitivity of the model for each of the parameter values and rate constants was tested. In general, intake was insensitive to small changes in microbial growth and composition parameters. Figure 3 demonstrates the sensitivity of the microbial nutrient use rate constants for starch (KAH), fiber (KBH) and protein (KPROT). Parameter estimates used in the model were .407, .460 and .262, respectively. Intake is insensitive to changes in KAH and KPROT over a wide range of parameter values. However, model behavior was highly sensitive to changes in KBH below the reference level of .460.

The fibrous fraction of the forage is most highly related to the filling effect in the rumen. Sensitivity of the model to the diet non-degradable fiber is shown in Figure 4. Intake is sensitive to the percent of DNBH over the entire range tested.

Table 1. **Description** of **nutrient composition** (%) of 42 forages.

Item	AH[1]	BH	NBH	NPROT	PROT	NPN	WSC
Mean	3.6	48.0	13.0	2.0	10.6	2.2	11.9
Standard deviation	2.8	5.2	4.6	.7	4.2	1.7	7.1
Minimum	.8	33.6	5.9	1.1	3.1	.9	2.3
Maximum	9.7	55.4	18.5	3.9	19.6	9.4	28.3

[1]AH is alpha hexose, BH is degradable beta hexose, NBH is non-degradable beta hexose, NPROT is non degradable protein, PROT is degradable protein, NPN is non-protein nitrogen, WSC is water soluble carbohydrate.

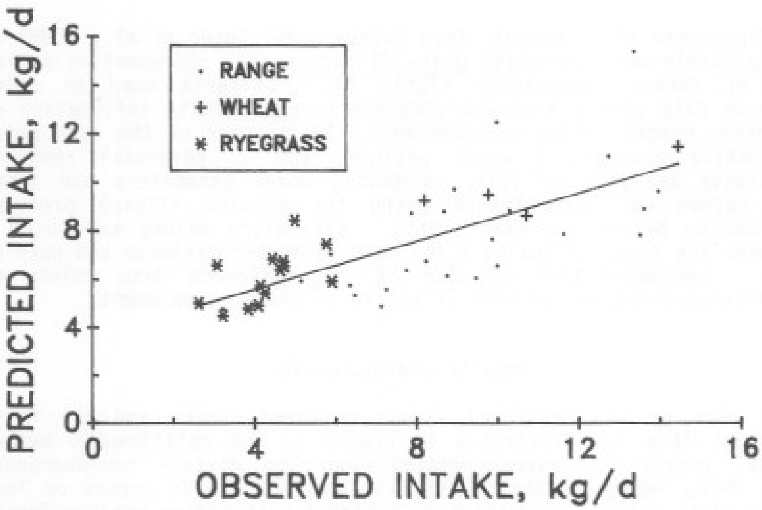

Figure 1. Model predicted versus observed forage intake.

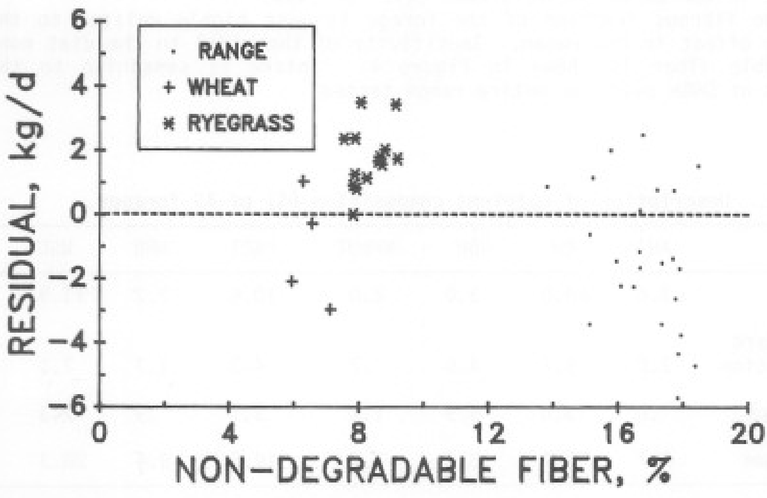

Figure 2. Residual intake (observed - model predicted) versus dietary non-degradable fiber.

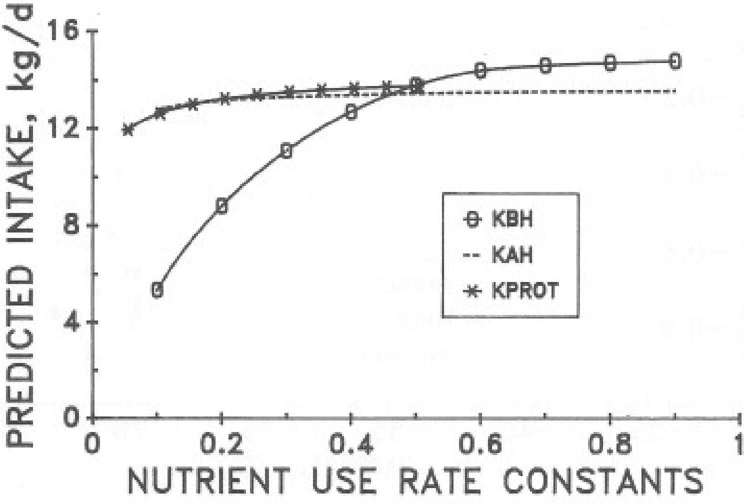

Figure 3. Sensitivity of model predicted forage intake to microbial use rate constants for fiber (KBH), starch (KAH) and protein (KPROT).

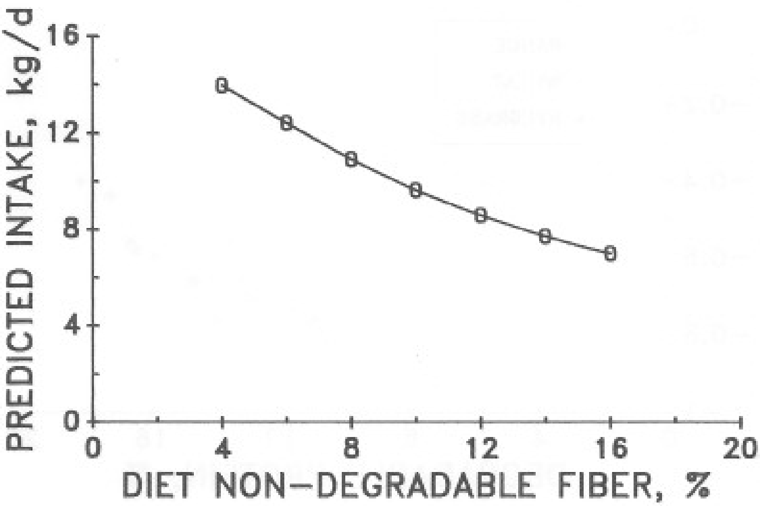

Figure 4. Sensitivity of model predicted forage intake to dietary non-degradable fiber.

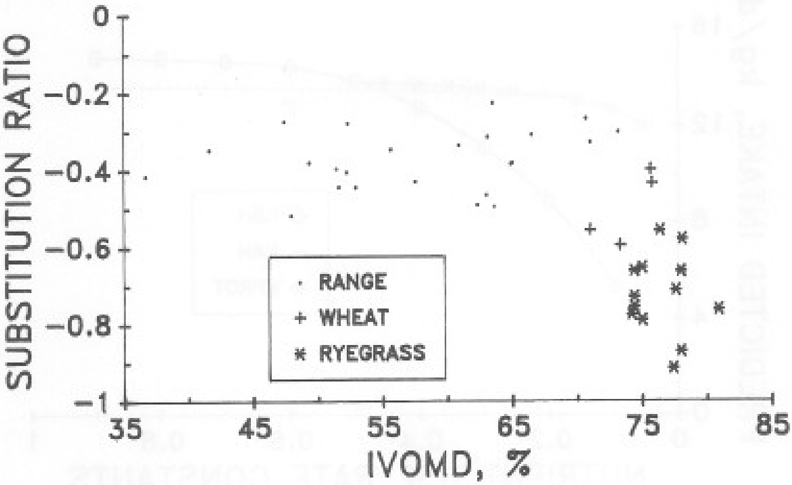

Figure 5. Change in model predicted forage intake (substitution ratio, kg forage/kg corn supplement) for forages of different in vitro organic matter digestibility (IVOMD).

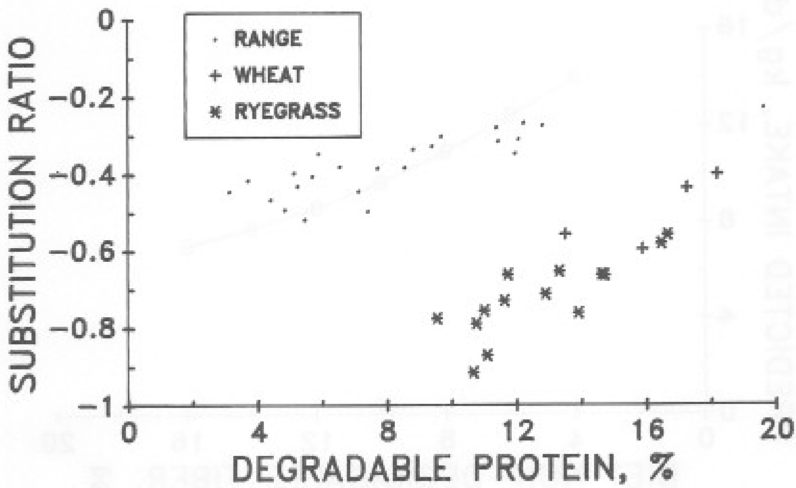

Figure 6. Change in model predicted forage intake (substitution ratio, kg forage/kg corn supplement) for forages of different degradable protein content.

Horn and McCollum (1987) found that the substitution effect of concentrate supplements on forage intake for both cattle and sheep become more pronounced (i.e. ratios become more negative) as forage digestibility increases. Supplementation of the 42 forage data points with 1 kg corn resulted in substitution effects consistent with literature values (Figure 5). Substitution ratio is equal to the model predicted intake with 1 kg corn minus the predicted intake without the supplement. As forage in vitro organic matter digestibility (IVOMD) increases above 65%, substitution ratios become more negative. The relationship between substitution effects and degradable protein in the forage (Figure 6) indicates that at higher levels of available protein (12 to 16%) greater substitution of concentrate for higher quality forage occurs.

Initial results with energy supplementation indicate that the model responds favorably regarding fermentation changes that occur by adding small amounts of concentrate to the forage diet. The systematic errors observed for unsupplemented diets may be a reflection of forage type and source of data.

Literature Cited

Nelder, J.A. and R. Mead. 1965 A simplex method for function minimization. Comp. J. 7:308.

Hyer, J.C. et. al. 1988. Mathematical simulation of feed intake by grazing beef cattle. Okla. Agr. Exp. Sta. MP-125:64.

Horn, G.W. and F.T. McCollum. 1987. Energy supplementation for grazing ruminants. In: Proc. Grazing Livestock Nutrition Conference. pp. 125-133. Jackson, Wyo.

Plegge, S.D. and R.D. Goodrich. 1987. Intake equations for feedlot cattle. Okla. Agric. Exp. Sta. MP-121:232.

A RUMINAL FILL MODEL TO PREDICT FORAGE INTAKE OF CATTLE GRAZING NATIVE RANGELANDS

M. L. Galyean[1] and J. W. Oltjen[2]

Story in Brief

A model with a limited number of commonly measured dietary inputs was developed to predict forage intake in cattle grazing native rangeland. Intake was considered to be limited by the ruminal fill of potentially digestible (PDNDF) and indigestible (INDF) neutral detergent fiber. The ruminal pool of PDNDF was assumed to disappear by digestion (rate constant k_d) and passage (rate constant k_p). The INDF pool disappears only by passage (k_p). A pool of potentially degradable nitrogen was used to adjust k_d and ruminal fill. Intake predictions from the model support the hypothesis that ruminal NDF fill is an important intake control mechanism in grazing ruminants. Although the model responded to protein supplementation in an expected manner, the magnitude of increased intake with protein supplementation was small and less than expected.

(Key Words: Digestion Models, Forage Intake, Neutral Detergent Fiber)

Introduction

Recent New Mexico studies (Krysl et al., 1987) suggested that the fill of non-digested dry matter in the gastrointestinal tract of cattle grazing blue grama rangeland was fairly constant across the year. These results can be interpreted to suggest that ruminal fill is an important factor in the long-term control of forage intake by grazing cattle. Previously, Hyer and Oltjen (1987) evaluated a dynamic rumen model and found the model to be sensitive only to degradable and non-degradable beta-hexose and nitrogen inputs. A potential problem with this previous model is that data for dietary inputs required by the model are not available on many forages, particularly native range forages that would be important in stocker programs. Moreover, while the model responded to carbohydrate (grain) supplementation in an expected manner, it did not adequately predict the response to protein supplementation. The nitrogen (N) content of forages is an important factor affecting digestion. Supplementation of N to high-fiber forages that are low in N content results in increased intake and associated changes in digestion and passage (McCollum and Galyean, 1985). Based on the model of ruminal cellulose digestion proposed by Waldo et al. (1972), we report herein a new model that was devised with simple and commonly measured dietary inputs.

Materials and Methods

Basic features of the model are depicted in Figure 1. Neutral detergent fiber (NDF) was chosen as a major input variable because of

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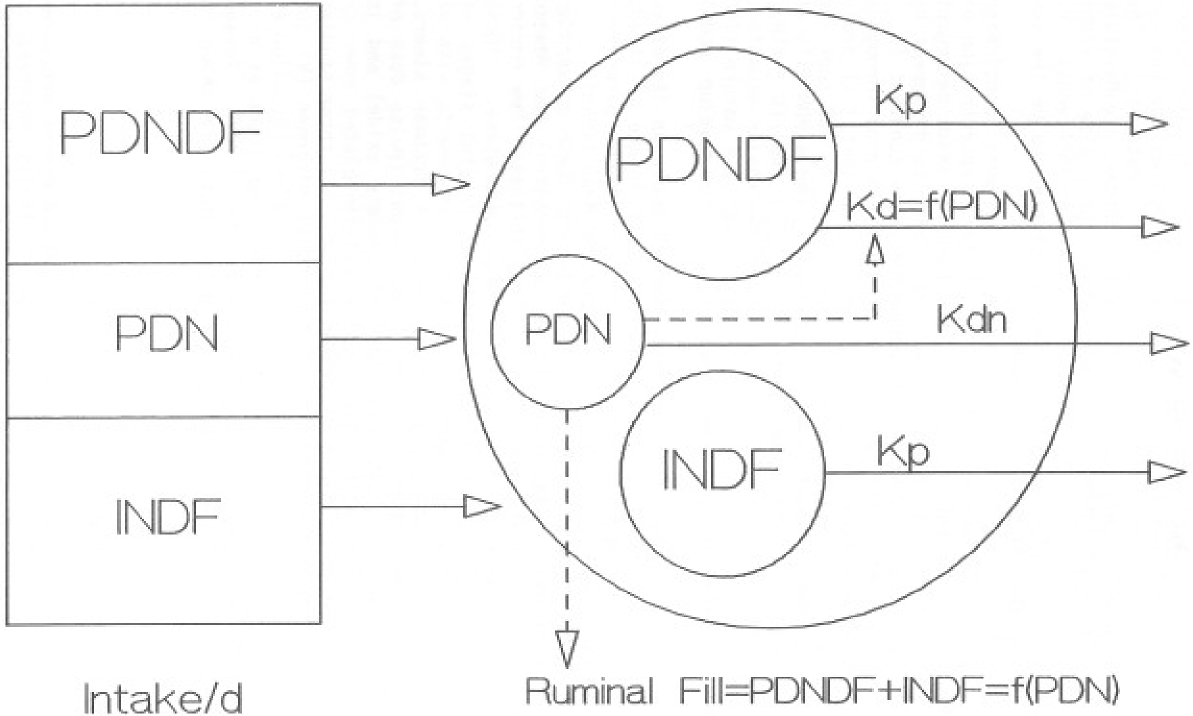

Figure 1. Schematic representation of the ruminal fill model. PDNDF is potentially digestible neutral detergent fiber (NDF), INDF is indigestible NDF and PDN is potentially degradable nitrogen. Rate constants are designated by k and functions are designated by f().

the feed constituents commonly measured, NDF is the most highly related to the fill effect of the diet (Mertens, 1987). Conceptually and analytically, NDF can be considered to consist of fractions that are potentially digested (PDNDF) and indigestible (INDF) in the rumen. Potentially digested NDF can leave the rumen by two routes: by passage at a specific rate (k_p) and by digestion at a specific rate (k_d). The INDF fraction disappears only by passage (k_p). Under steady-state conditions, the intake of PDNDF equals the fill or pool size of PDNDF multiplied by the sum of k_p and k_d. Likewise, intake of INDF equals the pool size multiplied by k_p. Ruminal fill was considered to be the sum of PDNDF and INDF pools divided by body weight.

In the model, k_d of PDNDF and ruminal fill were considered functions of potentially degradable N (PDN). Dietary concentration of PDN was defined as percent total N minus percent acid detergent insoluble N. The PDN pool in the rumen was considered to disappear by passage and digestion, and a combined disappearance rate constant (k_{dn}) was set at .07 h^{-1}. Ruminal fill was adjusted by the PDN pool through a simple linear regression equation with the restriction that fill could not exceed 15 g/kg of body weight. The adjustment of k_d by PDN took the form of a Michaelis-Menten equation with a maximum k_d and a PDN fill at half maximal k_d (k), such that k_d was equal to (k_{dmax} x PDN)/(k + PDN). Values for k_p in the model were scaled by a linear regression equation, such that k_p was adjusted relative to the mean intake by a mature (750 kg) steer of all the native range forages used to develop model parameters.

Given the maximal fill calculated from the PDN pool, an iterative procedure was used to determine forage organic matter intake at steady state after 3 days (integration interval .02 day). Model parameters were estimated using the simplex method of Nelder and Mead (1965).

Data from three studies conducted at New Mexico State University with steers grazing blue grama rangeland in south-central New Mexico (McCollum et al., 1985; Krysl et al., 1987) and northeast New Mexico (Funk et al., 1987) were used to develop model parameters. These studies provided 24 intake estimates, obtained at varying stages of forage growth and maturity, that were averages of measurements with at least four Hereford x Angus or Hereford x Angus x Brahman steers. Organic matter intake was determined from fecal output (pulse dose of ytterbium-labeled forage or continuous dose of chromic oxide) and in vitro organic matter indigestibility. Esophageal-fistulated cows or steers were used to collect samples of grazed forage. All three studies measured forage neutral detergent fiber (NDF), total nitrogen (N) and acid detergent insoluble N. Either in vitro 48-h digestion (McCollum et al., 1985; Krysl et al., 1987) or in situ 72-h digestion (Funk et al., 1987) were used to estimate potential degradeability of NDF. Forage composition and intake estimates for the 24 data points are shown in Table 1.

Results and Discussion

Parameter estimates and their asymptotic standard errors are shown in Table 2. All estimates were within ranges typically observed in experiments that have measured digesta kinetics in grazing cattle. Error sum of squares was 34.71, indicating forage organic matter intake could be predicted with a standard error of 1.4 kg (.37% body weight). Actual vs predicted forage intake is shown in Figure 2. Although substantial over- and under-estimations were apparent for a few points,

Table 1. Steer body weights, forage organic matter intake and nutrient composition for the data points used in development of the model.

Body wt, kg	Organic matter intake, kg	Percent of organic matter PDNDF[a]	INDF	PDN	Stage of growth[b]
221.0	2.97	30.05	52.35	.87	D
270.0	6.48	49.81	25.09	2.56	G
293.0	5.89	47.83	27.97	2.40	G
307.0	5.34	36.07	33.83	1.54	G
342.0	7.14	31.09	33.81	1.20	ED
308.0	4.68	33.78	47.42	1.33	D
385.0	7.09	37.59	41.21	2.50	G
413.0	10.57	49.15	31.55	1.80	G
411.0	7.89	39.57	36.23	1.30	ED
425.0	8.12	41.32	36.78	.70	D
505.0	12.37	60.98	22.32	1.90	G
541.0	11.58	49.27	26.53	1.70	G
620.0	12.15	44.36	26.84	1.00	ED
374.0	8.60	42.99	24.71	4.10	G
392.0	8.98	40.37	32.23	2.40	G
396.0	7.48	41.53	37.87	2.30	ED
433.0	9.33	36.73	37.77	1.30	D
471.0	12.29	57.20	23.70	2.50	G
512.0	12.70	57.08	23.32	1.90	G
585.0	9.08	39.48	37.32	1.10	ED
232.2	5.78	44.54	23.56	1.60	G
248.8	6.59	50.83	28.97	1.10	SD
271.9	7.04	52.23	26.67	.94	SD
296.1	7.97	52.73	26.57	1.58	G

[a]PDNDF is potentially digestible neutral detergent fiber (NDF), INDF is indigestible NDF and PDN is potentially degradable nitrogen.

[b]Stage of forage growth: G is growing, ED is early dormancy, D is dormancy and SD is summer dormancy (drought).

which increased the fitted sum of squares, the model reasonably fit most observations. It is important to also consider that the actual forage intake observations are subject to substantial error because of the techniques used to measure fecal output and forage indigestibility (Galyean et al., 1987). Thus, these results support the hypothesis that ruminal fill of NDF is a major factor regulating intake of native range forage.

Supplemental feeds, particularly protein meals and grains, are often provided to grazing cattle. As developed, the model would not be sensitive to fermentable carbohydrate (grain) supplementation. However, the PDN component of the model should allow prediction of intake responses to the provision of protein supplements. To test the ability of the model to respond to protein supplementation, iterations were performed with or without inclusion of 1 kg of cottonseed meal. This level of supplementation has been shown to increase intake and rate of passage in steers fed prairie hay similar in composition to many of the range forages used in the present data set (McCollum and Galyean, 1985). Changes in forage intake with cottonseed meal supplementation relative to basal forage PDN are shown in Figure 3. The model responded in an

Table 2. Parameter equations and estimates (± standard errors) developed with the 24 data points.

Equation[a]	Parameter estimate
$k_d = (PDN \times k_{dmax}) / (k + PDN)$ where PDN is the potentially degradable N pool (g)	k_{dmax} = .044 ± .004 k = 17.7 ± 1.1
$k_p = k_{pp} \times (bk_0 + bk_1 \times OMI/(16584 \times BW/750))$ where bk_0 is $(1-bk_1)$, OMI is organic matter intake (kg) and BW is body weight (kg)	k_{pp} = .033 ± .002 bk_1 = .19 ± .04
$RFBW = b_0 + b_1 \times (PDN \times k_{dn} \times 24)$ where k_{dn} is .07 h^{-1}	b_0 = 13.59 ± 1.13 b_1 = .0019 ± .0003

[a] k_d is rate of digestion (h^{-1}), k_p is rate of passage (h^{-1}) and RFBW is ruminal neutral detergent fiber fill/body weight (g/kg).

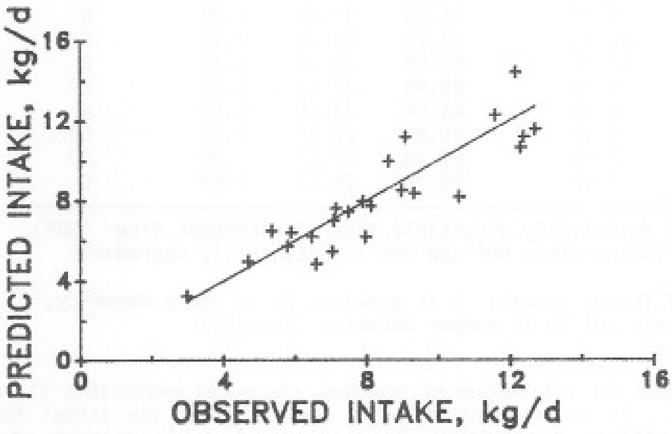

Figure 2. Organic matter intake versus model-predicted intake. The solid line represents the ideal situation of perfect agreement between actual and predicted data.

appropriate manner, in that forages low in PDN showed the greatest increase in intake with supplemental cottonseed meal, and forages adequate in PDN showed little change. However, increases in intake with supplementation were much lower than expected, rarely exceeding 5%.

Based on observations in the literature, one might expect intake of forages with less than 1% PDN to increase by 20% or more with protein supplementation. Additional parameters may be needed in the model to account for the positive effects that protein supplementation has on ruminal digestion and passage of NDF. Conversely, intake changes with protein supplementation may result in part from metabolic changes

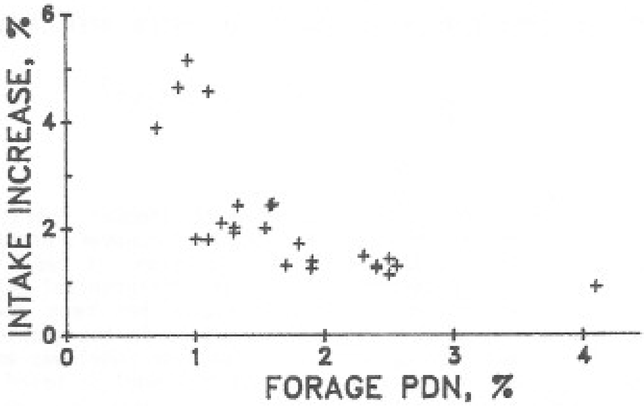

Figure 3. Increase in model-predicted intake with supplementation of 1 kg of cottonseed meal (CSM) versus potentially degradable nitrogen (PDN) content of the forage.

associated with postruminal protein supply that are not accounted for adequately by a ruminal model. Further evaluation of the model with regard to protein supplementation is needed.

In general, these results suggest a simple model based on fill of potentially digestible and indigestible NDF can be used to predict forage intake of cattle grazing native rangelands. Further work with the model will involve the use of forage intake estimates from other locations in an effort to assess its general potential for predicting forage intake.

Literature Cited

Funk, M.A. et al. 1987. Steers grazing blue grama rangeland throughout the growing season. I. Dietary composition, intake, digesta kinetics and ruminal fermentation. J. Anim. Sci. 65:1342.

Galyean, M.L. et al. 1987. Marker-based approaches for estimation of fecal output and digestibility in ruminants. Okla. Agr. Exp. Sta. MP-121:96.

Hyer, J.C. and J.W. Oltjen. 1987. Evaluation of a dynamic rumen model for prediction of forage intake of grazing ruminants. Okla. Agr. Exp. Sta. MP-119:243.

Krysl, L.J. et al. 1987. Digestive physiology of steers grazing fertilized and non-fertilized blue grama rangeland. J. Range Mgmt. 40:493.

McCollum, F.T. and M.L. Galyean. 1985. Influence of cottonseed meal supplementation on voluntary intake, rumen fermentation and rate of passage of prairie hay in beef steers. J. Anim Sci. 60:570.

McCollum, F.T. et al. 1985. Cattle grazing blue grama rangeland. I. Seasonal diets and rumen fermentation. J. Range Mgmt. 38:539.

Mertens, D.R. 1987. Predicting intake and digestibility using mathematical models of ruminal function. J. Anim. Sci. 64:1548.

Nelder, J.A. and R. Mead. 1965. A simplex method for function minimization. Comp. J. 7:308.

Waldo, D.R. et al. 1972. Model of cellulose disappearance in the rumen. J. Dairy Sci. 55:125.

MATHEMATICAL SIMULATION OF FEED INTAKE BY GRAZING BEEF CATTLE

J.C. Hyer[1], J.W. Oltjen[2] and M.L. Galyean[3]

Story in Brief

Various computer programs are available to stocker operators to assist in economic decisions about stocker cattle. However, accuracy of economic forecast is limited by imprecise predictions of feed intake, affecting weight gains. The conceptual basis and differential equations of a mathematical model to predict forage intake has been developed which can account for the effect of supplementation in the grazing beef steer. A previously evaluated dynamic rumen function model was employed as the fermentation component of the model and the model is based on the assumption that forage intake by the grazing ruminant is limited by rumen fill. Mathematical equations that describe nutrient utilization, synthesis and passage are described.

(Key Words: Mathematical Model, Forage Intake, Stocker Cattle)

Introduction

Considerable evidence exists which suggests that feed intake of cattle grazing predominantly forage based diets, below 66% in digestibility is limited by the capacity of the reticulo-rumen and the rate of clearance from this organ (Conrad, 1966; Ellis, 1978). This implies that rate of passage, rate of digestion and ruminal fill are important factors regulating feed intake. When supplements are added to a forage diet, changes in forage intake occur due to changes in digestion and passage associated with the additional nutrients. Because of the complexity of the interaction between the supplement and forage, simple regression relationships are inadequate to define relationships beyond the range of data for which the relationship is developed.

Previously, a dynamic rumen model was evaluated to determine its potential use in predicting intake of grazing ruminants and accounting for supplementation affects on forage intake. The model responded appropriately with regard to energy supplementation. Therefore, the structure of the rumen model has been adopted as the fermentation component of a feed intake model for beef cattle. The work presented here is based on the hypothesis that rumen fill governs intake for cattle consuming forage based diets. This mechanistic approach to control of forage intake should be adaptable to various supplement compositions and different forage types. A description of differential equations used in the model are described.

Materials and Methods

The dynamic model of rumen function (France et al., 1982) was utilized as the fermentation component for a feed intake model.

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Initially, the rumen model simulated a mature wether sheep (50 kg) eating a reference Italian ryegrass forage diet at 1.5% of body weight (Hyer and Oltjen, 1987). Genetic size scaling rules (Taylor, 1980) based on mature body size relationships were utilized to adjust the rate and state variables of this model to beef cattle. State variables and nutrient fractions have been described previously (Hyer and Oltjen, 1987) however, a definition of each dietary fraction is given in Table 1. To simulate the processes of digestion and passage as they occur within the rumen, nutrient fractions are partitioned into those that flow from the rumen at the particulate rate of passage (PPR) and at the liquid rate of passage (LPR) (Table 2). Those components that are rapidly solubilized flow with the faster LPR and the fibrous fractions of the feed pass out at the PPR. It was assumed that 50 percent of the microbial population flows with the liquid and 50% with the particulate phase.

It was assumed that forage intake is limited by a level of fill in the rumen. Rumen fill (RF) is considered to be the sum of the nutrient pools within the rumen. Once rumen fill is determined, an iterative procedure is used to adjust organic matter intake so that a given level of rumen fill at steady state conditions is reached. Three days are required to achieve steady state with an integration interval of .002 d.

Table 1. Principal variables used in the model.

Symbol	Description
AH	alpha hexose pool (starch)
BH	degradable beta-hexose pool (digestible cellulose)
BUG	pool of microbial matter (microbial mass)
NBH	non-degradable rumen beta-hexose (indigestible cellulose)
NPN	non-protein nitrogen pool (NPN)
NPROT	rumen non-degradable protein pool (bypass protein)
PROT	rumen degradable protein pool (degraded protein)
RV	rumen metabolic volume
WSC	water soluble carbohydrate pool (soluble carbohydrate)

Table 2. Nutrient fractions flowing with the particulate and liquid phase.

Liquid	Particulate
NPN	AH
WSC	BH
BUG[1]	NBH
	BUG[1]
	PROT
	NPROT

[1] 50% of the microbial mass flows with each phase.

Results and Discussion

A differential equation is used to describe the change of each nutrient pool. The metabolic volume of the rumen (RV, 1) is defined as the effective volume where various reactions occur within the rumen (France et al., 1982).

$$RV = 75 * (BW/MBW)$$

where BW is empty body weight (kg) and MBW is mature BW (kg). Hence, RV for a mature medium framed steer (MBW, 750 kg) is 75 1. The ratio of BW to MBW adjusts rumen volume by mature body size. This adjustment also assumes that RV increases in proportion to BW to the first power.

Over time, steady state conditions occur within the rumen:

$$dRV/dt = DV + SV - v$$

where DV and SV are rates of fluid inflow from dietary and salivary sources, respectively and v is the rate of outflow of fluid and associated digesta from the rumen. Osmotic pressure effects on absorption rates are not directly measured in the model. It was assumed that in a steady state situation over one day, osmotic pressure effects sum to zero.

Initial passage rate estimates were determined to be 4 and 10%/hour for the PPR and LPR (M.L. Galyean, personal communication). Rates of passage (ROP) were related to dry matter intake (DMI (kg/d) by a linear relationship:

$$PPR\ (\%/h) = .04 *(.25 + .75 * (DMI/DMI_{ref}))$$

$$LPR\ (\%/h) = .10 * (.50 + .50 * (DMI/DMI_{ref}))$$

where: $DMI_{ref}\ (g/d) = (BW/\ MBW * 8055)$.

Estimates for the intercept and slope of each equation were determined from literature values.

The non-degradable components of the diet in the rumen (NBH and NPROT, g/1) are undigested and must flow from the rumen:

$$dNBH/dt = 1/RV * (DNBH - NBH * PPR * 24 * RV)$$

$$dNPROT/dt = 1/RV * (DNPROT - NPROT * PPR * 24 * RV)$$

DNBH and DNPROT represent the dietary proportion (g/d) of the NBH and NPROT. The rate at which NBH and NPROT pass out of the rumen is a function of the nutrient pool (NPROT, NBH) and PPR. The remainder of the nutrient pools and the microbial population within the rumen change according to the following:

Substrate pool change = inflow - outflow + synthesis - utilization

where synthesis occurs due to the degradation of forage components by enzymes and utilization is the rate at which the microbial populations utilize nutrients (France et al., 1982). The dynamic properties of AH, DBH and DPROT (g/l) are:

dAH/dt = 1/RV*(DAH - AH * PPR * 24 * RV)-KAH * AH * BUG

dBH/dt = 1/RV*(DBH - BH * PPR * 24 * RV)-KBH * BH * BUG

dPROT/dt = 1/RV*(DPROT - PROT * PPR * 24 * RV) - KPROT * PROT * BUG

again DAH, DBH, and DPROT are dietary inputs (g/d) of AH, BH and PROT, respectively. The utilization rate of each nutrient is dependent on the quantity of available substrate in the nutrient pool (AH, BH and PROT), the concentration of the microbial population (BUG, g/l) and the rate constants for nutrient use (KAH, KBH, KPROT). Rate constants were estimated by solving the equations for a 50 kg sheep eating the reference Italian ryegrass forage at 1000 g/d. Estimates of .407, .460 and .262 were calculated for KAH, KBH and KPROT, respectively. Each rate constant was multiplied by 10 to the -.27 power to account for the differential rates between a mature wether (MBW, 75 kg) and a mature steer (Taylor, 1980).

Inputs of NPN into the animal are from the diet (DNPN), the saliva (SNPN), the degradation of degradable protein by the microbial population (DGNPN) and the non-protein nitrogen released by microbial catabolism (MCNPN). Utilization of NPN is by outflow from the rumen (ONPN) and usage by the microbial population for maintenance and growth (MGNPN):

dNPN/dt = 1/RV * (DNPN+SNPN+DGNPN - MGNPN-NPN*LPR) + MCNPN

Inflow to the soluble carbohydrate pool (WSC, g/l) can come from four sources: dietary (DWSC), degradation of AH (DGAH) and BH (DGBH) by enzymes and soluble carbohydrate released by microbial catabolic activity (MCSC). Outflow is by flow from the rumen (FWSC) and microbial growth (MGWSC):

dWSC/dt = 1/RV * (DWSC+DGAH+DGBH-FWSC-MGWSC) + MCWSC

Microbial growth (GBUG) is represented:

GBUG = U * RV * BUG

where: U= Um*1/(1+Kc/WSC+Kn/NPN+Kcn/(WSC*NPN))

which is the specific growth rate of the population dependent on the availability of NPN and WSC. Um is the maximum value of U as WSC and NPN go to infinity and Kc, Kn and Kcn are constants (France et al., 1982). When substrate is limiting for microbial growth and maintenance, microbial catabolism (DBUG) occurs:

$DBUG = \lambda * RV * BUG$

where: $\lambda = \lambda_u * 1/(1+Ku*U)$

lambda (λ) is the specific rate of catabolism per day and is a function of U and a constant (Ku), where λ_u is the maximum rate of obtained when G=0. The rate of change of the BUG:

$$dBUG/dt= 1/RV*(U*BUG+\lambda*BUG-PBUG*BUG*LPR)-1/RV*(1-PBUG)*PPR*24*BUG*RV$$

where PBUG is equivalent to the portion of the BUG that passes from the rumen according to the liquid rate of passage.

Rumen fill (RF) is determined by taking the sum of each of the nutrient and microbial pools within the rumen on a concentration basis:

$$RF= AH + BH + BUG + NBH + NPN + NPROT + PROT + WSC$$

RF was estimated using flow rates from the reference forage diet (Hyer et al., 1987).

Primary driving equations for a broad based feed intake model that quantifies supplementation effects on forage intake have been developed. Integration of digestion and passage with rumen fill parameters allows the effects of small amounts of supplements to be integrated into the model. Further work will be directed toward evaluation of the model with different forage types.

The feed intake model has application to both research and production situations. As a research tool, a conceptual basis for the quantification of energy supplementation effects on forage intake has been developed. As additional information on forage type and substitution effects becomes available, the model can be further evaluated and refined. As a production tool, the intake model can be implemented into larger cattle production models or current economic models for stocker operators.

Literature Cited

Conrad, H.R. 1966. Symposium on factors influencing voluntary intake of ruminants: physiological and physical factors limiting feed intake. J. Anim. Sci. 25:227.

Ellis, W.C. 1978. Determinants of grazed forage intake and digestibility. J. Dairy Sci. 61:1828.

France, J., et al. 1982. A mathematical model of the rumen. J. Agric. Sci., Camb. 99:343.

Hyer, J.C. and J.W. Oltjen. 1987. Evaluation of a dynamic rumen model for prediction of forage intake for grazing ruminants. Okla. Agr. Exp. Sta. MP-119:243.

Taylor, St. C. S. 1980. Genetic size-scaling rules in animal growth. Anim. Prod. 30:161.

VALUE OF WHEAT MIDDLINGS AS A WINTER SUPPLEMENT FOR FALL CALVING BEEF COWS

K.S. Lusby[1] and R.P. Wettemann[2]

Story in Brief

Forty two fall calving beef cows wintered on native range were fed Negative Control (.8 to 1.25 lb/day of soybean meal), Positive Control (2.0 to 3.0 lb/day of soybean meal) or wheat middlings (5.0 to 7.6 lb/day) fed at a level to supply the same daily protein as the Positive Control. Cows fed the Negative Control lost significantly more weight and condition than Positive Control cows. Cows fed wheat middlings tended to lose less weight and body condition than cows fed the Positive Control although differences were small. Pregnancy rates reflected differences in weight and condition loss. Only 73 percent of Negative Control cows became pregnant compared to a 93 percent pregnancy rate for Positive Control and wheat middlings cows (P<.08). Calves of Negative Control cows gained less (P<.01) weight throughout the study than calves of cows on the other two treatments. As with cow weight and condition changes, calves of wheat middlings cows tended to gain more weight than calves of Positive Control cows. Cows fed the additional energy from wheat middlings apparently gave slightly more milk as evidenced by heavier calf weights. However, cows of the Positive Control were able to meet their protein and energy requirements from the level of soybean meal fed.

(Key Words: Beef cows, Soybean meal, Wheat middlings, Winter, Native range)

Introduction

Wheat middlings are the offal of the wheat kernel after the milling process for removal of flour. About 140,000 tons of wheat middlings are available per year in Oklahoma, and are frequently used in cattle supplements. Middlings contain about 16 percent crude protein but are discounted for their relatively high (8 percent) crude fiber content. In spite of the large amount of middlings fed annually to cattle in Oklahoma, little research has been conducted to establish the nutritional value of the protein and energy in wheat middlings for beef cattle. The objective of this study was to compare winter performance of lactating, fall calving beef cows and their calves when supplemented with soybean meal or wheat middlings fed at a rate to supply the same amount of daily protein.

Materials and Methods

Forty two mature fall calving Hereford and Hereford x Angus cows were allotted to three supplemental feed treatments based on breed and weight. All calves were born from Sept. 5 to Nov. 7. Treatments were (1) soybean meal fed at 40 percent of the typically recommended level (negative control), (2) soybean meal fed at the recommended level

[1]Professor [2]Regents Professor

Table 1. Composition of supplements (% as fed).

	Treatments		
	Negative Control	Positive Control	Wheat Middlings
Ingredients,			
Soybean meal	88.8	96.3	
Wheat middlings			98.2
Dicalcium phosphate	9.4	3.7	
Limestone			1.8
Potassium chloride	1.8		
Crude protein, actual %	41.6	44.4	17.6
Feeding levels, lbs./day:			
11/11 to 12/09	.8	2.0	5.0
12/09 to 3/31	1.25	3.0	7.6

(positive control), and (3) wheat middlings fed at a level to supply the same daily protein as the positive control. Composition of supplements and amounts that were fed daily are shown in Table 1.

All cows grazed in a single pasture of dormant tallgrass native range and were gathered 6 days each week for supplement feeding in individual covered stalls. Cows and their calves were weighed at 28 day intervals after overnight withdrawal from feed and water. Supplement feeding began on Nov. 11, 1986 and ended on March 31, 1987. Prairie hay was fed only on a few days in January when snow covered the forage. One cow from the Negative Control group was removed from the study in December after she developed cancer eye. Cows were exposed by natural service to Hereford bulls from Dec. 1, 1986 to Feb 2, 1987. Pregnancy was determined by rectal palpation on April 14.

Results and Discussion

As expected, cow weight and condition losses over the total trial period were greater (P<.01) for the Negative Control than for the Positive Control treatment, demonstrating that a protein deficiency existed (Table 2). Cows fed wheat middlings tended to lose less weight (9 lbs., P<.20) and body condition (.3 units, P<.08) than Positive Control cows from November to the end of the study.

Pregnancy rates reflected differences in body weight and condition losses of the cows. Only 73 percent of Negative Control cows became pregnant compared to 93 percent for Positive Control and wheat middlings cows (P<.08)

Calves of Negative Control cows gained less (P<.01) weight throughout the study than calves of the other two treatments. As with cow weight and condition changes, calves of cows supplemented with wheat middlings tended to gain more weight (14 lbs.) than calves of Positive Control cows.

These results indicate that additional energy supplied by the wheat middlings did not appreciably improve cow or calf performance during the winter period. Forage supply was adequate for the entire

Table 2. Effects of supplement treatments on cow and calf performance.

	Treatments				
	Negative Control (1)	Positive Control (2)	Wheat Middlings (3)	Comparison[a] 1 vs 2,3	2 vs 3
Number of cows	13	14	14		
Initial wt, 11/11/86	1008	1012	1010		
Cow weight changes, lbs.					
11/11 to 12/09	-32	4	-1	.01	NS
12/09 to 1/7	-7	-6	-1	NS	NS
1/7 to 2/3	-53	-42	-27	.02	.08
2/3 to 3/3	-42	-31	-34	NS	NS
3/3 to 3/31	-10	14	11	.01	NS
Total 11/11 to 3/31	-144	-62	-53	.01	NS
Cow condition change[b]					
11/11 to 3/31	-1.3	-.8	-.5	.01	.08
Cows pregnant, %	73	93	93	.08	NS
Calf weight gains					
11/11 to 12/09	43	44	43	NS	NS
12/09 to 1/7	12	22	23	.01	NS
1/7 to 2/3	5	7	11	NS	NS
2/3 to 3/3	17	24	30	.01	NS
3/3 to 3/31	15	21	26	.03	NS
Total 11/11 to 3/31	92	119	133	.01	NS

[a]Orthogonal Contrasts; NS = nonsignificant (P>.20)
[b]9 point scale

trial period. Cows fed the additional energy lost slightly less weight and apparently gave slightly more milk as evidenced by heavier calf weights. However, under the conditions of this study, cows were able to meet their protein and energy requirements from the level of soybean meal fed to the Positive Control. Based on the amount of wheat middlings fed and the slight improvements in cow and calf weight changes, one would predict that forage intake was lower for cows supplemented with wheat middlings than for adequate amounts of soybean meal.

These results suggest that wheat middlings can be used to replace soybean meal when the cost per pound of protein is less. When adequate forage is available, the additional energy apparently does not enhance weight changes of lactating cows. This may not be the case, however, with non-lactating cows as demonstrated in a similar study described in this publication.

WHEAT MIDDLINGS VS SOYBEAN MEAL AND CORN/SOYBEAN MEAL SUPPLEMENTS AT TWO PROTEIN LEVELS FOR WINTERING SPRING CALVING BEEF COWS

K.S. Lusby[1] and R.P. Wettemann[2]

Story in Brief

Eighty four spring calving Hereford and Hereford x Angus cows and heifers wintered on native range were fed supplements consisting of two levels of daily crude protein from soybean meal, wheat middlings or a corn/soybean meal mixture. Each supplement was fed to provide a low level of crude protein (.4 lb in November and .8 lb thereafter) or a moderate level (.8 lb in November and 1.2 lb thereafter). Feeding additional energy in the form of wheat middlings or corn/soybean meal supplements did not improve winter weight losses of cows at the low level of protein supplementation over soybean meal alone. However, when the moderate level of protein was fed, spring calving cows had significantly less winter weight loss than cows fed the same level of protein from soybean meal. Cow weight and condition changes were similar for wheat middlings and 16 percent crude protein corn/soybean supplements at both levels of protein. Pregnancy rates tended to be higher for groups fed wheat middlings or corn/soy supplements at both the low and moderate levels of protein. Calf weaning weights tended to be increased by feeding the higher level of protein and by feeding increased energy particularly at the low level of protein.

(Key Words: Beef cows, Energy, Protein, Wheat middlings, Native range)

Introduction

Wheat middlings are the offal of the wheat kernel after the milling process for removal of flour. Over 140,000 tons per year are available for use in livestock feeds in Oklahoma. Wheat middlings contain about 16 percent crude protein but are discounted for their relatively high (8 percent) crude fiber content. In spite of the large amount of middlings fed annually to cattle in Oklahoma, little research has been conducted to establish the nutritional value of the protein and energy in wheat middlings for beef cattle. The objective of this study was to compare winter performance of spring calving beef cows and their calves when supplemented with soybean meal, wheat middlings or corn/soybean meal supplements fed at two levels of daily protein.

Materials and Methods

Eighty four spring calving Hereford and Hereford x Angus cows and heifers wintered on dormant native tallgrass range were fed supplements consisting of two levels of daily crude protein (CP) from soybean meal (40% CP), wheat middlings (16% CP) or a corn/soybean meal mixture (16% CP). Each supplement was fed to provide a low level of crude protein (.4 lb in November and .8 lb thereafter) or a moderate level (.8 lb in

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Table 1. Composition (as fed) of supplements and daily amounts fed.

	Low protein			Mod. protein		
	SBM	Midds	Corn/soy	SBM	Midds	Corn/soy
Ingredients, %						
Soybean meal	88.8		23.1	96.3		21.9
Wheat midds		94.4			98.2	
Corn			69.3			76.3
Dicalcium phosphate	9.4	2.8	5.4	3.7		1.8
Limestone		.9			1.8	
Potassium chloride	1.8	1.9	2.2			
Crude Protein,						
90% DM basis, %	37.4	15.3	13.5	40.0	15.6	14.9
Feeding rates per day:						
11/04 to 12/03	.8	2.0	2.0	2.0	5.0	5.0
12/03 to 4/21	1.25	3.0	3.3	3.0	7.6	7.9

November and 1.2 lb thereafter). Supplements were formulated to provide approximately equal daily amounts of calcium, phorphorus and potassium. About half the cows were two-year old heifers having their first calves with the remainder being primarily three-year-old heifers calving for the second time. Composition of supplements and daily amounts fed are shown in Table 1.

All cows grazed in a single pasture and were gathered 6 mornings each week for supplement feeding in individual covered stalls. Cows were weighed and body condition was determined (scale of 1 = very thin, 5 = moderate, 9 = very fat) at 28-day intervals after overnight withdrawal from feed and water. Supplement feeding began on November 4, 1986 and ended on April 21, 1987. Prairie hay was fed only on a few days in January when snow covered the forage. Cows were exposed by natural service to Hereford bulls from May 1 to July 15, 1987. Pregnancy was determined by rectal palpation on October 8 when calves were weaned.

Results and Discussion

Weight and body condition score changes (Table 2) are calculated from the start of the trial through the end of January which represents the period up to the beginning of calving. Changes are also given from start of the trial to the last cow weight before calving as well as through the end of the supplementation period in late April and through the following summer.

Cows and heifers fed soybean meal at the moderate level of protein gained significantly more weight from November to calving (+34 vs -22 lbs). Feeding the moderate level of soybean meal also reduced (P<.05) weight losses through the entire winter supplementation period (-113 vs -159 lbs). Responses to increased energy from wheat middlings or corn/soy supplements depended on the level of protein fed. When the low level of protein was fed, additional energy in the form of wheat middlings or corn/soybean supplements did not decrease winter weight losses over soybean meal alone. However, when the moderate level of

Table 2. Effects of soybean meal, wheat middlings and corn/soybean meal supplements of performance of cows and calves

	Low protein			High protein		
	SBM	Midds	Corn/soy	SBM	Midds	Corn/soy
No. of cows	14	14	14	14	14	14
Initial wt. Nov 4, lb.	897	891	900	897	894	894
Precalving weight changes, lb.						
Nov 4-Dec 3	-30[a]	-28[a]	-23[a]	-7[b]	0[b]	-14[ab]
Dec 3-Dec 31	-37[a]	-23[a]	-26[a]	-18[a]	15[bc]	-2[b]
Dec 31-Jan 27	50[b]	36[bc]	29[c]	40[bc]	35[bc]	67[a]
Nov 4-Jan 27,	-18[c]	-15[c]	-20[c]	15[b]	50[a]	50[a]
Nov 4 to calving	-22[a]	-25[a]	-8[a]	34[b]	69[c]	52[bc]
Initial condition score[f]	5.5	5.4	5.5	5.7	5.6	5.4
condition change, Nov 4-Jan 27	-1.1[a]	-.7[bc]	-.9[bc]	-.4[cd]	-.2[d]	.3[d]
Weight changes through end of calving[g] Nov 4-Apr 21	-159[a]	-158[a]	-140[ab]	-113[b]	-55[c]	-57[c]
Condition change,[g] Nov 4-Apr 21	-1.2[a]	-1.3[a]	-1.2[a]	-.6[b]	-.3[bc]	.1[c]
Calf birth weight	73[a]	73[a]	72[a]	78[b]	76[ab]	74[a]
Percent pregnant[g]	63	79	100	83	94	92
Weaning weight	372[a]	410[b]	402[ab]	421[b]	412[b]	420[b]

[abcde]Means on a line with different superscript letters differ P<.05).
[f]Condition score scale: 1 = very thin, 5 = moderate, 9 = very obese.
[g]Included data only from cows weaning a calf.

protein was fed, feeding energy in the form of wheat middlings or corn/soybean meal supplements significantly improved cow and heifer weight gains from the start of supplementation to the beginning of calving and through the entire winter supplentation period.

Cow weight changes before calving and over the wintering period were very similar at both low and moderate levels of protein for groups fed corn/soybean meal and wheat middlings supplements. These results suggest that wheat middlings are approximately equal in value to isonitrogenous mixtures of corn and soybean meal when used as a protein and energy supplements for cows grazing low quality forage. The greater fiber content and lower energy content of wheat middlings compared to mixtures of corn and soybean meal is apparently offset by more favorable affects on forage intake and/or digestibility.

Calf birth weights were significantly higher for calves of cows fed supplements at the moderate level of protein (76 vs 73 lbs.). Feeding additional energy at either low or moderate levels of protein did not increase birth weight.

Pregnancy rates tended to be higher (P<.15) for groups fed wheat middlings or corn/soy supplements at both levels of protein. Lowest rebreeding rates were seen with cows and heifers fed soybean meal at the low level of protein. However, pregnancy data from this study should be interpreted with caution because of small numbers of cows per group.

Calf weaning weights in October tended (P<.06) to be increased by feeding the higher level of protein. Weaning weights were higher (P<.05) for groups fed wheat middlings or corn/soy supplements at the low protein level although cow weight change was not affected, suggesting that the additional energy was used to promote greater milk production rather than to improve cow weight or body condition.

Further research is planned to more clearly determine how much of the response to energy or protein level occured before versus after calving. A similar study with SBM and wheat middlings fed to fall calving cows that were lactating throughout the winter feeding period (Lusby and Wettemann, 1988) showed that additional energy was probably being used to support increased milk production because cow weight changes were not affected but calf gains were improved with the energy supplement. If this trend were to hold true for spring calving cows, the best use of increased supplemental energy might be obtained prior to calving.

In conclusion, beneficial effects of additional energy on cow weight and condition changes appeared to occur only if total needs for protein were met. Wheat middlings were shown to be about equal to blends of corn and soybean meal having the same percent protein when used as a supplement to winter range forage. The lower energy content of wheat middlings compared to corn is apparently offset by beneficial changes in forage intake and/or digestibility that result in similar total intake of digestible energy.

Literature Cited

Lusby, K.S. and R.P. Wettemann. 1988. Value of wheat middlings as a winter supplement for fall calving cows. OSU MP-125:69.

DIGESTIVE AND METABOLIC CHANGES IN FALL-CALVING BEEF COWS DUE TO STAGE OF PRODUCTION AND EARLY POSTPARTUM PROTEIN SUPPLEMENTATION

J.M. Gonzalez[1], C.A. Hibberd[2], R.R. Scott[1] and B.D. Trautman[1]

Story in Brief

Fourteen fall-calving Hereford x Angus cows were maintained on low-quality native grass hay (4.7% crude protein) during late gestation and early lactation to characterize digestive changes due to stage of production and early postpartum protein supplementation. Supplemented cows received 2.5 lb cottonseed meal/day starting at calving. During the first 5 weeks of lactation, control cows lost 106.3 lb while supplemented cows gained 48.6 lb. In addition, supplemented cows produced more milk (6.7 lb/day) and calf weight gain (21.3 lb) than control cows. Hay organic matter intake increased 33% for control cows and 110% for supplemented cows during the first five weeks after calving. Compared to control cows, supplementation increased total organic matter digestibility and intake to the extent that digestible organic matter intake approximately doubled. This study illustrates that small quantities of supplemental protein (2.5 lb cottonseed meal/day) efficiently improve utilization of low-quality forage and performance of lactating beef cows. Thus, supplementation programs for fall-calving beef cows should be initiated immediately after calving.

(Key Words: Beef Cattle, Lactation, Native Range, Cottonseed Meal, Intake, Digestibility)

Introduction

Fall-calving beef cows maintained on native range experience marked physiological changes during late gestation and early lactation. In addition, the nutritional quality of native range declines during the fall months. Increased nutrient demands coupled with decreased forage quality create large nutrient deficiencies that must be satisfied for cows to lactate and rebreed normally.

Small quantities of supplemental cottonseed meal (2.14 lb/day) effectively reduce body weight and condition losses in lactating beef cows maintained on native range in the fall (Gonzalez et al., 1987). Although protein supplementation should improve forage utilization, the impact of small quantities of supplemental protein on changes in digestive function of lactating beef cows grazing low-quality native range is unknown. This experiment was designed to characterize changes in digestive function of lactating beef cows due to physiological status and early postpartum protein supplementation.

Materials and Methods

Fourteen mature, late-gestation Hereford x Angus cows (1208 lb initial weight) were housed individually and fed coarsely chopped (2-

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inch screen) native grass hay free choice. Cows were treated similarly prepartum but paired based on calving date and randomly assigned to either a control or a supplemented group (2.5 lb cottonseed meal/day). Calves were weighed within 24 h of birth and bull calves elastrated.

The trial consisted of nine periods (7 days/period). On day 3 of each period, all cows and calves were weighed. Cow body condition scores (1=emaciated, 9=obese) were assigned by three independent evaluators. Milk production was measured during week 5 using the weigh-suckle-weigh technique.

Fresh hay was placed in the feeders every day, and hay refusals were weighed and subsampled on days 3, 5 and 7. Fecal grab samples were collected twice daily (0800 and 2000 h) on days 4 to 7, refrigerated, composited and dried. Hay, hay refusal, supplement and fecal composite samples were ground and analyzed for dry matter, ash and acid insoluble ash content. Organic matter (OM) digestibility was calculated by the marker ratio technique using acid insoluble ash as the reference marker.

Changes in the physiological status of the control group were evaluated using polynomial equations. To evaluate response to postpartum cottonseed meal supplementation, data were analyzed as a split-plot design with treatment as the main unit, cows as replications and periods as the subunits. Treatment responses within each period were evaluated by t-test.

Results and Discussion

The native grass hay used in this study contained 4.7% crude protein and 5.2% lignin (Table 1). Fall-calving beef cows grazing native tallgrass pastures in Oklahoma experience a forage base providing as little as 3.79% CP and 35.8% crude fiber in October (Waller et al., 1972).

Precalving weight and body condition changes were similar for both groups (Figure 1). All cows lost an average of 142.3 lb (12.7% of precalving weight) at calving. After calving, control cows (no supplement) rapidly lost body weight (-3.0 lb/day) and condition (-.14 units/week). In contrast, supplemented cows gained weight (+1.4 lb/day) and body condition (+.005 units/week) after calving. Increased nutrient requirements due to milk synthesis coupled with low hay quality created a large nutritional void in the control cows. Consequently, unsupplemented cows mobilized body stores to meet the nutrient demands of the mammary gland.

Table 1. Chemical composition of native grass hay and cottonseed meal supplement.

Item	Hay	Cottonseed meal
	----% (DM basis)----	
Crude protein	4.70	44.03
Acid detergent fiber	34.80	19.51
Lignin	5.20	2.79

In addition to improved cow performance, cottonseed meal supplementation also increased milk production (6.7 lb/day). Consequently, calves suckling supplemented cows gained more weight (21.3 lb, P<.09) than calves suckling control cows by week 5 postpartum (Figure 1).

Hay OM intake of control cows decreased 21% for both groups during the last three weeks of gestation (Figure 2). Decreased hay intake in late gestation may be due to the physical size of the conceptus which

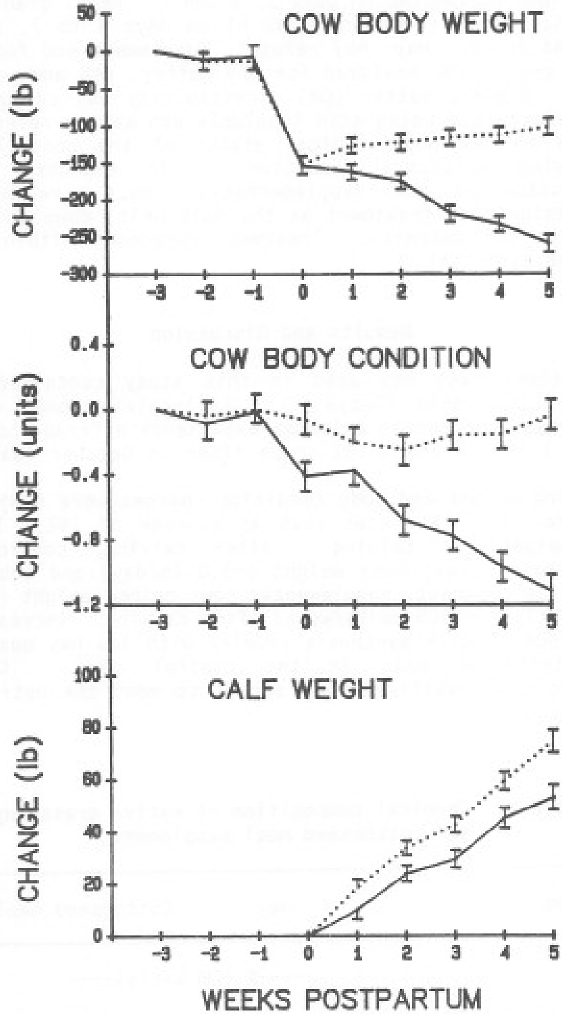

Figure 1. Changes in cow body weight and condition and calf weight due to stage of production and postpartum protein supplementation (——— control, ······· 2.5 lb CSM/day).

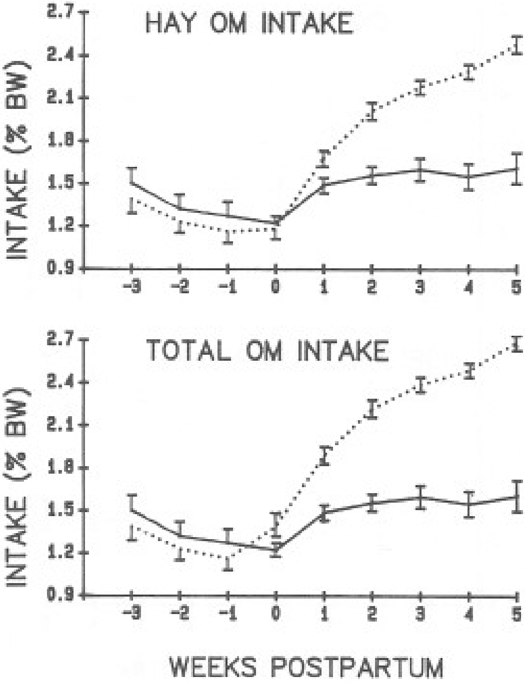

Figure 2. Effect of stage of production and postpartum protein supplementation on organic matter intake (——— control, ······· 2.5 lb CSM/day).

could decrease digestive capacity. After calving, hay OM intake increased rapidly (33% in five weeks) and stabilized at about 1.6% of body weight. Increased hay intake after calving may be attributed to increased physiological demands from lactation in addition to increased abdominal space.

Supplementation (2.5 lb cottonseed meal/day) rapidly increased hay OM intake after calving (Figure 2). In fact, hay OM intake of supplemented cows continued to increase through week 5 after calving. By the end of the study, supplemented cows consumed 54% more hay OM (2.5% body weight) than control cows (1.6% body weight). In addition to increased hay OM intake, supplemented cows received 2.3 lb of supplemental OM from cottonseed meal. Thus, supplemented cows consumed 67% more total OM than control cows by week 5 postcalving.

Organic matter digestibility was increased ($P<.01$) for supplemented cows after calving (Figure 3). This response coupled with increased total OM intake resulted in a marked increase in digestible OM intake for supplemented cows. In fact, digestible OM intake of supplemented cows approximately doubled that of control cows by the end of the study.

Small quantities of cottonseed meal supplement have a tremendous impact on the performance of lactating beef cows maintained on low-

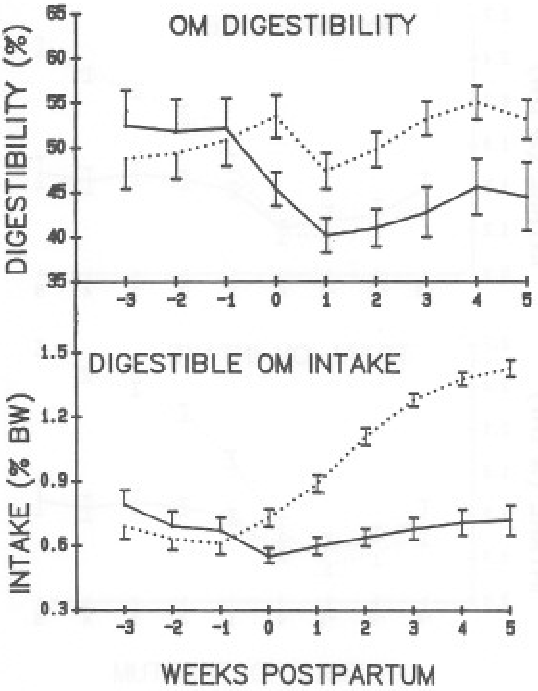

Figure 3. Effect of stage of production and postpartum protein supplementation on organic matter digestibility and digestible organic matter intake (——— control, ······· 2.5 lb CSM/day).

quality grass hay. Much of this response is due to the fact that control cows consumed only .76 lb protein/day which is only 38% of their NRC requirement. Supplemented cows received 1.1 lb of cottonseed meal protein/day plus an additional 1.3 lb protein from the hay which totals 120% of their NRC requirement. Supplemental protein improves forage utilization as well as bacterial growth. Consequently, protein supplementation should improve both the energy and protein status of lactating beef cows. Thus, the protein requirements of beef cows in early lactation should not be ignored if producers desire optimum performance.

Lactating beef cows maintained on low-quality grass hay without supplement rapidly lost large quantities of body weight (3.0 lb/day) and condition (.14 units/week). These losses occurred because nutrient requirements increased while energy intake was limited by the poor nutritional quality of the forage. In contrast, cows fed 2.5 lb cottonseed meal/day gained weight and body condition. Supplemental protein probably stimulated ruminal bacterial activity resulting in increased hay digestion and intake. Thus, supplemented cows were able to consume approximately twice as much digestible OM as control cows.

This difference explains the large response to cottonseed meal supplementation in this study. Consequently, supplementation programs for fall-calving beef cows grazing low-quality native range should be initiated immediately after calving in order to realize the maximum response to small quantities of protein supplement.

Literature Cited

Gonzalez, J.M. et al. 1987. Early postpartum protein supplementation for fall-calving beef cows. Okla. Agr. Exp. Sta. Misc. Pub. MP-119:272.

Waller, G.R. et al. 1972. Chemical composition of native grasses in central Oklahoma from 1947 to 1962. Okla. Agr. Exp. Sta. Bull. B-697.

BYPASS PROTEIN SUPPLEMENTATION OF FALL-CALVING BEEF COWS GRAZING DORMANT NATIVE RANGE

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Story in Brief

Seventy-seven lactating Hereford X Angus cows were fed supplements containing different amounts of blood meal to evaluate the effect of supplemental bypass protein on cow weight, body condition, milk production and calf growth. Cows grazed dormant native tallgrass pastures from January 2 through March 26, 1987. Supplements were formulated to provide 1.42 lb crude protein/day with either .40 or .71 lb of bypass protein. In addition, supplements were fed at two energy levels (2.6 or 5.2 lb TDN/day). Increased supplemental energy (5.2 lb TDN/day) decreased losses of cow body weight and condition and increased milk production and calf weight gain. Bypass protein supplementation also decreased cow body weight losses but did not affect body condition. Cows receiving bypass protein produced more milk (1.0 to 1.7 lb/day). Calves suckling cows supplemented with bypass protein gained an average of 7.5 lb additional body weight during the 83-day study. This study suggests that the productivity of lactating beef cows grazing dormant native range may be improved with bypass protein supplementation.

(Key Words: Beef Cattle, Native Range, Supplement, Blood Meal)

Introduction

Fall-calving beef cows grazing dormant native range require protein supplementation to adequately lactate and rebreed. Traditionally, ruminal degradable protein sources such as soybean meal or cottonseed meal have been used in protein supplements. Ruminal microorganisms utilize ruminal degradable protein to supply ammonia for fiber digestion and bacterial protein synthesis. When the diet supplies enough digestible energy and/or animal requirements are low, ruminal bacteria can synthesize enough protein to meet the requirements of the cow. With lactating beef cows grazing dormant native range, however, requirements for lactation are high and the digestibility of the forage is low. Under these circumstances, protein feeds that are more resistant to ruminal degradation (bypass proteins) can be used to augment the supply of bacterial protein reaching the small intestine. Thus, fall-calving beef cows grazing dormant native range may benefit from bypass protein supplementation. The objective of this study was to evaluate the effects of level of supplemental bypass protein and energy on the productivity of fall-calving beef cows grazing dormant, tallgrass native range.

Materials and Methods

Seventy-seven fall-calving Hereford X Angus cows (average calving date = October 26, 1986) were grazed on dormant native grass

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pastures from January 2 through March 26 at the Southwest Livestock and Forage Research Station, El Reno, OK. Native grass pastures were dominated by little bluestem with smaller quantities of big bluestem, switchgrass and indiangrass. Cattle were managed as one large group and rotated among pastures every two to four weeks to equalize forage quality throughout the study. Cows were blocked by previous treatment, weight and body condition into four supplementation groups. Supplements (Table 1) were formulated to supply 1.42 lb crude protein/day with 2.6 or 5.2 lb TDN. Soybean hulls were utilized as the supplemental energy source. Blood meal was added to increase the bypass protein supply from .40 to .71 lb/day. Supplements were pelleted and the weekly allotment individually fed five days per week. In addition, cows had access to a mineral mix composed of 50% dicalcium phosphate, 45% trace mineralized salt and 5% potassium chloride.

Cows were weighed every two weeks following an 8-hour shrink. Condition scores were assigned (1=emaciated, 9=obese) by four independent evaluators. Calves were weighed following a 4-hour shrink. Milk production was estimated every 2 to 4 weeks using the weigh-suckle-weigh technique. Calves were fasted for 12 hours and suckled at 2000 and 0800 hours.

Data were subjected to least squares analysis with calf age (covariate), calf sex, energy level, protein source and the energy level by protein source interaction included in the model. Because the interaction was not significant for any variable (P>.46), differences due to energy level or protein source were evaluated by F-test.

Table 1. Feedstuff and chemical composition of supplements.

	Low TDN[a]		High TDN[a]	
Bypass protein:	Low	High	Low	High
Feed composition, % (DM basis)				
Soybean meal	91.49	41.06	25.92	4.33
Blood meal		18.72		8.93
Soybean hulls		30.73	68.29	80.37
Molasses	3.35	3.35	3.35	3.35
Dicalcium phosphate	3.42	4.11	1.51	1.94
Trace mineralized salt[b]	1.52	1.40	.73	.70
Sodium sulfate	.15	.59	.17	.36
Vitamin A (30,000 IU/g)	.06	.06	.03	.03
Dairy Flavors	.02	.02	.02	.02
Nutrient supply, lb/day				
Crude protein	1.42	1.42	1.42	1.42
Bypass protein	.40	.71	.40	.71
TDN	2.6	2.6	5.2	5.2
Feeding level, lb DM/day	3.28	3.58	6.87	7.17

[a]TDN=Total Digestible Nutrients.
[b]Trace mineralized salt contained 92% NaCl, .25% Mn, .2% Fe, .033% Cu, .03% S, .007% I, .005% Zn and .0025% Co.

Results and Discussion

Increased supplemental energy (5.2 lb TDN/day) decreased weight (P<.0001) and body condition (P<.09) losses of lactating beef cows (Table 2). In addition, cows fed 5.2 lb TDN/day produced more milk (P<.0001) and supported calves that gained more weight (P<.0003) than cows fed 2.6 lb TDN/day. Increased supplemental energy should increase the productivity of lactating beef cows grazing dormant native range because the digestibility of dormant grass is low.

Bypass protein supplementation in the form of blood meal decreased (P<.09) body weight loss of lactating beef cows (Table 1). Body condition, however, was not altered (P=.90) by additional bypass protein. Cows receiving blood meal supplements produced 1.0 to 1.7 lb more milk (P<.006) than cows fed soybean meal-based supplements. Consequently, calves suckling cows that were supplemented with blood meal gained 7.5 lb more weight (P<.08) than calves suckling soybean meal-supplemented cows.

The productivity of lactating beef cows grazing dormant native grass is limited by low forage digestibility and forage protein content. Microbial fermentation of low-quality forage is increased by protein supplementation. The ability of ruminal bacteria to meet the protein requirement of the lactating cow may be limited by low forage digestibility. Under these circumstances, excess ruminal degradable protein would be used for energy rather than protein. Bypass protein

Table 2. Performance of fall-calving beef cows supplemented with different amounts of energy and bypass protein.

	Low TDN		High TDN			Probability	
Bypass protein:	Low	High	Low	High	SE[a]	Bypass	Energy Level
Cow weight, lb							
Initial	1,037	1,038	1,036	1,030	21.3	.90	.85
Final	951	968	998	1,004	19.8	.58	.04
Change, 83 days	-86	-70	-38	-26	8.0	.09	.0001
Cow body condition, units							
Initial	5.01	4.99	5.08	5.16	.172	.87	.49
Final	4.64	4.64	4.89	4.94	.139	.91	.06
Change, 83 days	-.37	-.35	-.18	-.22	.090	.90	.09
Milk production, lb/day							
Initial	10.0	10.0	10.1	9.4	.58	.55	.65
Final	7.9	9.0	10.5	11.4	.55	.07	.0001
Change, 83 days	-2.0	-1.0	.3	2.0	.49	.006	.0001
Calf body weight, lb							
Initial	166	169	168	167	5.3	.77	.96
Final	246	258	264	270	8.5	.30	.08
Change, 83 days	80	88	96	103	4.1	.08	.0003

[a]Standard error of the treatment mean.

augments the supply of bacterial protein reaching the small intestine and should increase the overall protein status of the lactating cow. Increased milk production and calf growth should result. In this study, supplemental bypass protein increased the productivity of fall-calving cows and their calves suggesting that inadequate protein supply to the small intestine may have limited cow productivity.

Although the results of this study are preliminary, the data suggest that management of supplemental protein source may improve the productivity of lactating beef cows grazing dormant native range. Additional research is needed to determine the correct quantity and balance of ruminal degradable and bypass protein necessary for optimum beef cow performance.

EFFECT OF PRESCRIBED BURNING ON FORAGE DIGESTION, RATE OF PASSAGE, AND INTAKE OF NATIVE GRASS BY BEEF COWS

R.R. Scott[1], C.A. Hibberd[2], B.D. Trautman[1] and C. Worthington[3]

Story in Brief

Eight ruminally cannulated beef cows grazed either burned or unburned rangeland to evaluate the effects of prescribed spring burning on forage digestion, particulate passage, and intake. Pastures were burned April 6 and grazed from April 29 through July 27. Initial crude protein content of diet samples was higher for burned forage, but declined rapidly. Thus, protein content of control forage was higher by the end of the trial. Forage from burned pasture was digested more rapidly and remained in the rumen longer than forage from unburned pasture. Consequently, digestibility of burned forage was higher than control forage throughout the study. Cows grazing burned range consumed more organic matter and digestible organic matter than cows grazing unburned range. In contrast, control cows attempted to compensate for low forage quality with increased indigestible organic matter intake and rate of passage, however, their adaptability was limited by the decreased digestibility of the forage. These results indicate that the primary response to burning is faster rate of forage digestion. This allows cattle to consume a larger quantity of more digestible forage which results in increased performance.

(Key Words: Beef Cattle, Rangeland, Burning, Digestion, Intake)

Introduction

Prescribed spring burning of rangeland removes standing, dormant forage thereby promoting palatable, higher quality regrowth. Increased protein content of burned forage is transient, however, and differences in chemical composition of burned and unburned forage are small. Increased performance of cattle grazing burned range (Scott et al., 1986) must be attributed to increased forage digestibility and/or intake. Similar intake of unburned and burned forage has been reported in Kansas (Smith et al., 1960). Rao et al. (1973) observed increased digestible energy intake for steers grazing burned rangeland even though protein content was similar to unburned range. Therefore, the objective of this study was to characterize the effects of prescribed burning on forage digestion, rate of passage and intake by beef cattle.

Materials and Methods

Three trials were conducted at the Southwest Livestock and Forage Research Laboratory located at El Reno, Oklahoma in 1986: May 9 to 18 (Period 1), June 13 to 22 (Period 2), and July 18 to 27 (Period 3). Tallgrass rangeland was dominated by little bluestem with smaller quantities of big bluestem, switchgrass, and indiangrass. Pastures were

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burned on April 6, 1986. Grazing was initiated on April 29 when burned pasture regrowth was 4 to 6 inches in height and concluded August 6.

Four mature, nonpregnant Hereford cows and four mature Angus x Hereford heifers fitted with ruminal cannulae were blocked by breed and weight and assigned to an unburned (control) or burned pasture. An additional nonpregnant Hereford cow grazed the control pasture and was utilized to estimate burning effects on rate of forage digestion. Both pastures were stocked with 325 lb calves at 3.2 acres/animal unit during the study.

Ytterbium-labeled prairie hay was ruminally dosed on days 1 through 6 of each period to estimate fecal output. Fecal grab samples were obtained 6 times over a 48 h period on days 5 and 6 and composited by animal. Fecal samples were dried, ashed, and subjected to Yb analysis by EDTA extraction. Fecal output was calculated as Yb dose divided by fecal Yb concentration.

Esophageal masticate was collected from each pasture on day 1 of each period. Masticate was washed with tap water and labeled with dysprosium. Labeled masticate was then pulse-dosed at 0900 on day 7 to estimate ruminal particulate passage rate. Samples of ruminal contents were obtained at 12, 24, 36, and 48 h postdosing. Particulate passage rate was estimated from regression of the natural logarithm of Dy concentration over time.

To evaluate the effect of burning on rate of forage digestion, 1 g ground masticate (burned or control) was placed in duplicate dacron bags and suspended in the rumen of the extra Hereford cow grazing the control pasture. Bags were incubated for 4, 12, 24, 36, 48, and 72 h. Organic matter solubility, potential digestibility, and rate of disappearance were predicted from bag washout, 72-h residues and the regression of organic matter residue against time, respectfully. Forage organic matter digestibility was estimated from the equation: $a + [b \times c/(c + k_d)]$ where a is the soluble component, b is potential digestibility, c is rate of disappearance, and k_d is particulate passage rate (Ørskov and McDonald, 1979).

Data were analyzed by least squares procedures with period, treatment, cow nested within treatment, and period by treatment interaction included in the model. Treatment differences within each period were evaluated by t-test. Seasonal trends were characterized by regression analysis for linear and nonlinear effects.

Results And Discussion

Crude protein content of the control pasture decreased linearly ($P<.01$) as the season progressed (Figure 1). Initially, crude protein content of burned pasture was higher ($P<.01$) than the control pasture, but declined more rapidly (nonlinear, $P<.01$). Consequently, the protein content of burned pasture was lower ($P<.01$) than the control pasture in periods 2 and 3. Rapid declines in protein content suggests that burned forage may grow faster and mature more rapidly than unburned forage.

Rate of forage OM digestion for burned forage was higher (.9 to 1.1 percentage units, $P<.10$) than control forage on all sampling dates (Table 1). In addition, digestion rates decreased as the forage matured. Forage organic matter digestibility decreased for both pastures as the season progressed. Organic matter digestibility of burned forage was consistently higher than control forage. Increased rate of forage OM digestion for burned forage and decreased passage rates combined to increase total digestibility.

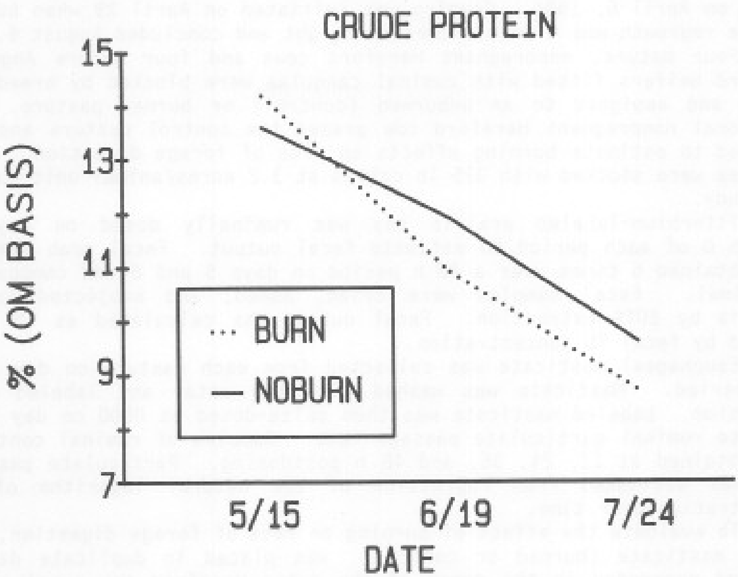

Figure 1. Crude protein content (OM basis) of burned and unburned tallgrass range.

Forage organic matter intake was highest in May when forage quality and digestibility were high and declined as the season progressed (Table 1). Cows grazing burned range consumed more forage organic matter at all sampling dates. In addition, cows on burned forage consumed more ($P<.05$) digestible organic matter throughout the study. This response represents an 18 to 30% increase in energy intake which explains increased performance of cattle grazing burned range (Scott et al., 1986).

Particulate passage rate tended to be higher for control forage at all sampling times (Table 1). Particulate passage rate tended to decrease as the season progressed. In addition, indigestible organic matter intake was higher for cows grazing control forage. These relationships suggest that cows grazing control forage attempted to increase forage intake to compensate for inadequate energy intake. In spite of these adaptive changes, control cows were unable to achieve a level of energy intake comparable to cows grazing burned range.

Cattle grazing burned range have access to improved quality forage as evidenced by increased performance (Scott et al., 1986). Differences in the chemical composition of burned and control forages are small (Woolfolk et al., 1975), however, and do not account for improved performance. In addition, crude protein content of burned forage fell below control forage after mid-June. Protein content does not explain increased cattle performance on burned range. The major response to burning in this study appeared to be increased rate of forage digestion. Increased digestion rate allowed cows grazing burned forage to consume a

Table 1. Forage digestion, rate of passage, and intake of cows grazing control and burned range.

Item	Period			
	May	June	July	SEM[a]
Organic matter				
Rate of digestion, %/h				
Control	6.4[b]	6.1[b]	5.4[d]	.05
Burn	7.3[c]	7.1[c]	6.5[e]	.05
Digestibility, %				
Control	51.8	44.2[b]	45.4	.85
Burn	58.0	53.8[c]	52.7	.85
Organic matter intake, % body weight				
Total				
Control[f]	2.14	1.77	1.62[b]	.076
Burn[g]	2.25	1.87	1.80[c]	.076
Digestible				
Control[g]	1.11[d]	.78[d]	.73[d]	.039
Burn[g]	1.31[e]	1.00[e]	.95[e]	.039
Indigestible				
Control[f]	1.03[b]	.99[d]	.88	.037
Burn[f]	.94[c]	.86[e]	.85	.037
Particulate passage rate, %/h				
Control	5.5	4.4	4.7	.50
Burn	4.5	4.1	4.2	.43

[a]SEM=standard error of least square means.
[b,c]Means within columns differ (P<.10).
[d,e]Means within columns differ (P<.05).
[f]Linear period response (P<.05).
[g]Nonlinear period response (P<.05).

larger quantity of more digestible forage. Consequently, total energy intake increased. In contrast, slower digestion rate for control forage forced cows to increase passage rate and indigestible organic matter intake in an attempt to increase energy intake.

Literature Cited

Rao, M.R. et al. 1973. Seasonal change in nutritive value of bluestem range. J. Range Manage. 26:419.

Scott, R.R. et al. 1986. Spring burning of native grass pasture for late-weaned fall-calving cows. Okla. Agr. Exp. Sta. Misc. Pub. MP-118:210.

Scott, R.R. et al. 1987. Response of fall-born calves to spring pasture burning or early summer protein supplementation. Okla. Agr. Exp. Sta. Misc. Pub. MP-119:283.

Smith, E.F. et al. 1960. The digestibility of forage on burned and unburned bluestem pasture as determined with grazing animals. J. Anim. Sci. 19:388.

Woolfolk, J.S. et al. 1975. Effects of nitrogen fertilization and late spring burning of bluestem range on diet and performance of steers. J. Range Manage. 28:190.

SOYBEAN MEAL SUPPLEMENTATION OF LIGHT WEIGHT BEEF CALVES GRAZING SPRING-BURNED TALLGRASS RANGE

R.R. Scott[1], C.A. Hibberd[2] and C. Worthington[3]

Story in Brief

Weaned, fall-born beef calves were maintained on spring-burned tallgrass range from May 21 through July 20 and supplemented with 0 (control), .5, 1.0, and 1.5 lb soybean meal/day. Diet samples averaged 15.9% crude protein in May and dropped to only 8.9% crude protein in July. Control calves (no supplement) gained 1.86 lb/day. Weight gain increased linearly with added increments of soybean meal. Feeding 1.5 lb soybean meal increased average daily gain .18 lb/day. Consequently, 7.2 lb soybean meal were required for each pound of added weight gain. Prescribed burning may increase forage quality to the extent that soybean meal supplementation is not effective. Thus, producers should not feed soybean meal to growing calves grazing burned range in early summer.

(Key Words: Beef Cattle, Soybean Meal, Prescribed Burning, Rangeland)

Introduction

Fall-born beef calves weaned in May have access to tallgrass range that averages 10% crude protein in May but declines to 6% crude protein by July (Waller et al., 1972). In order to gain 1.5 to 2.0 lb/day, 400 lb calves require 11.5 to 12.7% crude protein in their diet (NRC, 1984). Previous research has illustrated that either soybean meal supplementation or prescribed spring burning increase the daily gain of fall-born calves in early summer (Scott et al., 1987). Although burning increases the crude protein content of burned range in May (14%), declining protein content is reflected by low ruminal ammonia concentrations (Scott et al., 1988). Thus, lightweight calves grazing burned range may respond to supplemental protein. The objective of this study was to evaluate the growth response of fall-born, spring-weaned beef calves to incremental levels of supplemental soybean meal while grazing burned range.

Materials and Methods

Fifty-seven crossbred, fall-born beef calves (average calving date, October 26, 1986) were weaned on April 15, 1987 and maintained on a weaning ration plus prairie hay in drylot for two weeks. A tallgrass pasture (71 acres) was burned on April 16. Calves were maintained on the burned pasture for three weeks before the trial was initiated on May 21. The pasture was stocked at a rate of 3.3 acres/animal unit for 60 days. Calves were randomly assigned to one of four treatments: 0, .5, 1.0 or 1.5 lb soybean meal/day (as-is basis). The soybean meal supplement contained 48.6% crude protein (dry matter basis). The weekly allowance of supplement was individually fed five times/week and a

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mineral mix consisting of 50% trace mineralized salt, 45% dicalcium phosphate and 5% potassium chloride was offered free choice. Calves were weighed every three weeks following an 18-hour shrink. Diet samples were obtained with four esophageally cannulated heifers. Forage samples were freeze-dried and the crude protein content determined by Kjeldahl. Orthogonal polynomials were utilized to evaluate the effects of incremental soybean meal supplementation on weight gain.

Results and Discussion

The crude protein content of diet samples collected on April 30 was 15.9% and declined to 8.9% by July 20 (Figure 1). Although the crude protein content of burned range is high in May, rapid declines in forage quality may result in crude protein concentrations as low as 7% by July (Scott et al., 1988). Consequently, the nutritional quality of the burned forage in this study was better than expected.

Average daily gain for unsupplemented calves was 1.86 lb/day (Table 1). Soybean meal supplementation increased average daily gain linearly ($P<.07$) to a maximum of 2.04 lb/day with 1.5 lb SBM. Although weight gain increased with soybean meal supplementation, soybean meal was poorly converted into weight gain. With 1.5 lb soybean meal/day, 7.2 lb of soybean meal were required for each additional pound of calf weight gain. With soybean meal priced at $180/ton, the cost of each pound of added gain was 65¢. Consequently, soybean meal supplementation on burned range in early summer may not be economically feasible.

Soybean meal supplementation typically increases forage digestibility, intake and weight gain of beef cattle grazing native

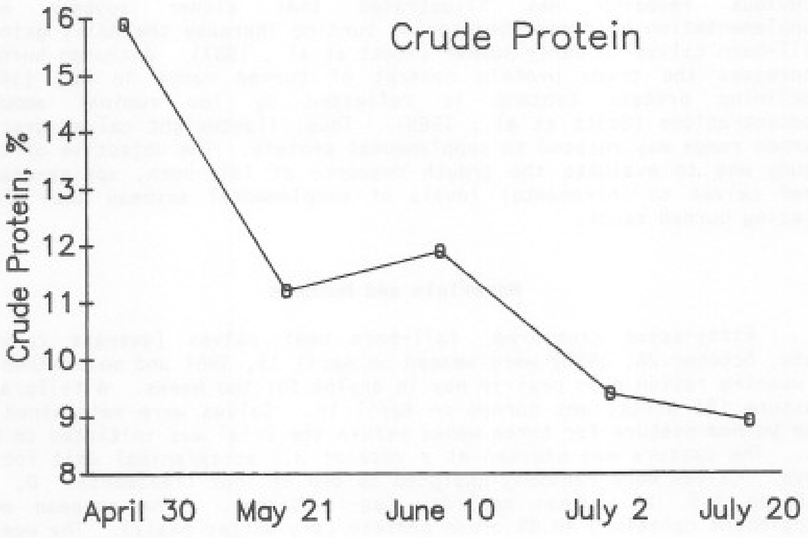

Figure 1. Seasonal changes in the crude protein content of diet samples from a burned native grass pasture (DM basis).

Table 1. Performance characteristics of beef calves fed incremental levels of soybean meal on burned pasture.

	Soybean meal (lb/day as-is)				
Item	0	.5	1.0	1.5	SE[a]
Number	14	15	14	14	
Actual SBM intake, lb/day	0	.42	.93	1.29	
Initial weight, lb	368	364	360	373	16.2
Average daily gain, lb[b]	1.86	1.92	1.92	2.04	.082
Conversion[c]		7.0	15.5	7.2	
Cost, ¢/lb added gain[d]		63.0	139.5	64.8	

[a]Standard error of the mean.
[b]Linear treatment response ($P<.07$).
[c]Conversion = lb supplement/lb additional gain.
[d]Soybean meal cost = $180/ton.

grass. In this study, increased weight gain with soybean meal supplementation may be attributed to greater energy intake rather than associative effects on forage digestibility. In fact, 1.5 lb of soybean meal supplies about 1.1 lb TDN which would account for the .18 lb increase in average daily gain.

Although soybean meal supplementation efficiently improves weight gain of lightweight calves grazing unburned range, supplementation of calves grazing burned range may not be cost-effective. Burning may improve ruminal nitrogen status to the extent that supplemental protein is not beneficial. Prescibed burning is a relatively inexpensive ($1/acre) management tool that improves forage quality and yield. The addition of soybean meal supplementation to a burning program, however, is neither nutritionally nor economically justifiable.

Literature Cited

NRC. 1984. Nutrient Requirements of Beef Cattle. National Research Council-National Academy of Sciences, Washington, DC.

Scott, R.R. et al. 1987. Response of fall-born calves to spring pasture burning or early summer protein supplementation. Okla. Agr. Exp. Sta. Misc. Pub. MP-119:283.

Scott, R.R. et al. 1988. Effect of prescribed burning on forage digestion, rate of passage, and intake of native grass by beef cows. Okla. Agr. Exp. Sta. Misc. Pub. MP-125:86.

Waller G.R. et al. 1972. Chemical composition of native grasses in central Oklahoma from 1947 to 1962. Okla. Agr. Exp. Sta. Bull. B-697.

INFLUENCE OF SUPPLEMENTAL SOYBEAN MEAL, CORN GLUTEN FEED OR BLENDS OF SOYBEAN MEAL AND CORN GLUTEN ON INTAKE AND UTILIZATION OF PRAIRIE HAY BY BEEF HEIFERS.

R.A. Younis[1], and D.G. Wagner[2]

Story in Brief

Fifteen crossbred beef heifers were used in three simultaneous 5 x 5 latin squares to determine the effect of supplementation with soybean meal, corn gluten feed or blends of these two on intake and digestibility of medium quality prairie hay. Prairie hay (4.9% crude protein, dry matter basis) was cut during the first half of July from a meadow harvested annually and was fed ad libitum. Treatments included: 1) Control, hay plus a mineral-vitamin mixture; 2) soybean meal supplement (1.4 lb of 49% protein per day); 3) a blend with 2/3 of the supplemental protein from soybean meal plus 1/3 from corn gluten feed (1.9 lb of 38.9% protein); 4) a blend with 1/3 of the protein from soybean meal plus 2/3 from corn gluten feed (2.4 lb of 28.5% protein); and 5) corn gluten feed (3.1 lb at 23.0% protein). Each supplement was fed to provide .67 lb or 300 grams of supplemental crude protein per day. Fifty grams (.11 lb) of a mineral-vitamin mix was fed daily on each treatment. Daily hay intakes were 12.8, 19.0, 18.1, 17.1 and 15.5 lb on the Control, soybean meal, 1/3 corn gluten feed, 2/3 corn gluten feed and corn gluten feed treatments, respectively. Total dry matter intakes (hay plus supplement) followed the same pattern, being 12.9, 19.5, 20.1, 19.6 and 18.7 lb on the same treatments. Ration dry matter digestibilities were 48.5, 55.5, 55.2, 54.7 and 54.2%, and total daily digestible dry matter intakes were 6.5, 11.6, 11.4, 11.1 and 10.4 lb on the Control, soybean meal, 1/3 corn gluten feed, 2/3 corn gluten feed and corn gluten feed treatments, respectively. Supplementation increased intake and digestibility on all treatments over the Control. However, a linear decrease in improvements was noted as corn gluten feed replaced soybean meal. Supplementation increased both hay intake and passage rate of hay approximately 50%.

(Key Words: Prairie Hay, Soybean Meal, Corn Gluten Feed, Protein.)

Introduction

Corn gluten feed (CGF) is a by product of wet-milling corn to produce corn syrup. It includes the corn bran and condensed steepwater solubles. CGF contains about 22 to 23% CP, 2% ether extract, 9% crude fiber and is high in phosphorus and potassium. CGF has become more widely available in recent years. As the corn refining industry has grown and as the export market has diminished, CGF has found wider use in the U.S. as a protein supplement.

Some studies have been conducted with CGF, primarily in beef finishing or dairy rations, but very limited work has been done investigating the use of CGF in range supplements for beef cattle. Even less work has been conducted to determine the effects of CGF or

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blends of CGF with proteins like soybean meal (SBM) on intake and digestibility of medium quality range forages similar to those grazed by cattle during summer months. Therefore, this study was done to investigate the effects of providing equal amounts of supplemental protein from SBM, CGF or blends of SBM and CGF on forage intake, digestibility, ruminal NH_3-N, rumen pH and rate of passage when fed with medium quality prairie hay to beef heifers.

Materials and Methods

Fifteen yearling crossbred Angus-Hereford heifers (approx. 700 lb) used in three simultaneous 5 x 5 latin squares. All animals were fed medium quality prairie hay ad libitum. Hay was harvested the first half of July from a meadow harvested annually. The treatments were: 1) Control, consisting of hay; 2) a SBM supplement; 3) a blend with one-third of the supplemental CP from CGF and two-thirds from SBM (1/3 CGF); 4) a blend with two-thirds of the supplemental CP provided by CGF and one-third from SBM (2/3 CGF), and 5) a CGF supplement.

A mineral and vitamin A mixture was fed at a level of 50 g/day (.11 lb) to all animals on all treatments. Supplements were fed once daily to provide 300 g (.67 lb) of supplemental protein per day. The SBM, 1/3 CGF, 2/3 CGF and CGF supplements (Table 1) were fed at rates of 1.41, 1.91, 2.43 and 3.08 lb per day, respectively.

Table 1. Intake of the supplements (DM basis).

	Supplement[a]				
Ingredient	C	SBM	1/3 CGF	2/3 CGF	CGF
	g/day (lb/day)				
Soybean meal		640 (1.41 lb)	406 (.89 lb)	198 (.44 lb)	
Corn gluten feed			464 (1.02 lb)	902 (1.99 lb)	1400 (3.08 lb)
Mineral and Vitamin mixture[b]	50 (.11 lb)	50	50	50	50
Total supplement	50 (.11 lb)	690 (1.52 lb)	920 (2.01 lb)	1150 (2.53 lb)	1450 (3.19 lb)

[a]C = Control; SBM = soybean meal; 1/3 CGF = corn gluten feed used to supply 1/3 of supplemental crude protein, balance from SBM; 2/3 CGF = corn gluten feed supplied 2/3 of supplemental crude protein, balance from SBM; CGF = corn gluten feed.

[b]Contained: Dicalcium phosphate 42.2%, KCl 18.1%, trace minerals 27.4% (.25% Mn, .2% Fe, .033% Cu, .0025% Co, .007% I, .005% Zn), Na_2SO_4 11.8% and vitamin A .5% (220 USP units/g).

Each period in the latin square lasted 14 d, with days 1 to 8 being used for adaptation. Prairie hay, fed and rejected, and supplements were weighed and sampled daily. Fecal grab samples were collected twice daily in each collection period. Chromic oxide was fed as an indigestible marker to estimate digestibilities. All samples for each animal in each period were placed in an individual plastic container and refrigerated until the end of the period. Hay, supplements and fecal samples were analyzed for moisture and chemical determinations. Rate of particulate passage values for hay were determined using Ytterbium. Chopped hay was labeled with Yb and fed as a single pulse dose on day 9 of each period according to the procedure of Teeter et al. (1984). The rumen of each animal was sampled via stomach tube on the last day of each period within two to four hours after feeding supplement. The pH of the ruminal fluid was measured immediately; then 200 ml fluid was acidified and frozen for later NH_3-N analysis.

Results and Discussion

Supplementation increased ($P<.01$) the intake of prairie hay from 12.8 lb (Control) to 19.0, 18.1, 17.1 and 15.5 lb on the SBM, 1/3 CGF, 2/3 CGF and CGF treatments, respectively (Table 2). Moreover, a significant linear ($P<.01$) decline was noted in forage intake as CGF

Table 2. Intake of prairie hay and measures of digestibility as influenced by supplementation with soybean meal (SBM), corn gluten feed (CGF) or blends of SBM and CGF.

Item	Control	SBM	1/3CGF	2/3CGF	CGF	SE[d]
Hay intake, lb[abc]	12.8	19.0	18.1	17.1	15.5	.43
%Body wt.	1.10	2.69	2.56	2.43	2.19	.061
Supplement intake, lb[a]	.1	1.5	2.0	2.5	3.2	
Total dry matter intake, lb[bc]	12.9	19.5	20.1	19.6	18.7	.43
%Body wt.	1.89	2.98	2.92	2.87	2.72	.061
Dry matter dig. %[b]	48.5	55.5	55.2	54.7	54.2	.75
Dig. dry matter intake, lb[bc]	6.5	11.6	11.4	11.1	10.4	.59
%Body Wt.	.88	1.65	1.62	1.57	1.47	.039
Apparent CP dig, %[bc]	23.6	51.9	50.5	46.5	45.1	1.38
Acid detergent fiber dig, %[bc]	37.7	44.6	44.5	43.8	43.4	.87

[a]Dry matter basis.
[b]Significant increase ($P<.01$) for supplemented diets vs Control diet.
[c]Significant linear decline ($P<.01$) with decreasing SBM and increasing CGF in the supplement.
[d]Standard error.

replaced SBM in the supplement. The increase in prairie hay intake was 48.4, 41.4, 33.6, and 21.1% on the same treatments, respectively. The 48% increase in forage intake on the SBM treatment is in agreement with previous studies by Guthrie et al. (1984).

Total ration dry matter digestibility was increased from 48.5% on the Control to 55.5, 55.2, 54.7 and 54.2% on the SBM, 1/3 CGF, 2/3 CGF and CGF, respectively. The improvements noted with the different supplementation programs are illustrated in Figure 1. Calculated or anticipated digestibilites were based upon the value obtained for prairie hay on the Control treatment and an assumed digestibility of 80% for the protein supplement. The addition of supplement should improve total ration digestibility since supplement is more digestible than hay. With the SBM treatment, the observed digestibility (55.5%) exceeded the calculated or anticipated digestibility (50.7%) showing the positive effect of supplemental protein on digestibility of prairie hay. Improvements in digestibility also were noted on the two blend treatments. The observed digestibility was close to the expected digestibility on the CGF treatment.

Digestible dry matter intake was increased ($P<.01$) by supplementation from 6.5 lb on the Control to 11.6, 11.4, 11.1 and 10.4 lb on the SBM, 1/3 CGF, 2/3 CGF and CGF treatments, respectively. This is an average increase of more than 70% in digestible dry matter intake above the Control. A linear ($P<.01$) decline in digestible dry matter

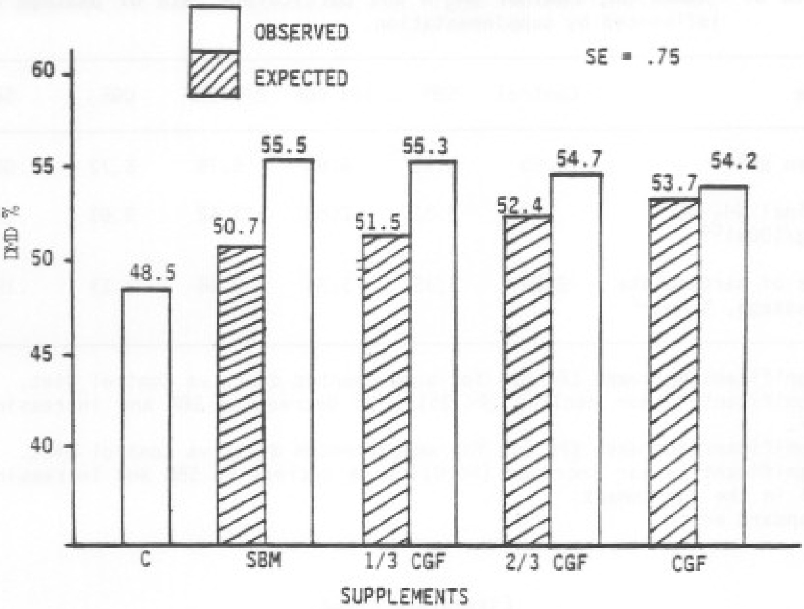

Figure 1. Comparison of observed vs. expected diet dry matter (DM) digestibilities. Expected digestibilities are based upon values obtained for the hay on the control treatment and 80% DM digestibility for the supplement.

intake was noted on the supplementation treatments as CGF replaced SBM in the supplement. Acid detergent fiber and apparent protein digestibilities were increased (P<.01) by supplementation. Protein, showed a linear decrease in digestibility, as did dry matter, as CGF replaced SBM in the supplement. Corrections for metabolic fecal nitrogen losses would yield higher protein digestibilities than noted herein, but the relative treatment differences would be similar to those noted.

Rumen pH was decreased (P<.01) by supplementation, but the actual amount appeared minimal, being 6.89 on the Control vs an average of 6.78 on the supplementation treatments (Table 3). The decrease reflects increased fermentation. Ruminal NH_3-N values were increased (P<.01) greatly by supplementation. A linear (P<.01) increase in ruminal NH_3-N was noted as CGF replaced soybean meal in the supplement. This implies protein in CGF was more rapidly or extensively degraded in the rumen than that in SBM or that NH_3-N was less completely utilized for microbial synthesis with CGF than with SBM supplements. Rate of particulate passage was increased (P<.01) an average of 53% by supplementation. Feeding of either SBM, blends of SBM and CGF, or CGF increased forage intake, improved digestibility of dry matter, protein and acid detergent fiber, and enhanced total digestible dry matter intake and rate of passage. However, improvements were generally greater with SBM than CGF.

Table 3. Rumen pH, ruminal NH_3-N and particulate rate of passage as influenced by supplementation.

Item	Control	SBM	1/3 CGF	2/3 CGF	CGF	SE[e]
Rumen pH[ab]	6.89	6.81	6.80	6.79	6.72	.030
Ruminal NH_3-N, mg/100ml[cd]	.57	2.31	2.55	3.42	3.63	.250
Rate of particulate passage, %/hour[c]	2.09	3.35	3.34	2.96	3.13	.185

[a]Significant decrease (P<.01) for supplemented diets vs Control diet.
[b]Significant linear decline (P<.05) with decreasing SBM and increasing CGF.
[c]Significant increase (P<.01) for supplemented diets vs Control diet.
[d]Significant linear increase (P<.01) with decreasing SBM and increasing CGF in the supplement.
[e]Standard error.

Literature Cited

Guthrie, M.J., D.G. Wagner and D.S. Buchanan. 1984. Effect of level of protein supplementation on intake and utilization of medium quality prairie hay by heifers. Okla. Agri. MP 116;156.

Teeter, R.G., F.N. Owens and T.L. Mader. 1984. Yetterbium chloride as a marker for particulate matter in the rumen. J. Anim. Sci. 58;465.

LEAD STEERS AS A MANAGEMENT TOOL FOR STRESSED STOCKER CATTLE

V.S. Hays[1], B.D. Johnson[1], D.R. Gill[2], K.S. Lusby[3], F.N. Owens[2], R.A. Smith[4] and R.L. Ball[5]

Story in Brief

Six trials involving 721 newly received steer and bull calves averaging 375 pounds were used in a study to evaluate the effects of lead steers (LS) on health and performance during a 28-d receiving period. The cattle were randomly sorted into pens of which contained a lead steer, a steer that was familiar with feed and water sources. There was a variable interaction between lead steers and loads of cattle. In some cases they were helpful and at other times very detrimental. It appeared that with light weight cattle which suffered high rates of morbidity that lead steers were detrimental. They tended to be helpful with the heavier, low morbidity cattle. Overall, lead steers did not influence the weight gains, or gain to feed ratio of stressed cattle. However, there was a significant decrease in feed intake (13.45 vs 13.91) as well as an increase in required medical treatments per head (3.67 vs 3.27) and morbidity (57.73 vs 53.71%) in the lead steer group over the controls. Among those cattle that became sick, lead steer pens tended to require more medical treatments (4.80 vs 4.37) as well as significantly increasing repulls as sick (26.66 vs 15.65). Due to the fact that lead steers could not have affected the performance of the cattle that were sick at processing, the data were analyzed excluding animals detected as sick during the first three days. There was no effect on daily gains, but an increase in both the medical treatments required and repulls as sick.

(Key Words: Lead Steer, Health, Performance, Stressed Stocker Cattle)

Introduction

Stress is a component of the bovine respiratory disease complex (BRDC). Weaning, the mixing of calves and changes in environment and nutrition all are perceived as stressful in calves (Phillips, 1982). Calves are subjected to additional stress when transported and processed. This reduces subsequent performance and increases disease susceptibility.

Newly received cattle are subjected often to additional stressors. Many young calves have never been exposed to feed bunks, water troughs and the complete diets associated with receiving programs in drylot facilities. Therefore, these groups of cattle go through a period of adjustment. It was hypothesized that if new cattle exposed to new surroundings had an animal acquainted with the surroundings, a lead steer (LS), adjustment might be less stressful and animal performance improved. Hence, this study was designed to evaluate the effects of a LS on the health and performance of newly received calves.

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[1]Graduate Assistant [2]Regents Professor [3]Professor [4]Associate Professor [5]Herdsman

Materials and Methods

Seven hundred twenty one head of cattle were assembled by order buyers and shipped to Pawhuska, Oklahoma in 1987 and 1988. The origin, arrival date and weight, number of head and transit shrink for each load is summarized in Table 1. Upon arrival, cattle were weighed individually, ear tagged and randomly placed in one of four to eight pens. Half of the pens contained a LS which had been exposed to the pen and the diet for a minimum of two weeks. LS were selected to be similar in age and weight to newly received cattle when possible.

Cattle in trials 1, 2 and 6 had free access to prairie hay and were fed 2 lb/head/day a pelleted feed supplement (Table 2) for the first 21 days. The amount of supplement was decreased to 1 lb/head/day during days 22 to 28. In trial 3, 4 and 5, cattle had ad libitum access to a 70% pelleted concentrate (Table 3) and received 2 lb prairie hay per head daily. There were no lead steers in the hospital pens.

On the morning following arrival, individual cattle in each pen were processed as follows:

1. Body temperature and time were recorded.

Table 1. Origin, arrival date, number of head, arrival weight and intransit shrink for each load of cattle.

	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
Trial 1	KY	2-16-1987	86	514	4.46
Trial 2	KY	2-20-1987	92	488	7.83
Trial 3	AL	7-12-1987	135	322	3.99
Trial 4	AL	9-07-1987	134	334	NA[a]
Trial 5	NC	9-16-1987	174	231	NA[a]
Trial 6	AR	1-22-1988	100	526	7.41

[a]NA=not available.

Table 2. Composition of feed supplement--Trial 1, 2, 6

Ingredient	% As Fed
Soybean meal	88.94
Cottonseed meal	5.00
Salt	3.00
Dicalcium phosphate	2.75
Vitamin A-30,000 IU/g	.11
Bovatec 68[a]	.15
Rovimix E 50% SD[b]	.09

[a]To provide 100 mg lasalocid per lb.
[b]DL-alpha-tocopherol acetate, to provide 200 IU/lb Vitamin E, Hoffmann-La Roche, Inc., Nutley, NJ 07110.

Table 3. Composition of feed supplement--Trial 4, 5

Ingredient	% As Fed
Corn, #2 ground	20.72
Soybean hulls	19.65
Wheat middlings	27.47
Cottonseed hulls	9.94
Rice meal-run by-products	9.94
Soybean meal	6.16
Cane molasses	4.77
Calcium carbonate	.95
Salt	.28
Vitamin A-30,000 IU/g	.01
Zinpro-100[a,b]	.08
Rovimix E 50% SD[c]	.01
Bovatec 68[d]	.02

[a]not included in control diet.
[b]Zinpro, Inc., Chaska, MN 55318.
[c]DL-alpha-Tocopherol acetate, to provide 50 IU/lb Vitamin E, Hoffman-La Roche, Inc., Nutley, NJ 07110
[d]To provide 15 mg of lasalocid per lb.

2. Cattle were vaccinated with IBR-PI3 (MLV) intermuscularly, _Leptospira pomona_ bacterin, and _Clostridia chavoei_, _septicum_, _novyi_ and _sordellii_ bacterin and dewormed with Ivomec[b].

3. Cattle with clinical signs of illness or a body temperature of 104F or greater received antibiotic treatment and sick animals were placed in the hospital pen and healthy animals were returned to their home pen.

Cattle were checked twice daily for signs of illness. Sick animals were moved to the processing area where body temperature was measured and severity of illness was clinically appraised. If body temperature exceeded 104 F the animal was considered sick. Sick animals received a medical treatment based on a specified sequence of antimicrobial drugs (Table 4). Sick animals were treated initially with the first drug in the sequence. If body temperature decreased within 24 h, this drug was continued for two more days. If no improvement was apparent within 24 h, the next drug in the sequence was administered. This process was repeated until a health improvement was detected.

Least squares analysis of variance were performed on data for all response criteria. Variables other than LS were superimposed across all trials and considered in the analysis. LS consumed supplement and hay at an approximate rate of 3% of their body weight. Total daily feed consumption for cattle in pens containing a LS was corrected by this amount. The initial model for weight gains, medical treatment, morbidity, feed intake, feed efficiency and repulls included trial (truck load), lead steer treatment and trial by lead steer treatment

[b]MSD Agvet, Rahway, NJ 070650

Table 4. Sequence of drugs used for treatment of BRDC.

Treatment No.1:[a]	Spectinomycin (Spectam)[b] -5 mg/lb.
Treatment No.2:[a]	Erythromycin (Gallamycin)[c] deep in the muscle -10 mg/lb.
Treatment No.3:[a]	Procain Penicillin G[d] subcutaneously -30,000 IU/lb.
Treatment No.4:	Oxytetracycline (Biomycin-C)[e] subcutaneously-5mg/lb. Plus Sulfamethazine Boluses (Sulmet-15gm)[f] 1 bolus/150 lb on day 1. 1 bolus/300 lb on subsequent days.

[a]Certain antimicrobial drugs used in this study were used for extra-label purposes or at extra-label dosages and require a veterinarian-client-patient relationship before use.
[b]Ceva Laboratories, Ft Scott, KS 66701.
[c]Ceva Laboratories, Ft Scott, KS 66701.
[d]Pfizer, Inc., Lee Summit, MO 64063.
[e]Boeringer-Ingelheim Animal Health, Inc., St Joseph, MO 64502.
[f]American Cyanamid, Co., Wayne, NJ 07470.

interaction as class variables. All models, excluding lead steer treatment, were reduced when sources of variation had observed significance levels greater than .20.

Results and Discussion

The effects of LS on daily gains, medical treatment and morbidity across all cattle are presented in Table 5. Daily Gains were similar for control cattle (2.01) and for calves in pens containing a LS (1.99). However, there was increased medical treatments required (3.67 vs 3.27) and higher morbidity (57.73% vs 53.71%) for the LS group.

Feed intake and gain to feed ratio averaged across pens are reported in Table 6. Feed intakes were significantly different (P<.04) with lead steer group intake depressed (13.45 vs 13.91) while gain to feed ratios were similar (0.143 and 0.142) for contol and LS groups respectively.

Performance of the cattle that became sick during the 28-d study are reported in Table 7. Again, LS cattle gained similar and tended to

Table 5. Effect of lead steers on weight gains, morbidity and mortality in stressed cattle.

Treatment	Control	LS
Number of head	356	345
Number of head never sick	133	115
Arrival weight, lb	384	381
Daily gain, lb[a]	2.01	1.99
Daily gain of head never sick, lb[a]	2.21	2.25
Medical treatments per head[a]	3.27	3.67
Morbidity, %[a]	53.71	57.73
Total Mortality, %	2.20	3.36

[a]Expressed as least square means.

Table 6. Effects of lead steers on feed intake and gain to feed ratio.

	Control	LS
Number of pens	20	20
Feed intake, lb[a,b]	13.91[c]	13.45[d]
Gain/feed[a]	.143	.142

[a]Expressed as least square means.
[b]Corrected for LS intake by removing 3% LS body weight per day.
[c,d]Means with different superscripts differ (P<.04)

Table 7. Effect of lead steers on daily gains and medical treatment in sick cattle.

	Control	LS
Number of head	223	230
Average daily gain, lb[a]	1.63	1.63
Medical treatments per head[a]	4.37	4.80
Repulls as sick %[a]	15.65[b]	26.66[c]

[a]Expressed as least square means.
[b,c]Means with different superscripts differ (P<.01)

Table 8. Effects of lead steers on daily gains, medical treatment, and morbidity in stressed cattle with sick head detected during first three days excluded.

	Controls	LS
Number of head	213	216
Arrival weight, lbs.	389	382
Average daily gain, lb[a]	2.10	1.99
Medical treatments per head[a]	1.31	1.71
Morbidity, %[a]	30.65	37.57

[a]Expressed as least square means.

(p=.19) increase medical treatments (4.80 vs 4.37) compared to controls. Repulls as sick were also significantly higher (p<.01) in the LS group (26.66%) vs the non LS group (15.65%).

Several cattle were treated for sickness at the time of processing. Because the lead steer treatment could not have influenced the initial illness of the cattle, the data also were analyzed excluding those treated as sick during the first three days of the trial (84 for controls and 75 for LS). The gains, medical treatments required per head and morbidity for this group of calves are reported in Table 8. Although gains were similar for LS and control calves (1.63 and 1.63 lb/day respectively), again there were more medical treatments required per morbid calf among the LS calves (1.71) compared with the controls (1.31). Addtionally, morbidity tended (P=.18) to be higher for the LS calves (37.57%) as compared with the controls (30.65%).

Weight gains, medical treatments and repulls as sick of the cattle that became sick during the trial with animals detected as sick during the first 3 days excluded are reported in Table 9. Repulls as sick among the control cattle were significantly lower (P<.03) than in the LS cattle (12.50% vs 22.77% respectively).

Under the conditions of this study, lead steer treatment had no effect on daily gains but tended to increase morbidity and medical treatments required per head. The possibility exists that when cattle from lead steer pens become sick and are removed from the lead steers, that this is a negative factor on performance. Additional trials with lead steers are needed to further evaluate their effects on performance and health. Additional data is being analyzed and will be reported in the future. In comparing individual trials, there is a current indication that lead steer treatment of heavier, low morbidity cattle may benefit performance and health.

Table 9. Effect of lead steers on daily gains, medical treatment and repulls as sick in sick cattle with head pulled on first 3 days excluded.

	Controls	LS
Number of head	80	101
Average daily gain, lbs.[a]	1.45	1.43
Medical treatments per head[a]	3.42	3.86
Repulls as sick, %[a]	12.50[b]	22.77[c]

[a]Expressed as least square means.
[b,c]Means with different superscripts differ (P<.03).

Literature Cited

Phillips, W.A. 1982. Factors associated with stress in beef cattle. Proc. Symposium on Management of Food Producing Animals. Volume II. Purdue Univ., p.640.

RESPIRATORY SYNCYTIAL VIRUS VACCINE FOR STRESSED STOCKER CATTLE

B.D. Johnson[1], V.S. Hays[1], D.R. Gill[2], R.A. Smith[3], F.N. Owens[2] and R.L. Ball[4]

Story in Brief

The effects of bovine respiratory syncytial virus (BRSV) vaccine on health and performance of stressed stocker cattle were measured in six trials using 754 newly received steer and bull calves and yearlings. Vaccination with bovine respiratory syncytial virus vaccine increased daily gains (1.56 vs 1.45 lb/day) and showed improvements in feed intake and feed efficiency over non-vaccinated calves. However, medical treatments required per head were higher (3.03 vs 2.88) and morbidity was increased by 5.6% with the vaccine. Additionally, the data was analyzed with those animals detected as sick during the first three days excluded because medical treatment could not have had an affect on the cattle that were sick at processing. Daily gains improved (1.63 vs 1.52), medical treatments increased (1.34 vs 1.23) and morbidity was higher (34.66 vs 30.09) in the vaccine group. Although, the incidence of bovine respiratory disease complex was increased, these data indicate that the administration of bovine respiratory syncytial virus vaccine improved weight gains and may have improved consumption and utilization of feed.

(Key Words: Bovine Respiratory Syncytial Virus, Stressed Stocker Cattle)

Introduction

Bovine respiratory syncytial virus (BRSV) has been isolated from nasal and ocular secretions following outbreaks of respiratory disease in calves (Jacobs and Eddington, 1971; Rosenquist, 1974; Lehmkuhl et al., 1979). Antibody surveys have shown that the virus is widely distributed and common in cattle populations (Rosenquist, 1983). In 1984, a modified live virus vaccine was licensed; however, it was later recalled. A new vaccine has since been developed and marketed for use in cattle. The objective of this research was to study the effect of BRSV vaccine on the health and performance of newly arrived stocker and feeder cattle.

Materials and Methods

Seven hundred fifty four head of cattle were assembled by order buyers and shipped to Pawhuska, Oklahoma in 1987. The origin, arrival date and weight, number of head and transit shrink for each trial are summarized in Table 1. Upon arrival, cattle were weighed individually, ear tagged and randomly placed in one of eight pens which had been assigned to one of the following treatments: unvaccinated controls or intramuscular vaccination with BRSV vaccine[5]. The vaccination treatments were applied at the time of processing.

[1]Graduate Assistant [2]Regents Professor [3]Associate Professor [4]Herdsman
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Table 1. Origin, arrival date, number of head, arrival weight and intransit shrink for each load of cattle.

	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
Trial 1	OK	1-17-1987	94	529	4.08
Trial 2	AR	1-18-1987	174	514	4.55
Trial 3	KY	2-16-1987	86	514	4.46
Trial 4	KY	2-20-1987	92	488	7.83
Trial 5	AL	9-07-1987	134	334	NA[a]
Trial 6	NC	9-16-1987	174	231	NA[a]

[a]NA=not available.

On the morning following arrival, individual cattle in each pen were processed as follows:

1. Body temperature and time were recorded
2. Cattle were vaccinated with IBR-PI3 (MLV) intermuscularly, Leptospira pomona bacterin, and Clostridia chavoei, septicum, novyi and sordellii bacterin and dewormed with Ivomec[6].
3. Cattle assigned to BRSV treatment received an intramuscular injection of bovine respiratory syncytial virus vaccine[5].
4. Cattle with clinical signs of illness or a body temperature of 104F or greater received antibiotic treatment and sick animals were placed in the hospital pen and healthy animals were returned to their home pen.

Cattle were checked twice daily for signs of illness. Sick animals were moved to the processing area where body temperature was measured and severity of illness was clinically appraised. If body temperature exceeded 104 F, the animal was considered sick. Sick animals received a medical treatment based on a specified sequence of antimicrobial drugs. If body temperature decreased within 24 h, the drug was continued for two more days. If no improvement was apparent within 24 h, the next drug in the sequence was administered. This process was repeated until a health improvement was detected.

In trials 1 through 4, cattle had free access to prairie hay and were fed 2 lb/head/day a pelleted feed supplement (Table 2) for the first 21 days. Supplement was decreased to 1 lb/head/day during days 22-28. Cattle in trial 5 and 6 had ad libitum access to a 70% pelleted concentrate (Table 3) and received 2 lb prairie hay per head each day. Two hospital pens were maintained to avoid mixing of treatment animals while out of their home pen.

Least squares analysis of variance was performed on data for all response criteria. Responses to the BRSV treatments were analyzed using individuals as the experimental unit except for the feed efficiency and feed intake responses which were analyzed using pens as the experimental unit. The initial models for weight gains, medical treatment, morbidity, feed intake and feed efficiency included trial (truck load), BRSV treatment and trial by BRSV treatment interaction as class variables. All models, excluding BRSV treatment, were reduced when sources of variation had observed significance levels greater than .20.

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[6]MSD Agvet, Rahway, NJ 070650

Table 2. Composition of feed supplement--Trial 1, 2, 3, 4

Ingredient	% As Fed
Soybean meal	88.94
Cottonseed meal	5.00
Salt	3.00
Dicalcium phosphate	2.75
Vitamin A-30,000 IU/g	.11
Bovatec 68[a]	.15
Rovimix E 50% SD[b]	.09

[a]To provide 100 mg lasalocid per lb.
[b]DL-alpha-tocopherol acetate, to provide 200 IU/lb Vitamin E. Hoffmann-La Roche, Inc., Nutley, NJ 07110.

Table 3. Composition of feed supplement--Trial 5, 6

Ingredient	% As Fed
Corn, #2 ground	20.72
Soybean hulls	19.65
Wheat middlings	27.47
Cottonseed hulls	9.94
Rice meal-run by-products	9.94
Soybean meal	6.16
Cane molasses	4.77
Calcium carbonate	.95
Salt	.28
Zinpro-100[ab]	.08
Vitamin A-30,000 IU/g	.01
Rovimix E 50% SD[c]	.01
Bovatec 68[d]	.02

[a]not included in control diet.
[b]Zinpro, Inc., Chaska, MN 55318.
[c]DL-alpha-Tocopherol acetate, to provide 50 IU/lb Vitamin E, Hoffman-La Roche, Inc., Nutley, NJ 07110
[d]To provide 15 mg of lasalocid per lb.

Results and Discussion

Effects of bovine respiratory syncytial virus vaccine on daily gains, sick pen days, morbidity and mortality are shown in Table 4. Daily weight gains tended to be improved (p=.12) with BRSV treatment from 1.45 to 1.56 lbs. However, the average number of medical treatments per head was lower in the control group vs the BRSV group (2.88 vs 3.03). Morbidity was high in both groups, but was lower (p=.07) in the nonvaccinated controls (59.09 vs 64.68%). Death loss among both groups of cattle were similiar (2.72 vs 2.69).

Feed intakes and gain to feed ratios are reported in Table 5. BRSV treament showed an increase in feed intake and gain to feed ratios

Table 4. Effect of BRSV vaccine on weight gains, morbidity and mortality in stressed cattle.

Treatment	Control	BRSV
Number of head	372	367
Number of head never sick	156	128
Arrival weight, lb	419	419
Daily gain, lb[a]	1.45	1.56
Daily gain of head never sick, lb[a]	1.62	1.72
Medical treatments per head[a]	2.88	3.03
Morbidity, %[a]	59.09	64.68
Total Mortality, %	2.69	2.72

[a]Expressed as least square means.

Table 5. Effects of BRSV vaccine on feed intake and gain to feed ratio.

	Control	BRSV
Number of pens	20	20
Feed intake, lb[a]	13.86	14.10
Gain/feed[a]	.103	.110

[a]Expressed as least square means.

by 1.7 and 6.8% respectively. These results as well as those above were not influenced by superimposed feed treatments. With increased morbidity and more medical treatments required per head, one might expect to see reduced weight gains and feed intake by vaccinated cattle. This was not the case.

The effects of BRSV vaccine on daily gains and medical treatments in the cattle that became sick during the trial are reported in Table 6. Although nonsignificant, daily gains of sick cattle favored the control cattle over the vaccinated cattle (1.50 vs 1.45 lbs. respectively) as well as the number of cattle repulled as sick (28.71 and 30.33).

There is a delay between vaccination and an immune response in animals. Due to this delay, the initial illness that occurs before the third day after vaccination usually can not be attributed the BRSV

Table 6. Effect of BRSV vaccine on daily gains and medical treatments in sick cattle.

	Control	BRSV
Number of head	214	238
Average daily gain, lb[a]	1.50	1.45
Medical treatments per head[a]	4.96	4.94
Repulls as sick, %[a]	28.71	30.33

[a]Expressed as least square means.

vaccine. Hence, the data were also analyzed with those cattle pulled as sick on the first three days excluded from the model (141 control head and 145 BRSV head). BRSV vaccine did not appear to effect the number of cattle detected sick during the first three days. The effects of BRSV vaccine on weight gains, medical treatments per head and morbidity with these head excluded are summarized in Table 7. Cattle which were vaccinated with BRSV had higher weight gains (1.63 vs 1.52 lb/head/day), required more medical treatments per head (1.34 vs 1.23) and had higher morbidity (34.66 vs 33.66) than nonvaccinated controls.

The effects of BRSV on the health and performance of the cattle that became sick during the trials excluding those pulled during the first three days are presented in Table 8. Average daily gains were improved ($p<.07$) by 11% (1.50 vs 1.23) and mean medical treatments decreased in vaccinated cattle. However, the sick cattle that required repulling increased (23.15% vs 16.33%) in the BRSV group.

Under the conditions of this study, weight gains of newly arrived cattle were improved by treatment with intramuscular bovine respiratory syncytial virus vaccine. This probably was due to the tendency for an increased feed intake. However, because of poorer health response to BRSV vaccine, further studies need to be conducted with BRSV before definite conclusions concerning its efficacy can be drawn.

Table 7. Effects of BRSV vaccine on daily gains, medical treatments and morbidity in stressed cattle with sick head pulled at proccessing or on day 1 or day 2 excluded.

	Controls	BRSV
Number of head	231	225
Arrival weight, lb	450	451
Average daily gain, lb[a]	1.52	1.63
Medical treatments per head[a]	1.23	1.34
Morbidity, %[a]	30.09	34.66

[a]Expressed as least square means.
[b,c]Means with different superscripts differ ($p<.02$).

Table 8. Effect of BRSV vaccine on daily gains, medical treatments, and repulls in sick cattle with head pulled during the first three days excluded

	Controls	BRSV
Number of head	75	97
Average daily gain, lb[a]	1.23	1.50
Medical treatments per head[a]	4.22	4.12
Repulls as sick, %[a]	16.33	23.15

[a]Expressed as least square means.

Literature Cited

Jacobs, J.W. and N. Eddington. 1971. Isolation of respiratory syncytial virus from cattle in Britain. Vet. Rec. 88:694.

Lehmkuhl, H.D. annd R.C. Cutlip. 1979. Experimentally induced respiratory syncytial virus infection in lambs. Am. J. Vet. Res. 40:124.

Rosenquist, B.D. 1974. Isolation of respiratory syncytial virus from calves with respiratory disease. J. Infect. Dis. 130:177.

Rosenquist, B.D. 1983. Viruses as etiologic agents of bovine respiratory disease. In: R.W. Loan (Ed.). Bovine Respiratory Disease, A Symposium. Tx. A and M Univ. Press, p. 363.

ZINC METHIONINE FOR NEWLY RECEIVED STOCKER CATTLE

B.D. Johnson[1], V.S. Hays[1], D.R. Gill[2], R.A. Smith[3], F.N. Owens[2] and R.L. Ball[4]

Story in Brief

In five 28-day receiving trials, 773 newly received steer and bull calves (301 pounds) were used to evaluate the effect of adding zinc methionine to the diet on health and performance. Half of the cattle received 3.6 g Zinpro100 which supplied 360 mg zinc per head daily in the form of zinc methionine. The data were analyzed excluding animals that were detected as sick during the first three days of the study because feed treatment could not have had an affect on the cattle that were sick at processing. The Zinpro supplemented cattle gained 10.7% faster (1.55 vs 1.40), required 5.8% fewer medical treatments (2.12 vs 2.25) and had a decrease in morbidity (46% vs 51%). For cattle that became sick during the study, there was a significant decrease ($P<.03$) in the required medical treatments per head (4.45 vs 4.94) among supplemented animals. Considering all cattle in the analysis, daily gains, feed intake and feed efficiency of the total group of animals were not significantly different between supplemented and control groups although again number of mean medical treatments per head were decreased slightly (3.2 vs 3.7) and morbidity was slightly lower (72% vs 74%) in the zinc supplmented group. It appears that the decline in medical treatments required would at least cover the cost of added zinc methionine.

(Key Words: Zinc Methionine, Supplemented, Newly Received Stocker Cattle)

Introduction

Zinc is an essential element which functions as an activator or constituent of several essential enzyme systems. Zinc has been shown to stimulate the immune system of mice, rats and chickens.

Zinc is removed from the circulating blood by the liver in response to viral, bacterial and parasitic infections (Pekarek et al., 1973). Hutcheson and Cummins (1987) reported that serum zinc levels declined after calves were challenged with virulent IBR virus. They also reported that serum levels were lower upon arrival than prior to shipment suggesting that the stress associated with transport may cause redistribution of zinc in calves. Spears (1988) found that stressed steers fed supplemental zinc tended to gain faster the first 14 days of a 28 day study. Compared with controls, steers fed zinc methionine consumed 5.2% more feed during the study. Therefore, the objectives of this study were to evaluate the health and performance responses of newly received, stressed cattle to dietary supplementation of zinc as zinc methionine at a rate of 3.60 g /head/day.

[1]Graduate Assistant [2]Regents Professor [3]Associate Professor [4]Herdsman

Material and Methods

Five truck loads of calves (designated as trials), were assembled by order buyers and shipped to Pawhuska, Oklahoma in the summer and fall of 1987. The origin, arrival date and weight, number of head and transit shrink for each load is summarized in Table 1. Upon arrival, cattle were weighed individually, ear tagged and randomly placed in one of eight pens holding 16 to 22 animals each. Pens were randomly assigned to zinc or control supplements.

Cattle had ad libitum access to a 70% concentrate pellet (Table 2) and were fed prairie hay (2 lbs./head/day) throughout the 28-d receiving period. The pellet contained either no supplemental zinc, or 365 mg Zinpro 100/lb DM of pellet (36.5 mg Zn/lb). Two hospital pens were maintained so that sick animals received their assigned feed while in their hospital pen.

Table 1. Origin, arrival date, number of head, arrival weight and intransit shrink for each load of cattle.

	Origin	Arrival Date	Number of Head	Arrival Wt., lb	% Shrink
Trial 1	AL	6-27-1987	145	316	4.66
Trial 2	AL	7-12-1987	135	322	3.99
Trial 3	AL	8-08-1987	145	302	8.37
Trial 4	AL	9-07-1987	134	334	Na[a]
Trial 5	NC	9-16-1987	174	231	Na[a]

[a]NA=not available.

Table 2. Composition of feed supplement.

Ingredient	As Fed %
Corn, #2 ground	20.72
Soybean hulls	19.65
Wheat middlings	27.47
Cottonseed hulls	9.94
Rice meal-run by-products	9.94
Soybean meal	6.16
Cane molasses	4.77
Calcium carbonate	.95
Salt	.28
Vitamin A-30,000 IU/g	.01
Zinpro-100[ab]	.08
Rovimix E 50% SD[c]	.01
Bovatec 68[d]	.02

[a]not included in control diet.
[b]Zinpro, Inc., Chaska, MN 55318.
[c]DL-alpha-Tocopherol acetate, to provide 50 IU/lb Vitamin E, Hoffmann-La Roche, Inc., Nutley, NJ 07110.
[d]To provide 15 mg of lasalocid per lb.

On the morning following arrival, individual cattle in each pen were processed as follows:

1. Body temperature and time were recorded.

2. Cattle were vaccinated with IBR-PI3 (MLV) intermuscularly, Leptospira pomona bacterin, and Clostridia chavoei, septicum, novyi and sordellii bacterin and dewormed with Ivomec[5].

3. Cattle with clinical signs of illness or a body temperature of 104 F or greater received antibiotic treatment and sick animals were placed in the hospital pen and healthy animals were returned to their home pen.

Cattle were checked twice daily for signs of illness. Sick animals were moved to the processing area where body temperature was measured and severity of illness was clinically appraised. If body temperature exceeded 104 F, the animal was considered sick. Sick animals received a medical treatment based on a specified sequence of antimicrobial drugs (Table 3). Sick animals were treated initially with the first drug in the sequence. If body temperature decreased within 24 h, this drug was continued for two more days. If no improvement was apparent within 24 h, the next drug in the sequence was administered. This process was repeated until a health improvement was detected.

Least squares analysis of variance was performed on data for all response criteria. Responses to the feed treatments were analyzed using pens as the experimental unit. The initial models for weight gains, medical treatment, morbidity, feed intake and feed efficiency included trial (truck load), feed treatment and trial by feed treatment interaction as class variables. All models, excluding feed treatment, were reduced when sources of variation had observed significance levels greater than .20.

Table 3. Sequence of drugs used for treatment of BRDC.

Treatment No.1:[a]	Spectinomycin (Spectam)[b] -5 mg/lb.
Treatment No.2:[a]	Erythromycin (Gallamycin)[b] deep in the muscle -10 mg/lb.
Treatment No.3:[a]	Procain Penicillin G[c] subcutaneously -30,000 IU/lb.
Treatment No.4:	Oxytetracycline (Biomycin-C)[d] subcutaneously-5mg/lb. Plus Sulfamethazine Boluses (Sulmet-15gm)[e] 1 bolus/150 lb on day 1. 1 bolus/300 lb on subsequent days.

[a]Certain antimicrobial drugs used in this study were used for extra-label purposes or at extra-label dosages and require a veterinarian-client-patient relationship before use.
[b]Ceva Laboratories, Ft Scott, KS 66701.
[c]Pfizer, Inc., Lee Summit, MO 64063.
[d]Boeringer-Ingelheim Animal Health, Inc., St Joseph, MO 64502.
[e]American Cyanamid, Co., Wayne, NJ 07470.

[5]MSD Agvet, Rahway, NJ 07065.

Results and Discussion

All the cattle were stressed as a result of handling, transportion, and their new environment which attributed to a high sickness rate of the newly received cattle. Because supplemental zinc in the receiving diet could not influence health on arrival, the data were analyzed with those animals that were detected as sick at processing and on day 1 or day 2 excluded. Daily gains, medical treatments, and morbidity of the remaining cattle are reported in Table 4. The zinc supplemented group of cattle had 10.7% faster daily gains (1.55 vs 1.40 lb/d), a 5.8% decline in required medical treatments (2.1 vs 2.3) and a slight decrease in morbidity (46% vs 51%).

The effects of zinc methionine on daily gains, medical treatments and repulls only for the sick cattle (animals pulled as sick at processing or during day 1 or day 2 excluded) are reported in Table 5. Responses were similar to those noted in cattle receiving supplemental zinc, with a slight increase in daily gains (1.25 vs 1.18 lb/d) and a decline in required medical treatments (4.10 vs 4.40). However, the number of repulls as sick was slightly lower in the control group (13% vs 20%) compared with the zinc group.

The effects of zinc methionine on performance and health of sick cattle including those sick on arrival are presented in Table 6. Again a slight increase (3.1%) in average daily gains (1.33 vs 1.29 lbs.), a significant decrease ($P<.03$) in medical treatments per head (4.45 vs 4.94) as well as a decline in the number of repulls as sick (20.70% vs 21.32%) was noted for cattle receiving the zinc feed treatment.

Table 4. Effects of Zinc Methionine on daily gains, medical treatments and morbidity in stressed cattle with sick head pulled at processing or on day 1 or day 2 excluded.

	Control	Zinc
Number of head	196	207
Arrival weight, lb	298	298
Average daily gain, lb/d[a]	1.40	1.55
Medical treatments per head[a]	2.25	2.12
Morbidity, %[a]	51.19	46.23

[a]Expressed as least square means.

Table 5. Effect of Zinc Methionine on daily gains, medical treatments, and repulls in sick cattle with head pulled during day 1 or day 2 excluded

	Control	Zinc
Number of head	103	111
Average daily gain, lb/d[a]	1.18	1.25
Medical treatments per head[a]	4.40	4.10
Repulls as sick, %[a]	13.37	19.88

[a]Expressed as least square means.

Daily gain, mean medical treatments per head, morbidity and mortality of all cattle (sick plus healthy) are shown in Table 7. Daily gains, feed intake and gain to feed ratios were similar for both treatments. However, the cattle receiving supplemental zinc required less ($P<.08$) medical treatments (3.21 vs 3.66). Although extremely high in both treatment groups, morbidity was slightly lower (72% vs 74%) in the zinc group. This level of illness may have masked any benefits from zinc supplementation.

Feed intake as well as gain to feed ratio are reported in Table 8. The calves in the zinc group consumed an average of 7.9 lb of pellets per day supplying an additional 322 mg of zinc above the control diet.

Table 6. Effects of zinc methionine on daily gains and medical treatments in sick cattle.

	Control	Zinc
Number of head	266	257
Average daily gains, lb/d[a]	1.29	1.33
Medical treatments per head[a]	4.94[b]	4.45[c]
Repulls as sick, %[a]	21.32	20.70

[a]Expressed as least square means.
[b,c]Means with different superscripts differ ($P<.03$).

Table 7. Effect of Zinc Methionine on weight gains, morbidity and mortality in stressed cattle

	Control	Zinc
Number of head	368	365
Number of head never sick	93	96
Arrival weight, lb	301	301
Daily gain, lb/d[a]	1.45	1.47
Daily gain of head never sick, lb[a]	1.69	1.75
Medical treatments per head[a]	3.66	3.21
Morbidity, %[a]	73.90	72.49
Total mortality, %	1.07	1.44

[a]Expressed as least square means.

Table 8. Effects of feeding zinc methionine on feed intake and gain to feed ratio

	Control	Zinc
Number of pens	20	20
Feed intake, lb[a]	9.88	9.88
Gain/feed[a]	.137	.140

[a]Expressed as least square means.

Brandt and Elliot (1987) reported that 350 mg of zinc/day increased feed intake, gains of morbid steers and reduced sick pen days and the reoccurrence of illness over non-zinc supplemented steers in a receiving study using feeder calves. The level of zinc consumed in this study elicited no improvement in feed intake or gain/feed ratio.

Supplemental zinc methionine, under the conditions of this study, increased performance, decreased the number of required medical treatments per head and slightly lowered morbidity in the newly received cattle. More trials need to be conducted with supplemental zinc methionine at different levels of intake during the receiving period to further evaluate responses to this compound.

Literature Cited

Brandt, R.T. and J.K. Elliot. 1987. Zinc and vitamin E effects on stressed feeder calves. Sw. Ks. Agr. Exp. Sta. RP-518:13.

Hutcheson, D.P. and J.M. Cummins. 1987. Effects of trace minerals on the immune system of cattle. Proc. 38th Montana Livestock Nutrition Conference, Special Report 23:12.1.

Pekarek, R.S., R.W. Wannemacher, Jr., M.C. Powanda and W.R. Beisel. 1973. Clinical Research. 21:608.

Spears, J.W. 1988. Evaluation of Zinc Methionine in Ruminant Diets. Zinpro Technical Manual, 1988.

RUMINAL DEGRADABILITY OF PROTEIN SUPPLEMENTS BY STOCKER CATTLE GRAZING WHEAT PASTURE

G.J. Vogel[1], M.A. Andersen[1] and G.W. Horn[2]

Story in Brief

Two experiments were conducted to evaluate rate and extent of in situ ruminal nitrogen disappearance of soybean meal, cottonseed meal, meat and bone meal and fish meal by cattle grazing wheat pasture. In each of two years, 8 multi-cannulated steers were used in a split-plot design in which steers grazed wheat pasture during the immature and mature stages of wheat forage growth. Extent of ruminal degradability of the protein supplements was calculated by combining nitrogen disappearance estimates with rate of passage. Extent of ruminal nitrogen degradability (%) was greatest for soybean meal (62.5), while cottonseed meal (53.7) was intermediate and meat and bone meal (44.0) and fish meal (40.1) had the lowest values. Because of the rapid rate of wheat forage nitrogen degradation, differences in the rate and extent of nitrogen disappearance from protein feeds should be considered when formulating supplements for stocker cattle grazing wheat pasture.

(Key Words: Wheat Pasture, Protein Supplements, Ruminal Degradability.)

Introduction

Wheat and other small grain forages are high-quality forages, and commonly contain 24 to 30% crude protein (CP) on a dry matter basis. Recent studies by Zorrilla-Rios et al. (1985) and Vogel et al. (1988) have shown that wheat forage nitrogen (N) exists kinetically as two distinct N pools with different rates of N disappearance. Approximately 50 to 75% of wheat forage N disappears at rates of 13 to 28 %/hr. Because of the rapid rate of degradation of wheat forage N and loss of ammonia-N that is not incorporated into microbial protein, performance of rapidly growing stocker cattle on wheat pasture may be limited by inadequate amounts of non-ammonia nitrogen (NAN) flowing to the small intestine. Therefore, performance of wheat pasture stocker cattle may be improved by supplementation with protein. However, results from studies have been conflicting. Grigbsy (1982) did not observe any affect of increased protein intake on weight gains when stocker cattle grazing wheat pasture were fed soybean meal-based supplements. Conversely, Lee (1985) reported that weight gains of stocker cattle fed 1.50 lb/day of meat and bone meal-containing supplement were increased by .20 lb/day as compared with calves fed control, milo- or hominy-based supplements. Differences in these two trials may have been due to the amount of ruminal degradable protein fed. Therefore, the objective of this research was to determine the rate and extent of ruminal N disappearance of several high-protein feedstuffs by stocker cattle grazing wheat pasture.

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Experimental Procedure

In each of two years, 8 mature multi-cannulated Hereford and Hereford X Angus steers (1221 $\pm$ 51 lb) were used in a split plot design with two grazing periods. Grazing periods occurred during rapid spring growth (immature, March 8 to March 20) and the "grazeout" (mature, April 18 to May 4) period on wheat pasture during 1986 and 1987. As part of another experiment, steers were randomly allotted to two treatments and received either a corn-based (control) or a 16 to 20% CP supplement containing 18 to 25% meat meal.

In each grazing period, duplicate dacron bags containing approximately 2.5 g of soybean meal (SBM), cottonseed meal (CSM, method of processing unknown), meat and bone meal (MBM) and fish meal (FSM) were incubated in situ in the rumen of each steer for 4, 8, 12, 24 and 36 hr in experiment 1 and also 48 hr in experiment 2. Residues from the bags were analyzed for nitrogen (N) content by the Kjeldahl procedure. Nitrogen disappearance estimates obtained in situ were fit using a nonlinear iterative procedure to estimate potential degradability (P) with the following equation: $P = a + b(1-e^{-ct})$ where

a = the highly soluble, rapidly disappearing fraction,
b = the fraction other than "a" that is potentially digestible,
c = the rate of disappearance of fraction "b",
t = time.

Using the estimated parameters (i.e., a, b and c) the extent of ruminal disappearance (RD) for each protein supplement was calculated using the equation of Ørskov and McDonald (1979) where $RD = a + (b*c)/(c+k)$. The rate constant, k, represents rate of passage. Rate of passage in year 1 was assumed to be 5 %/hr while in year 2 rate of passage was estimated by mordanting meat and bone meal with chromium (Cr) and regressing Cr concentration of duodenal samples on time after a 200 g intraruminal dose of the mordanted meal.

All protein supplements were characterized chemically by total N analysis, solubility of N in .15 normal NaCl, pepsin insoluble N (PIN) and organic matter (OM). The composition of the wheat forage grazed is reported in the previous paper in this research report (Vogel et al., 1988).

Results and Discussion

The composition of the protein supplements is shown in table 1. Total CP content ranged from 39.8 to 60.6%. Soluble N comprised 14.5 to 21.0% of total N while PIN ranged from 6.3 to 18.5% of total N.

Parameters describing N disappearance in situ and extent of ruminal N degradability are presented in table 2. Treatment and grazing period did not influence (P>.20) the kinetics of N disappearance. Although the year x protein supplement interaction was significant (P<.05), the data were pooled across years because the rank order of protein supplements in each year was similar.

Of the N present in the protein supplements, virtually all was potentially degradable for SBM (97.4%) while approximately 77.3% was potentially degradable for CSM. The animal protein supplements (i.e., MBM and FSM) were more (P<.05) resistant to ruminal degradation with roughly 57% of total N being potentially degradable. Most likely, the heat applied during the drying of MBM and FSM makes the meals more resistant to ruminal degradation. When the potentially degradable N was partitioned into soluble N (i.e., fraction a) and insoluble but

Table 1. Composition (DM basis) of protein supplements.

Item	Protein supplement[a]				SEM[b] (n=6)
	SBM	CSM	MBM	FSM	
Organic matter, %	93.02	93.02	68.49	79.04	2.27
Crude protein, %	49.94	39.81	47.44	60.56	1.75
Nitrogen					
Total, %	7.51	6.37	7.59	9.69	.28
Soluble, % of total N	14.90	14.59	14.50	20.95	1.24
PIN[c], % of total N	8.62	18.52	11.51	6.28	.92

[a]SBM = soybean meal, CSM = cottonseed meal, MBM = meat and bone meal, FSM = fish meal.
[b]Standard error of the mean.
[c]Pepsin insoluble nitrogen.

Table 2. Parameters from the exponential equation describing nitrogen disappearance and extent of ruminal nitrogen degradability of SBM, CSM MBM and FSM for steers grazing wheat pasture.

Item	Protein supplement[a]				SEM[b]
	SBM	CSM	MBM	FSM	
Fraction a, %	17.62[f]	33.05[c]	23.66[e]	28.77[d]	.96
Fraction b, %	79.78[c]	44.26[d]	35.18[e]	26.25[f]	1.63
Potentially degradable, %	97.40[c]	77.31[d]	58.84[e]	55.02[e]	1.51
Rate of N disappearance, %/hr	6.57[d]	4.75[e]	8.03[c]	5.06[e]	.49
Ruminal degradability, %	62.53[c]	53.68[d]	43.99[e]	40.09[f]	.52

[a]SBM = soybean meal, CSM = cottonseed meal, MBM = meat and bone meal, FSM = fish meal.
[b]Standard error of the mean.
[c,d,e,f]Means in the same row with different superscripts are different ($P<.05$).

degradable N (i.e., fraction b), SBM contained the smallest ($P<.05$) proportion of soluble N (17.6%) and the largest ($P<.05$) proportion of insoluble but potentially degradable N (79.8%). Cottonseed meal (33.0), MBM (23.7%) and FSM (28.8%) each had substantial quantities of N present in fraction "a" which is assumed to be rapidly degraded within the rumen. It is interesting to note that fraction "a" for FSM was greater than 52% of the total potentially degradable N indicating that after the initial loss of soluble N, little was degraded in the rumen. Ørskov et al. (1983) fed sheep and cattle grass hay and reported similar fraction "a" values for CSM (32.2%), FSM (30.4%) and MBM (23.7%).

The insoluble but degradable N (i.e., fraction b) ranged from 26.3 (FSM) to 79.9% (SBM) of total N. Rate of N disappearance of this fraction (%/hr) was greatest for MBM (8.03%), while rate of N disappearance for SBM (6.6%) was intermediate. Cottonseed meal (4.75%) and FSM (5.1%) had the lowest (P<.05) rates of N disappearance. However, because fraction "b" for MBM and FSM was small (35.2 and 26.3%, respectively) ruminal digestion of these protein supplements was almost complete within 20 hours (figure 1). Nevertheless, the rates of N disappearance (%/hr) are comparable to those reported by Ørskov et al. (1983) where rates of N disappearance for SBM, CSM, MBM and FSM were 5.48, 8.25, 7.74 and 1.90 %/hr, respectively.

Extent of ruminal N degradability for the protein supplements was calculated assuming a passage rate of 5 %/hr in year 1 and by obtaining rate of passage estimates using Cr-mordanted MBM in year 2. Meat and bone meal was assumed to represent rate of passage for all protein supplements since different protein sources fed at the same level should not change passage rates to a large degree. Rate of passage of the mordanted MBM averaged 4.85 %/hr. Ruminal N degradation was greatest (P<.05) for SBM (62.5%) which was approximately 8.9, 18.5 and 22.4 percentage units greater than CSM, MBM and FSM, respectively. Consequently, greater amounts of N from supplemental MBM and FSM would be expected to pass to the small intestine. The differences in ruminal degradability of the protein supplements may partially explain the discrepancies in animal performance in the studies reported by Grigsby (1982) and Lee (1984).

In conclusion, these data indicate that rate and extent of ruminal N degradation of SBM, CSM, MBM and FSM differ when fed to cattle grazing wheat pasture. These results should be considered in formulation of supplements for growing cattle on wheat pasture.

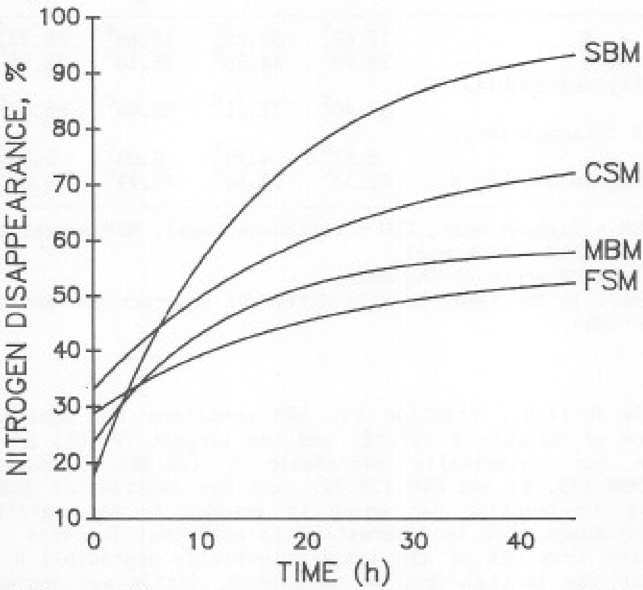

Figure 1. **Nitrogen disappearance curves for soybean meal (SBM), cottonseed meal (CSM), meat and bonemeal (MBM) and fishmeal (FSM).**

Literature Cited

Lee, R.W. 1985. Bypass protein supplementation for cattle grazing wheat pasture. Kansas Cattle Feeders Day Report of Progress 474, p. 7.

Grigsby, M.E. 1982. Supplements for stockers on winter wheat pasture. Proc. Clayton Livestock Research Center. New Mexico Agr. Rep. Sta. p. 17.

Ørskov, E.R. et al. 1983. Studies on the degradation and outflow rate of protein supplements in the rumen of sheep and cattle. Livestock Prod. Sci. 10:17.

Ørskov, E.R. and I. McDonald. 1979. The estimation of protein degradability in the rumen from incubation measurements weighted according to rate of passage. J. Agric. Sci. Camb. 92:499.

Vogel, G.J. et al. 1988. Kinetics of ruminal disappearance of wheat forage nitrogen in steers grazing wheat pasture at two stages of forage maturity. Oklahoma Agr. Exp. Sta. Res. Rep. MP-125:41.

Zorrilla-Rios, J. et al. 1985. In situ disappearance of dry matter and nitrogen of wheat forage, corn gluten meal, cottonseed meal and soybean meal in steers grazing wheat pasture at two stages of maturity. Oklahoma Agr. Exp. Sta. Res. Rep. MP-117:169.

EFFECT OF MEAT MEAL SUPPLEMENTATION OF WHEAT PASTURE STOCKER HEIFERS ON FORAGE INTAKE AND NITROGEN BALANCE

M.A. Andersen[1], G.J. Vogel[1], G.W. Horn[2] and K.B. Poling[3]

Story in Brief

The effect of meat meal supplementation on forage intake and nitrogen balance of free-grazing growing heifers on wheat pasture was studied. Eight ruminally cannulated growing Hereford x Angus heifers were fed 2 lb/day (trial 1) and 3 lb/day (trial 2), of a corn-based, control supplement or a supplement containing 24% meat meal (as-fed basis). Forage intake and nitrogen balance were measured during three grazing periods. Intake of wheat forage organic matter, expressed as a percentage of body weight, was increased 39 and 18% by meat meal supplementation of heifers in these studies. Nitrogen retention of heifers was not influenced by meat meal supplementation. These results indicate that improved forage intake, possibly resulting from a correction in amino acid balance of non-ammonia nitrogen flowing to the small intestine, is a primary mechanism by which supplementing growing cattle on wheat pasture with protein supplements of low ruminal degradability, such as meat meal, has increased performance.

(Key Words: Wheat Pasture, Protein Supplementation, Nitrogen Balance.)

Introduction

The crude protein content of wheat forage is typically high (i.e., 20 to 30% of dry matter). However, supplementing wheat pasture stocker cattle with a "bypass" protein such as meat meal has been shown to increase daily weight gains (Horn et al., 1987 and Lee, 1985). This may partially be due to greater amounts of protein reaching the small intestine, compensating for the rapid ruminal degradation and loss of wheat forage nitrogen (Zorrilla-Rios et al., 1985) or a more balanced flow of amino acids to the small intestine. Including meat meal in supplements of steers grazing wheat pasture did not affect ruminal pH, ammonia concentration or molar proportions of volatile fatty acids (Andersen et al., 1987). This study was conducted to evaluate the effect of inclusion of meat meal in supplements of growing heifers grazing wheat pasture on forage intake and nitrogen balance.

Materials and Methods

Eight ruminally cannulated Hereford x Angus heifers grazed wheat pasture from February through March 1987 (trial 1) and from November through December, 1987 (trial 2). Heifers were randomly allotted to one of two treatments and received (2 lb/day in trial 1 and 3 lb/day in trial 2) either a corn-based, control supplement or a supplement containing meat meal. Supplements were administered to the heifers directly through the rumen cannulas. Ingredient composition of the

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supplements is shown in table 1. Yeast Culture was included in the supplements of trial 1 in an attempt to improve palatability and intake of the meat meal-containing supplement by cattle of a companion grazing and performance trial on wheat pasture. The supplement for trial 2 was formulated and fed at a level to provide the same amount of crude protein per kg of metabolic body weight as in trial 1. Within each trial, supplements were isocaloric and contained similar amounts of Ca, P and Mg. Forage intake and nitrogen balance measurements were made during 4 experimental periods. Each experimental period consisted of a supplement adaptation period of at least 2 weeks followed by periods of (1) one day for adaptation to catheterization and the fecal and urine collection harnesses and bags and (2) four days for collection of total feces and urine. Data of the second experimental period of trial 1 was deleted because it was extremely variable, which was attributed to the fact that the heifers were fairly light weight (i.e., about 400 lb) and the stress of the collection equipment. The remaining collection periods were March 7-13 in trial 1; and November 12-16 and December 2-6 in trial 2.

Total collection of feces and urine were made by the procedure of Stillwell et al. (1983). Feces were collected from bags every 24 h in trial 1, and every 12 h in trial 2. Total fecal contents were weighed, then mixed in a paddle mixer and subsampled. Subsamples were dried in a forced air oven at 55 C. Dry matter, organic matter (OM) and nitrogen (N) were determined on each subsample. Subsamples were composited by animal in proportion to the fecal dry matter output for the day corresponding to the subsample. Indigestible neutral detergent fiber was used as an internal indigestible marker to determine forage OM digestibility. In vitro digestibility of supplements was deter-

Table 1. Composition of supplements (% of DM).

Ingredient	Control	Meat meal
	Trial 1	
Corn	79.3	62.2
Meat meal	----	25.4
Cottonseed hulls	3.8	3.8
Calcium carbonate	2.7	----
Dicalcium phosphate	5.2	----
Magnesium oxide	.7	.2
Molasses	4.2	4.2
Diamond V Yeast Culture	3.0	3.0
Trace mineralized salt	.3	.3
Salt	.7	.7
Rumensin premix[a]	.14	.14
	Trial 2[b]	
Meat meal	----	25.0
Corn	91.8	75.0
Calcium carbonate	2.7	----
Dicalcium phosphate	5.1	----
Magnesium oxide	.4	----

[a]Added to provide 75 mg monensin/lb of supplement.
[b]Monensin provided to all heifers in gelatin capsules at level of 231 mg/day.

mined, and daily fecal outputs were corrected for indigestibility of the supplements in calculating forage intake.

Urine bags were emptied every 12 h. Total urine volume was measured, then urine was diluted to an exact volume. Aliquots (i.e., 10% of the final volume) were acidified, composited and refrigerated until analyzed for N content at the end of each period.

Hand clipped forage samples were collected during each period to determine dry matter and OM of wheat forage. A second set of forage samples were collected by use of esophogeal cannulated steers, and were frozen and lyophilized for use in determining indigestible neutral detergent fiber content of forage. A third set of forage samples were hand clipped, and frozen immediately in liquid nitrogen. These samples were lyophilized, and subsequently analyzed for N, soluble N, non-protein nitrogen (NPN), and soluble carbohydrate concentrations. Nitrogen of wheat forage was determined by the Kjeldahl procedure, NPN content was determined by the difference between total N and protein N precipitated in a 10% H_2SO_4 and Na-tungstate solution. Soluble N was determined as N soluble in the mineral mixture (2% v/v; pH = 6.5) of the "Ohio" in vitro fermentation media (Johnson, 1969). Soluble carbohydrates were determined by the procedure of Balwani (1965).

Results and Discussion

Forage N components (table 2) appeared typical for wheat forage during this time of the year, with the exception that total N concentration was slightly lower than normal in trial 1. This may be related to the unusually large fluctuations in temperature and moisture during the 1987 wheat pasture year.

Effects of meat meal supplementation on forage intake and N balance during trial 1 are shown in table 3. Supplementation with meat meal increased (P<.15) forage OM intake from 1.5 to 2.1% of body weight (BW). Total N intake was greater (P<.05) in heifers fed meat meal supplements. This was due to greater forage intake and greater intake of supplemental N. Total N excretion was greater (P<.06) for heifers supplemented with meat meal, as both fecal and urinary excretion of N was increased (P<.10). Nitrogen retained (g/day) was greater (P<.09) in heifers supplemented with meat meal, however N retained expressed as

Table 2. Chemical composition (DM basis) of wheat forage.

Item	Trial 1	Trial 2	
		Period 1	Period 2
	--------- % of dry matter ---------		
Organic matter	87.05	97.6	98.6
Nitrogen	2.98	3.87	3.38
Soluble N, % of total N	24.42	47.79	48.67
NPN, % of N	12.76	20.96	23.67
Soluble carbohydrate, %	23.19	-----	-----
IVOMD[a], %	81.57	84.34	85.15

[a]In vitro organic matter digestibility of esophageal extrusa.

Table 3. Effect of meat meal supplementation on forage intake and nitrogen balance of heifers (Trial 1)[a].

Item	Control	Meat meal	SE[b]	OSL[c]
Observations	4	4		
Weight, kg	193	186	13.8	
Forage organic matter intake				
kg	2.90	3.96	.448	.20
g/kg of body weight	15.3	21.2	2.43	.14
Nitrogen intake, g/day	123	183	16.9	.05
Nitrogen excretion, g/day				
Total	55.9	76.6	6.02	.06
Fecal	20.0	27.0	2.07	.06
Urinary	35.9	49.6	4.67	.09
Nitrogen retention, g/day	67.3	106.7	12.90	.09
% of N intake	54.8	57.1	3.47	.66
% of absorbed N	65.5	67.1	3.61	.77

[a]Least-squares means.
[b]Standard error.
[c]Observed significance level.

a percentage of N intake or of absorbed N was not influenced by supplementation with meat meal.

Forage intake and N balance data of trial 2 are shown in table 4. Forage OM intake, expressed as a percent of body weight, was increased 18% (P<.13) by meat meal supplementation. As in trial 1, supplementation with meat meal did not affect N retention.

Intake of wheat forage OM, expressed as a percentage of body weight, was increased 39 and 18% by meat meal supplementation of

Table 4. Effect of meat meal supplementation on forage intake and nitrogen balance of heifers (Trial 2)[a].

Item	Control	Meat meal	SE[b]	OSL[c]
Observations	7[d]	8		
Weight, kg	309	324	19.8	
Forage organic matter intake				
kg	4.78	5.79	.584	.28
g/kg of body weight	15.1	17.8	1.07	.13
Nitrogen intake, g/day	213	279	22.6	.10
Nitrogen excretion, g/day				
Total	120	155	18.5	.24
Fecal	48	62	7.6	.35
Urinary	72	93	12.7	.24
Nitrogen retention, g/day	93	124	15.8	.24
% of N intake	44.3	43.0	4.76	.86
% of absorbed N	57.1	54.9	5.01	.69

[a]Least-squares mean.
[b]Standard error.
[c]Observed significance level.
[d]One heifer was deleted from analysis of data because of problems with her urinary catheter.

heifers in these studies. Nitrogen retention of heifers was not affected by meat meal supplementation. These results indicate that the improvement in forage intake, possibly resulting from a correction in the balance of amino acids flowing to the small intestine, is a primary mechanism by which supplementation of growing cattle on wheat pasture with protein supplements of low ruminal degradability, such as meat meal, has increased performance.

Literature Cited

Andersen, M.A. et al. 1987. Effect of meat meal supplementation of steers grazing wheat pasture on rumen fermentation. Oklahoma Agr. Exp. Sta. Res. Rep. MP-119:226.

Balwani, T.L. 1965. Soluble carbohydrates of the corn plant at different stages of maturity, and their digestibilities by rumen bacteria. M.S. Thesis. Ohio State University, Columbus.

Horn, G.W. et al. 1987. Effect of inclusion of high protein feedstuffs in supplements on stocker cattle performance on wheat pasture. Oklahoma Agr. Exp. Sta. Res. Rep. MP-119:223.

Johnson, R.R. 1969. Techniques and Procedures in Animal Science Research. p. 175.

Lee, Robert W. 1985. Bypass protein supplementation for cattle grazing wheat pasture. Kansas Cattle Feeders Day. Progress Report 474. p. 7.

Stillwell, M.A. et al. 1983. Total urine collection from free-grazing heifers. J. Range Management. 36:798.

Zorrilla-Rios, J. et al. 1985. 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. Okla. Agr. Exp. Sta. Res. Rep. MP-117:169.

INFLUENCE OF MEAT MEAL SUPPLEMENTATION ON FORAGE INTAKE AND SITE AND EXTENT OF DIGESTION OF STEERS GRAZING WHEAT PASTURE

M.A. Andersen[1], G.J. Vogel, G.W. Horn[2] and K.B. Poling[3]

Story in Brief

Eight cannulated steers grazed wheat pasture and were fed a corn-based supplement or a supplement containing 24% meat meal. Supplements provided similar amounts of TDN, calcium, phosphorus and magnesium. Meat meal supplementation resulted in a slight (i.e., 12%) increase in forage organic matter intake. Meat meal supplementation did not alter organic matter and nitrogen digestion in the rumen or their flow to and absorption from the post-ruminal tract. Although efficiency of metabolizable energy utilization theoretically could be improved if the ratio of protein absorbed to energy intake were increased, meat meal supplementation did not increase this ratio. The increased performance of wheat pasture stocker cattle fed meat meal supplements probably is related primarily to increased forage intake.

(Key Words: Wheat Pasture, Protein Supplementation, Growing Cattle.)

Introduction

Wheat pastures are high in crude protein, and typically contain 20-30% during most of the grazing season. However supplementing wheat pasture stocker cattle with a high bypass protein feed, such as meat meal, has increased daily weight gains approximately .25 lb/day (Horn et al., 1987; Lee, 1985). This may be partially due to (1) greater protein flow to the small intestine, compensating for the ruminal degradation and loss of wheat forage nitrogen (Zorrilla-Rios et al., 1985) or (2) a more optimum amino acid balance at the small intestine. Supplementing steers on wheat pasture with meat meal did not affect ruminal pH, ammonia concentration or molar proportions of volatile fatty acids (Andersen et al., 1987). These data represent the results from our second year evaluating the effect of including meat meal in supplements on the site and extent of nutrient digestion and on forage intake of steers grazing winter wheat pasture.

Materials and Methods

Eight ruminally, duodenally and ileally cannulated Hereford and Hereford x Angus steers grazed a common winter wheat pasture during the 1987 grazing season. Steers were randomly allotted to two treatments and fed 2.6 lb (as-is) of a corn based (control) supplement or a supplement containing 24% meat meal (as-fed basis). Supplements were placed directly into the rumen once daily. Ingredient composition of supplements are reported by Andersen et al. (1988) elsewhere in this research report. Forage intake, and site and extent of nutrient

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digestion were determined while steers grazed forage of two distinct maturities. Immature forage was characterized as rapidly growing forage in the early spring; mature forage was characteristic of wheat shortly after heading. Hand clipped forage samples were taken during each experimental period. Samples were frozen immediately over liquid nitrogen and subsequently lyophilized. Nitrogen (N) of wheat forage was determined by the kjeldahl procedure, non-protein nitrogen (NPN) content was determined by difference between total N and protein N precipitated in a 10% H_2SO_4 and Na-tungstate solution. Soluble N was determined as N soluble in the mineral mixture (2% v/v; pH = 6.5) of the "Ohio" in vitro fermentation media (Johnson, 1969). Soluble carbohydrates were determined by the procedure of Balwani (1965). A second set of forage samples, obtained from esophageal cannulated steers were assayed for indigestible neutral detergent fiber. Chemical composition of forage is shown in table 1.

Chromic oxide was utilized as a nutrient flow and fecal output marker. Organic matter (OM) digestibility was determined using indigestible neutral detergent fiber as an internal indigestible marker. Forage OM intake was corrected for supplement intake by subtracting the indigestible portion of the supplement determined in vitro, from the estimated fecal output. Digestion of nutrients in the rumen, small intestine, and large intestine were determined by difference.

Results and Discussion

Effects of meat meal supplementation on forage intake and digestion measurements are shown in table 2. Meat meal supplementation did not significantly influence (P>.10) any of the measurements reported. Data of one steer were deleted from analysis because of problems that developed with an intestinal cannula while grazing immature forage. A second steer was removed from the study while grazing mature forage because of a similar problem.

Table 1. Chemical composition of immature and mature wheat forage.

Item	Forage maturity	
	Immature	Mature
Dry matter (DM), %	27.76	24.85
Organic matter (OM), %	95.34	93.38
OM digestibility, %	87.26	70.60
Crude protein, % of DM	19.31	13.75
Nitrogen		
Total N, % of DM	3.09	2.20
Soluble N		
% of DM	1.50	.76
% of total N	48.52	34.22
Non-protein nitrogen		
% of DM	.28	.37
% of total N	8.89	17.16
Soluble carbohydrates, % of DM	30.24	21.43
In vitro dry matter digestibility, %	84.69	80.92

Table 2. **Effect of meat meal supplementation on forage intake and site of digestion of steers grazing winter wheat pasture.**

Item	Immature		Mature		Stage of maturity
	Control	Meat meal	Control	Meat meal	
No. of observations	3	4	3	3	
Body weight, kg	477	503	550	587	**
Forage organic matter intake,					
kg	12.1	14.3	8.9	10.6	*
g/kg body weight	22.1	25.0	11.3	12.5	**
Total nitrogen intake, g	502	621	246	372	*
True ruminal digestion, g/kg intake					
Organic matter	687	767	403	349	**
Nitrogen	685	691	224	284	**
Ruminal N loss, %[b]	50.3	54.0	-24.8	1.6	**
Degraded N/kg OMTDR[c]	32.4	34.6	9.0	13.7	*
Flow to small intestine					
Organic matter					
g	5000	5419	6712	7653	*
g/kg intake	421	374	759	746	*
g/kg body weight	10.5	10.7	12.3	13.2	
Non-ammonia nitrogen					
g	243	274	307	351	
g/kg N intake	500	460	1248	984	**
g/kg body weight	.51	.54	.56	.61	
Bacterial N, %	37.4	32.4	37.0	25.2	
Feed N, %	62.6	67.6	63.0	74.8	

Table 2. continued

Item	Immature		Mature		Stage of Maturity
	Control	Meat meal	Control	Meat meal	
Absorption from small intestine					
Organic matter					
g/kg intake	187	151	181	222	
% of flow	44.6	40.2	24.0	28.9	**
g/kg body weight	4.72	4.31	2.96	3.92	*
Non ammonia nitrogen					
g/kg N intake	282	266	677	545	**
% of flow	58.2	58.6	54.2	55.5	
g/kg body weight	.31	.32	.31	.34	
Absorbed protein:energy					
g NAN/kg DOMI[d]	13.8	12.6	26.8	26.6	**
g NAN/MJ ME intake	1.24	1.14	3.9	3.88	**
Flow to large intestine, g/d					
OM	2744	3245	5097	5384	**
NAN	95	113	140	156	*
Absorption from large intestine					
Organic matter					
g/kg intake	97	104	279	229	**
% of flow	38.3	46.4	47.9	43.5	
g/kg body weight	2.2	3.0	4.5	4.1	*
Non-ammonia nitrogen					
g/kg intake	119	103	266	192	*
% of flow	46.6	53.3	46.3	42.7	
g/kg body weight	.10	.12	.12	.12	

[a] * = ($P<.05$), ** = ($P<.01$).
[b] Ruminal N loss = nitrogen intake-N flow to small intestine.
[c] Nitrogen absorbed per kg OM truly digested in the rumen.
[d] Grams NAN disappeared from small intestine per kg digestible organic matter intake.

Organic matter (OM) intake of immature and mature forage by steers supplemented with meat meal was 13.6% and 10.6% greater, respectively. Although not significant (P>.10), this trend of increased forage intake was similar to that seen in wheat pasture heifers supplemented with meat meal (Andersen et al., 1988). Using net energy system equations for a 400 lb steer consuming wheat forage at 2.5% of body weight, a 10% increase intake could account for the .25 lb/day increase in daily gains observed by Horn et al. (1987) and Lee, (1985).

Meat meal supplementation did not influence ruminal digestion of OM or N. Nitrogen degraded per kg OM truly digested in the rumen, and N loss before the small intestine also were not affected by meat meal supplementation. Loss of N before the small intestine averaged more than 50% while steers were grazing immature forage. Beever and Siddons (1986) reported a loss of 30% of N before the small intestine in cattle fed medium to high N forages, and considered their loss to be high. They suggested it was the result of a dietary imbalance of N:readily digested carbohydrate. However, ruminal pH values of our steers in this study were low, averaging only 5.5, and volatile fatty acid concentrations were high (145 m moles/L), suggesting the presence of a large amount of soluble carbohydrates for ruminal fermentation. Calculated amounts of non-ammonia nitrogen (NAN) absorbed from the small intestine averaged 1.2 grams/MJ metabolizable energy (ME) intake while steers grazed immature wheat forage. Improving this ratio may improve the efficiency of ME utilization (MacRae et al, 1985).

Forage organic matter intake and nitrogen intake of steers grazing mature forage was reduced approximately 50% (P<.01). When steers grazed mature forage, ruminal digestion of organic matter and nitrogen (g/kg intake) were greatly reduced (P<.01), nitrogen loss in the rumen shifted from more than 50% to -13%, N degraded per kg OM fermented in the rumen (degraded N/kg OMTDR) was significantly reduced (P<.01), and flow of OM and N (g/kg intake) was significantly greater. Digestion of OM in the small intestine was greater (P<.01), and NAN absorbed in the small intestine per kg of digestible OM intake was 2-fold greater (P<.01) in steers grazing mature forage.

Steers grazing mature wheat forage showed a gain of N in the rumen and N flowing to the duodenum, indicating a net gain of N by N recycling. Nitrogen recycling may indicate a need for more ruminal degradable protein, however ruminal ammonia concentration was more than adequate (38 mg/100 ml). Non-ammonia nitrogen flow to the small intestine of steers fed the control supplement averaged 125% of N intake while grazing mature forage. The N disappearance from the large intestine does not account for all of the additional N flowing to the small intestine, therefore some of the NAN absorbed in the small intestine in these steers must have been deaminated and recycled to the rumen, to account for the additional N flow. This indicates a portion of the protein absorbed from the small intestine may have been used as glycolytic precursors, possibly necessary for reducing equivalent production, which may be limiting in high acetate ruminal fermentations (MacRae et al., 1985).

These data are interpreted as indicating that the increased performance of wheat pasture stocker cattle supplemented with meat meal is probably related to an increase in forage intake. Supplementation with meat meal did not affect ruminal digestion, flow of nutrients to and(or) absorption of nutrients from the post-ruminal tract, of steers grazing winter wheat pasture. High ruminal N losses while steers were grazing immature forage suggests possible benefits for supplementation with a ruminal undegradable protein with the objective of improving the ratio of protein absorbed to ME intake. While steers grazed mature forage, there was a reduction in forage intake and a shift in digestion of OM and NAN to the post-ruminal tract. Nitrogen recycled from NAN absorbed in the small intestine while steers grazed mature wheat forage suggests that protein may have been utilized as glycolytic precursors. Although supplemental rumen undegradable protein might be expected to improve ME utilization of wheat forage, its influence on forage intake tends to explain the response to supplementation.

Literature Cited

Andersen, M.A., et al. 1988. Effect of meat meal supplementation of wheat pasture stocker cattle on forage intake and nitrogen balance. Oklahoma Agr. Exp. Sta. Res. Rep. MP-125:122.

Andersen, M.A., et al. 1987. Effect of meat meal supplementation of steers grazing wheat pasture on rumen fermentation. Oklahoma Agr. Exp. Sta. Res. Rep. MP-119:226.

Balwani, T.L. 1965. Soluble carbohydrates of the corn plant at different stages of maturity, and their digestibilities by rumen bacteria. M.S. Thesis. Ohio State University, Columbus.

Beever, D.E. and R.C. Siddons. 1986. Digestion and metabolism in the grazing ruminant. In: L.P. Milligan, W.L. Grovum and A. Dobson. (Ed.). Control of Digestion and Metabolism in Ruminants. pp. 479-497. Prentice-Hall, Englewood Cliffs, NJ.

Horn, G.W., et al. 1987. Effect of inclusion of high protein feedstuffs in supplements on stocker cattle performance on wheat pasture. Oklahoma Agr. Exp. Sta. Res. Rep. MP-119:223.

Johnson, R.R. 1969. Techniques and Procedures in Animal Science Research. p. 175.

Lee, Robert W. 1985. Bypass protein supplementation for cattle grazing wheat pasture. Kansas Cattle Feeders Day. Report of Progress 474. p. 7.

MacRae, J.C., et al. 1985. The efficiency of utilization of metabolizable energy and apparent absorption of amino acids in sheep given spring- and autumn-harvested grass. Brit. J. Nutr. 54:197.

Zorrilla-Rios, J., et al. 1985. 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. Okla. Agr. Exp. Sta. Res. Rep. MP-117:169.

EFFECT OF A MONENSIN RUMINAL DELIVERY DEVICE ON WEIGHT GAINS OF GROWING STEERS ON WHEAT PASTURE

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Story in Brief

The effect of a monensin ruminal delivery device on weight gains of wheat pasture stockers was evaluated using 60 fall-weaned Hereford and Hereford x Angus steer calves during each of two years. Treatments were monensin device versus no device (control). The monensin ruminal delivery device increased weight gains by .20 to .24 lb/day during the 112-day trials, which is similar to effects of feeding monensin to stocker cattle grazing wheat pasture.

(Key Words: Monensin, Bolus, Wheat Pasture, Stocker Cattle.)

Introduction

Consumption of supplements by cattle grazing pastures is highly variable among animals. Wheat forage is a high-quality, highly palatable forage, and achieving desired levels of supplement consumption by cattle grazing wheat pasture is sometimes particularly difficult. Additionally, many wheat pasture stocker operations are fairly extensive; and some producers are not willing, or cannot for practical reasons, feed supplements. Rumensin (monensin) is a feed additive that increases rate of weight gain of wheat pasture stocker cattle by about 0.2 lb/day (Horn et al., 1981; Wagner et al., 1984). Administration of monensin to cattle as a ruminal bolus would be advantageous by resulting in a more consistent daily dosage of monensin, and would eliminate labor and equipment cost of supplementation programs. The objective of this trial was to evaluate the effect of a monensin ruminal delivery device (MRDD) on weight gains of wheat pasture stocker cattle.

Materials and Methods

Sixty fall-weaned Hereford and Hereford x Angus steer calves were used in each of two years. The calves were from a common cow herd from the OSU Animal Science Range Cow Research Center. After a weaning and receiving period of approximately 28 days, the calves were weighed and randomly assigned, within breed and three initial weight groups, to two treatments (i.e., MRDD versus no device). The MRDDs contained a core of 16.5 g monensin incorporated into a controlled release polymer and were prepared by Lilly Research Laboratories, Greenfield, Indiana. Expected rate of release of monensin from the devices was 100 mg/day.

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The calves were vaccinated for IBR, BVD, PI_3, 7-way clostridium and 5-way Lepto during the receiving period, and the MRDDs were administered to the calves 11 days prior to placing the calves on wheat pasture in year 1 and immediately prior to wheat pasture in year 2. All calves were implanted with Compudose in year 1 but not in year 2. Fecal grab samples were collected from half the steers in year 1, during the initial weighing prior to being placed on wheat pasture in order to estimate coccidia oocysts. Levels of fecal oocysts were minimal and were not monitored in year 2.

The steers grazed a single wheat pasture of 115 acres at the Forage and Livestock Laboratory (El Reno, Oklahoma) for about 112 days each year, and had free choice access to water and a commercial mineral mixture[6] throughout the trial.

Live weights of the steers were measured (dates indicated in table 1) after overnight shrinks of about 16 hours in drylot without feed and water. Individual weights of the steers at the beginning and end of grazing wheat pasture were measured twice. The steers were observed daily for signs of bloat throughout the wheat pasture grazing period.

Data of each year were analyzed separately by analysis of variance using the General Linear Models procedure of the Statistical Analysis System.

Results and Discussion

Data of six steers (2 control and 4 MRDD) were deleted in year 1. Two steers were deleted because of chronic health problems and four were deleted because an implant could not be detected by palpation at the end of the trial. Two "control" steers were deleted in year 2. One was removed from the trial because of acute coccidiosis and another because of a broken leg.

Least square means of initial and final weights, daily gains during the three periods of the trials and for the entire grazing period of each trial are shown in Table 1. In year 1, the MRDD increased ($P<.005$) gains of steers during period I and the total trial by .44 and .20 lb/day, respectively. The treatment by initial weight group interaction for the overall daily gains of the steers tended to be significant ($P = .12$), and an explanation for the interaction is not apparent. Daily weight gains of steers of initial weight groups 1 (354 lb), 2 (419 lb) and 3 (467 lb) for the total trial were increased, respectively, .35, .02 and .23 lb by the MRDD. Therefore, there was no indication that the effectiveness of the MRDD decreased as initial weight of the steers increased.

Weight gains were exceptionally good during period II of year 1, and were attributed to the fairly slow gain seen during period I and to the very mild and open winter. Hay was fed only four days of the trial (i.e., 12/13, 2/8, 2/10 and 2/12) because of light snow cover of wheat pasture. About 10 lb/head of old world bluestem hay was fed on each of these 4 days. In total, the 1985-86 wheat pasture year was very mild and weight gains of stocker cattle were exceptionally good.

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[6]Wheat Gainer Mineral No. 2. Farmland Industries. Guaranteed analysis: CA 15-17%, Mg 10.0%, P 4.0%, salt 19-21%, I .0002%, Vitamin A, 100,000 USP Units/lb.

Table 1. Effects of monensin ruminal delivery device on performance of growing cattle on wheat pasture.

Item	Year 1 (1985-86)		Year 2 (1986-87)	
	Control	MRDD[a]	Control	MRDD[a]
Number of steers	28	26	28	30
Initial wt., lb	409	417	423	429
Final wt., lb	699	729	546	578
Grazing period[b]	--------- Daily gain, lb ---------			
Period I, 11/18-12/19/85, 31 (35)[c] days	1.35	1.79[d]	.14	.80[e]
Period II, 12/19-1/30/86, 42 (43) days	3.51	3.68	1.75	1.84
Period III, 1/30-3/11/86, 40 (34) days	2.52	2.55	1.25	1.23
Overall, 11/18-3/11/86, 113 (112) days	2.56	2.76[d]	1.09	1.33[e]

[a]Monensin ruminal delivery device.
[b]Dates are actual dates of year 1. Corresponding days of each month of year 2 differed from these by 1 to 7 days.
[c]Parenthetical numbers are actual days of each grazing period in year 2.
[d]Different from control (P<.005).
[e]Different from control (P<.001).

Although weight gains of the cattle in year 2 were much lower than the previous year, similar effects of the MRDD were observed. The MRDD increased (P<.001) daily weight gains during period I and the total trial by .66 and .24 lb, respectively. Mean initial weights of steers of the three initial weight groups were 375, 411 and 479 lb. The treatment by initial weight group interaction for weight gains during all three periods and the entire trial was not significant (P>.18), and indicates that the effectiveness of the MRDD was not dependent on initial weight of the cattle used in the trial.

Weight gains of the steers in year 2 were very poor compared with year 1, and reflect the tremendous influence that weather has on performance of wheat pasture stocker cattle. The 1986-87 wheat pasture year was very wet and cold. About 8 lb/head/day of old world bluestem hay was fed to the cattle during the 21-day period, January 16 to February 5. Record amounts of rainfall were received in February, and the cattle were in mud for much of the grazing period on wheat.

The two years of data provide good contrast with regard to the impact of weather on cattle performance, and should be kept in mind when projecting the performance of stocker cattle on wheat pasture. In year 1, the steers gained about 300 total lb or about 2.7 lb/day. During the 1986-87 wheat pasture year, the steers gained only about 140 total lb or 1.2 lb/day. These two years likely represent extremes with regard to the average performance of about 1.8 lb/day for similar cattle on this pasture during previous years.

The incidence of bloat was very low during both years of the study, and effects of the MRDD on the incidence and severity of bloat could not be evaluated.

Watson and Laby (1978) and File et al. (1980) reported significant (P<.05) live weight gain responses of growing steers or heifers to an intraruminal continuous release capsule that provided monensin. The capsules were reported to provide 114 to 180 mg monensin per day, and the cattle grazed ryegrass and subterranean clover or spring and autumn white clover, fescue and phalaris pastures.

The MRDD containing 16.5 g monensin that was used in this trial was effective in increasing live weight gains of growing cattle on wheat pasture. Weight gains of steers that weighed about 350 to 470 lb at the start of the 112-day grazing period on wheat pasture were increased .20 to .24 lb/day by the MRDD.

Literature Cited

File, G. C. et al. 1980. Performance and digestion responses to monensin sodium by herbage-fed cattle and sheep. Anim. Prod. in Australia 13:486.

Horn, G. W. et al. 1981. Effect of monensin on ruminal fermentation, forage intake and weight gains of wheat pasture stocker cattle. J. Anim. Sci. 52:447.

Wagner, D. G. et al. 1984. Supplemental feeding of grain and protein for stocker cattle on small grains pastures. In: Gerald W. Horn (Ed.). Proceedings of the National Wheat Pasture Symposium. pp 327-343. Okla. Agr. Exp. Sta. MP-115.

Watson, M. J. and R. H. Laby. 1978. The response of grazing cattle to monensin administered from a controlled release capsule. Proc. Nutr. Soc. Aust. 3:86.

STEER GAIN RESPONSE TO MONENSIN AND CHLORTETRACYCLINE ADDITION TO SUMMER PROTEIN SUPPLEMENTS

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Story in Brief

Beef steers grazing on native range were fed one of three supplements during the late-summer period (midJuly to September 30, 77 days). Supplements were 1 lb/head/day of either a soybean meal cube, or soybean meal cubes containing either monensin or chlortetracycline. Late summer weight gains were similar for the steers fed monensin and chlortetracycline and were greater than the gains of cattle receiving the soybean meal cube.

(Key words: range, cattle, monensin, chlortetracycline, protein supplementation)

Introduction

Several studies have demonstrated the value of feeding protein supplements to stocker cattle grazing native range in late summer. Additionally, ionophores have been utilized to further enhance gains. Low levels of chlortetracycline may also promote growth as well as provide some protection against insect-borne diseases and footrot.

The following trial was conducted to evaluate the response of stocker cattle to the addition of either monensin or chlortetracycline to a late-summer protein supplement.

Materials and Methods

Cattle were delivered to the Pawhuska Station in April and utilized in a grazing management study until the current trial was initiated. Forty-five crossbred steers were randomly allocated to one of three treatment groups. Each treatment group was maintained on native range at the Pawhuska Research Station. The treatment groups were rotated among three pastures every seven days. The trial was initiated on July 15 and ended on September 30. At both times the steers were weighed in the morning following a 16 hour shrink.

Treatments (table 1) consisted of either a soybean meal cube (SBM), or the same cube containing either monensin (100 mg/lb supplement; M) or chlortetracycline (350 mg/lb of supplement; C). Supplements were group-fed three times weekly at a rate of 2.3 lb supplement per head per feeding (.99 lb/head/day). Free choice mineral was available to the cattle at all times.

Results and Discussion

Weight gains of the SBM cattle agree well with gains noted previously for protein-supplemented cattle in this area of Oklahoma.

Assistant Professor[1] Professor[2] Herd Manager[3]

Table 1. Ingredient composition of supplements (% as-fed).

Ingredient	SBM	SBM+M[a]	SBM+C[b]
Soybean meal	88.9	88.7	88.5
Alfalfa, dehy.	6.0	6.0	6.0
Vit. A-30	.15	.15	.15
Dicalcium phosphate	1.0	1.0	1.0
Cane molasses	4.0	4.0	4.0
Rumensin-60	--	.17	--
Aureomycin 100	--	--	.35

[a,b]M=monensin, C=chlortetracycline.

Table 2. Days on trial, initial weight, and weight gains of steers.

	SBM	SBM+M	SBM+C	SEM
Days on trial	77	77	77	
Initial weight, lbs/head	598	607	606	
Weight gain, lbs/head[a]				
Total	108	130	138	9.1
Daily	1.4	1.7	1.8	.1

[a]SBM+M > SBM (P<.10); SBM+C > SBM (P<.025); SBM+M = SBM+C (P>.50).

Monensin improved (P<.10) performance 20% in comparison to cattle receiving no additive in their supplement (Table 2). Similarly, chlortetracycline improved (P<.025) gains 28% compared to the SBM group. Although the average gain for the C group was 8 lbs more than that of the M cattle, the difference was not significant (P>.50).

Based on Oklahoma City Stockyards prices for September 1987, addition of the ionophore or the antibiotic increased gross sale value of the steers $12.80/head and $17.40/head, respectively.

EFFECTS OF FESCUE ENDOPHYTE ON PERFORMANCE OF GRAZING STEERS

W.E. McMurphy[1], K.S. Lusby[1], S. Muntz[2], J. Cantrell[2] and S.C. Smith[3]

Story in Brief

Seventy five Angus, Brahman X Angus, Angus X Brahman-Angus and Simmental X Brahman-Angus 7 to 12-month-old steers (500 lbs) were used to study effects of endophyte and clover on performance of steers grazing fescue. The study was conducted at the Kerr Center near Poteau in eastern Oklahoma. Pasture treatments were: (1) 83% endophyte infected Kentucky 31 fescue, (2) 76% infected Kentucky 31 interseeded with clover and (3) reseeded endophyte-free Kentucky 31 fescue. Each pasture was replicated 3 times. Steers grazed 197 days from November 6, 1986 to May 21, 1987. Weights and rectal temperatures were taken at 42 day intervals except for the April-May period which was 28 days. Steers grazing endophyte-free fescue gained 364 lbs/steer compared to 247 lbs for infected fescue and 369 lbs for fescue-clover steers. Body temperature was higher for endophyte-infected fescue only at the May weight.

(Key Words: Fescue, Endophyte, Stockers)

Introduction

Performance of cattle grazing fescue has typically been much poorer than predicted from analyses of the forage. Toxic factors have long been suspected but not identified until 1976 when a fungus endophyte living within the cell structure of the fescue plant was isolated. Since then, research has shown that fescue stands with little or no infection of the endophyte produce significantly better animal performance than infected stands. The objective of this study was to evaluate performance of stocker steers grazing endophyte-free and infected stands of fescue and also infected stands interseeded with clover.

Materials and Methods

A grazing study with stocker cattle was initiated at the Kerr Center near Poteau, Oklahoma in the fall of 1985. Pasture treatments were (1) endophyte infected Kentucky 31 fescue, (2) infected Kentucky 31 interseeded with clover and (3) reseeded endophyte-free Kentucky 31 fescue. Pastures were established by interseeding existing endophyte infected Kentucky 31 fescue with clover and reseeding endophyte-free Kentucky 31 fescue. Reseeded pastures were established by spraying infected fescue three times with Paraquat beginning in the spring of 1984 to prevent seed production. Seed had been purchased one year earlier, stored for a year and then tested to ensure a zero endophyte level. Fertilization consisted of 0-50-50 (N, phosphate, potash) for fescue-clover, and 104-45-54 for infected and endophyte-free pastures. Each pasture type was replicated 3 times based on soil type to provide 9

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pastures in a wagon wheel arrangement around a central weighing facility.

Individual performance data were obtained from seven to ten steers initially allotted to each fescue-clover pasture and ten steers per pasture for the other treatments based on weight and breed. Additional steers were added as needed to equalize forage utilization between pastures with data from added steers only used to establish stocking rates. No supplemental hay was fed. By April 9, forage growth in some pastures began to exceed the amount being grazed and additional steers were added.

Clovers used were Redland red, Regal ladino, Mt. Barker subterranean and Yucci arrowleaf clover with red clover the dominant clover in the pastures. Pastures ranged from 10.6 to 13.9 acres. All steers were implanted with Ralgro at the initiation of the study. Cattle weights were taken after overnight withdrawal from forage and water.

Results and Discussion

Results of the 1986-87 grazing season are shown in Table 1. Analysis of forages showed an endophyte infection rate of 83 percent for infected pastures and 76 percent for clover-fescue pastures. One of three pastures established to be endophyte-free showed a 6 percent infection rate. An explanation for this is not apparent at this time.

Steers grazing endophyte-free fescue gained 122 lb more ($P<.01$) over the 197 day period than steers grazing infected fescue. Individual gains of steers grazing fescue-clover pastures were similar to gains on endophyte-free pastures. Higher gains on endophyte-free pastures compared to infected pastures were observed at every weigh period. Increased gains between infected and endophyte-free pastures were also

Table 1. Weights and gains of steers grazing fescue.[a]

	Treatments		
	Endophyte Infected Fescue	Infected Fescue & Clover	Endophyte Free Fescue
No. Steers	29	19	27
Initial wt. (Nov. 6)	508	491	510
Gains, lb.			
Nov-Dec, 42 days	78[d]	85[c]	104[b]
Dec-Jan, 42 days	30[c]	47[b]	42[b]
Jan-Mar, 42 days	29[d]	62[b]	51[c]
Mar-Apr, 42 days	66[d]	96[b]	86[c]
Apr-May, 28 days	44[c]	80[b]	82[b]
Total fescue gain	247[c]	369[b]	364[b]
Final Wt., May 21	755[c]	860[b]	874[b]
Stocking rate (acres per steer)	1.1	1.4	1.5

[a]Least squares means.
[bcd]Means on the same line with different superscripts differ ($P<.05$)

seen during the previous (1985-86) grazing season (71 lb) although no differences were noted during the months of December and March.

Interseeding infected pastures with clovers produced individual gains similar to those seen on endophyte infected pastures. As ambient temperatures increased in the spring and growth of both clover and fescue accelerated, it was obvious that clover was making up an increasing percentage of the total diet at the expense of fescue. Stocking rates (Table 1) on clover-fescue pastures were lower than for other treatments until spring, however, because of reduced nitrogen fertilization rates on clover pastures. Compared to endophyte infected pastures, endophyte free pastures were grazed more closely and uniformly, especially during the spring months. The combination of over 100 lb/head higher gain and more complete utilization of the forage shows that forage intake was greater with endophyte free fescue. A much greater amount of forage was left ungrazed on both fescue-clover and endophyte infected pastures at the end of the grazing season compared to endophyte-free pastures.

Elevated body temperature is commonly reported for cattle grazing infected pastures. Rectal temperatures (Table 2) taken at each weighing showed that body temperature was only elevated for cattle grazing infected pastures at the May final weight. This was also seen in the first year of the study. Cattle grazing clover-fescue pastures had temperatures intermediate between the other treatments at the May weighing. Rectal temperatures of some individuals were as high as 107 F at 7:30 AM and severe stress was noted in several steers from infected pastures. Steers grazing endophyte infected pastures showed the typical signs of "fescue cattle", rough haircoats, gaunted, and high respiration rates. Mud covered the backs of many of these steers and was caused by standing in mudholes and swatting the back with a mud-covered tail. Steers from endophyte-free pastures were in excellent condition with smooth, clean haircoats and apparently full rumens.

In summary, the presence of fescue endophyte at an 83 percent infection rate severely reduced steer gains during the Nov-May period. Forage utilization was reduced especially during the spring months. Interseeding clover into infected pastures increased daily gain but at the expense of stocking rate because of limitations that clover puts on the nitrogen fertilization program.

Table 2. Effects of fescue endophyte on rectal temperature of grazing steers.

	Treatments		
	Endophyte Infected Fescue	Infected Fescue & Clover	Endophyte Free Fescue
Temperatures			
December	101.8	102.1	102.0
January	102.0	102.5	102.3
March	102.2	102.2	102.0
April	102.1	102.1	101.9
May	103.9[c]	103.5[b]	102.8[a]

[abc]Means on the same line with different superscripts differ (P<.05)

CARRYOVER EFFECTS OF FESCUE ENDOPHYTE ON FEEDLOT PERFORMANCE OF STEERS

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Story in Brief

Seventy two Angus, Brahman-Angus and Angus or Simmental X Brahman-Angus, 13 to 19-month-old steers were used to study effects of fescue grazing on subsequent feedlot performance. Steers had been grazed from November to May on: (1) Kentucky 31 fescue (83 % endophyte infected), (2) Kentucky 31 (76 % infected) interseeded with a mixture of clovers, and (3) Endophyte-free Kentucky 31 fescue. Steers were removed from fescue pastures near Poteau in eastern Oklahoma on May 21, held for 6 days on ryegrass pastures and shipped to a feedlot in western Oklahoma. Steers were then fed for 117 days and slaughtered. Compared to steers from high endophyte fescue, steers previously grazed on endophyte-free pastures gained 25 lb. less ($P<.01$) during the 6-day period on ryegrass, shrunk 7 lb. more in transit to the feedlot, gained 11 lb. less in the feedlot from start to mid-point of feeding ($P<.07$), and gained 6 lb. less from mid-point to final weight. Total gain from termination of fescue grazing to slaughter favored steers from endophyte infected pasture by 49 lb. ($P<.07$). Gains of fescue-clover steers were not significantly different from endophyte-free steers. Except for carcass weight, carcass traits were not significantly affected by type of fescue previously grazed. Cattle previously grazed on endophyte infected fescue made significant compensatory gain during the first 49 days in the feedlot.

(Key Words: Growing Cattle, Fescue, Endophyte, Feedlot, Finishing)

Introduction

A number of trials have shown reduced pasture performance of cattle grazing endophyte infected fescue forage. Because many thousands of these cattle are shipped to high plains feedlots for finishing, information about carryover effects of the endophyte toxin on subsequent performance in the feedlot is extremely important. The object of this study was to evaluate cattle feedlot performance and carcass chacteristics of steers with large differences in previous pasture performance due to endophyte infection from grazing fescue pastures.

Materials and Methods

Seventy two Angus, Brahman-Angus and Angus or Simmental X Brahman-Angus, 13 to 19-month-old steers were used to study effects of fescue grazing on subsequent feedlot performance. All steers had been raised at the Kerr Center near Poteau in eastern Oklahoma where the study was

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conducted. Steers had been grazed from Nov. 7, 1986 to May 21, 1987 on: (1) Kentucky 31 fescue (83 % endophyte infected), (2) Kentucky 31 fescue (76 % infected) interseeded with a mixture of clovers, and (3) Endophyte-free Kentucky 31 fescue.

Steers were removed from fescue pastures on May 21, hauled about 2 miles to a ryegrass pasture adjacent to shipping facilities and held for 6 days on ryegrass pasture. Steers were weighed off ryegrass at 5 PM, loaded directly onto trucks, and shipped during the night to the Henry C. Hitch Feedyard near Guymon in western Oklahoma. The 6-day holding period on ryegrass and nighttime shipping were used to minimize heat stress of steers from endophyte-infected pastures. On arrival at the feedyard, steers were put in their pen and rested until the following morning when they were individually weighed on electronic scales, had rectal temperatures taken and were given routine processing procedures for incoming cattle. Processing consisted of IBR-BVD-Lepto, BRSV, 7-way clostridial, injections of Vitamin A and copper, implanting with Synovex-S and deworming with ivermectin. Steers were then fed for 117 days on a high concentration finishing ration with high moisture corn, steam flaked corn and steam flaked wheat. All steers were slaughtered at Booker Packing Company, in Northern Texas about 50 miles from the feedlot.

Final weight off fescue on May 21 was taken after overnight withdrawal from feed and water. All other weights were taken unshrunk. Calculations of weight gain to the mid-point of finishing and to final finished weight were based on 4 percent pencil shrinks for mid-period and final weights. Final steer weights were taken individually on September 21. Steers were killed the following morning and graded early in the morning of September 23.

Results and Discussion

Initial shrunk weights off fescue pastures are shown in Table 1. Steers from infected fescue pastures weighed about 120 lbs. less than steers from fescue-clover or endophyte-free pastures. It is interesting that during the 6 day period when cattle were held on ryegrass pasture close to the shipping facility, steers previously grazing endophyte-free fescue gained 25 lbs. less ($P<.01$) than those previously on infected pasture or fescue-clover pastures. Because the shipping weight was taken without shrink, this suggests that steers previously grazed on infected fescue take on large fills when offered another more palatable forage. Steers from infected fescue also tended to shrink less in transit to the feedlot.

Steers from infected pastures continued to gain faster than the other treatments ($P<.02$) during the first 49 days on feed. From the time of removal from fescue grazing through the first 49 days of feeding, gains were almost identical for endophyte-free and fescue-clover steers (203 vs. 202 lb). Total gains during this same period for infected fescue steers was 246 lbs, showing (1) that effects of the endophyte in this study were not permanent and (2) that compensatory gain began almost immediately after removal from the infected fescue. Gains during the second half of the finishing period were similar for all three groups, suggesting that most of the compensatory growth occurred relatively early in the feeding period.

Body temperatures at the time of processing at the feedlot were similar for all groups, in contrast the elevated temperatures recorded for steers on infected pastures at the termination of the grazing study

Table 1. Weight gains and body temperatures through the finishing period of steers that had grazed fescue pastures.[a]

	Treatments		
	Endophyte Infected Fescue	Infected Fescue & Clover	Endophyte Free Fescue
No. Steers	27	19	26
Weight off Pasture (May 21)	755[c]	878[b]	875[b]
Gains			
On Ryegrass (May 21-26)	38[b]	39[b]	13[c]
Shrink (May 26-28)	-30	-48	-37
Gains in Feedlot			
On Feed to July, 49 days	238[b]	211[c]	227[bc]
July to Finish, 68 days	224	233	218
On Feed to Finish, 117 days	462	444	445
Ship to Finish, 118 days	432[c]	396[b]	408[b]
Total Gain Off Fescue to Finish, 122 days	470[c]	435[bc]	421[b]
Final Finish Wt.	1225[c]	1313[b]	1296[b]
Body Temp on Feed (May 28)	101.8	101.7	101.6
Body Temp in July	103.7	103.4	103.5

[a]Least squares means.
[bc]Means on the same line with different superscript letter differ (P<.05)

(Lusby et al., 1988). Ambient temperatures in Poteau on the morning steers were weighed off fescue approached 90 F with very high humidity while temperatures in Guymon the morning steers were processed into the feedlot were about 58 F with low humidity. Elevated temperature in endophyte infected cattle is apparently not caused by an infection but caused by a failure of the body temperature regulatory mechanism under heat stress. While affected steers could not maintain body temperature in the hot, humid eastern Oklahoma climate, they had little difficulty in cool, dry climate of the Oklahoma panhandle.

One steer from endophyte infected pasture showed a rectal temperature of 107.3 F at the time of removal from pasture. This steer was not shipped to the feedlot because managers felt he might not survive the stress of transportation. Steers from endophyte infected pastures showed the typical appearance of rough haircoats, increased respiration rate and general unthrifty appearance. Rectal temperatures at 49 days on feed were again similar across all treatments. All temperatures were higher than "normal" for cattle but were probably not atypical for steers on a full feed of high concentrate.

Carcass results are shown in Table 2. Carcass weights were significantly lighter for steers previously grazed on infected fescue reflecting lighter final live weights. Fat thickness over the rib and yield grades also indicated a slight increase in finish for treatments with the heaviest carcass weights. However, quality grade and ribeye areas were not affected by grazing treatments.

Table 2. Carcass traits of steers previously grazed on fescue pastures.[a]

	Treatments		
	Endophyte Infected Fescue	Infected Fescue & Clover	Endophyte Free Fescue
Slaughter			
% KHP[e]	2.2	2.1	2.2
Quality grade (11=G+)	11.4	11.0	11.3
Hot Carc. Wt.	791[d]	858[bc]	833[b]
REA (sq. in.)	12.9	13.6	13.0
Fat Thickness (in.)	.36[c]	.44[b]	.41[b]
Yield Grade (in.)	2.69	2.88	2.97
Slaughter			
Quality Grade			
% G	48.2	57.9	52.0
% Ch	51.8	42.1	48.0
Yield Grade			
% #1	3.7	5.3	16.0
% #2	59.3	57.9	40.0
% #3	33.3	31.6	40.0
% #4	3.7	5.3	4.0

[a]Least squares means.
[bcd]Means on a line wit different superscript letter differ (P<.05).
[e]Kidney, heart and pelvic fat.

This study shows that although steers from infected pastures may go on feed at substantially lighter weights than steers from endophyte-free or fescue-clover pastures, there is considerable compensatory gain during the finishing period. If heat stress can be minimized during shipment to the feedlot and during processing, steers showing the effects of the endophyte can perform very well in the feedlot.

EFFECTS OF PROGRAMMED FEED INTAKE ON PERFORMANCE AND CARCASS CHARACTERISTICS OF FEEDLOT STEERS

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Story in Brief

Ninety three predominantly small-framed Hereford yearling steers (645 lb) were used to determine the effect of two different methods of limit feeding on feedlot performance. Steers were fed a high corn diet either ad libitum, 80% of ad libitum for first 56 days and ad libitum for remainder of trial or were fed to obtain constant daily weight gains (3.29 or 2.96 lb). Daily feed intakes over the 138 day trial were 20.28, 18.43, 18.87 and 17.54 lb/day for ad libitum, 80%, high programmed and low programmed steers, respectively. Carcass adjusted daily gains were reduced by 6.2% with limit feeding (3.37 vs 3.16 lb), whereas feed efficiency was increased by 4% (6.03 vs 5.79 lb feed/lb gain). The most efficient steers were those programmed to obtain specific weight gains (6.03 vs 5.73). The estimated metabolizable energy value of the diet was increased by 2.9% with limit feeding (2.89 vs 2.97 mcal/kg). The percentage of steers grading choice was reduced from 95.8% to 72% with limit feeding. Animal behavior, passage rate and diet digestibility were not altered by limit feeding. Improvements in feed efficiency in programmed fed steers possibly could be attributed to reduced day-to-day fluctuations in feed intake by individual steers and reduced animal-to-animal variation in gains.

(Key Words: Feedlot Steers, Limit Feeding, Programmed Feeding)

Introduction

Several recent studies have reported that feed efficiency of feedlot cattle can be improved by controlling or limiting feed intake. Most of these studies have controlled intake by feeding certain pens of cattle a specific percentage of the feed consumed by pens of cattle with ad libitum access to feed. This approach to controlled feeding has been shown to increase feed efficiency by around 5% (Lofgreen, 1969; Plegge et al., 1985, 1986; Hicks et al., 1987) in several trials, whereas in other trials efficiency was not altered or was decreased by approximately 1% (Davis et al., 1973; Lofgreen et al., 1983). The optimum level of restriction appears to be in the range of 90 to 95% of ad libitum. Another approach to controlled feeding was recently tested by Lofgreen et al. (1987) in which three groups of steers were fed either ad libitum or 90% or 80% of ad libitum until the steers reached a weight of 700 pounds at which time all steers were fed ad libitum untill slaughter. Over the 193 day feeding trial, there was a trend towards increased feedlot performance with restricted feeding. Feed efficiency was improved by 5.4% and 4.7% with 90% and 80% of ad libitum feeding during the first portion of the trial. The final approach to limit feeding (Zinn, 1986) is to limit the amount of feed provided so that

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cattle will achieve a prescribed daily weight gain. Zinn observed that feed efficiency was improved 4.3% by programming feed intake.

Reducing feed intake should not improve efficiency according to the net energy equations. These equations precisely predict feedlot results of cattle with ad libitum access to feed. However, the above studies indicate that controlled feeding improves efficiency so that prediction should be inaccurate. Suggested reasons for improved feed efficiency with controlled feeding include reduced feed wastage, increased diet digestibility, reduced animal activity, and reduced gut and liver size which in turn reduce the maintenance requirement. The objectives of this study were to evaluate the effects of programming feed intake to obtain specific weight gains and of limiting intake only during the first half of a feeding period on the performance of feedlot steers. We also measured the effect of controlled feeding on diet digestibility, passage rate, animal activity, feed waste and liver weight.

Materials and Methods

Ninety-six crossbred (primarily British crosses) yearling steers which had been wintered on wheat pasture near Dalhart, Texas were trucked to Goodwell, Oklahoma on June 3, 1987. On arrival, all cattle were individually weighed, ear tagged, implanted with Synovex-S, and injected with ivermectin and a BRSV vaccine. These steers were predominantly Herefords (78 head) of small frame size. The steers were divided into twelve pens of eight head each and four treatments were randomly assigned to the pens. The treatments were: 1) controls - fed ad libitum, 2) fed at 80% of ad libitum for first 56 days and ad libitum for remainder of trial, 3) programmed to gain 3.29 lb/day and 4) programmed to gain 2.96 lb/day.

Steers were fed a cracked corn high concentrate ration twice daily (0700 and 1600) for the 138 day trial (Table 1). Chopped alfalfa hay was used to dilute the ration to 60 percent concentrate to start the cattle on feed. Roughage content of the diet was decreased sequentially in three steps until the cattle were on their final ration by 28 days on

Table 1. Diet composition, dry matter basis.[a]

Ingredient	Ration Sequence 1	2	3	4[a]
Corn, cracked	52.70	62.28	71.87	80.02
Chopped alfalfa	38.36	28.78	19.19	11.04
Cane molasses	3.88	3.88	3.88	3.88
Pelleted supplement[b]	5.06	5.06	5.06	5.06

[a]To provide 12.25% protein, .53% calcium, .78% potassium, .33% phosphorus, 94.7 Mcal NEm/cwt, 61.1 Mcal NEg/cwt and 30 g lasalocid/ton of total feed.

[b]Consisted of, as a percentage of the diet: soybean meal, 2.04; wheat middlings, .64; meat meal, .60; calcium carbonate, .53; dicalcium phosphate, .07; urea, .49; salt, .50; potassium chloride, .04; bovatec (68 g/lb), .02; vitamin A (30000 IU/g), .01; vitamin E, .01; trace minerals, .01; mineral oil, .10.

feed. For those pens programmed to obtain specific daily weight gains, daily feed allotments (increased every two weeks) were determined in the manner described by Zinn (1986). Amounts of feed offered to cattle being restricted for the first 56 days of the trial were adjusted daily based on the previous day's intakes of pens with ad libitum access to feed.

On days 34 through 40 of the trial, chromic oxide was included in the diet at a level of 0.2% and on days 40, 42 and 44 fecal grab samples were obtained from 4 to 8 steers per pen. Fecal samples were analyzed for starch, ash, acid-insoluble ash and chromium content. Fecal measurements for day 40 were used to estimate digestibility of the ration and measurements for days 42 and 44 were used to estimate passage rate through the rumen. On days 40 and 41, the steers were observed every 30 minutes for 24 hours (2000 to 1950) to monitor the time spent eating, standing, laying, standing and ruminating, or laying and ruminating.

Cattle weights were off truck weights (shrunk) at the start of the trial but were taken on full-feed on days 28, 56, 84, 112 and 138. To calculate gain and efficiency, full weights were reduced by 4% to compensate for digestive tract fill. Steers were trucked to Holcomb, Kansas on day 139 of the trial (October 22, 1987) for slaughter, and carcass data were obtained. Three steers were removed from the trial for causes not related to the experimental treatments. This trial was analyzed as a completely randomized design using a general linear models procedure. Orthogonal comparisons included ad libitum vs the mean of the three limited intake treatments, 80% of ad libitum vs the mean of the high and low programmed steers, and high (3.29 lb gain/day) programmed vs low (2.96 lb/day) programmed.

Results and Discussion

The effects of limit feeding on steer performance are presented in Table 2. Carcass adjusted daily gains tended to be reduced ($P<.10$) with limit feeding (3.37 vs 3.16 lb/day) and liveweight gains were reduced ($P<.05$) by 7.3% (2.88 vs 2.67 lb/day). During the first 56 days of the feeding period gains were reduced ($P<.01$) by 18.7% with limit feeding (3.26 vs 2.65 lb/day), whereas, during the last 82 days there was no difference in gain between treatment groups. Those cattle which were fed at 80% of ad libitum during the first 56 days appeared to make compensatory gains during the second half of the trial (2.62 vs 2.78 lb/day for ad lib and 80% steers). Steers in the high programmed (3.29 lb/day) and low programmed treatment groups (2.96 lb/day) gained only 83.6 and 86.8% of their programmed gains. Over the 138 day trial, feed intakes were 90.9, 93.0 and 86.5% of ad libitum for 80%, high programmed and low programmed steers, respectively. Over the first 56 days, intake for the 80% steers actually was 84.2% of ad libitum.

During the first 56 days of the feeding period, feed efficiency was not effected ($P>.10$) by limit feeding. However, during the second half of the trial feed efficiency tended ($P<.10$) to be increased (7.2%) with limit feeding (7.96 vs 7.39 lb feed/lb gain). These results are quite similar to those of two earlier limit feeding trials conducted at Goodwell (Hicks et al., 1987). Over the entire trial feed efficiency on a carcass weight basis tended to be increased ($P<.10$) by 4% with limit feeding (6.03 vs 5.79). The most efficient steers were those programmed to obtain specific weight gains. Dietary net energy values for maintenance (NEm) and gain (NEg) and metabolizable energy values (ME)

Table 2. Effect of limit feeding on steer performance.

	Ad Lib	80 %	High Prog	Low Prog	SEM	Contrasts[e]
No. of Pens	3	3	3	3		
No. of Head	22	24	23	24		
Weight, lbs						
Initial	644	645	646	645	1.1	
Day 138	1084[a]	1058[ab]	1067[ab]	1041[b]	8.1	AL*,HL*
Daily Gain, lbs						
0-56 days	3.26[a]	2.55[b]	2.86[b]	2.53[b]	.11	AL**,HL+
57-138 days	2.62	2.78	2.67	2.59	.11	
0-138 days	2.88[a]	2.69[ab]	2.75[ab]	2.57[b]	.06	AL*,HL+
0-139 days[d]	3.37	3.11	3.30	3.06	.09	AL+,HL+
DM Intake, lbs						
0-56 days	18.71[a]	15.75[b]	17.15[ab]	15.68[b]	.50	AL**,HL+
57-138 days	20.81[a]	20.27[a]	20.10[a]	18.81[b]	.37	AL*, HL*
0-138 days	20.28[a]	18.43[b]	18.87[b]	17.54[c]	.23	AL**,HL**
Feed/Gain						
0-56 days	5.75	6.20	6.02	6.21	.22	
57-138 days	7.96	7.35	7.54	7.27	.23	AL+
0-138 days	7.06	6.87	6.88	6.84	.09	AL+
0-139 days[d]	6.03	5.93	5.72	5.73	.11	AL+
Net Energy, Mcal/cwt						
Maintenance	84.2[b]	87.5[a]	87.1[a]	88.6[a]	.87	AL**
Gain	56.1[b]	58.4[a]	58.1[a]	59.0[a]	.57	AL**
Metabolizable energy, Mcal/kg	2.89[b]	2.97[a]	2.96[a]	2.99[a]	.02	AL**

[abc]Means in the same row with different superscripts differ (P<.05).
[d]Based on carcass weight divided by .62, an assumed dressing percent.
[e]AL=Ad lib vs limited, HL=High programmed vs low programmed; **(P<.01), *(P<.05), +(P<.10).

were calculated from performance by the method described by Hays et al. (1987). Estimated NEm, NEg and ME values were significantly increased (P<.01) by 4.2, 4.3 and 2.9%, respectively, with limit feeding. The estimated NEm and NEg values for the ad libitum fed steers were lower (84.2 and 56.1 Mcal/cwt) than those predicted from diet composition (94.7 and 61.1 Mcal/cwt).

Effects of limit feeding on carcass characteristics are presented in Table 3. Dressing percentage tended (P<.10) to be lower for steers fed 80% of ad libitum for the first 56 days than for programmed steers (65.8 vs 66.6%). The percent of steers grading choice tended to be reduced (P<.10) with limit feeding (96 vs 72%) as also was noted in previous trials (Hicks et al., 1987). Final liver weight was not altered by limit feeding in these cattle. Thus, if maintenance requirements are correlated to liver mass, reduced maintenance requirements most likely cannot explain the observed improvements in feed efficiency.

Limit feeding did not alter steer behavior in this group of cattle (Table 4). These steers spent 15.5, 6.6 and 54.4% of their time ruminating, eating and laying, respectively. Passage rate and diet digestibility also were not altered by limit feeding (Table 5). With these cattle reduced animal activity or increased diet digestibility

Table 3. Effect of limit feeding on carcass characteristics.

	Ad Lib	80 %	High Prog	Low Prog	SEM	Contrasts[e]
Carcass wt, lb	690[a]	668[ab]	685[ab]	664[b]	7.3	AL[+], HL[+]
Dressing Percent	66.27	65.79	66.80	66.47	.34	80[+]
Rib eye area, sq in	12.25	12.25	12.23	12.79	.28	
KPH, %	2.02	1.96	1.94	2.08	.11	
Fat thickness, in	.54	.54	.57	.49	.05	
Marbling Score[d]	14.15[a]	12.71[b]	13.54[ab]	12.71[b]	.40	AL[*]
Percent Choice	95.8[a]	62.5[b]	78.6[ab]	75.0[ab]	9.3	AL[+]
USDA Yield Grade	2.95	2.85	2.99	2.57	.21	HL[*]
Percent YG 4	0.0[b]	0.0[b]	13.1[a]	0.0[b]	3.6	
Cutability, %	50.0	50.2	49.9	50.9	.5	
Liver Abscesses						
Severity[f]	2.5	2.1	2.0	2.0	.30	
Incidence, %	38.1	41.7	13.1	41.7	11.2	
Liver Wt, lb	12.77	13.25	13.54	13.03	.38	

[abc]Means in the same row with different superscripts differ (P<.05).
[d]12=slight plus, 13=small minus, 14=average small
[e]AL=Ad lib vs limited, 80=80% vs programmed, HL=High programmed vs low programmed; [*](P<.05), [+](P<.10).
[f]0=no abscess, 1=one or two small abscesses, 2=moderate abscesses, 3=severe abscesses.

Table 4. Effect of limit feeding on steer behavior.

	Ad Lib	80 %	High Prog	Low Prog	SEM
Time spent, %					
Ruminating	14.32	17.10	14.15	16.32	1.87
Eating	5.57	7.90	5.90	7.12	1.41
Laying	54.03	56.25	54.95	52.17	3.31

Table 5. Effect of limit feeding on diet digestibility.

	Ad Lib	80 %	High Prog	Low Prog	SEM
DM Intake, lb					
days 36-42	20.03	15.63	17.75	16.25	
Digestibility, %					
Total Diet	71.2	74.6	70.1	71.2	5.09
Starch	89.6	92.2	90.5	91.5	3.96
Passage rate, %/hr	3.23	2.95	3.32	3.14	.35
Fecal Starch, %					
day 40, 7/13/87	22.74	18.65	17.22	18.49	3.15
day 42, 7/15/87	17.34	15.61	19.54	18.20	2.84
day 44, 7/17/87	22.25	13.05	19.11	17.39	3.44
Mean	21.05	15.82	18.59	17.99	2.19

apparently cannot account for the improvement in feed efficiency noted with limit feeding. However, it must be noted that rather large variation in digestibility parameters here does not rule out this possibility.

Another potential reason for improvements observed in feed efficiency with limit feeding is reduced feed wastage. On day 43 of this trial concrete bunk pads were cleaned so that feed wastage over a 24 hour period could be monitored. No feed wastage was observed in these steers. Other potential reasons for improvement are reduced animal-to-animal variation and reduced day-to-day variation in feed intake within a pen with limit feeding (Zinn, 1986). Zinn notes that animals fed under ad libitum conditions tend to have very wide day-to-day (and within day) fluctuations in feed intake which may result in digestive disturbances and decreased feed utilization. During the 24 hour observation period aggressive eaters and timid eaters were noted in both ad libitum fed and limit fed pens. Animal-to-animal variation in time at the bunk was not reduced with limit feeding. However, day-to-day variation in pen intake was reduced with programming of feed intakes because steers were fed constant amounts of feed over two week intervals (Figure 1). In steers fed 80% of ad libitum for the first 56 days, day-to-day variation was not altered because feed allotments were adjusted daily based on intakes of pens with ad libitum access to feed (Figure 2).

Reduced animal-to-animal variation in daily gain with limit feeding is another potential cause of increased feed efficiency.

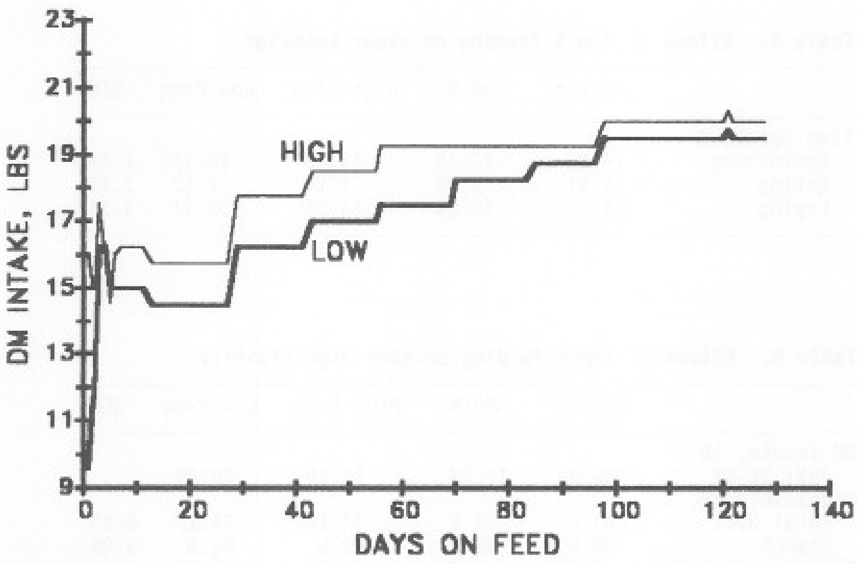

Figure 1. Feed dry matter intake versus time on feed for steers programmed to obtain specific weight gains. Feed allotments increased every two weeks.

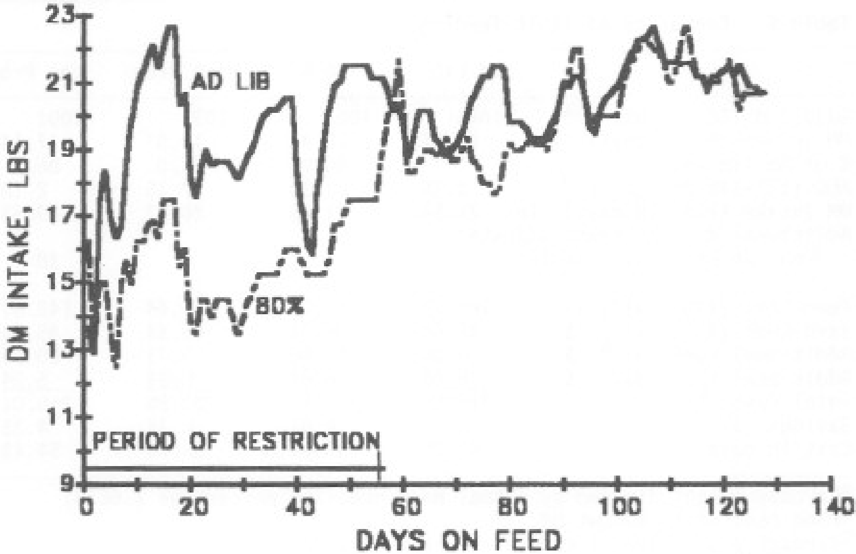

Figure 2. Feed dry matter intake versus time on feed for ad libitum fed steers and steers fed 80% of ad libitum for first 56 days of trial.

Coefficients of variation for carcass adjusted daily gains were 15.4, 16.7, 14.2 and 11.1% for ad libitum, 80%, high programmed and low programmed cattle, respectively. Animal-to-animal variation in daily gains was reduced with programming of feed intakes.

Economic analysis of this data is presented in Table 6. The number of additional days that limit fed steers would have to be fed to reach an adjusted final weight equal to that of the ad libitum fed steers was calculated assuming that gains observed during the last 28 days on feed were maintained. Additional feed cost were then calculated assuming that feed intake was the same as that observed in the last 28 day period. Total feed, yardage and interest cost per steer was $210.66, $217.61, $203.88 and $215.01 for ad libitum, 80%, high programmed and low programmed cattle, respectively. A potential savings of $6.78 per head was noted in the steers fed to gain 3.29 lb/day. This data indicates that restricting intake by more than 7% resulted in increased cost.

In summary, results of this trial suggest that limit feeding improves feed efficiency of feedlot steers but reduces rate of gain. Specific reasons for this improvement were not determined. Reduced liver size, reduced animal activity, reduced feed wastage or increased diet digestibility were not noted with this group of cattle and cannot explain improvements in feed efficiency. Reduced day-to-day fluctuations in feed intake and reduced animal-to-animal variation in gains in programmed steers possibly could account for some improvement in feed efficiency.

Table 6. Economics of limit feeding.

	Ad Lib	80 %	High Prog	Low Prog
Adjusted 138 day wt, lb[a]	1040	1007	1033	1001
DM Intake (0-138 days), lb	20.28	18.43	18.87	17.54
% of Ad lib intake		90.9	93.0	86.5
ADG (113-138 days), lb	2.16	2.33	2.15	2.18
DM Intake (113-138 days), lb	21.54	21.06	20.97	19.51
Additional days to reach adjusted final wt of ad lib cattle		14	3	18
Feed Cost (138 day)[b], $	165.12	150.06	153.64	142.81
Yard Cost (138 days)[c], $	45.54	45.54	45.54	45.54
Additional Feed Cost[b], $	0.00	17.40	3.71	20.72
Additional Yard Cost[c], $	0.00	4.62	0.99	5.94
Total Cost, $	210.66	217.61	203.88	215.01
Savings, $		-6.95	6.78	-4.35
Cost/lb gain, cents	53.20	55.09	51.75	54.43

[a]Carcass weight divided by actual mean dressing percentage (.6633)
[b]Feed cost of $5.90/cwt DM.
[c]Yardage plus interest cost of 33 cents/day.

Literature Cited

Davis, G.V. et al. 1973. Effect on performance of restricting feed intake of finishing steers. Kansas State Univ., Garden City Exp. Sta., Cattle Feeders' Day Bull. 571:28.

Hays, V.S. et al. 1987. calculating dietary net energy concentrations from feedlot performance data. In: F.N. Owens (ed.). Symposium Proceedings: Feed Intake By Beef Cattle. Okla. Agri. Exp. Sta. MP-121:360.

Hicks, R.B. et al. 1987. Effect of controlled feed intake on performance of feedlot steers and heifers. Okla. Agri. Exp. Sta. Res. Rep. MP-119:320.

Lofgreen, G.P. 1969. Limit vs full feeding. Ninth California Feeders' Day, p.64.

Lofgreen, G.P. et al. 1983. Influence of restricted feeding in finishing beef cattle. New Mexico State Univ. Clayton Livestock Res. Center Progress Rep. No. 34.

Lofgreen, G.P. et al. 1987. Feeding restriction influence on feedlot performance. J. Anim. Sci. 65 (Suppl. 1):430 (Abstr.).

Plegge, S.D. et al. 1985. Effect of feed intake on performance of yearling steers. Minnesota Cattle Feeders' Report, p.14.

Plegge, S.D. et al. 1986. Effect of restricting feed intake on performance of yearling steers. Minnesota Cattle Feeders' Report, p.1.

Zinn, R.A. 1986. Influence of type and frequency of implants on performance of limit-fed vs ad libitum-fed steers. California Cattle Feeders' Day, p. 47.

SIMULATION OF THE ECONOMIC EFFECT OF VARIABILITY WITHIN A PEN OF FEEDLOT STEERS

M.T. Smith[1], J.W. Oltjen[2] and D.R. Gill[3]

Story in Brief

A computer simulation model was developed to quantify the economic effect of variation in initial weight and body condition among cattle fed and marketed uniformly. In general, as variation in initial body weight increased, average net return decreased. Respective mean profits for steers having standard deviations of 40, 80, 120 and 160 lb around an initial weight of 700 lb were $45.96 ± .14, $40.26 ± .59, $24.51 ± .69 and $9.98 ± .77. Similarly, increased variation in body condition decreased average net return, although not at the same rate as initial weight. Respective mean profits for steers having standard deviations of .6, 1.2, 1.8 and 2.4 around an initial body condition score of 5 (1, extremely thin, to 9, extremely fat) were $46.43 ± .13, $45.97 ± .26, $43.85 ± .38 and $37.76 ± .90. These results suggest that variation, particularly in initial weight among cattle fed and marketed as a group, should be minimized in order to realize maximum profit potential. This should be of particular interest to those utilizing retained ownership as a marketing option.

(Key Words: Computer Simulation, Feedlot Cattle, Economic Analysis)

Introduction

Predictability and product uniformity are becoming increasingly important in the beef cattle industry. However, due to the diversity in age, weight, condition and breed type, today's feeder cattle differ in feedlot performance and composition of growth. Within a pen of cattle, these variables make it extremely difficult for all carcasses to meet desired market specifications for weight, quality grade and cutability. Yet, despite this variability among feeder steers, it is still common to find rather diverse cattle being fed, managed and marketed uniformly.

It is logical to assume that variability will have a detrimental effect on the profitability of a feedlot enterprise. Yet little, if any, research has been conducted to quantify the interaction between animal variation and economic outcome. At the biological level studies such as this may be cost prohibitive; however, computer simulation lacks these cost constraints. Therefore, it is a useful tool for evaluating these types of problems. To be successful, a precise computer model for estimation of feedlot performance and carcass quality is required. The objective of this research was to develop a computer program to simulate the economic effects of variation in initial weight and body condition within a pen of feedlot steers.

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[1]Graduate Student [2]Assistant Professor [3]Regents Professor

Materials and Methods

A computer program was developed to evaluate the effect of within pen variability on the economic outcome of feeding yearling steers. A dynamic beef cattle growth model (Oltjen et al., 1986) was used to simulate body weight gain and composition of growth, the two variables of major interest in this study. Variables predicted in the growth model include body weight, empty body fat and feed intake. Intake is derived from a prediction equation (Fox and Black, 1977) included in the program, and is adjusted for weight, frame-size, initial weight when started on feed, body fat, and dietary energy content (NRC, 1987). Carcass weight and composition was calculated using equations of Garrett and Hinman (1969); carcass grades were estimated using equations of Fox and Black (1984).

For this analysis steers were of moderate frame size and anabolic implants were used. One ration, having NEm and NEg values of .94 and .62 Mcal/lb, respectively, was fed for the entire 130 day feeding period. All cattle were slaughtered on the same day, regardless of variation in body weight or composition. To enable economic analysis, income was calculated for each steer on a carcass grade and yield basis. The price structure used in calculating carcass value is shown in Table 1. Offal value was added and kill costs subtracted for a more realistic evaluation of the animals true worth. The following expense costs were also used: purchase price of $78/cwt, feed cost of $4.50/cwt (as fed), processing cost of $8.00/hd and yardage costs of $.05/day. Interest rate for the purchase of cattle and feed was assumed to be 11 percent. Net return was calculated for each animal and pen averages determined. The input values used in the program are industry averages and reflect High Plains market conditions as of January 1, 1988.

Mean initial body weight was set at 700 lb and mean initial condition score at 5 (1, extremely thin to 9, extremely fat). Standard deviations of body weight and condition score were set at various increments and a random number generator was used to provide normally distributed initial animal variation. Each individual steer in pens of 100 animals was simulated and pen performance evaluated.

Results and Discussion

The effect of variation in initial body weight on profit is shown in Figure 1. Profit is calculated as the mean of all pen average net

Table 1. Price structure for determining carcass value

Adjustments[1], $/cwt					
Weight		Quality Grade		Yield Grade	
<500 lb	-5	Standard	-24	1	+1
500-550 lb	-4	Select	-6.5	2	+1
550-900 lb	0	Choice	0	3	0
>900 lb	-5	Prime	+3	4	-10
				5	-14

[1]Base value = $95/cwt, offal value = $8.47/cwt, kill cost = $25/hd.

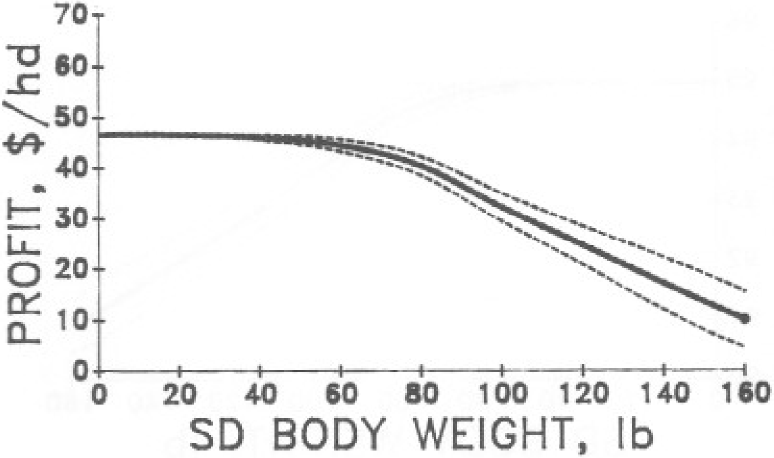

Figure 1. Relationship between profit and standard deviation (SD) of initial body weight for steers fed 130 days. Dotted lines represent one standard deviation from the mean.

returns and was maximized when the standard deviation of body weight (SDBW) was zero. As variation in initial body weight increased, profit decreased in a curvilinear manner. Respective mean profits for steers having standard deviations of 40, 80, 120 and 160 lb around an initial weight of 700 lb were \$45.96 ± .14, \$40.26 ± .59, \$24.51 ± .69 and \$9.98 ± .77.

Decreased profit is primarily due to a reduction in carcass value (Figure 2), as it is affected by undesirable carcass weights, quality and cutability. Average carcass value was relatively constant at \$95/cwt until SDBW exceeds 40 lb, and decreased linearly with standard deviations of body weight greater than 80 lb. Respective average carcass values for steers with standard deviations of 40, 80, 120 and 160 lb were \$94.99, \$94.41, \$92.55 and \$90.88/cwt. The price structure for determining carcass value was changed in the program to evaluate the relative sensitivity of net return to change in the price break between Select and Choice grade carcasses. Holding all other factors constant, net profit was assessed at a discount for Select carcasses of -\$9.00. Relatively little difference was found in net profit at SDBW of 40 lb or less. There was a \$1.50 decrease in profit per head at SDBW of 80 lb and a \$.68 decrease at SDBW of 120 lb. These results suggest that net returns are relatively insensitive to a change in the carcass quality grade price differential between choice and select.

The effect of variation in initial body weight on profit over various feeding periods is shown in Figure 3. Net returns increase almost linearly with increased time on feed when SDBW equals zero. This is due primarily to increased weight of carcasses with desirable characteristics. This trend should not be continuous as points will be reached where carcass weights will become excessive and carcass cutability reduced. Profit is not only reduced with increased variation

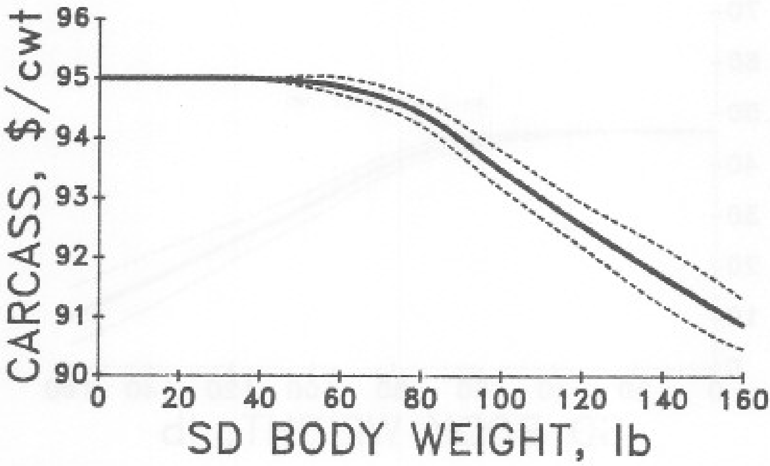

Figure 2. Relationship between carcass value and standard deviation (SD) of initial body weight for steers fed 130 days. Dotted lines represent one standard deviation from the mean.

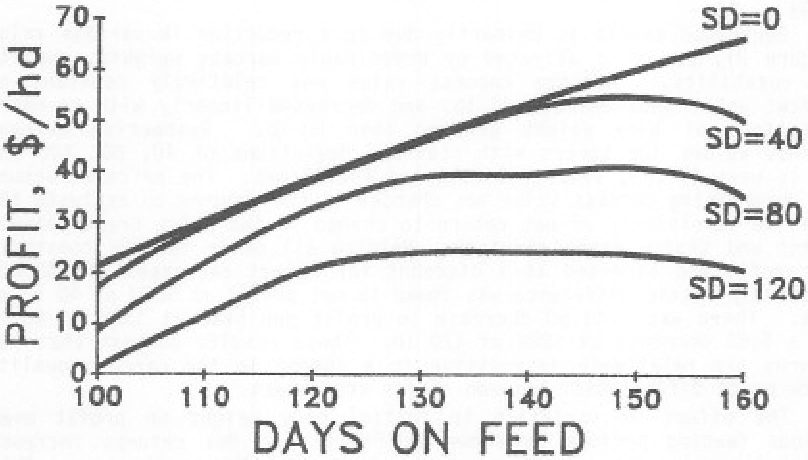

Figure 3. Relationship between profit and days on feed for steers with different initial weight standard deviation (SD).

in initial body weight, but is also maximized with fewer days on feed. These results suggest that to maximize the profit potential of a group of cattle managed and marketed uniformly, variation in initial body weight should be minimized; however, if cattle of diverse initial weight are to be fed, it is economically beneficial to market them earlier than one would market a group of cattle with similar initial weights. Cattle of lighter mean initial weights, (425 lb) showed a similar trend toward decreased profit as SDBW increased. However, there was greater variability about the calculated mean profit with lighter weight cattle.

Figure 4 shows the effect that variation in body condition has on net profit. Increased variation in body condition decreased average net return, although not at the same magnitude of initial body weight variation. Respective mean profits for steers having standard deviations of .6, 1.2, 1.8 and 2.4 around an initial body condition score of 5 were \$46.43 ± .13, \$45.97 ± .26, \$43.85 ± .38 and \$37.76 ± .90. As with variation in initial weight, decreased profit is due primarily to undesirable carcass characteristics; however, carcass weight is affected little by variation in body condition. Initial weight and body composition have an effect on feed intake and therefore subsequent feedlot performance (Hyer et al., 1986); however, the feed intake equation used herein may not be sensitive enough to these factors. This is noted in Figure 3 where profits appear to increase linearly for SDBW = 0.

Simulations in this report present minimal, or conservative, estimates of the effect of variation. In actual practice, these values serve as the smallest expected decrease in profit for a given standard deviation. The results support the practice of sorting incoming feedlot cattle for uniformity in expected days on feed. However, in cases when this is not done or is impractical, such as a cow-calf producer retaining ownership of a limited number of cattle, variation may be costly.

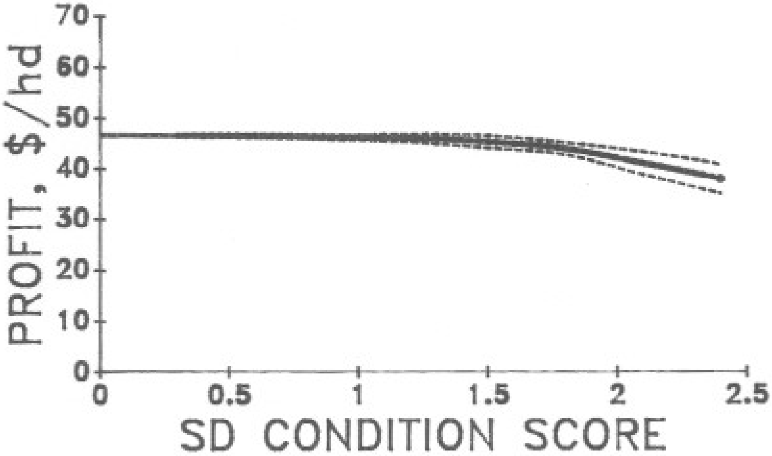

Figure 4. Relationship between profit and standard deviation (SD) of condition score for steers fed 130 days. Dotted lines represent one standard deviation from the mean.

Literature Cited

Fox, D.G. and J.R. Black. 1977. A system for predicting performance of growing and finishing beef cattle. Michigan State Beef Cattle-feeding Research Report 328:141.

Fox, D.G. and J.R. Black. 1984. A system for predicting body composition and performance of growing cattle. J. Anim. Sci. 58:725.

Garrett, W.N. and N. Hinman. 1969. Re-evaluation of the relationship between carcass density and body composition of beef steers. J. Anim. Sci. 28:1.

Hyer, J.C. et al. 1986. Relationship of body composition and feed intake of beef steers. J. Anim. Sci. 63(Suppl. 1):421.

NRC. 1987. Predicting feed intake of food-producing animals. National Academy Press, Washington, D.C.

Oltjen, J.W. et al. 1986. Development of a dynamic model of beef cattle growth and composition. J. Anim. Sci. 62:86.

THE EFFECT OF SORTING ON FEEDLOT ANIMAL PERFORMANCE

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Story in Brief

Four hundred twenty five crossbred feeder steers (787 lb) were visually divided into a light group and heavy group, individually weighed and placed into two pens. Each pen was subsequently divided on day 45 into two additional pens on the basis of above or below pen average performance and fed for an additional 67 days. Mean initial weights for the light and heavy pens were 763 and 810 lbs, respectively. Over the first 45 days, steers in the light group gained an average of 2.6 lb/day (164 steers below average, 2.33 lb and 49 steers above average, 3.65 lb) and steers in the heavy group gained an average of 3.05 lb/day (128 steers below average, 2.46 lb and 84 steers above average, 3.96 lb). Over the remaining 67 days, poor performing and good performing steers from the light group gained 3.10 and 3.98 lb/day, respectively. Poor performing and good performing steers from the heavy group gained 3.48 and 3.70 lb/day, respectively. These data are inconclusive as to whether sorting actually improved performance of the poorer performing steers, but they demonstrate the diversity of performance of cattle in a single feedlot pen.

(Key Words: Feedlot steers, sorting)

Introduction

Feedlot cattle are usually handled, treated and monitored as a pen, not as individuals. Within any pen of cattle, both slow and rapidly gaining cattle must be present because in research trials, where animals are individually weighed, wide differences are generally detected. Reasons for slow animal gains include genetic, environmental, health and injury factors. The relative difference in animal value at the end of a feeding period may be as much as $300/head between the best performer and the poorest performer (Martin et al. 1986; Strasia et al. 1987). This does not consider animals that have been railed during the feeding period. Such differences in performance occur in both cattle of one brand (ranch cattle) as well as cattle assembled by order buyers. Ideally, feeder cattle should be sorted into performance groups prior to being placed on feed, however, most production/management systems are not attuned to handling cattle in this manner. Management problems arise from the logistics of time and facilities necessary for the feedlot cowboy staff to move, weigh and sort pens of cattle. The objective of this study was to determine the benefit of sorting feedlot cattle on the basis of performance after approximately 45 days on feed, on subsequent animal performance.

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Materials and Methods

Four hundred twenty five crossbred steers averaging 787 lb were gathered from a pasture adjacent to the H.C. Hitch feedlot (Guymon, OK), driven into the feedlot and visually sorted into a light group and a heavy group on September 24, 1987. The steers were individually weighed full, identified, implanted with Synovex-S and injected with IBR, BVD, PI-3, Leptospirosis and 7-way clostridial vaccines, Ivermectin, Vitamin A and copper. The steers were placed on the normal feedlot program, progressing through the ration step-up program and onto the finish ration with the amount of diet delivered to the bunk determined by the feed caller. The diet consisted of high moisture corn-steam flaked corn, corn silage supplement and an additive mix (94 Mcal NEm and 62 Mcal NEg per cwt of ration).

The light group was weighed full on day 44 as a lot, average daily gain was calculated and the steers then were individually weighed. Those steers with gains above the pen mean were sorted to one new pen and those steers with gains below the pen mean were sorted to another new pen. On day 45, this procedure was repeated with the steers in the initial heavy group. Animals were not co-mingled and the original two pens became four pens based on performance. Final full weights were taken on the day 112 and on day 113 the steers were trucked 60 miles to Booker, Texas for slaughter where carcass data were obtained. For calculating daily gains, all weights were shrunk by 4%.

Results and Discussion

The initial visual sort resulted in average initial weights of 763 and 810 lb in the light and heavy groups. The steers in the light and heavy groups had daily feed intakes of 19.11 and 20.35 lb during the initial period and gained 2.63 and 3.05 lb/day, respectively (Table 1). Over the first 45 days, the good performers of the light group gained 56.7% faster (P<.05) than the poor performers (2.33 vs 3.65 lb/day); and gains remained 28.4% faster (P<.05) over the final 67 days (3.10 vs 3.98 lb/day). Compared to gains the first 45 days, subsequent gain of poor performers was increased by 33% whereas gain of good performers was increased by only 9%. Over the first 45 days, the good performers of the heavy group gained 61.0% faster (P<.05) than the poor performers (2.46 vs 3.96 lb/day) but gains remained only 6.3% faster over the final 67 days (3.48 vs 3.70 lb/day). Compared to gains over the first 45 days, subsequent gain of poor performers was increased by 41.5% whereas, gain of good performers had decreased by 6.6%. This data tends to indicate that rate of gain of slow gaining steers was increased by sorting whereas gain of rapidly growing steers was not altered by sorting. It is impossible to determine if these differences were due to sorting because no unsorted controls were included in the test.

Over the final 67 days, good performers in the light group were 14.5% more efficient than poor performers (7.36 vs 6.29 lb DM/lb gain) and in the heavy group good performers were 17.8% more efficient than poor performers (6.90 vs 5.67). Calculated metabolizable energy values of the feed were 7.6% and 6.3% greater for good than poor performers in the light and heavy groups, respectively.

In both groups, carcasses were significantly (P<.05) heavier for good than poor performers due their greater daily gains. Rib eye area also tended to be greater for good than poor performers. In the light

Table 1. Effect of sorting on steer performance.

	Light Group		Heavy Group	
	Poor	Good	Poor	Good
No. of steers	164	49	128	84
Weights, lb.*				
Initial	762[a]	765[a]	810[b]	810[b]
0-45 days	871[a]	936[b]	923[b]	991[c]
46-112 days	1087[a]	1213[c]	1169[b]	1253[d]
Daily Gains, lb.				
0-45 days	2.33[a]	3.65[b]	2.46[a]	3.96[c]
46-112 days	3.10[a]	3.98[d]	3.48[b]	3.70[c]
0-112 days	2.79[a]	3.85[c]	3.08[b]	3.80[c]
Dry matter intake, lbs.				
0-45 days	<<----19.11--->>		<<----20.35---->>	
46-112 days	20.53	24.20	21.24	21.56
Feed/Gain, 46-112 days	7.36	6.29	6.90	5.67
Calculated ME, Mcal/kg				
46-112 days	3.04	3.27	3.19	3.39
Carcass weight, lb.	664[a]	730[c]	706[b]	748[c]
Dressing percent	63.7[b]	62.6[a]	62.9[a]	62.2[a]
Rib eye area, sq. in.	11.9[a]	12.2[ab]	12.0[a]	12.6[b]
Fat thickness, in.	.46[ab]	.52[b]	.50[b]	.44[a]
KPH	1.97[a]	2.18[b]	1.91[a]	2.00[a]
Percent choice	42.9	48.9	52.1	47.4
Yield grade	2.76[a]	3.10[c]	2.96[bc]	2.83[ab]

[abcd] Means in the same row with different superscripts differ (P<.05).
* Full weights, no 4% pencil shrink.

group, good performers had greater (P<.05) fat thickness than poor performers whereas, in the heavy group poor performers were fatter (P<.05) than good performers.

In summary, these data are inconclusive as to whether sorting improved performance of slower gaining steers, but they demonstrate the diversity of performance of cattle in a single feedlot pen.

Literature Cited

Martin. J.J. et al. 1986. Metabolizable energy of steam flaked wheat and corn in feedlot rations. Ok. Ag. Exp. Sta. MP-118:107.

Strasia, C.A. et al. 1987. A comparison of monensin, narasin, salinomycin and tylosin on feedlot performance of steers. Ok. Ag. Exp. Sta. MP-119.

CARCASS TRAITS: IMPACT OF RATE OF GAIN

F.N. Owens[1], I.S. Shin[2] and D. R. Gill[1]

Story in Brief

Feedlot performance from a total of 2771 feedlot steers fed in OSU research trials over the past 12 years was compiled to determine the relationship between specific carcass measurements and rate of gain during the feeding period. Ribeye area continued to increase as rate of gain increased to 4.5 lb live weight gain per day. As rate of gain increased, fat thickness over the rib, kidney-heart-pelvic fat and marbling increased at decreasing rates. Both dressing percentage and cutability decreased as rate of gain increased, but as hot weight was greater for faster gaining cattle, total weight of lean cuts increased. No indication of a plateau in lean deposition was noted though lean cuts as a proportion of live weight tended to decrease slightly as rate of gain increased.

(Key Words: Feedlot, Carcass Measures, Growth Rate.)

Introduction

"Any steers gaining over 2 pounds per day are depositing fat, not lean!" This is a commonly accepted concept. It was extrapolated from a number of experiments in which groups of cattle have gained weight at different rates, either due to limit feeding or to differences in diet composition (Byers and Rompala, 1979). In such experiments, cattle usually are slaughtered at similar weights so they differ in age and in time-on-feed. Swine experiments indicate that older animals are leaner; backgrounding experience also supports the idea that frame size is dependent on animal age. Hence, age can bias this relationship so that cattle gaining faster are younger at slaughter and thereby fatter. Some evidence indicates that diet and end-products of fermentation can influence carcass composition independent of rate of gain.

If faster gaining cattle are fatter, this should reduce their cutability and value per pound providing they have adequate marbling to grade. Though comforting to producers with slow gaining animals, selecting or feeding for slow rates of gain to improve carcass merit seems backward. If fast rates of gain are primarily due to increased fat deposition, then selecting sires on the basis of gain during performance tests would mean that cattle are being selected partially for increased fat deposition at the expense of protein! Selection could simultaneously increase protein deposition, though curves relating empty body weight gain which have been widely circulated indicate that rate of protein gain plateaus when rate of empty body weight gain approaches 2 lb per day while rate of fat deposition skyrockets at this point. The objective of our research was to determine the relationship of carcass measurements of steers to rate of live weight gain of individual steers within a series of feeding trials.

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[1]Regents Professor [2]Graduate Student

Materials and Methods

Information on individual animal performance on 2771 steers fed in 15 different feedlot trials over the past 12 years was compiled. Cattle were predominantly medium framed yearlings, crosses of a wide variety of breeds typical of feedlot cattle in the Southern Great Plains, and were implanted and fed in tests of a wide variety of feed additives. Indicators of deposition of lean (ribeye area, cutability, weight of lean cuts) and of fat deposition (fat thickness over the rib, kidney-pelvic-heart percentage, dressing percentage and marbling) were regressed first against rate of live weight gain of steers across all trials and, in a second comparison, within each of the 110 to 160 day trials. Calculating regressions within trials would help to remove some environmental and genetic components which could be involved in these relationships. To check for curvilinearity, regressions were calculated against rate of live weight gain and rate of live weight gain squared. When the quadratic function was significant ($P<.05$) it was retained; if not, it was removed from the model. Of primary interest was total weight of lean cuts, calculated as cutability times hot carcass weight. Plots of relationships were prepared to illustrate these relationships.

Results and Discussion

Relationships between rate of weight gain and carcass measurements across all steers are presented in table 1. For clarity, these equations were used to calculate expected means for cattle gaining live weight at rates of 1 to 4.5 lb per day as presented in table 2. In addition, plots of specific relationships showing the distribution of values for individual animals are presented in figures 1 through 5. First, ribeye area increased linearly ($P<.05$) with rate of weight gain indicating that more lean tissue was being deposited by steers gaining at faster rates. The curvilinearity of ribeye area was not significant (quadratic term, $P=.11$; table 1). Despite a wide range in values for individual steers (figure 1), the trend is certainly upward. Yield grade, fat thickness over the rib, kidney-pelvic-heart fat percent, marbling score, hot carcass weight and dressing percentage also

Table 1. Statistical relationships of carcass traits to rate of gain.

	Ribeye area in^2	Yield grade	Cutability %	Rib fat in	KPH %	Marbling score	Hot weight lb	Lean cuts lb	Dressing %	Lean cuts % WT
Intercept	11.01	.877	54.87	.115	.648	9.89	440	250.3	60.27	33.2
Linear effect										
ADG	.432	.917	-2.16	.153	1.105	2.26	87.28	30.14	1.66	-.53
Prob.[a]	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.002	.0001
Quadratic effect										
ADG	NS	-.107	.250	-.018	-.166	-.359	-3.14	NS	-.317	NS
Prob.	.111	.0001	.0001	.0001	.02	.0001	.04	.77	.0001	.89
Mean value	12.42	2.68	50.56	.421	2.41	13.28	691	349.2	62.17	31.4
R^2	.05	.05	.05	.02	.03	.01	.42	.37	.02	.06

[NS] Not significant and deleted from the model.
[a]Probability of significance of above effect.

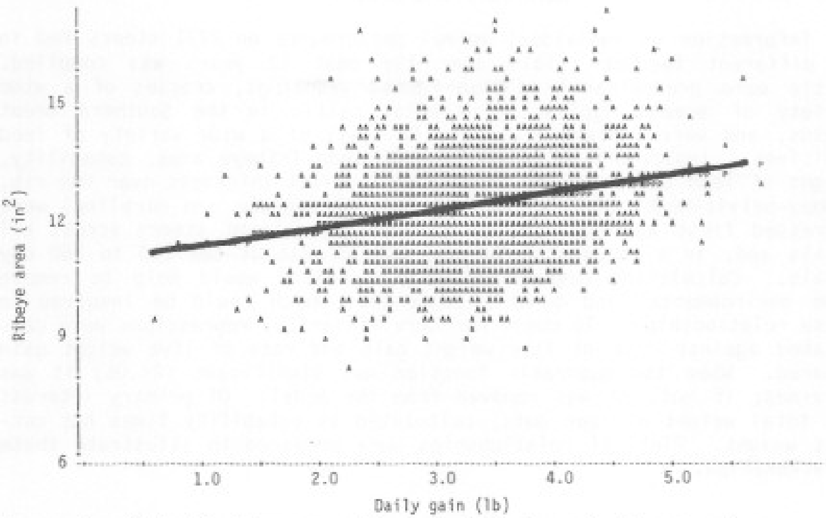

Figure 1. Plot of ribeye area (square inches) against rate of live weight gain for finishing steers. Statistics are in table 1.

increased, but at decreasing rates as rate of gain increased. Because fat thickness increased, cutability, an index of the percentage of carcass weight in closely trimmed lean cuts, was lower for steers gaining at more rapid rates. Fat thickness tended to plateau at a daily gain of about 3 pounds per day (figure 2) in marked contrast to previous suggestions that total fat deposition should increase greatly at rates of gain above 2 pounds per day. Note that marbling score plateaued for steers at 3 pound daily gains and was lower with faster rates of gains (table 2). This may indicate that steers making extremely rapid gains were of a type that had very large mature size and limited marbling.

Because carcass weights were greater for cattle gaining at faster rates while cutability decreased (figure 3), the weight of lean cuts, which should serve as an index of quantity of lean cuts produced by cattle gaining at the various rates of gain, increased (table 2). Despite this increase in weight of lean cuts, expressed as a percentage of final live weight, lean cuts as a percentage of live weight decreased as rate of live weight gain increased (figure 4). Changes, however, were quite small. Based on this regression (table 2), steers gaining at a rate of 1 lb daily were depositing .330 lb of closely trimmed lean cuts, whereas steers gaining at the rate of 4.5 lb daily were depositing .308 lb of lean for every lb weight gain, a decrease of only 6.7% despite the 3.5 pound increase in daily gain.

Surprisingly, dressing percentage was lower with more rapid rates of gain (figure 5) and heavier carcasses. Dressing percentage reflects two factors - it increases as more fat is deposited but it decreases as proportional size of the gut and viscera increase. One would expect from the hot weights and fat thickness over the rib that faster gaining

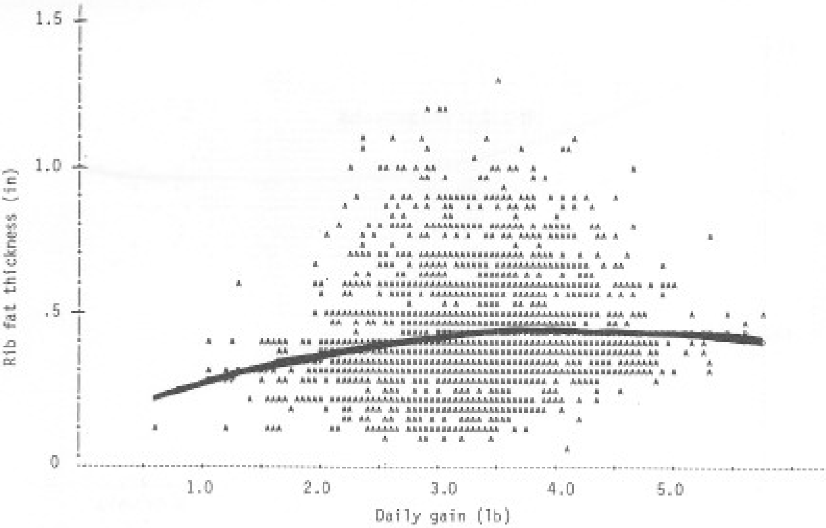

Figure 2. Numerical relationship of carcass tratis to rate of gain by steers.

Table 2. Numerical relationship of carcass traits to rate of gain by steers.

Rate of gain lb/day	Rib eye area in^2	Yield grade	Cuta-bility %	Rib fat in	KPH %	Marb-ling score	Hot weight lb	Lean cuts lb	Dress ing %	Lean cuts % WT
1.00	11.44	1.69	52.96	0.25	1.59	11.79[a]	524	280	61.61	33.0
1.50	11.66	2.01	52.19	0.31	1.93	12.47	564	296	62.05	32.5
2.00	11.87	2.28	51.55	0.35	2.19	12.97	602	311	62.32	32.2
2.50	12.09	2.50	51.03	0.39	2.37	13.30	639	326	62.44	31.8
3.00	12.31	2.67	50.64	0.42	2.47	13.44	674	341	62.40	31.6
3.50	12.52	2.78	50.37	0.44	2.48	13.40	707	356	62.20	31.3
4.00	12.74	2.83	50.23	0.45	2.41	13.19	739	371	61.84	31.0
4.50	12.95	2.84	50.21	0.45	2.26	12.79	769	386	61.32	30.8

[a] Slight plus=12; Small minus=13.

cattle should be fatter and thereby that dressing percentage should be higher with higher rates of gain. Such an increase in dressing percentage was not apparent. The other factor, viscera weight, would be expected to be greater for cattle gaining more rapidly because size of the gut and liver must expand to handle larger amounts of nutrients. A change in gut size and weight could explain the lower dressing percentages for faster gaining cattle.

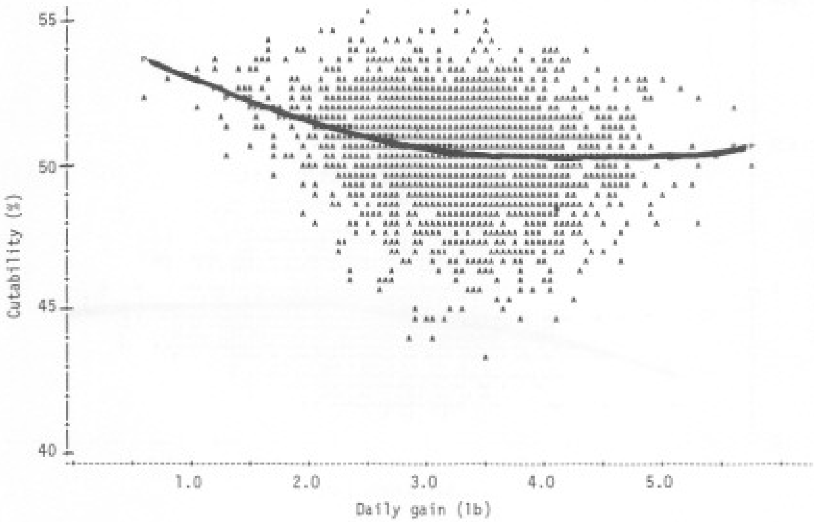

Figure 3. Plot of cutability (closely trimmed retail cuts as a percentage of carcass weight) against rate of live weight gain for finishing steers. Statistics are in table 1.

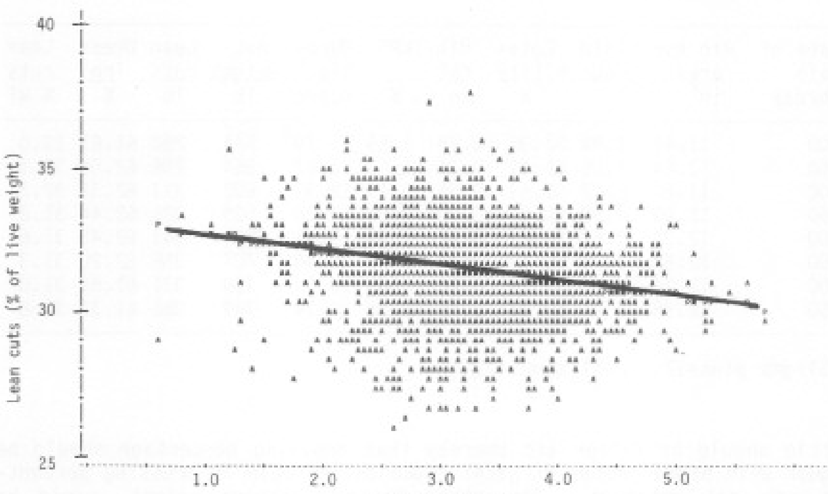

Figure 4. Plot of closely trimmed retail cuts as a percentage of live weight against rate of live weight gain for finishing steers. Statistics are in table 1.

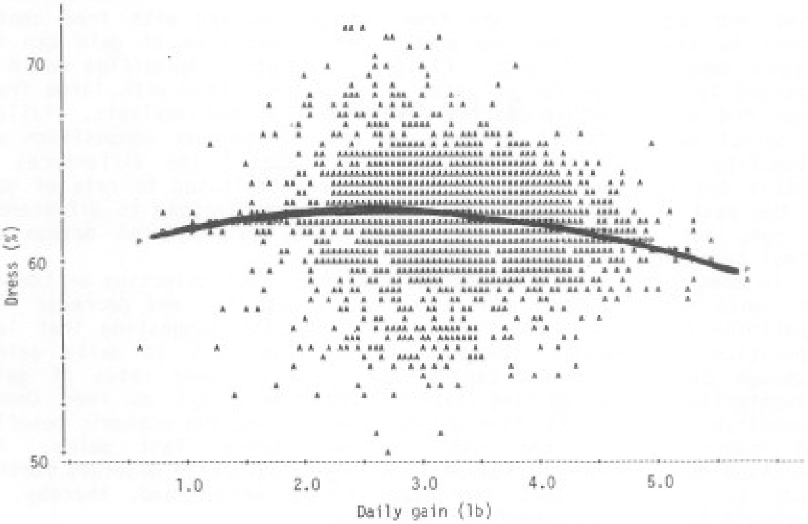

Figure 5. Plot of dressing percentage (hot carcass weight/live weight) against rate of live weight gain for finishing steers. Statistics are in table 1.

To determine whether certain environmental or genetic factors might be biasing the relationship of carcass traits to rate of gain, regressions were calculated including trial in the model. Results are presented in table 3. Including trial in the model had little impact on the relationships though mean values changed slightly.

In summary, curves relating carcass measurements to rate of gain indicate that deposition of lean did not plateau for cattle gaining up to 4.5 lb/d. Fat deposition, however, did increase at a decreasing rate as rate of gain increased, so cutability decreased. Although the incremental change in lean deposition was lower with more rapid rates of gain, no plateau in lean deposition was reached over the range of

Table 3. Relationship of carcass traits to rate of gain by steers with effect of trial removed.

Rate of gain lb/day	Rib eye area in^2	Yield grade	Cutability %	Rib fat in	KPH %	Marbling score	Hot weight lb	Lean cuts lb	Dressing %	Lean cuts % WT
1.00	11.98	2.0	52.2	0.25	2.0	11.8[a]	505	264	62.8	32.8
1.50	12.01	2.2	51.6	0.31	2.2	12.3	558	288	62.7	32.4
2.00	12.03	2.5	51.1	0.35	2.3	12.8	606	310	62.6	32.0
2.50	12.06	2.6	50.7	0.39	2.4	13.1	650	330	62.4	31.6
3.00	12.09	2.8	50.3	0.42	2.4	13.3	691	348	62.2	31.3
3.50	12.11	2.9	50.0	0.44	2.4	13.4	728	364	61.9	30.9
4.00	12.14	3.0	49.8	0.45	2.5	13.4	760	379	61.5	30.6
4.50	12.16	3.0	49.7	0.45	2.5	13.2	788	392	61.0	30.3

[a] Slight plus=12; Small minus=13.

gains achieved. Results are from cattle provided with free choice access to feed. Restricting energy intake and rate of gain can influence composition of gain. Plateaus in protein deposition would be expected to occur at faster rates of gain for cattle with large frame sizes and with growth-promoting feed additives and implants. Failure to detect major effects of rate of gain on carcass composition and cutability in our study indicates that some of the differences in protein and fat deposition which have been attributed to rate of gain in the past probably should have been ascribed instead to differences in age, nutrient availability and balance, experimental design and animal type and sex.

In conclusion, cattle producers concerned that selection or feeding for rapid rates of gain will greatly increase fat and decrease lean deposition can draw comfort from these results suggesting that lean deposition continues to increase to at least 4.5 lb daily gains. Although carcass leanness can be enhanced by slower rates of gain, slaughtering faster gaining cattle with fewer days on feed should accomplish the same objective without sacrificing the economic benefits and reductions in fixed costs attained through fast gains. The decreased dressing percentage of faster gaining cattle deserves further study as it may reflect increased viscera weight and, thereby, an increased energy requirement for maintenance.

Literature Cited

Byers, F. M. and R. E. Rompala. 1979. Rate of protein deposition in beef cattle as a function of mature size and weight and rate of empty body growth. Ohio Agr. Res. Devel. Center Beef Cattle Research Report Anim. Sci. Series 79-1. p. 48.

EFFECTS OF WEEKLY OR BI-WEEKLY ROTATIONAL FEEDING OF LASALOCID AND MONENSIN ON PERFORMANCE OF FEEDLOT STEERS

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Story in Brief

One hundred sixty crossbred yearling steers, weighing an average of 782 lb, were used to determine the effects of lasalocid, monensin/tylosin and their weekly and bi-weekly rotational feeding on performance of feedlot steers. Weekly or bi-weekly rotational feeding of ionophores did not statistically alter rate of live gain, carcass adjusted daily gain, feed intake, or feed efficiency on either a live basis or carcass weight basis. None of the treatments statistically altered carcass characteristics except that ionophore rotation at 14-d intervals decreased dressing percentage compared to lasalocid fed continuously (65.8 vs 64.8). The results of this experiment showed no effect of weekly or bi-weekly rotational feeding of monensin/tylosin and lasalocid on animal performance.

(Key Words: Feedlot Steers, Ionophore Rotation, Lasalocid, Monensin)

Introduction

Ionophores are routinely fed to feedlot cattle to improve efficiency of feed use. Rotation among non-ionophore antibiotics on a seasonal or yearly basis has proven beneficial and is currently a routine practice in the poultry and swine industry. Some microbiological research indicates that resistance to monensin also renders a microbe resistant to lasalocid in vitro (Dawson, 1985), yet these two ionophores differ in their chemical affinity for minerals and in their effects on feed intake. In a previous trial (Martin et al., 1984) in which ionophores were switched on day 56 of a feeding trial, gain and feed efficiency were increased by approximately 5 to 11% compared to feeding either ionophore singly over the trial. Results of a recent New Mexico trial (Hubbert et al., 1987) has indicated that rotation of the two ionophores, lasalocid and monensin/tylosin, at 7-day intervals resulted in greater gains and feed intakes than when either ionophore was fed continuously. Though scheduling a rotation of ionophores (and tylosin) might result in fluctuations in feed intake and reduced protection against liver abscesses, such an ionophore rotation program would be mechanically simple to implement in a feedyard.

Materials and Methods

One hundred sixty crossbred (primarily British crosses) yearling steers which had been wintered on wheat pasture near Dalhart, Texas were trucked to Goodwell, Oklahoma on June 3, 1987. On arrival, all cattle were individually weighed, ear tagged, implanted with Synovex-S, and injected with ivermectin and a BRSV vaccine. The steers were divided

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into five weight groups of 32 head each (4 pens) and four treatments were randomly assigned to each pen of eight steers in each block. The dietary treatments were: 1) lasalocid (30 g/ton) fed continuously, 2) monensin (26 g/ton) plus tylosin (10 g/ton) fed continuously, 3) treatments 1 and 2 rotated weekly and 4) treatments 1 and 2 rotated bi-weekly (every 14 days).

Steers were fed a cracked corn high concentrate ration twice daily (0700 and 1600) for the 95 day trial (Table 1). Chopped alfalfa hay was used to dilute the ration to 60 percent concentrate to start the cattle on feed. Roughage content of the diet was decreased sequentially in three steps until the cattle were on their final ration by 28 days on feed. Cattle on the rotation treatments were started on the supplement containing lasalocid. Monensin was fed at 13 g/ton for the first two weeks of the trial.

Cattle weights were off truck weights (shrunk) at the start of the trial but were taken on full-feed on days 28, 56, 84 and 95. For calculation purposes, all full weights were shrunk by 4% to compensate for digestive tract fill. Steers were trucked to Holcomb, Kansas on day 97 of the trial (September 9, 1987) for slaughter, and carcass data were obtained. This trial was analyzed as a randomized complete block design with five replications per treatment. Statistical comparisons included continuously fed lasalocid or monensin/tylosin vs. rotation, monensin/tylosin vs. lasalocid and weekly vs. bi-weekly rotation.

Results and Discussion

Effects of rotational feeding of ionophores on cattle performance are presented in Table 2. Daily gains of steers were generally lower ($P=.17$) with ionophore rotation during the first 56 days of the trial (3.49 vs 3.30 lb/day for continuous vs rotation). However, daily gains of rotation fed cattle tended to be greater ($P<.10$) during the second half of the trial than those fed a single ionophore continuously (2.71 vs 2.92 lb/day). Over the entire trial, neither daily live gain or carcass adjusted daily gain were statistically altered by rotational feeding of ionophores. Likewise, feed intake was not altered by any of the treatments. Feed efficiency tended ($P<.10$) to be reduced with rotational feeding of ionophores during the first half of the trial (5.84 vs 6.11 lb DM/lb gain for controls and rotation), but was improved ($P<.01$) during the second half of the trial (7.54 vs 6.72). During days

Table 1. Diet composition, dry matter basis.[a]

	Ration Sequence			
Ingredient	1	2	3	4[a]
Corn, cracked	52.70	62.28	71.87	80.02
Chopped alfalfa	38.36	28.78	19.19	11.04
Cane molasses	3.88	3.88	3.88	3.88
Pelleted supplement[b]	5.06	5.06	5.06	5.06

[a]To provide 12.25% protein, .53% calcium, .78% potassium, .33% phosphorus, 94.7 Mcal NEm/cwt and 61.1 Mcal NEg/cwt.
[b]Provided either 26 g monensin/ton plus 10 g tylosin/ton or 30 g lasalocid/ton.

Table 2. Effect of ionophore rotation on steer performance.

Item	Monensin Tylosin	Lasalocid	7-d Rotation	14-d Rotation	Contrasts[d]
No. of steers	40	40	40	40	
No. of pens	5	5	5	5	
Weight, lb:					
Initial	782	788	782	776	
56 days	1015	1027	1004	1003	
95 days	1130	1131	1119	1125	
Daily gains, lb:					
0-56	3.45	3.53	3.24	3.36	
57-95	2.83	2.58	2.84	2.99	CR^{+}
0-95	3.20	3.14	3.08	3.21	
0-97[c]	3.73	3.77	3.66	3.65	
Daily feed, lb DM:					
0-56	20.08	20.57	19.93	20.27	
57-95	20.08	20.06	19.35	19.46	
0-95	20.08	20.36	19.69	19.94	
Feed/gain:					
0-56	5.85	5.82	6.16	6.05	CR^{+}
57-95	7.13[ab]	7.94[a]	6.90[b]	6.54[b]	CR**,MTL*
0-95	6.29	6.50	6.41	6.22	
0-97[c]	5.39	5.41	5.39	5.47	
Metabolizable energy, Mcal/kg	3.02	2.97	2.99	3.03	
Net energy, Mcal/cwt					
Maintenance	90.2	87.8	88.8	90.4	
Gain	59.9	58.5	59.1	60.2	

[a,b]Means in the same row with different superscripts differ ($P<.05$).
[c]Based on carcass weight divided by .62, an assumed dressing percent.
[d]CR=Continuous vs rotation, MTL=Monensin/Tylosin vs Lasalocid; **($P<.01$), *($P<.05$), $^{+}$($P<.10$).

57-95, cattle fed monensin continuously were more efficient ($P<.05$) than those fed lasalocid continuously (7.13 vs 7.94). However, when averaged over the entire trial feed efficiency was not altered by any of the treatments. Comparison of NEg values with those expected (Tables 1 and 2) indicates that cattle gained less efficiently than expected (61.6 vs 59.4 Mcal/cwt for expected vs actual).

Effects of ionophore rotation on carcass characteristics are presented in Table 3. Dressing percentage was greater ($P<.05$) for steers fed lasalocid continuously than bi-weekly rotation steers (65.8 vs 64.8). In addition, weekly rotation steers tended ($P<.10$) to dress greater than bi-weekly rotation steers (65.6 vs 64.8). Because shrink of transported cattle has been reduced by lasalocid in some trials (Brazle et al., 1987), it is of interest that cattle fed lasalocid had a slightly higher dressing percentage. Cattle on the 14-d rotation were fed lasalocid the final 10 days before slaughter whereas cattle on the 7-d rotation were switched to monensin/tylosin 3 days before slaughter. Differences in dressing percentage were not significantly altered by ionophore being fed at slaughter in this trial. The percentage of the steers grading choice across all treatments was 77.5% and 5.6% of the steers produced USDA Yield Grade 4 carcasses. The incidence of liver abscesses was greater ($P<.10$) for steers fed lasalocid than those fed

Table 3. Effect of ionophore rotation on carcass characteristics.

Item	Monensin Tylosin	Lasalocid	7-d Rotation	14-d Rotation	Contrasts[e]
Carcass wt, lb	709	715	705	700	
Dressing %	65.4[ab]	65.8[a]	65.6[ab]	64.8[b]	WBW+
Rib eye area, sq in	12.6	12.8	12.6	12.7	
KHP, %	2.48	2.55	2.58	2.59	
Fat thickness, in	.57	.54	.53	.56	
Marbling score[c]	13.25	13.45	12.90	12.95	
Percent choice	72.5	85.0	80.0	72.5	
Percent YG 4	7.5	7.5	0.0	7.5	WBW+
USDA Yield Grade	3.08	2.97	3.00	3.00	
Cutability, %	49.6	49.9	49.8	49.8	
Liver abscesses:					
Incidence, %	7.5	22.5	12.5	12.5	MTL+
Severity[d]	1.70	2.44	2.10	2.10	

[a,b]Means in the same row with different superscripts differ ($P<.05$).
[c]12=slight plus, 13=small minus
[d]0=no abscesses; 1=one or two small, well organized inactive abscesses; 2=two to four well organized abscesses without inflammation; 3=one or more active abscesses with inflammation, only among cattle with abscesses.
[e]MTL=Monensin/Tylosin vs Lasalocid, WBW=Weekly vs Bi-Weekly; +($P<.10$).

monensin (22.5 vs 7.5%) with the rotational treatments being intermediate (12.5%).

In summary, the results of this trial showed no advantage for weekly or bi-weekly rotational feeding of monensin/tylosin and lasalocid. This contrasts with the results of Hubbert et al. (1987) in which weekly rotational feeding of monensin and lasalocid increased daily gains by 25.3% and improved feed efficiency by 12% compared to continuously fed monensin. However, in the New Mexico study, cattle were on feed only 56 days with only 12 head per treatment. Rotation at more frequent intervals might prove useful.

Literature Cited

Brazle, F.K. et al. 1987. The effect of oxytetracycline and lasalocid in mineral mixtures on gains of heifers grazing native grass pasture. J. Anim. Sci. 65 (Suppl. 1):142 (Abstr.).

Dawson, K.A. et al. 1985. Some physiological characteristics of isolated rumen bacteria after adaptation to increased concentrations of monensin. J. Anim. Sci. 61 (Suppl. 1):491 (Abstr.).

Hubbert, M. et al. 1987. Influence of alternate feeding of monensin and lasalocid on performance of feedlot heifers - preliminary data. New Mexico State Univ. Clayton Livestock Res. Center Progress Rep. 47.

Martin, J.J. et al. 1984. Comparison of ionophores for feedlot steers. Okla. Agri. Exp. Sta. Res. Rep. MP-116:266.

COMPARISON OF THE SITE AND EXTENT OF ORGANIC MATTER DIGESTION BETWEEN CORN AND FOUR DIVERGENT SORGHUM GRAIN HYBRIDS

M.N. Streeter[1], D.G. Wagner[2], C.A. Hibberd[3], F.N. Owens[2] and D.S. Buchanan[3]

Story in Brief

Corn and four divergent sorghum grain hybrids were dry rolled before incorporation into 85% grain diets. Sorghum grain hybrids were grown during the summer of 1986 in a single location to reduce variation caused by the environment. The four sorghum hybrids represented yellow, cream, hetero-yellow and red endosperm types. Diets were fed at 2% of body weight to 5 Angus x Angus-Hereford steers (532 lb) equipped with large ruminal and L-type duodenal and ileal cannulae to determine the site and extent of organic matter (OM) digestion. Total tract OM digestibility was greater for corn (76.6%) than red (66.6%) or yellow (66.1%) but was not different from cream (73.3%) or hetero-yellow (68.5%). Feed OM digestion in the rumen was greater for corn (81.8%) than for hetero-yellow (57.8%), yellow (60.9%) and red (55.6%). Ruminal OM digestibility of cream was not different from corn or other sorghum grain hybrids. Organic matter digestibility through the ileum tend to reflect differences observed in the total tract. Corn (76.6%) OM digestibility through the ileum was greater than observed for hetero-yellow (63.8%), red (60.2%) and yellow (58.8%), but not different from cream (70.3%). Based on OM digestibility of sorghum grain hybrids in this study it appears some current sorghum grain hybrids may approach the digestibility of corn.

(Key Words: Sorghum Hybrid, Corn, Organic Matter Digestion)

Introduction

Sorghum grain is an important energy source for feedlot diets in the High Plains region. Increasing water demands in the High Plains may decrease water available for irrigated corn production in the future. Sorghum grain is a viable alternative to corn, requiring less water to produce a crop than corn. However, sorghum grain is generally considered to have lower feeding value than corn even though the gross composition of the grain types is similar. Recent studies with sorghum hybrids having pure yellow endosperm suggest this sorghum type may approximately equal the feeding value of corn. Estimates for the value of sorghum are based on sorghum varieties not used today and are, therefore, in need of adjustment. Therefore, the objectives of this study were to determine differences in chemical composition and site and extent of organic matter digestion between corn and currently available sorghum grain hybrids.

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Materials and Methods

Five diets were developed (Table 1) using corn and four currently available divergent sorghum grain hybrids. The four sorghum grains had either red, cream, hetero-yellow or pure yellow endosperm. All sorghum grain hybrids were grown in a single location during the summer of 1986, to reduce variation due to the environment. All grains were dry rolled before incorporation into high grain rations (85.0%) containing urea as the only supplemental nitrogen (N) source.

Diets were fed twice daily at 2% of individual body weight (DM basis) to 5 Angus x Angus-Hereford steers (532 lb) fitted with large ruminal and L-type duodenal and ileal cannulae. Diets were randomly assigned in a 5x5 Latin Square with experimental periods of 14 days. Days 1 through 11 were used for diet adaptation. Digesta and fecal samples were collected at 1200, 1800 and 2400 hours on day 12, 600, 1500 and 2100 hours on day 13 and 300 and 900 hours on day 14. The sampling schedule resulted in sample collection every 3 hours in a 24 hour period to reduce the effect of diurnal variation of chromic oxide flow. Ruminal fluid, for ammonia determination, was collected during the last 4 sampling times. Additionally, ruminal fluid, for bacterial isolation, was collected at 1400 hour on day 14 of each sampling period. Digesta and fecal samples were composited across day and time within periods. Ruminal, digesta and fecal samples were sub sampled at the end of each period and frozen. Duodenal, ileal and fecal samples were freeze dried and ground through a 1mm screen in a laboratory Wily mill prior to chemical analysis. All samples were analyzed for all or part of the following chemical components: dry matter (DM), organic matter (OM), pH and chromium. Organic matter, truly fermented in the rumen, was calculated using determined microbial OM, N and purine N values. The site and extent of OM digestion was determined using chromium ratios.

Data were analyzed using least squares procedures. Least squares means were separated using least significant difference protected by an initial F test.

Results and Discussion

The crude protein content (Table 2) of red grain (10.4%) was greater than ($P<.05$) observed for cream (9.7%), hetero-yellow (9.6%) and yellow (9.5%) but was not different ($P>.05$) from corn (10.0%). Corn

Table 1. Diet Composition Dry Matter Basis

Ingredient	% DM
Dry Rolled Grain	85.0
Cottonseed Hulls	8.0
Molasses	3.0
Urea	1.2
Supplement	
Dicalcium phosphate	0.44
Calcium carbonate	0.93
Potassium chloride	0.57
Sodium sulfate	0.36
Trace mineralized salt	0.25
Chromic oxide	0.20
Vitamin A (IU/Kg)	2200

Table 2. Chemical Composition of Grains and Diets.

Item (%)	Corn	Cream	Hetero	Red	Yellow
Grain					
Crude Protein	10.0[ab]	9.7[bc]	9.6[bc]	10.4[a]	9.5[c]
Starch	72.2[c]	78.3[ab]	72.9[bc]	79.6[a]	78.7[ab]
Feed					
Crude Protein	12.1[c]	12.5[b]	12.6[b]	13.5[a]	12.6[b]
Starch	64.7	62.6	65.4	65.2	65.1

[abc] Means in the same row with different superscripts differ (P<.05)

contained more crude protein (P<.05) than yellow but was not different from cream or hetero-yellow. Red (79.6%), yellow (78.7%) and cream (78.3%) grains were not different (P>.05) in starch content, but contained more (P<.05) starch than corn (72.2%). Hetero-yellow (72.9%) contained less (P<.05) starch than red but was not different from cream or yellow. The crude protein content of hetero-yellow (12.6%), yellow (12.6%) and cream (12.5%) feeds were not different (P>.05) but were greater than (P<.05) observed for corn (12.1%) and less than (P<.05) observed for red (13.5%). Diets were not different in starch content and averaged 64.6%.

Organic matter intake (Table 3) was not different (P>.05) between corn (4629 g/d), cream (4625 g/d), hetero-yellow (4608 g/d) and yellow (4601 g/d). Red OM intake (4582 g/d) was less than (P<.05) that for corn and cream, but did not differ (P>.05) from hetero-yellow or yellow.

Total tract OM digestibility was greater (P<.05) for corn (76.6%) than hetero-yellow (68.5%), red (66.6%) and yellow (66.1%), but was not different (P>.05) from cream (73.3%). Cream was also not different (P>.05) from hetero-yellow, red or yellow. A large proportion of total OM digestion should be starch; therefore, particle size, protein solubility and digestibility differences between grain sources may be the cause of differences in total tract OM digestibility.

Ruminal OM digestion corrected for microbial OM was greatest for corn (81.8%) and lowest for red (55.6%). Corn had greater (P<.05) ruminal OM digestibility than hetero-yellow (57.8%), red (55.6%) and yellow (60.9%), but was not different (P>.05) from cream (67.7%). Within sorghum hybrids, hetero-yellow, red and yellow were not different (P>.05) from cream.

Organic matter disappearance in the small intestine was not different between grain sources and averaged 33.9% of OM entering the small intestine. The small intestine digested an average of 18.6% of OM intake. The small intestine appeared to compensate for lower ruminal OM digestion with cream (19.2%), hetero-yellow (23.0%) and red (21.3%) compared to yellow (15.1%).

Ileal OM appearance (g/d) for corn (1081) was less than (P<.05) for hetero-yellow (1646), red (1811) and yellow (1892). The amount of corn OM passing the ileum was not different (P>.05) from passage of cream OM (1362 g/d). Cream OM appearance at the ileum was less than (P<.05) observed with yellow (1892 g/d), but not different (P>.05) from observed with hetero-yellow or red. Organic matter appearance at the ileum was not different (P>.05) between hetero-yellow, red and yellow. Digestibility of OM through the ileum was greater (P<.05) for corn (76.6%) and cream (70.3%) than for yellow (58.8%). Corn OM

Table 3. Comparison of corn and sorghum grain hybrid organic matter digestion.

Item	Corn	Cream	Hetero	Red	Yellow
OM Intake (g/d)	4629[a]	4625[a]	4608[ab]	4582[b]	4601[ab]
Total Tract OM Digestibility	76.6[a]	73.3[ab]	68.5[b]	66.6[b]	66.1[b]
Ruminal Environment					
pH	5.97	5.83	5.94	5.92	5.86
Ammonia N (mg/dl)	7.60	7.81	8.36	9.45	10.02
Duodenal Appearance					
Feed OM (g/d)	840[a]	1504[ab]	1939[b]	2042[b]	1800[b]
Corrected Ruminal OM Digestion					
% Intake	81.8[a]	67.7[ab]	57.8[b]	55.6[b]	60.9[b]
Disappearance in the Small Intestine					
OM g/d	656	912	1076	993	706
% OM Entry	37.8	36.5	38.7	34.8	21.6
% OM Intake	14.2	19.2	23.0	21.3	15.1
Ileal Appearance					
OM g/d	1081[a]	1362[ab]	1646[bc]	1811[bc]	1892[c]
Digestion Through the Ileum					
% OM Intake	76.2[a]	70.3[ab]	63.8[bc]	60.2[bc]	58.8[c]
% Total OM	100.1	95.6	93.0	89.8	89.5
Disappearance in the Large Intestine					
OM g/d	-1.7	139.6	207.9	287.0	337.8
% OM Entry	-0.8	9.9	12.2	15.4	18.1
% OM Intake	-0.1	3.1	6.4	4.7	7.3

[abc] Means with different superscripts in the same row differ ($P<.05$).

digestibility through the ileum was also greater than ($P<.05$) observed for hetero-yellow (63.8%) and red (60.2%). Ileal OM digestibility for hetero-yellow and red was not different ($P>.05$) from cream or yellow. Ileal OM digestibility expressed as a percent of total tract digestion was not different between grain sources and averaged 93.6%. However, corn (100.1%) and cream (95.6%) appeared to have a greater percentage of total OM digestion occurring before the ileum than red (89.8%) or yellow (89.5%). Organic matter digested before the ileum may be of greater benefit in supporting efficient gain than digestion in the large intestine.

Organic matter disappearance from the large intestine was not different between treatments and averaged 11.1% of OM entry. Disappearance of OM from the large intestine expressed as a percent of OM entry appeared to be greatest for yellow (18.1%) and red (15.4%), intermediate for hetero-yellow (12.2%) and cream (9.9%) and lowest for corn (-0.8%). Negative OM digestibility in the large intestine may be the result of starch fermentation and subsequent excretion of microbial OM.

Corn and cream OM were more completely digested through the ileum and total tract than other sorghum grain hybrids. However, through the ileum and in the total tract corn was numerically greater than all sorghum grain hybrids tested. Based on OM digestibility it appears that some currently available sorghum grain hybrids may have greater feeding value relative to corn than older, more traditional hybrids like red. The pure yellow hybrid included in this study does not support previous research suggesting pure yellow sorghum hybrids to be of greater nutritional value than other sorghum hybrids.

COMPARISON OF THE SITE AND EXTENT OF NITROGEN DIGESTION BETWEEN CORN AND FOUR DIVERGENT SORGHUM GRAIN HYBRIDS

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Story in Brief

Corn and four divergent sorghum grain hybrids were dry rolled before incorporation into 85% grain diets. Sorghum grain hybrids were grown during the summer of 1986 in a single location to reduce variation caused by the environment. The four sorghum hybrids represented yellow, cream, hetero-yellow and red endosperm types. Diets were fed at 2% of body weight to 5 Angus x Angus - Hereford steers (532 lb) equipped with large ruminal and L - type duodenal and ileal cannulae to determine the site and extent of nitrogen (N) digestion. Total tract non-ammonia N (NAN) digestibility was greater for corn (63.5%) than for yellow (56.9%) and red (54.8%), but not different than cream (60.9%) or hetero-yellow (60.4%). Feed N escape of ruminal digestion was less for corn (49.6%) than for all sorghum hybrids. Red (81.0%) had greater feed N escape of ruminal digestion than cream (65.9%), but did not differ from hetero-yellow (71.6%) or yellow (69.0%). The efficiency of microbial protein production did not differ between grain sources and averaged 20.3 g of microbial crude protein / kg organic matter truly fermented. Digestion of NAN through the ileum was greatest for corn (65.1%), cream (64.1%) and hetero-yellow (63.4%) and least for red (56.6%) with yellow (59.0%) being intermediate. Nitrogen digestion was complete at the ileum (104.2% of total). Non ammonia N disappearance in the small intestine averaged 63.8% of NAN entry. The small intestine appeared to compensate for lower ruminal feed N digestion. The small intestine was the primary site of NAN digestion (116% of total). Differences in feed N escape and similar digestion through the ileum may result in differences in the quality of protein absorbed from the small intestine.

(Key Words: Sorghum Hybrid, Corn and Nitrogen Digestion)

Introduction

The majority of the crude protein requirement of feedlot cattle is fulfilled by the grain component of the diet; therefore, digestion of grain protein is of great importance. Ruminal digestion of grain protein may be of greater benefit to cattle than passage of low quality grain protein to the small intestine for subsequent digestion and absorption. Corn is the preferred grain by the feedlot industry. However, increasing energy costs and water demands for irrigated corn production make sorghum grain a viable alternative. Sorghum grain is generally considered to have a lower feeding value than corn even though the gross composition of the grain types is similar. However, estimates for the feeding value of sorghum are based on sorghum varieties not currently produced. Sorghum grain protein is considered to be less digestible in the rumen and total tract than corn protein. Therefore,

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ruminal escape of low quality sorghum protein is of particular importance. Furthermore, a relationship between the digestibility of sorghum grain protein and starch has been postulated based on the physical and chemical structure of the sorghum berry. Unfortunately, this suggestion has been widely accepted, but little information exists supporting the concept. Therefore, the objectives of this study were to determine differences in chemical composition and the site and extent of nitrogen digestion between corn and currently available sorghum grain hybrids.

Materials and Methods

Five diets were developed (Table 1) using dry rolled corn and four currently available divergent sorghum grain hybrids. The four sorghum grains had either red, cream, hetero-yellow or pure yellow endosperm. All sorghum grain hybrids were grown in a single location during the summer of 1986 to reduce variation due to the environment. Diets were high grain (85%) containing urea as the only supplemental nitrogen (N) source to facilitate estimation of grain protein escape of ruminal digestion.

Diets were fed twice daily, at 2% of individual body weight (DM basis), to 5 Angus x Angus - Hereford steers (532 lb) fitted with large ruminal and L - type duodenal and ileal cannulae. Experimental periods and digesta sampling were conducted as described by Streeter et al. (1988). Ruminal fluid, for bacterial isolation, was collected at 1400 hour on day 14 of each sampling period. Ruminal, digesta and fecal composite samples were sub sampled at the end of each period and frozen. Digesta and fecal samples were managed as described by Streeter et al. (1988). Samples were analyzed for all or part of the following chemical constituents: dry matter (DM), crude protein nitrogen (N), total purine nitrogen, ammonia N, pH and chromium. Ruminal escape of feed N was calculated using determined microbial OM, N and purine N values. The site and extent of N digestion was determined by using total purine N and chromium ratios.

Data were analyzed using least squares procedures. Least squares means were separated using least significant difference protected by an initial F test.

Table 1. Diet Composition Dry Matter Basis

Ingredient	% DM
Dry Rolled Grain	85.0
Cottonseed Hulls	8.0
Molasses	3.0
Urea	1.2
Supplement	
Dicalcium phosphate	0.44
Calcium carbonate	0.93
Potassium chloride	0.57
Sodium sulfate	0.36
Trace mineralized salt	0.25
Chromic oxide	0.20
Vitamin A (IU/Kg)	2200

Results and Discussion

Crude protein content (Table 2) of feed was greater (P<.05) for red (13.5%) than for corn (12.1%), cream (12.5%), yellow (12.6%) and hetero-yellow (12.6%). Corn feed contained less (P<.05) crude protein than cream, hetero-yellow or yellow. Corn grain (72.6%) contained less (P<.05) starch than red (79.6%), yellow (78.7%), and cream (78.28%), but was not different from hetero-yellow (72.9%). Within sorghum hybrids, red contained more (P<.05) starch than hetero-yellow but was not different from yellow or cream. Cream and yellow were also not different (P>.05) from hetero-yellow. Starch content of the diets was not different between grain sources and averaged 64.6%.

Nitrogen intake (Table 3) was low for corn compared to the sorghum grain diets. The red sorghum diet resulted in greater N intake than the other sorghum diets. Nitrogen intake was adequate to meet animal requirements with all diets.

Total tract non ammonia N (NAN) digestibility was greatest for corn (63.5%) and least for red (54.8%). Digestibility of cream (60.9%) and hetero-yellow (60.4%) did not differ (P>.05) from corn. Yellow (56.9%) had a lower NAN digestibility than corn (P<.05), but was not different from cream or hetero-yellow (P>.05). Red NAN digestibility was less (P<.05) than corn and cream, but not different from yellow or hetero-yellow (P>.05). Red is a traditional sorghum hybrid typical of sorghum grain compared to corn in the past. Therefore, it was expected that red would have a lower total tract NAN digestibility than corn. Based on limited animal performance research, yellow was expected to differ very little from corn. However, cream and hetero-yellow were the only sorghum hybrids not different from corn. Differences between sorghum hybrids and corn were presumably the result of differences in protein solubility and particle size.

The ruminal environment was not different between diets. Ruminal pH averaged 5.90 across all diets. Ruminal ammonia N level was 8.65 mg/dl averaged across all diets. Total feed N digestion in the rumen was greatest for corn (64.6%) and lowest for red (39.7%). Corn had greater (P<.05) ruminal feed N disappearance than all sorghum hybrids. Within sorghum hybrid, cream (52.4%) had greater (P<.05) ruminal feed N disappearance than red, but not greater than (P>.05) yellow (49.8%) or hetero-yellow (48.0%). Ruminal feed N disappearance was not different (P>.05) between red, hetero-yellow and yellow. Feed N escape of ruminal digestion was greatest for red (81.0%) and lowest for corn (49.6%). Corn escape of ruminal digestion was less than (P<.05) all sorghum hybrids. Cream (65.9%) feed N escape was less than (P<.05) red, but not

Table 2. Chemical Composition (%) of Grains and Diets.

Item		Corn	Cream	Hetero	Red	Yellow
Grain						
	Crude Protein	10.0^{ab}	9.7^{bc}	9.6^{bc}	10.4^{a}	9.5^{c}
	Starch	72.2^{c}	78.3^{ab}	72.9^{bc}	79.6^{a}	78.7^{ab}
Feed						
	Crude Protein	12.1^{a}	12.5^{b}	12.6^{b}	13.5^{c}	12.6^{b}
	Starch	64.7	62.6	65.2	65.2	65.1

^{abc} Means in the same row with different superscripts differ (P<.05).

Table 3. Influence of corn and four sorghum grain hybrids on nitrogen digestion.

Item	Corn	Cream	Hetero	Red	Yellow
Intake (g/d)					
Total N	93.8[a]	97.3[b]	98.0[b]	103.9[c]	97.7[b]
Non-Urea N	67.1[a]	70.5[b]	71.3[b]	77.3[c]	71.1[b]
Total tract N digestibility based on:					
Fecal NAN	63.5[a]	60.9[ab]	60.4[abc]	54.8[c]	56.9[bc]
Ruminal Environment					
pH	5.97	5.83	5.94	5.92	5.86
Ammonia N (mg/dl)	7.60	7.81	9.45	8.36	10.02
Duodenal N Appearance					
Feed N (g/d)	33.1[a]	46.1[b]	51.0[b]	62.6[c]	49.0[b]
Total Feed N (%)	64.6[a]	52.4[b]	48.0[bc]	39.7[c]	49.8[bc]
Feed N Escape	49.6[a]	65.9[b]	71.6[bc]	81.0[c]	69.0[bc]
Microbial Efficiency					
g MCP/kg OMF	16.6	18.0	22.0	21.2	23.0
Ileal N Appearance					
NAN (g/d)	32.6[a]	34.8[ab]	35.7[ab]	45.1[c]	40.3[bc]
NAN Digestibility					
% intake	65.1[a]	64.1[ab]	63.4[ab]	56.6[c]	59.0[bc]
% total tract	102.9	105.6	105.3	103.2	103.9
NAN Disappearance in the Small Intestine					
g/d	63.3	65.6	70.2	71.0	64.7
% entry	65.9	64.3	66.1	61.1	61.4
% intake	67.5	67.0	68.3	71.5	66.1
% total	106.7	110.2	119.5	125.4	118.2

[abc] Means in the same row with different superscripts differ (P<.05).

different (P>.05) from hetero-yellow (71.6%) or yellow (69.0%). Hetero-yellow and yellow feed N escape was not different (P>.05) from red. Escape of low quality grain protein to the small intestine may not be beneficial to animal performance. Sorghum grain protein escape of ruminal digestion has been proposed as a factor limiting post ruminal starch digestion and animal performance. Therefore, cream may have some ruminal advantage when compared to other sorghum hybrids. True microbial efficiency (g microbial crude protein/kg organic matter truly fermented) was not different between grain sources and averaged 20.3.

The amount (g/d) of NAN appearing at the ileum was least for corn (32.6 g/d) and greatest for red (45.1 g/d). Corn had less (P<.05) NAN appearing at the ileum than yellow (40.3 g/d) or red. Cream (34.8 g/d) and hetero-yellow (35.7%) ileal NAN appearance was greater than (P<.05) red, but not different from (P>.05) corn or yellow. Differences in grams NAN appearing at the ileum translated into identical difference in digestibility through the ileum. Corn (65.1%) had a greater (P<.05) NAN digestibility through the ileum than red (56.6%) and yellow (59.0%), but not different from (P>.05) cream (64.1%) and hetero-yellow (63.4%). Red was less than (P<.05) cream and hetero-yellow, but not different (P>.05) from yellow. Ileal NAN digestibility as a percent of total digestion was not different (P>.05) between diets and averaged 104.2%. Ileal NAN digestibility greater than 100% indicates microbial fermentation in the large intestine and excretion of microbial N in the feces.

Non ammonia N disappearance in the small intestine did not differ (P>.05) between grain sources. The average NAN disappearance was 67.0 g/d. Disappearance of NAN as a percent of NAN entry into the small intestine averaged 63.8 across all diets. NAN disappearance (% entry) appeared to be greater for hetero-yellow (66.1%), corn (65.9%), and cream (64.3%) than red (61.1%) and yellow (61.4%). Disappearance of NAN expressed as a percent of N intake did not differ (P>.05) between diets and averaged 68.1%. Disappearance of NAN in the small intestine expressed as a percent of total NAN disappearance did not differ (P>.05) between treatments and averaged 116.0%. Disappearance as a percent of total digestion suggests that all NAN absorption occurred in the small intestine in this experiment.

The rumen appears to be the major site resulting in differences between true digestibility of corn and sorghum hybrid N. Hybrids similar to the cream and hetero-yellow were close to the N digestibility of corn in the total tract and through the rumen and ileum. Equal NAN digestibility through the ileum and in the small intestine, combined with unequal ruminal escape of feed protein, suggests that the quality of protein absorbed from the small intestine may not be equal among treatments. Protein solubility and particle size differences may be the cause of differences between sorghum grain hybrids and corn. The pure yellow sorghum grain hybrid tested does not appear to be equal to corn with regard to N digestibility. Moreover, yellow did not have the greatest N digestibility in the rumen or total tract of the sorghum hybrids tested.

Literature Cited

Streeter, M.N., D.G. Wagner, C.A. Hibberd, F.N. Owens and D.S. Buchanan. 1988. Comparison of the site and extent of organic matter digestion between corn and four divergent sorghum grain hybrids. Okla. Agric. Exp. Sta. Res. Rep. MP-125-175.

PROCESSED GRAINS: DISAPPEARANCE OF DRY MATTER AND STARCH FROM MOBILE DACRON BAGS

Hector Anzola[1], Beth Doran[1] and F.N. Owens[2]

Story in Brief

Site and extent of disappearance of dry matter and starch from 14 different combinations of grains and processing methods were measured using calves equipped with ruminal and intestinal cannulas and ileo-rectal anastomoses. Digestion in the rumen was estimated from disappearance after 15 h of incubation. For postruminal digestion, bags were incubated for 3 h in pepsin-HCl, inserted into the duodenal cannula and recovered when defecated. Rolling whole corn or oats increased disappearance of dry matter and starch both in the rumen and in the small intestine. Compared with rolled grain, steam flaked grain had greater disappearance of DM in the rumen for corn and milo grains. Ruminal starch disappearance was increased by flaking each of the grains. Ensiling rolled corn, especially at 35% moisture, increased disappearance of dry matter and starch in the rumen and in the intestines. As corn and milo were more extensively processed, intestinal supply of digestible starch tended to increase. Changes in site of starch digestion with processing of wheat, barley and oats were minor as compared with corn and milo.

(Key Words: Mobile Dacron Bag, Starch Digestion, Grains, Processing, Ruminal Bypass.)

Introduction

Starch digestion in the rumen and intestines for various grains was reviewed recently (Owens et al., 1986). Corn and milo grains are processed routinely to increase total tract digestion of starch. Effects of various methods of processing of cereals remain poorly defined regarding quantitative changes in ruminal escape and in small intestinal digestion of escape starch.

The objective of this experiment was to determine the impact of grain source and grain processing on the extent of disappearance of dry matter and starch in the rumen and the small intestine of calves.

Materials and Methods

Experimental methods for measuring ruminal and intestinal disappearance of dry matter and starch are described in a companion paper (Anzola et al., 1988). In addition, feed samples and bags containing residues were subjected to dry matter and starch analyses.

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Results and Discussion

Dry matter disappearance at various sites of the digestive tract for the 14 feeds are presented in table 1. Processing drastically increased ruminal and total tract disappearance of dry matter. Ruminal, total tract and postruminal DM disappearance of whole corn and whole oats were very low; digestion at each site was increased ($P<.05$) by dry rolling. Compared to rolling of the grain, steam flaking increased ($P<.05$) ruminal digestibility for corn and milo but not for wheat or barley. Steam flaking also increased ($P<.05$) intestinal disappearance of DM from corn, milo and wheat but not for barley. Ensiling rolled corn to form the high moisture corn tended to increase ruminal, intestinal and total tract disappearance of DM. Though ruminal and total tract disappearance were changed less by fermentation than by steam flaking, amounts of dietary DM disappearing in the small intestine from these two processing methods were virtually identical.

Total tract dry matter disappearance in pigs of ground barley from mobile nylon bags was studied by Sauer et al. (1984). Their values exceeded ours, probably due to the fine grinding which they used plus fermentation in the large intestine of their pigs which was avoided by our anastamoses. Fine grinding usually increases extent of disappearance in the rumen and the small intestine.

Table 1. Effect of processing grains on dry matter disappearance from mobile dacron bags.

	Mobile bag disappearance of protein			
Feedstuffs	Ruminal (15 h) %	Total tract %	Small intestine by difference %	Small intestine % of supply
Corn				
Whole shelled	3.8^{g}	4.8^{g}	1.0^{g}	1.0
Dry rolled	19.1^{ef}	46.1^{e}	27.0^{e}	33.4
25% moisture	19.4^{ef}	56.7^{d}	37.3^{cd}	46.3
35% moisture	27.2^{cd}	66.3^{c}	39.1^{cd}	53.7
Steam flaked	49.1^{a}	86.5^{a}	37.4^{cd}	73.5
Milo				
Dry rolled	16.9^{ef}	49.5^{e}	29.0^{e}	34.9
Steam flaked	33.8^{bc}	82.0^{ab}	48.2^{b}	74.3
Oats				
Whole	$.1^{g}$	4.1^{g}	4.0^{g}	4.0
Dry rolled	15.2^{f}	30.4^{f}	15.2^{f}	17.9
Wheat				
Dry rolled	46.1^{a}	79.9^{b}	33.8^{ed}	62.7
Steam flaked	27.3^{cd}	86.5^{a}	59.2^{a}	81.4
Barley				
Dry rolled	23.3^{cd}	67.9^{c}	44.6^{bc}	58.1
Steam rolled	22.7^{cd}	68.3^{c}	45.6^{bc}	59.0
Diet	35.0^{b}	68.4^{c}	33.4^{de}	51.4
SE[h]	2.0	2.0	3.0	

[abcdefg]Means with similar superscripts in a column do not differ ($P<.05$).
[h]Standard error of the means.

Rolling of whole corn or oats increased (P<.05) extent of starch disappearance in the rumen, small intestine and total tract (table 2). Compared to rolling the grain, steam processing increased (P<.05) starch disappearance from the rumen, small intestine and total tract for all four grains tested (corn, milo, wheat, barley). However, extent of starch digestion in the rumen was not changed by ensiling of rolled corn at 25% moisture; ensiling at 35% moisture increased extent of ruminal and total tract starch disappearance (P<.05) and tended to increase intestinal disappearance of starch. Ruminal starch disappearance at 15 h ranked these 13 combinations of grains and processing methods corn as: 1) steam flaked corn, 2) steam flaked wheat, 3) steam flaked milo, 4) rolled oats, 5) rolled wheat, 6) steam rolled barley and 7) high moisture corn (35%). These rankings are reasonably similar to their ranking in acidosis potential (Britton and Stock, 1986) except that ruminal starch disappearance of high moisture grain was considerably lower than expected. Perhaps a digestion time shorter than 15 h would more accurately predict acidosis potential. Alternatively, higher moisture feeds may increase acidosis by reducing the time which ruminants spend chewing and salivating.

The quantity of starch disappearing in the small intestine (% of supply) within each grain increased as particle size was reduced except for steam flaking of corn. Across feedstuffs, particle size was poorly

Table 2. Effect of processing grains on starch disappearance from mobile dacron bags.

	Mobile bag disappearance of protein			
Feedstuff	Ruminal (15 h) %	Total tract %	Small intestine by difference %	Small intestine % of supply
Corn				
Whole shelled	0.0^{h}	7.4^{g}	7.4^{b}	7.4
Dry rolled	9.4^{f}	20.4^{f}	11.0^{b}	12.1
25% moisture	4.0^{h}	11.6^{g}	7.6^{b}	7.9
35% moisture	21.7^{e}	56.3^{a}	34.6^{b}	44.2
Steam flaked	49.4^{b}	82.5^{a}	33.1^{b}	65.4
Milo				
Dry rolled	3.5^{h}	15.0^{f}	11.5^{b}	11.9
Steam flaked	36.5^{d}	56.9^{b}	20.4^{b}	32.1
Oats				
Whole	18.8^{f}	21.2^{f}	2.4^{c}	3.0
Dry rolled	26.4^{e}	31.6^{e}	5.2^{c}	7.1
Wheat				
Dry rolled	24.7^{e}	56.6^{b}	31.9^{b}	42.4
Steam flaked	44.3^{c}	87.6^{a}	43.3^{a}	77.7
Barley				
Dry rolled	17.1^{f}	38.8^{d}	21.7^{b}	26.2
Steam rolled	21.8^{e}	47.4^{c}	25.6^{b}	32.7
Diet	82.6^{a}	95.0^{a}	12.4^{b}	71.3
SE[i]	8.5	4.6	10.5	

[abcdefgh]Means with similar superscripts in a column do not differ (P<.05).

[i]Standard error of the means.

related to intestinal starch digestion. Intestinal starch digestion was quite low for rolled oats (2096 um) and for several forms of corn (2329-4758 um) and rolled milo (1482 um), intermediate for barley (2418-2644 um) and flaked milo (1333 um) and highest for wheat (1865-2245 um) and processed corn (2430-3388 um; see table 1 of Anzola et al., 1988 for particle sizes). This ranking probably reflects differences in starch structure or accessibility among these grains and quite closely parallels expected rates of gain of feedlot cattle fed these grains.

Processing to increase the surface area of the cereal for contact with the ruminal microbes and enzymes presumably is responsible for the extensive disappearance of starch from steam flaked corn and milo. The higher the amount of corneus endosperm (corn, milo) the greater the response to starch gelatinization and fine grinding.

In summary, rolling whole grains increased disappearance of dry matter and starch both in the rumen and in the small intestine. Steam flaking further increased disappearance of DM and starch in the rumen for corn and milo grains. Ruminal starch disappearance was increased by flaking each of the grains. Ensiling rolled corn, especially at 35% moisture, increased disappearance of dry matter and starch in the rumen and in the intestines. Changes in site of digestion starch digestion with processing of wheat, barley and oats were minor as compared with corn and milo. Supply of starch disappearing from the small intestine ranked the grains as: Low: rolled oats, whole, rolled or 25% moisture corn, rolled milo; Intermediate: barley and flaked milo; Highest: wheat and steam flaked or 35% high moisture corn grain. Within grains, particle size appeared to limit starch digestion though effects of and need for processing of wheat and barley were limited. Though the mobile dacron bag procedure shows promise for evaluating site of digestion, further verification with in vivo measurements is needed. Of primary concern are appropriate ruminal incubation times and particle size of feedstuffs. Effects of chewing and rumination on the grain particles are avoided by using mobile dacron bags; this may explain why disappearance values are much lower than in vivo estimates of intestinal and total tract digestion (Owens et al., 1986) even though rankings of grains and effects of processing appear realistic.

Literature Cited

Anzola, H. et al. 1988. Processed grains: Disappearance of protein from mobile dacron bags. Okla. State Agr. Exp. Sta. Res. Rep. MP-125:189.

Britton, R.A. and R.A. Stock. 1986. Acidosis, rate of starch digestion and intake. Feed Intake Conference Proceedings. Okla. Agr. Exp. Sta. MP-121:125.

Owens, F.N. et al. 1986. Limits to starch digestion in the ruminant small intestine. J. Anim. Sci. 63:1634.

Sauer, W.C. et al. 1984. The mobile nylon bag technique for determining dry matter and digestibility energy in barley for pigs. J. Anim. Sci. 59(Suppl 1):272.

PROCESSED GRAINS: DISAPPEARANCE OF PROTEIN FROM MOBILE DACRON BAGS

Hector Anzola[1], Beth Doran[1] and F.N. Owens[2]

Story in Brief

Site and extent of disappearance of crude protein from 14 different combinations of grains and processing methods were measured using calves equipped with ruminal and intestinal cannulas and ileo-rectal anastomoses. As an estimate of digestion in the rumen, disappearance after 15 h of incubation was measured. For postruminal digestion, bags were incubated for 3 h in pepsin-HCl, inserted into the duodenal cannula and recovered when defecated. Rolling whole corn or oats increased ruminal and postruminal protein digestion. Further processing (high moisture or steam flaking) increased ruminal and total tract digestion of protein from corn, milo and oats but had little effect on wheat or barley grain. Small intestinal digestion of protein escaping from the rumen was increased by processing of the grain except for wheat grain. But the total quantity of protein disappearing from the small intestine decreased with more extensive processing of the grain because of increased ruminal digestion. Effects of steam flaking on site of digestion were minor for wheat and barley grains. Ensiling rolled corn, especially at 35% moisture, more than doubled crude protein disappearance in the rumen.

(Key Words: Mobile Dacron Bag, Protein Digestion, Grains, Processing, Ruminal Bypass.)

Introduction

Values for extent of protein digestion in the rumen and intestines for various grains are rare. In the NRC (1985) publication only three estimates of ruminal escape protein are provided: barley (21%), corn (65%) and sorghum (52%). Commercial grain processing procedures, commonly used to increase total tract digestion of starch, will alter ruminal escape of cereal grain protein (Aguirre et al., 1984). The magnitude and even the direction of change can vary with the method of processing. Effects of various methods of processing of cereals on ruminal escape and small intestinal digestion of protein need to be tested.

The mobile dacron bag technique has been used in pigs to measure digestibilities of various protein sources and cereals (Sauer et al., 1983) and in ruminants to test ruminal and postruminal degradation of several protein sources (de Boer et al., 1987; Nalsen et al., 1987). Although these reports provide information on disappearance of DM and crude protein, information on the effect of grain processing on protein disappearance is not available.

The objective of this experiment was to determine the impact of grain source and processing on the extent of disappearance of protein in the rumen and the small intestine of calves.

[1]Graduate Assistant [2]Regents Professor

Materials and Methods

Two Holstein calves (330 lb) were fitted with duodenal cannulas and also with anastomoses between the distal ileum and the distal rectum so that digesta from the small intestine would bypass the large intestine and flow directly from the small intestine to the rectum for defecation. The calves were housed in individual pens and had free access to water. Calves were fed a concentrate diet composed of 20.1% dry rolled corn, 20% chopped prairie hay, 19.8% dry rolled sorghum, 13.8% soybean meal, 12.6% dehydrated alfalfa hay crumbles, 5.9% molasses, 5.9% dry ground wheat, .9% dicalcium phosphate and 1% salt plus a trace mineral supplement. Animals were adjusted to their diets for a minimum of 14 days prior to being used in experiments and were fed 2.5% (dry matter basis, DM) of body weight daily in two equal feedings at 0800 and 1600 hours.

Protein disappearance was measured at two different sites. Ruminal disappearance consisted of ruminal incubation for 15 hours. Total tract disappearance consisted of ruminal incubation plus a 3 h pepsin-HCl digestion followed by insertion into the duodenum and recovery from feces. Extent of digestion in the small intestine was calculated as total tract minus ruminal disappearance because the ileo-rectal anastamosis forced bags physically to bypass the large intestine. To calculate digestion as a percent of input or duodenal flow, extent of digestion was divided by ruminal escape.

The mobile dacron bags (3.5 by 5.5 cm) were constructed of dacron cloth with a mesh size of 60 to 70 microns. Approximately 2.0 g of each feedstuff were placed in each bag; bags were sewn shut. Corners of bags were rounded to reduce abrasion of the intestine.

Fourteen different unground feedstuffs were employed. They consisted of dry rolled, whole shelled, steam flaked and high moisture corn, with the latter at both 25 and 35% moisture levels; dry rolled and steam flaked milo; whole and dry rolled oats; dry rolled and steam flaked wheat; dry rolled and steam rolled barley. Table 1 presents the chemical composition and the particle sizes of these feedstuffs. The same batch of grain was processed to produce each of the processed forms by a number of feedlots and feed companies.

Twelve bags containing each of the 14 feedstuffs were inserted into nylon stockings and incubated for 15 h in the rumen of an 850 lb cannulated beef steer fed the diet described above. Upon removal from the rumen, four bags of each feedstuff were washed thoroughly, dried and analyzed. The other eight bags of each feed were incubated for 3 h in a pepsin-HCl solution. After pepsin digestion, each bag was inserted into the small intestine via the duodenal cannula at a rate of one bag each 30 min. Upon defecation, the dacron bags were collected, rinsed under cold running tap water until the wash water was clear and dried in a forced air oven at 90 C for 24 h.

Feed samples and bags containing residues were subjected to dry matter and Kjeldahl nitrogen analyses. Blank bags containing a known weight of sliced Tygon tubing were used to correct for influx of non-adherent nitrogen. Bags plus residue contents were weighed and digested intact for Kjeldahl nitrogen analysis.

To detect specific effects of processing method, a total of 72 contrasts were drawn: whole vs rolled, corn vs oats and their interaction; steam flaked vs rolled, comparison of all grains, and their interaction; high moisture vs rolled corn and high moisture (35%) vs lower moisture (25%) corn.

Table 1. Chemical composition of processed cereal grains.

Feedstuff	Dry matter %	Crude protein %	Starch %	Particle size diameter um	SD[a] um
Corn					
Whole shelled	88.8	9.9	49.5	4758	1006
Dry rolled	88.4	10.3	65.3	2785	823
25% moisture	75.0	10.1	53.7	2329	716
35% moisture	65.0	10.2	82.1	2430	737
Steam flaked	83.8	9.9	53.5	3388	1007
Milo					
Dry rolled	87.0	10.8	55.3	1482	472
Steam flaked	85.0	11.1	50.7	1333	444
Oats					
Whole	91.8	13.3	29.0	2438	655
Dry rolled	91.5	12.0	31.7	2096	639
Wheat					
Dry rolled	89.7	15.7	42.7	1865	576
Steam flaked	88.1	15.9	44.9	2245	682
Barley					
Dry rolled	88.7	14.1	39.2	2418	722
Steam rolled	88.2	15.0	40.6	2644	780
Diet	91.4	19.0	36.5	1922	624

[a]Standard deviation in particle size.

Results and Discussion

Because washing should remove endogenous secretions and a portion of the bacteria in the bags, disappearance estimates by this procedure should more closely approximate true than apparent digestibility of dry matter and crude protein and would be expected to exceed apparent digestion values. As cattle were equipped with anastomoses to bypass the large intestine, disappearance values from this study do not include additional fermentation losses which would occur in the large intestine and cecum.

Rolling of whole corn or oats greatly increased ($P<.05$) protein disappearance, both in the rumen (38 vs 4%; 52 vs 2%) and the total tract (60 vs 4%; 61 vs 3%; table 2). Rolling of either corn or oats also increased ($P<.05$) both the fractional and the total disappearance of protein from the small intestine. Intestinal disappearance of crude protein was very low compared to the theoretical true protein digestibility of most protein sources (90%; NRC, 1976) or the mean intestinal digestibility of escape protein of 66% (NRC, 1985). Only with thoroughly processed grains were these values attained. Except for wheat and 25% moisture corn, more extensive processing and smaller particle size increased fractional protein disappearance in the small intestine. This is the first time that processing effects on postruminal protein disappearance has been quantitated directly. Perhaps previous estimates of true total digestibility by regression are in error due to underestimation of microbial protein digestion or that the large particle size of the grain and lack of mastication severely limited intestinal protein digestion from the bags.

Table 2. Effect of processing grains on protein disappearance from mobile dacron bags.

	Mobile bag disappearance of protein			
Feedstuff	Ruminal (15 h) %	Total tract %	Small intestine by difference %	% of supply
Corn				
Whole shelled	3.5[f]	3.8[g]	.3[e]	.3
Dry rolled	38.3[d]	60.0[ef]	21.7[bcd]	35.1
25% moisture	72.2[b]	74.4[c]	2.2[e]	7.9
35% moisture	90.4[a]	100.0[a]	9.6[de]	100.0
Steam flaked	99.0[a]	100.0[a]	1.0[e]	100.0
Milo				
Dry rolled	60.4[c]	75.8[c]	15.4[cde]	38.9
Steam flaked	97.9[a]	100.0[a]	2.1[e]	100.0
Oats				
Whole	2.5[f]	2.6[g]	.1[e]	.1
Dry rolled	51.5[c]	61.3[ef]	9.8[de]	20.2
Wheat				
Dry rolled	55.6[c]	89.8[b]	34.2[ab]	77.0
Steam flaked	55.6[c]	76.8[c]	21.2[bcd]	47.7
Barley				
Dry rolled	57.2[c]	72.8[cd]	15.6[cde]	36.4
Steam rolled	52.6[c]	77.9[c]	25.3[bc]	53.4
Diet	22.4[e]	68.5[cde]	46.1[a]	59.4
SE[g]	3.2	3.1	4.6	

[abcdef]Means with similar superscripts in a column do not differ ($P<.05$).

[g]Standard error of the means.

For crude protein, differences ($P<.05$) between methods of processing grains were found for whole vs rolled grains, steam flaked vs rolled, high moisture vs dry rolled corn and 25% vs 35% high moisture corn in total tract disappearance. Steam flaked and rolled grains differed ($P<.02$) in ruminal and intestinal disappearance of crude protein.

As compared with dry rolled grain, steam flaking greatly increased ruminal, intestinal (as a fraction of supply) and total tract disappearance of protein from corn and milo grains. With these grains, total tract disappearance was virtually complete. The amount of protein reaching the small intestine from the grain, however, was reduced by flaking. This contrasts with the suggestion of Hinman and Johnson (1974) that flaking denatures milo protein and increases ruminal escape. They attributed an increased post-ruminal protein flow to the grain alone and may not have accounted fully for increased microbial protein synthesis associated with flaking of milo. Flaking or steam rolling of wheat and barley had little impact beyond dry rolling on site or extent of protein disappearance from these grains.

Published information on the effects of grain source and grain processing on site and extent of digestion is limited. Total tract apparent digestibility of nitrogen from whole and dry rolled corn was reported by Aguirre et al. (1984) to be 69.4 and 70.9%, respectively, compared with bag losses of only 4 and 60% for these corn forms in our anastomosed steers (table 2). Differences are presumably due to particle size and animal preparation. Hvelplund (1985) indicated that recovery of the bags from the ileum gave 6% lower estimates for protein digestion than recovery of bags from the feces.

Four ground cereals (rye, triticale, wheat and barley) were tested in pigs using mobile dacron bags by Graham et al. (1985). Crude protein disappearance from all four grains exceeded 94%. Only steam flaked corn and milo attained degradations that high in our trial, but again, particle size reduction will increase protein exposure and digestion.

Increases in the surface area of the cereal for contact with the ruminal microbes and enzymes presumably is responsible for the extensive disappearance of crude protein from steam flaked corn and milo. The higher the amount of corneus endosperm (corn, milo) the greater the response in protein disappearance to starch gelatinization and fine grinding.

In summary, moderate processing by rolling whole corn or oats increased ruminal and postruminal protein digestion whereas further processing (high moisture or steam flaking) increased ruminal and total tract digestion of protein from corn, milo and oats but had little effect on wheat or barley grain. Generally, processing increased small intestinal digestion of protein escaping from the rumen, but the total quantity of protein disappearing from the small intestine was decreased by extensive grain processing. Effects of steam flaking on site of digestion were most drastic with corn and milo grains. Although the mobile bag shows promise for evaluating protein escape and intestinal protein digestion, effects of grain particle size on digestibility, both from bags and in vivo, deserves further scrutiny.

Literature Cited

Aguirre, E.O. et al. 1984. Corn grain processing and site of digestion by heifers. Okla. Agr. Exp. Sta. Res. Rep. MP-116:190.

de Boer, G. et al. 1987. Mobile nylon bag for estimating intestinal availability of rumen undegradable protein. J. Dairy Sci. 70:977.

Graham, H. et al. 1985. Use of a nylon bag technique for pig feed digestibility studies. Brit. J. Nutr. 54:719.

Hinman, D.D. and R.R. Johnson. 1974. Influence of processing methods on digestion of sorghum starch in high concentrate beef cattle rations. J. Anim. Sci. 39:417.

Hvelplund, T. 1985. Digestibility of rumen microbial protein and undegraded dietary protein estimated in the small intestine of sheep and by the in sacco procedure. Acta. Agric. Scand. (Suppl. 5):132-144.

Nalsen, T. et al. 1987. Determination of protein degradation in the rumen and intestine of heifers using a dacron bag technique. Okla. State Agr. Exp. Sta. Res. Rep. MP-119:153.

National Research Council. 1976. Nutrient Requirements of Beef Cattle. 5th Ed. National Academy Press. Washington, DC.

National Research Council. 1985. Ruminant Nitrogen Usage. National Academy Press. Washington, DC.

Sauer, W.C. et al. 1983. A modified nylon bag technique for determining apparent digestibilities of protein in feedstuffs for pigs. Can. J. Anim. Sci. 63:233.

YTTERBIUM LABELING OF GRAIN: EFFECT OF GRAIN PROCESSING, PARTICLE SIZE AND EXTRACTION METHOD

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Story in Brief

Five types of grain (corn, wheat, milo, barley and oats) subjected to one of six processing methods [high moisture ensiling (25% and 35% dry matter), steam flaking, whole, rolling or steam rolling] were labeled with ytterbium. Ytterbium content was analyzed following either extraction by EDTA or ashing. Ytterbium concentrations determined after ashing were an average of 21% higher (5.88 vs 4.84 mg/g DM) and more repeatable (SE = .28 and .53) than after EDTA extraction. Form of grain processing and particle size affected both the amount of feed recovered after labeling and washing (whole > rolled > steam flaked) and the quantity of ytterbium bound (steam flaked and steam rolled > rolled > whole). Differences in grain recovery and extent of labeling with ytterbium are related partially to differences in the particle size.

(Key Words: Ytterbium Extraction, Grain Processing, Particle Size.)

Introduction

Rare earth elements, such as ytterbium (Yb) have an affinity for plant cell walls and once attached can be used to study the rate of passage of particulate digesta in ruminants (Hart and Polan, 1984). However, the binding affinity or capacity of particulate matter for Yb varies with the type of feed indicating that (1) the functional groups that bind Yb vary with the feedstuff, (2) the molecular environment of functional groups varies with the feedstuff or (3) some types of particulate matter form multiple bonds with Yb (Teeter et al., 1984). With the immersion-washing procedure, feed composition is modified somewhat by the removal of soluble components.

Daily intakes of .8 g Yb per steer are recommended (Karimi et al., 1987) to achieve 2 ppm in the final fecal extract for analysis by atomic absorption. Although information concerning binding capacities of various roughages have been published (Teeter et al., 1984), values of the Yb binding capacities of grains and the percentage of grain lost during the immersion-washing procedure are lacking.

Two methods for preparation of samples for Yb analysis have been proposed. One method (Ellis et al., 1982) is quite time consuming, involving ashing a dry sample and extraction of Yb from the ash with acid. A second method (Hart and Polan, 1984) is rapid, consisting simply of extracting Yb with an EDTA solution. These two methods also vary in the size of the sample employed, with the ash method using 1 to 2 grams of sample compared with only .2 g with the EDTA extraction. The smaller the sample size, the greater the error in representative sampling.

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Yb concentrations in feed also may differ depending on the extraction method employed. Higher values have been suggested with the ashing procedure. However, Karimi et al. (1987) noted no reduction in the reliability of measurement with the EDTA extraction.

The objectives of our research were: 1) to determine the relationship between the method of grain processing and the binding capacity for Yb, 2) to investigate the effect of grain processing method on recovery of Yb-labeled product and 3) to compare results from these two methods for Yb extraction.

Materials and Methods

Five types of grain (corn, wheat, milo, barley and oats) subjected to one of six processing methods [high moisture ensiled (25% and 35% dry matter), steam flaked, whole, rolled or steam rolled] were treated with Yb to study passage rate. Grains were processed commercially from a single batch of each grain. Two and one-half grams of $YbCl_3 \cdot 3H_2O$ were dissolved in one liter of distilled water, poured onto 50 grams of air dry feedstuff and allowed to soak for 48 hours, during which time the mixture was stirred three to four times each day (Galyean, 1984). The grain solution then was filtered through a 250 micron screen and washed six times with distilled water over a six hour period. The labeled grain was dried at 60 C. Percentage recovery of the grain was expressed as final dried weight of the grain after the immersion-washing procedure divided by the initial as-fed weight of the grain before labeling with Yb.

The grains were characterized before immersion by dry sieving through a series of screen sizes (8mm, 4mm, 2mm, 1mm, 500 microns, 250 microns and 125 microns) to attain a particle size distribution (table 1).

Yb was extracted from samples of each batch of labeled grain by the EDTA extraction of Hart and Polan (1984) and by ashing plus acid extraction (Ellis et al., 1982). Yb concentrations of the extracts were

Table 1. Particle size distribution of processed grains.

	Size of sieve openings							
Grain and form	8mm	4mm	2mm	1mm	500um	250um	125um	Pan
	---- Percentage of grain remaining on screen ----							
Steam flaked corn	28.9	38.5	18.8	7.9	3.6	1.6	.2	.7
Whole shelled corn	25.8	73.4	.8	--	--	--	--	--
Rolled corn	3.2	49.4	40.6	6.0	.4	.2	.2	--
25% High moisture corn	4.6	37.4	39.9	11.3	4.8	1.1	.2	.9
35% High moisture corn	5.0	36.2	42.8	13.0	2.2	.3	--	.6
Rolled wheat	--	6.3	79.0	13.5	.8	.1	.3	.1
Steam flaked wheat	--	31.5	55.0	11.8	.9	.2	.2	.4
Rolled milo	--	--	57.6	41.7	.6	--	.1	.1
Steam flaked milo	--	9.7	43.7	30.0	10.1	4.8	.7	1.1
Rolled barley	--	30.3	67.0	2.6	.1	--	--	--
Steam rolled barley	--	40.8	58.8	.3	--	--	--	--
Rolled oats	--	16.0	77.2	4.6	1.1	.4	.4	.4
Whole oats	--	14.9	82.2	2.7	.1	--	--	--

measured by atomic absorption spectrophotometry using a nitrous oxide flame. To determine potential differences in Yb binding, statistical analysis of the data involved a one way classification of each labeled grain with replication within grain serving as the error term. Differences between methods of processing within grain and amount of Yb bound were estimated. Simple linear regression was used to compare the two methods of Yb extraction.

Results and Discussion

Mean ytterbium concentrations for the 13 feeds are reported for the EDTA and ashed extraction methods (table 2). Ytterbium concentrations were greater for 12 of the 13 feeds tested by acid extraction of ash than by the EDTA extraction method. Averaged across feeds, the ash extraction procedure proved more repeatable than the EDTA extraction method (SE = .28 and .53, respectively). These variations might be due to the fact that the zero solutions and standards were not prepared using an identical matrix as the samples; this could alter the analytical estimates of Yb concentrations in the samples. Hart and Polan (1984) and Karimi et al. (1987) reported previously that extraction with a chelate (EDTA) simplified analysis of digesta samples without reducing the reliability of the measurement. In our study, the correlation between the two methods was high (r^2=.83; P<.0001) but EDTA extraction tended to underpredict the Yb concentration. This difference may be important when choosing an extraction method for samples having low Yb concentrations.

The intercept and slope of the regression between the two extraction methods were estimated to be 1.47 mg/g DM and .91, respectively (SE = .68 and .12; P<.05 and <.0001). The non-zero intercept indicates that passage rates estimated by the regression of the natural logs of

Table 2. Ytterbium concentrations of feeds.

	Yb concentration (mg/g DM)			
Feed	EDTA extraction	SE	Ashed extraction	SE
Steam flaked corn	4.88	.66	6.16	.07
Whole shelled corn	1.20	.06	1.53	.00
Rolled corn	3.40	.07	4.52	.46
25% High moisture corn	2.23	.13	3.26	.11
35% High moisture corn	2.52	.13	3.19	.11
Rolled wheat	5.18	.51	5.72	.72
Steam flaked wheat	11.59	1.21	10.35	.02
Rolled milo	5.64	1.06	5.92	.00
Steam flaked milo	6.45	.38	7.13	.21
Rolled barley	5.93	.40	9.05	.12
Steam rolled barley	6.85	.25	9.88	.35
Rolled oats	4.51	.06	5.77	.28
Whole oats	2.60	.07	3.94	.00
Average of all feeds	4.84	.53	5.88	.28

the Yb concentration will not be equal. Hence, passage rates determined by the EDTA extraction method will not be the same as with the ash-acid extraction method. If the regression intercept is not zero, even though the feed/digesta extraction ratios are similar, extrapolation to zero time will give different estimates of rumen fill, with the EDTA extraction method predicting smaller rumen volumes.

The dry matter content of the labeled feeds and the percentage feed recovered following immersion-washing varied among the feeds tested (table 3). Form of processing affected the amount of feed recovered, with whole > rolled > steam flaked. This trend can be related primarily to differences in particle size. However, the type of feed and solubility of its components were important. Additional amounts of high moisture corn and rolled wheat had to be labeled because of loss of very small particles and(or) soluble components.

Particle size also affected the amount of Yb bound to the feed. Rolling of oats and corn both increased ($P<.0001$) the amount of Yb bound compared to the whole forms of either grain. Teeter et al. (1979; 1984) also reported that binding capacities were greater for rolled than for whole milo and corn. Steam flaking of corn, milo and wheat further increased ($P<.001$) Yb binding (1.65, 1.21 and 4.63 mg/g DM) as compared with rolled forms of these grains. Steam rolled barley bound more ($P<.01$) Yb/g DM than dry rolled barley. Hence, binding of Yb tended to be related to the method of processing with steam rolled and steam flaked > dry rolled > whole. Differences in the amounts of Yb bound can be related to differences in the amounts of surface exposed for Yb binding.

Solubility of feed components also may be important in the binding capacity of the grain. Dry rolled corn bound greater ($P<.001$) concentrations of Yb than high moisture corn. The decreased binding of Yb with high moisture corn may be due to higher solubility of the starch in the ensiled product. However, differences in binding between the 25% and 35% high moisture corn were small ($P>.05$).

Differences in the amounts of grain recovered and labeled with Yb may be related to differences in particle size, although particle size alone cannot account for all the variability. Ellis et al. (1982)

Table 3. Dry matter and percentage feed recovered.

Feed	Dry matter of feed recovered	Percentage recovered[a]
Steam flaked corn	84.74	72.38
Whole shelled corn	90.85	97.50
Rolled corn	90.36	86.04
Rolled wheat	89.75	53.74
Steam flaked wheat	88.39	76.18
Rolled milo	97.36	83.59
Steam flaked milo	94.10	64.23
Rolled barley	95.29	72.65
Steam rolled barley	95.34	84.72
Rolled oats	96.34	80.11
Whole oats	95.84	90.13

[a]Percentage grain recovered was expressed as weight of dried grain after the immersion-washing procedure divided by the initial weight of the grain before labeling.

noted that feeds higher in fiber tended to have greater binding capacities. Starch, in contrast, has a low binding capacity suggesting that groups other than those presented by polyglucans are involved. Certain processing methods, such as ensiling and heat treatment, may alter the chemical and physical composition and solubility of components (e.g., starch, protein) which in turn will influence binding and recovery. Intracellular components of feedstuffs, such as protein and nucleic acids may physically bind Yb, but the opportunity for exposure would be much lower than for surface structures. Nevertheless, their exposure for binding should increase with processing.

Variations among grains and forms of grain both in extent of labeling and in recovery following immersion-washing are disconcerting. First, they indicate that labeled feed will differ from unlabeled feed in physical and possibly chemical properties and subsequently in ruminal kinetics (e.g., ruminal distribution, wetability, flow rate). Whether the depression in digestion rates attributed previously to Yb (Teeter et al., 1984; Mader et al., 1984) is due to altered composition (removal of small particles and soluble components) or to attachment of rare earth to microbial binding sites is uncertain. Because Yb concentrations increase during in situ incubation, reduced microbial attachment is presumed. If this reflects altered wetability and density, altered passage also might be of concern. Difference in total Yb uptake with grain processing indicate that structural components presumably differ in extent of labeling. If true, and if these components differ in extent of ruminal digestion and rates of passage, comparison among grains may prove misleading. One alternative to the immersion-washing procedure would be to dose the rare earth directly into the rumen. Unfortunately, haphazard binding to small particles and solutes (e.g., VFA) drastically complicates interpretation of data obtained by ruminal dosing.

The search for the perfect marker is likely to continue. It remains uncertain whether the ideal particle to mark should be subject to the same fermentation and density and particle size changes in the rumen as untreated feedstuffs or whether, as with mordanted fiber, that the ideal particle should be inert to such changes. Marker migration certainly is reduced by mordanting. But if digestible particles are preferentially retained in the rumen, fermentability of the particle should be retained in order to monitor and understand ruminal kinetics of dietary particles. It is unfortunate that particulate marker procedures are not checked routinely by comparing ruminal fill with duodenal flow. Despite lack of confidence in the precision of marker procedures, observed changes in passage rate due to animal, feed or feeding factors seem to be reliably and repeatably detected. Consequently, one should be less concerned about reliability of observed differences than about extrapolating marker values to in vivo conditions.

Literature Cited

Ellis, W.C. et al. 1982. Solute and particulate flow markers. In: F. N. Owens (Ed.) Protein Requirements for Cattle: Symposium. Oklahoma State University MP-109:37.

Galyean, M. 1984. Techniques and Procedures in Animal Nutrition Research. New Mexico State University, Las Cruces.

Hart, S.P. and C.E. Polan. 1984. Simultaneous extraction and determination of ytterbium and cobalt ethylenediaminetetraacetate complex in feces. J. Dairy Sci. 67:888.

Karimi, A.R. et al. 1987. Simultaneous extraction of Yb, Dy, Co from feces with DCTA, DTPA or EDTA. Oklahoma Agr. Exp. Sta. Res. Rep. MP-119:118.
Mader, T.L. et al. 1984. Comparison of forage labeling techniques for conducting passage rate studies. J. Anim. Sci. 58:208.
Teeter, R.G. et al. 1979. Ytterbium chloride as a ruminal marker. J. Anim. Sci. 49(Suppl. 1):412.
Teeter, R.G. et al. 1984. Ytterbium chloride as a marker for particulate matter in the rumen. J. Anim. Sci. 58:465.

EFFECT OF DIETARY SALT LEVELS ON PERFORMANCE OF FEEDLOT STEERS

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Story in Brief

One hundred nineteen crossbred yearling steers, weighing an average of 784 lb, were used to determine the effect of dietary salt levels (.5, .25 or 0%) on performance of feedlot steers. Dietary salt levels did not statistically alter rate of live gain (3.14, 3.06 and 3.16 lb/day for .5, .25 and 0% salt); carcass adjusted daily gain (3.77, 3.74 and 3.84); feed intake (20.36, 20.16 and 20.26 lb/day); or feed efficiency on either a live (6.50, 6.61 and 6.40) or carcass weight basis (5.41, 5.40 and 5.28). In addition, none of the treatments statistically altered carcass characteristics. The results of this experiment showed no effect of dietary salt concentration on animal performance.

(Key Words: Feedlot Steers, Dietary Salt Level, Lasalocid)

Introduction

Salt levels in feedlot rations typically range from 0 to 1%. Lower concentrations help to reduce accumulation in runoff from feedlots and can reduce the quantity of supplement to pellet. As ionophores exert their action through altering mineral transport, concentrations of minerals (K and Na) might be expected to alter their efficacy. Although no interaction between ionophore source (monensin vs lasalocid) and potassium level (.43 to 1% of diet dry matter) was noted in one feeding trial (Ferrell et al., 1983), mineral levels definitely alter ruminal function (Doran et al., 1986) and water intake and excretion (Ferrell et al., 1982) which may parallel or oppose effects of ionophores. Mineral levels also alter resistance of ruminal microbes to the ionophores (Dawson et al., 1985). For optimal efficacy of ionophores, the optimum or minimum levels of dietary salt need to be determined, but regardless of any mineral-ionophore interaction, the combination which produces maximum animal performance, not maximum ionophore effect should be fed.

Materials and Methods

One hundred nineteen crossbred (primarily British crosses) yearling steers which had been wintered on wheat pasture near Dalhart, Texas were trucked to Goodwell, Oklahoma on June 3, 1987. On arrival, all cattle were weighed individually, ear tagged, implanted with Synovex-S and injected with ivermectin and a BRSV vaccine. The steers were divided into five weight groups of 24 head each (3 pens of 8 steers). Treatments were randomly assigned to pens within each block. The dietary treatments were 0.5%, 0.25% and 0% supplemental salt.

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Table 1. Diet composition, dry matter basis.[a]

Ingredient	Ration Sequence 1	2	3	4[a]
Corn, cracked	52.70	62.28	71.87	80.02
Chopped alfalfa	38.36	28.78	19.19	11.04
Cane molasses	3.88	3.88	3.88	3.88
Pelleted supplement[b]	5.06	5.06	5.06	5.06

[a]To provide 12.25% protein, .53% calcium, .78% potassium, .33% phosphorus, 94.7 mcal NEm/cwt, 61.1 mcal NEg/cwt and .5% salt, .25% salt or 0% salt.
[b]Provided 30 g lasalocid/ton of total feed.

Steers were fed a high concentrate cracked corn ration twice daily (0700 and 1600) for the 95 day trial (Table 1). Chopped alfalfa hay was used to dilute the ration to 60 percent concentrate to start the cattle on feed. Roughage content of the diet was decreased sequentially in three steps until the cattle were on their final ration by 28 days on feed.

Cattle weights were off truck weights (shrunk) at the start of the trial but were taken on full-feed on days 28, 56, 84 and 95.
For calculation purposes, all full weights were reduced by 4% to compensate for digestive tract fill. Steers were trucked to Holcomb, Kansas on day 97 of the trial (September 9, 1987) for slaughter, and carcass data were obtained. This trial was analyzed as a randomized complete block design with five replications per treatment. Statistical comparisons included linear and quadratic contrasts.

Results and Discussion

Effects of dietary salt concentration on cattle performance and carcass characteristics are presented in Tables 2 and 3. No effects of dietary salt concentration were statistically significant. Carcass adjusted daily gains and feed efficiency were about 2% greater with no added dietary salt than with .5 or .25% dietary salt. Similarly, Roth et al. (1970) noted no difference in performance of feedlot steers and heifers fed either 0 or .5% dietary salt in an 84-day Kansas trial. Salt is necessary in the diet for finishing steers primarily as a source of sodium, but the amount needed is low enough to be met by sodium in feed and water. Further, animals can be maintained on low sodium diets for some time because of their efficient conservation mechanisms (NRC, 1984). Thus, it may take several months for a sodium deficiency to occur.

Before completely deleting supplemental salt from a feedlot diet one must consider other potential health effects. The incidence of bloat in pastured cattle appears to be increased when dietary sodium is low relative to potassium. Because a sodium deficiency reduces salivary flow, it may eventually reduce feed intake and reduce ruminal buffering and osmolarity, as well, which may increase the incidence of ruminal dysfunction.

Table 2. Effect of dietary salt levels on steer performance.

Item	0.5% Salt	0.25% Salt	0% Salt
No. of steers	40	39	40
No. of pens	5	5	5
Weight, lb:			
Initial	788	782	782
56 days	1023	1007	1022
95 days	1131	1117	1128
Daily gains, lb:			
0-56	3.53	3.31	3.55
57-95	2.58	2.71	2.61
0-95	3.14	3.06	3.16
0-97[a]	3.77	3.74	3.84
Daily feed, lb DM:			
0-56	20.57	20.47	20.47
57-95	20.06	19.72	19.96
0-95	20.36	20.16	20.26
Feed/gain:			
0-56	5.82	6.22	5.79
57-95	7.94	7.36	7.68
0-95	6.50	6.61	6.40
0-97[a]	5.41	5.40	5.28
Metabolizable energy, mcal/kg	2.97	2.94	2.99
Net energy, mcal/cwt			
Maintenance	87.8	86.4	88.5
Gain	58.5	57.6	58.9

[a]Based on carcass weight divided by .62, an assumed dressing percent.

Table 3. Effect of dietary salt level on carcass characteristics.

Item	0.5% Salt	0.25% Salt	0% Salt
Carcass wt, lb	715	709	716
Dressing %	65.9	66.2	66.1
Rib eye area, sq in	12.8	12.7	13.2
KHP, %	2.55	2.40	2.42
Fat thickness, in	.54	.47	.58
Marbling score[a]	13.45	13.28	13.05
Percent choice	85.0	76.4	77.1
Percent YG 4	7.5	2.5	10.7
USDA Yield Grade	2.97	2.79	2.91
Cutability, %	49.9	50.3	50.0
Liver abscesses:			
Incidence, %	22.5	18.2	17.9
Severity[b]	2.63	2.25	2.13

[a]12=slight plus, 13=small minus
[b]0=no abscesses; 1=one or two small, well organized inactive abscesses; 2=two to four well organized abscesses without inflammation; 3=one or more active abscesses with inflammation, only among cattle with abscesses.

Literature Cited

Dawson, K.A. et al. 1985. Some physiological characteristics of isolated rumen bacteria after adaptation to increased concentrations of monensin. J. Anim. Sci. 61(Suppl. 1):491.

Doran, B.E. et al. 1986. Effect of supplemental potassium and monensin on ruminal digestion and passage rates. Okla. Agr. Exp. Sta. Res. Rep. MP-118:131.

Ferrell, M.C. et al. 1982. Ionophores and digestibility of feedlot rations. Okla. Agr. Exp. Sta. Res. Rep. MP-112:220.

Ferrell, M.C. et al. 1983. Potassium levels and ionophores for feedlot steers. Okla. Agr. Exp. Sta. Res. Rep. MP-114:54.

National Research Council. 1984. Nutrient Requirements of Beef Cattle, 6th rev. ed. Washington, D.C. National Academy Press.

Roth, G.M. et al. 1970. Protein, salt, and premix aspects of all-concentrate cattle finishing rations. Kansas State Univ., Cattlemen's Day 536:19.

LIVER ABSCESSES IN FEEDLOT CATTLE

I.S. Shin[1], F.N. Owens[2] and D.R. Gill[2]

Story in Brief

Feedlot performance from a total of 2774 feedlot steers and heifers fed in OSU research trials over the past 12 years were compiled to determine the relationship between liver abscess severity and feedlot performance and carcass characteristics. Severity scores were no abscesses, one small abscess (minor or 1), several abscesses or one moderately-sized abscess (moderate or 2) and many small or large severe abscesses (severe or 3). Eighteen percent of the total cattle had liver abscesses but only 9.7 percent had moderate and severe abscesses. Cattle with moderate and severe abscesses had rates of weight gain 2.5 and 3.7% less than those with no abscesses. They also had lower final live and carcass weights than cattle with no or only minor abscesses. The only carcass characteristic consistently altered by moderate and severe abscesses was rib eye area which was slightly reduced (by .14 to .26 square inches). Our results suggest that severity of a liver abscess dictates its impact on performance; minor liver abscesses had little impact on cattle performance. but moderate and severe abscesses reduced rate of gain and rib eye areas slightly.

(Key Words: Feedlot, Liver Abscesses, Abscess Severity.)

Introduction

Liver abscesses in feedlot cattle have been attributed to abrupt increases in intake of high-energy feeds (Brown et al., 1973). The bacteria, Fusobacterium novotum, a ruminal microorganism, frequently can be isolated from liver abscesses and is implicated as the causative organism. These bacteria enter the portal blood stream through lesions in the ruminal wall and imbed in the liver (Smith, 1944).

In a summary of over 42,000 cattle from the Great Plains, the liver abscess incidence was 32.9% (Montgomery, 1979). Feeding certain antibiotics can reduce the incidence of liver abscesses. The effects of abscesses on feedlot performance differs according to report, ranging from no effect (Bohman et al., 1979) to a depression in daily gain of over 5 percent (Foster and Woods, 1970). Abscess incidence may be less important than severity because abscesses vary both in number and in size. Severity can range from a single minor white spot to an open wound. Rust (1980) reported that severe abscesses reduced dressing percentage by 0.7% and increased cutability (by reducing fat cover) by 0.29%. Our report represents a compilation of data over the past 12 years to examine the effect of liver abscesses on performance and carcass characteristics of feedlot cattle relative to non-abscessed cattle fed simultaneously in the same study.

[1]Graduate Assistant [2]Regents Professor

Materials and Methods

Data from 15 feeding trials from 1975 to 1986, which included 2774 steers and heifers, were subjected to least squares analysis to determine the effects of liver abscesses on performance and carcass characteristics. Each diet was fed to 16 to 50 growing cattle. All diets were high in concentrate and generally were based on corn grain in the dry rolled, high moisture or steam flaked form. In many of the trials, tylosin was included to reduce the incidence of liver abscesses. At slaughter, each liver was examined visually and manually and scored according to the condition of liver abscess using a scoring described previously (Elanco, 1974). A score of 1 was given for one minor spot no larger than 1 inch in diameter, whereas several large or open liver wounds received a score of 3. Animal performance and carcass characteristics were compared only with cattle in the same trial fed the same ration to avoid the possibility that certain rations might increase both rate of gain and liver abscess incidence.

Results and Discussion

Least square means for animals with non-abscesses (0), a minor abscess (1), moderate abscess (2) or severe abscess (3) are presented in table 1. Averaged across all trials, the incidence of liver abscesses was 18 percent. The percentage of animals with abscess scores of 1, 2 and 3 was 8.3, 3.9 and 5.7 percent, respectively.

Averaged over the total data set, cattle with moderate abscesses had lower initial weights than the other three groups. In final live weight, the moderate and severe abscess groups weighed 10 to 30 lb less than the minor and the non-abscessed groups. On a carcass adjusted

Table 1. Least square means of performance and carcass characteristics for cattle with various degrees of liver abscesses.

	Liver Abscess Score			
	0	1	2	3
Number of cattle	2277	229	109	159
Percentage	82.1	8.3	3.9	5.7
Weight, lb				
Initial	681^{a}	684^{a}	668^{b}	682^{a}
Final, live	1106^{a}	1110^{a}	1080^{b}	1096^{ab}
Final, carcass/.62	1105^{a}	1111^{a}	1079^{c}	1092^{ab}
Carcass	685^{a}	689^{a}	669^{b}	677^{ab}
Daily gain				
Live basis	3.27^{a}	3.27^{a}	3.15^{b}	3.19^{ab}
Carcass final basis	3.26^{a}	3.28^{a}	3.14^{b}	3.15^{b}
Dressing percentage	61.97	62.08	61.91	61.79
Ribeye area, sq. in.	12.29^{a}	12.27^{a}	12.03^{b}	12.13^{ab}
Marbling score	13.30	13.17	13.07	13.38
KHP, %	2.45	2.43	2.41	2.41
Fat thickness, in.	.42	.42	.40	.41
Yield grade	2.78	2.74	2.68	2.72

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

basis (carcass weight/.62), final weights were from 13 to 32 lb lower in steers with moderate and severe abscesses. This calculates to a reduction for moderate and severe abscesses in live daily gains by 2.5 to 3.7%, and a reduction in carcass weight adjusted gains by 3.4 to 4.3% during the entire feeding period. Whether the abscess began early or late in the feeding period is not known though the greatest nutritional stress should be during the diet adaptation period which is the first 30 days on feed. Among the carcass characteristics, only ribeye area was decreased, being from 0.14 to 0.26 square inches less for steers which had moderate and severe abscesses. Carcass weights were 8 to 20 lb lower for steers with moderate and severe abscess scores. As all these cattle were fed in groups, no information about effects of liver abscesses on feed intake and efficiency is available. These results indicate that liver abscesses affect feedlot performance but have limited impact on carcass characteristics with minor abscesses having no detectable effect. The reduction in rate of gain by severe abscesses was considerably less than the 15% noted by Farlin et al. (1982).

The unadjusted raw means are presented in table 2. These are not adjusted to compare performance of abscessed cattle with contemporary cattle in the same experiment so statistical power is limited. Based on these raw means, an overall depression in performance also was found for animals with moderate and severe abscesses. The initial weight was 9 to 42 lb lower for moderate and severe abscess groups. Likewise, final live weight was 28 to 44 lb lower for moderate and severe abscess group than for the other two groups. On a carcass adjusted basis, final live weights were reduced by 26 to 37 lb which depressed daily gain by 4.0 to 7.3% for moderate and severe abscess groups as compared to the healthy and minor abscess groups. Adjusted daily gain was depressed significantly only for animals with severe abscesses.

Table 2. Unadjusted means of performance and carcass characteristics for cattle with various degrees of liver abscesses.

	Liver Abscess Score			
	0	1	2	3
Number of cattle	2277	229	109	159
Percentage	82.1	8.3	3.9	5.7
Weight, lb				
Initial	684^{ab}	687^{a}	645^{c}	675^{b}
Final, live	1116^{a}	1112^{a}	1072^{b}	1084^{b}
Final, carcass/.62	1118^{a}	1118^{a}	1081^{b}	1092^{b}
Carcass	693^{a}	693^{a}	670^{b}	677^{b}
Daily gain				
Live basis	3.31^{a}	3.26^{a}	3.13^{b}	3.07^{b}
Carcass final basis	3.33^{a}	3.30^{a}	3.34^{a}	3.20^{b}
Dressing percentage	62.13	62.34	62.49	62.46
Ribeye area, sq. in.	12.45^{a}	12.41^{a}	12.01^{b}	12.14^{b}
Marbling score	13.23^{b}	13.13^{b}	13.87^{a}	13.74^{a}
KHP, %	2.42	2.35	2.42	2.34
Fat thickness, in.	$.43^{a}$	$.39^{b}$	$.37^{c}$	$.39^{bc}$
Yield grade	2.70	2.62	2.60	2.63

[abc]Means in a row with different superscripts differ ($P<.05$) by Duncan's Multiple Range Test.

Based on these non-adjusted means, liver abscess score slightly altered certain carcass measurements. Ribeye area was lower ($P<.05$) for those steers which had moderate and severe abscess scores. In contrast, marbling score was highest ($P<.05$) for steers with moderate and severe abscesses. Fat thickness was considerably lower ($P<.05$) for those three groups with liver abscesses compared with the non-abscessed group.

From these results, we concluded that severe liver abscesses can detectably depress performance and may reduce ribeye area and fat thickness. The slightly lower carcass weights and daily gains of moderately and severely abscessed steer may account for part of the reductions in ribeye area and fat thickness, though an increased marbling score was unexpected. When considering value versus the cost of liver abscess control, one must include as costs both the loss in value of the liver which is eventually passed from the packer back to the cattle producer, and effects of abscesses on cost of production. Differences in rate of gain from this summary were minor suggesting that abscesses should have only a minor impact on cost of production. If 10% of the cattle had abscesses which depressed gain by 6%, pen gain would be depressed by only .6% by liver abscesses.

Although effects on feed efficiency could not be monitored, it would be surprising if feed efficiency were markedly altered by abscesses with such minor changes in rate of gain. Only by inoculating animals with the abscessing organism can total costs be checked directly as antibiotics used for control may have other effects and cattle prone to abscesses are likely to be those animals with variable feed intakes and poor efficiencies. If abscesses rupture during evisceration or if they adhere to the carcass, trimming of the carcass can be excessive and costly. Though of greater direct concern to the packer than the producer, this cost, again, is eventually passed back to the producer through a discounted price for slaughter cattle.

Literature Cited

Bohman, V.R. et al. 1979. The effect of liver flukes and abscesses on growth of feedlot cattle. J. Anim. Sci. 49(Suppl. 1):183.

Brown, H. et al. 1973. Tylosin phosphate (TP) and tylosin urea adduct (TUA) for the prevention of liver abscesses, improved weight gains and feed efficiency in feedlot cattle. J.Anim. Sci. 37:1085.

Chick, B.F., et al. 1980. Production Effects of liver fluke (Fasciola hepatica) infection in beef cattle. Aust. Vet. J. 56:588.

Elanco. 1974. Tylan premix Technical Manual. Elanco Products Division, Eli Lilly Co. Indianapolis, IN.

Farlin, S. et al. 1982. Severity of liver abscesses and feedlot performance. Beef Cattle Report. Nebraska Agr. Exp. Sta. MP-43:57.

Foster, L. and W. Woods. 1970. Liver losses in finishing cattle. Beef Cattle Progress Report. University of Nebraska. EC 70:218:1.

Montgomery, T.H. et al. 1979. The primary causes of liver condemnations in commercially fed cattle. J. Anim. Sci. 49(Suppl. 1):60.

Rust, S. et al. 1980. Liver abscesses and feedlot performance. Okla. Agr.Exp. Sta. Res. Rep. MP-107:148.

Smith, H.A. 1944. Ulcerative leisons of the bovine rumen and their possible relations to hepatic abscesses. Amer. J. Vet. Res. 5:234.

WATER INTAKE BY FEEDLOT STEERS

R.B. Hicks[1], F.N. Owens[2], D.R. Gill[2], J.J. Martin[3] and C.A. Strasia[4]

Story in Brief

Water intake of six pens of 47 crossbred yearling steers (733 lb) fed either 0, .25 or .5% percent dietary salt was monitored over a 92-day period during the summer in the Oklahoma Panhandle. Daily water intake of a group of 120 steers also was recorded. Daily water intake averaged 9.8 gallons per head. Temperature and dry matter intake were the major factors effecting water intake. For each one degree increase in daily maximum temperature, water intake increased by 0.1 gallons. Water intake increased by 0.3 gallons for each one pound increase in dry matter intake. Increasing amounts of precipitation and dietary salt both caused water intake to decrease slightly. The following water intake prediction equation was developed: water intake, gallons/day = -4.939 + (.104 * maximum temperature, ‡F) + (.292 * dry matter intake, lb/day) - (2.597 * precipitation, in) - (1.174 * dietary salt level, %).

(Key Words: Feedlot Steers, Water Intake, Dietary Salt Level)

Introduction

Little information is published concerning water intake of feedlot cattle. The minimum requirement of cattle for water is a reflection of that needed for body growth and of that lost by excretion in the urine, feces, or sweat or by evaporation from the lungs or skin (NRC, 1984). Several factors are known to modulate water intake of cattle including dry matter intake, nature of the diet and temperature (Winchester and Morris, 1956; ARC, 1980; Murphy et al., 1983). The objectives of this study were to determine the water intake patterns of feedlot steers and the effects of dry matter intake, dietary salt levels and environmental factors (temperature, rainfall, wind) on these patterns.

Materials and Methods

A group of 239 crossbred yearling steers which had been wintered on wheat pasture near Dalhart, Texas were trucked to Goodwell, Oklahoma on June 3, 1987. On arrival, all cattle were weighed individually, ear tagged, implanted with Synovex-S and injected with ivermectin and a BRSV vaccine. These steers were divided into two experiments which are reported elsewhere in this publication (Hicks et al., 1988a, 1988b).

Steers were fed a cracked corn high concentrate ration twice daily (0700 and 1600) for the 95 day trial. Chopped alfalfa hay was used to dilute the ration to 60 percent concentrate to start the cattle on feed. Roughage content of the diet was decreased sequentially in three steps until the cattle were on their final ration by 28 days on feed. The composition of the final ration was 80% cracked corn, 11% chopped alfalfa, 3.9% cane molasses and 5.1% supplement.

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Daily water intake was monitored with in-line water meters over a 92-day period in these experiments in three pairs of pens (pens shared water tanks). These three pairs received either no added dietary salt (16 head), .25% dietary salt (15 head) or .5% dietary salt (16 head). In addition, daily water intake was monitored on half the barn (120 head) with a meter in the main line serving the barn. The sodium concentration of this water was 17.5 to 18 parts per million. Daily weather data including maximum temperature, minimum temperature, wind velocity and precipitation were collected from the Goodwell weather station.

Results and Discussion

The effect of dietary salt level on water intake by month are presented in Table 1. Mean water intakes over the entire trial were 10.18, 8.98 and 9.33 gallons per day for the 0, .25 and .5% dietary salt pens, respectively. Water intakes tended to be lowest in June, July and August for cattle receiving .25% dietary salt. These cattle fed .25% salt also tended to consume less feed (19.87, 18.40, 18.80 lb/day for 0, .25 and .5% salt, respectively); although, data presented elsewhere in this publication (Hicks et al., 1988b) indicates that feed intake of feedlot steers was not altered significantly by dietary salt level (0, .25 or .5%). The equations of Winchester and Morris (1956) and Murphy et al. (1983) were used to predict water intake. Those equations predicted that water intake of the steers receiving .25% dietary salt would be lowest (Table 1) due to their lower feed intake.

The system of Winchester and Morris (1956) predicts water intake based on dry matter intake and ambient temperature (Table 2). For an average temperature of 75½ F as was observed in this experiment, their equation estimated total water intake (including water contained in feed) to be .58 gallons per lb of dry matter consumed. This is 10 to 15% greater than what was measured; however, their equation may be more accurate for diets higher in roughage.

Murphy et al. (1983) developed a water intake prediction equation for Holstein cows based on dry matter intake, milk production, sodium intake and minimum temperature. Their equation excluding the milk

Table 1. Water intakes by month as influenced by dietary salt level.

	0% Salt	.25% Salt	.5% salt
No. Head	16	15	16
Weights, lb:			
Initial	733	732	733
Final	1078	1046	1063
Dry Matter Intake, lb/day	19.87	18.40	18.80
Water Intake, gal/day:			
June (last 22 days)	9.64±1.23	7.43±1.33	8.87±1.54
July	10.48±1.40	10.00±1.50	10.02±1.06
August	10.43±3.32	9.01±2.25	9.16±2.03
Sept. (first 8 days)	9.54±1.53	9.23±1.81	8.55±1.73
Overall	10.18±2.23	8.98±2.00	9.33±1.67
Estimated Water Intake:			
Winchester & Morris, 1956	11.17	10.34	10.57
Murphy et al., 1983	13.07	12.90	13.09

Table 2. Water intake prediction equations.

Winchester and Morris (1956)

Temperature, °F	Gallons of water/lb of DM[a]
40	.37
50	.40
60	.46
70	.54
80	.62
90	.88

Murphy et al. (1983)[b]

Water intake, lb/day = 35.18 + 1.58DMI + .11SODIN + 2.64TMIN

[a]Includes both drinking water and water in feed.
[b]DMI = dry matter intake, lb/day; SODIN = sodium intake, g/day; TMIN = weekly mean minimum temperature, °C.

production factor is also presented in Table 2. Predicted water intakes by their equation were 28 to 44% greater than measured values. Both systems over-predicted intake the most for steers receiving .25% salt.

Monthly weather data and the mean water intake for one half the barn (120 steers) are presented in Table 3. Water intakes of all cattle were greatest in July and August when temperatures were the greatest as would be expected based on the available literature. In a review of data, Winchester and Morris (1956) noted that the rate of water intake per unit of dry matter ingested remains relatively constant from around 10 to 40 F but above 40 F, water intake increases with ambient temperature at an accelerating rate. The NRC (1981) reported that under controlled temperature conditions that cattle tend to increase water intake as temperature rises, with 80.6 F being the temperature where a marked changes in water intake by lactating cows is noted. Below that point water consumption is considered to be primarily a function of dry matter intake (NRC, 1981).

Stepwise regression of the daily weather variables vs daily water intake indicated that at all three salt levels maximum temperature was the major variable effecting water intake. However, the percentage of variation explained by maximum temperature was low (13, 13 and 34% for 0, .25 and .5% salt). Stepwise regression of weekly mean weather data and weekly mean dry matter intakes vs weekly water intake yielded the equations presented in Table 4. For the 0 and .5% salt groups, maximum temperature explained about 81% of the variation in water intake.

Table 3. Monthly weather data and mean water intake.

	June	July	August	September	Overall
Daily Temperature, °F					
Mean maximum	88.1±6.7	91.2±6.8	89.4±11.5	84.6±7.7	89.3±8.8
Mean minimum	60.1±3.2	61.3±3.7	62.4±5.9	57.1±1.4	61.0±4.5
Mean wind speed, mph	5.1±1.3	7.0±2.3	6.1±3.0	4.9±2.3	6.0±2.5
Precipitation, inches	3.39	1.51	3.01	.87	8.78
Daily water intake, gal/steer for 120 steers	8.9±1.5	10.0±2.7	10.5±4.1	8.5±1.4	9.8±3.0

Table 4. Equations for different dietary salt levels.

	Coefficients (Standard Error)		
	0% Salt	.25% Salt	.5 % Salt
Intercept	-2.305 (2.156)	-2.584 (2.486)	-11.035 (2.000)
TMAX[a]	0.1416 (0.0237)		0.1846 (0.0224)
DMI[a]		0.6415 (0.1335)	0.2015 (0.0629)
PREC[a]	-2.019 (1.007)	-5.097 (1.407)	
r^2	.8671	.7557	.9032

[a]TMAX = weekly mean maximum temperature, °F; DMI = dry matter intake, lb/day; PREC = weekly mean precipitation, in.

However, for the .25% salt group, maximum temperature did not enter the model.

Stepwise regression across all salt groups combined yielded the following equation: Water intake, gallons/day = -4.939 + .1040TMAX + .2923DMI - 2.5971PREC - 1.1739SALT. Additional factors offered but not selected by the computer for including in the regression were weekly mean minimum temperature and weekly mean wind velocity. A summary of the steps leading to this equation are presented in Table 5. The major factors affecting water intake in this equation are maximum temperature and dry matter intake (explain 65% of variation). In contrast to the equation of Murphy et al. (1983), maximum temperature instead of minimum temperature entered the model, and increasing dietary salt levels caused a decrease, not an increase in water intake. Murphy et al. (1983) noted that water intake increased by .013 gallons for each additional gram of sodium fed, whereas, our data shows water intake to decrease by approximately .03 gallons for each additional gram of sodium fed. In comparison with our maximum salt intake of 43 grams with .5% dietary salt, dairy cows often consume 100 grams of salt daily from diets containing .45% added salt.

In summary, feedlot cattle fed during the summer (maximum daily temperatures of about 90 F) required about 10 gallons of water per day. The major factors affecting water intake in these cattle were maximum temperature and dry matter intake. Based only on water intake data from three groups of cattle (16 head/group) fed 0 to .5% supplemental salt, increasing dietary salt levels tended to decrease water consumption. With higher levels of salt, water intake probably would have increased.

Table 5. Summary of stepwise regression.

Step	Variable entered[a]	Partial r^2	Model r^2
1	TMAX	.4996	.4996
2	DMI	.1501	.6497
3	PREC	.0527	.7024
4	SALT	.0337	.7361

[a]TMAX = weekly mean maximum temperature, °F; DMI = dry matter intake, lb/day; PREC = weekly mean precipitation, in; SALT = dietary salt level, %.

Literature Cited

Agricultural Research Council. 1980. The Nutrient Requirements of Ruminant Livestock. Commonwealth Agricultural Bureau, Slough, England.

Hicks, R.B. et al. 1988a. Effects of weekly or bi-weekly rotational feeding of lasalocid and monensin on performance of feedlot steers. Okla. Agr. Exp. Sta. Res. Rep. MP-125:171.

Hicks, R.B. et al. 1988b. Effect of dietary salt levels on performance of feedlot steers. Okla. Agr. Exp. Sta. Res. Rep. MP-125:200

Murphy, M.R. et al. 1983. Factors affecting water consumption by Holstein cows in early lactation. J. Dairy Sci. 66:35.

National Research Council. 1981. Effect of Environment on Nutrient Requirements of Domestic Animals. Washington, D.C. National Academy Press, pp. 30-31, 60-61.

National Research Council. 1984. Nutrient Requirements of Beef Cattle, 6th rev. ed. Washington, D.C. National Academy Press.

Winchester, C.F. and M.J. Morris. 1956. Water intake rates of cattle. J. Anim. Sci. 15:722.

HIGH WHEAT CONCENTRATE MIXTURES CONTAINING DIFFERENT SOURCES OF PROTEIN FOR LACTATING DAIRY COWS

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

Story in Brief

The response of 24 Holstein cows, in their second or greater lactation, to high wheat rations containing different sources of protein were evaluated. Treatments were: a) control (60% corn with cottonseed meal), b) wheat (60%, with cottonseed meal), c) wheat (60%, with whole cottonseed), and d) wheat (60%, with corn gluten meal and blood meal). The concentrate mixtures and alfalfa hay were fed separately in a 50:50 ratio in individual stanchions twice daily. Dry matter intakes and milk yields for cows fed the respective rations were 52.2, 48.3, 48.0, 50.2 and 67.0, 60.2, 62.9, 62.5 lb/day. Percentages of milk fat and protein were 3.55, 3.42, 3.49, 3.50 and 3.12, 3.17, 3.18, 3.22. Concentration of ruminal NH_3-N was similar for all treatment groups, whereas blood urea-N was lower for cows fed the control corn ration. Molar percentage of acetic acid was higher and isovaleric lower in ruminal fluid of cows fed the corn ration than in cows fed other rations, whereas molar percentages of other VFA were similar for all groups. Ruminal pH was lowest for cows fed the wheat mixture with 60% wheat and cottonseed meal, and highest for cows fed the corn control ration.

(Key Words: Wheat, Protein, Milk Yield, Dairy Cows.)

Introduction

There has been increasing interest in utilizing wheat for livestock feeding due to declining wheat prices brought about by surplus wheat production. Utilization of different amounts of hard red winter wheat in dairy cattle rations has been studied. Faldet et al. (1986) found a linear decrease in milk yield (66.9, 65.5, 65.1 and 63.7 lb) as the percentage of wheat was increased in the concentrate mixture from 0 to 40, 60 and 80%. Calculated ruminal undegradable protein (RUP) decreased as wheat was introduced into the ration. Nalsen et al. (1987) substituted wheat for corn on a weight and a protein basis. Calculated as-fed protein composition of the three concentrate mixtures were 12.2, 15.1 and 12.2%. Calculated ruminal undegradable protein was 6.2, 3.8 and 2.6% respectively. Milk yield of cows fed the three rations was 76.0, 74.1 and 72.6 lb. Thus, milk yield was intermediate when wheat was substituted for corn on a weight basis, rather than balancing the concentrate mixture for equal protein.

Supplying ruminal undegradable protein to the small intestine appears to be a critical factor in maintaining high milk yields when wheat comprises the major source of energy in the ration. The objective of this experiment was to compare the performance of lactating cows fed wheat-based concentrate mixtures with different protein sources using alfalfa hay as the only forage in the ration.

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Materials and Methods

Twenty-four Holstein cows were used in a feeding trial. All cows were in their second or greater lactation and started on the feeding trial 6 to 8 weeks postpartum. A switchback design with three 4-week periods was used. The first two weeks of each period were allowed for adjustment to rations and prevent carryover effects, whereas the last two weeks of each period were used to compare treatments. Treatments consisted of four concentrate mixtures (Table 1). The control ration was a 60% corn-based concentrate mixture and the remaining three mixtures contained 60% wheat. Wheat-based concentrate mixtures were calculated to be nearly isonitrogenous. Sources of protein supplied in the mixtures varied in order to obtain different amounts of energy and ruminal undegradable protein, lysine and methionine. Alfalfa hay was the only source of forage, and was fed separately from the concentrate mixture in individual stanchions twice daily. The rations were adjusted as needed to maintain a 50% concentrate and 50% alfalfa hay consumption on a dry matter basis. Daily concentrate and hay weighbacks were composited weekly and analyzed for dry matter and crude protein. Weekly samples of concentrate and alfalfa hay were also taken for analysis.

Milk weights were recorded twice daily. On four consecutive milkings of each week, milk samples were obtained to determine fat and protein content.

Table 1. **Concentrate mixtures fed with alfalfa hay**[1].

Composition	Corn Control	Wheat (CSM)	Wheat (WCS)	Wheat (High RUP)
Ingredients, (% as-fed)				
Corn	60	--	--	9
Wheat	--	60	60	60
Sorghum (Milo)	5.5	5.5	5.5	--
Cottonseed meal	10	10	--	--
Blood meal	--	--	--	1.5
Corn gluten meal	--	--	--	5
Whole cottonseeds	--	--	20	--
Soybean hulls	15	15	5	12
Cottonseed hulls	--	--	--	3
Fixed portion[2]	9.5	9.5	9.5	9.5
Calculated analysis (as-fed)				
Net energy, Mcal/100 lb	74.3	74.3	78.9	74.1
Crude fiber, %	7.9	8.4	6.9	7.7
Total protein, %	12	14.3	13.7	14.2
Rumen undeg. protein, %	5.54	3.60	3.32	4.99
Rumen undeg. lysine, %	.19	.13	.12	.16
Rumen undeg. methionine, %	.09	.05	.06	.08

[1]Concentrate:forage, 50:50 (dry basis).

[2]Fixed portion of concentrate mixture: Molasses 5, dicalcium phosphate 2.0, sodium bicarbonate 1.25, salt .75, magnesium oxide .5%.

At the end of each period, ruminal fluid samples were taken by stomach tube 3 to 4 hours after the morning concentrate feeding to determine ruminal pH, ammonia-N and volatile fatty acid concentrations. A sample of blood from the median caudal vein was also taken at this time to determine plasma urea-N concentrations.

Results and Discussion

Total dry matter consumption was higher for cows fed the corn-based concentrate mixture (52.2 lb) than for cows fed the wheat-based mixtures (48.8 lb), as was consumption of both hay and concentrate (Table 2). Faldet et al. (1986) and Nalsen et al. (1987) also noticed a decrease in concentrate and hay intake when wheat was introduced into the ration. Decreased feed intake of cows fed the wheat-based rations may be due to altered ruminal fermentation by wheat starch. Alternatively, palatability and/or acceptability of wheat rations may be a problem. With 60% wheat in the concentrate mixture, wheat intake averaged 17 lb/day on an as fed-basis. Protein intake exceeded NRC requirements for all treatments.

Average daily milk production was significantly higher when cows were fed the corn control ration (67 lb) than for those fed the wheat-based rations. The highest milk production on the wheat-based rations was found with the 60% wheat mixture with whole cottonseed. Cows fed the ration with whole cottonseed produced more milk than cows fed the 60% wheat mixture with cottonseed meal. Cows fed the high RUP concentrate mixture (corn gluten meal and blood meal) tended to yield more milk than those fed the wheat ration in which cottonseed meal supplied the required protein, i.e., 62.5 vs. 60.2 lb ($P<.07$). Because milk fat production was similar across treatments, fat corrected milk (FCM) production paralleled actual milk production. Milk protein tended

Table 2. Feed intake and milk yield by cows.

Item	Corn Control	Wheat (CSM)	Wheat (WCS)	Wheat (High RUP)
Dry matter intake, lb/day				
Concentrate mixture	26.8^{a}	24.8^{b}	24.7^{b}	25.6^{b}
Alfalfa hay	25.4^{a}	23.5^{cb}	23.3^{c}	24.5^{ab}
Total	52.2^{a}	48.3^{cb}	48.0^{c}	50.2^{b}
Protein intake				
Amount, lb/day	8.9^{a}	9.1^{a}	8.7^{ab}	9.7^{c}
% of NRC requirement	134^{a}	153^{b}	140^{a}	156^{b}
Milk yield				
Milk, lb/day	67.0^{a}	60.2^{c}	62.9^{b}	62.5^{bc}
Fat test, %	3.55	3.42	3.49	3.50
FCM, lb/day	62.3^{a}	54.6^{c}	57.8^{b}	57.3^{b}
Protein, %	3.12^{b}	3.17^{ab}	3.18^{ab}	3.22^{a}

[abc]Means with different superscripts differ ($P<.05$).

to be higher when cows were fed the ration with high ruminal undegradable protein. This may be the result of supplying a larger amount of limiting amino acids at the site of milk protein synthesis.

Molar percentage of acetic acid was higher for cows on the corn control ration (Table 3), suggesting conditions more favorable for milk fat production. Isovaleric acid concentration and total volatile fatty acid concentration were higher when cows were fed the wheat-based rations than when fed the corn control ration. Ruminal pH was significantly lower for cows on the wheat-based rations than for those on the corn control ration. Similarly, Faldet et al. (1986) noted a linear decrease in ruminal pH as wheat was increased in the concentrate mixture. This suggests a more rapid breakdown of the wheat starch than of corn starch in the rumen, and may have resulted in the lower acetic acid concentrations found with the wheat-based concentrate mixtures. Lower ruminal pH and altered molar proportions of volatile fatty acid concentrations have been suggested as possible regulators of feed intake. The lowest ruminal pH was found with cows fed the wheat-based mixture where cottonseed meal supplied the required crude protein. Mineral buffers (Table 1) were added to all of the rations, and helped maintain ruminal pH to where problems with digestive disorders should not occur.

Ruminal ammonia-N concentrations tended to increase with the wheat-based rations, suggesting increased ruminal protein digestion with wheat. Blood urea-N concentrations were lower for cows on the corn-based ration, but did not differ among wheat-based rations.

Inclusion of a high ruminal undegradable protein tended to increase milk production when wheat was included in the diet of lactating cows.

Table 3. Responses of cows to experimental rations.

Item	Corn Control	Wheat (CSM)	Wheat (WCS)	Wheat (High RUP)
Ruminal fluid pH	6.27[a]	5.86[b]	6.13[a]	6.17[a]
Total VFA conc., mm/l	215.9[a]	288.2[b]	252.6[b]	248.2[b]
Volatile fatty acid, molar %				
Acetic	64.8[a]	61.0[b]	60.6[b]	61.5[b]
Propionic	21.5	23.2	24.5	23.1
Butyric	11.3	12.3	11.6	12.2
Isobutyric	.40	.34	.19	.34
Valeric	1.23	.98	.93	1.11
Isovaleric	.92[a]	2.15[b]	2.13[b]	1.78[b]
Acetic to propionic ratio	3.0	2.6	2.5	2.7
Blood urea-N, mg/dl	11.6[a]	16.1[b]	15.2[b]	15.2[b]
Ruminal ammonia-N, mg/dl	4.9	6.7	6.3	6.2

[ab]Means with different superscripts differ ($P < .05$).

Calculated rumen undegradable protein was still lower than the corn-based ration which may have limited the milk production response. Although the calculated ruminal undegradable protein of the wheat ration with whole cottonseed was lower than the other three rations (Table 1), milk yield was similar to that of cows fed the high ruminal undegradable protein ration. Net energy for lactation was highest for the wheat mixture with whole cottonseed which may have increased milk production.

Literature Cited

Faldet, M.A. et al. 1986. Influence of different levels of wheat in the concentrate mixture on production responses of lactating dairy cows fed alfalfa hay as the only forage. Ok. Agr. Exp. Sta. MP-118:71.

Nalsen, T. et al. 1987. Substituting wheat for corn in a concentrate mixture for dairy cows on a weight basis. Ok. Agr. Exp. Sta. MP-119:149.

INFLUENCE OF GRAIN SOURCE (WHEAT VS. CORN) ON RUMINAL AND POSTRUMINAL STARCH AND AMINO ACID DEGRADATION IN HEIFERS USING A MOBILE DACRON BAG TECHNIQUE

C. Campbell[1], F.N. Owens[2] and H. Anzola[1].

Story in Brief

Two heifers fitted with ruminal and duodenal T-type cannulas were used to estimate starch and amino acid digestibility of wheat and corn at different sites in the gastrointestinal tract using the mobile nylon bag technique. Approximately 3 grams of each sample (wheat or corn) was placed into 3.0 by 5.0 cm nylon bags. Bags were suspended in the rumen for 15 hr, incubated for 3 hr in a pepsin-HCL solution, placed into the duodenal cannula and recovered from feces. For corn but not wheat, starch disappearance during ruminal incubation and postruminal passage increased as particle size was reduced. Ruminal disappearance of protein from corn and wheat was 5.2% and 58.7%. However, total tract disappearance of protein from corn and wheat was similar. Postruminal disappearance, as a fraction of dietary protein for threonine and sulfur-amino acids, was 46% and 19% lower for wheat than for corn. Results indicate that the first limiting amino acids for ruminants can change with grain source. Hence, amino acid balance, in addition to ruminal protein escape must be considered in diet formulation.

(Key Words: Mobile Dacron Bag, Starch, Amino Acid.)

Introduction

Several variables determine the usefulness of cereal grains for livestock. One of these variables is the rate and extent at which nutrients are hydrolyzed into simpler, more useful forms to be utilized by the animal. With dairy cows, the rate and amount of starch digestion can have an direct effect on milk fat production. Increasing the rate of starch digestion in the rumen can lower ruminal pH and decrease fiber digestion by ruminal microbes.

Little information is available on ruminal digestibility of wheat starch. Waldo (1973) suggested that 94% of wheat starch was fermented in the rumen, compared to 74% for ground corn. Turgeon et al. (1983) reported that ruminal digestion of starch was 52% for whole corn and 61% for cracked corn. Post-ruminal starch digestion values were 40 and 33%, so that total tract starch digestibilities were 91.5 and 94.3%, respectively.

The rate and extent of protein degradation, and, more specifically, amino acid degradation are other important factors. In early lactation, amino acid supply to the small intestine may limit production. The depression in milk production observed in some studies where wheat is fed as the main concentrate (Faldet et al, 1986; Nalsen et al., 1987) may be the result of extensive degradation of wheat protein in the rumen which limits supply of feed amino acids to the small intestine.

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[1]Graduate Assistant [2]Regents Professor

The objective of this experiment was to compare the extent of starch and amino acid degradation of wheat and corn in the rumen and intestines of cattle.

Materials and Methods

Two Hereford heifers fitted with permanent ruminal and duodenal T-type cannulas were fed a wheat or corn-based concentrate mixture plus sorghum silage. The two rations consisted of 55% concentrate and 45% forage on a dry matter basis. Heifers were fed twice daily and adapted to the diet for 7 days.

Bags were constructed of dacron and measured 3.0 by 5.0 cm with a mesh size of 60 to 70 microns. Corn and wheat samples were ground using a 2-mm screen and sieved to obtain particle sizes of $<$ 250 microns, 250 to 500 microns, 500 to 1000 microns, 1000 to 2000 microns and $>$ 2000 microns. These were used to determine the impact of particle size on starch degradation. To evaluate amino acid degradation, wheat and corn samples ground through the 2-mm screen were used. Approximately 3.0 grams of each sample (wheat or corn) were placed in nylon bags which were double sewn and glued. Edges were melted to prevent unraveling. Four bags containing each grain sample (wheat or corn) at each particle size were used to determine ruminal starch degradation, while two bags containing each grain sample were used to determine intestinal starch degradation. Amino acid degradation from wheat and corn in the rumen and intestinal tract was compared using 1 bag of each sample at the respective sites. Bags containing the wheat samples were placed in the rumen of the heifer fed the wheat-based ration and bags containing corn samples in the rumen of the heifer fed the corn-based ration. Nylon bags were inserted into nylon stockings with approximately 7 bags placed in each leg and separated from each other with twist ties. Bags were incubated in the rumen for 15 hours. After ruminal incubation, the nylon bags were soaked in a pepsin-HCL solution (1 gram pepsin per liter; 0.1 N HCL) for 3 hours at 37 C. The solution was adjusted to pH 2. Bags then were placed into the T-type duodenal cannulas and recovered from the feces. The bags were thoroughly washed and dried in a forced-air oven at 60 C for 48 hours. The MacRae and Armstrong procedure was used for starch analysis, and 6 N HCL hydrolysates were used for amino acid analyses.

Results and Discussion

Ruminal and total tract starch disappearance was greater ($P < .002$) for wheat than corn (Table 1). The magnitude of difference was largest for particles greater than 500 microns, while differences were minor for particles less than 500 microns.

An interaction between grain source and particle size both for ruminal ($P < .05$) and total tract ($P < .01$) digestion was detected. Disappearance of starch from corn tended to be highest with particles less than 250 microns, both in the rumen and total tract, i.e. 32 and 100% respectively. Very little corn starch was degraded in the rumen when particles were greater than 1000 microns. In contrast, ruminal wheat starch degradation was highest for 500 and 1000 micron particles. Though there was no significant difference among particle sizes in total tract disappearance of starch from wheat, starch from particles less than 1000 microns tended to be more extensively degraded after passage

Table 1. **Starch disappearance from corn and wheat particles in the rumen and total tract.**

Particle size (microns)	Corn Grain		Wheat Grain		S.E.
	Rumen	Total Tract	Rumen	Total Tract	
	------------	Disappearance (%)	------------		
< 2000	8[b]	33[b]	28[a]	88	15.3
1000-2000	4[b]	47[b]	40[ab]	83	10.8
500-1000	17[ab]	58[b]	54[b]	97	10.8
250-500	25[ab]	94[a]	29[a]	96	10.8
> 250	32[a]	100[a]	22[a]	96	15.3

[ab]Means in a column with different superscripts differ ($P < .05$).

through the total tract than for particles over 1000 microns in diameter. The relationship between particle size of the grain and pore size of the dacron material should be taken into consideration. This relationship may affect the amount of particles capable of filtering out of the dacron bags, and thus affecting calculated starch degradation.

The major site of degradation of protein differed between corn and wheat (Table 2). Very little corn protein was degraded in the rumen, as compared to the small intestine, i.e. 5.2 vs 90.5%, whereas disappearance of wheat protein was higher in the rumen than in the lower tract, i.e. 58.7 vs 40.0%. Though the major site of degradation differed for corn and wheat, total tract degradation of wheat protein tended to be more complete than corn protein.

Similar to protein disappearance, degradation of lysine, threonine, sulfur amino acids and essential amino acids from corn was higher in the small intestine than the rumen. Ruminal and total tract lysine disappearance was higher for wheat than corn, although postruminal disappearance was similar for the two grains. For wheat, similar quantities of threonine disappeared in the rumen (43.9%) and intestines (48.8%). In contrast, 75% of the threonine from corn was degraded in the lower tract. Unlike lysine and threonine, a larger quantity of sulfur amino acids from wheat escaped ruminal degradation, however, extensive postruminal degradation resulted in higher total tract disappearance of sulfur amino acids from wheat than corn. As with protein, total tract degradation of essential amino acids in wheat was more complete than in corn.

This study illustrates that wheat starch is more extensively degraded in the rumen than corn starch. This response may decrease ruminal fiber digestion and, without proper management, decrease fat test in lactating dairy cows. As with starch, ruminal degradation of protein and essential amino acids was higher for wheat than corn. Thus if these two grains are supplemented with protein to provide the same amount of protein in the diet, ruminal escape protein will be much lower with a wheat-based diet. Alternative protein supplements that are higher in ruminal undegradable protein than soybean or cottonseed meal

Table 2. Protein and amino acid disappearance from corn and wheat

	Corn	Wheat
Protein		
Feed, %	8.91	15.03
Ruminal disappearance, %	5.2	58.7
Postruminal disappearance, % of fed	90.5	40.0
Postruminal disappearance, g/100 g DM	8.06	6.01
Total tract disappearance, %	95.6	98.7
Lysine		
Feed, %	.20	.38
Ruminal disappearance, %	30.0	36.8
Postruminal disappearance, % of fed	55.0	55.3
Postruminal disappearance, g/100 g DM	.11	.21
Postruminal disappearance, g/100 g CP fed	1.2	1.4
Total tract disappearance, %	85.0	92.1
Threonine		
Feed, %	.28	.41
Ruminal disappearance, %	10.7	43.9
Postruminal disappearance, % of fed	75.0	48.8
Postruminal disappearance, g/100 g DM	.21	.20
Postruminal disappearance, g/100 g CP fed	2.4	1.3
Total tract disappearance, %	85.7	92.7
Sulfur amino acids		
Feed, %	.41	.39
Ruminal disappearance, %	24.4	10.3
Postruminal disappearance, % of fed	56.1	79.5
Postruminal disappearance, g/100 g DM	.23	.31
Postruminal disappearance, g/100 g CP fed	2.6	2.1
Total tract disappearance, %	80.5	89.7
Essential amino acids		
Feed, %	4.22	5.55
Ruminal disappearance, %	16.4	43.1
Postruminal disappearance, % of fed	72.0	51.7
Postruminal disappearance, g/100 g DM	3.04	2.87
Postruminal disappearance, g/100 g CP fed	34.1	19.1
Total tract disappearance, %	88.4	94.8

may be required to provide a ration similar or higher in rumen undegradable protein than a corn-based ration. Expressed per unit of dietary protein, quantities of threonine and sulfur amino acids would be much lower with a wheat-based than a corn-based diet. Thus, first-limiting amino acids might be expected to change with grain of the basal diet as discussed by Owens (1986).

Literature Cited

Faldet, M.A. et al. 1986. Effect of different levels of wheat in concentrate mixture on responses of lactating dairy cows fed sorghum silage as the only forage. Okla. Agr. Exp. Sta. MP-118:66.

Nalsen, T. et al. 1987. Substituting wheat for corn in a concentrate mixture for dairy cows on a weight basis. Okla. Agr. Exp. Sta. MP-119:149.
Owens, F.N. 1986. Protein utilization in ruminants:Current concepts in formulating ruminant diets. Proceedings:AFIA Nutrition Symposium
Turgeon, O.A. et al. 1983. Corn particle size mixtures, roughage level and starch utilization in finishing steer diets. J. Anim. Sci. 57:739.
Waldo, D.R. 1973. Extent and partition of cereal grain starch digestion in ruminants. J. Anim. Sci. 37:1062.

SUPPLEMENTATION OF RATIONS FOR LACTATING DAIRY COWS WITH PROTECTED ISOLEUCINE

F.N. Owens[1], L.J. Bush[2], T. Nalsen[3] and G.D. Adams[4]

Story in Brief

A typical ration for lactating dairy cows was supplemented with 6g/day of protected isoleucine. Intake of dry matter by both supplemented and unsupplemented cows was relatively high, averaging 62.3 lb/day, and intake of total protein was 126% of NRC requirements. Neither milk yield nor its composition was affected by supplementation with protected isoleucine under the conditions of this experiment.

INTRODUCTION

Under some conditions, certain amino acids have been found to be limiting for high milk production by dairy cows. Lysine and methionine have been identified by some researchers as the amino acids most likely to be limiting for cows fed typical rations; however other amino acids have been suggested as limiting on the basis of infusion studies or other types of estimates of amino acid supply and need for milk synthesis. By calculation of the amount of different amino acids needed for high milk yield and those available at the site of absorption, it appears that isoleucine may limit milk yield under some conditions. The purpose of this trial was to determine whether supplementation of a typical ration with protected isoleucine would affect milk yield and composition by dairy cows.

MATERIALS AND METHODS

Twelve Holstein cows were started at 7 to 11 weeks after calving on an experiment in which treatments were alternated according to a switchback design with three periods of four weeks each. The treatments were 5 daily supplement of 6 grams of protected isoleucine[5] and a central (no supplementation). The protected isoleucine was premixed with a small amount of ground corn and added to the concentrate of the appropriate cows at one feeding each day. All cows were fed a ration consisting of 50% concentrates (Table 1), 35% sorghum silage, and 15% alfalfa hay on a dry basis. The concentrate mixture and silage were mixed together before feeding the allotted amount to each cow, whereas the hay was fed separately in individual stanchions. Samples of concentrate mixture, silage and hay were taken weekly for determination of dry matter and protein content. Weighbacks of refused feed were taken daily and during each of the last two weeks of each period a composite was made of the concentrate-silage weighback for each cow to determine dry matter and protein content.

Milk weights were recorded at each milking and samples were taken at four consecutive milkings each week for determination of fat and protein content. The cows were weighed on two consecutive days prior to starting the experiment and during the last week of each period.

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[1]Professor [2]Professor Emeritus [3]Graduate Student [4]Instructor [5]Research product generously supplied by Degussa Corp., Teterboro, NJ 07608.

Results and Discussion

Intake of total dry matter was relatively high for both groups and not affected by supplementation with protected isoleucine (Table 2). Intake was greater than predicted on the basis of commonly accepted prediction equations. This, along with higher than expected protein

Table 1. Composition of concentrate mixture for cows.

Item	Amount
Ingredients (% as fed)	
Corn	50
Sorghum grain	10.5
Soybean meal, solv.	30
Molosses, liquid	5
Salt	.75
Sodium bicarbonate	1.25
Magnesuim oxide	.5
Calculated analysis (as fed basis)	
Net energy (NEl), Mcal/100 lb	74.1
Crude fiber, %	2.9
Crude protein, %	18.8
Rumen escape protein, %	8.0

Table 2. Responses of cows to experimental rations

	Treatment group	
Item	Control	Isoleucine
Dry matter intake, lb		
Concentrate mix	31.3	31.4
Silage	21.9	21.9
Hay	9.1	9.1
Total	62.3	62.4
Crude Protein intake		
Amount, lb	9.74	9.78
% of DM	15.6	15.6
% of NRC requirement	126	126
Milk yield		
Milk, lb/day	70.5	70.6
Fat, %	3.94	4.01
Protein, %	3.09	3.09
4% FCM	69.7	70.6
Weight change lb/4-week period	21.0	17.9

content of the alfalfa hay, i. e., 20.2% on a dry basis, resulted in total protein intake approximately 26% in excess of 1978 NRC requirements. Under these conditions, amino acids which might otherwise be limiting were likely supplied in ample quantity for milk synthesis.

Milk production of the cows was not affected by the addition of protected isoleucine to the ration. Likewise, the fat and protein content of the milk was similar for both groups and within acceptable limits for Holstein cows. It does not appear that isoleucine was a limiting factor for milk production under conditions where cows are fed a ration containing adequate or excess total protein, especially with the protein sources used in this experiment. With corn and sorghum grain as the principal energy sources in the concentrate mixture, the amount of protein estimated to escape ruminal degradation was 8.0% or 42.6% of dietary protein(Table 1). If other ingredients comprised the concentrate mixture, the percentage of ruminal escape protein could be considerably lower and if blood meal were used as a supplement, its notably low isoleucine content might be of concern.

The goal of most trials with amino acid supplementation or escape has been to increase rate of production; current diets are formulated to attain near maximum production. Though more difficult to study, efficiency and economics of production needs to be considered, not total production alone when evaluating new feedstuffs, byproducts and feed additives. Such a change will force researchers and producers to consider the many factors involved in production efficiency from the diverse diets fed in different areas and seasons of the year. This could have a bearing on availability of different amino acids at the site of absorption in the intestine and there by on the likelihood that a given amino acid will limit production.

EFFECT OF YEAST CULTURE ON INTAKE AND PRODUCTION OF DAIRY COWS FED HIGH WHEAT RATIONS

J.A. Quinonez[1], L.J. Bush[2], T. Nalsen[1], and G.D. Adams[3]

Story in Brief

The effect of supplementing rations with yeast culture on milk yield and feed intake was evaluated using 24 Holstein cows. Treatments were: (a) control corn mixture, (b) control plus 3 lb yeast culture/ton, (c) wheat mixture (60% wheat), and (d) wheat mixture plus yeast culture. Concentrate mixtures were calculated to be isonitrogenous and approximately equal in energy content. Concentrates and alfalfa hay (50:50) were each fed separately in individual stanchions twice each day at about 12-hour intervals. Dry matter intake by cows fed the corn mixtures was higher than that of cows fed the wheat mixtures (52.6 and 52.0 vs. 48.0 and 47.2 lb). Milk yield was higher for cows fed the corn rations than for those fed wheat (70.5 and 68.6 vs. 67.1 and 66.9 lb). Dry matter intake and milk yield were unaffected by the addition of yeast culture under the condition of this trial. Ruminal pH was higher and digestibility of dry matter and protein was lower in cows fed corn than in those fed wheat. Milk protein, ruminal NH_3-N and blood urea-N were not affected by treatment.

Introduction

In many areas of the U.S., wheat is competitive in price with other feed grains used as an energy source in dairy rations. However, the extent to which wheat can replace other feed grains in concentrate mixtures for dairy cows appears to be limited because of reduced feed intake and milk yield when large amounts of wheat are used.

In work by McPherson and Waldern (1969), feed intake and milk yield were similar for cows fed rations wherein Gaines soft white wheat replaced barley in concentrate mixtures up to 93% of the mixture. In contrast, Cunningham et al. (1970) observed that milk yield was significantly lower when soft red winter wheat replaced corn to the extent of 66.7% than when it comprised only 33.3% of a concentrate mixture.

In recent work at the Oklahoma station (Faldet et al., 1986), cows were fed concentrate mixtures containing 0, 40, 60 and 80% hard red winter wheat replacing corn and some protein supplement so that protein content was held constant.

Intake of both concentrate and hay was lower when cows were fed the rations containing wheat. Milk yield declined as the amount of wheat in the concentrate increased (66.9, 65.5, 65.1 and 63.7 lb/cow/day for cows fed mixes with 0, 40, 60 and 80% wheat).

Very little research on supplementing rations of ruminants with yeast cultures has been reported during the last two decades, although many nutritionists recommend their inclusion in rations for high producing dairy cows (McCullough, 1986). Rumen studies suggest that the inclusion of yeast cultures in diets for cattle enhance the number

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of cellulolytic bacteria and increase the digestibility of cellulose and the synthesis of microbial protein (Huber, 1987). In one recent report (Gomez-Alarcon et al., 1987) adding yeast to diets for dairy cows at a rate of 3g/d increased milk production and feed intake was noted. Arambel and Tung (1987), after having supplemented Holstein Heifer diets with yeast, found that cellulolytic bacteria numbers in the rumen and digestibilities of DM, protein and hemicellulose were increased.

Sniffen (1986) suggested that yeast products could provide the necessary amino acids to provide adequate isoacids for bacterial growth and action; however, no evidence for this was presented. Phillips and Von Tungeln (1985) found that the addition of yeast culture to the poststress diet of feeder calves did not increase either dry matter intake nor poststress performance. On the other hand, Fallon and Harte (1987) observed that DM intake and live weight of calves were increased when a barley/soya diet including yeast culture was given to calves.

Lassiter et al. (1958) reported that addition of live yeast culture at the rate of 1% of a grain ration had no significant effect on production of 4% fat-corrected milk, fat test or feed intake by dairy cows. Digestibility of crude protein and ether extract were significantly reduced upon inclusion of yeast in the ration and cows fed yeast gained less weight than those receiving a control ration. Similarly, Jordan and Ward (1959) found that a live yeast culture added at 2% of the grain mixture had no significant effect on milk production or fat test of Holstein cows.

Harris and Lobo (1987) in a study conducted with 2 groups of mid-lactation Holstein cows supplemented with 40 g of yeast culture/cow, found no significant differences on milk yield, fat, protein and FCM for cows starting and completing the 90 day study. Since groups were maintained at about 150 cows/group, some cows were removed each month and results showed a significant increase in milk fat, FCM and decrease in milk protein for cows entering the groups during the experiment.

Factors likely contributing to the variability in responses obtained to feeding live-cell yeast to ruminant animals include level of feed intake, number and kind of organisms in the yeast culture, viability of the cultures, and specific ingredient combinations comprising the rations. There is a need for information concerning responses that can be obtained from feeding yeast cultures currently available in the feed trade using ration combinations typical of those used in the livestock industry.

This research was conducted to explore the possibility that the addition of yeast culture to the concentrate mixture might impact the microbial action in the rumen of cows in a favorable manner that would be reflected in improved performance by cows when large amounts of wheat are fed.

Materials and Methods

The responses of lactating dairy cows to rations with and without yeast culture were measured in a well-controlled feeding trial. The experimental rations were: (1) typical corn-base concentrate mixture, (2) corn-base mixture plus yeast culture (YEA-SACC[4]), (3) high-wheat concentrate mixture, and (4) high-wheat mixture plus YEA-SACC. These

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[4]Product of Alltech Biotechnology Center, Nicholasville, KY.

concentrate mixtures constituted 50% of the total ration and alfalfa hay was the only forage (Table 1).

Twenty-four Holstein cows received the experimental rations in sequences of a switchback design with three 4-week periods. The first two weeks of each period were allowed for adjustment to rations with data from the final two weeks used for comparisons among treatments. The concentrate mixes were fed in individual stanchions in two equal portions twice daily at approximately 12-hour intervals. Alfalfa hay was fed in individual stalls once each day with an opportunity provided for the cows to consume hay during a second period approximately 12 hours later. The hay was fed approximately 4 hours after feeding of the concentrate mixtures. Samples of both concentrate mixes and hay were taken weekly for analysis.

Milk yield was recorded twice daily and samples were taken at four consecutive milkings each week for determination of fat and protein content. During the last week of each period, a rumen fluid sample (approximately 250 ml) was taken from each cow by stomach tube at 3 to 4 hours after concentrate feeding. The pH of the sample was determined immediately and an appropriate amount of sample was processed for later analysis for ruminal VFA and NH^3-N. Also, a sample of blood was obtained from the median caudal vein for determination of blood plasma urea-nitrogen concentration.

During the second period of the trial, chromium sesquioxide (Cr_2O_3) was mixed with the concentrate mixes for 20 cows at a concentration of .27% for use as an indigestible marker to permit calculation of apparent

Table 1. Composition of concentrate mixtures.

Item	Control (Corn-Base)	Yeast (Corn-Base)	Control (Wheat-Base)	Yeast (Wheat-Base)
Ingredients (%, as fed)				
Corn	65	65	18	18
Wheat[1]	--	--	60	60
Sorghum grain	6	6	--	--
Cottonseed meal, solv. ext.	9.5	9.5	2.5	2.5
Fixed portion[2]	19.5	19.5	19.5	19.5
Yeast culture(YEA-SACC)[3]	-	+	-	+
Calculated analysis (as fed)				
Net energy, Mcal NE /100 lb	75.6	75.6	76.7	76.7
Total protein, %	12.0	12.0	12.0	12.0
Rumen undegradable protein, %	5.8	5.8	3.3	3.3
Crude fiber, %	7.9	7.9	7.7	7.7

[1]Hard red winter wheat, No.2 grade.
[2]Fixed portion of concentrate mix: soybean hulls 15, dicalcium phosphate 2.0, salt .75, sodium bicarbonate 1.25, and magnesium oxide .5%.
[3]Product produced by ALLTECH, Nicholasville, KY; included in mix at level of 3 lb/ton.

digestibility of different nutrient components. Following a preliminary period of 10 days, fecal "grab" samples were collected at 4-hour intervals for a period of four days. Concentrate mixes, orts and feces were analyzed for chromium and these plus the hay were analyzed for dry matter, total protein and neutral detergent fiber.

Results and Discussion

The coefficient of variability for most variables measured was quite low (e.g., 3.4% for milk yield and 5.8% for total dry matter intake), indicating a high level of consistency in the responses of cows in the trial. Intake of dry matter by cows fed the concentrate mixtures containing wheat was lower ($P < .001$) than that of cows fed mixtures containing corn as the principal energy source. Intake of both concentrate and alfalfa hay were affected by grain type, indicating that factors other than palatability of the concentrate mixtures were involved (Table 2). Total protein content of all the rations was calculated to be the same; therefore, the larger amount of protein intake by cows fed rations containing corn simply reflected greater feed intake by those cows, especially with regard to protein derived from the forage component.

As previously observed in other trials, milk yield of cows fed concentrate mixtures containing corn was higher than that of cows fed mixtures containing 60% wheat (69.5 vs 67.0 lb/day). Milk fat test of cows fed the corn mixtures was also increased ($P < .01$), resulting in an advantage in 4% fat-corrected milk yield of 4.5 lb/day in comparison to that of cows fed the wheat mixtures. Neither yield nor fat content was

Table 2. Feed intake and milk yield of cows.

Item	Control (Corn-Base)	Yeast (Corn-Base)	Control (Wheat-Base)	Yeast (Wheat-Base)
Dry matter intake, lb/day				
Concentrate mix	26.6	26.2	24.6	23.9
Alfalfa hay	26.0	23.4	23.3	
Total	52.6	52.0	48.0	47.2
Protein intake, lb/day				
Concentrate mix	3.40	3.32	3.45	3.45
Alfalfa hay	5.43	5.40	4.94	4.89
Total	8.83	8.72	8.39	8.34
Milk yield				
Milk, lb/day	70.5	68.6	67.1	66.9
Fat test, %	3.36	3.48	3.17	3.22
FCM, lb/day	63.9	63.3	59.1	59.1
Protein, %	2.99	3.01	3.00	3.02
Gross feed efficiency (Milk/total DM intake)	1.35	1.33	1.41	1.43

affected by inclusion of yeast culture in the concentrate mixtures. Neither grain type nor addition of yeast culture affected milk protein content.

The molar percentage of acetic acid in the ruminal fluid at 3 to 4 hours after concentrate feeding was higher for cows fed the mixtures containing corn than for those fed mixtures with wheat (65.4 vs 60.9, Table 3). This was accompanied by a lower molar percentage of propionic acid in the rumen fluid of cows fed the corn mixtures compared to those fed wheat (21.9 vs 26.6) which was consistent with the observed differnce in milk fat content. No significant differences in VFA proportions were attributable to inclusion of yeast culture in the concentrate mixtures.

The pH of the ruminal fluid was higher in cows fed the corn mixtures than in those fed wheat (6.2 vs 5.9), which was consistent with the changes in VFA proportions noted above. These differences were consistent with other observations that both the protein and carbohydrate fractions of wheat are degraded very rapidly in the rumen of cows. Addition of yeast culture did not affect ruminal pH and neither grain type nor yeast culture had any effect on concentration of ruminal NH_3-N or blood plasma urea-N (Table 4).

Table 3. Effect of diets on molar proportion of ruminal VFA.

Acid	Control (Corn-Base)	Yeast (Corn-Base)	Control (Wheat-Base)	Yeast (Wheat-Base)
Acetic	65.61	65.10	60.94	60.88
Propionic	21.98	21.82	26.59	26.59
Isobutyric	.35	.45	.35	.33
Butyric	10.03	10.23	9.46	9.61
Isovaleric	1.02	1.22	.86	.86
Valeric	1.01	1.18	1.79	1.73

Table 4. Effect of diet on ruminal pH and NH_3-N concentration blood urea-N and total apparent digestibility of ration components

Item	Control (Corn-Base	Yeast (Corn-Base	Control (Wheat-Base	Yeast (Wheat-Base
Ruminal pH	6.18	6.27	5.86	6.01
Ruminal NH_3-N, mg/dl	4.6	5.2	4.5	5.0
Blood urea-N, mg/dl	12.4	12.3	12.0	12.9
Ration digestibility,%				
Dry matter	68.9	68.2	72.6	70.3
Total protein	65.4	64.5	71.2	69.8
Neutral-detergent fiber	58.4	58.4	63.6	58.3

Apparent digestibility of total dry matter and protein was lower for cows fed mixtures containing corn than for cows fed the wheat mixtures (Table 4). Thus, it appeared likely that both the site of digestion and the extent of total digestion was different for the two types of grain.

Since the carbohydrate of grains is mainly starch, the lack of a difference in apparent digestibility of NDF due to type of grain was not unexpected. Addition of yeast culture to the concentrate mixtures did not result in an increase in apparent digestibility of any of the ration components measured under the conditions of this trial. The possibility exists that different results might be obtained under conditions where all components of the ration are fed together in a complete ration.

Literature Cited

Arambel, M.J. and T. Tung. 1987. Fungal additives for lactating cows. Proc. Pacific N.W. Nutr. Conf., Portland, OR.

Cunningham, M.D., et al. 1970. Percent protein and amounts of soft red winter wheat for lactating cows. J. Dairy Sci. 53:1787-1790.

Faldet, M.A., et al. 1986. Influence of different levels of wheat in the concentrate mixture on production responses of lactating dairy cows fed alfalfa hay as the only forage. Okla. Agric. Exp. Sta. MP118:71-76.

Fallon, R.J. and F.J. Harte. 1987. The effect of yeast culture inclusion in the concentrate diet on calf performance. ADSA 82nd annual meeting. June 21. Pp 143.

Gomez-Alarcon, R, et al. 1987. Effect of aspergillus oryzae on rumen digestion and milk production in dairy cows. Rumen Function Conference. Nov. 18.

Harris B., Jr., and R. Lobo. 1988. Feeding yeast culture to lactating dairy cows. 65th Annual Meeting, Southern Dairy Sci. Assoc. January 31 1988.

Huber, J.T. 1987. Fungal additives for lactating cows. Proc. Pacific N.W. Nutr. Conf. Jordan, H. and G.M. Ward. 1959. Feeding value and in vitro performance of live yeast cultures. J. Dairy Sci. 42:1742.

Lassiter, C./A., et al. 1958. Effect of a live yeast culture and trimethylalkyammonium stearate on the performance of milking cows. J. Dairy Sci. 41:1077-1080.

McCullough, M.E. 1986. Feed for 20,000 pounds of milk - an update. Hoard's Dairyman. April 10. pp 357.

McPherson, R.G. and D.E. Waldern. 1969. Pacific Northwest soft white wheat for lactating cows. J. Dairy Sci. 52:84.

Phillips, W.A. and D.L. Vontungeln. 1985. The effect of yeast culture on the poststress performance of feeder calves. Nutrition Report International. August. 32:287.

Sniffen, C.J. 1986. Natural growth stimulators: Micronutrient requirements of the rumen - the role of yeast cultures in the rumen. Proc. Alltech's 2nd Annual Biotechnology Symposium.

HIGH PROTEIN WHEAT FOR SWINE

C.V. Maxwell[1], D.S. Buchanan[2], W.G. Luce[3], M.D. Woltmann[4] and R. Vencl[5]

Story In Brief

Swine producers are interested in high protein wheat as a means of reducing further the need for supplemental protein in wheat based diets. This study was conducted to compare the performance of growing-finishing swine fed diets containing a high protein wheat (Brawney) with those fed a common hard red winter wheat diet (TAM-105) or a corn based diet. During the growing and finishing periods, pigs fed the Brawney wheat diet had reduced average daily gain when compared to pigs fed the corn diet. Average daily gain between pigs fed the corn based diet and the TAM-105 wheat diet was not significant. Average daily feed intake was lowest in both the growing and finishing phase in pigs fed the Brawney wheat diet. Feed efficiency was not affected by grain source during the growing period. During the finishing period, feed required per unit of gain was higher in pigs fed the TAM-105 wheat based diet than those fed the corn based diet. This study suggest that Brawney wheat is inferior to either TAM-105 wheat or corn as the primary grain source in swine growing-finishing diets.

(Key words: Swine, Brawney Wheat, TAM-105 Wheat, Corn)

Introduction

Wheat in Oklahoma has periodically been competitively priced with other grains more commonly used in swine rations. The value of wheat as a feed grain is based primarily upon energy value of the grain, but the higher protein and lysine levels in wheat results in reduced protein supplement in the ration which also increases the value of wheat relative to other grains. Some producers have been interested in high-protein wheats which should reduce further the need for supplemental protein in swine rations. This study was conducted to compare performance of growing-finishing swine fed diets containing a high protein wheat (Brawney) with those fed a standard hard red winter wheat diet (TAM-105) or a corn based diet.

Materials and Methods

This trial was conducted at the Livestock and Forage Research Station at El Reno, Ok and consisted of 394 pigs in 25 pens equipped with self-feeders and nipple waterers. Pigs from a line selected for rapid growth for 6 generations and improved growth efficiency for one generation were randomly allotted within growth line to three dietary treatments (Table 1). The treatments consisted of: (1) a corn-soybeanmeal diet (2) a hard red winter wheat-soybean meal diet or (3) protein wheat-soybean meal diet. Both the hard red winter wheat (TAM-105) and the high protein wheat (Brawney) were produced at the Livestock

[1]Professor [2]Associate Professor [3]Regents Professor [4]Graduate Assistant [5]Herdsman.

Table 1. Composition of experimental rations.

Item	Grower Diets 1 Corn	2 TAM-105 Wheat	3 Brawney Wheat	Finisher Diets 1 Corn	2 TAM-105 Wheat	3 Brawney Wheat
	---% Composition (as-fed)---					
Corn, Yellow	77.12	--	--	82.65	--	--
Wheat	--	80.62	81.36	--	86.70	87.20
Soybean meal (44%)	19.03	15.75	15.00	14.06	10.25	9.75
Dicalcium phosphate	1.84	1.46	1.87	1.68	1.25	1.26
Calcium carbonate	.76	.92	.92	.76	.95	.95
Salt	.50	.50	.50	.50	.50	.50
Vit TM mix[a]	.25	.25	.25	.25	.25	.25
Aureomycin 10[b]	.50	.50	.50	.10	.10	.10
Calculated analysis						
% Protein	15.16	17.08	18.67	13.46	15.46	17.03
% Lysine	.75	.75	.75	.62	.62	.62
% Met + Cys	.53	.48	.48	.49	.44	.43
% Threonine	.60	.59	.58	.53	.51	.50
% Calcium	.75	.75	.75	.70	.70	.70
% Phosphorus	.65	.65	.65	.60	.60	.60

[a]Supplied 4,000,000 IU vitamin A, 3,000,000 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.
[b]Supplied 10g Aureomycin/lb.

and Forage Research Station in El Reno, OK. Analyzed protein and amino acid content of both wheat varieties are presented in Table 2. Diets were formulated, using the analyzed lysine value for the wheat varieties, to contain 0.75 percent lysine during the growing phase and 0.62 percent lysine during the finishing phase.

Results and Discussions

During the growing period, average daily gain was similar in pigs fed the corn-soybean meal (treatment 1) or the TAM-105 wheat soybean meal diet (treatment 4, Table 3). Pigs fed the Brawney wheat-soybean meal diet (treatment 3) grew 8.0 and 5.8 percent slower ($P<.01$) than those fed the corn or TAM-105, diets, respectively. Average daily feed intake was also lower ($P<.08$) in pigs fed Brawney wheat (treatment 3) than in pigs fed the corn based diet (treatment 1). Although actual feed required per unit of gain was higher for pigs fed the Brawney wheat-soybean meal diet, differences in efficiency of gain were not significant.

Table 2. Analyzed Composition of Wheat[a].

Item	Wheat Variety	
	Brawney	TAM-105
Crude Protein	14.84	12.63
Lysine	.39	.37
Threonine	.43	.36
Isoleucine	.49	.40
Valine	.63	.56

[a]Average of two samples of each variety.

Table 3. Comparison of two varieties of wheat with corn on performance of growing swine.

	Treatment		
	Corn 1	TAM-105 Wheat 2	Brawney Wheat 3
Pigs per treatment, no.	126	126	142
Pens per treatment, no.	8	8	9
Average daily gain, lb.	1.74[a]	1.70[a]	1.60[b]
Average daily feed intake, lb.	4.68[c]	4.58[cd]	4.41[d]
Feed per lb. gain, lb.	2.68	2.69	2.75

[a,b]Means in the same row with different superscripts differ (P<.01).
[c,d]Means in the same row with different superscripts differ (P<.08).

Average daily gain during the finishing phase (Table 4) followed the same pattern observed during the growing phase, although gain in pigs fed the TAM-105 wheat based diet (treatment 2) was more similar to gain observed in pigs fed the Brawney wheat based diet (treatment 3) than those fed the corn based diet (treatment 1). Pigs fed the corn diet grew more rapidly than those fed the Brawney wheat based diet (P<.07) whereas gain in pigs fed the TAM-105 wheat based diet was intermediary. Average daily feed intake was not significantly affected by source of grain in the diet although pigs fed the Brawney wheat based diet during the finishing phase again consumed the least feed. Feed

Table 4. **Comparison of two varieties of wheat with corn on performance of finishing swine.**

	Treatment		
	Corn 1	TAM-105 Wheat 2	Brawney Wheat 3
Pigs per treatment, no.	124	123	140
Pens per treatment, no.	8	8	9
Average daily gain, lb.	2.13^{a}	2.08^{ab}	2.07^{b}
Average daily feed intake, lb.	7.20	7.39	7.12
Feed per lb. gain, lb.	3.45^{c}	3.66^{d}	3.56^{cd}
Backfat, in.	1.42^{e}	1.38^{f}	1.39^{ef}

^{a,b}Means in the same row with different superscripts differ (P<.07).
^{c,d}Means in the same row with different superscripts differ (P<.05).
^{e,f}Means in the same row with different superscripts differ (P<.09).

required per pound of gain was increased by 6 percent (P<.05) in pigs fed the Tam-105 diet (treatment 2) when compared to those fed the corn diet (treatment 1). Feed efficiency in pigs fed the Brawney wheat diet was intermediary. Backfat thickness tended to be slightly higher in pigs fed the corn diet (treatment 1) although this difference approached significance (P<.09) only when compared to pigs fed the TAM-105 diet (treatment 2).

This study suggest that Brawney wheat is inferior to either TAM-105 wheat or corn as the primary grain in swine growing-finishing diets. In addition, the reduction in soybean meal needed with the higher protein Brawney wheat is minimal since Brawney wheat was only slightly higher in lysine. Although Brawney wheat was 17.5 percent higher in protein than TAM-105 wheat, lysine was only 5.4 percent higher.

RAW MUNGBEANS AS A PROTEIN SOURCE FOR GESTATING GILTS

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M.D. Woltmann[4], R. Vencl[5], S.A. Norton[4] and G.N. Dietz[4]

Story in Brief

A total of 546 crossbred gilts from six seasons were used to evaluate raw ground mungbeans as a partial replacement for soybean meal in diets of bred gilts. A control diet consisting of sorghum grain and soybean meal was fed in all six seasons. During three seasons the treated group was fed a similar diet with the supplemental protein being 89% mungbeans and 11% soybean meal (high level). In the other three seasons the treatment group was fed the control diet with the supplemental protein being 61% mungbeans and 39% soybean meal (moderate level). Feeding the high level of mungbeans resulted in decreased weight gain in gestation and less weight loss during lactation as compared to gilts fed the control diet. Little difference was noted in litter size at birth but litter size at 21 and 42 days for gilts fed the moderate level of mungbeans was less than those fed the control diet. Little difference was noted on survival rate to 21 or 42 days or individual and litter weights at birth and 21 days. When weighed at 42 days pigs from gilts fed the high level of mungbeans had a lower individual pig weight and less litter weight than pigs from gilts fed the control diet. This study suggests that moderate or high levels of mungbeans may result in decreased survivability to 21 and 42 days and decreased individual pig and litter weights at 42 days.

(Key words: Swine, Mungbeans, Reproductive Performance)

Introduction

Oklahoma is the leading state in mungbean production in the United States with 50,000 to 70,000 acres in production annually. During the harvesting and processing of mungbeans for the canning industry, the undersized beans or split-beans are of little economic value and have traditionally been utilized in livestock feeds.
In addition, overproduction has, at times, resulted in a depressed market and considerable interest in feeding the surplus beans to livestock.

Since mungbeans are high in protein (approximately 26%) and lysine (approximately 1.8%), they could be an alternative protein source and energy source for use in swine diets. However, growth inhibitors (sometimes referred to as trypsin inhibitors) are know to be present in raw mungbeans. The use of raw mungbeans may be limited in swine rations. Thus the objective of this study was to determine if the supplemental protein provided by soybean meal in a bred sow ration could be partially replaced by ground raw mungbeans.

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[1]Regents Professor, [2]Professor, [3]Associate Professor, [4]Graduate Student, [5]Herd Manager.

Experimental Procedure

A total of 546 crossbred gilts bred to crossbred boars (1983 fall, 1984 spring, 1984 fall, 1985 spring, 1985 fall and 1986 spring) were randomly allotted from two lines selected for rapid or slow growth to the dietary treatments. A control sorghum grain-soybean meal type diet (control) was fed each season (Table 1). In the first three seasons, the other dietary treatment (High level) was a sorghum grain based gestation diet with a combination of raw ground mungbeans and soybean meal providing the supplemental protein (Table 1). Mungbeans were included at a level at which tryptophan became limiting which resulted in a supplemental protein containing 89% mungbeans and 11% soybean meal with mungbeans providing 85% of the supplemental lysine.

In the last three seasons the treatment group (moderate level) was the gestation diet with one-half of the supplemental lysine supplied by mungbeans at the expense of soybean meal which resulted in supplemental protein containing 61% mungbeans and 39% soybean meal (Table 1).

In all seasons, gilts were housed outside in dirt lots during gestation and group fed five lb. of feed per head per day. At day 110

Table 1. Composition of experimental diets.

	Gestation diets			
	Control	Mungbeans moderate level	Mungbeans high level	
Ingredients, %	(1)	(2)	(3)	Lactation diets
Sorghum grain, ground	81.22	76.63	73.23	77.84
Soybean meal, 44%	14.39	7.30	2.48	17.82
Mungbeans, ground[a]	-----	11.51	19.80	-----
Dicalcium phosphate	1.76	1.86	1.91	1.68
Calcium carbonate	1.04	1.01	.99	1.07
Salt	.34	.34	.34	.34
Vitamin-trace mineral mix[b]	.25	.25	.25	.25
Chlorotetracycline[c]	1.00	1.00	1.00	1.00
Total	100.00	100.00	100.00	100.00
Calculated composition, %				
Protein	13.64	13.03	13.03	14.85
Lysine	.62	.62	.62	.68
Calcium	.84	.84	.84	.84
Phosphorus	.63	.63	.63	.63

[a]27.0, 1.86, 1.10, .82, .20 and .34% for crude protein, lysine, isoleucine, threonine, tryptophan and methionine + cystine, respectively.

[b]Supplied 800,000 IU Vitamin A, 80,000 IU Vitamin D, 3,400 IU Vitamin E, 800 mg riboflavin, 4,000 mg pantothenic acid, 5,400 mg niacin, 4 mg Vitamin B_{12}, 660 mg menadione sodium bisulfite, 1.5 g manganese, 13.6 g iron, 18 mg selenium, 3.6 mg iodine, 1.8 g copper and 18 g zinc per lb of premix.

[c]Supplied 200 g chlorotetracycline per ton of complete feed.

of pregnancy, gilts were moved to individual farrowing crates and litters were penned seperately until weaning at 42 days. Beginning at day 110, all gilts were fed a common lactation diet (Table 1) at a rate of 4.5 lb. per head per day until farrowing. After farrowing, the gilts were self-fed the lactation diet for the duration of the 42 day lactation period. Pigs had access to creep feed from 21 to 42 days of age.

Results and Discussion

Dietary treatment effects on weight change during gestation and lactation and subsequent reproductive performance is shown in Table 2. Feeding the high level of mungbeans (19.80% of the diet) decreased gestation weight gain as compared to the gilts fed the control diet ($P<.05$) or the moderate level of mungbeans (11.51% of the diet; $P<.05$). Conversely, gilts fed the high level of mungbeans lost less weight during lactation than those fed the other two treatments and were different ($P<.05$) than those fed the control diet. This is consistent with other studies where sow weight loss during lactation is greatest in sows which have the greatest weight gain during gestation.

No significant difference was noted among dietary treatments for litter size at birth but litter size at 21 and 42 days was less for

Table 2. The effect of feeding raw mungbeans to gestating gilts on weight change, litter size, survival rate and litter weight.

Item	Control (1)	Mungbeans moderate level (2)	Mungbeans high level (3)
No. gilts	289	116	141
Weight at breeding, lb	286.82	283.80	282.70
Gestation gain, lb	123.24^a	126.26^a	115.82^b
Lactation gain, lb	-34.48^a	-33.46^{ab}	-21.91^b
Litter size			
Birth	9.60	9.24	9.56
21 days	7.95^a	7.27^b	7.91^{ab}
42 days	7.72^a	7.15^b	7.72^{ab}
Survival rate, %			
Birth to 21 days	83.80	80.11	84.11
Birth to 42 days	81.43	78.93	82.01
Pig weight			
Wt at birth, lb	3.34	3.34	3.25
Wt at 21 days, lb	11.42	11.54	11.26
Wt at 42 days, lb	24.00^a	24.68^a	22.78^b
Litter weight			
Wt at birth, lb	31.54	30.48	30.24
Wt at 21 days, lb	89.19	84.13	86.52
Wt at 42 days, lb	181.50^c	176.18^{cd}	171.15^d

^{a,b}Means with different superscripts differ ($P<.05$).
^{c,d}Means with different superscripts differ ($P<.10$).

gilts fed mungbeans at the moderate level than those fed either the control diet or the high level of munbeans. Significant differences ($P < .05$) were noted for both litter size at 21 and 42 days between gilts on treatments 2 and 1. Variation in the mungbeans fed in the first three seasons (high level) as compared to the mungbeans fed the last three seasons (moderate level) may be the explanation for the decrease in litter size at 21 or 42 days for gilts fed the moderate level of mungbeans but not the high level of mungbeans.

Only small differences ($P > .10$) were noted among treatments for survival rate from birth to 21 or 42 days. However, gilts fed the moderate level of mungbeans (treatment 2) tended to have a lower survival rate than those fed the control diet or the high level of mungbeans.

Little difference was noted among treatments for individual pig weight or litter weights at birth or 21 days. However pigs from gilts fed the high levels of mungbeans had a lower average litter weights at 42 days ($P < .10$) than pigs from gilts fed the control diet. This study suggests that mungbean levels of 11.5 to 19.8% of the diet may result in decreased litter size at 21 and 42 days and decreased individual pig and litter weights at 42 days. Growth inhibitory factors in raw mungbeans may explain the decrease in reproductive performance shown in Table 2.

NUTRIENT COMPOSITION OF 15 VARIETIES OF OKLAHOMA SORGHUM GRAIN

W.G. Luce[1], C.V. Maxwell[2], S.E. Hawkins[3], D.W. Weibel[4], M.D. Woltmann[5], and L.E. Bulgerin[6]

Story in Brief

Fifteen varieties of hybrid sorghum grain grown in five Oklahoma locations for two years were analyzed for tannin, dry matter, crude protein, lysine, threonine, isoleucine, methionine, cystine and 12 additional amino acids. Significant differences among varieties were found for tannin, crude protein and lysine expressed as % of crude protein. Little differences among varieties were found for threonine, isoleucine and methonine + cystine expressed as % of sorghum grain or % of crude protein or lysine expressed as % or sorghum grain. Sorghum grain grown in non-irrigated locations was nearly 8% higher in crude protein than sorghum grain grown in irrigated locations but was nearly 6% lower in lysine when expressed as percent of crude protein. Bird resistant varieties were higher in crude protein, lysine as expressed as % of sorghum grain and tannin. These results suggest that significant nutrient composition differences exist among varieties of hybrid sorghum grain expecially between bird resistant and non-bird resistant varieties. Irrigated sorghum grain may also differ significantly in nutrient composition when compared to non-irrigated sorghum grain.

(Key words: Sorghum grain, Protein, Amino acids, Tannin)

Introduction

Sorghum grain is an important crop in Oklahoma with approximately 20 million bushels produced annually and is a major feed grain for livestock in the Southwestern U.S. Sorghum grain is usually characterized as being variable in nutrient content. Previous work at this institution has shown it to vary from 11.1 to 16.5% crude protein on a dry matter basis for nine different varieties. Research evaluating varieties of sorghum grain produced in Oklahoma for various amino acids and tannin was not available and very limited for crude protein and dry matter. Thus 15 varieties of sorghum grain grown in Oklahoma were analyzed for these components.

Experimental Procedure

All hybrid sorghum grain varieties were grown in 1984 and/or 1985 performance trials at five different Oklahoma Agricultural Experiment Branchs as shown in Table 1. No sorghum grain was harvested at Mangum in 1985 because of inadequate rainfall resulting in abandonment of the test plots.

[1]Regents Professor, [2]Professor, [3]Assistant Professor, [4]Professor Emeritus, [5]Graduate Student, [6]Laboratory Technician.

Table 1. Hybrid sorghum grain varieties analyzed.

	Location									
	Altus[a]		Goodwell[a]		Haskell[b]		Mangum[b]		Perkins[b]	
Variety	1984	85	1984	85	1984	85	1984	85	1984	85
Asgrow Chaparal	--	+	--	+	--	+	--	--	--	+
Asgrow Topaz	+	+	+	+	+	+	+	--	+	+
Dekalb DK-39Y	+	--	+	--	+	--	+	--	+	--
Dekalb DK-59E	--	+	--	+	--	+	--	--	--	+
Funk GS 384	--	+	--	+	--	+	--	--	--	+
Jacques 308	+	--	+	--	+	--	+	--	+	--
PAG 4462	+	+	+	+	+	+	--	--	+	+
PAG 5572	--	+	--	+	--	+	--	--	--	+
Paymaster BR90	+	+	+	+	+	+	--	--	+	+
Paymaster 930	+	--	+	--	+	--	+	--	+	--
Pioneer Brand B864	+	--	+	--	+	--	+	--	+	--
T-E-Dinero-E	+	+	+	+	+	+	+	--	+	+
T-E-Y 60	+	--	+	--	+	--	+	--	+	--
Warner W-744 DR	--	+	--	+	--	+	--	--	--	+
Warner W-840	+	+	+	+	+	+	+	--	+	+

[a] = Irrigated

[b] = Non-irrigated

+ = Variety grown in that location for respective year.

- = Variety was not grown in that location for respective year.

All sorghum grain samples were analyzed on a dry matter basis for tannin, dry matter, crude protein, lysine, threonine, isoleucine, methionine and cystine. Amino acid concentrates were determined from acid hydrolysates by ion exchange chromatography using a Beckman model 121 automatic amino acid analyzer. Values for methionine (an essential amino acid) and cystine (a non-essential amino acid) were combined in all the data reported since cystine can meet up to 50% of the methionine requirements of swine. Tannin content was estimated using the vanillin assay.

Results and Discussion

Least square means for dry matter, crude protein and tannin for each variety are shown in Table 2. Little differences were noted among varieties for dry matter with a range of only 88.64 to 89.32%. Crude protein values expressed on a dry matter basis among varieties were significant ($P < .01$) ranging in value from 10.86% for the Dekalb DK-39Y variety to 13.02% for Dekalb DK-59E.

The tannin content among varieties were significant ($P < .01$). This was expected since three of the varieties in the study were high tannin-bird resistant; Paymaster BR90, Pioneer Brand B864 and Warner W-744DR. These three varieties had a tannin content of 2.36, 2.51 and 2.51% respectively. The other 12 varieties ranged in tannin from .01 to .23%.

Table 2. Effect of variety on dry matter, crude protein and tannin content of sorghum grain.[a]

Variety	Dry Matter	Crude Protein[b]	Tannin[b]
	%	%	%
Asgrow Chaparral	88.84 ± .21[c]	12.48 ± .51[c]	.19 ± .27[c]
Asgrow Topaz	89.12 ± .14	11.28 ± .33	.10 ± .17
Dekalb DK-39Y	88.69 ± .19	10.86 ± .47	.06 ± .25
Dekalb DK-59E	88.80 ± .21	13.02 ± .51	.23 ± .27
Funk GS 384	88.73 ± .21	12.77 ± .51	.22 ± .27
Jacques 308	88.89 ± .19	12.61 ± .47	.01 ± .25
PAG 4462	89.09 ± .14	11.74 ± .30	.11 ± .19
PAG 5572	89.32 ± .21	12.71 ± .51	.17 ± .27
Paymaster BR 90	88.82 ± .14	11.42 ± .35	2.36 ± .19
Paymaster 930	88.86 ± .19	12.96 ± .47	.03 ± .25
Pioneer Brand B864	88.64 ± .19	12.12 ± .47	2.51 ± .25
T-E-Dinero-E	88.94 ± .14	11.73 ± .33	.09 ± .17
T-E-Y 60	88.94 ± .19	11.08 ± .47	.02 ± .25
Warner W-744 DR	88.75 ± .21	11.83 ± .51	2.51 ± .27
Warner W-840	89.21 ± .14	11.60 ± .33	.05 ± .17

[a]Percent of sorghum grain on a dry matter basis

[b]Significant differences among varieties ($P < .01$)

[c]Standard error

Least square means for lysine, threonine, isoleucine and methionine + cystine expressed as percent of sorghum grain on a dry matter basis are shown in Table 3. No significant differences ($P > .10$) were observed among varieties. Least square means for the same amino acid expressed as percent of crude protein is shown in Table 4. Little differences were noted among varieties for threonine, isoleucine and methionine + cystine. However, a difference among varieties for lysine expressed as percent of crude protein was significant ($P < .01$). Lysine threonine, isoleucine and methionine + cystine means for all varieties increased linearly as crude protein increased ($P < .01$). Partial correlation coefficients for lysine, threonine, isoleucine and methionine + cystine and crude protein were .55, .44, .83 and .36 respectively.

Two locations where sorghum grain samples were collected (Altus and Goodwell) were irrigated during both years while three locations (Haskell, Mangum and Perkins) were non-irrigated both years (Table 1). Nutrient differences between irrigated and non-irrigated (dry land) sorghum are presented in Table 5. Sorghum grain grown in non-irrigated plots was higher in crude protein ($P < .01$), isoleucine when expressed as percent of crude protein ($P < .05$) and methionine + cystine when expressed as % of crude protein ($P < .05$). Sorghum grain grown on irrigated plots was higher in lysine when expressed as percent of crude protein ($P < .01$) and threonine expressed as percent of crude protein ($P < .10$). Little difference was noted for other nutrients analyzed (Table 5). No significant differences ($P > .10$) between years among varieties were found for any nutrient analyzed. However, a significant treatment X year interaction for irrigated and non-irrigated sorghum grain was found (Table 6). Considerably less rainfall during the months of July and August in 1984 than in 1985 for the non-irrigated locations of Haskell and Perkins may explain the reduced yields and interaction.

Table 3. Effect of variety on lysine, threonine, isoleucine and methionine + cystine content of sorghum grain.[ab]

Variety	Lysine	Threonine	Isoleucine	Methionine + Cystine
	%	%	%	%
Asgrow Chaparral	.24 ± .01[c]	.39 ± .03[c]	.52 ± .03[c]	.37 ± .05[c]
Asgrow Topaz	.24 ± .01	.36 ± .02	.47 ± .02	.36 ± .03
Dekalb DK-39Y	.24 ± .01	.33 ± .03	.41 ± .03	.30 ± .04
Dekalb DK-59E	.26 ± .01	.40 ± .03	.51 ± .03	.35 ± .05
Funk GS 384	.25 ± .01	.39 ± .03	.49 ± .03	.36 + .05
Jacques 308	.27 ± .01	.40 ± .03	.51 ± .03	.31 ± .04
PAG 4462	.26 ± .01	.37 ± .02	.48 ± .02	.35 ± .03
PAG 5572	.27 ± .01	.41 ± .03	.51 ± .03	.43 ± .05
Paymaster BR 90	.27 ± .01	.35 ± .02	.46 ± .02	.29 ± .03
Paymaster 930	.24 ± .01	.37 ± .03	.52 ± .03	.36 ± .04
Pioneer Brand B864	.28 ± .01	.38 ± .03	.49 ± .03	.31 ± .04
T-E-Dinero-E	.25 ± .01	.38 ± .02	.48 ± .02	.32 ± .03
T-E Y-60	.25 ± .01	.36 ± .03	.45 ± .03	.33 ± .04
Warner W-744 DR	.25 ± .01	.27 ± .03	.47 ± .03	.32 ± .05
Warner W-840	.26 ± .01	.38 ± .02	.48 ± .02	.35 ± .03

[a] Percent of sorghum grain on a dry matter basis

[b] No significant differences among varieties ($P > .10$)

[c] Standard error

Table 4. Effect of variety on lysine, threonine, isoleucine and methionine + cystine expressed as % of crude protein.[a]

	Lysine[b]	Threonine	Isoleucine	Methionine + Cystine
	(% of CP)	(% of CP)	(% of CP)	(% of CP)
Asgrow Chaparral	1.95 ± .08[c]	3.12 ± .21[c]	4.20 ± .15[c]	2.99 ± .35[c]
Asgrow Topaz	2.12 ± .06	3.20 ± .14	4.18 ± .10	3.17 ± .22
Dekalb DK-39Y	2.27 ± .08	3.08 ± .19	3.85 ± .14	2.83 ± .32
Dekalb DK-59E	2.06 ± .09	3.01 ± .21	3.93 ± .15	2.62 ± .35
Funk GS 384	2.00 ± .09	3.01 ± .21	3.86 ± .15	2.88 ± .33
Jacques 308	2.14 ± .08	3.20 ± .19	4.07 ± .14	2.50 ± .32
PAG 4462	2.19 ± .06	3.19 ± .15	4.06 ± .10	2.94 ± .24
PAG 5572	2.14 ± .09	3.19 ± .21	4.03 ± .15	3.30 ± .35
Paymaster BR90	2.34 ± .06	3.09 ± .14	4.02 ± .10	2.61 ± .24
Paymaster 930	1.88 ± .08	2.83 ± .19	4.05 ± .14	2.75 ± .32
Pioneer Brand B864	2.28 ± .08	3.16 ± .19	4.06 ± .14	2.59 ± .32
T-E Dinero-E	2.15 ± .06	3.25 ± .14	4.10 ± .10	2.77 ± .22
T-E-Y-60	2.29 ± .08	3.29 ± .19	4.07 ± .14	3.03 ± .32
Warner W-744 DR	2.14 ± .09	2.38 ± .21	3.99 ± .15	2.70 ± .35
Warner W-840	2.26 ± .06	3.24 ± .14	4.14 ± .10	3.00 ± .22

[a] Dry matter basis

[b] Significant differences among varieties ($P < .01$)

[c] Standard error

Table 5. Irrigated vs. non-irrigated sorghum grain.

Item[a]	Irrigated	Non Irrigated	SEM[b]	Significance[c]
Crude protein, %	11.56	12.47	.17	**
Lysine, % of SG[d]	.25	.26	.004	
Lysine, % of CP[e]	2.21	2.08	.03	**
Threonine, % of SG	.36	.37	.01	
Threonine, % of CP	3.16	3.00	.07	†
Isoleucine, % of SG	.47	.50	.01	*
Isoleucine, % of CP	4.05	4.03	.05	
Methionine + Cystine				
% of SG	.31	.37	.02	*
% of CP	2.73	2.96	.11	
Dry matter, %	88.89	88.93	.07	

[a]Dry matter basis

[b]Standard error of mean

[c]** = $P<.01$, * = $P<.05$, † = $P<.10$

[d]SG = sorghum grain

[e]CP = crude protein

Table 6. Significant treatment X year interactions for nutrient content of sorghum grain.

Item	1984 Irrigated	1984 Non-Irrigated	1985 Irrigated	1985 Non-Irrigated
Crude protein, %**	11.18	13.23	11.93	11.72
Lysine				
% of crude protein**	.23	.20	.21	.22
Threonine				
% of sorghum grain*	.35	.40	.38	.35
Isoleucine				
% of sorghum grain*	.45	.53	.48	.47

** Significant season X treatment interaction ($P<.01$)
 * Significant season X treatment interaction ($P<.05$)

Table 7 compares nutrient composition of resistant vs. non-bird resistant varieties of sorghum grain. Paymaster BR90, Pioneer Brand B864 and Warner W-744DR were the bird resistant varieties with the remainder being non-bird resistant. Bird resistant varieties were higher in crude protein ($P<.10$), lysine expressed as % of sorghum grain ($P<.05$) and tannin ($P<.01$).

Non-bird resistant varieties were higher in threonine expressed as % of sorghum grain ($P<.05$), threonine expressed as % of crude protein ($P<.01$), isoleucine expressed as % of crude protein ($P<.10$), methionine + cystine expressed as % of sorghum grain ($P<.10$) and methionine + cystine expressed as % of crude protein ($P<.05$). Little difference was noted for lysine expressed as % of crude protein or isoleucine expressed as % of sorghum grain or dry matter.

Table 7. Resistant vs. non-bird resistant sorghum grain.

Item[a]	Bird Resistant	Non-bird Resistant	SEM[b]	Significance[c]
Crude protein	14.67	12.00	1.01	†
Lysine, % of SG[d]	.27	.25	.004	*
Lysine, % of CP[e]	2.16	2.12	.05	
Threonine, % of SG	.34	.38	.01	*
Threonine, % of CP	2.80	3.15	.09	**
Isoleucine, % of SG	.48	.49	.01	
Isoleucine, % of CP	3.83	4.06	.08	†
Methionine, + Cystine				
% of SG	.31	.35	.33	†
% of CP	2.52	2.89	.12	*
Dry matter, %	88.78	89.00	.08	
Tannin, %	2.42	.11	.09	**

[a]Dry matter basis

[b]Standard error of mean

[c]** = $P < .01$, * = $P < .05$, † = $P < .10$

[d]SG = sorghum grain

[e]CP = crude protein

These results suggest that significant nutrient composition differences occur among varieties of hybrid sorghum grain especially between bird resistant and non-bird resistant varieties. Irrigated and non-irrigated sorghum grain may also differ significantly in nutrient composition. Consideration of these variables is critical to the optimal utilization of sorghum grain.

FAT ADDITION TO WHEAT BASED DIETS FOR GROWING-FINISHING SWINE

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Story in Brief

A study involving a total of 398 growing-finishing swine was conducted to determine the effect of adding fat to wheat based diets on performance. Average daily gain during the growing and finishing periods was reduced by 8 and 4 percent, respectively in pigs fed a wheat-soybean meal diet compared to those fed the corn-soybean meal diet. Feed efficiency was similar between pigs fed the wheat or corn-soybean meal diet. Addition of fat to the wheat diet to provide a diet isocaloric with the corn-based diet (1.5 percent fat) improved gain and feed efficiency in the finishing, but not the growing period. Addition of fat at a level of 5 percent to the wheat-soybean meal diet improved gain by 6 and 5 percent, respectively in the growing and finishing phases when compared to pigs fed a wheat-soybean meal control diet. Similarly, feed efficiency was improved by 6.0 and 10 percent during the growing and finishing phase, respectively by the addition of 5 percent fat. Backfat was increased in pigs fed the high fat diet when compared to those fed the wheat-soybean meal diet. This study suggests that adding fat to wheat based diets may improve gain and efficiency in growing-finishing swine to levels equivalent to those observed in pigs fed corn based diets.

(Key words: Swine, Wheat, Corn, Fat)

Introduction

A summary of studies comparing wheat with corn based diets at Oklahoma State University indicate that gain and efficiency are reduced slightly when wheat is substituted for corn in swine growing-finishing diets. One possible explanation for these differences in performance may be due to the lower fat and energy content of wheat. Diets formulated on an equal energy basis, as is commonly the procedure used by large swine feeding companies and the feed manufacturing industry, may result in a more favorable comparison of wheat vs. corn. Fat is the dietary constituent commonly used to adjust energy levels in swine diets. This experiment was conducted to determine the effect of adding fat on performance of growing-finishing swine fed wheat based diets.

Materials and Methods

This study was conducted at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma and involves a total of 26 pens and 398 growing-finishing swine. All diets were formulated to contain 0.75 percent lysine during the growing phase pig weights of (43 to 121 lb.) and 0.65 percent lysine during the finishing phase pig weights of (121 to 225 lb.). The four treatments (Table 1) were : (1) a control

[1]Professor [2]Regents Professor [3]Associate Professor [4]Graduate Assistant
[5]Herdsman

Table 1. Composition of Experimental Rations.
Growing Phase

Ingredients	Corn	Wheat	Wheat + 1.50% fat	Wheat + 5.00% fat
	Treatment			
	Composition (as-fed)			
Wheat, hard red winter		80.62	78.95	75.17
Corn	77.12	--	--	
Soybean meal, 44%	19.03	15.75	15.60	15.00
Fat (80%)[a]	--	--	1.83	6.25
Dicalcium phosphate	1.84	1.46	1.45	1.35
Calcium carbonate	0.76	0.92	0.92	0.98
Salt	0.50	0.50	0.50	0.50
Vitamin TM Premix[b]	0.25	0.25	0.25	0.25
Aureomycin 10[c]	0.50	0.50	0.50	0.50
Calculated Composition				
Metabolizable energy, kcal	1446	1412	1446	1522
Crude protein, %	15.16	16.77	16.79	16.77
Lysine, %	0.75	0.75	0.75	0.75
Ca, %	0.75	0.75	0.75	0.75
P, %	0.65	0.65	0.65	0.65
Finishing Phase				
Wheat, hard red winter	--	80.70	84.75	81.25
Corn	82.65	--	--	
Soybean meal, 44%	14.06	10.25	10.25	9.50
Fat (80%)[a]	--	--	1.95	6.25
Dicalcium phosphate	1.68	1.25	1.25	1.15
Calcium carbonate	0.76	0.95	0.95	1.00
Salt	0.50	0.50	0.50	0.50
Vitamin TM premix[b]	0.25	0.25	0.25	0.25
Aureomycin 10[c]	0.10	0.10	0.10	0.10
Calculated Composition				
Metabolizable energy, kcal	1456	1420	1456	1530
Crude protein, %	13.46	15.09	15.16	15.09
Lysine, %	0.62	0.62	0.62	0.62
Ca, %	0.70	0.70	0.70	0.70
P, %	0.60	0.60	0.60	0.60

[a]Dry Fat 480, Merrick Foods, Middleton, Wisconsin.
[b]Supplied 4,000,000 IU vitamin A, 3,000,000 IU vitamin D, 4g riboflavin, 20 g pantothentic acid, 30 g niacin, 800 g choline chloride, 15 mg vitamin B12, 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.
[c]10g Aureomycin per lb.

corn-soybean meal diet; (2) a control hard red winter wheat-soybean meal diet; (3) a hard red winter wheat-soybean meal diet with a dry fat product added at a level to provide metabolizable energy levels equivalent to the calculated metabolizable energy level in the corn based diet; (4) a hard red winter wheat-soybean meal diet with fat added at a level of 5 percent of the diet. NRC (1979) metabolizable energy values were used for wheat and corn. A metabolizable energy value of 1475 and 3206 kcal per pound was used for soybean meal and dry fat, respectively.

Results and Discussion

During the growing period (Table 2), pigs fed a wheat-soybean meal based diet (treatment 2) grew 8 percent slower (P<.05) than those fed the corn-soybean meal diet (treatment 1). Addition of fat at a level to produce a diet equivalent in energy with the corn-soybean meal diet failed to improve gain over that observed for pigs fed the wheat-soybean meal diet (treatment 2 vs. treatment 3). Addition of fat at the 5 percent level (treatment 4), however, improved average daily gain 6 percent (P<.05) when compared to pigs fed the wheat-soybean meal control diet (treatment 2) and resulted in gains similar to those observed in pigs fed the corn-soybean meal diet (treatment 1). Feed efficiency was similar in pigs fed the corn-soybean meal diet and the wheat-soybean meal diets (treatments 1 and 2). Addition of 5 percent fat (treatment 4) improved feed efficiency by 6 percent (P<.05) when compared to pigs fed the wheat control diet or the wheat-soybean meal diet with 1.5 percent added fat (treatment 2 and 3, respectively). Differences in feed intake were not significant.

During the finishing phase (Table 3), pigs fed the wheat based diet (treatment 2) grew 4 percent slower (P<.05) than those fed the corn based diet (treatment 1). Addition of fat to provide an energy level equivalent to that in pigs fed the corn based diet (treatment 3) or at a level of 5 percent of the diet (treatment 4) improved average daily gain

Table 2. The effect of fat on performance of growing swine (43-121 lb.).

	Treatments			
	1 Corn-soy	2 Wheat-soy	3 Wheat-soy + 1.5% fat	4 Wheat-soy + 5% fat
Pigs/treatment, no.	102	105	95	96
Pens/treatment, no.	7	7	6	6
Avg. initial wt.,lb.	42.2	43.3	41.2	44.1
avg. final wt.,lb.	120.8	119.7	117.8	124.4
Avg. daily gain, lb.	1.78[a]	1.63[b]	1.64[b]	1.72[a]
Avg. daily feed intake, lb.	4.70	4.35	4.37	4.31
Feed/lb. gain, lb.[c]	2.65[ab]	2.69[a]	2.69[a]	2.52[b]

[a,b] Means in the same row with a different superscript differ (P<.05).
[c] Treatment 1 and treatment 4 differ (P<.07).

Table 3. Effect of fat on performance of finishing swine (123 lbs. to market).

	Treatments			
	1 Corn-soy	2 Wheat-soy	3 Wheat-soy + 1.5% fat	4 Wheat-soy + 5% fat
Pigs/treatment, no.	102	102	94	96
Pens/treatment, no.	7	7	6	6
Avg initial wt.,lb.	120.8	119.7	117.8	124.4
Avg final wt., lb.	222.4	223.5	226.7	229.7
Avg daily gain, lb.	2.04[a]	1.96[b]	2.02[ab]	2.06[a]
Avg daily feed intake,lb.[c]	6.90[a]	6.65[ab]	6.48[ab]	6.37[b]
Feed/lb. gain, lb.[d]	3.47[a]	3.52[a]	3.30[b]	3.17[b]
Adj. backfat, in.	1.23[ab]	1.21[a]	1.23[ab]	1.25[b]

[a,b] - Means in the same row with a different superscript differ ($P<.05$).
[c] - Treatment 1 and treatment 3 differ ($P<.08$).
[d] - Treatment 3 and treatment 4 differ ($P<.09$).

to levels similar to gains observed in pigs fed the corn-soybean meal control diet (treatment 1). Average daily feed intake was lower (P<.05) in pigs fed the diet with 5 percent added fat (treatment 4) when compared to pigs fed the corn-soybean meal control diet (treatment 1). Addition of 1.5% fat (treatment 3) tended (P<.08) to reduce feed intake when compared to intake of pigs fed the corn control diet (treatment 1). As was observed in the growing phase, feed efficiency was similar between pigs fed the corn-soybean meal control diet (treatment 1) or the wheat soybean meal control diet (treatment 2). Addition of fat to the wheat-soybean meal diet (treatment 2) to provide a calculated metabolizable energy level equivalent to that of pigs fed the corn-soybean meal diet (treatment 3) improved feed efficiency by 5 percent (P<.05). Addition of fat at the 5 percent level (treatment 4) resulted in an additional improvement in feed efficiency (treatment 3 vs. treatment 4; P<.09) resulting in a total improvement in efficiency of feed utilization of 8.6% (treatment 2 vs treatment 4; P<.05). Adding fat at the 5 percent level, but not the 1.5% level increased backfat (P<.05).

This study suggest that adding fat to swine rations to provide calculated metabolizable energy levels equivalent to those in swine fed a corn-soybean meal diet (1.5% fat) had no effect on gain or feed efficiency during the growing period (43 lbs. to 121 lb.). However, during the finishing period (121-225 lbs.) the addition of 1.5 percent fat resulted in improved average daily gain and feed efficiency. The improvement in feed efficiency during the finishing phase was greater than one would expect based upon the calculated metabolizable energy of the diet suggesting that the metabolizable energy estimates for wheat during the finishing phase may be low or the addition of fat may result in a decrease in feed wastage. This is consistent with the improved feed efficiency and a trend for a reduced feed intake in finishing swine fed the wheat based diet containing 1.5% fat when compared to those fed the corn based diet. The addition of 5 percent fat in both the growing and finishing period resulted in an improvement in average daily gain and feed efficiency when compared to pigs fed a wheat-soybean meal diet without added fat. Although a significant increase in backfat was observed in pigs fed the wheat based diet with 5 percent fat (treatment 4) when compared to pigs fed the wheat control diet with no added fat (treatment 2), it should be noted that this increase was small and resulted in a backfat thickness similar to that observed in pigs fed the corn control diet (treatment 1). Additional studies are needed to determine why small amounts of added fat may result in improvement in performance of finishing but not growing swine fed wheat based diets.

Literature Cited

NRC. 1979. Nutrient Requirements of Swine. National Academy of Sciences, Washington, D.C.

EFFECT OF SWINACOL[a] (FERRIC CHOLINE CITRATE) ON PERFORMANCE OF EARLY WEANED PIGS

W.G. Luce[1], C.V. Maxwell[2], R.D. Coffey[3] and K.S. Brock[4]

Story in Brief

A three week feeding trial involving 68 pigs was conducted to determine the effect of feeding Swinacol, a commercial product, on the performance of early weaned pigs. The two treatments were a control complex 1.3% lysine starter diet and the control diet with five pounds of Swinacol added per ton of feed. Little differences were noted between the two treatments. The failure of Swinacol to improve performance is probably because the starter diet provided all known minerals and vitamins required for pigs this age plus two growth promotors.

(Key words: Ferric Choline Citrate, Early Weaned Pigs)

Introduction

Number of pigs weaned per sow per year is a highly important economic trait in swine production. Producers have increasingly gone to early weaning (3-4 weeks) in an effort to increase the number of pigs produced per sow per year. A palatable, 1.3% lysine diet that is well fortified with minerals, vitamins and other feed additives is essential for early weaned pigs. The purpose of this trial was conducted to see if "Swinacol", primarily an iron supplement containing ferrous fumerate and ferric choline citrate plus additional minerals and vitamins would improve performance of early weaned pigs fed the standard Oklahoma State University 1.3% lysine starter diet.

Experimental Procedure

A three week feeding trial involving a total of 68 pigs (two replications of 32 and 36 pigs respectively) was conducted to determine the effect of feeding Swinacol, a commercial product, on the performance of early weaned pigs. In both replicates, pigs were weaned and randomly allotted within litter to two treatment groups at an average age of 26 days. The treatments were a control complex 1.3% lysine starter diet (Treatment 1) as shown in Table 1 and the control diet with five pounds of Swinacol added per ton of complete feed (Treatment 2).

Pigs were individually fed in metal cages in an environmentally controlled room. Temperature was maintained at 86 F during the first week of the trial and lowered to 3 F weekly for the duration of the three week trial. Pigs had ad libitum access to feed and water throughout the trial. Feed wastage was measured by placing metal containers under each feeder and making weekly determinations of weight and dry matter content of the waste feed. This results in a more accurate measure of feed intake.

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[a]Agri-Star, Inc., Louisburg, KS 66053

Table 1. Composition of control diet.

Ingredient	%
Corn, ground	36.08
Soybean meal, 44%	31.50
Whey, dried	30.00
Dicalcium phosphate	.90
Calcium carbonate	.82
Vitamin-trace mineral mix[a]	.40
ASP-250[b]	.25
Copper sulfate	.05
Total	100.00
Calculated composition	
M.E., kcal/lb	1438.00
Crude protein, %	20.60
Lysine, %	1.30
Calcium, %	.90
Phosphorus, %	.70

[a]Supplied 800,000 IU of Vitamin A, 80,000 IU Vitamin D, 3,400 IU Vitamin E, 800 mg riboflavin, 4,000 mg pantothenic acid, 5,400 mg niacin, 4 mg Vitamin B_{12}, 600 mg menadione sodium bisulfate, 50,000 mg choline chloride, 18 g zinc, 18 g iron, 5 g manganese, 36 mg iodine, 2 g copper and 18 mg of selenium per pound of premix.
[b]Supplied 200 g chlorotetracycline, 100 g sulfamethazine and 50 g penicillin per ton of feed.

Pigs were observed daily to determine if feed was being consumed. Pigs not consuming feed for two consecutive days were removed from the experiment. In replicate 1, a total of five pigs were removed with four removed from Treatment 1 (Control) and one pig removed from Treatment 2 (Swinacol). In replicate 2, two pigs were removed from Treatment 1 and one pig removed from Treatment 2.

Results and Discussion

Performance data for the combined replicates is presented in Table 2. Performance in replicate 2 was superior to that observed in replicate 1 resulting in a replicate effect for average daily gain, feed intake and feed efficiency. However, the effect of treatment was consistent across replication resulting in only one significant ($P<.05$) replicate X treatment interaction for average daily feed intake for week 2 of the trial.

Little differences were noted in average daily gain except in week 3 when the pigs on Treatment 1 (Control) gained more ($P<.05$) than the pigs on Treatment 2 (Swinacol). Overall average daily gain for the three week trial were .81 and .75 lb per day for Treatment 1 and 2 respectively.

Table 2. The effect of swinacol on performance of early weaned pigs.

Item	Treatment 1[a] (Control)	Treatment 2[a] (Swinacol)
Avg. daily gain, lb.		
Week 1	.51	.48
Week 2	.55	.56
Week 3[b]	1.38	1.21
Overall (week 1-3)	.81	.75
Avg. daily feed intake, lb		
Week 1	.74	.70
Week 2	1.28	1.16
Week 3	1.70	1.70
Overall (week 1-3)	1.24	1.18
Feed per lb gain, lb		
Week 1	2.12	1.64
Week 2	2.63	2.22
Week 3[b]	1.10	1.39
Overall (week 1-3)	1.56	1.59

[a]Least square means
[b]Significant difference between treatments ($P<.05$)

Little differences were noted in average daily feed intake or feed required per pound of gain except in week 3 when the pigs on Treatment 1 (Control) required less ($P < .05$) feed per pound of gain than pigs on Treatment 2 (Swinacol). Overall average daily feed intake for the three week trial were 1.24 and 1.18 lb and overall feed required per pound of gain were 1.56 and 1.59 lb for treatments 1 and 2 respectively.

The control ration in this study is a palatable, complex starter ration that is well fortified in all known minerals and vitamins that are required for pigs of this age and contains two growth promotors (ASP-250 and copper sulfate). This probably accounts for the failure of Swinacol to further improve performance in this study.

EFFECTS OF POTASSIUM CHLORIDE AND FASTING ON BROILER PERFORMANCE DURING SUMMER

M.O. Smith[1] and R.G. Teeter[2]

Story in Brief

A study utilizing 1120 broilers was conducted to evaluate the effects of fasting and potassium chloride supplementation on the performance of broilers reared on floor pens during naturally occuring summer conditions. Daily 12-hour feed withdrawal for the four week duration of the experiment reduced total feed consumption but did not significantly depress body weight gain. Addition potassium chloride had no effect in feed consumption or body weight gain. Broiler body temperature was reduced and survival enhanced by the fasting and potassium chloride treatments.

(Key Words: Fasting, Potassium Chloride, Summer Stress, Survival.)

INTRODUCTION

Floor pen studies provide an experimental method which permits simultaneous comparison of groups of birds on various treatments. Similar data on production efficiency may be obtained from large field experiments but require much greater expenditure. In contrast, less expensive laboratory experiments provide only limited data on production efficiency under commercial conditions.

The broilers' capacity to tolerate high temperatures can be enhanced by feed restriction (McCormick et al., 1979; Smith and Teeter, 1987a). Food in the digestive tract during periods of hyperthermia influences the rate of change in body temperature and affect survival. A depression in growth rate is observed when post brooding temperatures exceed 75 F. It has been theorized that this decline is a direct result of the reduced feed intake (Squibb et al., 1959). Reduced consumption of a complete diet implies a reduction in intake of proteins and other nutrients, which independent of fluctuating animal nutrient replacements, could account for the growth rate depression. Although fasting increases survival because the reduction in food intake reduces body temperature, the expected decline in growth may offset the benefits of increased survival. Environmental chamber studies have demonstrated body weight gain of broilers to be unaffected by the fasting exercise (Smith and Teeter, 1987a), however, floor pen studies under more producer-oriented conditions are needed to confirm or refute these findings. Body weight gain of heat stressed broilers has been reported to increase with potassium chloride supplementation (Teeter and Smith, 1986; Smith and Teeter, 1987b) while potassium chloride and fasting have been shown to have additive effect on survival (Smith and Teeter, 1987c).

[1]Research Associate [2]Associate Professor

The objective of this study was to evaluate the effects of feed withdrawal and potassium chloride supplementation on the performance of pen-reared broilers subjected to naturally occuring heat stress.

MATERIALS AND METHODS

Commercial broiler chicks were raised on a common rice hull covered floor pen and fed a corn-soybean meal based diet until they reached four weeks of age. On day 28, 1120 birds were randomly allocated to 32 pens within a floor-pen house and assigned to four treatments of 8 replicates each in a randomized block design. A growing-finishing diet (Table 1) was fed for the duration of the trial. Treatments evaluated were full feed with no water additive, .48% KCl in water, tap water with birds fasted for 12 hours and a combination of fasting and KCl. Birds on the fasted treatments had their feed removed at 0600 hours and replaced at 1800 hours daily. During the 56 day experimental period the high ambient temperature ranged from 88 F to 102 F while relative humidity varied from 66% to 95%. On day 54, four samples of litter from each pen were collected, composited and moisture content determined. Body temperature was determined on five birds per pen on day 55, when the ambient temperature was 95 F. Feed and water consumption were monitored and totals calculated at experiment termination. On day 56, feed weigh-back was determined by removing feed from each block of pens before proceeding to the next block. Birds were group weighed by pen and final body weight recorded.

RESULTS AND DISCUSSION

Live weight at eight weeks, feed consumption and feed efficiency values are shown in (Table 2). There was a trend for the birds receiving potassium chloride and for fasted birds to weigh less than control birds although the differences was not significant. Both feed withdrawal and potassium chloride supplementation reduced total feed consumed. Feed efficiency was improved for the fasted birds and for those that were fasted as well as supplemented with potassium chloride. Total water consumption was increased by potassium chloride but not fasting (Table 3), while body temperature was decreased by both

Table 1. Composition of basal diet.

Ingredient	Percent
Ground Corn	56.80
Soybean Meal	36.00
Tallow	3.00
Dicalcium Phosphate	2.35
Calcium Carbonate	.90
Salt	.50
Vitamin Mix	.25
Trace Mineral Mix	.10
DL-Methionine	.10

[1]Diet calculated to contain .89% K, .22% Na and .34% CL

Table 2. Body weight, feed consumption and feed efficiency of broilers.

	Avg. Wt At Eight Weeks (g)	Avg. Feed Consumed (g)	Gain/Fed
Control	2920[a]	6733[a]	.43[b]
KCl	2858[a]	6363[b]	.45[b]
Fasted	2859[a]	5895[c]	.48[a]
KCl + Fasted	2659[b]	5356[d]	.49[a]

[abc]Means in columns with unlike superscripts differ (P<.05)

Table 3. Water consumption, body temperature and survival of heat stressed broilers.

	Water Cons. (l)	Body Temp. (C)	Survival (%)
Control	17.6[b]	109.6[a]	85.4[c]
KCl	20.3[a]	108.1[c]	90.4[bc]
Fasted	18.1[b]	108.7[b]	95.4[ab]
KCl + Fasted	19.4[a]	107.8[d]	98.2[a]

[abcd]Means in columns with unlike superscripts differ (P,.05)

treatments. Control birds experienced 15% mortality as a result of the high environmental temperature but the addition of potassium chloride to the drinking water and feed withdrawal resulted in an increase in the number surviving to market by 7 to 14% (Table 3).

The usual result of heat stress imposition is lowered production. Data reported here indicates that feed and water management during the summer can offset the detrimental effects of heat stress. Feed removal during the heat of the day and the encouragement of increased water consumption serve to reduce body temperature by decreasing the total heat load being experienced by the bird. An increase in survival and consequently an increase in the total number of birds reaching market will counter any slight body weight reduction attributed to the fasting exercise.

LITERATURE CITED

McCormick, C.C. et al., 1979. Fasting and diet affect the tolerance of young chickens exposed to acute heat stress. J. Nutr. 107:1979

Smith, M.O. and R.G. Teeter,1987a. Body weight gain of fasted heat stressed broilers. Okla. Agr. Exp. Sta. Res. Rep. MP-119:165.

Smith, M.O. and R.G. Teeter, 1987b. Potassium balance of the 5 to 8-week old broiler exposed to constant heat on cycling high temperature stress and the effects of supplemental potassium

chloride on body weight gain and feed efficiency. Poultry Sci. 66:487.
Smith, M.O. and R.G. Teeter, 1987c. Effects of potassium chloride and fasting on broiler performance under simulated summer conditions. Okla. Agr Exp. Sta. Res Rep. MP-119:161.
Squibb, R.L. et al., 1959. Growth and blood constituents of immature New Hampshire fowl exposed to constant temperature of 99F for 7 days. Poultry Sci. 38:270.
Teeter, R.G. and M.O. Smith, 1986. High chronic ambient temperature stress effects on broiler acid-base balance and their response to supplemental ammonium chloride potassium chloride and potassium carbonate. Poultry Sci. 65:1777.

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TABLE OF EQUIVALENTS

U.S. Metric

Length:

1 inch = 2.54 centimeters
1 foot = 30.48 centimeters
= 0.3048 meters
1 yard = 0.9144 meters
1 mile = 1609.34 meters
= 1.609 kilometers

Area:

1 square inch = 6.452 sq. centimeters
1 sq. foot = 0.0929 sq. meter
1 sq. yard = 0.8361 sq. meter
1 acre = 0.4047 hectare
1 sq. mile = 259.0 hectares

Volume:

1 cubic inch = 16.387 cu. centimeter
1 cu. foot = 0.0283 cu. meter
1 cu. yard = 0.7646 cu. meter
1 fluid ounce = 29.573 milliliters
1 pint = 0.4732 liter
1 quart = 0.9463 liter
1 gallon = 3.7853 liters

Weight:

1 ounce = 28.50 grams
1 pound = 453.592 grams
= 0.4536 kilogram
1 ton = 907.2 kilograms

Metric U.S.

1 millimeter = 0.03937 inch
1 centimeter = 0.3937 inch
1 meter = 39.37 inches
= 3.281 feet
= 1.094 yards
1 kilometer = 0.6214 mile

1 sq. centimeter = 0.155 sq. inch
1 sq. meter = 1.196 sq. yards
= 10.764 sq. feet
1 hectare = 2.471 acres
1 sq. kilometer = 0.386 sq. mile
= 247.1 acres

1 cu. centimeter = 0.061 cu. inch
1 cu. meter = 35.315 cu. feet
= 1.308 cu. yards
1 milliliter = 0.0338 ounce
1 liter = 33.81 ounces
= 2.1134 pints
= 1.057 quarts
= 0.2642 gallon
1 kiloliter = 264.18 gallons

1 gram = 0.03527 ounce
1 kilogram = 35.274 ounces
= 2.205 pounds
1 metric ton = 2204.6 pounds
(1,000 kg)

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