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To: Clientele in Animal Agriculture

Re: 1991 Animal Science Research Report

On behalf of our Animal Science Research team, we take this opportunity to forward our 1991 Annual Research Report to you. The report covers our wide array of Animal Science research activities and provides you with a current, timely report on important findings.

Animal agriculture is the largest segment of Oklahoma and United States agriculture. Twenty-two to twenty-five percent of all jobs in the U.S. are related to agriculture, including food production, processing and distribution. The discovery of new technology and the implementation of it have allowed U.S. agriculture to be the most progressive and efficient in the world. We are pledged to the continued development, dissemination and implementation of new technology to better serve animal agriculture and all citizens, domestically and worldwide. Many new challenges lie at our doorstep; these include not only the traditional challenges of continuing to improve efficiency and understanding of the fundamentals of biology and biological processes, including their manipulation, but also timely concerns regarding environmental, water quality, waste management, food safety, food processing, product development, diet-health, animal rights, genome mapping and other issues important to all of us.

We trust the research reports herein will prove informative and useful to you.

Yours truly,

Don

Donald G. Wagner
Head, Animal Science Department

DGW/csw

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Confidence in Research Results

Viability 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 likely that the treatment caused the differences that were observed.

In some articles there are table 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 studies 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 value 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.

In as far as possible, research reported in this publication was conducted conforming to the Guide for the Care and Use of Agricultural Animals in Agricultural Research and Teaching (1988). Testing of feed additives, drugs and other pharmaceuticals was done in accordance with appropriate Food and Drug Administration regulations. Slaughter of meat animals, collection of dairy products and further processing of animal food products was conducted under appropriate health regulations and USDA inspection.

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EVALUATION OF SALERS CROSSBRED COWS IN A COMMERCIAL COW HERD

D.S. Buchanan[1], D.K. Darnell[2] and J. Dhuyvetter[3]

Story in Brief

This study was conducted for the purpose of evaluating the Salers breed as a component of a commercial cow herd. Fifty Salers-Hereford heifers, 28 Angus-Hereford heifers and 29 Hereford heifers were managed together for a period of three years on a commercial cattle ranch in northwest Wyoming. Salers-Hereford cows had the heaviest calves at 205 days and there were only minor differences in birth weight, calving difficulty and cow condition score. The advantage in 205-day weight over calves from the Angus-Hereford cows was not as large as the advantage over Hereford. Salers-Hereford cows produced the most calves, on average, during the three years of the study and the total weight, over three years, of their calves was 415 and 153 lb more than calves from Hereford and Angus-Hereford cows, respectively.

(Key Words: Beef Cattle, Breeds, Birth Weight, Weaning Weight, Salers.)

Introduction

The Salers (pronounced Sah-lairs) is a breed of beef cattle with a relatively short history in the United States. The breed originated in a mountainous area of France which may suggest hardiness and an ability to withstand harsh conditions. To date, Salers cattle have not been evaluated extensively in North America. This research was initiated with the intent of evaluating the breed, as a component of a crossbred cow herd, under range conditions. This report contains results from the entire experiment which was planned to last three years. Preliminary reports were presented previously (Buchanan et al., 1989, 1990).

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Materials and Methods

Pregnant yearling heifers, representing three breed groups, were set aside from the herd at the Pitchfork Ranch near Meteetse in northwest Wyoming. There were 50 Salers x Hereford, 28 Angus x Hereford and 29 straightbred Hereford heifers. All females were managed together for the duration of the study.

Calves were sired by Angus or Salers bulls and were born during January to April of each year. Each calf was weighed within 24 hours of birth and a calving ease score was assigned (1 = no difficulty, 2 = minor difficulty, 3 = major difficulty). Calves were weaned at approximately eight months of age. A weaning weight was obtained and adjusted to 205 days. At weaning, pregnancy status of each cow was determined and cow condition score was evaluated (1 = emaciated to 9 = obese). Non-pregnant females were culled. The number of calves produced by each female and the total weight of those calves was determined following weaning of the third year.

Data on yearly calf performance and cow condition were analyzed by ordinary least squares procedures with breed of female, year, sire breed (Angus or Salers), sex, age of the dam and appropriated two-way interactions in the model. The total number and weight of calves and the third year pregnancy status were analyzed by ordinary least squares with a model that contained only breed of female.

Results and Discussion

The average date of birth was calculated as the number of days after January 1. Calves were born progressively later each year (Table 1). Salers-Hereford and Angus-Hereford females had calves approximately 14 days earlier ($P<.05$) as first calf heifers. These differences diminished as the cows matured. Angus-Hereford and Salers-Hereford two year old cows also had easier births

Table 1. Average date of birth (days after January 1).

Age of cow	Hereford	Angus-Hereford	Salers-Hereford
Two	47.3[b]	34.4[a]	32.6[a]
Three	73.8	68.3	70.0
Four	91.9	90.2	90.6

[a,b] Means in the same row that do not share a superscript differ ($P<.05$).

(P<.05) than Hereford two year old cows (Table 2). These differences disappeared as the cows matured so that none of the four year old cows from any breed group required assistance.

There were no significant breed group differences in birth weight (Table 3) for any of the ages of females, although Salers-Hereford cows had slightly heavier calves than the other cow groups at ages two and four. This additional birth weight did not result in any increased calving difficulty. Salers-Hereford cows had the heaviest calves at 205 days (Table 4) and Hereford cows had the lightest (P<.05) calves each year of the study. The Salers-Hereford advantage in 205-day weight was significant (P<.05) when the cows were two and four years old.

Table 2. Average calving score (1 = no difficulty, 2 = minor difficulty).

Age of cow	Hereford	Angus-Hereford	Salers-Hereford
Two	2.45[a]	1.87[b]	1.91[b]
Three	1.08	1.12	1.10
Four	1.00	1.00	1.00

[a,b] Means in the same row that do not share a superscript differ (P<.05).

Table 3. Average birth weight (lb).

Age of cow	Hereford	Angus-Hereford	Salers-Hereford
Two	63.9	63.2	66.2
Three	67.6	69.7	67.7
Four	74.8	75.7	76.3

Table 4. Average 205-day weight (lb).

Age of cow	Hereford	Angus-Hereford	Salers-Hereford
Two	347.7[a]	380.6[b]	403.2[c]
Three	418.6[a]	454.3[b]	462.4[b]
Four	465.7[a]	494.4[b]	524.3[c]

[a,b,c] Means in the same row that do not share a superscript differ (P<.05).

Salers-Hereford cows had the lowest body condition score (Table 5) throughout the study. The differences were significant (P<.05) only between Angus-Hereford and Salers-Hereford as two year old cows. It is likely that the slightly lower body conditions score resulted partially from the much heavier calves weaned by the Salers-Hereford cows.

Salers-Hereford cows produced more calves (P<.05) and more total weight of calves (P<.05) during the three years of this study than Hereford cows (Table 6). They also had an advantage over the Angus-Hereford cows for both characteristics, but the differences were not significant. Ideally, each cow would have produced three calves. Failure to do so was largely the result of failure to calve as a three year old and exit from the herd at that time. The total weight of calves was larger than the number of calves x average 205-day weight because the actual weaning weight was used to calculate total weight and calves were generally weaned at eight or nine months.

Only one of the cows that weaned a calf as a four year old was diagnosed open when that calf was weaned (Table 7). That cow was a Salers-Hereford, but this did not result in a significant difference in average pregnancy rate.

Table 5. Average cow condition score (1 = emaciated, 9 = extremely obese).

Age of cow	Hereford	Angus-Hereford	Salers-Hereford
Two	4.7^{ab}	5.0^{a}	4.7^{b}
Three	5.1	5.1	5.0
Four	5.0	5.1	4.9

^{a,b} Means in the same row that do not share a superscript differ (P<.05).

Table 6. Average number and total weight (lb) of calves produced in three years.

	Hereford	Angus-Hereford	Salers-Hereford
Number	2.38^{a}	2.66^{ab}	2.84^{b}
Total weight	1082.8^{a}	1345.3^{b}	1498.3^{b}

^{a,b} Means in the same row that do not share a superscript differ (P<.05).

Table 7. Average pregnancy rate in cows that weaned a calf during the third year.

	Hereford	Angus-Hereford	Salers-Hereford
Pregnancy rate	1.00	1.00	.98

These results show a clear advantage in calf performance for calves out of Salers-Hereford cows. Their calves were heavier at weaning and were not enough larger at birth to cause any additional calving difficulty. Salers-Hereford cows also produced more calves during the duration of this study than did the other breed groups. There may be a concern about the ability of the Salers-Hereford cow to maintain sufficient condition, but these results do not show any adverse effect on reproductive performance to this point. It appears, for the fairly harsh environment in which these cattle are maintained, that Salers crossbred cows may have advantages for the commercial cattle producer and could be a useful contributor to the United States cattle industry.

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RELATIONSHIP BETWEEN GENOTYPE OF SIRE AND DAM AND SERUM INSULIN-LIKE GROWTH FACTOR-I

L.J. Spicer[1], E.D. Tinker[2], R.P. Wettemann[3] and D.S. Buchanan[4]

Story in Brief

Five breeds of sires (Hereford, Angus, Simmental, Brown Swiss, Jersey) were crossed with two breeds of dams (Hereford, Angus) to form eight crossbred groups of F_1 cows. Five to 20 mature cows per crossbred group were bled during the luteal phase of an estrous cycle and serum insulin-like growth factor-I and progesterone were measured. Breed of sire had a significant effect on IGF-I concentrations whereas breed of dam had no effect. IGF-I and body condition scores were positively correlated across breed groups. In conclusion, serum concentrations of IGF-I are influenced by breed/genotype in cattle.

(Key Words: Insulin-like Growth Factor-I, Body Condition Score, Crossbred Cows.)

Introduction

Numerous studies have shown a positive association between concentrations of insulin-like growth factor-I (IGF-I) in blood of farm animals and skeletal mass, protein accretion and body weight gain. In addition, concentrations of IGF-I in blood of cattle are affected by quantity and composition of diet. A recent study has shown significant correlations between serum IGF-I and feed consumption and feed conversion in Angus cattle (Bishop et al., 1989). Results of studies like these suggest that selection for an improved economic trait (e.g., feed conversion) may alter expression of a single gene product such as IGF-I. However, much of this work has been conducted with animals of a single breed type. Because previous studies have demonstrated possible genetic determinants of blood concentrations of IGF-I in several species including cattle (Echternkamp et al., 1990), we set out to

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

determine if serum concentrations of IGF-I varied with several breed combinations of cattle.

Materials and Methods

Eighty-one cows were used in this study from a cow herd composed of eight crossbred cow groups produced by mating Hereford, Angus, Simmental, Brown Swiss and Jersey bulls to Angus and Hereford cows. Only cows which had normal, single births and were nursing a calf 85 days after calving were included in the study. Two blood samples were collected by venipuncture from these cows at a seven day interval approximately 85 days after calving. Body condition scores (BCS) (1 to 9; 9=fat) were assigned to each cow at the time a blood sample was collected. Concentrations of progesterone in all blood samples were measured by radioimmunoassay. Only those samples from cows with luteal activity (blood progesterone > 2 ng/ml) were assayed for IGF-I concentrations. Data were analyzed by separating variation among the eight crossbred cow groups into that due to breed of cows' sire and breed of cows' dam. Simple correlation coefficients were calculated for serum IGF-I and BCS.

Results and Discussion

Breed of sire but not of dam had a significant effect on concentrations of IGF-I and BCS of mature cows. Crossbred cows with Angus and Hereford sires had significantly greater concentrations of IGF-I in serum than did crossbred cows with Simmental, Brown Swiss or Jersey sires. There were no differences in serum IGF-I between Simmental, Brown Swiss or Jersey crossbred groups. Least squares means for the crossbred groups are listed in Table 1. Body condition score was greater in Angus and Hereford crossbred cows than Jersey crossbred cows (Table 1). Simmental crossbred cows had BCS similar to those of Hereford, Angus and Brown Swiss crossbred cows. In addition, serum IGF-I and BCS were positively correlated across crossbred groups ($r=0.55$, $P<.001$). Although Jersey crossbred cows had lower serum IGF-I and BCS than Hereford and Angus crossbred cows, previous results have shown that a greater percentage of these Jersey crossbred cows returned to luteal activity following calving than did the Hereford and Angus crossbred cows (89% vs 56%) (Tinker et al., 1989).

In summary, this research shows that IGF-I is influenced by breed type and BCS. Thus, IGF-I may hold potential as a genetic marker for economical and biologically efficient beef production.

Table 1. Least squares means for serum concentrations of IGF-I and body condition scores (BCS) of cows with luteal activity 85 days postpartum.

Crossbred group	N[a]	IGF-I (ng/ml)	BCS
Hereford x Angus	12	89.3[b]	5.6[b]
Angus x Hereford	11	81.0[b]	5.5[b,c]
Simmental-sired	14	66.2[c]	5.2[b,c]
Brown Swiss-sired	11	56.3[c]	5.1[c]
Jersey-sired	33	65.0[c]	4.5[d]
Pooled SE		4.5	0.1

[a] Number of cows.
[b,c,d] Group averages within a column with different superscript are different ($P < .05$).

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THE INTERACTION OF DIETARY LYSINE LEVEL AND DIVERGENT GROWTH GENOTYPES IN GROWING-FINISHING PIGS

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

Story in Brief

The effect of increasing levels of dietary lysine was examined in four lines of pigs selected for different postweaning growth criteria. The selection criteria were increased gain under ad libitum intake (F), increased gain under limited intake (L), decreased gain (S) and an unselected control (C). A total of 1,499 barrows and gilts from these lines were fed a diet of either the recommended level of lysine or one that contained .05% or .10% above the recommended level. Carcass data were collected on 247 barrows randomly selected. Significant line by level of lysine interactions were observed for both the growing and finishing phase average daily gain. Performance increased with increasing lysine level in the F and L lines. This interaction was not observed for any of the other performance or carcass parameters analyzed. Level of lysine differences were significant for growing phase feed:gain and daily intake and finishing phase feed:gain. No significant differences due to lysine level were observed for any of the carcass parameters examined. These data suggest that increasing lysine level improved efficiency and decreased intake across lines and increased daily gain of the F and L lines during the growing phase.

(Key Words: Swine, Genotype, Lysine, Growth, Composition.)

Introduction

Lysine is the first limiting amino acid in most swine diets. Amino acids are important because they are the basic units or "building blocks" of protein and are essential for lean growth. Currently the Nutrient Research Council (NRC, 1988) recommends .75% dietary lysine for growing pigs from 45 to 110

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lb and .60% for finishing pigs from 110 lb to market weight. These recommendations do not take into account genetic difference in potential for lean and fat growth.

The objective of this study was to determine the response in growth and carcass characteristics of four lines of pigs selected for differing postweaning growth criteria to increasing levels of dietary lysine.

Materials and Methods

Four lines of pigs selected for different postweaning growth criteria were assigned to one of three diets that varied in lysine level. Lines were selected for: rapid postweaning gain under ad libitum intake (F), rapid postweaning gain under 83% of predicted intake (L), slow postweaning gain (S), and an unselected control (C). The diets were a control that contained .75 and .62% lysine for the growing and finishing phases, respectively (0), .05% additional lysine in each phase (+.05) and .10% additional lysine in each phase (+.10) (Table 1).

Table 1. Composition of the control diets[a].

Ingredient	Growing[b]	Finishing[c]
Corn	76.86	82.32
Soybean meal, 44%	19.53	1.30
Dicalcium phosphate	1.64	1.50
Calcium carbonate	.82	.82
Salt	.40	.40
Vitamin-trace mineral	.25	.25
Tylan 10	.50	.10

[a] Lysine levels of the two treatment diets were increased by replacing corn with lysine hydrochloride (1.28 and 2.55 lb for +.05 and +.10, respectively)

[b] Balanced to .75% lysine.

[c] Balanced to .62% lysine.

The selection lines were replicated in spring and fall farrowing replicates. Diets were assigned in two years of the spring replicate and one year of the fall replicate. Barrows and gilts were placed on test in confinement facilities at nine weeks of age. Diets were assigned to a pen that contained between 14 and 18 barrows and gilts from the same selection line. A pen was switched from the growing to the finishing diet when the pen averaged 120 lb and individual pigs were removed from test at the first weekly weighing of at least 220 lb. Total pen feed consumption was recorded for the growing and finishing phases separately. As pigs were removed from test they were ultrasonically probed at the shoulder, last rib and last lumbar vertebra. One barrow from each litter was randomly chosen for slaughter. A total of 90 pens that included 1,499 barrows and gilts were tested over the three groups. In addition, 247 barrows were slaughtered and various carcass measurements taken. Percent carcass lean and lean gain per day on test were estimated using prediction equations suggested for ribbed carcasses (Weber, 1987).

The data were analyzed by a least squares procedure that accounted for the effects of selection line, dietary level of lysine, sex, year within replicate and all appropriate interactions.

Results and Discussion

Least squares means by line for growth, intake, efficiency and probed backfat are presented in Table 2. The S is the most unique of the four lines. When comparing S to the other three lines they had decreased intake, growth rate and backfat, but were not different in efficiency. Similar results were reported by Woltmann et al. (1989) when comparing the F and S lines. The carcasses of S were more desirable than the other three lines (Table 3), in that they had larger loin eyes, less backfat and higher percentages of carcass lean. Lean gain per day on test was lower for S, however this difference was not as great as for overall daily gain. The F had a 17% higher lean gain than the S, while there was a 29 and 37% difference in overall daily gain for the growing and finishing period, respectively. Similar percentage differences were present when comparing these traits in the S and the other two lines.

A significant ($P<.01$) line by lysine level interaction was observed for daily gain in both the growing and finishing phases (Tables 4 and 5). In the growing phase the two lines selected for increased growth (F and L) responsed to increasing levels of lysine. For the finishing phase no consistent trends for level of lysine were observed within line. This suggests that the F and L lines have an increased lysine requirement for the growing period. This may be due to a relatively higher lean growth rate in these lines during this early growth period.

Table 2. Least squares means by line[c] for growth, intake, efficiency and probed backfat.

	C	F	L	S
Growing phase gain[a]	1.76	1.78	1.72	1.38
Finishing phase gain[a]	2.04	2.15	2.08	1.57
Growing phase intake[a]	4.60	4.67	4.44	3.61
Finishing phase intake[a]	6.87	7.32	6.97	5.27
Growing phase feed:gain	2.62	2.65	2.60	2.64
Finishing phase feed:gain	3.46	3.50	3.42	3.49
Probed average backfat[b]	1.31	1.29	1.19	.98

[a] Lb/day.
[b] Ultrasonically probed backfat in inches adjusted to 230 lb.
[c] C=unselected control, F=selected for rapid postweaning gain under ad libitum intake, L=selected for rapid postweaning gain under limited intake and S=selected for slow postweaning gain.

Table 3. Least squares means by line[d] for carcass parameters.

	C	F	L	S
Average backfat[a]	1.43	1.33	1.29	1.21
Loin eye area[b]	4.47	4.41	4.46	4.87
Percent lean	45.1	46.1	46.8	49.3
Lean gain[c]	.69	.73	.70	.63

[a] Carcass backfat in inches adjusted to 230 lb.
[b] Square inches adjusted to 230 lb.
[c] Estimated lean gain while on test in lb/day.
[d] C=unselected control, F=selected for rapid postweaning gain under ad libitum intake, L=selected for rapid postweaning gain under limited intake and S=selected for slow postweaning gain.

Table 4. Average daily gain (lb/day) least squares means for the interaction of line by level of lysine for the growing phase[a].

Line[b]	Diet[c] 0	+.05	+.10
C	1.81	1.80	1.67
F	1.76	1.76	1.82
L	1.68	1.73	1.76
S	1.34	1.42	1.38

[a] Line by level of intake interaction significant (P<.01).
[b] C=unselected control, F=selected for rapid postweaning gain under ad libitum intake, L=selected for rapid postweaning gain under limited intake and S=selected for slow postweaning gain.
[c] Percent additional lysine compared to the control diet.

Table 5. Average daily gain (lb/day) least squares means for the interaction of line by level of lysine for the finishing phase[a].

Line[b]	Diet[c] 0	+.05	+.10
C	2.06	1.98	2.08
F	2.14	2.16	2.15
L	2.13	2.04	2.06
S	1.54	1.65	1.54

[a] Line by level of intake interaction significant (P<.01).
[b] C=unselected control, F=selected for rapid postweaning gain under ad libitum intake, L=selected for rapid postweaning gain under limited intake and S=selected for slow postweaning gain.
[c] Percent additional lysine compared to the control diet.

The interaction of line by lysine level was not significant (P>.10) for any of the intake and efficiency traits. Significant differences for level of lysine was observed for growing phase intake and feed:gain (P<.06) and finishing phase feed:gain (P<.07). In general, intake decreased and efficiency improved with increasing levels of lysine.

Effects of level of lysine and the line by level of lysine interaction were not significant for the carcass parameters examined (Table 7).

These results indicate genotype has an effect on lysine requirements. This may be related to the genetic potential for intake. Daily lysine requirements are an absolute amount, but are commonly expressed as a percentage of the diet. To meet these daily requirements it is assumed that the pig will eat a minimum amount of feed. The percentage lysine requirement of a genotype will be determined by both the absolute lysine requirement and the genetic potential for intake.

Table 6. Least squares means by diet for growth and performance traits.

	Diet[d]		
	0	+.05	+.10
Growing phase intake[ab]	4.36	4.43	4.21
Finishing phase intake[a]	6.61	6.68	6.52
Growing phase feed:gain[b]	2.66	2.64	2.58
Finishing phase feed:gain[c]	3.47	3.51	3.42

[a] Lb/day.
[b] Diet effects significant (P<.06).
[c] Diet effects significant (P<.07).
[d] Percent additional lysine compared to the control diet.

Table 7. Least squares means by diet for carcass parameters.

	Diet[d]		
	0	+.05	+.10
Average backfat[a]	1.31	1.33	1.31
Loin eye area[b]	4.48	4.57	4.61
Percent lean	46.7	47.0	46.7
Lean gain[c]	.69	.69	.68

[a] Carcass backfat in inches adjusted to 230 lb.
[b] Squares inches adjusted to 230 lb.
[c] Estimated daily lean gain in lb/day.
[d] Percent additional lysine compared to the control diet.

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PRODUCTIVITY OF MATURE CROSSBRED COWS CONTAINING 0, 1/4 AND 1/2 BRAHMAN BREEDING IN SPRING AND FALL CALVING SYSTEMS

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Story in Brief

Four- to eight-year-old cows containing 0, 1/4 or 1/2 Brahman breeding were evaluated for measures of productivity. A total of 853 records produced in 1987, 1988 and 1989 spring and fall calving seasons were considered. Traits analyzed were birth weight, age-adjusted weaning weight, weaning conformation and weaning condition of calves produced. Additionally, four measures of cow efficiency were evaluated. These were percent calf crops born and weaned, and pounds of calf produced per pound of actual and unit of metabolic cow weight. As percentage Brahman in cows increased, birth weights of calves decreased, and fall-born calves were lighter at birth than spring-born calves. Weaning weights were heavier for calves out of 1/4 and 1/2 Brahman cows than those out of 0 Brahman cows. Fall-born calves were lighter at weaning than spring-born calves, but the effect of calving season decreased considerably, as percentage Brahman in cows increased. Calf conformation and condition at weaning was affected similarly. Cows of 0 Brahman breeding tended to have higher percent calf crops born and weaned than the other two groups, but 1/4 and 1/2 Brahman cows weaned more pounds of calf per pound of actual and unit of metabolic cow weight. Spring calving cows were also more efficient than fall calving cows. These results suggest that 1/4 and 1/2 Brahman cows may be effectively utilized in central Oklahoma, and that spring calving may be more efficient than fall calving.

(Key Words: Crossbreeding, Beef Cattle, Brahman, Productivity, Calving Season.)

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Introduction

In order to optimize cow productivity, a producer must select a breed or combination of breeds that best fit the environmental and management conditions of the operation. In general, commercial production systems are most efficient when crossbred females are utilized. The advantages of crossbred females are from the combination of desirable characteristics of two or more breeds, and from maternal heterosis (hybrid vigor).

Crossbreeding systems involving Brahman-cross females are very popular in the warm and humid climate of the southern United States. This is due to their tolerance of the heat and humidity, their superior maternal instinct and the production characteristics of their crossbred calves. The lifetime utility of this type of female, however, has yet to be adaquately evaluated in the more temperate regions of the United States. This study was designed to compare the productivity of mature crossbred cows, containing 0, 1/4 and 1/2 Brahman breeding, in central Oklahoma, for both spring and fall calving programs.

Materials and Methods

Breeding females evaluated in this study are out of Angus and Hereford cows randomly assigned (within breed) to spring and fall calving herds, and were born in 1981, 1982 or 1983. Sires used in these initial matings were purebred Angus, Brahman and Hereford bulls, as well as crossbred Brahman x Angus and Brahman x Hereford bulls. Matings were such that the resulting calves would be of the following six breed types: Angus x Hereford and Hereford x Angus, containing no Brahman breeding; Brahman-Angus x Hereford and Brahman-Hereford x Angus, containing 1/4 Brahman breeding; and Brahman x Angus and Brahman x Hereford, containing 1/2 Brahman breeding. Performance of these calves through weaning was reported by Bolton et al. (1986). Productivity of the two- to six-year old percentage Brahman females and factors affecting productivity have been reported by McCarter et al. (1987a,b, 1988, 1989a,b).

All females in this study were born on and maintained at the Southwestern Livestock and Forage Research Laboratory, near El Reno, OK until calves were weaned in 1986. At that time, the cows were transferred to the Lake Carl Blackwell Experimental Range, west of Stillwater, where they have since been maintained on native range and bermuda grass pastures. Results presented are from the 1987, 1988 and 1989 calf crops, when the cows were between four and eight years of age. Calving occurred from late February to early May, and from early September to late November for spring and fall seasons, respectively. Calves from the 1987 and 1988 calf crops

resulted from breeding seasons consisting of approximately 45 days of artificial insemination to Limousin and Salers sires, followed by 30 days of natural service by Limousin bulls. Calves from the 1989 calf crops all resulted from a 75 day breeding season of artificial insemination to Angus, Gelbvieh and Polled Hereford sires. Weaning occurred at an average age of 205 days for calves born in the spring and 240 days for calves born in the fall.

Calf traits that were analyzed included birth weight, age-adjusted weaning weight, weaning conformation (muscling) score and weaning condition score. Weights were recorded on all calves within 24 hours of birth. Weaning weights were adjusted to 205 or 240 days according to season of birth. Conformation scores ranged from 11 to 16 with 11 being light "beef-type" muscling and 16 being heavy muscling. Condition scores ranged from 5 to 7 with 5 being moderate condition and 7 being heavy condition. Measures of cow efficiency that were analyzed included percent calf crop born, percent calf crop weaned, pounds of adjusted calf weaning weight per pound of cow weight, and pounds of adjusted calf weaning weight per unit of cow metabolic body weight. Both percent calf crop measures were based on the number of cows exposed during the breeding season. All data were analyzed using least squares procedures to determine the effects of percentage Brahman, calving season and the interaction between percentage Brahman and calving season.

Results and Discussion

Birth weight was affected by percentage Brahman and calving season, but the interaction between the two effects was not important. Least squares means for birth weight are presented in Table 1. These means indicate that as

Table 1. Least squares means[a] for birth weight[b] of calves by percent Brahman cow group and calving season.

	Calving season	
Cow group	Spring	Fall
0 Brahman[c]	85.7[j]	78.7
1/4 Brahman[c]	82.5[k]	78.9
1/2 Brahman[c]	79.7[l]	76.2

[a] Means are adjusted for sex of calf, sire breeds, years and two-way interactions.
[b] lb.
[c] Means in row are different (P<.05).
[j,k,l] Means within column not sharing common superscripts are different (P<.05).

the percentage Brahman in cows increased, birth weight of their calves tended to decrease. In addition, fall-born calves were lighter at birth than spring-born calves, regardless of the breed composition of the cow.

All three weaning characteristics were affected by the interaction of percentage Brahman in the cow with season of birth. As shown in Table 2, cows containing 1/4 or 1/2 Brahman breeding weaned heavier calves than 0 Brahman cows, regardless of calving season. It is also apparent that calving season had less of an effect on the weaning weights of calves as the percentage Brahman in cows increased. Calving season appeared to have had little effect on weaning weight of calves out of 1/2 Brahman cows, but fall-born calves were substantially lighter at weaning than spring-born calves out of 0 Brahman cows. Weaning conformation and weaning condition of calves were found to have a similar trend, but to a lesser degree. Least squares means for weaning conformation and weaning condition are presented in Tables 3 and 4, respectively.

Percent calf crops born and weaned were affected by calving season; percentage Brahman and the interaction of percentage Brahman with calving season were not important factors. Spring calving cows had and weaned higher percent calf crops than fall calving cows, averaged across percentage Brahman breed groups (Tables 5 and 6). Although the interaction between breed group and calving season was not significant, least squares means indicate that 0 Brahman cows tended (P<.15) to have an advantage in percent calf crop born in fall calving seasons.

Table 2. Least squares means[a] for age-adjusted weaning weight[b] of calves by percent Brahman cow group and calving season.

	Calving season	
Cow group	Spring	Fall
0 Brahman[c]	536.1[j]	473.8[j]
1/4 Brahman[c]	570.4[k]	540.5[k]
1/2 Brahman	569.6[k]	567.3[l]

[a] Means are adjusted for sex of calf, sire breeds, years, cow condition score and two-way interactions.
[b] lb.
[c] Means in row are different (P<.05).
[j,k,l] Means within column not sharing common superscripts are different (P<.05).

Table 3. Least squares means[a] for weaning conformation score of calves by percent Brahman cow group and calving season.

	Calving season	
Cow group	Spring	Fall
0 Brahman[c]	13.0[jk]	12.5[j]
1/4 Brahman	13.0[j]	12.9[k]
1/2 Brahman[c]	12.8[k]	13.1[k]

[a] Means are adjusted for sex of calf, sire breeds, years, cow condition score and two-way interactions.
[c] Means in row are different (P<.05).
[j,k,l] Means within column not sharing common superscripts are different (P<.05).

Table 4. Least squares means[a] for weaning condition score of calves by percent Brahman cow group and calving season.

	Calving season	
Cow group	Spring	Fall
0 Brahman[c]	5.9	5.4[j]
1/4 Brahman[c]	6.0	5.6[k]
1/2 Brahman[c]	5.8	5.6[jk]

[a] Means are adjusted for sex of calf, sire breeds, years, cow condition score and two-way interactions.
[c] Means in row are different (P<.05).
[j,k] Means within column not sharing common superscripts are different (P<.05).

Table 5. Least squares means[a] for percent calf crop born by percent Brahman cow group and calving season.

	Calving season	
Cow group	Spring	Fall
0 Brahman	86.4	85.4
1/4 Brahman	85.2	78.5
1/2 Brahman	85.0	77.6

[a] Means are adjusted for sire breeds, years and two-way interactions.

Table 6. Least squares means[a] for percent calf crop weaned by percent Brahman cow group and calving season.

	Calving season	
Cow group	Spring	Fall
0 Brahman	86.4	83.3
1/4 Brahman[c]	84.8	76.3
1/2 Brahman	85.3[d]	77.5

[a] Means are adjusted for sire breeds, years and two-way interactions.
[c] Means in row are different (P<.05).
[d] Value numerically higher than corresponding value in Table 5 due to bias in overall mean estimation by statistical model. Differences between values within tables are unbiased, but numerical comparisons between tables are not appropriate.

Table 7. Least squares means[a] for age-adjusted pounds of calf weaned per pound of actual cow weight by percent Brahman cow group and calving season.

	Calving season	
Cow group	Spring	Fall
0 Brahman[c]	.464[j]	.424[j]
1/4 Brahman[c]	.530[k]	.506[k]
1/2 Brahman[c]	.516[k]	.483[l]

[a] Means are adjusted for sex of calf, sire breeds, years and two-way interactions.
[c] Means in row are different (P<.05).
[j,k,l] Means within column not sharing common superscripts are different (P<.05).

Least squares means for individual cow efficiency scores, based on actual cow weight and metabolic weight, are presented in Tables 7 and 8, respectively. For both scores, percentage Brahman and calving season were important sources of variation, but there did not appear to be an interaction between the two effects. Regardless of the measure of individual efficiency, 1/4 and 1/2 Brahman cows produced more pounds of calf per unit of weight, than 0 Brahman cows, and 1/4 Brahman cows had a slightly higher efficiency than 1/2 Brahman cows. Spring calving cows were also found to be more

Table 8. Least squares means[a] for age-adjusted pounds of calf weaned per unit of metabolic cow weight by percent Brahman cow group and calving season.

	Calving season	
Cow group	Spring	Fall
0 Brahman[c]	2.728[j]	2.451[j]
1/4 Brahman[c]	3.027[k]	2.895[k]
1/2 Brahman[c]	2.967[k]	2.831[k]

[a] Means are adjusted for sex of calf, sire breeds, years and two-way interactions.

[c] Means in row are different (P<.05).

[j,k] Means within column not sharing common superscripts are different (P<.05).

efficient than fall calving cows. These results, in combination with the previously cited reports from this experiment, support the conclusion that cows with 1/4 Brahman breeding may be used to advantage in Oklahoma.

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INFLUENCE OF COBALT-DEXTROSE-LACTONE ON GLUCOSE, VOLATILE FATTY ACIDS AND REPRODUCTIVE PERFORMANCE OF BEEF COWS

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Story in Brief

Spring calving Hereford and Hereford x Angus cows (n=91) grazing native range pastures were used in this study. Cows were fed protein/energy supplements to achieve a body condition score of 5.5 at parturition. Cobalt-dextrose-lactone (CDL) was added to the diet of half of the cows on each supplemental treatment. Glucose was quantified in plasma on four consecutive days during gestation and weekly during lactation. Progesterone was quantified in weekly samples to determine the onset of luteal activity and cows were exposed to fertile bulls for a 70 day breeding season. Volatile fatty acids (VFA) were quantified in rumen samples collected during lactation. Treatment with CDL increased concentrations of glucose in plasma during gestation but not during lactation. Addition of CDL to diets increased total VFA in the rumen. The percentage acetate in the rumen was increased and the percentage buterate was decreased. CDL did non influence days from calving to the onset of luteal activity and conception, or the percentage of cows that became pregnant during the breeding season.

(Key Words: Beef Cow, Cobalt, Glucose, Reproduction, VFA.)

Introduction

Nutrient intake and body energy reserves influence reproduction in beef cows. Concentrations of glucose in plasma of cows may be used to evaluate nutritional status and are related to rebreeding performance in nutritionally stressed cows (Selk et al., 1985). Propionate is a precursor for gluconeogenesis and increased concentrations of this volatile fatty acid are associated with increased concentrations of glucose in plasma. In a preliminary trial, CDL increased glucose concentrations but did not influence concentrations of insulin or nonesterfied fatty acids in plasma of cows fed chopped prairie hay during early gestation. The objective of this study was to

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evaluate the influence of CDL on concentrations of glucose in plasma and reproductive performance of beef cows on range pastures.

Materials and Methods

Ninty-one spring calving Hereford and Hereford x Angus cows were fed supplements to evaluate the efficacy of replacing soybean meal as a protein source with wheat middlings (Ovenell et al., 1990). Supplements were fed to provide 1.2 lb of crude protein/day from soybean meal (diet 1) or wheat middlings (diet 4) or .8 (diet 2) or 1.0 (diet 3) lb of crude protein/day from wheat middlings. Cobalt-dextrose-lactone (CDL; .60% cobalt; Agro-K, Minneapolis, MN) was fed to half of the cows on each supplemental treatment at a rate of 7.04 g/day. CDL was fed from approximately 100 days before calving until 85 days post partum. All cows calved between February 4 and April 5 and had an average body condition score (BCS; 1=emaciated, 9=obese) of 5.5 at calving. Weights and BCS of cows were determined after 16 h without feed and water every 28 days during treatment. Calf weights were recorded at birth and at weaning. Fertile bulls were introduced on May 5 and remained for a 70 day breeding season.

Blood samples were collected on four consecutive days during the last trimester of gestation and weekly between 25 and 85 days post partum. Glucose concentrations in plasma were quantified in all samples. Progesterone was quantified in plasma samples collected weekly to determine the onset of luteal activity. Volatile fatty acid concentrations were quantified in rumen samples collected (during lactation) on May 18 from 42 cows.

Results and Discussion

Concentrations of glucose in plasma of beef cows during late gestation are depicted in Figure 1. Glucose concentrations were greater ($P<.05$) on all four days in cows treated with CDL compared with control cows. Average concentrations of glucose were $67.3\pm.9$ and $68.8\pm.9$ mg % for control and CDL cows, respectively. Body weights and body condition scores were not influenced by the addition of CDL to diets. Control cows lost 92 pounds from late pregnancy until the middle of the breeding season (June 6) and CDL treated cows lost 104 pounds ($P>.20$). CDL did not influence concentrations of glucose in blood samples collected each week during lactation (Figure 2).

Concentrations of volatile fatty acids in rumen samples are summarized in Table 1. CDL increased the molar % acetate and decreased the molar % butyrate in the rumen of lactating cows. Total concentrations of volatile fatty acids were increased ($P<.05$) when CDL was added to the diet. Apparently

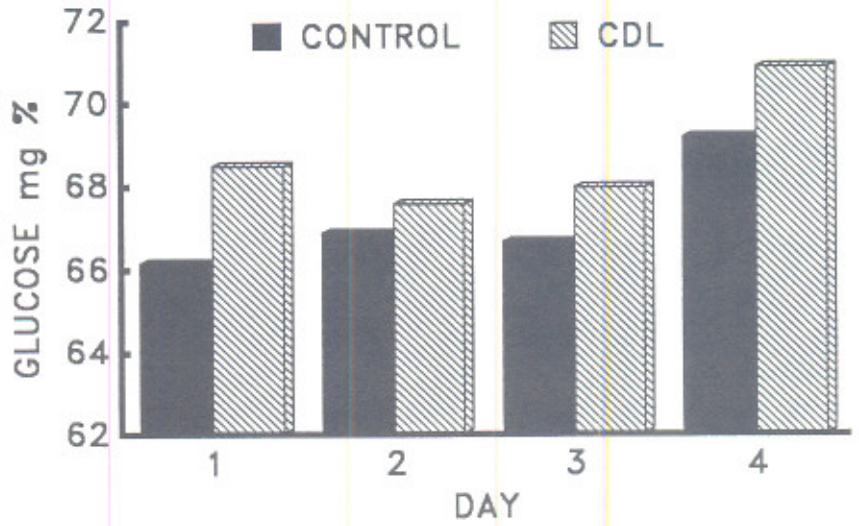


Figure 1. Concentrations of glucose in plasma during late gestation in control cows and cows fed cobalt-dextrose-lactose (CDL).

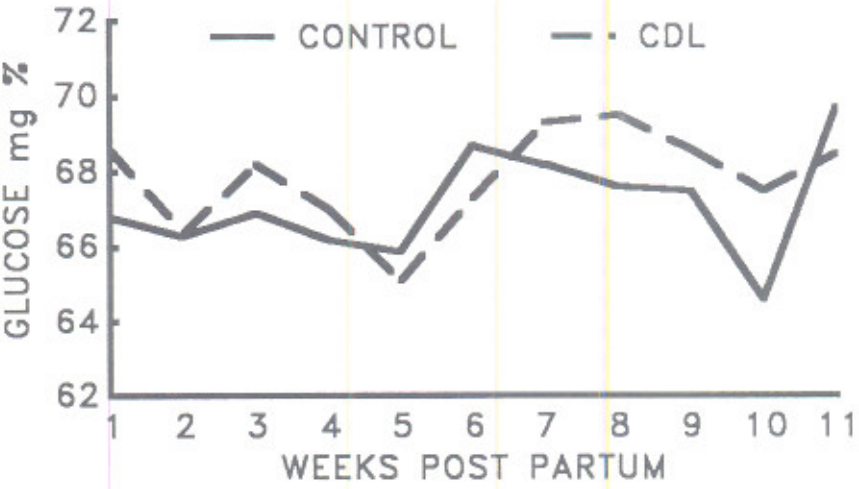


Figure 2. Concentrations of glucose in plasma during lactation in control cows and cows fed cobalt-dextrose-lactose (CDL).

Table 1. Influence of CDL in the diet of lactating beef cows on VFA's in the rumen (May 18).

	Treatment		
VFA	Control	CDL	SE
Acetate, Molar %	71.2[a]	73.0[b]	.5
Propionate, Molar %	13.6	13.2	.3
Butyrate, Molar %	10.3[c]	9.3[d]	.2
Isobutyrate, Molar %	1.9	1.7	.2
Isovalerate, Molar %	2.9	2.7	.1
Total Concentration, Millimolar	33.6[a]	45.5[b]	3.5

[ab] Means with different superscripts differ $P < .05$.
[cd] Means with different superscripts differ $P < .01$.

CDL altered rumen function in cows on forage diets.

Calf weights were adjusted for sex of the calf and age of the dam. There was a trend ($P < .11$) for an interaction between the effects of diet and addition of CDL to the supplement of cows on birth weights of calves (Figure 3). Diets 1 and 2 contained less energy than Diets 3 and 4. Calves from cows on Diets 1 and 2 that were fed CDL had increased birth weights while birth weights of calves from cows on Diets 3 and 4 were not influenced by CDL treatment. Weaning weights of calves was not influenced by addition of CDL to the diet of cows.

Reproductive performance for control and cows treated with CDL is summarized in Table 2. CDL did not influence the percentage of cows with luteal activity at 60 days post partum, the percentage of cows pregnant after a 70 day breeding season, or the average number of days between calving and conception. Increased glucose during gestation may be more beneficial to cows that have decreased body energy stores. Feeding CDL to beef cows on low quality forage increased glucose concentrations in plasma during gestation but did not influence reproductive performance of cows with moderate body condition scores.

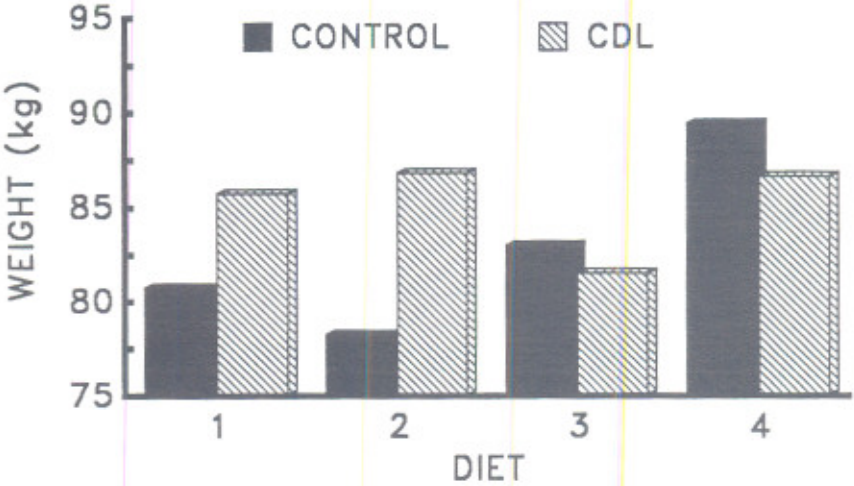


Figure 3. Influence of cobalt-dextrose-lactose (CDL) on birth weight of calves.

Table 2. Reproductive efficiency of control and CDL treated beef cows.

	Treatment	
Criteria	Control	CDL
Luteal Activity at 60 d post partum, %	78	69
Pregnant, %	93	98
Calving to conception, d	96 ± 3	90 ± 3

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PLASMA ESTRADIOL AFTER IMPLANTING STEERS WITH ESTRADIOL BENZOATE

D.K. Bishop[1], R.P. Wettemann[2], B.S. Beard[3], G. Cross[3], J.L. Ellis[1], S.D. Flock[3], B.N. Patterson[3] and M.T. Spicer[1]

Story in Brief

Angus x Hereford steers (n=8) were used to evaluate the rate of absorption of estradiol from estradiol benzoate-progesterone implants (Synovex-S). Steers weighed an average of 548 lb and were fed maintenance diets. All steers were implanted on Day 0 and reimplanted on Day 21. Plasma estradiol was quantified in samples collected on Day -2, -1, 0, 1, 2, 3, 7, 10, 12, 14, 17, 19, 21, 23, and 26. Half of the steers were exposed to a warm environment from Day 12 through Day 19 and the others were exposed to a cool environment. Concentrations of estradiol in plasma increased after initial implantation and following reimplantation. Concentration of estradiol in plasma were not influenced by ambient temperature.

(Key Words: Estradiol, Implant, Steers, Synovex-S, Temperature.)

Introduction

Concentrations of estradiol in plasma of steers implanted with growth stimulants may vary and influence performance. Plasma estradiol concentrations increased in calves implanted with estradiol benzoate and progesterone, and growth rate was correlated with estradiol concentrations (Castree et al., 1988). Absorption rates of hormones from implants may change with time, and reimplantating increases estradiol concentrations and weight gains in steers (Wagner et al., 1976). The rate of absorption of hormones from implants may influence growth rate, feed efficiency and behavior of cattle. The objectives of this study were to evaluate concentrations of estradiol in plasma after an initial implanting with estradiol benzoate-progesterone (Synovex S) and after reimplanting, and to determine if ambient temperature alters concentrations of estradiol in plasma of implanted steers.

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

Materials and Methods

Eight Angus x Hereford steers with an average weight of 548 lb were used in this study. All steers were implanted with 20 mg estradiol benzoate and 200 mg progesterone (Synovex-S) on Day 0 and were reimplanted on Day 21. Implants were placed under the skin in the middle 1/3 of the dorsal side of the ear. Steers were fed maintenance diets and subjected to ambient temperatures during November in Stillwater, Oklahoma. During Days 12 through 19 of treatment, 4 steers were maintained in a building where temperatures were maintained at 87 ± 1°F. Ambient temperatures were recorded at 8:00 a.m. and 4:00 p.m. during the study. Rectal temperatures of steers were recorded on Day 14.

Blood samples were obtained from steers by venipuncture on Days -2, -1 and 0 prior to implanting, and on Days 1, 2, 3, 7, 10, 12, 14, 17, 21, 22, 23 and 26 after the initial implanting. Blood samples (12 h intervals) were collected for 48 h after each implanting. Oxalic acid was added to blood and samples were cooled to 5°C and centrifuged to recover plasma. Estradiol was quantified in plasma by radioimmunoassay.

Results and Discussion

Concentrations of estradiol in plasma of steers are summarized in Figure 1. Estradiol concentrations increased in response to the first implant (Day 0). Maximum concentrations of estradiol in plasma after initial implantation (25 pg/ml) occurred 36 h after treatment. During the first three weeks after

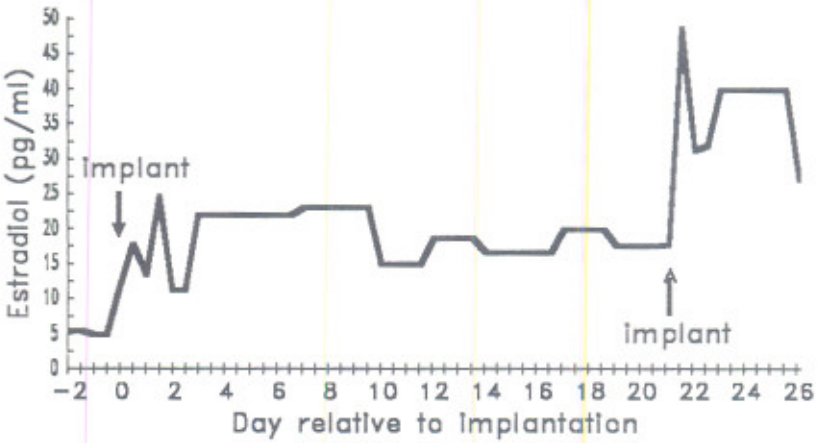


Figure 1. Concentrations of estradiol in plasma of steers after implantation with estradiol benzoate-progesterone.

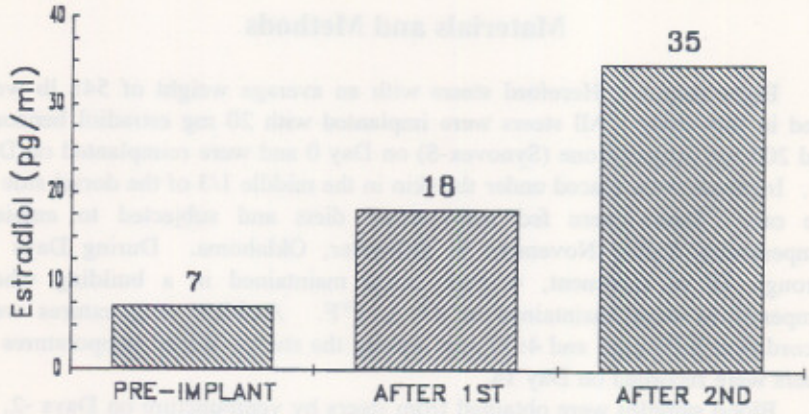


Figure 2. Mean concentrations of estradiol in plasma of steers implanted twice.

implantation, concentrations of estradiol averaged 18 pg/ml (Figure 2). Estradiol concentrations increased after reimplanting on Day 21 and averaged 35 pg/ml during the next 5 days.

Maximum ambient temperatures ranged from 48 to 77°F during the study. The average ambient temperatures during Day 12 to Day 19 of the study was 59 ± 1 and 87 ± 1°F for steers housed outside and inside, respectively. Rectal temperatures of steers on Day 14 were were not significantly different for animals maintained outside and inside. More extreme environmental temperatures (i.e., > 90°F) than evaluated in the present study may influence body temperature of animals and estradiol release from implants.

Implanting growing steers with Synovex-S increased concentrations of estradiol in plasma. Reimplanting steers resulted in an additional increase in estradiol concentrations in plasma. Exposure of steers to a warm environment for 8 days did not alter concentration of estradiol in plasma compared with steers exposed to a cool environment. Additional studies are needed to evaluate the influence of heat stress on concentrations of estradiol in the plasma of steers implanted with growth stimulants.

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EFFECTS OF BOVINE SOMATOTROPIN ON OVARIAN FUNCTION IN CATTLE

L.J. Spicer[1] and D.J. Langhout[2]

Story in Brief

The direct effect of bovine somatotropin (BST) on ovarian function in cattle was evaluated by using a serum-free culture system of bovine granulosa cells. Granulosa cells were obtained from small (1 to 5 mm) follicles collected from cattle and cultured for 4 days. Culture medium was collected for quantification of progesterone, and cell numbers were determined. In the presence of insulin, BST significantly increased granulosa cell numbers and progesterone production after 2 days of treatment. We conclude that BST may have direct effects on ovarian function in cattle.

(Key Words: Bovine Somatotropin, Granulosa Cells, Progesterone, Cattle.)

Introduction

Recent attempts to improve production efficiency in domestic animals has concentrated on the use of bovine somatotropin (BST) (Enright, 1989). However, long-term BST treatment has been reported to affect reproductive performance in cattle. Therefore, since direct effects of BST on bovine ovarian cells have not been reported previously, we set out to determine the effects of BST on cell growth and progesterone production of bovine granulosa cells.

Materials and Methods

Ovaries were obtained at a nearby commercial slaughterhouse from non-pregnant beef and dairy cattle. Granulosa cells from 1 to 5 mm follicles were collected by aspiration using a needle and syringe and washed three times in serum-free medium. At each wash, cells were separated from medium via centrifugation (200 x g for 10 min). Medium was a 1:1 mixture of Dulbecco's

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Modified Eagles Medium and Ham's F10 containing 0.12 mM gentamicin and 38.5 mM sodium bicarbonate. Between 2 and 4 x 10^5 viable cells in 20 to 50 μl of medium were added to plastic multiwell plates containing 1 ml medium. Cultures were kept at 37°C in a 95% air- 5% CO_2 atmosphere, and medium was changed every 24 hours. To obtain optimal attachment, cells were maintained in the presence of 10% fetal calf serum for the first 48 hours of culture. After this time, granulosa cells were washed twice with 0.5 ml serum-free medium and incubations continued in serum-free medium with or without added hormones. Hormonal treatments were maintained for 2 days.

At the termination of each experiment, numbers of cells were determined using a Coulter counter. Culture medium was also collected for determination of concentrations of progesterone (as a measure of steroidogenic capacity of cells) by radioimmunoassay.

Experimental data are presented as the least squares means ± SE of measurements from replicated experiments. Each culture well was a replicate and each experiment contained four replicates per treatment. Progesterone production was expressed as [ng.$(10^5$ cells$)^{-1}$.(24 h$)^{-1}$] using cell numbers at the termination of the experiment for the calculation.

Results

In serum-free medium with no additional hormones, BST (0, 10, 30, 100, 300 and 1000 ng/ml) had no significant effect on cell numbers (Figure 1A) or progesterone production (Figure 1B). However, when insulin was added, BST had a dose-dependent effect on cell numbers and progesterone production, compared with insulin treatment alone (Figure 1). The doses of 30, 100, 300 and 1000 ng/ml BST caused significant increases in cell numbers (Figure 1A). When 100, 300 or 1000 ng/ml BST was added to insulin-containing medium, a significant increase in progesterone production was observed (Figure 1B). When granulosa cells were cultured with 10% FCS during the 2-d BST treatment, no significant effect of BST was seen on cell proliferation or steroidogenesis (data not shown).

Discussion

Results of the present study suggest that BST has a direct effect on bovine granulosa cells. However, only in the presence of insulin did BST have an enhancing effect on both cell growth and progesterone production. Previous in vitro studies have shown that ST can enhance (by 1.5- to 15.0-fold) steroidogenesis by rat (Jia et al., 1986) and porcine (Hsu and Hammond,

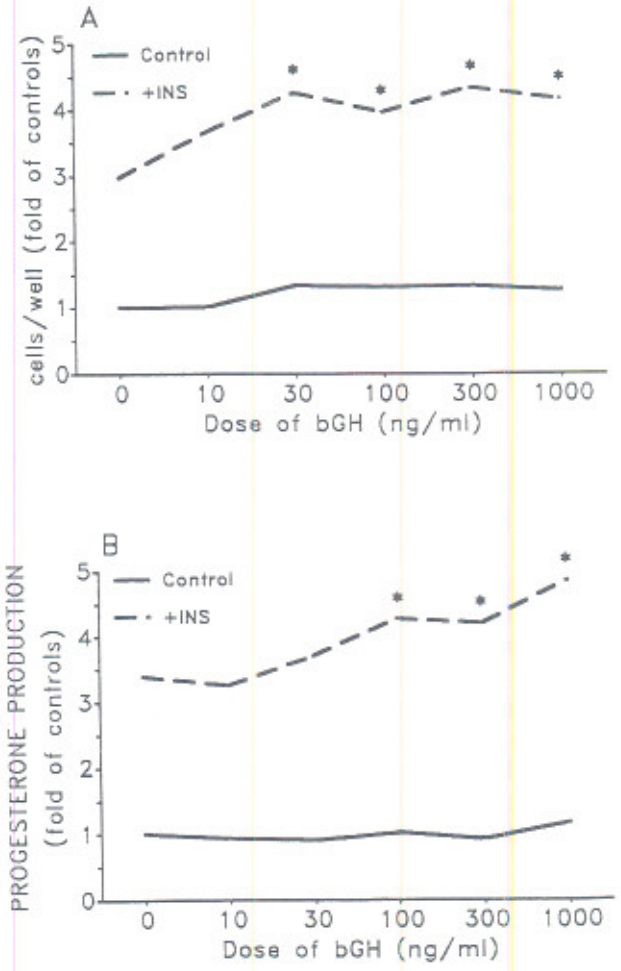


Figure 1. Effect of bovine somatotropin (BST; USDA-bGH-B1) on granulosa cell numbers (Panel A) and progesterone production (Panel B) in the absence or presence of insulin (INS) at d 4 of culture. Granulosa cells were obtained from small follicles and treated as described in Materials and Methods. Values are least squares means of quadruplicate culture wells from three separate experiments and expressed as fold of controls without insulin or BST. *, mean differs ($P<.05$) from treatment without addition of BST. Pooled SE = 0.18-fold of controls for Panel A and pooled SE = 0.17-fold of controls for Panel B. Cell numbers averaged 0.41 cells/well ($x10^5$) for controls without insulin or BST (Panel A). Progesterone production averaged 7 ng/10^5cells/24 h for controls without insulin or BST (Panel B).

1987) granulosa cells. This is the first report suggesting that ST affects granulosa cell proliferation in any species.

Although the present and previous studies establish granulosa cells as a site of ST action, its physiologic relevance remains unclear. Average concentrations of BST in beef and dairy cattle are usually less than 10 ng/ml, and thus fall below the effective doses of BST used in the present study. However in BST- and growth hormone-releasing hormone (GHRH)-treated cattle, BST levels usually exceed 100 ng/ml (Gluckman et al., 1987). Thus, in BST- and GHRH-treated cattle BST may be a physiologically relevant promoter of ovarian follicular function.

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EFFECT OF DIETARY INTAKE ON OVARIAN FUNCTION IN HEIFERS

L.J. Spicer[1], W.J. Enright[2], M.G. Murphy[3] and J.F. Roche[3]

Story in Brief

To determine if alterations in dietary intake of heifers can influence follicular growth and(or) steroid concentrations in follicular fluid, cyclic heifers (n=23) were individually fed for 10 weeks either: a) 1.8% of body weight (BW) in dry matter (DM) per day (GAIN; n=7), b) 1.1% of BW in DM per day (MAINT; n=8) or c) 0.7% of BW in DM per day (LOSE; n=8). After 10 weeks of treatment, heifers were ovariectomized 36-40 hours after prostaglandin $F_{2\alpha}$ synchronization. Heifers weighed 979, 853 and 769 lbs in the GAIN, MAINT and LOSE groups, respectively, at time of ovariectomy. Mean diameter of follicles $\geq$ 10 mm was greater for GAIN than for MAINT or LOSE heifers. Numbers of follicles did not differ between LOSE, MAINT and GAIN heifers. Progesterone concentrations were greater in small and medium follicles of GAIN than MAINT or LOSE heifers, but were unaffected by diet in large follicles. Estradiol concentrations in estrogen-active follicles were two-fold greater in GAIN heifers than either MAINT or LOSE heifers. In conclusion, reduced dietary intake inhibits preovulatory follicular growth and steroidogenesis in heifers.

(Key Words: Estradiol, Follicular Fluid, Heifers)

Introduction

Ovarian follicular development is controlled by numerous systemic and local intraovarian factors (Spicer and Echternkamp, 1986). One of these factors is insulin-like growth factor-I (IGF-I)(Hammond et al., 1988). Previous studies have shown that concentrations of IGF-I in peripheral blood are altered by feed restriction and energy balance in cattle (Houseknecht et al., 1988; Spicer et al., 1990). Because poor nutrition has been associated with decreased reproductive efficiency in cattle (Dunn et al., 1980), it is possible

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that reduced IGF-I secretion is one of the mediators of reduced reproductive efficiency. However, no direct link between decreased feed intake and decreased ovarian follicular function has been reported. Thus, the objectives of the present study were to determine if alterations in dietary intake of heifers can influence concentrations of estradiol and(or) progesterone in follicular fluid (FFL)(as an indicator of steroidogenic capacity), and(or) follicular growth.

Materials and Methods

Cyclic Hereford x Friesian heifers (n=23, mean ± SE, BW = 822 ± 15 lbs) were synchronized before the start of the study using two intramuscular injections of a synthetic prostaglandin (PG) $F_{2\alpha}$ analog given 11 days apart (cloprostenol; Estrumate, Coopers Animal Health, Berks, UK). The heifers had an average body condition score of 3.4 at the start of the study (range 2.5 to 4.0, scale = 1 to 5), were housed individually, and fed a diet of 50% grass silage (17.5% crude protein) and 50% concentrates (barley and soybean meal; 14% crude protein) on dry matter (DM) basis. The study was carried out during June and July.

The heifers were separated into four blocks by body weight and allocated to: a) 0.7% of BW in DM per day (LOSE; n=8), b) 1.1% of BW in DM per day (MAINT; n=8) or c) 1.8% of BW in DM per day (GAIN; n=7) in a randomized complete block design. The heifers were maintained on the diets for 10 weeks, and observed for signs of estrous behavior once daily for a 2-hour period. All cows continued to cycle throughout the study. Before ovariectomy after 10 weeks of treatment, estrous cycles were again synchronized (two injections 11 days apart) with $PGF_{2\alpha}$.

Ovaries were removed per vagina 36-40 hours following the second injection of $PGF_{2\alpha}$ after heifers were sedated epidurally with xylazine (25 mg intramuscular injection). The surface diameter of all follicles ≥ 6 mm was recorded and their FFL collected individually. The FFL from follicles 1-5.9 mm in diameter was collected and pooled within each ovary. FFL was stored at -20°C until analyzed for concentrations of progesterone and estradiol by radioimmunoassay.

Results and Discussion

Mean body weights of LOSE, MAINT and GAIN heifers were 769 ± 20, 853 ± 18 and 979 ± 29 lbs, respectively, at time of ovariectomy; these differences were significant ($P < .05$).

Mean ovarian weights of LOSE, MAINT and GAIN heifers were 14.7 ± 1.6, 11.8 ± 1.6 and 13.3 ± 1.8 g, respectively; these values did not differ (P>.10). Similarly, previous studies have shown that underfeeding of dairy heifers did not affect ovarian weight (Spicer et al., 1984).

Mean numbers of small (1-5.9 mm) and medium plus large (≥ 6.0 mm) follicles per heifer were not affected (P>.10) by dietary treatments. Numbers of small follicles for LOSE, MAINT and GAIN heifers were 17.8, 18.8 and 20.9, respectively (pooled SE = 2.5). Numbers of medium plus large follicles for LOSE, MAINT and GAIN heifers were 2.8, 2.6 and 2.1, respectively (pooled SE=0.7).

Mean diameter of large follicles (≥ 10 mm) was greater (P<.05) for GAIN than for MAINT or LOSE heifers (Figure 1). This suggests dietary restriction may inhibit preovulatory follicular growth in heifers. However, mean diameter of medium follicles (6.0 - 9.9 mm) did not differ (P>.10) between dietary treatments (Figure 1).

Mean concentrations of progesterone in FFL of small and medium follicles increased (P<.05) with level of dietary intake (Figure 2) such that

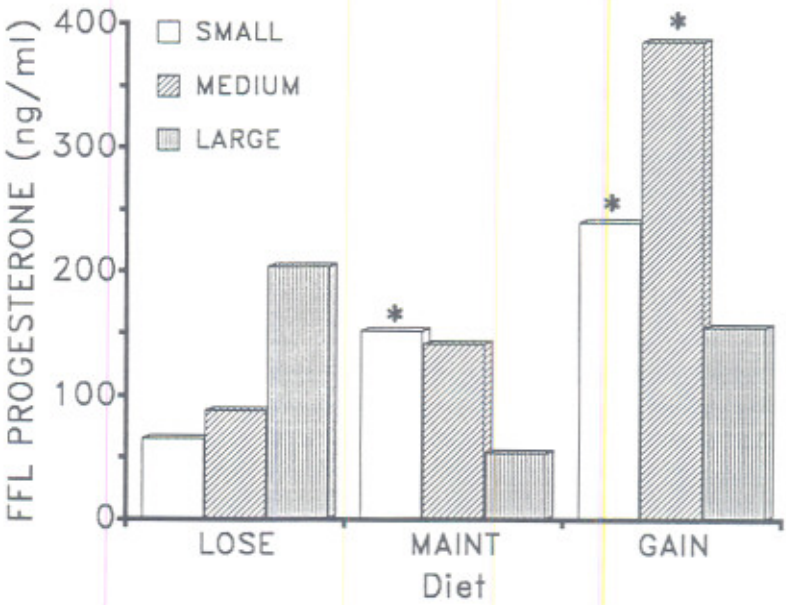


Figure 1. Least-squares means of diameter of medium (6.0 - 9.9 mm) and large (≥ 10 mm) follicles collected during the preovulatory period of heifers fed either LOSE, MAINT and GAIN diets. Asterisk indicate mean differs (P<.05) from respective LOSE and MAINT mean. Pooled SE = 0.6 mm for medium and 0.7 mm for large follicles.

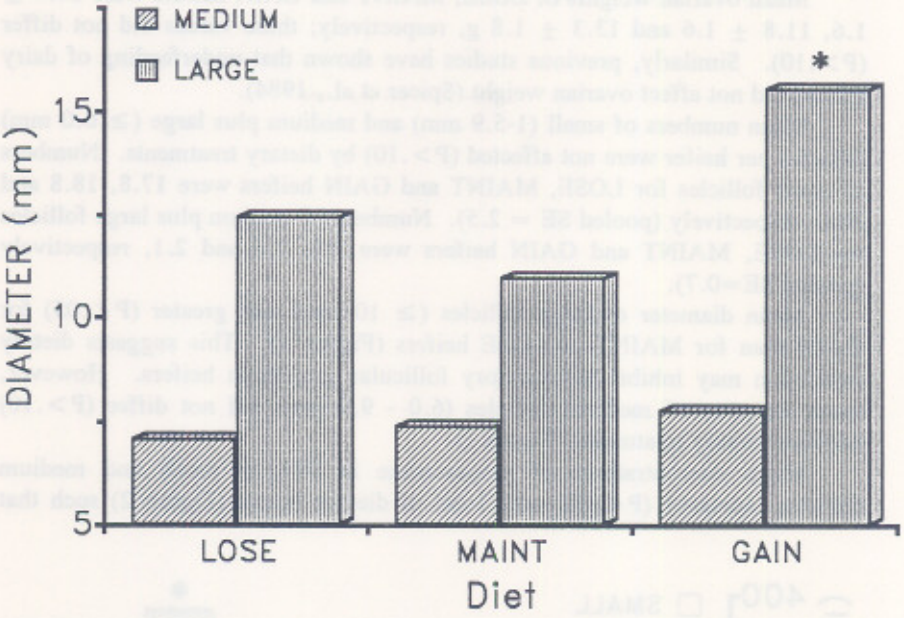


Figure 2. Least-squares means of concentrations of progesterone in follicular fluid (FFL) of small, medium and large follicles collected during the preovulatory period of heifers fed either LOSE, MAINT or GAIN diets. Asterisks indicate mean differs ($P<.05$) from respective LOSE mean. Pooled SE = 69, 91 and 104 ng/ml for small, medium and large follicles respectively.

GAIN heifers had 4-fold greater concentrations than LOSE heifers. However, concentrations of progesterone in large follicles were not affected ($P>.10$) by dietary treatment. These results suggest that dietary restriction may inhibit production of progesterone by small and medium follicles.

Mean concentrations of estradiol in small, medium or large follicles were not affected ($P>.20$) by level of dietary intake. Large follicles (559 ng/ml) had 25- to 85-fold greater ($P<.01$) concentrations of estradiol than small (6.8 ng/ml) or medium (21.6 ng/ml) follicles. FFL data also were analyzed as estrogen-active (E-A; concentrations of estradiol > progesterone in FFL) or estrogen-inactive (E-I; concentrations of progesterone > estradiol in FFL), since E-A follicles in cattle are predominantly healthy (nonatretic) follicles (Spicer and Echternkamp, 1986). Progesterone concentrations (97 vs 183 ng/ml) in FFL of E-A and E-I follicles did not differ ($P>.10$) between LOSE,

MAINT and GAIN heifers. However, estradiol concentrations were greater ($P<.05$) in E-A follicles of GAIN (1232 $\pm$ 87 ng/ml) than LOSE (511 $\pm$ 66 ng/ml) or MAINT (544 $\pm$ 71 ng/ml) heifers. Estradiol concentrations in E-I follicles were not affected ($P>.10$) by diet.

In summary, results of the present study demonstrated that decreased dietary intake in cyclic heifers is associated with: 1) decreased concentrations of progesterone in FFL of small and medium follicles, and 2) decreased size of large follicles.

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EFFECT OF ELEVATED AMBIENT TEMPERATURE ON SWEATING RATE, RECTAL TEMPERATURE AND RESPIRATION RATE OF HEIFERS

J.A. Vizcarra[1], R.P. Wettemann[2], D.K. Bishop[1], S. Al-Shorepy[1], M. Aslam[1], L.A. Baker[1], B. De Rodas[1] and D.L. Wall[1]

Story in Brief

The effect of elevated ambient temperature on sweating rate, rectal temperature and respiration rate was evaluated in heifers adapted to cool (47 F) or warm (65 F) ambient temperatures. Sweating rate was measured on the ribs and on the rump. When exposed to elevated ambient temperature (92 F), heifers adapted to a cool environment tended to produce more sweat than heifers adapted to a warm environment. Exposure of heifers to heat stress, after adaptation to a cool environment, increases rectal temperature, respiratory rate and sweating rate within 135 min.

(Key Words: Acclimatization, Heat Stress, Rectal Temperature, Respiration Rate, Sweat.)

Introduction

Sudoriferous (sweat) glands are the main avenue of heat dissipation and body temperature regulation in cows (McDowell et al., 1961; Amakiri, 1974). The rate of sweating over different body regions has been investigated. Fourteen parts of the body were measured by Berman (1957) and the highest evaporation rates occurred on the muzzle, neck, vulva and front flank. Hyperthermia causes decreases in feed consumption, milk production and estrous behavior of cattle. Finch et al. (1982) concluded that sweating response was a good indicator of thermoregulatory ability of cattle.

Different methods to measure the rate of sweating have been investigated. In humans, suitable methods have been developed for measuring cutaneous water loss from the whole body surface, but the collection of moisture from cattle skin presents great difficulty. The objectives of this study were to determine an efficient method to measure the sweating rate of cattle, and to determine the effect of adaptation of cattle to a

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[1]Graduate Student [2]Regents Professor

cool or warm environment on sweating rate respiration rate, and rectal temperature when cattle were exposed to elevated ambient temperature.

Materials and Methods

Four mature heifers were acclimated to either 47 F or 65 F for 8 days. They were then exposed to 92 F for 135 min and sweating rate, rectal temperature and respiration rate were determined. A 32.5 cm^2 patch of absorbant lab mat (paper backed with a thin plastic film) was soaked in a saturated solution of calcium chloride and water for 30 min. Patches were dried at 125 F for 24 h. Each dried patch was sealed in a plastic bag to minimize absorbtion of moisture from the atmosphere. Hair was removed from the rib and rump areas of heifers. The plastic bag and the patch were weighed. The patch was removed from the bag, and placed immediately on the animal and covered with aluminum foil for 10 min. The patch was removed, placed in the plastic bag and re-weighed. The uptake of moisture was measured by the difference of weight of the patch before and after exposure to the heifer. Respiration rate was determined by counting movement of the ribs for a period of 30 seconds. Rectal temperature was obtained with a clinical thermometer.

Results and Discussion

The amount of sweat collected on the rump and ribs, rectal temperature and respiration rate increased with time after exposure to elevated ambient temperature. The amount of sweat measured on the rump increased linearly ($P<.02$) with time when animals were heat stressed. There was a tendency ($P<.11$) for the heifers that were adapted to the cool environment to produce greater amounts of sweat on the rump than the heifers adapted to the warm environment when the animals were exposed to 92 F for 135 min (Fig. 1). The increase in rectal temperature during exposure to heat stress was also greater ($P<.01$) for heifers adapted to the cool environment compared with heifers adapted to the warm environment (Figure 2).

As the rectal temperature of heifers increased between 100.2 and 102.5 F, the sweating rate on the rump tended to increase ($r=.41$; $P<.12$) (Figure 3). Sweating rate increased to 1 gm/100 cm^2/10 min in some heifers when rectal temperature was 102.5 F. Rectal temperatures of the heifers were correlated ($r=.77$) with respiratory rates.

We conclude that heifers adapted to cooler ambient temperature have greater sweating rates and rectal temperatures when exposed to heat stress than heifers adapted to a warmer environment. Absorption of sweat by calcium chloride can be used to quantify sweating rate in cattle.

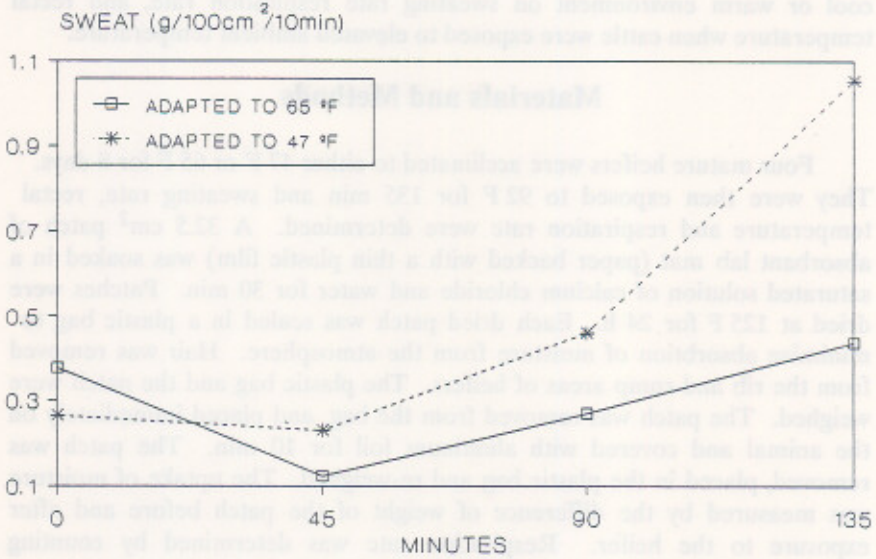


Figure 1. Sweating rate of heifers adapted to a cool or warm environment and exposed to 92°F.

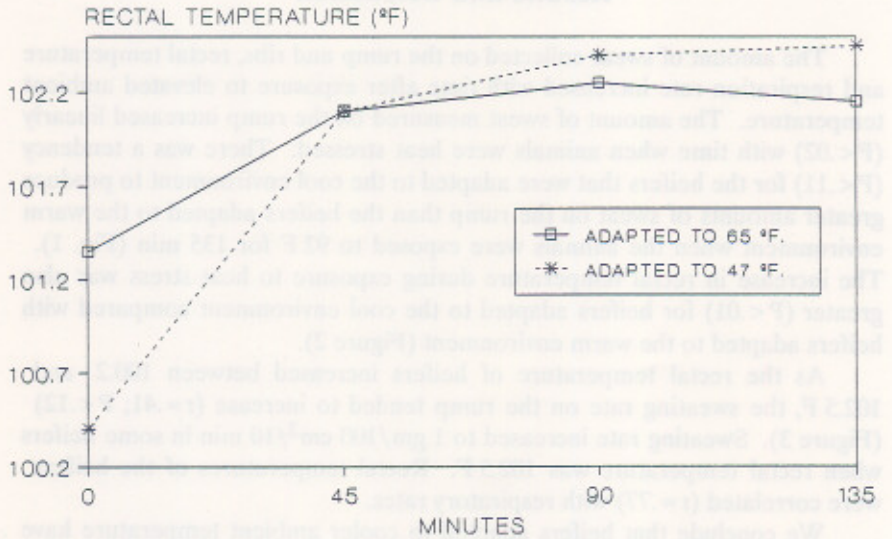


Figure 2. Rectal temperature of heifers adapted to a cool or warm environment and exposed to 92°F.

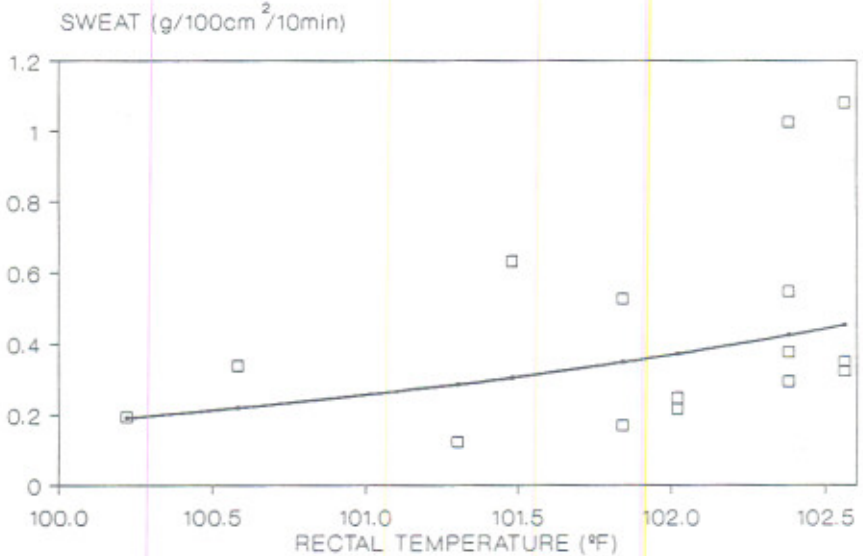


Figure 3. Relation between sweating rate and rectal temperature.

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RELATIONSHIP BETWEEN THE OCCURRENCE OF PUBERTY IN HEIFERS AND THE CESSATION OF LUTEAL ACTIVITY AFTER NUTRITIONAL RESTRICTION

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Story in Brief

The relationship between the occurrence of puberty with the cessation of luteal activity after nutritional restriction was evaluated in fifteen Angus x Hereford heifers. Heifers attained puberty at a body weight of 655 lb and a BCS of 5.5. After 5.1 months of nutritional restriction, heifers became anestrus at a weight of 602 lb and a BCS of 3.0. The Spearman's rank correlation coefficient between date of puberty and date of cessation of luteal activity was -.50 ($P < .06$). This indicates that the heifers that attained puberty first were the last to cease luteal activity during nutritional restriction.

(Key words: Anestrus, Heifer, Nutrition, Progesterone, Puberty.)

Introduction

Age at the onset of puberty, is a major limitation for efficient beef production. Increased feed intake increases weight gain and usually decreases the age at which heifers reach puberty. The mechanism by which nutrition influences reproduction in cows has not been established, but it is documented that body condition influences reproductive performance (Selk et al., 1988). The objective of this study was to evaluate the relationship between the occurrence of puberty with the cessation of luteal activity after nutritional restriction.

Materials and Methods

Fifteen Angus x Hereford heifers were fed a complete diet to supply NRC requirements from 8 months of age until puberty. After all heifers exhibited normal estrous cycles, nutritional anestrus was induced by feeding a limited diet of 6.6 lb of low quality hay per day.

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Blood samples were taken biweekly before puberty and weekly after puberty. Concentrations of progesterone were determined by radioimmunoassay. Onset of puberty was considered to have occurred at the first of two successive weekly samples when concentrations of progesterone were greater than 1 ng/ml. Cessation of ovarian luteal activity was indicated by concentrations of progesterone less than 1 ng/ml for more than one week.

Results and Discussion

Heifers attained puberty at 14.1 ± 0.2 months of age. At puberty, heifers weighed 655 ± 13 lb and had a body condition score of 5.5 ± 0.1 (BCS; 1=emaciated, 9=obese).

About 5 months after all heifers exhibited normal luteal activity, nutritional anestrus was induced by feeding a limited diet of 6.6 lb of low quality hay per day. Luteal activity, or estrous cycles, ceased after diets of heifers were restricted for 5.1 ± 0.5 months. At the onset of anestrus, heifers weighed 602 ± 18 lb and had a BCS of 3.0 ± 0.2. Although heifers were an average of 10.5 months older at the onset of anestrus than at puberty, they weighed 8% less ($P < .02$) and had 45% less BCS ($P < .01$) (Figure 1).

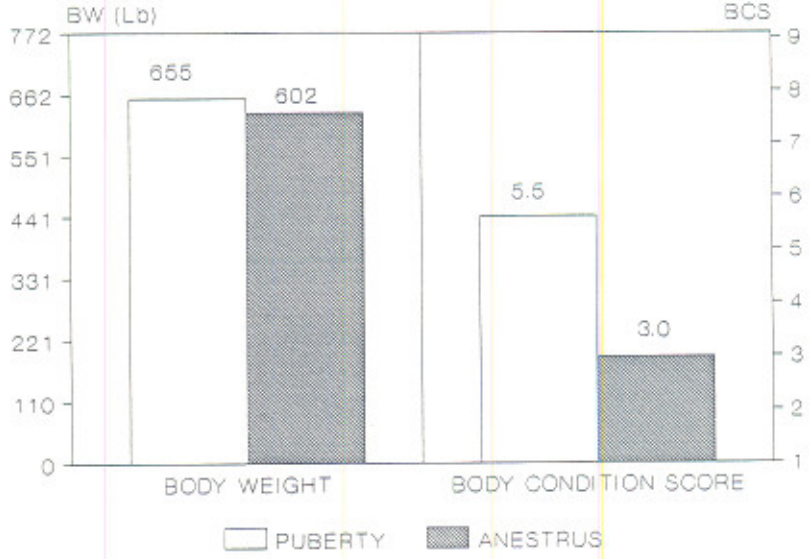


Figure 1. Body weight and body condition score of heifers at puberty and at anestrus.

The number of days of restricted feeding to induce anestrus is summarized in Figure 2. Heifers were divided into three groups based on the number of days to puberty after the start of the evaluation of pubertal cycles. Heifers that started luteal activity during the first two weeks (early), required 185 days of nutritional restriction to become anestrus (n=8). The heifers that started cycling 28-48 days later (moderate) needed 136 days (n=3) and the animals that started cycling last needed 106 days (n=4) to stop cycling. A Spearman's rank correlation coefficient was computed between date at puberty and the date at cessation of luteal activity. The correlation ($r=-.50$; $P < .06$), indicates that the heifers that first attained puberty were the last to cease luteal activity during nutritional restriction.

Body weight and body condition score did not differ between groups at the initiation of nutritional restriction or at the onset of anestrus (Table 1). However, the daily weight loss was greater in the "late" group compared with the "early" group.

Identification of heifers that initiate puberty at a younger age may represent animals with the ability to continue estrous cycles with reduced nutrient intake.

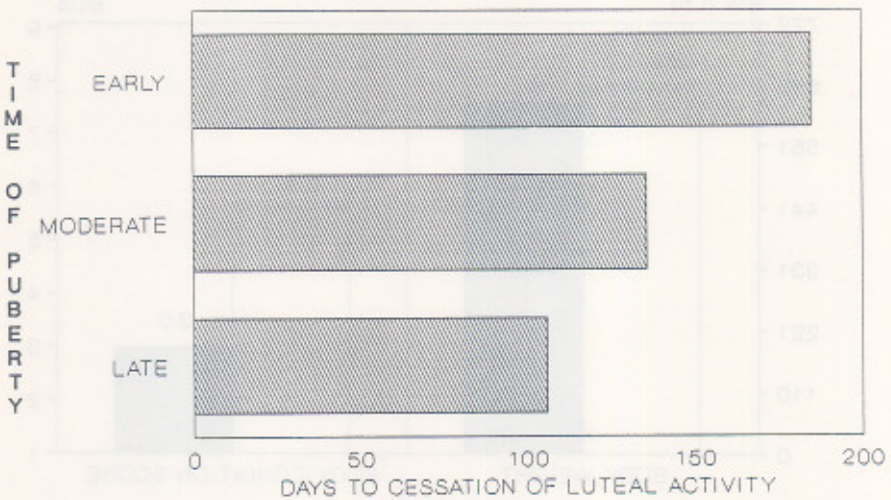


Figure 2. Relationship between time of puberty and days of nutritional restriction until the cessation of luteal activity.

Table 1. Body weight (BW) and body condition score (BCS) of heifers at initiation of nutritional restriction and at anestrus.

	Time of Puberty		
Characteristic	Early	Moderate	Late
Initial BW,lb	781	776	798
Initial BCS	5.6	5.2	5.3
Total BW loss to anestrus, lb	194	163	172
Daily BW loss to anestrus, lb	1.0[a]	1.3[ab]	1.7[b]
BCS loss to anestrus	1.8	2.0	2.9

[ab] Means with different superscripts differ ($P < .01$).

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INFLUENCE OF GROWTH RATE ON BODY COMPOSITION OF BEEF HEIFERS AT PUBERTY

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Story in Brief

Eighteen Angus x Hereford heifers were blocked by body weight to three nutritional regimes to evaluate the effect of growth rate on body composition at puberty: 1) full fed to gain 3.0 lb/day; 2) limit fed to gain 1.5 lb/day; 3) maintenance fed to gain .4 lb/day for 16 weeks then fed to gain 3.0 lb/day. Progesterone in plasma was quantified weekly to determine the onset of puberty (luteal activity). Heifers were slaughtered within 10 days after puberty. Total body fat was determined in five categories: 1) omental-mesenteric, 2) udder, 3) kidney-pelvic-heart, 4) subcutaneous and 5) intermuscular. At puberty, full fed animals had greater body weights, greater body condition scores and more total body fat (as a proportion of carcass weight) than either the limit or maintenance fed animals. We conclude that carcass composition, body weight and body condition score at puberty can be altered by rate of gain.

(Key Words: Beef Heifer, Body Fat, Carcass, Progesterone, Puberty.)

Introduction

Improvements in reproductive efficiency could greatly increase the profitability of beef production. Weaned calf production is very inefficient. Bellows et al. (1979) estimates that less than 75% of postpartum cows and replacement heifers exposed to bulls, become pregnant during the breeding season and calve the following year. Of the nonpregnant animals, postpartum cows remained anestrus while heifers did not reach puberty during the breeding season. Adequate growth and development of the replacement heifers could greatly increase the efficiency of production.

Most producers set a target age at puberty of 12 to 16 months. However, age is not the only factor affecting puberty. Factors such as breed, weight and body condition or body energy reserves may influence when the

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first estrus occurs. Body energy reserves influence reproductive performance in postpartum cows and could regulate the onset of puberty. Wagner et al. (1988) indicated that total fat in the carcass of beef cows could be accurately estimated by using a body condition scoring (BCS) system of 1 to 9. Steers fed diets to achieve greater daily gains had increased fat in their carcasses (Waldman et al., 1971). Consequently, alterations in growth rate may influence carcass composition which, in turn, could affect age and/or weight at puberty.

The objectives of this experiment were to determine the effect of growth rate of heifers on carcass composition, age and weight at puberty.

Materials and Methods

Eighteen Angus x Hereford heifers were blocked by weight to three treatments. Treatments were: 1) full fed to gain 3.0 lb/day (n=7); 2) limit fed to gain 1.5 lb/day (n=5); 3) maintenance fed to gain .4 lb/day for 16 weeks then fed to gain 3.0 lb/day (n=6). Heifers were weighed and BCS was recorded every 28 days after a 16 hour withdrawal of feed and water.

Progesterone in plasma was quantified weekly to determine onset of luteal activity. Progesterone concentrations greater than 1 ng/ml for two consecutive weeks were used as the criterion for the onset of puberty. Date of first sample greater than 1 ng/ml was used to determine age at puberty. Heifers were slaughtered within 10 days after the second progesterone sample greater than 1 ng/ml.

Omental-mesenteric (OM), kidney-pelvic-heart (KPH) and udder fat were physically removed from the carcasses at slaughter and carcass weight was determined. After a 48 to 72 hour chill, one side of each carcass was physically separated into lean, bone, subcutaneous fat, intermuscular fat and soft tissue. Total body fat represents the sum of OM, KPH, udder, subcutaneous and intermuscular fat; intramuscular fat was not determined. Percent total body fat was calculated by dividing total body fat by adjusted carcass weight (carcass weight + KPH+OM+udder).

Results and Discussion

Rate of gain had a significant effect on the age and weight (Table 1) at which heifers reached puberty. Full and maintenance fed heifers were younger (389 and 371 days; respectively) at puberty ($P<.01$) than the limit fed heifers (431 days). Conversely, the full fed heifers were heavier (829 lb; $P<.01$) at puberty than either the limit (692 lb) or maintenance (664 lb) fed

Table 1. Influence of rate of gain on age and weight at puberty

Measurement	Treatment			SE
	Full	Limit	Maintenance	
No. of animals	7	5	6	-
Age, days	389[c]	431[b]	371[c]	38
Live weight, lb	829[b]	692[c]	664[c]	39
Adj. carcass weight [a], lb	505[b]	412[c]	381[c]	50

[a] Adj. carcass weight = carcass weight + (KPH + OM + udder).
[b,c] Values in the same row not sharing a common superscript differ ($P<.01$).

heifers. Increased live weight of the full fed heifers is further reflected in their heavier ($P<.01$) carcass weights compared with the limit and maintenance fed heifers.

Body energy reserves or BCS at puberty was also affected by rate of gain (Table 2). Full fed heifers had a BCS of 6.8 ($P<.01$) at puberty compared with 5.7 for the limit and maintenance fed heifers. This one unit increase in BCS was reflected by a greater ($P<.01$) amount of total fat (178.8 lb) in the full fed heifers compared with either limit (89.6 lb) or maintenance (69.2 lb) fed heifers. Hence, heifers did not initiate estrous cycles when they attained a certain percentage body fat. When fat was expressed as a percent of adj. carcass weight, the full fed animals had a greater ($P<.01$) proportion of fat at puberty than the limit or maintenance fed animals. These results support the findings of Wagner et al. (1989) in postpartum cows indicating that BCS can be used to estimate total carcass fat in heifers.

In conclusion, carcass composition, live weight and BCS at puberty can be altered by rate of gain. Thus, body energy reserves may not be the only factor that regulates puberty in the heifers.

Table 2. Influence of rate of gain on BCS[a] and carcass fat at puberty

Measurement	Treatment			SE
	Full	Limit	Maintenance	
BCS	6.8[d]	5.7[e]	5.7[e]	.2
Total fat, lb[b]	177.8[d]	89.6[e]	69.2[e]	13.3
Carcass fat (%)[c]	35.2[d]	21.2[e]	18.2[e]	2.3

[a]BCS = Body condition score (1 = emaciated; 9 = extremely fat).
[b]Total fat = OM + KPH + udder + subcutaneous + intermuscular.
[c]Carcass fat = Total fat, lb / Adj. carcass weight, lb.
[d,e]Values in the same row not sharing a common superscript differ ($P < .01$).

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EFFECT OF COOKING ON THE LIPID COMPOSITION OF BEEF STEAKS

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Story in Brief

Forty-eight rib steaks from steers serially slaughtered at 28 day intervals (0-196 days-on-feed) were used to assess the effect of cooking on the lipid composition of beef. Rib steaks were sectioned into lateral and dorsal halves after removal of all exterior fat and epimysial connective tissue. The dorsal half was broiled to an internal temperature of 158°F, a medium degree of doneness. Moisture, lipid and fatty acid content of both halves were examined. Cooking loss averaged 34.5%. Moisture content decreased with cooking an average of 20.4%. Total lipid and neutral lipid increased 15.3% and 13.9%, respectively, with cooking. Cooking increased polar lipid concentrations 54%. Saturated fatty acids increased 3.9% while the monounsaturated fatty acids and polyunsaturated fatty acids decreased 2.1% and 2.0%, repectively, with cooking. Cooking changed the saturated to unsaturated fatty acid ratio from .97 to 1.13.

(Key Words: Beef, Cooking, Lipids, Fatty Acids.)

Introduction

In 1989, per capita beef consumption was 1.5 oz./day, cooked weight basis (USDA, 1989). Beef consumption peaked in 1976 but has since declined due to cost factors and increased concern over diet health issues. Today's consumers are questioning if beef can fit into a healthy diet. The American Heart Association (AHA, 1985) recommends that adults consume 30% or less of their total daily coloric intake from fat, 10% or less of their daily caloric intake from saturated fats, and 300 mg or less cholesterol per day. The AHA also recommend that adults need no more that 6 oz. of meat, poultry or seafood per day (about two small, 3 oz. servings). If an adult consumes 2000 calories per day, a 3 oz. serving of cooked lean beef would contribute 4.0% and 1.6% of their daily caloric intake from fat and saturated fat, respectively, and 23% of the

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recommended daily cholesterol intake while contributing essential amino acids, B vitamins, zinc and iron (USDA, 1990).

Based on these figures, beef can fit into a healthy diet as prescribed by the AHA. However, the concern lies in the values calculated for cooked products. Limited research is available as to changes in lipid concentrations and fatty acid composition that may take place during cooking. Most of the values for small portion sizes have been extrapolated from cooking 8-12 oz. steaks. Another factor important in calculation of these values is in determining the accurate SFA content. Stearic acid (C18:0), a saturated fatty acid, has been shown to have little or no effect on serum cholesterol levels (Hegsted, 1965). Work by Bonanome and Grundy (1988), showed that a high stearic acid diet lowered serum cholesterol 14% compared to a diet high in palmitic acid (C16:0). Thus the belief is that a corrected SFA content should be calculated (%SFA - %C18:0) to most accurately predict negative effects on serum cholesterol. The objective of this study was to assess the effect cooking may have on the moisture, lipid and fatty acid content of beef steaks.

Materials and Methods

Forty-eight steaks from the 9th rib of Angus x Hereford steers serially slaughtered at 28 day intervals (0-196 days-on-feed (DOF)) were sectioned into lateral (RAW) and dorsal (COOK) halves after removal of all exterior fat and the epimysial connective tissue. Dorsal halves, approximately 4 oz., were broiled to an internal temperature of 158°F, a medium degree of doneness. Both RAW and COOK halves were pulverized in liquid nitrogen and stored at -22°F until subsequent chemical analyses.

Both RAW and COOK were analyzed for moisture, lipid and fatty acid content. Duplicate samples were dried at 216°F for 24 hours to determine moisture content Samples were then solvent extracted to obtain two fractions: neutral lipid (NL) and polar lipid (PL). The NL contains mono-, di-, and triglycerides while the PL contains the phospholipids. Aliquots from both the NL and PL were dried at 216°F for 24 hours after solvent removal to determine percent lipid. The percent lipid in the NL and PL were then added to obtain the total lipid (TL) content. Approximately 40 mg of NL and PL were esterified and analyzed using a HP5890A Gas Chromatograph to obtain fatty acid profiles.

Data were analyzed using the split-plot analysis of variance with animal considered the whole plot and steak as the sub plot.

Results and Discussion

Moisture and lipid composition of the longissimus muscle (LM) are reported in Table 1. Cooking loss averaged 34.5%. Moisture content decreased

Table 1. Moisture and lipid composition of the longissimus muscle.

Percent	Trt	Days-on-Feed (DOF) 0	28	56	84	112	140	168	196	SEM
Moisture[ac]	Raw	74.59	74.08	73.32	73.64	70.45	68.93	68.59	67.47	1.13
	Cook	57.55	55.11	53.40	52.80	47.96	45.47	47.83	48.43	
Total Lipid[ac]	Raw	2.52	3.06	4.96	4.09	9.48	9.73	9.83	11.65	0.94
	Cook	11.82	15.32	16.60	18.42	25.50	28.42	24.89	25.64	
Neutral Lipid[ac]	Raw	1.84	2.45	4.34	3.44	8.88	9.03	9.14	10.95	0.91
	Cook	10.57	14.20	15.49	17.23	24.28	27.15	23.68	24.42	
Polar Lipid[a]	Raw	0.68	0.61	0.61	0.65	0.62	0.71	0.69	0.70	0.03
	Cook	1.25	1.17	1.11	1.19	1.23	1.28	1.21	1.19	
Cooking Loss	Cook	34.33	35.89	33.38	35.66	34.34	33.57	34.02	34.69	1.78

[a] Treatment effect (P<.01)

[c] Treatment by DOF interaction (P<.10)

an average of 20.4%. TL, NL and PL content increased with cooking (P<.01). This increase is mainly due to the loss in moisture content incurred during cooking. The lipid values in this experiment exceed those published by the USDA (1990) for cooked beef rib steaks. This increase in lipid content would result from (1) removal of the epimysium and/or (2) using the AHA recommended serving size. These would lead to greater moisture losses and lipid concentration in the LM during cooking. These results suggest that extrapolating USDA (1990) values to predict smaller portion sizes may not be accurate.

Fatty acid changes for RAW and COOK are reported in Table 2. SFA concentration increased 3.9% with cooking (P<.01). The greatest increase was at 0 DOF. Cooking decreased monounsaturated fatty acid (MUFA) and polyunsaturated fatty acid (PUFA) concentrations 2.1% and 2.0%, respectively (P<.01). The largest loss in MUFA content occurred at 168 DOF, while the largest loss in PUFA content occurred at 0 DOF. The changes in fatty acid content with cooking increased SFA to unsaturated fatty acid (UNSFA) ratio from .97 to 1.13. The loss of the UNSFA during cooking is due to the fact that fatty acid melting points decrease with their degree of unsaturation and thus making them more susceptible to oxidation during cooking.

In summary, cooking results in moisture, MUFA and PUFA losses and consequent increases in lipid and SFA concentrations. These changes resulted in an overall increase in the SFA:UNSFA ratio with cooking such that over 50% of the fat in cooked beef rib steaks is saturated. Based on these results of this study, the contribution of 3 oz./day of cooked beef rib steak would be 8.0% and 4.2% of the daily caloric intake from fat and saturated fat, respectively. When a corrected SFA (CSFA) content is calculated (Table 3), 3 oz./day of cooked beef rib steak would contribute only 2.7% of the daily caloric intake from saturated fat .

Table 2. Fatty acid composition of the longissimus muscle.

Percent	Trt	Days-on-Feed (DOF) 0	28	56	84	112	140	168	196	SEM
SFA[ab]	Raw	47.30	50.24	50.90	49.70	50.61	48.26	47.14	47.79	0.32
	Cook	55.28	54.27	53.36	53.34	53.05	51.55	50.72	51.30	
MUFA[ac]	Raw	39.91	41.60	41.89	43.24	44.98	46.69	48.75	48.73	0.38
	Cook	38.57	41.09	41.29	41.41	42.08	43.86	45.04	45.29	
PUFA[ab]	Raw	12.31	8.15	6.85	7.16	4.48	4.93	4.18	3.42	0.26
	Cook	5.22	4.38	4.87	4.80	4.22	4.21	4.10	3.62	
SFA:UNSFA[ab]	Raw	0.90	1.01	1.04	0.99	1.02	0.93	0.89	0.92	0.01
	Cook	1.26	1.19	1.16	1.15	1.14	1.07	1.03	1.05	

[a] Treatment effect (P<.01)

[b] Treatment by DOF interaction (P<.05)

[c] Treatment by DOF interaction (P<.10)

Table 3. Stearic, oleic and corrected SFA concentrations in the longissimus muscle.

Percent	Trt	Days-on-Feed(DOF) 0	28	56	84	112	140	168	196	SEM
C18:0[ab]	Raw	17.36	17.38	17.80	15.72	15.71	14.29	13.38	13.92	0.28
	Cook	22.83	20.59	19.17	18.96	18.23	17.38	16.12	17.10	
C18:1[a]	Raw	34.95	36.40	36.85	38.04	38.92	40.31	41.58	41.86	0.31
	Cook	33.90	36.53	37.05	37.23	38.07	39.64	40.30	40.49	
CSFA[abc]	Raw	29.92	32.86	33.10	33.98	34.90	33.97	33.76	33.87	0.19
	Cook	32.45	33.68	34.19	34.38	35.07	34.17	34.60	34.20	

[a] Treatment effect (P<.01)

[b] Treatment by DOF interaction (P<.05)

[c] % SFA minus % C18:0

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EFFECT OF TIME-ON-FEED ON THE NUTRIENT COMPOSITION OF BEEF STEAKS

S.K.Duckett[1], D.G.Wagner[2], H.G.Dolezal[3], L.D.Yates[4], A.C.Clutter[4] and S.G.May[1]

Story in Brief

Forty-eight Angus x Hereford steers were used to assess the effect of time-on-feed on the nutrient composition of beef rib steaks. The steers were fed a high concentrate diet and serially slaughtered at 28 day intervals over a 196 day feeding period. Day 0 served as a grass-fed control. At slaughter, steaks from the ninth rib were removed and trimmed of exterior fat and epimysial connective tissue for chemical analyses. Increased time-on-feed resulted in a cubic increase in intramuscular fat content with a resultant linear decrease in moisture and protein content. The most substantial increase in fat content was noted after 84 days on feed. Ash content decreased cubically but individual mineral concentrations did not differ significantly. Total and neutral lipid contents both increased linearly with time-on-feed. Polar lipid concentrations remained constant over time-on-feed. With increased time-on-feed, the neutral lipid fraction became more unsaturated. The ratio of saturated fatty acids to unsaturated fatty acids differed quadratically over time.

(Key Words: Beef, Proximate Composition, Lipids.)

Introduction

Due to an increasingly health conscious society, the inclusion of beef as part of the American diet has been the focus of debate, primarily due to beef's saturated fat content and possible link to coronary heart disease (CHD) (Truswell, 1978). Current recommendations by the American Heart Association regarding dietary fat focus on replacing the intake of saturated fat with that of unsaturated fats. Monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) have been shown to reduce plasma LDL-cholesterol and consequently reduce the risk of CHD (Mattson & Grundy, 1985).

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As time on a high concentrate diet increases, cattle deposit greater amounts of fat which consequently decreases moisture and mineral concentrations in the muscle. This increase in intramuscular fat content is due primarily to an increase in triglycerides as the phospholipids remain constant throughout growth (Link, 1970). PUFA are predominately located in the phospholipid fraction and since this fraction is diluted by the increase in triglycerides, PUFA decrease with increased time-on-feed (TOF). Conversely, changes in the MUFA and saturated fatty acids (SFA) over TOF have not been studied extensively. The objective of this study was to assess the effect of time-on-feed on the nutrient composition of beef steaks.

Materials and Methods

Forty-eight Angus x Hereford steers, approximately 16 months of age were obtained from a native range stocker operation in northwestern Oklahoma. Steers were blocked by weight into eight equally sized groups to be serially slaughtered at 28 day intervals (0-196 days). Steers were fed a high concentrate diet (87.50% dry matter, 2.11 Mcal/kg NEm, 1.36 Mcal/kg NEg) except for Day 0 which served as a grass-fed control. All steers were conventionally slaughtered at the Oklahoma State University Meat Laboratory. A one inch boneless rib steak corresponding to the ninth rib was removed from each carcass, vacuum packaged and stored at -20°F. After removal of all exterior fat and epimysial connective tissue, the lateral half of each longissimus muscle (LM) was pulverized in liquid nitrogen prior to chemical analyses.

Duplicate samples were dried at 216°F for 24 hours, extracted with ether and then ashed at 1250°F for 8 hours to determine moisture, crude fat and ash content, respectively (AOAC, 1984). Crude protein content was determined using the KJELTEC Auto 1030 Analyzer. Individual mineral concentrations were determined using a Perkin-Elmer Model 403 Atomic Absorption Spectrometer. Samples were solvent extracted to obtain two fractions: neutral (NL) and polar (PL) lipid. The NL fraction contains mono-, di- and triglycerides while the PL fraction contains the phospholipids. NL and PL were esterified and analyzed for fatty acid content using a HP5890A Gas Chromatograph.

General Linear Model procedure of SAS was used to test the effect of time-on-feed (TOF). Differences between means were compared using Tukey's t-tests. Orthogonal polynomials were computed to determine linear, quadratic and cubic effects over TOF.

Results and Discussion

The performance and carcass data of these steers along with palatability attributes have been reported previously (May et al. 1989). Proximate composition data of the LM is reported in Table 1. Increased TOF resulted in a cubic increase in fat content with a concomittant linear decrease in moisture and protein contents ($P<.01$). The fat content in the LM doubled between 84 and 112 days on feed but did not differ ($P>.05$) from 0 to 84 or from 112 to 196 days. Ash content decreased cubically ($P<.05$), however, Ca, P, Mg, Na, K and Fe concentrations (Table 2) did not differ ($P>.05$). Mg and K did show a tendency for a cubic effect ($P<.10$). All values are in agreement with those published in the USDA Agricultural Handbook 8-13 (USDA, 1990).

Percent total lipid (Figure 1) increased linearally with increased TOF which resulted in a similar increase in NL ($P<.05$). PL content did not differ ($P>.05$) with increased TOF. The amount of NL increases proportionally with the increase in total lipid. When expressed as a percentage of total lipid (Figure 2), NL increased quadratically while the PL decreased quadratically. Therefore, increases in the amount of NL coincided directly with increases in total lipid. Thus as animals deposit greater amounts of intramuscular fat during growth the relative proportions of PL are diluted with the increasing amounts of NL.

Table 1. Proximate composition of the LM.

TOF	% Moisture	% Protein	% Fat	% Ash
0	74.58^{a}	21.71^{a}	2.09^{a}	1.09^{a}
28	74.08^{a}	21.83^{a}	2.62^{a}	1.08^{a}
56	73.32^{ab}	20.51^{ab}	4.10^{a}	1.07^{ab}
84	73.64^{a}	21.41^{ab}	4.02^{a}	1.08^{a}
112	70.45^{bc}	19.50^{b}	8.67^{b}	0.99^{bc}
140	68.93^{c}	20.33^{ab}	9.35^{b}	0.99^{bc}
168	68.59^{c}	20.58^{ab}	9.64^{b}	0.99^{b}
196	67.47^{c}	20.07^{ab}	10.14^{b}	0.98^{c}
SEM	0.70	0.41	0.80	0.02

^{abc} Means with different superscripts in the same column differ significantly ($P<.05$).

Table 2. Mineral composition of the LM[a].

TOF	Mg	Na	K	Ca	Fe	P	Zn
			mg/100 g sample				
0	17.78	85.35	329.83	19.55	5.36	226.00	5.66
28	20.96	86.33	315.23	24.98	5.08	188.73	6.70
56	19.31	92.76	321.79	23.45	5.12	198.93	8.11
84	20.75	100.65	336.31	23.17	5.30	185.43	12.17
112	21.97	91.91	324.85	30.50	5.37	189.07	8.43
140	15.44	92.40	295.27	15.05	4.97	216.47	7.48
168	17.71	107.85	283.72	21.02	5.76	204.47	8.94
196	19.66	89.00	332.97	24.33	5.68	202.00	9.41
SEM	0.70	4.68	5.09	2.17	0.08	7.31	0.66

[a] Means did not differ across TOF (P>.05).

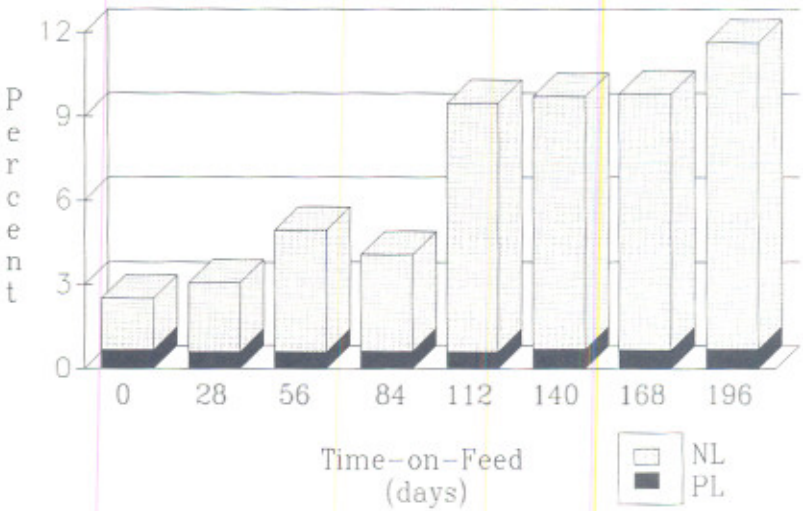


Figure 1. Lipid composition of the LM.

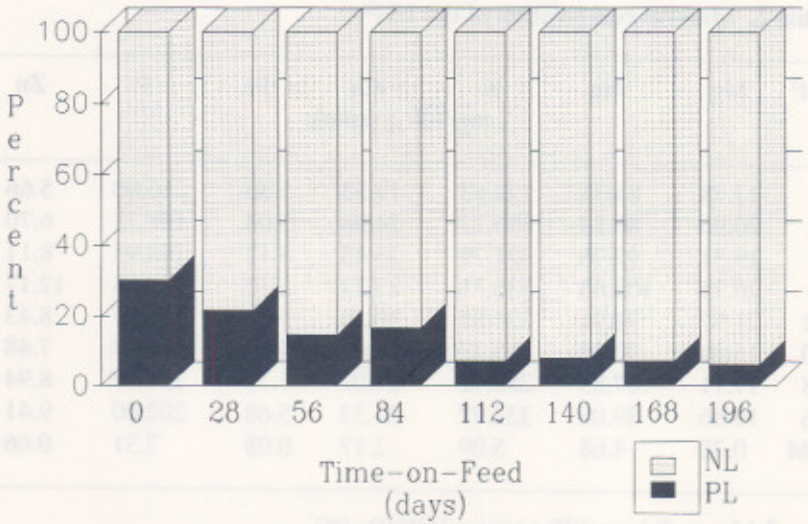


Figure 2. Percent NL and PL in the LM on a TL basis.

Oleic (C18:1), stearic (C18:0) and palmitic (C16:0) acids were the most abundant fatty acids present, respectively, and accounted for approximately 80% of total lipid. The percent SFA (Figure 3) in the LM showed a quadratic effect ($P<.01$) while the percent MUFA showed a linear increase of 8.8% and percentage PUFA showed a linear decrease of 8.1% ($P<.01$) over TOF. Over two-thirds of the PUFA were located in the PL, thus, since PL decreased as a percentage basis of TL, the PUFA were diluted by the increase in the NL. The increase in MUFA was due primarily to a significant increase in oleic acid (C18:1) ($P<.05$). Increased TOF resulted in increased unsaturation in the NL fraction. The ratio of SFA to unsaturated fatty acids (UNSFA) (Table 3) differed quadratically ($P<.01$) with TOF following the same trend as the change in SFA due to the cancellation effect of the MUFA increase and PUFA decrease. On the average the SFA:UNSFA ratio was 0.97, meaning that over 50% of the fat in the LM was unsaturated.

In summary, cattle need to consume a high concentrate diet approximately 112 days before slaughter to acquire the level of intramuscular fat in the LM to obtain the choice quality grade. Extending the time cattle are fed a high concentrate diet past 112 days does not significantly increase intramuscular fat deposition but does reduce PUFA concentrations and increase the MUFA content in the LM.

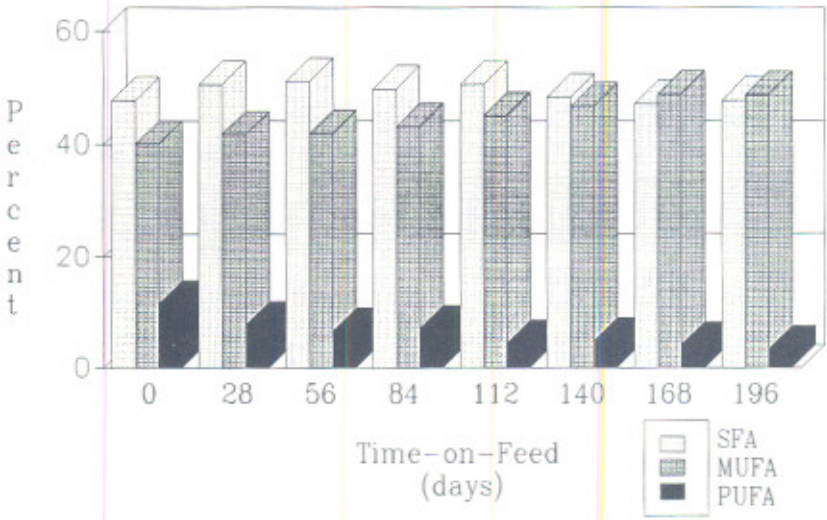


Figure 3. Fatty acid composition of the LM.

Table 3. Ratio of saturated fatty acids to unsaturated fatty acids in the LM.

TOF	SFA:UNSFA
0	0.92^{ab}
28	1.02^{ab}
56	1.05^{a}
84	0.99^{ab}
112	1.02^{ab}
140	0.94^{ab}
168	0.89^{b}
196	0.92^{ab}
SEM	0.01

^{a,b} Means with different superscripts differ significantly ($P<.05$).

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THE EFFECT OF TEMPERATURE ON THE PROTEIN SOLUBILITY OF BEEF SHOULDER CLODS

G. Gadea de Lopez[1] and L.W. Hand[2]

Story in Brief

The study of protein functionality of raw materials used in meat processing is important for final product quality and yields. In this study, the effect of temperature on the solubility of beef shoulder clod muscle proteins was evaluated in the range of -2 to 26°C at 2°C intervals. Samples were treated with 2% NaCl, 0.03 M phosphate or 1.1 M KI for the extraction of total, sarcoplasmic and myofibrillar fractions, respectively. Regression models indicated maximum amounts of solibilized total protein were obtained at 14°C, sarcoplasmic at 26°C and myofibrillar at 6°C. This research indicates that 14°C is the temperature to obtain maximum solubility of beef shoulder clods used in meat products.

(Key Words: Protein Solubility, Beef Clods, Temperature.)

Introduction

With the increased interest in the consumption of low-fat, low-sodium meat products, research addressing the effects of processing conditions on the functionality of meat proteins have become a matter of major importance. The problems of adequate water binding have become a main issue in processing with the increased amount of added water present in low fat products due to the USDA "40 percent rule" (Federal Register, 1988). Water binding potential (expressed as water holding capacity, WHC) and protein solubility may be considered the two most important functional properties that define the characteristics of the final product. Previous studies typically examined functionality of trimmings using high salt concentrations to obtain maximal protein extractions. However, these results may not be as useful in a lower salt system, as is the current industry norm. The objective of this study was to determine the effect of temperature on the water holding capacity and solubility of beef shoulder clod muscle proteins.

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[1]Graduate Student [2]Assistant Professor

Materials and Methods

Three USDA Choice beef shoulder clods were obtained (approximately 72 hr post-mortem) from a local supplier. The clods were frozen (-29±2°C for 72 hr) and thawed (3±1°C, 72 hr). Each clod represented one replication.

The clod muscles were separated and trimmed of all visible fat. The weight of the clods after fat removal was 5.4±0.1 kg. The meat was ground (grinder, model 5424852, Biro Mfg. Co., Marblehead, OH) using a 2.54 cm plate and reground through a 5 mm plate before mixing (Leland ribbon-paddle mixer) for 1 min. The ground meat was divided into 16 portions and vacuum packaged (Multivac, Kansas City, MO). One sample portion was used for the determination of protein (20.21%, SE 0.388), fat (5.82%, SE 1.03) and moisture (72.67%, SE 0.81) content (AOAC, 1984). Each sample was randomly assigned to one of 15 temperature treatments (from -2 to 26°C, 2°C intervals, ±0.1°C) and frozen (-29±2°C) until analyzed. Each sample was thawed (3±1°C) for eighteen hours prior to the start of protein extraction.

Total proteins were extracted (quadruplicate) using a modified version of the method of Hand et al. (1985). The samples were weighed (50±0.1 g) in 250 mL Nalgene bottles and allowed to equilibrate to the required temperature. Then, a 100±0.1 mL NaCl 2% (w/v) solution (also at the required temperature) was added to each sample. The bottles were placed in a covered shaker water bath (model BKS-350, Gallenkamp and Co., Sussex, England) and shaken at 120 rpm for 10 min. The temperature of the water bath (±0.1°C) was regulated by a refrigerated circulator (Lauda model RMS-20, Brinkmann Instruments, Westbury, NY). After the extraction period, samples were centrifugated at 1860 x g for 10 min (model J-6M Beckman Instruments, Palo Alto, CA) at the same temperature of extraction, and filtered through #1 Whatman filter paper. The protein content of the filtrates was determined by the Biuret method (Gornall et al., 1949).

Sarcoplasmic and myofibrillar proteins were extracted using a 0.03 M potassium phosphate solution at pH 7.4 and 1.1 M potassium iodide in a 0.1 M phosphate solution at pH 7.4, respectively, according to a modified version of the methods of Helander (1957) and Sayre and Briskey (1963). Samples weighing 5±0.05 g were placed in 50 mL polycarbonate tubes (quadruplicate) and temperature was equilibrated to that required by each treatment. Sarcoplasmic proteins were extracted first with 30 mL of 0.03 M potassium phosphate at pH 7.4 (also at the same temperature). The samples were shaken at 90 rpm for 2 hr. After the extraction period, the tubes were centrifuged at 3640 x g for 15 min at the temperature of extraction. After separation of the supernatant, 30 mL of KI 1.1 M solution (pH 7.4) were added to each tube. The samples were shaken for 4 hr at 90 rpm and centrifuged at 3640 x g for 15 min. The supernatant containing the extracted myofibrillar proteins was separated by

filtration. Sarcoplasmic and myofibrillar extracts were analyzed for protein content using the Biuret method (Gornall et al., 1949).

Water holding capacity was determined by a modified method of Jauregui et al. (1981). The temperature of operation was varied, as needed for each of the treatments, and the centrifugation time and rotor speed were changed from 15 min and 30,900 x g to 45 min and 3640 x g, respectively. This experiment was performed in triplicate.

The results from this experiment were analyzed using linear regression (Steel and Torrie, 1980) and the analysis of variance was performed with the SAS program (SAS Institute, Inc., Version 6.1), with temperatures as treatments.

Results and Discussion

The effect of temperature on the total salt extractable protein is shown in Figure 1. The regression line ($P<0.05$) indicated that a maximum amount was solubilized at 14°C, within the range studied. Reports from other studies have indicated that the optimal temperature for the extraction of total protein from beef and pork combination sources is 7.2°C, using a 7.5% NaCl solution (Gillett

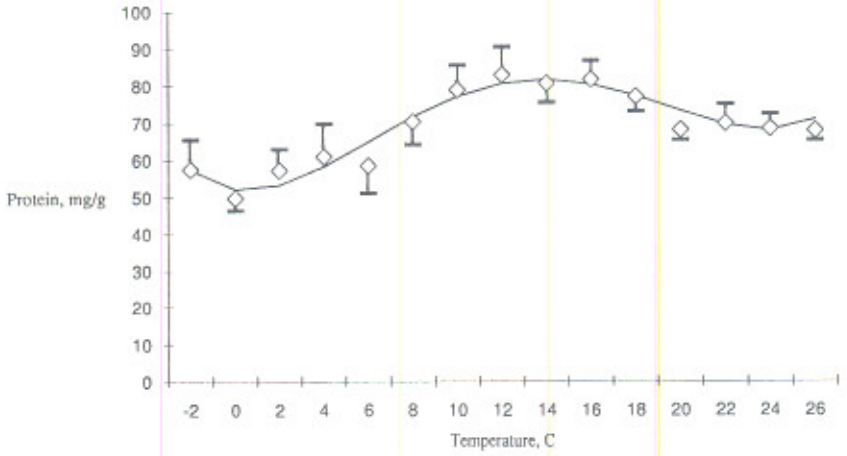


Figure 1. Effect of temperature on the solubility of total salt extractable proteins.

Solid line indicates significant regression line.
Diamonds and connecting bars indicate treatment means and standard errors.

et al., 1977). However, the NaCl solution used in this study was 2.0%, a level more characterisic of current meat industry conditions, especially in light of lower salt and sodium products.

Figure 2 shows the effect of the temperature on the solubility of sarcoplasmic proteins. The significant model indicated that the point of maximum solubility is 26°C. However, there were small magnitudes of change in the range of 6° and 16°C before increasing to the maximum at 26°C.

The effect of temperature on myofibrillar protein solubility is shown in Figure 3. The regression curve ($P<0.05$) indicated that the optimum temperature for extraction of myofibrillar proteins is 6°C. These results compare with those of Rust (1977), which suggest that the optimum temperature for the extraction of contractile proteins appears to be in the range of 4.4-7.2°C. The extent of protein recovery achieved in the total soluble, sarcoplasmic and myofibrillar solubility methods is comparable to the results of Helander (1957) and Ashgar and Yeates (1974), utilizing similar methodology.

Temperature had no ($P>0.05$) effect on water holding capacity (WHC). The overall mean was 43.7% (±0.2) which is similar to the findings of Jauregui et al. (1981).

From this study it can be concluded that maximum amounts of total salt extractable proteins are solubilized at 14°C. This temperature information could

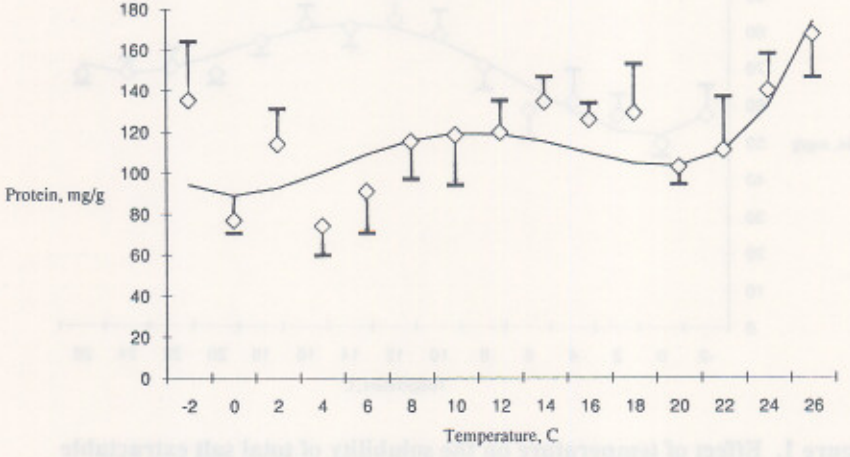


Figure 2. Effect of temperature on the solubility of sarcoplasmic proteins.

Solid line indicates significant regression line.
Diamonds and connecting bars indicate treatment means and standard errors.

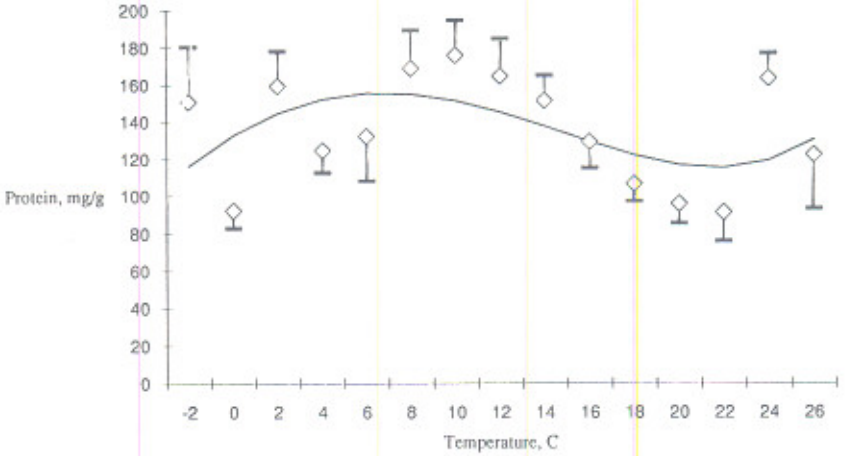


Figure 3. Effect of temperature on the solubility of myofibrillar proteins.

Solid line indicates significant regression line.
Diamonds and connecting bars indicate treatment means and standard errors.

be used to assist low fat meat products to perform to their maximum functionality capability. Further research is necessary to ascertain if these temperatures are still optimal in a final product such as a low fat, high moisture frankfurter.

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PROCESSING TEMPERATURE EFFECTS ON LOW FAT, HIGH MOISTURE, BEEF FRANKFURTERS

J.L. Hensley[1] and L.W. Hand[2]

Story in Brief

Beef frankfurters were conventionally manufactured using four different fat and added moisture combinations (6/32 Treatment 1, 11/22 Treatment 2, 14/16 Treatment 3, 23/-2 Treatment 4) and processed at three different chopping temperatures (9°, 12° and 15°C). Percent moisture was highest at 12°. As temperature increased, Instron hardness values increased in both higher fat levels, with 23% harder. Fat levels 6% and 11% were softer than both the higher fat levels and were not influenced by temperature. Higher yields were obtained in the higher fat, lower added moisture treatments but the yields decreased as temperature increased. Purge loss recorded over an eight week period, was highest for the lowest fat, highest added moisture treatment and continued to increase as days increased. The highest fat, lowest added moisture level showed the lowest amount of purge. As temperature increased the amount of purge increased in the treatments containing the lowest fat and highest added moisture levels.

(Key Words: Beef Franks, Purge, Yield, Chopping Temperatures, Added Water.)

Introduction

Recent USDA cooked sausage labeling changes have given the red meat industry an opportunity to provide consumers with economical, low fat products. The changes allow for the total fat and added moisture level not to exceed 40%, whereas the traditional level was 30% fat and 10% added water. Fat content can easily be reduced by formulation. However, when water is not added in place of fat, a rubbery texture usually occurs. Increasing the water level beyond traditional levels tends to put increased pressure on the meat system. This increased pressure can partially explain the excess purge, higher cooking losses and soft texture normally associated with low fat beef products.

Endpoint processing temperatures have been established as critical control

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points in frankfurter manufacture in relationship to maximum protein extraction (Jones and Mandigo, 1982). However, these temperatures were not related to low fat/high moisture systems. Optimum temperatures for maximum protein stability were reported to be between 10^{o} and 12^{o}C (Gadea, 1990). Therefore, the objective of this study is to evaluate low/fat high moisture beef frankfurters using different chopping temperatures to maximize product yield and quality.

Materials and Methods

Beef shoulder clods and 50% fat beef trim, obtained locally, were individually ground (Grinder, Biro Mfg. Marblehead, OH) through a 1.27 cm plate. Samples taken from each were then reground through a .32 cm plate and analyzed for fat, moisture and protein (AOAC 1984) for formulation purposes. Appropriate lean, fat and water proportions for four different fat/added moisture levels were found using a least cost formulation computer program. Treatments were formulated for fat and moisture combinations of 10% fat, 30% added water (Trtmt 1); 15% fat, 25% added water (Trtmt 2); 20% fat, 20% added water (Trtmt 3); and 30% fat, 10% added water (Trtmt 4). However, when final product proximate analysis was performed actual fat/added water combinations differed from the targets (Table 1).

Percentage water (26%) for initial salt mixing was held constant among all treatments. This percentage was found by dividing the entire amount of water by the amount of lean formulated for treatment 1. The appropriate amount of water was mixed with the lean portion and spices (A.C. Legg, Birmingham, AL) in a 6 blade vacuum bowl chopper (Seydelmann K64, Robert Reiser, Canton, MA) for 30 seconds on low speed. The fat portion and remaining water was then added. This mixture was then chopped for 4 minutes on high speed with the last 30 seconds being under vacuum. All fat

Table 1. Target and actual fat/added water combinations.

	Target		Actual	
Treatment	Fat	Added Water[a]	Fat	Added Water[a]
1	10	30	6	32
2	15	25	11	22
3	20	20	14	16
4	30	10	23	-2

[a] Added water = moisture - 4(protein)

moisture combinations were chopped at 3 different endpoint chopping temperatures (9^{o}, 12^{o}, and 15^{o}C) by incorporation of the appropriate amount of crushed carbon dioxide (CO_2).

The batter was then stuffed into 32 mm cellulose casings (NOJAX$^{\tilde{a}}$, Chicago, IL) and heat processed (Alkar 1 truck smokehouse, Lodi, WI). All treatments were replicated two times. Each treatment batch size was 11.33 kgs. Franks were allowed to cool for 18 hours at 4^{o}C before cooking yields were obtained by weighing the franks and dividing by the weight of the raw batter.

Frankfurters were then peeled and vacuum packaged (M855 Multivac, Kansas City, MO) 5 links per package. Samples from each treatment were frozen at -23^{o}C until proximate analysis and texture data could be obtained. The remaining packages were stored at 4^{o}C for purge analysis.

Purge loss was measured on 2 packages from each treatment stored at 40^{o}F. Each package was opened and the purge present was poured though a funnel into a 15 mL graduated centrifuge tube. The franks were then placed into the funnel to drain off any purge that was on the surface of the franks. Weights of the franks and empty packages were then recorded. The vacuum packages were dried in the smokehouse, to insure residual purge in the corners of the package was removed and weights were then obtained. Purge loss was then reported as a percentage of content weight. Purge was measured once a week for 8 weeks, with week 1 being the first week after production.

Compression values (quadruplicate) were determined by axially compressing a 3 cm sample 62.5% of it's height for two cycles with an apparatus attached to an Instron (Model 4500, Instron Corp. MA) which was set at a crosshead speed of 500/mm/minute and a 1kN load cell. Values obtained were hardness, springiness and cohesiveness.

Significant interactions ($P<.05$) between fat level and temperature and between temperature and day were analyzed using analysis of variance and linear regression. Significant regression lines are plotted and nonsignificant values are expressed as a line with no slope.

Results and Discussion

Table 2 shows the effect of temperature on proximate analysis. At 12^{o}C percent moisture was the highest. This can be directly related to the added water content. Although these differences were not statistically different, they are nonetheless very important to producers, where the added water content of their product could mean the difference between a profit or a loss.

Figure 1 illustrates the hardness of the franks with respect to a significant interaction between fat and temperature. Hardness is the force required to break the protein bonds of the product. This can be associated with the

Table 2. The effects of processing temperature on moisture, protein and added water.

Temperature, °C	Moisture		Protein		Added Water[a]	
	Mean	SE	Mean	SE	Mean	SE
9	69.43	2.78	13.05	.48	17.21	4.68
12	70.81	2.89	12.63	.50	20.27	4.79
15	68.15	3.28	13.64	.59	13.57	5.54

[a] Added water = moisture - 4 protein).

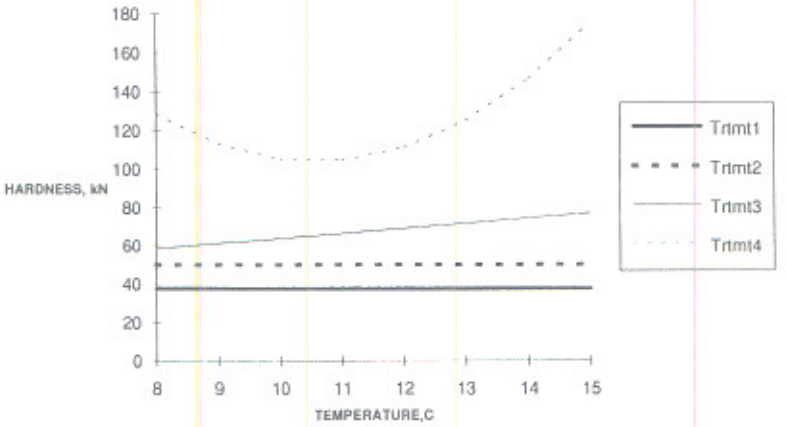


Figure 1. Hardness values associated with fat and temperature interactions.

amount of force required to compress a sample between molar teeth (Brady and Hunecke, 1985.). Eating qualities are very important in the marketability of franks, therefore it is essential to examine the hardness associated with varying fat and added water combinations. Treatment 4, higher fat content had higher hardness values than did those of other treatments. A higher peak force was noticed at 15°C for both treatments 3 and 4. This can be explained by increased protein extraction and less water holding capacity which would make the product harder. Temperature had no effect ($P < .05$) on the hardness values of treatments 1 and 2. The combination of higher added moisture and lower fat resulted in a much softer product, as shown by the much lower average hardness values. This may result in a detrimental consumer acceptance of low

fat, beef franks.

Figure 2 illustrates the smokehouse yields obtained as a result of significant interactions between fat and temperature. In the two higher fat level treatments (Treatments 3 and 4), as temperature increased the yield decreased ($P < .05$). This may be due to the findings of Gadea (1990) where the optimum temperature for water holding capacity was $6^{o}C$, which is lower than those examined in this experiment. Yields for both treatments 1 and 2 were not effected by temperature and their average yields were lower than the other products.

The significant interaction between temperature and fat level in respect to purge loss is illustrated in Table 3. As the level of fat was lowered and added water increased from treatment 4 to treatment 1, the percentage purge increased. As expected, the treatment with the highest fat level and lowest added moisture level showed the lowest percentage purge. These findings are in agreement with those of Claus et. al (1989). Temperature had little effect on purge within fat level except in treatment 2, where $9^{o}C$ exhibited a higher percentage purge then either $12^{o}C$ or $15^{o}C$. In industry, many processors chop to endpoint chopping temperatures which typically range from $16\text{-}18^{o}C$. It is believed that it is necessary to chop to these high temperatures in order to fully comminute the product and more specifically the fat portion. However, it is possible in some instances to have the product fully comminuted while still maintaining a low temperature, especially with the speed of modern day machinery and the use of carbon dioxide (CO_2) or liquid nitrogen.

The significant interaction between fat level and day is shown in Figure 3. As expected, the percentage purge increased as the number of days

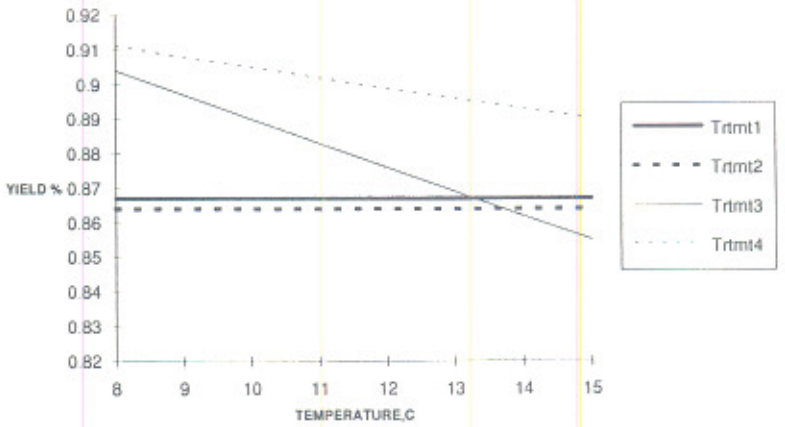


Figure 2. Smokehouse yields for fat and temperature interactions.

Table 3. The effect of temperature and treatment on percentage purge.

	Treatment							
	1		2		3		4	
Temperature, °C	Mean	SE	Mean	SE	Mean	SE	Mean	SE
9	6.69[a]	.46	2.06[cd]	.21	3.05[b]	.33	.55[e]	.09
12	6.58[a]	.45	2.74[bc]	.31	2.25[bcd]	.17	.72[e]	.04
15	6.14[a]	.61	2.67[bc]	.33	1.32[de]	.22	.57[e]	.03

[abcde] Means followed by different superscripts are different (P<.05)

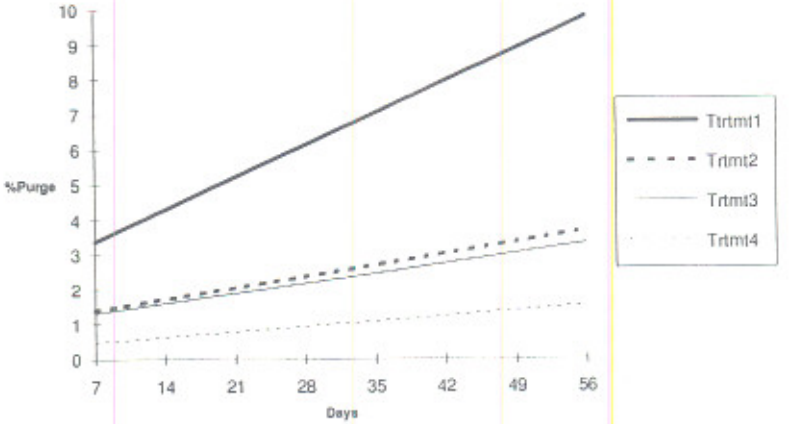


Figure 3. Significant interactions of fat and storage time purge.

increased. However, treatment 1 increased purge at a faster rate than did those of lower fat levels. This is probably due to the fact that more water was available in the product from the higher added moisture.

Summary

It is possible to manufacture high moisture, low fat, all beef franks. However, it is essential to maintain a low temperature during processing if the added water in the product is going to be bound and profitable yields are going to be achieved. Consumers will not purchase low fat franks if purge is not minimized. The frankfurters at lower fat higher added moisture levels were softer and this could be perceived by consumers as objectionable. In order for the beef industry to penetrate the highly competitive, low fat frankfurter market, additional research is essential to give the consumer a high quality product while allowing the processor to make a profit.

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INCREASED UTILIZATION OF MUSCLES FROM THE TWO-PIECE BEEF CHUCK

J.W. Lamkey[1], K.A. Dunlavy[2], and H. Glen Dolezal[3]

Story in Brief

Selected muscles from the two-piece beef chuck were used to determine the effect of four brine solutions on the assessment of palatability by a sensory panel. The supraspinatus, infraspinatus, rhomboideus/splenius, complexus and triceps brachii were selected based on size and tenderness ratings. All brine solutions were formulated to contain 1% salt and 2.5% phosphate. Muscles were pumped to 120% of their original weight. Three of the brines contained sodium lactate, isolated soy protein, or a combination of isolated soy protein and sodium lactate. A control was comprised of muscles without any brine injected. As the amount of solids in the brine increased, the yield of the steaks obtained from the muscles increased. Thaw loss was highest for the salt and phosphate brine with no difference between treatments in regard to cooking loss. A trained sensory panel indicated that injected steaks were more tender than the control. Sodium lactate was found to improve the water binding ability of steaks equivalent to the soy injected steaks without the detection of off flavors. This study suggests that more tender and juicy steaks can be obtained from the two-piece chuck by injection of a brine solution that contains sodium lactate without an objectionable increase in off flavors. The moisture retention of the steaks with sodium lactate is superior to steaks with only salt and phosphate.

(Key Words: Beef, Sodium Lactate, Soy Protein, Palatability.)

Introduction

An increase in the desire for more convenient meat items has prompted processors to develop new methods to improve the utilization of muscles historically associated with beef chuck roasts. One method that is currently used is restructuring. Restructuring is a process where selected muscles (usually obtained from the less utilized portions of the carcass) are trimmed of bone, fat, and connective tissue, ground and reshaped into a product that can be cut to steaks or utilized as a roast. Although restructuring is a technology that gives

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processors the ability to improve the tenderness of chuck muscles, the acceptance of these products at the retail level has been limited. This results from the "ground beef texture" perceived by many and the fact that these products must be sold under frozen storage conditions. In addition, during the manufacture of such a product, the processor must remove large amounts of connective tissue which requires more labor and produces a low-value by-product.

An alternative to the restructuring process is the injection of whole muscles with a brine solution that increases the tenderness of the muscle and creates a product that is more suitable for rapid cooking methods. This study investigates the utilization of various non-meat ingredients and the potential for increasing the utilization of the muscles from the chuck.

Materials and Methods

Two piece chucks (n=20) were selected from carcasses having marbling scores ranging from small to modest and preliminary yield grades from 3.0 to 3.5. Each chuck was vacuum packaged and transported to the Oklahoma State University Meat Laboratory. The infraspinatus, supraspinatus, triceps brachii, rhomboideus/splenius, and complexus muscles were removed and yields obtained. The chucks were randomly assigned to blocks of two. Muscles from the same anatomical location in each block were randomly assigned to one of five treatments. The treatments consisted of one control and four brine formulations. All brines were formulated to contain 1% salt, and 2.5 % sodium phosphate. Three of the brines additionally contained either 2% isolated soy protein (SI), 2% sodium lactate (SL) or a combination of SI and SL. All muscles were injected to 120% of their original weight and each treatment vacuum tumbled for two hr (20 min on, 10 min off). At the completion of each cycle, the muscles were stored at 40°F overnight. At the end of the storage period, each muscle was weighed to determine the amount of purge accumulated.

Each muscle was individually wrapped in oxygen permeable film and wrapped a second time with plastic-lined freezer paper. The muscles were placed in a freezer until cut into one inch steaks. Each steak was individually vacuum packaged and stored frozen until analyzed.

Steaks were allowed to thaw overnight at 40°F to allow for the insertion of copper-constantan thermocouples. Steaks were cooked to 104°F, turned and removed when 158°F internal temperature was reached. Weights of the steaks were obtained prior to and at the end of cooking to determine cooking losses.

Two steaks from each muscle were obtained for sensory evaluation by a trained panel. Panelists were initially subjected to salt solutions of increasing strength to screen for salt thresholds. Trained panelists evaluated tenderness,

flavor intensity, saltiness, off-flavor, and connective tissue amount. Each panelist was given five samples per session for evaluation.

Cooked steaks were objectively measured for tenderness using the Warner-Bratzler shear apparatus attached to an Instron Universal Testing Machine (Model 4502). Data collection and analysis software were used to obtain peak force and energy required to shear the samples. Approximately eight cores measuring one-half inch in diameter were obtained from each steak assuring that the muscles fibers were oriented parallel to the longitudinal axis. A 1 kN load cell traveling at a speed of 50 mm/min sheared each sample perpendicular to the direction of the muscle fibers. One steak from each muscle was used for analysis.

A randomized complete block design was used for statistical analysis with two chucks comprising one block and the muscles from those chucks were randomly assigned to one of five treatments. Main effects and interactions were analyzed by the general linear models procedure with mean separations using Tukeys Least Significant Difference approach (Steel and Torrie, 1960). All statistical analysis was performed using the Statistical Analysis System for personal computers.

Results and Discussion

The weights and yields associated with the selected muscles from the two-piece beef chuck are reported in Table 1. The total yield averaged 15.2% with the triceps brachii comprising the major portion. The smallest yield was obtained from the rhomboideus/splenis muscle.

Table 1. Weights and yields of selected muscles from the two-piece beef chuck.

	Muscle[a]				
	SS	IS	RS	CP	TB
Weight, lb	2.22	3.62	1.58	2.56	4.76
Yield, %	2.35	3.65	1.69	2.57	5.08

[a] SS = Supraspinatus
IS = Infraspinatus
RS = Rhomboideus/splenius
CP = Complexus
TB = Triceps brachii

After treatment with the brine solutions, the steaks cut from the muscles were heaviest (P<.05) for the muscles containing soy protein (Table 2). The differences in weights of the steaks are due to the loss of moisture (purge) after the muscles were tumbled and before the muscles were frozen. This loss was anticipated since the treatments with soy protein and sodium lactate contain more solids than do the other treatments, resulting in higher retention of the brine. Upon thawing of the steaks prior to cooking, the amount of moisture lost due to purge was greatest for the sodium phosphate and salt solution. Thaw loss associated with the other brines, as a percentage of the total weight, was not different from the control (Table 2). It can be assumed, therefore, that sodium lactate aids in the ability for the muscle proteins to retain moisture but does not show a synergistic effect for water binding ability in the presence of soy protein. Although the magnitude of the cook loss decreased with the addition of sodium lactate or soy protein isolate, there was no significant difference in the loss in weight due to cooking between treatments.

Thaw loss associated with different muscle types was greatest (P<.05) for the supraspinatus (Table 3). This increase in thaw loss requires further examination to determine the primary reason. There was no difference in the cook loss between the muscles studied.

A trained sensory panel indicated that all muscles became more tender with the addition of a brine solution (Table 4). Among the brines used, soy protein in the presence of sodium lactate was associated with the most tender

Table 2. Effect of brine solution on the thaw loss and cook loss of beef steaks.

	Treatment[a]					
	Control	SP	SL	SI	SIL	s.e.
Weight, lb.	0.73^{c}	0.84^{b}	0.92^{b}	0.96^{b}	0.98^{b}	.04
Thaw loss, oz	4.6^{c}	6.9^{b}	4.3^{c}	4.2^{c}	3.1^{c}	.40
Cook loss, oz	33.0	33.5	29.0	28.7	27.8	6.9
Moisture, %	74.2^{d}	79.1^{b}	76.1^{cd}	77.1^{bc}	73.8^{d}	1.1
Fat, %	6.5^{ab}	5.6^{b}	7.0^{a}	5.5^{b}	5.5^{b}	.3

[a] SP = Salt and sodium phosphate
SI = Isolated soy protein
SL = Sodium lactate
SIL = Isolated soy protein and sodium lactate

b,c, Means in same row with different superscripts are significantly different (P<.05)

Table 3. Effect of muscle type on the thaw loss and cook loss of beef steaks.

	Muscle[a]					
	SS	IS	RS	CP	TB	s.e.
Weight, lb	0.57^{e}	0.96^{c}	0.71^{d}	0.78^{d}	1.40^{b}	.04
Thaw loss, oz	6.0^{b}	3.5^{d}	4.4^{bcd}	5.2^{bc}	3.8^{cd}	.40
Cook loss, oz	30.0	29.3	29.5	31.7	31.5	6.9
Moisture, %	77.8^{b}	75.88^{bc}	75.6^{bc}	74.7^{c}	76.3^{bc}	1.1
Fat, %	3.7^{c}	7.01^{bc}	8.1^{b}	6.5^{c}	4.7^{d}	.30

[a] SS = Supraspinatus
IS = Infraspinatus
RS = Rhomboideus/splenius
CP = Complexus
TB = Triceps brachii

b,c,d,e Means in same row with different superscripts are significantly different (P<.05)

Table 4. Effect of brine solution on sensory assessment by a trained panel.

	Treatment[a]					
	Control	SP	SL	SI	SIL	s.e.
Tenderness	4.3^{e}	4.9^{d}	5.3^{cd}	5.7^{bc}	5.9^{b}	.1
Juiciness	4.4^{d}	4.8^{cd}	5.3^{b}	5.1^{bc}	5.3^{b}	.1
Connective tissue	4.5^{c}	4.7^{d}	5.2^{c}	5.5^{c}	5.8^{b}	.1
Flavor intensity	4.4^{c}	4.7^{c}	5.1^{b}	4.6^{c}	5.1^{b}	.1
Saltiness	5.5^{b}	4.9^{c}	4.0^{d}	4.8^{c}	3.8^{d}	.1
Off flavor	3.6^{bc}	3.7^{b}	3.6^{bc}	2.9^{d}	3.2^{cd}	.1

[a] SP = Salt and sodium phosphate
SI = Isolated soy protein
SL = Sodium lactate
SIL = Isolated soy protein and sodium lactate

b,c,d,c Means in same row with different superscripts are significantly different (P<.05)

steaks (P<.05), followed by the steaks containing soy protein and sodium lactate added separately. From the data obtained by the sensory panel, sodium lactate appears to work synergistically with soy protein to increase tenderness. Although this can be partially explained by the increased ability to retain moisture, other factors not yet determined must also be considered.

The perception of juiciness by the trained sensory panel indicated an increase with the addition of sodium lactate or soy protein (Table 4). The highest juiciness scores were associated with the steaks that contained sodium lactate, followed by those steaks containing soy protein without sodium lactate. All brine solutions were scored higher for juiciness, but the steaks containing only salt and phosphate were not significantly different from the control. The detection of connective tissue decreased with the addition of soy protein and sodium lactate to the brine solution. This decrease in the detection of connective tissue is most likely due to the dilution of the connective tissue by the added moisture and solids. There is an additive effect between soy and sodium lactate that would substantiate the dilution effect.

Flavor intensity increased above the control with the addition of sodium lactate to the brine solution (Table 4). The ability of sodium lactate as a flavor potentiometer has been indicated by other researchers. The perception for salt intensified (P<.05) with the addition of the brine solution which would be expected since all the steaks contained salt except for the control. The addition of sodium lactate further intensified the sensory panel's ability to detect salt. Off flavors associated with the steaks were indicated with the addition of soy protein. It is interesting to note that although soy increased the perception of off flavors, the addition of sodium lactate to the brine containing soy protein reduced those off flavors such that they were not different from the control.

The sensory panel indicated that the infraspinatus muscle was the most tender of the muscles studied with the complexus muscle being the least tender (Table 5). Juiciness and tenderness followed a similar rating for the muscles. Flavor intensity was highest (P<.05) for the triceps brachii, followed by the infraspinatus and the rhomboideus/splenceus. Saltiness and off-flavor were not different among the muscles studied.

Implications

This study suggests that sodium lactate has potential as an ingredient in brine solutions for the stability and palatability of muscles obtained from the chuck. The improvement in tenderness through the injection of brine solutions may be a viable alternative to the restructuring of beef muscles.

Table 5. Effect of muscle type on the sensory assessment by a trained panel.

	Muscle[a]					
	SS	IS	RS	CP	TB	s.e.
Tenderness	5.0[c]	6.3[b]	5.2[c]	4.1[d]	5.4[c]	.1
Juiciness	4.8[c]	5.5[b]	5.2[bc]	4.3[d]	5.0[c]	.1
Connective tissue	5.1[c]	6.0[b]	4.8[d]	4.4[e]	5.4[c]	.1
Flavor intensity	4.7[c]	4.8[bc]	4.8[bc]	4.6[c]	5.1[b]	.1
Saltiness	4.5	4.6	4.6	4.9	4.5	.1
Off flavor	3.2	3.5	3.4	3.6	3.3	.1

[a] SS = Supraspinatus
IS = Infraspinatus
RS = Rhomboideus/splenius
CP = Complexus
TB = Triceps brachii

b,c,d,e Means in row with different superscripts are significantly different ($P<.05$)

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CHARACTERIZATION OF INTERMEDIATE VALUE STEAKS FROM THE BEEF CHUCK

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Story in Brief

Two new retail steaks from the beef chuck (top blade and mock tender) and beef top loin steaks were purchased from a U.S. Choice retailer to contrast cooking, tenderness, and chemical properties. Top blade steaks had the shortest cooking time, lowest shear force (most tender), fewest tough ratings, and cheapest price per pound. Mock tender steaks had the least cooking shrinkage and were similar to top loin steaks for cooking time, shear force, and percentage tough steaks. Furthermore, cooked steaks from the mock tender had the lowest fat and caloric contents as well as the highest protein and moisture levels per three ounce serving. Results indicate that among steaks broiled to a medium degree of doneness, beef top blade and mock tender steaks are at least comparable to top loin steaks in tenderness and nutritional composition.

(Key words: Beef, Steaks, Tenderness, Proximate Analysis.)

Introduction

Over past years, beef chuck prices increased $8.00/cwt (8%) to add $2.00/cwt and $1.25/cwt to carcass and fed steer values, respectively (NCA, 1990). A portion of this price increase may be attributed to increased utilization of the chuck for ground beef production and perhaps, new merchandising methods for the chuck involving intermediate value whole muscle steaks. Aside from fabrication procedures, very little palatability and nutritional information is available for these new cuts. The recent revision of USDA Handbook No. 8-13 (USDA, 1990) only addresses traditional arm and blade steaks at various levels of trim. Accordingly, the purpose of this study was to characterize top blade and mock tender steaks from the beef chuck for tenderness and proximate composition relative to boneless top loin (strip) steaks.

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Methods and Materials

Eighty-seven steaks (approximately 1 in. thick) were purchased from a U.S. Choice (USDA, 1989) beef retailer to represent the mock tender (*supra spinatus*), top blade (*infra spinatus*), and top loin (*longissmus dorsi*) boneless cuts. Steaks were purchased on 10 different days, over a four week, period to minimize the risk of repeated sampling from a similar subprimal. Retail package information (number of steaks, price per pound, and package price) was recorded and all steaks were vacuumed packaged and frozen (-22^{o} F).

A random sample of steaks (n = 60; 20 for each muscle type) were thawed (35^{o} F) for 24 hours and subsequently charbroiled on Farberware Open-Hearth broilers to an internal temperature of 158^{o} F (medium degree of doneness). Data were collected to assess cooking time (minutes per 3 oz. serving) and cooking shrinkage (% weight loss). After a two hour cooling period to room temperature, steaks were cored (0.5 in diameter) to determine Warner Bratzler peak shear force using an Instron Model 4500. An average of four cores from each steak was tested to reflect tenderness. The cooked steak (including the cores used for the shear data) was stored at -22^{o} F for subsequent chemical analysis.

The remaining 27 raw steaks and all cooked steaks were individually frozen in liquid nitrogen, powdered in a Waring Blender and analyzed for percent moisture (oven drying), fat (ether extract), and protein (Kjeldal).

Data were analyzed using steak type as the main effect. Duncan's Multiple Range Test was used to partition subclass means.

Results and Discussion

Cooking properties, tenderness values, and retail prices stratified by steak type are presented in Table 1. Cooking time (minute/100g) was less ($P<.05$) for top blade steaks than for either mock tender or top loin steaks. Cooking shrinkage was similar ($P>.05$) for top blade and top loin steaks, but highest ($P<.05$) for mock tender steaks (28.0, 28.6, and 32.4%, respectively). Furthermore, top blade steaks had the lowest ($P<.05$) shear force values (most tender) while steaks from the mock tender and top loin were similar ($P>.05$). Likewise, top blade steaks had the lowest ($P<.05$) percentage of tough steaks (shear force values of 10 lbs or more) although, all three steak types averaged well within the tender range.

Average price per pound was the lowest ($P<.05$) for top blade steaks, intermediate for steaks from the mock tender and highest ($P<.05$) for top loin steaks. Due to increasing consumer demand for the mock tender during the sampling period, price per pound was the most variable for mock tender steaks

Table 1. Cooking properties, tenderness, and retail price by steak type.

ITEM	TOP LOIN	TOP BLADE	MOCK TENDER
Number of Steaks	20	20	20
Raw Weight, oz	6.9[b]	5.5[c]	5.0[c]
Cooking Time, min/100 g	16.8[b]	12.3[c]	15.6[b]
Cooking Shrink, %	28.6[c]	28.0[c]	32.4[b]
Shear Force, lb.	7.7[b]	5.9[c]	8.6[b]
Tough Steaks, %[a]	15.0	0	15.0
Price, $/lb.	6.21[b]	2.37[d]	2.61[c]

[a] Shear force values of 10 pounds or higher.
[b,c,d] Means in the same row with a common superscript letter are not different (P>.05).

($1.94 initially vs $3.38 ending). Price variation was minimal among top loin and top blade steaks ($0.30 and $0.10, respectively).

Chemical composition at raw and cooked endpoints stratified by steak type is presented in Table 2. Among raw steaks, intramuscular lipid content was the lowest (P<.05) for the mock tender, intermediate for the top loin and highest (P<.05) for the top blade. Moisture content of raw steaks tended to be inversely related to lipid content. Protein content was similar (P>.05) among top blade and mock tender steaks, but highest (P<.05) for top loins. At the cooked endpoint, no (P>.05) differences were noted among top blade and top loin steaks, however, mock tender steaks were lowest (P<.05) for lipid and highest (P<.05) for protein and moisture retention.

Similar results were observed when chemical constituents of cooked steaks were expressed per 3 ounce serving (Table 3). Mock tender steaks were lowest (P<.05) for lipid and caloric content and highest (P<.05) in protein and moisture. No (P>.05) differences were noted between steaks from the top blade and top loin. (Our values for the top loin coincide directly with values reported by USDA, 1990.)

Implications

New merchandizing methods for the beef chuck have increased the price of beef (NCA, 1990). Chuck cuts are cheaper than and at least comparable to

Table 2. Chemical composition of raw and cooked[a] steaks.

ITEM	TOP LOIN	TOP BLADE	MOCK TENDER
RAW[b]			
Fat, %	6.1[e]	7.7[d]	3.7[f]
Protein, %	22.7[d]	20.3[e]	20.7[e]
Moisture, %	69.2[f]	71.2[e]	75.2[d]
COOKED[c]			
Fat, %	11.9[d]	11.2[d]	6.3[e]
Protein, %	29.9[e]	30.4[e]	32.0[d]
Moisture, %	57.2[e]	56.3[e]	60.9[d]

[a] Broiled to a medium degree of doneness (158° F).
[b] n = 27 (5 top loin, 8 top blade, 14 mock tender steaks).
[c] n = 20 for each steak type.
[d,e,f] Means in the same row with a common superscript letter are not different (P>.05).

Table 3. Chemical composition of cooked steaks expressed per three ounce serving.

ITEM	TOP LOIN	TOP BLADE	MOCK TENDER
Fat, g	10.1[a]	9.5[a]	5.4[b]
Protein, g	25.4[b]	25.8[b]	27.2[a]
Moisture, g	48.6[b]	47.9[b]	51.8[a]
Calories, kcal	199.9[a]	196.3[a]	164.7[b]

[a,b] Means in the same row with a common superscript letter are not different (P>.05).

the top loin in tenderness and chemical composition. The top blade steak has not yet been recognized for its true value. An added quality of mock tender and top blade steaks is their deep orientation within the chuck, which leads to minimal fat trim and a leaner, healthier appearing retail cut, with minimum plate waste.

Also worthy of noting, is the definite need for cookery information at the retail case. If steaks from the chuck are to be utilized effectively, consumers

must be informed of the correct cooking procedures (methods and recommended degree of doneness).

Red meats can provide a wholesome, balanced diet to the health conscious consumer. But this cannot happen without continued efforts from producers and industry leaders.

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THERMAL RESISTANCE OF *ESCHERICHIA COLI* O157:H7 IN GROUND BEEF PATTIES.

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Story in Brief

Escherichia coli O157:H7 has been implicated in several foodborne outbreaks of hemorrhagic colitis associated with the consumption of ground beef. An industrial model was used to determine the survival of *E. coli* O157:H7 under different processing conditions for precooked ground beef patties. Quarter pound (112g) ground beef patties were inoculated with *E. coli* O157:H7 and D values (the time necessary to kill 90% of the inoculum) were determined at 135° F, 140° F and 145° F. The D value for 135° F is 168 sec, 140° F is 26 sec and 145° F is 11.6 sec. These results suggest that end point temperatures less than 160°F are more effective at killing *E. coli* O157:H7 in ground beef than previously reported. Lower end point temperatures coupled with proper holding times will increase yields and palatability of precooked beef patties and reduce thermal processing costs to the industry while maintaining product safety.

(Key Words: *E. coli* O157:H7, D values, Precooked Ground Beef Patties.)

Introduction

Public and government concerns of the microbiological safety of precooked beef patties has led the Food Safety and Inspection Service to raise the end point temperature of precooked beef patties from 140° F to 160° F. This increased end point temperature decreases palatability and product yield due to decreases in product moisture and increased toughness and dryness.

Little information is available on the distribution and survival of *E. coli* O157:H7 or other enterohemorrahagic serotypes in fresh and processed retail beef products. Doyle and Schoeni (1987) examined the distribution of this organism in fresh ground beef and reported that 6 (3.7%) of 164 beef samples assayed contained *E. coli* O157:H7. More recently Read *et al.* (1989) reported that 11% (25 of 225 samples) of ground beef samples contained the organism.

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The decimal reduction time (D value), which is the time required to destroy 90% of the *E. coli* organisms in a product, has been reported for ground beef. Doyle and Schoeni (1984) used 1 gram samples of inoculated ground beef and determined the D value at six different temperatures. They found *E. coli* O157:H7 to be more heat sensitive than *Salmonella*. However, the samples examined in this study were small one gram samples and therefore do not represent an equivalent thermal transfer process for the typical industry 112 gram ground beef pattie. The objective of this study was to determine the thermal resistance of *E. coli* O157:H7 in ground beef patties processed under typical industry conditions.

Materials and Methods

Bacterial strains and culture conditions.

E. coli O157:H7 #43895 was obtained from the American Type Culture Collection (Atlanta, GA). This strain was isolated from raw ground beef implicated in a hemorrhagic colitis outbreak. The culture was stored at -75°C and was routinely grown in Luria broth (LB) at 37°C. To ensure the use of a consistent, synchronous culture the growth curve of *E. coli* O157:H7 was determined in LB broth incubated at 37°C with continuous shaking (100 rpm). Inocula for experiments consisted of mid-log phase cells harvested by centrifugation at 13,000 x *g* for 10 min. Cells were resuspended in fresh LB to the desired cell density (10^6, 10^8 or 10^9 CFU/ml) prior to inoculation of ground beef.

Inoculation methods for ground beef patties.

Twenty eight quarter pound (112g) ground beef patties were inoculated with *E. coli* O157:H7 (10^9 CFU/ml) by spraying each side twice with the concentrated *E. coli* culture (.75 ml/spray) followed by grinding (.32cm plate) and reforming the ground beef into quarter pound patties. The resulting final inoculum was 2.7 x 10^7 CFU of *E. coli* O157:H7 per gram of ground beef. This was confirmed by sampling a raw patty and plating appropriate dilutions on MacConkey Sorbitol Agar (MSA, Oxoid Co.).

In initial experiments, a dropwise inoculum technique was used to add concentrated *E. coli* (10^9 CFU/ml) to ground beef trim. The inoculated beef was mixed, then ground twice in an attempt to ensure distribution of the inoculum. Quarter pound patties were then formed.

Thermal destruction of E. coli O157:H7 in ground beef patties.

Patties were placed in plastic bags and heated in a water bath to 135° F, 140° F or 145° F (9 patties/temperature). Once the initial temperature was reached, (determined by thermal couples in each patty) one patty was removed to determine the inactivation at the come-up-time, two more were removed for time 0 and immediately frozen in liquid nitrogen to represent industry's Individually Quick Frozen (IQF) technique. Duplicate patties were removed at appropriate intervals for 135° F (2.15 min.), 140° F (23 sec) or 145° F (12 sec). All patties were quick frozen and stored at -20° F.

Isolation and detection of *E. coli* O157:H7 in ground beef patties.

Surviving *E. coli* were determined by serially diluting (1:10) three randomly selected 12.5g meat samples/patty in 0.1% peptone and plating appropriate dilutions on MSA. *E. coli* colonies (white, opaque, raised) were counted and typical colonies were serologically confirmed as ***E. coli*** O157:H7. Duplicate tests were done for each temperature treatment and holding time. An average of these results was plotted to determine the D value for each temperature.

A resuscitation or recovery procedure (Doyle and Schoeni, 1984) and a Hydrophobic Grid Membrane Filter (HGMF) technique (Todd *et al.*, 1988) were initially compared to the direct plating procedure described above to determine the most reliable method for the enumeration of *E. coli* O157:H7 from precooked ground beef patties. All typical colonies were confirmed as *E. coli* O157:H7 using a latex agglutination kit (Oxoid) specific for the O157:H7 serotype.

Results and Discussion

Inoculation and enumeration methods for ground beef patties.

Initial results from the dropwise inoculation technique indicated an even distribution of the cells at a low inoculum level (10^5 CFU/g) but an uneven distribution at a high level of inoculum (10^8 CFU/g). Larger volumes of media would have dispersed the *E. coli* more uniformly, but the integrity of the patties would have suffered. A spray technique was devised as a means of inoculating pre-formed patties to reduce the uneven distribution of the inoculum. The spray technique was found to distribute the inoculum more evenly as determined from plate counts of inoculated, raw patties. Patties inoculated by dropwise addition of the concentrated culture to the batch of ground beef had *E. coli* counts

differing by more than one log ($<1.0 \times 10^5$ vs 1.0×10^5). Patties inoculated by spraying the concentrated culture on the preformed patty had *E. coli* counts differing by less than one log (1.0×10^7 vs 8.0×10^7). These results indicate that the *E. coli* cells were poorly redistributed by mixing and grinding after inoculation. This may be due to the *E. coli* cells binding to the meat proteins. The spray treatment decreased variability to a manageable level.

Three procedures were compared to determine the most reliable method for the enumeration of *E. coli* O157:H7 from precooked ground beef patties. The HGMF technique was effective for enumerating *E. coli* when high counts were present. However when lower numbers of cells were present and low dilutions had to be plated, the filter was often blocked with meat fibers. This impeded the efficient and rapid plating of samples and therefore prevented the use of this procedure.

A comparison of the direct plating procedure on MSA to the resuscitation plating procedure is shown in Table 1. Resuscitation or recovery plating is used to allow injured cells in a sample time to repair before selective medium is added. This may allow for the enumeration of injured cells that may survive in a food sample. The results indicate that plate counts of precooked beef patties did not increase with the resuscitation plating on TSA. In fact, counts of both patties in trial two were higher with direct plating on MSA than resuscitation plating. Based on these results, direct plating on MSA was chosen as the procedure for enumeration of *E. coli* from precooked beef patties.

Table 1. Recovery of *E. coli* O157:H7 using resuscitation vs direct plating.

	TSA/MSA[a] (CFU/g)	MSA[b]
Trial 1		
patty 1	1.0×10^1	$< 1 \times 10^1$
Trial 2		
patty 1	$< 1.0 \times 10^1$	1.2×10^2
patty 2	$< 1.0 \times 10^1$	1.0×10^2

[a] Overlay of MSA (MacConkey Sorbitol Agar) on TSA (Trypticase Soy Agar).
[b] MSA direct plating procedure

Thermal destruction of E. coli in ground beef systems.

The thermal inactivation studies have shown that increasing the holding time at a given temperature decrease the number of survivor CFU as expected (Figure 1). Calculations of D values based on the thermal inactivation curves indicate that at all three temperatures (135° F, 140° F, 145° F) the D values are approximately one-half those previously reported by Doyle and Shoeni (1984). At 135°F, the reported D value was 270 sec compared to 168 sec found in this study. At 140°F, the reported D value was 45 sec compared to 26 sec found in this study and at 145°F the D value was reported to be 24 sec compared to 11.6 sec found in this study. These differences in D values may be a reflection of the differences in sample size (1 gram vs 112 gram) between the two studies. Larger samples take longer to reach the endpoint temperature in their center. This would result in an increase in the latent thermal inactivation and a decrease in the number of survivors. Other possible reasons for the differences was their use of a culture in late stationary phase where cells are expected to be more resistant than in mid-log phase (active growing state) as used in our study. They also used a different strain of serotype O157:H7.

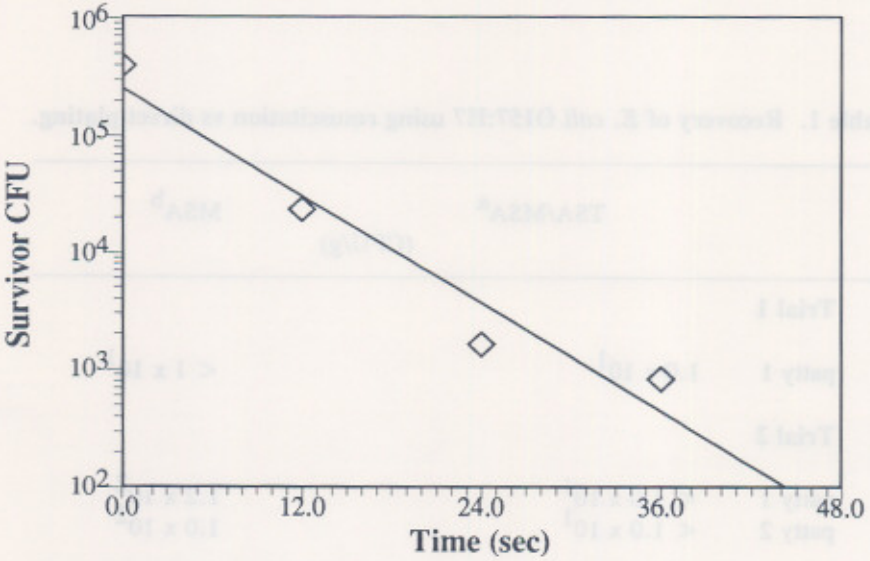


Figure 1. Thermal inactivation of *E. coli* O157:H7 at 145°F in ground beef patties.

These results suggest that endpoint temperatures of 135°F, 140°F and 145°F are effective at destroying *E. coli* in ground beef patties if a suitable holding time is utilized. When applied to industry production, this should result in increased yields and palatability of precooked beef patties and reduced thermal processing costs to the meat industry while maintaining product safety.

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SHRINKAGE OF WHEAT PASTURE STOCKER CATTLE

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Story in Brief

Two trials were conducted to determine 1) shrinkage and rate of refill of stocker cattle removed and subsequently placed back on wheat pasture and 2) the effect of transit time on shrinkage of cattle that had been grazing wheat pasture or had been given access to Bermudagrass hay and water for the previous 24 hours. In trial 1, 24 Hereford x Angus yearling steers (688 lb ± 7.5) were weighed, randomly divided into two groups (Group 1 = controls), and held in drylot pens overnight without access to feed or water. Group 2 was trail driven for 1.6 miles before being placed in drylot pens. Mean 24 hour shrink was not different between the two groups (8.12% ± .31 vs 7.97% ± .43). Both groups essentially refilled to initial weights by 6 hours after being placed back on wheat pasture. In trial 2, the same steers were weighed (714 lb ± 9.0) and group 2 was placed in drylot pens and given access to bermudagrass hay and water for 24 hours. The cattle were then weighed individually, loaded onto livestock trailers and hauled for two, thirty minute periods and three, one-hour periods for a total of 4 hours. Steers of Group 1 tended to shrink more than group 2 over the 4-hour haul (5.16% vs 4.37%), possibly reflecting the slower rate of passage of bermudagrass hay.

(Key Words: Shrinkage, Stocker Cattle, Wheat Pasture.)

Introduction

Stocker operators, cattle feeders and scientists are constantly seeking more information on shrinkage of feeder cattle. Price adjustments to compensate for different shrinkage conditions is common practice in the beef cattle industry (Brownson et al., 1981). Generally, the loss of weight from an overnight shrinkage will vary with the type of feed being consumed by the cattle. Cattle consuming diets high in moisture tend to shrink more when removed from feed than cattle fed diets high in dry matter. The objectives of this study were to (1) determine shrinkage of wheat pasture stocker cattle

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removed from pasture for a 24 hour period, (2) determine rate of refill and (3) determine amount of shrinkage during short-term transit.

Materials and Methods

Trial 1

Twenty-four Hereford X Angus steers (688 lb ± 7.5) that were grazing a wheat pasture (24% dry matter (DM); 24% crude protein (CP) and 66% in vitro dry matter digestibility (IVDMD) on a DM basis) immediately adjacent to a cattle handling/weighing facility were removed from pasture at 2:00 pm (0 hour) on March 26, 1990. The steers were medium-frame number 1 muscle thickness, 11 to 13 months of age and had been on wheat pasture for about 120 days. Immediately after removal from wheat pasture the steers were individually weighed to the nearest pound on scales equipped with a suspension-type load cell and an electronic weighing system. The steers were then randomly allocated to two groups. Group 1 served as the control whereas steers of group 2 were driven by foot up and down an adjacent dirt road for a total of 1.6 miles prior to being returned to the cattle facility. Both groups of steers were then comingled and held in drylot for a 24-hour period without feed and water. During this period of shrinkage, the steers were reweighed individually at 5, 10, 17 and 24 hours to determine cumulative shrinkage. After the 24-hour weight, the steers were placed back on wheat pasture and were reweighed after 6 and 25 hours to determine the extent to which they had refilled or recovered their 0-hour (i.e., preshrunk) weight.

Trial 2

This trial was initiated on April 12, 1990 using the same steers as Trial 1. The steers were removed from wheat pasture at 8:00 am, weighed and Group 2 (714 lb mean weight) was placed in drylot pens and given free-choice access to bermudagrass hay (8.4% CP, and 40% IVDMD on a DM basis) and water for approximately 24 hours. Immediately after the initial weighing, Group 1 (714 lb mean weight) was placed back on wheat pasture (26% DM; 21% CP and 69% IVDMD on a DM basis) for 24 hours. The steers were then gathered again (April 13, 7:30 am), weighed (Group 1: 719 lb. ± 11.7, Group 2: 708 ± 15.4) and placed in one of two bumper-type livestock trailers. The trailer carrying Group 1 was 15.3' X 6' in size with a wood timber floor (1/2" spaces between the lengthwise timbers). Group 2's trailer was 16' X 6' in size; also with a wood timber floor (3/4"-1" spaces

between the crosswise timbers). One steer in Group 1 was removed from the trial because of insufficient space on the trailer. The loaded trailers were then weighed (unattached from the hauling trucks) at the Oklahoma State University Feed Mill scales and hauled for two 30 minute periods (beginning at 8:25 am) and three one hour periods in the vicinity of Stillwater. Upon completion of transit the cattle were unloaded and weighed individually.

Results and Discussion

Trial 1

Mean steer weights, shrink, and standard errors are illustrated in Table 1. Cumulative 24 hour shrink was not different ($P>.68$) for the two groups (Group 1 = 8.12% ± .31 vs Group 2 = 7.97% ± .43). The data indicate a quadratic affect ($P<.0001$), reflecting that the cattle shrank more during the earlier portion of the food and water depravation period. The regression equation for predicting shrinkage (R^2 = .97) was: $Y = 2.00 + .4141(X) - .0068(X)^2$, where: Y = predicted shrinkage, X = hours off feed and water. Weight losses of the steers during the 24-hour shrinkage in drylot were recovered by 6 hours after being returned to wheat pasture as shown by the "refilled weights" at the bottom of Table 1. Weights were similar at both times of 6 and 25 hours after the steers were returned to wheat pasture.

Trial 2

Mean steer weights (by group and individual), shrinkage and standard errors are illustrated in Table 2. Cumulative shrinkage during transit (for each group) was determined by subtracting the cattle + trailer weight, after each hauling period, from the prehaul cattle + trailer weight with adjustments made to trailer weight for accumulation of feces and urine. Waste accumulations were estimated by linearly regressing prehaul empty trailer weight with post-haul, empty trailer weight. Predicted waste accumulations were then added to the prehaul trailer weight and the resulting total subtracted from the observed total weight of each hauling period, to yield group cattle weights. The group cattle weights (after each hauling period) were then compared to the initial group cattle weight to determine cumulative shrinkage. Mean individual cumulative shrinkage over the trial was greater ($P<.06$) for Group 1 (5.09% ± .20 vs 3.85% ± .33) and tended to be greater ($P<.12$) for Group 1 during the transit period (5.16% vs 4.37%). These results may indicate that wheat pasture cattle given access

Table 1. Mean weights, shrinkage and standard errors for steers by group (Trial 1).

	Control (Group 1)				Trailed (Group 2)			
	Wt, lb[a]	SE	Shrink, %[b]	SE	Wt, lb[a]	SE	Shrink, %[b]	SE
Number of steers:	12				12			
Hours off feed								
0	688	±8.4			688	±13.0		
5	662	±8.5	3.87	±.19	660	±13.0	4.04	±.27
10	650	±8.2	5.61	±.21	650	±12.8	5.58	±.33
17	640	±7.9	6.98	±.26	639	±13.2	7.13	±.42
24	633	±8.0	8.12	±.31	633	±12.6	7.97	±.43
Refilled weights								
6[c]	687	±9.2			699	±13.4		
25[c]	694	±8.8			690	±13.0		

[a] Mean weight of group.
[b] Mean of individual cumulative shrinks.
[c] Hours after steers were returned to wheat pasture.

Table 2. Mean individual and group weights, shrinkage and standard errors for steers during transit (Trial 2).

	Control (Group 1)				Hay-fed (Group 2)			
	IWT, lb[a]	SE	GWT, lb[b]	SHRINK, %[c],	IWT, lb[a]	SE	GWT, lb[b]	SHRINK, %[c]
Number of steers:	12		11		12		12	
Hours in transit								
0	719	±11.7	713		708	±15.4	706	
.5			710	.46			702	.55
1.0			700	1.80			698	1.05
2.0			696	2.46			690	2.28
3.0			689	3.37			682	3.32
4.0	682	±10.8	676	5.16	680	±13.6	675	4.37
IShrink[d]	5.09	±.20			3.85	±.33		

[a] Individual mean weight of steers.
[b] Mean group weight of steers (on trailer).
[c] Cumulative shrink.
[d] Mean individual shrink over the trial..

to a medium quality hay for a 24 hour period prior to transit, shrink less than cattle removed from pasture immediately prior to transit. This is possibly due to a slower feedstuff passage rate for cattle given hay. The regression equation for predicting shrinkage (R^2 = .98) of cattle during transit was: Y = -0.0424 + 1.18X, where: Y = predicted shrinkage, X = hours in transit.

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EFFECT OF POST-RUMINAL PROTEIN INFUSIONS ON FEED INTAKE AND UTILIZATION OF LOW QUALITY HAY BY BEEF STEERS

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Story in Brief

Two experiments studied the effect of daily duodenal nitrogen infusions on feed and water intake. Crossbred cannulated steers (936 lb) were fed free choice a low quality (4.5%) prairie hay diet. Steers were infused (750 ml) four times (8:30 am, 12:30 pm, 4:30 pm and 8:30 pm) daily with either sodium bicarbonate buffer (control), methionine-supplemented casein or urea-glucose solutions (Experiment 1). In the second trial, urea or urea-glucose mixtures were infused as in Experiment 1. Dry matter feed intake and water consumption were increased by nitrogen infusions in both studies. Steers dosed with the urea-glucose solution tended to eat more DM (6.7%) and drink more water (12.5%) than the animals infused with casein. Duodenal dry matter flow, ruminal and total tract digestibilities also were increased by postruminal nitrogen infusion. The increase in ruminal ammonia and plasma urea concentrations of steers dosed with urea-glucose, suggest that a high percentage of the infused material was recycled to the rumen to enhance rate of ruminal digestion. However the increase in duodenal flow but constant fecal output suggests that ruminal fill was not the factor limiting hay intake.

(Key Words: Beef Cattle, Hay, Duodenal Infusions, Protein.)

Introduction

Low voluntary feed intake and low digestibility limit performance of animals fed poor quality forages. Deficiencies of protein or B-vitamins reduce feed intake in most animals. Duodenal infusions of intact proteins or non-protein nitrogen, such as urea have increased both voluntary feed intake and digestibility of low quality forages in sheep (Egan and Moir, 1965).

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More recently, Garza et al., (1991) found that feed intake and ruminal digestibilities in beef steers fed a high concentrate diet were increased by daily duodenal infusions of urea-glucose solutions. Whether these responses were due to an increased post-ruminal supply of nitrogen or glucogenic compounds to the small intestine is not clear. These two trials were designed to examine the effects of daily duodenal infusions of sodium bicarbonate buffer, methionine-supplemented casein, urea-glucose or urea solutions on voluntary feed and water intake, ruminal contents and site of DM digestion in beef steers fed a prairie hay diet.

Materials and Methods

Experiment 1

Nine crossbred Angus x Hereford steers (950 lb) housed in individual slatted-floor pens were used in three simultaneous Latin square experiments. Animals had ad libitum access to a prairie hay diet (4.5% CP). Previous to the daily feeding and throughout the study, animals received 50 g of a mineral premix[3]. During the experimental periods, each lasting 16 days, daily duodenal infusions (treatments) were provided consisting of either sodium bicarbonate buffer (control); methionine-supplemented casein or a urea-glucose solution, prepared and dosed as outlined by Garza et al., (1991). Chromic oxide was dosed (3 g/dose) twice daily (8:00 am and 8:00 pm) during the last week of each experimental period, to estimate digestibility. Ruminal liquid, duodenal contents and fecal grab samples were taken three times daily on day 14 and 15 of each period. Steers had a minimum of 10 days with no infusion between experimental periods to avoid any carry-over effect. During this period, daily feed and water intakes were recorded.

Sampling, pH measurements, ruminal content calculations and chemical analysis procedures for chromium, and ruminal fluid ammonia-N (NH_3-N) were similar to Garza et al., (1991).

Data were analyzed using a general linear models procedure. Animal, period and treatment were the classes in the statistical model. Orthogonal contrasts were used to compare treatment effects of control versus others and casein versus glucose-urea infusion.

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[3]Contained: Dicalcium phosphate 42.3%, KCl 17.9% trace mineral salt 28.1% (.25% Mn, .2% Fe, .033% Cu, .0025% Co, .007% I, .005 % Zn), Na_2SO_4 11.2% and vit A .57% (100,000 IU/g).

Experiment 2

Eight Angus x Hereford steers (923 lb) housed in individual slatted-floor pens were fed as in Experiment 1 in a crossover experiment with two 7-day experimental periods. Steers received daily duodenal infusions of either urea (85 g) or urea (85 g) plus glucose (285 g) solution; all steers also received a duodenal B-vitamin premix. Daily infusions, schedule and doses were similar to those used in Experiment 1. Jugular blood samples (30 ml) were collected sequentially during the last day of each period at 8:00 am, 10:00 am and 12:00 pm. Immediately after withdrawal, blood samples were centrifuged and the remaining plasma was transferred to plastic tubes and frozen for later plasma urea analysis.

Data were analyzed using animal, period and treatment in the statistical model. Repeated measurements (blood samples) were analyzed using the animal x period x treatment interaction as the main plot error term.

Results and Discussion

Experiment 1

Voluntary feed and water intake increased ($P<.001$) with supplemental duodenal nitrogen; responses tended to be higher (14.3 lb/day and 5.4 gallons/day) for the urea-glucose treatment than for the casein infusion (13.4 lb/day and 4.8 gallons/day; Table 1). Increased feed intake has been observed with sheep fed low quality forages and duodenally infused with casein or urea (Egan and Moir, 1965). However, their doses were transitory and intake returned to pre-treatment levels within 3 to 5 days following each dose. In our study, feed intake returned to pretreatment levels after the infusions were stopped. In some cases intakes were slightly depressed during the post-infusion compared to the infusion period.

Total ruminal liquid volume was similar for the control and the urea-glucose treatment; however, animals duodenally infused with the casein solution had larger (14.2 vs 12.7 and 12.1 gallons) rumen liquid volume and had more ($P<.02$) free ruminal liquid than urea-glucose infused steers.

Daily duodenal dry matter flow ($P<.002$), ruminal dry matter digestibility ($P<.06$) and total tract dry matter digestibility ($P<.001$) all were enhanced by postruminal infusion of urea-glucose or casein solutions (Table 2). Ammonia nitrogen (NH_3-N) concentrations in ruminal liquid and total blood urea levels are presented in Table 2. Steers receiving the urea-glucose mixture had higher levels ($P<.001$; .82 mg/dl and 15.5 mg/dl) than steers receiving the casein (.28 mg/dl and 7.64 mg/dl) or the control (.16 mg/dl and

Table 1. Effect of duodenally nitrogen infusions on feed intake, water consumption and ruminal parameters in beef steers fed low quality hay (Experiment 1).

Item	Treatments				Orthogonal contrast	
	Buffer	Casein	Urea-glucose	SE	B vs C, U [a]	C vs U
Feed intake, lb	10.8	13.4	14.3	.36	.001	.09
Water intake, gallons	3.5	4.8	5.4	.20	.001	.07
Rumen contents:						
Total weight, lb	123.0	135.4	115.8	4.07	NS	.004
Ruminal DM, %	13.4	12.3	12.6	.60	NS	NS
pH	7.0	6.8	6.9	.02	.001	.05
Liquid:						
Total volume, gallons	12.7	14.2	12.1	.40	NS	.002
Free, gallons	6.4	7.5	6.1	.38	NS	.02
Bound to feed, gallons	6.3	6.7	5.9	.44	NS	NS
Solids:						
Total DM, lb	16.4	16.7	14.8	1.0	NS	NS

[a] B= buffer (control); C= casein; U= Urea-glucose solutions.

Table 2. Effect of duodenally nitrogen infusions on site and extent of digestion in beef steers fed low quality hay (Experiment 1).

Item	Treatments				Orthogonal contrast	
	Buffer	Casein	Urea-glucose	SE	B vs C, U [a]	C vs U
Duodenal pH	2.5	2.6	2.7	.04	NS	NS
Duodenal flow, DM lb/day	7.1	9.0	8.8	.36	.002	NS
Fecal output, DM lb/day	6.4	6.8	6.7	.43	NS	NS
Digestibility :						
Ruminal, %	23.5	31.8	36.7	4.47	.06	NS
Intestinal, %	8.8	16.1	13.2	4.24	NS	NS
Percent of flow, %	9.6	22.6	19.0	5.53	NS	NS
Total tract, %	32.3	48.0	50.7	4.71	.001	NS
Ammonia-N and Urea-N, mg/dl						
Ruminal NH_3-N	.16	.28	.82	.03	.001	.001
Plasma urea-N	3.96	7.64	15.50	1.57	.006	.01

[a] B= buffer (control); C= casein; U= Urea-glucose solutions.

3.96 mg/dl) treatments. These results suggest that nitrogen recycling to the rumen of those steers receiving the urea-glucose treatment was high and may have influenced feed intake by stimulating ruminal bacterial activity and increasing the rate of ruminal digestion. It is not possible to determine from this experiment the percentage of nitrogen from infused materials that was recycled to the rumen. Data from blood urea and ruminal NH_3-N suggest that casein may have altered feed intake in a manner different from urea. Casein may have had a more localized effect within the small intestine and based on blood urea levels, was not all deaminated. The increase in daily duodenal flow with infusions make one question the idea that ruminal fill and output limit forage intake. The 25% increase in duodenal flow but only a 10% increase in fecal output with nutrient infusions suggest that with this low quality forage, N supply to and fermentation in the large intestine responded to infusions. Thus, fecal output, not ruminal output probably limited feed intake with this diet. The fact that intake response was equal to or greater than the response from casein indicated that the effect was not due directly to the added amino acids.

Experiment 2

The increase in forage intake in Experiment 1 could be ascribed to either the supplemental N or the supplemental energy provided. In this experiment, we measured which was more important. Because N is definitely deficient we compared urea to urea-glucose infusions. Daily DM intake (16.2 vs 15.3 lb/day; $P<.03$) water consumption (5.9 vs 5.2 gallons/day) and total plasma urea concentrations (13.0 vs 12.1 mg/dl) were greater for the steers infused the urea than the urea-glucose solution (Table 3). Regardless of

Table 3. Effect of post-ruminal urea or glucose-urea infusions on feed and water intake of steers fed a low quality hay diet (Experiment 2).

	Treatments		
	Urea	Urea-glucose	SE
Intake :			
Feed, lb DM/day	16.2[a]	15.3[b]	.24
Water, gallons/day	5.9[c]	5.2[d]	.24
Plasma urea-N, mg/dl	13.0	12.1	.97

[a,b] Means in the same row with different superscript differ ($P<.02$).
[c,d] Means in the same row with different superscript differ ($P<.10$).

treatment, plasma urea concentration peaked approximately two hours postfeeding ($P < .05$) and tended to decline thereafter (Figure 1).

Results indicated that under the feeding conditions of this experiment, additional duodenal energy in the form of glucose failed to enhance feed intake. This finding is in agreement with other studies (Rogers et al., 1979) where abomasal infusions of glucose in dairy cows fed silage did not affect feed intake; however mixtures of casein plus glucose infused similarly increased feed intake and milk yield.

In summary, feed and water intake were increased by both casein or urea. An additional glucose supply did not increase intake. Providing non-protein sources post-ruminally may prove useful and economical to promote feed intake and animal performance of cattle fed low quality forage. Relative responses to ruminal vs postruminal infusion need to be tested.

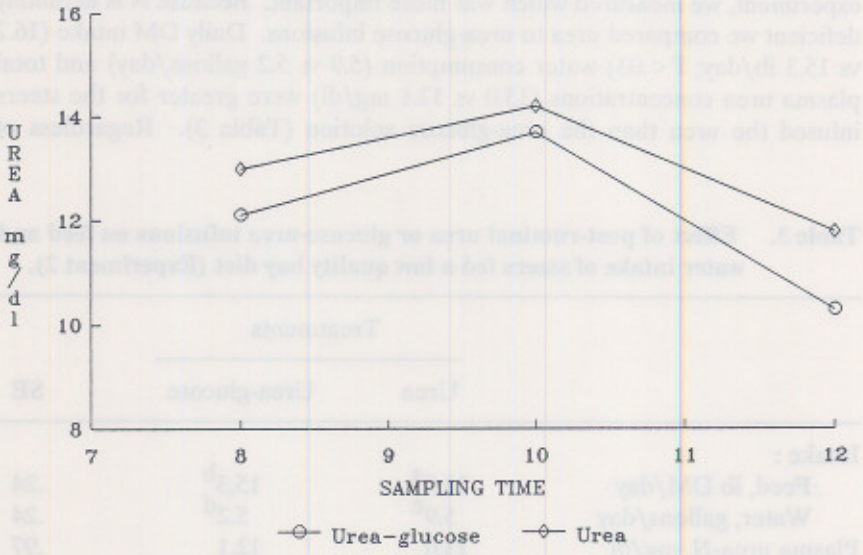


Figure 1. Effect of post-ruminal urea or urea-glucose infusions on plasma urea levels in steers fed a prairie hay diet.

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EFFECTS OF GROWING DIETS AND GRAZING REGIMEN ON FEEDLOT PERFORMANCE AND CARCASS TRAITS

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Story in Brief

One hundred sixty, 463 pound, crossbred steer and bull calves were randomly allocated into 4 winter growing treatments for 84 days. Calves in Treatment 0.0 grazed dormant native range and were offered 4.7 pounds of a 38% protein supplement three days a week; Treatments 1.0, 1.5, and 2.0 were program-fed (net energy basis) a high concentrate ration to gain 1.0, 1.5, and 2.0 pounds daily, respectively. Observed gains were 1.53, 2.01 and 2.54 lbs/day. During the summer grazing season, calves were either double stocked and grazed for 84 days intensive early stocking (IES) or single stocked and grazed seasonlong (SLS) for 153 days. Following these grazing periods, cattle (IES average weight 677 pounds; SLS 743 pounds) were placed in the feedlot. Daily gains in the feedlot of both pasture treatments were similar (IES 4.13; SLS 4.17 lb/day), however, feed intake was 16% less for the IES than the SLS cattle (25.7 vs 29.2 lb/day). As a result, IES required 12.7% less feed per pound of gain. Neither the higher feed intake or lower efficiency of the SLS cattle can be explained by their higher initial feedlot weight. Programmed feeding before grazing compared to winter grazing, increased initial weight at the time cattle entered the feedlot with a 49 pound difference between the highest and lowest treatments. At slaughter, this difference had again increased to 75 pounds. Body composition of all treatment groups at slaughter were similar. Thus, the higher gains during the winter period produced heavier cattle and carcasses. Level of programmed feeding level did not alter feedlot daily gain or feed efficiency.

(Key Words: Backgrounding, Calves, Program-fed, Grazing Systems, Feedlot Performance.)

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Introduction

Programmed feeding of energy dense diets during the growing phase allows one to restrict feed intake to match desired rate of gain. Per unit of net energy supplied, concentrates usually are priced lower than forages, require less labor to handle and to feed and maintain a more consistent nutrient profile than do forages. In contrast, in conventional growing programs one feeds low energy diets to restrict energy intake and thereby attains a desired rate of gain. Feedlot and carcass performance may be altered by the previous growing program. Compared to those grown on low energy diets, calves grown on high energy diets were more efficient during both the growing and finishing phases (Merchen et al., 1986, Pritchard, 1987; Goldy et al., 1988); moreover, they tended to have higher quality and yield grades, and a greater degree of kidney, pelvic, and heart fat (McCarthy et al., 1985).

The objectives of this study were to evaluate the effects of programmed feeding of high energy diets to growing calves during winter and summer grazing periods as well as examine subsequent feedlot performance and carcass merit.

Materials and Methods

The experimental procedures for the winter and grazing portion of this experiment were discussed in last year's research report (McLean et al., 1990). During the programmed feeding portion of the experiment, 160 cattle were stratified by weight and randomly divided into 8 groups of 20 each. Two groups were combined and released to pasture (0.0) where they were wintered on dormant range grass for 84 days and fed 4.7 lbs per head of a 38% protein range cube three times a week. The remaining 6 groups (2 pens per group; 20 steers per pen) were assigned to gain 1.0, 1.5 or 2.0 lbs per day for 84 days. The program-fed cattle were fed once daily (Table 1). The amounts fed are indicated in Table 2. All pens had an adequate amount of

Table 1. Ingredient composition of program-fed diet -- Experiment One.

Ingredient	% As Fed
Corn, #2 (Whole)	81.08
Supplement	18.92

Table 2. Programmed feed intake.

	Pounds dry matter intake/day Treatment		
Days	1.0	1.5	2.0
1-14	7.04	8.35	9.74
15-28	7.19	8.61	10.14
29-42	7.33	8.87	10.54
43-56	7.48	9.13	10.93
57-70	7.63	9.38	11.32
71-84	7.77	9.63	11.71

bunk space to allow all steers to eat simultaneously. After 84 days, each pen was divided into two groups (10 animals each) and steers were assigned to either intensive early stocking (IES) or single stocking and grazing (SLS) treatments. The forage consisted of tallgrass prairies and was available in excess of demand. Following the grazing period and prior to shipment to the feedlot, all cattle were reimplanted with Synovex-S® and dewormed with Ivermectin. On July 18, 1989 the IES cattle were transported 310 miles to Panhandle State University for feedlot finishing; SLS cattle were shipped on September 26, 1989. The cattle were individually weighed as they came off the trucks, placed in 10 head pens with two replicate pens for each level of wintering for each of the two summer grazing systems. Program-fed cattle were penned with their original pen mates at the feedlot. The cattle were given ad libitum access to feed with fresh feed added twice daily throughout the feedlot phase. They were staged through a series of four diets to a 91% concentrate diet in 14 days (Table 3). In these diets, ground corn replaced alfalfa hay and cottonseed hulls (2 to 1 ratio) to achieve 50%, 60%, 70%, and 80% concentrate levels. Cattle were fed to a point at which experienced cattle buyers estimated the cattle should grade 70% choice and have a dressing percentage typical for their type. The IES cattle were fed for 142 days; SLS cattle were fed 128 days. The IES cattle were trucked to Booker, Texas (80 miles) for slaughter and collection of carcass data; SLS cattle were trucked to Dodge City, Kansas (120 miles) for slaughter. All feedlot gains and feed efficiencies were adjusted to a standard dressing percentage (64%).

Effects of wintering treatment and pasture type (IES vs SLS) on feedlot measurements were tested statistically. The only interaction between wintering and grazing classes was in overall feedlot daily gain.

Table 3. Feedlot diet composition (final diet).

Item	Diet %	Supplement %
Corn dry rolled	79.61	
Alfalfa hay ground	5.02	
Cottonseed hulls	3.90	
Cane molasses	4.38	
Cottonseed meal	3.55	50.08
Meat & bone meal	1.42	20.00
Corn distillers grains	.81	11.40
Salt	.35	5.00
Calcium carbonate	.35	4.49
Urea, 46% N	.30	4.20
Ammonium sulfate	.21	3.00
Vitamin A & D_3	---	.40
Monensin, 60 gram/454g	---	.25
Trace mineral premix	---	.20
Vitamin	---	.20

Results and Discussion

Performance of the cattle during the winter period is summarized in Table 4. The efficiency of feed utilization for the program-fed cattle was 34, 25, and 21% higher than expected for the respective 1.0, 1.5, and 2.0 lb per day targets. Much of the weight advantage gained by at the end of the wintering period was lost during the spring grazing phase (McLean et al., 1990). Weight of steers at entry into the feedlot reflected their winter treatments. Cattle programmed for 2.0 lbs per day weighed 49 lbs more than the dry wintered cattle. They remained 75 lbs heavier ($P<.05$) at slaughter. There was no evidence of compensatory gain for the cattle fed for slower gains. During the first 28 days on feed, ADG was greater ($P<.05$) for the cattle which had been program-fed during the winter period (5.80 vs 4.98) than for the cattle which had been wintered on dry grass.

In the feedlot phase (Table 5), the intensive early grazed (IES) cattle consumed less feed ($P<.05$) than the SLS cattle (25.1 vs 29.2) lb DM/day. Adjusted daily gains for the two groups were similar (IES=4.13 vs SLS=4.17); however, an interaction ($P<.05$) was detected for feedlot gain between winter and spring grazing treatments. Previous program feeding proved more advantageous for IES than SLS calves, perhaps because there

Table 4. 84-day dry winter or programmed feeding performance.

	Treatment			
	0.0	1.0	1.5	2.0
Allocation wt., lb	445	459	463	465
Off wt., lb	547.95[a]	586.10[b]	629.95[c]	676.07[d]
Total gain, lb	80.05[a]	126.85[b]	166.49[c]	211.20[d]
ADG, lb	.96[a]	1.53[b]	2.01[c]	2.54[d]
Avg daily feed, lb	---	7.41	9.00	10.71
Feed/gain, actual	---	4.87	4.53	4.26
Feed/gain, theoretical	---	7.40	6.00	5.36
Change in backfat Depth, in	.006[a]	.035[b]	.046[b]	.059[c]

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

was a shorter time interval for IES calves to forget how to eat concentrate diets. Feed efficiency differed (P<.05) being 6.05 for the IES and 6.93 for the SLS cattle. The major difference in these two groups was the much higher feed intake by SLS cattle especially those programmed to gain at faster rates during the wintering period. Differences in the carcass traits except weight were minor (Table 6). Although these cattle were uniform in weight at the start of the experiment (January, 1989), differences in body size were extreme at slaughter. The smallest steer in the SLS group weighed 1000 lbs; the largest weighed 1619 lbs. For IES cattle, the lightest steer weighed 966 and the heaviest weighed 1499 lbs. This diversity illustrates the difficulty in sorting cattle only once for an experiment that takes 13 months.

Compared to cattle with a short period of intensive grazing, cattle subjected to prolonged grazing (SLS) lost feedlot efficiency. Feed intake for the SLS cattle appeared excessive. Several checks were instigated during this study to ensure that the reported intakes were accurate. Occasionally pens of commercial cattle have feed intakes this high. Had the corn fed in this test been steam flaked, perhaps intakes and efficiency would have been better. Sindt et al. (1991) reported that steers grazed on bromegrass followed by sudangrass consumed 14.9% more feed and were 14.9% less efficient in the feedlot than cattle that grazed on bromegrass and then finished. Rapid gains during the first 28 days in the feedlot period for the calves that had been

Table 5. Live cattle performance -- feedlot period

	Growing Treatment				
		Programmed ADG, pounds			
	Dry wintered	1.0	1.5	2.0	Mean
Off pasture wt, lb					
IES[f]	697	714	745	772	732[d]
SLS[f]	763	778	789	818	787[e]
Initial feedlot wt, lb					
IES	649	669	690	702	677[d]
SLS	728	728	743	774	743[e]
Mean	689[c]	699[cb]	716[b]	738[a]	
Slaughter weight, lb*					
IES	1201	1295	1245	1313	1264
SLS	1260	1237	1311	1299	1277
Mean	1231[b]	1266[ab]	1278[ab]	1306[a]	
ADG, lb*					
IES	3.89	4.40	3.91	4.30	4.13
SLS	4.15	3.97	4.44	4.11	4.17
Mean	4.02	4.19	4.18	4.21	
Total gain, lb*					
IES	552	626	556	611	586
SLS	532	509	567	525	534
Mean	542	568	562	568	
Feed intake, lb					
IES	25.33	25.17	23.98	25.93	25.10[d]
SLS	26.67	26.70	32.42	31.08	29.22[c]
Mean	26.00	25.94	28.20	28.51	
Feed efficiency, lb*					
IES	6.47	5.67	6.10	5.96	6.05[d]
SLS	6.37	6.67	7.21	7.47	6.93[c]
Mean	6.42	6.17	6.65	6.72	

*Expressed as LSMEANS.

a,b,cMeans with different superscripts within winter feeding treatments differ ($P<.05$).

d,eMeans with different superscripts within summer grazing treatments differ ($P<.05$)

[f]IES = Intensive early stocking, SLS = seasonlong stocking

Table 6. Carcass characteristics.

	Growing Treatment				
		Programmed ADG, pounds			
	Dry wintered	1.0	1.5	2.0	Mean
Carcass weight, lb*					
IES[e]	768.6	829.0	797.1	840.6	808.8
SLS[e]	806.6	791.7	838.8	831.6	817.2
Mean	787.6[a]	810.2[ab]	817.9[ab]	836.0[b]	
% Choice*					
IES	52.77	53.33	40.00	60.00	51.5
SLS	50.00	76.25	51.66	61.11	59.8
Mean	51.39	64.79	45.83	60.56	
Marbling Score[f]					
IES	383	401	400	409	398.4
SLS	381	438	405	420	410.7
Mean	383	420	402	414	
REA, sq. in,*					
IES	13.38	14.00	12.97	13.64	13.5
SLS	13.62	12.73	13.60	13.03	13.3
Mean	13.45	13.37	13.29	13.34	
KPH, %*					
IES	1.94	2.00	1.95	1.95	2.0
SLS	2.04	2.02	1.83	1.77	1.9
Mean	2.00	2.02	1.90	1.86	
Yield Grade[g]					
IES	2.87	2.78	3.09	3.17	
SLS	2.96	3.22	3.12	3.27	
Mean	2.92	3.00	3.11	3.22	

*Expressed as LSMEANS.

a,b,c,dMeans with different superscripts within winter feeding treatments differ ($P < .05$).

[e]IES = Intensive early stocking, SLS = seasonlong stocking

[f]300-399 = Sight (Select); 400-499 = Small (Choice).

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CHEMICAL COMPOSITION OF DIETS CONSUMED BY CATTLE GRAZING NATIVE RANGE OR PLAINS BLUESTEM PASTURE

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Story in Brief

Esophageal masticate was collected from native range and plains bluestem pasture in mid-May, late-June, mid-August and mid-October. Severe winter kill of plains bluestem prevented collection in May. Standing crop and species composition of both pastures were estimated each month. Diet crude protein was highest on native range in May and October; June and August were lower. On plains bluestem, protein content was lower in June and October, while August was 18% higher. Protein content of plains bluestem was greater than native range. Pepsin insoluble protein tended to increase as total forage protein decreased. Fiber content of diets on native range increased from May to June and then remained constant through the rest of the summer. Fiber content of plains bluestems was lowest in August. In vitro organic matter disappearance of native range was greatest in May. In vitro organic matter disappearance of plains bluestem was similar across months and was always higher than native range. Plains bluestems provides a higher quality diet during June, August and October and therefore is a good complement to native range in forage management systems in the Southern Rolling Plains.

(Key Words: Grazing, Cattle, Standing Crop, Species Composition.)

Introduction

Native range and old world bluestems are two primary forage resources for beef cattle production in southwestern Oklahoma. Because these forages have different production curves and yields, incorporating them into an integrated forage system can improve animal performance and carrying capacity. Understanding the nutritive qualities of these forages at various times of the grazing season will improve recommendations for management of beef herds and forage systems.

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In many areas of the country the chemical composition of forages grazed by ruminants has not been characterized. Some studies have evaluated the nutrient composition of clipped forage samples. However, because of selective grazing, diets usually contain 1 to 2% more crude protien (CP) and 2 to 5% more digestible organic matter (OM) than clipped samples.

These data are preliminary results of a 2-year study evaluating the nutritional value of plains bluestem (*Bothriochloa ischaemum*) pasture and native range in southwestern Oklahoma. This part of the study was conducted to examine the nutritive quality of diets consumed by cattle grazing the forages.

Material and Methods

Research Site

The study was conducted at the Marvin Klemme Range Research Station in Washita County, OK. Precipitation at Clinton, OK, approximately 10 miles north, was 27.2 inches (normal, 25.2 inches) from January through October in 1990. The station is located in the Rolling Red Plains resource area (SCS, 1982). Soils on the range area are in the Cordell Series and are mapped as Red Shale Range sites. The 125 acres of native range has never been cultivated. The 14 acres of plains bluestem pasture was established in 1989. Soils within this pasture are a St. Paul silty loam. Grazing and fertilization of the old world bluestem were the only range or pasture management practices implemented. The plains bluestem pasture was fertilized on July 26 with 65 lb of nitrogen and 47 lb of phosphorous/acre to produce 4000 lb/acre.

Sampling Procedures

Four trials were conducted in 1990. Trial dates were mid-spring (14-15 of May), mid-growing season (25-26 of June), mid-summer (13-14 of August) and early dormancy (13-14 of October). Because of winter kill, the plains bluestem pasture was allowed to recover until mid-June before initiation of grazing. Therefore, the mid-spring trial does not include plains bluestem.

Standing crop in the experimental pastures was estimated during each trial period. The dry-weight-rank method (Gillen and Smith, 1986) was utilized to estimate species composition of both pastures. Herbage samples were individually weighed in the field then dried to a constant weight. Live:dead ratios in the quadrats were estimated using simultaneous equations relating total sample dry matter to dry matter of the live and dead fractions.

Russian thistle was included in measurements on the plains bluestem pasture in June and August. Cattle readily consumed the plant during these trials. In October, russian thistle had matured and was not grazed by the cattle. Therefore, it was not included in estimates of available forage.

Four steers fitted with esophageal cannulae were allowed to graze each experimental pasture for 1 week before diet sampling. Masticate samples were obtained from each pasture on two consecutive days. The steers were fitted with screen bottom collection bags and were allowed to graze for 30 to 45 minutes. Steers were herded as they grazed to obtain a more uniform sampling of the entire pasture. After collection, samples were mixed by hand and a 20% aliquot was stored frozen in a plastic bag. Prior to laboratory analysis, masticate was composited across days within steer then lyophilized and ground in a Wiley mill to pass a 2 mm screen.

Laboratory Analyses

Masticate samples were analyzed for DM, ash and kjeldahl nitrogen (AOAC, 1990). Pepsin insoluble N was determined utilizing a modification of the procedure described by AOAC (1990). Crude protein was estimated as 6.25 x N. Insoluble CP is reported as a percentage of total sample CP. Neutral detergent fiber and ADF were determined by nonsequential methods (Goering and Van Soest, 1970). All values were adjusted to an OM basis.

In vitro organic matter disappearance (IVOMD) was determined as described by Tilley and Terry (1963). Incubation tubes were inoculated with a 50:50 rumen fluid:McDougall's buffer containing urea. Rumen fluid was collected from rumen cannulated heifers maintained on a 50% alfalfa:50% prairie hay diet.

Statistical Analysis

Standing crop and species composition data were not statistically analyzed. Masticate composition data were analyzed as a factorial treatment design. Models contained pasture, month and month x pasture as sources of variation and were tested with residual error. A protected least significant difference procedure was utilized to separate means.

Results and Discussion

Standing Crop

Residual standing crop on native range increased from May until August, then decreased in October (Table 1). Residual standing crop

Table 1. Standing crop and species composition of plains bluestem pasture and native range at the Marvin Klemme Range Research Station in southwestern Oklahoma (1990).

Species	Month			
	May	June	August	October
Native range				
Total available DM, lb/acre	1505	1718	2114	1538
			%	
Sideoats grama	21	28	26	28
Blue/hairy grama	17	11	21	17
Buffalograss	14	15	14	17
Little bluestem	T[a]	T	3	3
Other grasses	13	26	15	30
Annual grasses	6	0	0	0
Forbs	27	18	20	4
Locoweed	1	0	0	0
Half shrubs	2	2	1	1
Live:dead ratio	2.5	1.3	.3	.9
Plains bluestem pasture				
Total available DM, lb/acre	---	1643	2121	2124
			%	
Plains bluestem	---	66	69	96
Shortgrasses	---	1	4	0
Other grasses	---	14	6	1
Forbs[b]	---	19	21	3
Live:dead ratio	---	.6	2.0	24.0

[a] T denotes trace amounts, less than 1% of total DM/acre.
[b] Russian thistle was excluded from standing crop estimates during October because of lack of utilization by cattle.

estimates were similar to total production estimates (between 600 and 1400 lb/acre; SCS, 1982). Therefore, total production at this particular site in 1990 was in excess of SCS estimates. Forage availability should not have limited intake in any month.

Total standing crop on the plains bluestem pasture in June and August were similar to that available on native range (Table 1). However, October standing crop of plains bluestem pasture (excluding russian thistle) was greater than on native range.

Species Composition

Species composition of the range site indicated the site was in excellent range condition (Table 1). Forbs composed a considerable portion of the total standing crop until October. This reduction in total forbs would be the result of forbs becoming senescent as the plant community entered early dormancy. Although wooly locoweed (*Astragalus mollissimus*) accounted for only 1% of the total available herbage in May, concentration of locoweed in esophageal masticate and ruminal contents appeared to be disproportionately high. Ralphs et al. (1986) reported that cattle preferentially grazed white locoweed (*Oxytropis sericea*) from high mountain pastures in Utah, especially the seedpods and flowers.

Live:dead ratios on native range decreased as the grazing season advanced from May until August (Table 1). In October, live:dead ratios increased due to fall regrowth.

The large increase noted for percent plains bluestem in October was probably due to recovery from the winter kill and exclusion of russian thistle from standing crop estimates. Live:dead ratios on plains bluestem increased as the grazing season advanced (Table 1).

Chemical Composition

The CP content of native range diets decreased ($P<.05$) 33% from May to June (Table 2), but then increased ($P<.05$) from June to October. Protein requirements for a 600 lb steer gaining 1.8 - 2.0 lb/day are 10.2 and 10.5%, respectively (NRC, 1984). Percent protein in the range diets met NRC requirements every month except June. Stocker steers (450 lb initial wt) grazing adjacent native range gained 1.8 lb/day from May until July 15 and 2.0 lb/day from July 16 until September 15 (McCollum and Gillen, unpublished data).

Plains bluestem diets contained more ($P<.05$) CP than native range during all months. Diet CP content on plains bluestem peaked ($P<.05$) during August. Hand clipped plains bluestem plants contained 10.6, 10.6 and 8.8% CP in June, August and October, respectively. Russian thistle contained 26.6 and 27.5% CP during June and August, respectively. Based on the nutrient content of these clipped samples, it is estimated that russian thistle contributed 23 to 40% of diets in June and August.

Insoluble CP, as a percent of total CP, increased as total CP decreased (Table 2). Calculation of insoluble CP as a percent of OM shows that absolute amounts remained fairly constant across months within a forage (native range: 5.0, 5.0 5.0 and 4.7%; plains bluestem: 6.4, 6.4 and 6.3%). Insoluble CP is an index of indigestible CP.

Table 2. Chemical composition of esophageal masticate collected from plains bluestem pasture (PB) and native range (NR) at the Marvin Klemme Range Research Station in southwestern Oklahoma (1990).

Item	Pasture	Month				SE[a]
		May	June	August	October	
CP, % of OM	NR	13.1^{c}	8.8^{eh}	10.0^{deh}	10.6^{dh}	.44
	PB	----	14.4^{dg}	17.5^{cg}	14.4^{dg}	.69
	SE[b]		1.13	1.69	.81	
Insoluble CP, % of total CP	NR	37.6^{f}	56.9^{cg}	50.3^{dg}	44.3^{eg}	2.05
	PB	----	44.3^{ch}	36.4^{dh}	44.0^{cg}	1.45
	SE		2.91	3.03	1.14	
NDF, % of OM	NR	68.2^{d}	80.6^{cg}	81.2^{cg}	77.7^{cg}	1.41
	PB	----	66.8^{dh}	61.9^{eh}	73.7^{ch}	2.10
	SE		2.91	4.17	.95	
ADF, % of OM	NR	36.0^{d}	38.9^{cg}	40.3^{cg}	38.8^{cg}	.51
	PB	----	31.9^{dh}	29.8^{dh}	36.9^{cg}	1.12
	SE		1.50	2.16	.66	
IVOMD, % of OM	NR	58.64^{c}	54.16^{dh}	54.20^{dh}	53.68^{dh}	.68
	PB	----	59.00^{cg}	60.75^{cg}	59.95^{cg}	.46
	SE		1.09	1.40	1.51	

[a] Standard error, NR n=16 and PB n=9.
[b] Standard error, n=7.
c,d,e,f Row means without common superscripts differ (P<.05).
g,h Column means without common superscripts differ (P<.05).

Neutral detergent fiber and ADF on native range followed similar patterns as the grazing season advanced. Both NDF and ADF increased ($P<.05$) from May through June then remained constant ($P>.05$) during the remainder of the grazing season (Table 2). The cell wall content (NDF) of a forage is involved in regulation of intake. Average intake by heifers grazing native range in June was 18% lower when compared to May (Gunter and McCollum, unpublished data). Plains bluestem diets contained less ($P<.05$) NDF and ADF than native range in all months except October when ADF was similar ($P>.05$).

In vitro organic matter disappearance from native range diets reflected ADF content. In vitro OM disappearance decreased ($P<.05$) 8% from May to June, then remained constant ($P>.05$) throughout the rest of the grazing season (Table 2). Acid detergent fiber content of native range diets was 7% higher in June than May. Plains bluestem diets were more ($P<.05$) digestible than native range during all months, but IVOMD of plains bluestem was similar ($P>.05$) among months. In vitro OM disappearance for forages is approximately equivalent to TDN. These diets did not meet the TDN requirements of a 600 lb steer gaining 2 lb/day (67% TDN; NRC, 1984). However, cattle grazing in adjacent range areas were gaining 1.8-2.0 lb/day.

Plains bluestems provides a higher quality diet during June, August and October and therefore is a good complement to native range in forage management systems in the Southern Rolling Plains.

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HIGH-STARCH VERSUS HIGH-FIBER ENERGY SUPPLEMENTS FOR STOCKER CATTLE ON WHEAT PASTURE: CATTLE PERFORMANCE AND ECONOMICS[1]

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Story in Brief

An energy supplement formulated from high-fiber by-product feeds (soybean hulls and wheat middlings) and fed at a level of .75 to 1% of body weight was superior to a corn-based high-starch energy supplement in terms of increasing weight gains of growing cattle and supplement conversion. Initial stocking densities of treatments receiving an energy supplement were increased one-third and net returns ($/head and $/acre) were greatest, over 9 different feed cost/cattle profit potentials, when the high-fiber energy supplement was fed. As compared with nonsupplemented cattle, this supplementation strategy has the added advantage of having one-third more cattle on hand to graze-out a greater proportion of the wheat acreage base in years in which the government farm program encourages graze-out. By increasing stocking density in the fall, the additional cattle would typically be purchased on seasonally-low markets.

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

Introduction

Provision of energy supplements for stocker cattle grazing wheat pasture has particular practical significance because of large potential fluctuations in amounts of available forage. The response of growing cattle on wheat and (or) other small grain pastures to supplemental grain has been very variable. In studies reported by Elder (1967), Lowrey et al. (1976a and 1976b) and Utley and McCormick (1975 and 1976) steer grazing days/acre or

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stocking densities were increased 1.25- to 2-fold by feeding grain at levels of 1 to 1.5% of body weight. Daily gains of steers were increased by .11 to .65 lb. Results of these studies are summarized in Table 1. Additional studies on wheat pasture are needed before confident recommendations can be made relative to this practice.

Energy supplements may have very different effects on ruminal pH and forage intake and utilization depending on the feedstuff composition of the supplement, the form and type of roughage and resulting rates of particle fragmentation (and therefore chewing and rumination times and salivation). To prevent the adverse effects of starch on ruminal fermentation, high fiber by-product feeds, such as wheat middlings, soybean hulls and corn gluten feed, offer opportunities to formulate energy supplements with fairly high energy densities. The potential for use of these by-product feeds in supplementing growing cattle on wheat pasture is particularly good because of the rapid rate of ruminal degradation of wheat forage and the relative low ruminal pH values of these cattle (Andersen and Horn, 1987). In general, supplementation studies using these by-product feeds for cattle grazing pastures or fed growing rations in drylot have resulted in higher ruminal pHs, decreased substitution ratios of supplement for forage and improved animal performance (Meijs, 1986; Trotter et al., 1981; McDonnell et al., 1982 and 1983; Merrill and Klopfenstein, 1984; Hibberd et al., 1986 and Fleck et al., 1988). These feedstuffs have not been studied as energy supplements for growing cattle on wheat pasture, and appear to have particularly good potential for use in self-fed energy supplements to stabilize stocking densities on wheat pasture.

The objective of this study was to compare cattle performance and the economics of providing a high-starch, corn-based versus a high-fiber energy supplement for growing cattle on wheat pasture.

Materials and Methods

One hundred ninety two fall weaned steer calves grazed clean tilled wheat pasture (Pioneer 2157) and received no supplement other than free choice access to a commercial mineral mixture or were hand fed 6 days/week a corn-based energy supplement (i.e., high-starch supplement) or a high-fiber energy supplement that contained about 47% soybean hulls and 46% wheat middlings (as fed basis). A fourth treatment was fed the high-fiber energy supplement ad libitum. Composition of the supplements is shown in Table 2. All of the supplements contained monensin (about 40 mg/lb) and the ad libitum fed supplement contained 8% salt. Stocking density on wheat pasture was increased 33% (i.e., from 2 to 1.5 acres/steer) where the energy

Table 1. Response of growing beef cattle to grain supplementation on small grain pastures.

Reference	Forage	Stocking density, steers/acre		Grain consumption, % of body wt	Daily gain of steers, lb		F/G[a]
		Control	Grain		Control	Grain	
Elder, 1967	Rye and wheat mix		+21%	1	1.38	1.72	9.4
Gulbransen, 1976	Oat	.....	Variable[b]	.....	2.44		10.3
Utley & McCormick, 1976	Rye	.77	1.49	1.5	2.33	2.98	7.2
Lowrey et al., 1976A	Rye, wheat ryegrass mix	1.01	2.02	1.2	1.98	2.09	7.0
Lowrey et al., 1976B	Rye, wheat ryegrass mix	1.01	2.02	1.1	2.20	2.33	6.7

[a] Grain conversion, lb/lb of increased gain per acre.
[b] Regression study.

Table 2. Composition of supplements[a].

Treatment:	High-starch	High-fiber	High-fiber
Method of feeding:	Hand-fed	Hand-fed	Free-choice
	% As-fed		
Ground corn	82.91		
Soybean hulls		46.75	45.25
Wheat middlings	8.88	45.96	37.83
Sugarcane molasses	4.92	4.96	5.01
Calcium carbonate	1.84	1.59	2.23
Dicalcium phosphate	.61		1.11
Magnesium oxide	.12		.50
Salt	.67	.67	8.00
Rumensin 60 Premix	.06	.06	.07
Calculated nutrient content (as-fed basis)			
NE_{gain}, Mcal/cwt	55.2	41.4	36.7
Crude protein, %	8.5	12.2	10.8
Calcium, %	.88	.88	1.34
Phosphorus, %	.44	.55	.67
Magnesium, %	.22	.31	.54
Monensin content, mg/lb	37.5	37.5	41.2

[a] All supplements were fed as 3/16-inch pellets.

supplements were fed. The supplements were fed for 96 days of the 115-day trial. Target level of consumption was .75 to 1% of mean body weight.

Economic Analysis of Supplementation Programs

An enterprise budgeting analysis was conducted to evaluate the profitability of the alternative supplementation programs. Using input and livestock performance data, annual net return estimates were derived for each supplementation program and the control (no supplementation). A sample enterprise budget for the nonsupplemented, control cattle (moderate net return potential as discussed below) is presented in Table 3. Input data is reported at the top of the budget, while livestock receipt and expense estimates are presented in the following section. The estimated return of $63.68 is a per-head return above operating (variable) costs.

To evaluate the sensitivity of results to both cattle and feed price conditions, per-head net returns were estimated for nine cattle/feed price combinations. Specific assumptions employed in the budgeting analysis are discussed below.

Budget Assumptions

Obviously, the profitability of energy supplementation of wheat pasture stockers is highly dependent upon cattle market conditions. Since the profitability of stocker programs are primarily determined by the relationship between cattle purchase and sale prices, rather than the absolute sale price, a procedure was developed to represent situations of high, moderate and low profit potential. Using a representative wheat pasture stocker enterprise, per-head net returns (in 1990 dollars) were estimated over the 10-year period (1980-89) holding all costs and returns constant except calf price and selling price. Average monthly prices for November steer calves (450 lb) and March feeder cattle (700 lb) at the Oklahoma City Livestock Market were used. The ten annual per-head net returns were then divided into three groups to reflect high, moderate and low net return situations. Next, the calf price was set at the ten year average of $89.00/cwt (1990 dollars). The sale price was then adjusted to reflect low ($76.00/cwt), moderate ($82.00) and high ($86.00) net return situations. Thus, the high, moderate and low return scenarios reflect price spreads of $3.00, $7.00 and $13.00/cwt, respectively.

Feed costs incurred in the 1989-90 experiments were approximately $7.00/cwt for all four rations. This expense included ingredient costs as well as a milling charge of $30/ton for pelleting and grinding plus $12/ton for bulk delivery of the supplements and reflects the "high feed cost" situation. Feed costs associated with the "moderate" and "low" cost situations are $5.50 and $4.00/cwt, respectively. The "low" feed cost estimate was based upon the

Table 3. Enterprise budget for the production of wheat pasture stockers with moderate net return potential and without energy supplementation, 1989-90.

Days on pasture	115	Calf price ($/lb)	0.89
Gain (lb)	246	Steer price ($/lb)	0.82
Death loss (%)	0.01	Hauling cost ($/cwt)	0.35
Calf weight (lb)	465	Marketing charge ($/cwt)	1.72
Suppl. hay (lb)	200	Vet-med expenses ($/hd)	8
Energy suppl. (lb)	0	Interest rate (%)	0.12
Labor (hr)	1.27	Hay price ($/lb)	0.03
Stk. dens (A/hd)	2	Suppl. price ($/lb)	0.07
		Wage rate ($/hr)	5
Pasture option	1	Mach. cost ($/hd)	6.09
1. Per acre	20		
2. Per lb of gain	0.3		
3. Per cwt stock	2.5		

LIVESTOCK RECEIPTS:	UNIT	PRICE	QUANTITY	VALUE
Steers	cwt	82.00	7.11	583.02
Less Death Loss	cwt	82.00	0.07	5.83
Total Receipts				577.19
OPERATING INPUTS:				
Steer Calves	cwt	89.00	4.65	413.85
Energy Supplement	lb	0	0.07	0.00
Supplemental Hay	lb	0.03	200	6.00
Hauling	cwt	0.35	11.69	4.09
Marketing	cwt	1.72	7.04	12.11
Vet-Med Expenses	hd	8.00	1	8.00
Mach. Operating Costs	hd	6.09	1	6.09
Interests on Oper. Capital	dol	0.12	141.82	17.02
Labor	hr	5.00	1.27	6.35
Pasture	acre	2.00	20	40.00
Total Operating Costs				513.51
Return Above Operating Costs	($/head)			63.68

lowest November price of the four rations' primary ingredients (middlings and corn) observed during the 1980-1989 period.

Labor was divided into two components: labor required to feed energy supplement and a base labor requirement that includes labor used in receiving cattle, checking cattle, etc. The base labor requirement was 1.27 hours/head for cattle stocked at a density of 2 acres/head, and 1.09 hours/head for a stocking density of 1.5 acres/head. Additional labor used to feed energy supplement was estimated as .96 hour/head for hand feeding and .48 hour/head for free-choice feeding. Labor was valued at $5.00 per hour. Machinery operating costs primarily reflect fuel, lubrication and repair expenses for a 3/4 ton pickup and were estimated using machinery cost calculations from the Oklahoma State University Enterprise Budget Generator. Veterinary expenses were $8.00 per head and include implants, eartags, worming and vaccinations, as well as a prorated share of sickpen charges. Hauling and marketing charges were assessed at rates of $.35/cwt and $1.72/cwt, respectively. Interest on operating capital reflects the cost of capital used to purchase the calf and other expense items, and was estimated based upon an annual interest rate of 12 percent.

Land was valued based upon its opportunity cost, the value that could have been received had it been used in its most profitable alternative use. In this case, land values are based upon the rental income that could be earned had the pasture been leased instead of grazed by the owner-operator. Results from two independent surveys conducted by the Department of Agricultural Economics indicated a wide variation in wheat pasture lease rates and terms. Based upon survey responses, a range of $20.00 to $40.00 per acre was determined to encompass most wheat pasture lease situations in Oklahoma.

Results and Discussion

Effects of the supplements on performance of the cattle from November 17, 1989 to March 12, 1990 (115 days) and supplement conversions are shown in Table 4. Weight gains were increased ($P<.02$) by supplementation (i.e., control versus mean of all supplements) and by the high-fiber versus the high-starch supplement ($P<.02$). Gains tended to be decreased ($P<.10$) by feeding the high-fiber supplement free-choice versus hand-feeding. Conversion of supplements, expressed as lb of supplement (as-fed) per lb of increased gain per acre, ranged from 4.88 to 6.54 which is substantially lower than conversions of 9 to 10 that have traditionally been used in evaluating energy supplementation programs for wheat pasture stocker cattle. Conversion of supplement was improved ($P<.09$) by the high-fiber versus high-starch supplement and by hand-feeding versus ad libitum feeding the

Table 4. Effect of type of energy supplement and method of feeding on performance of steers grazing wheat pasture.

Treatment: Method of feeding:	Control	High-starch Hand-fed	High-fiber Hand-fed	High-fiber Free-choice
Number of steers	48[a]	48	48	48
Stocking density, acres/head	2	1.5	1.5	1.5
Supplement consumption[b], lb/day[c]		4.20	4.27	4.98
% of body wt		.71	.72	.84
Initial wt, (11/17) lb	464	464	463	466
Final wt, (3/12) lb	710	716	732	725
Daily gain, (115 days) lb	2.14	2.19	2.35	2.25
Beef gain, lb/acre	123	168	180	173
Supplement conversion[d]		5.95	4.88	6.54

[a] Four replicates of 12 steers/replicate per treatment.
[b] Control steers had free-choice access to a commercial mineral supplement.
[c] Supplements were fed 96 days of the 115-day trial.
[d] Lb of supplement (as-fed) per lb of increased gain per acre.

high-fiber supplement. Greater variation in daily intake of the free-choice (2.01 to 8.72 lb) versus hand-fed (3.0 to 5.0 lb) supplement and potential effects on rumen function and forage intake may be part of the explanation for the decreased conversion of the high-fiber supplement fed free-choice.

Budget Analysis Results

Results from budgeting the three supplementation programs and control are summarized in Table 5. Net returns are returns above operating costs, as estimated in the enterprise budget in Table 3. To reflect the variety of pasture leasing situations present in central Oklahoma, per-head net return estimates are reported for four different land values. As mentioned earlier, land is valued at its opportunity cost, the value it could earn in its next best alternative use. For example, if surplus pasture could be leased at a rate of $3.00/cwt/month and 500 pound steers were stocked at a density of 2 acre/head, a pasture charge of $30.00 per acre should be assessed. Land values of $20.00, $30.00 and $40.00 per acre are considered. The final situation reflects a lease rate of $2.50/cwt/month. In this case, both supplemented and unsupplemented cattle are assessed a land charge of $45.00/head. With the exception of the land charge, all cost and return values are identical across the four leasing situations.

Several expenses are increased as a result of implementing the supplementation programs. The most significant increases occur in the feed, labor and machinery operating cost categories. Hauling and marketing costs also increase nominally as a result of selling heavier cattle. An expense that is lowered through supplementation is the pasture cost. For example, as a result of the .5 acre/head reduction in stocking density, the pasture charge is reduced from $40.00 to $30.00/head when land is valued at $20.00/acre. Under high feed costs, total operating costs exceed those reported in Table 3 by $25.26, $26.13 and $28.46 for the high-starch, high-fiber (hand fed) and high-fiber (free choice) programs, respectively. The profitability of the supplementation program depends upon whether revenues from additional gain are sufficient to cover these additional expenses.

Net returns from the three supplementation programs are compared to returns earned from unsupplemented cattle in Table 6. Each of the values represents the difference between per-head returns earned with the supplementation program and returns under the control. For example, in the low feed/low cattle price situation with a $20.00 land value, net returns under the high-fiber, hand-fed program exceed returns earned without supplementation by $3.93/head ($25.38-21.45). Feeding of the high-fiber supplement using the hand-fed method is the most profitable supplementation program evaluated. Per-head returns from the program exceed returns without supplementation for four of the nine price situations

Table 5. Per-head net returns from control and three alternative supplementation programs, 1989-90.

	Control	High-starch Hand-fed	High-fiber Hand-fed	High-fiber Free-choice
		$/Head		
$20.00/ACRE:				
Low Feed/Low Cattle	21.45	13.25	25.38	17.65
Low Feed/Moderate Cattle	63.68	55.84	68.98	60.66
Low Feed/High Cattle	84.80	77.13	90.78	82.16
Moderate Feed/Low Cattle	21.45	6.97	19.00	10.21
Moderate Feed/Mod. Cattle	63.68	49.56	62.60	53.21
Moderate Feed/High Cattle	84.80	70.86	84.43	74.72
High Feed/Low Cattle	21.45	0.70	12.62	2.77
High Feed/Moderate Cattle	63.68	43.29	56.22	45.77
High Feed/High Cattle	84.80	64.58	78.02	67.28
$30.00/ACRE:				
Low Feed/Low Cattle	1.45	-1.75	10.38	2.65
Low Feed/Moderate Cattle	43.68	40.84	53.98	45.66
Low Feed/High Cattle	64.80	62.13	75.78	67.16
Moderate Feed/Low Cattle	1.45	-8.03	4.00	-4.79
Moderate Feed/Mod. Cattle	43.68	34.56	47.60	38.21
Moderate Feed/High Cattle	64.80	55.86	69.43	59.72
High Feed/Low Cattle	1.45	-14.30	-2.38	-12.23
High Feed/Moderate Cattle	43.68	28.29	41.22	30.77
High Feed/High Cattle	64.80	49.58	63.02	52.28
$40.00/ACRE:				
Low Feed/Low Cattle	-18.55	-16.75	-4.62	-12.35
Low Feed/Moderate Cattle	23.68	25.84	38.98	30.66
Low Feed/High Cattle	44.80	47.13	60.78	52.16
Moderate Feed/Low Cattle	-18.55	-23.03	-11.00	-19.79
Moderate Feed/Mod. Cattle	23.68	19.56	32.60	23.21
Moderate Feed/High Cattle	44.80	40.86	54.43	44.72
High Feed/Low Cattle	-18.55	-29.30	-17.38	-27.23
High Feed/Moderate Cattle	23.68	13.29	26.22	15.77
High Feed/High Cattle	44.80	34.58	48.02	37.28
$2.50/CWT/MO:				
Low Feed/Low Cattle	16.45	-1.75	10.38	2.65
Low Feed/Moderate Cattle	58.68	40.84	53.98	45.66
Low Feed/High Cattle	79.80	62.13	75.78	67.16
Moderate Feed/Low Cattle	16.45	-8.03	4.00	-4.79
Moderate Feed/Mod. Cattle	58.68	34.56	47.60	38.21
Moderate Feed/High Cattle	79.80	55.86	69.43	59.72
High Feed/Low Cattle	16.45	-14.30	-2.38	-12.23
High Feed/Moderate Cattle	58.68	28.29	41.22	30.77
High Feed/High Cattle	79.80	49.58	63.02	52.28

Table 6. Comparison of per-head net returns from three alternative supplementation programs to the control, 1989-90.[a]

	High-starch Hand-fed	High-fiber Hand-fed	High-fiber Free-choice
		$/Head	
$20.00/ACRE:			
Low Feed/Low Cattle	-8.20	**3.93**	-3.80
Low Feed/Moderate Cattle	-7.84	**5.30**	-3.02
Low Feed/High Cattle	-7.67	**5.98**	-2.64
Moderate Feed/Low Cattle	-14.48	-2.45	-11.24
Moderate Feed/Mod. Cattle	-14.12	-1.08	-10.47
Moderate Feed/High Cattle	-13.94	-0.37	-10.08
High Feed/Low Cattle	-20.75	-8.83	-18.68
High Feed/Moderate Cattle	-20.39	-7.46	-17.91
High Feed/High Cattle	-20.22	-6.78	-17.52
$30.00/ACRE:			
Low Feed/Low Cattle	-3.20	**8.93**	**1.20**
Low Feed/Moderate Cattle	-2.84	**10.30**	**1.98**
Low Feed/High Cattle	-2.67	**10.98**	**2.36**
Moderate Feed/Low Cattle	-9.48	**2.55**	-6.24
Moderate Feed/Mod. Cattle	-9.12	**3.92**	-5.47
Moderate Feed/High Cattle	-8.94	**4.63**	-5.08
High Feed/Low Cattle	-15.75	-3.83	-13.68
High Feed/Moderate Cattle	-15.39	-2.46	-12.91
High Feed/High Cattle	-15.22	-1.78	-12.52
$40.00/ACRE:			
Low Feed/Low Cattle	**1.80**	**13.93**	**6.20**
Low Feed/Moderate Cattle	**2.16**	**15.30**	**6.98**
Low Feed/High Cattle	**2.33**	**15.98**	**7.36**
Moderate Feed/Low Cattle	-4.48	**7.55**	-1.24
Moderate Feed/Mod. Cattle	-4.12	**8.92**	-0.47
Moderate Feed/High Cattle	-3.94	**9.63**	-0.08
High Feed/Low Cattle	-10.75	**1.17**	-8.68
High Feed/Moderate Cattle	-10.39	**2.54**	-7.91
High Feed/High Cattle	-10.22	**3.22**	-7.52
$2.50/CWT/MO:			
Low Feed/Low Cattle	-18.20	-6.07	-13.80
Low Feed/Moderate Cattle	-17.84	-4.70	-13.02
Low Feed/High Cattle	-17.67	-4.02	-12.64
Moderate Feed/Low Cattle	-24.48	-12.45	-21.24
Moderate Feed/Mod. Cattle	-24.12	-11.08	-20.47
Moderate Feed/High Cattle	-23.94	-10.37	-20.08
High Feed/Low Cattle	-30.75	-18.83	-28.68
High Feed/Moderate Cattle	-30.39	-17.46	-27.91
High Feed/High Cattle	-30.22	-16.78	-27.52

[a] Bold numbers represent positive differences

when land is valued at $20.00/acre. Under a $30.00/acre land value, returns from the hand-fed high-fiber supplement are positive under low and moderate feed prices, and are positive for all price situations under high land values. The high-starch (hand fed) and high-fiber (free choice) programs are considerably less profitable; per-head net returns exceed those of control cattle only under low feed costs with land values of $30.00/acre or more.

Several potential cost reductions from the supplementation programs were not factored into the budgeting analysis due to a lack of definitive data. One important area of potential savings may result from reduced death loss and (or) medical expenses due to a reduction in the incidence of bloat from feeding monensin to the supplemented cattle. As shown in Table 3, net returns are increased nearly $6.00/head (i.e., $5.83/head) for each 1% reduction in death loss. Other savings might be realized from reduced labor or machinery use and costs of cattle facility, fence and water development by concentrating cattle in fewer pastures. The negative values reported in Table 6 may also be interpreted as the savings that must be realized through reduced death loss, medical expenses, and other cost reductions not accounted for that would make supplementation profitable relative to the control program.

Returns are expressed on a per acre basis in Table 7. Per-acre net returns are estimated by dividing per head returns by the appropriate stocking density (2 acre/head for the control and 1.5 acre/head for each of the supplementation programs). Per-acre returns should be compared when land is the limiting factor of production; that is, the producer wishes to maximize total returns from a fixed acreage of land. Per-acre returns from the high-fiber, hand-fed program exceed those of the control for all nine price situations when pasture is valued at $20.00 or $30.00/acre (Table 8). With the exception of three price situations (moderate feed/low cattle, high feed/low cattle and high feed/moderate cattle), per-acre returns from the high-starch and free-choice programs also exceed returns earned without supplementation.

Table 7. Per-acre net returns from control and three alternative supplementation programs, 1989-90.

	Control	High-starch Hand-fed	High-fiber Hand-fed	High-fiber Free-choice
	----------	----------	$/Acre----------	----------
$20.00/ACRE:				
Low Feed/Low Cattle	10.73	8.83	16.92	11.77
Low Feed/Moderate Cattle	31.84	37.23	45.99	40.44
Low Feed/High Cattle	42.40	51.42	60.52	54.77
Moderate Feed/Low Cattle	10.73	4.65	12.67	6.81
Moderate Feed/Mod. Cattle	31.84	33.04	41.73	35.47
Moderate Feed/High Cattle	42.40	47.24	56.29	49.81
High Feed/Low Cattle	10.73	0.47	8.41	1.85
High Feed/Moderate Cattle	31.84	28.86	37.48	30.51
High Feed/High Cattle	42.40	43.05	52.01	44.85
$30.00/ACRE:				
Low Feed/Low Cattle	0.72	-1.17	6.92	1.77
Low Feed/Moderate Cattle	21.84	27.23	35.99	30.44
Low Feed/High Cattle	32.40	41.42	50.52	44.77
Moderate Feed/Low Cattle	0.72	-5.35	2.67	-3.19
Moderate Feed/Mod. Cattle	21.84	23.04	31.73	25.47
Moderate Feed/High Cattle	32.40	37.24	46.29	39.81
High Feed/Low Cattle	0.72	-9.53	-1.59	-8.15
High Feed/Moderate Cattle	21.84	18.86	27.48	20.51
High Feed/High Cattle	32.40	33.05	42.01	34.85
$40.00/ACRE:				
Low Feed/Low Cattle	-9.28	-11.17	-3.08	-8.23
Low Feed/Moderate Cattle	11.84	17.23	25.99	20.44
Low Feed/High Cattle	22.40	31.42	40.52	34.77
Moderate Feed/Low Cattle	-9.28	-15.35	-7.33	-13.19
Moderate Feed/Mod. Cattle	11.84	13.04	21.73	15.47
Moderate Feed/High Cattle	22.40	27.24	36.29	29.81
High Feed/Low Cattle	-9.28	-19.53	-11.59	-18.15
High Feed/Moderate Cattle	11.84	8.86	17.48	10.51
High Feed/High Cattle	22.40	23.05	32.01	24.85
$2.50/CWT/MO:				
Low Feed/Low Cattle	8.23	-1.17	6.92	1.77
Low Feed/Moderate Cattle	29.34	27.23	35.99	30.44
Low Feed/High Cattle	39.90	41.42	50.52	44.77
Moderate Feed/Low Cattle	8.23	-5.35	2.67	-3.19
Moderate Feed/Mod. Cattle	29.34	23.04	31.73	25.47
Moderate Feed/High Cattle	39.90	37.24	46.29	39.81
High Feed/Low Cattle	8.23	-9.53	-1.59	-8.15
High Feed/Moderate Cattle	29.34	18.86	27.48	20.51
High Feed/High Cattle	39.90	33.05	42.01	34.85

Table 8. Comparison of per-acre net returns from three alternative supplementation programs to the control, 1989-90.[a]

	High-starch Hand-fed	High-fiber Hand-fed	High-fiber Free-choice
	----------$/Acre----------		
$20.00/ACRE:			
Low Feed/Low Cattle	-1.89	**6.19**	**1.04**
Low Feed/Moderate Cattle	**5.39**	**14.15**	**8.60**
Low Feed/High Cattle	**9.02**	**18.12**	**12.37**
Moderate Feed/Low Cattle	-6.08	**1.94**	-3.92
Moderate Feed/Mod. Cattle	**1.20**	**9.89**	**3.63**
Moderate Feed/High Cattle	**4.84**	**13.89**	**7.41**
High Feed/Low Cattle	-10.26	-2.31	-8.88
High Feed/Moderate Cattle	-2.98	**5.64**	-1.33
High Feed/High Cattle	**0.65**	**9.61**	**2.45**
$30.00/ACRE:			
Low Feed/Low Cattle	-1.89	**6.19**	**1.04**
Low Feed/Moderate Cattle	**5.39**	**14.15**	**8.60**
Low Feed/High Cattle	**9.02**	**18.12**	**12.37**
Moderate Feed/Low Cattle	-6.08	**1.94**	-3.92
Moderate Feed/Mod. Cattle	**1.20**	**9.89**	**3.63**
Moderate Feed/High Cattle	**4.84**	**13.89**	**7.41**
High Feed/Low Cattle	-10.26	-2.31	-8.88
High Feed/Moderate Cattle	-2.98	**5.64**	-1.33
High Feed/High Cattle	**0.65**	**9.61**	**2.45**
$40.00/ACRE:			
Low Feed/Low Cattle	-1.89	**6.20**	**1.04**
Low Feed/Moderate Cattle	**5.39**	**14.15**	**8.60**
Low Feed/High Cattle	**9.02**	**18.12**	**12.37**
Moderate Feed/Low Cattle	-6.08	**1.94**	-3.92
Moderate Feed/Mod. Cattle	**1.20**	**9.89**	**3.63**
Moderate Feed/High Cattle	**4.84**	**13.89**	**7.41**
High Feed/Low Cattle	-10.26	-2.31	-8.88
High Feed/Moderate Cattle	-2.98	**5.64**	-1.33
High Feed/High Cattle	**0.65**	**9.61**	**2.45**
$2.50/CWT/MO:			
Low Feed/Low Cattle	-9.39	-1.31	-6.46
Low Feed/Moderate Cattle	-2.11	**6.65**	**1.10**
Low Feed/High Cattle	**1.52**	**10.62**	**4.87**
Moderate Feed/Low Cattle	-13.58	-5.56	-11.42
Moderate Feed/Mod. Cattle	-6.30	**2.39**	-3.87
Moderate Feed/High Cattle	-2.66	**6.39**	-0.09
High Feed/Low Cattle	-17.76	-9.81	-16.38
High Feed/Moderate Cattle	-10.48	-1.86	-8.83
High Feed/High Cattle	-6.85	**2.11**	-5.05

[a] Bold numbers represent positive differences

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INFLUENCE OF WINTER GROWING PROGRAM AND SUMMER GRAZING PROGRAM ON PERFORMANCE OF HEIFERS GRAZING TALLGRASS PRAIRIE

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Story in Brief

Beef heifers were backgrounded for 42 days on either dormant range plus protein cubes or limit-fed a high concentrate ration in drylot to gain 1.0, 1.5 or 2.0 lb/head/day. On May 1 after backgrounding, the heifers were allocated to either 150 day seasonlong grazing or 80 day intensive-early stocking programs. Weight gain on range during the backgrounding phase was .27 lb/day. The three limit-fed groups gained 1.09, 1.91, and 2.15 lb/day, respectively. Because of poor forage growing conditions, weight gains during the summer were low relative to past years and stocking was too heavy on the intensive-early stocking treatment. Cattle backgrounded on range gained more weight than cattle previously fed concentrate diets. During the first 80 days of grazing, total weight gain by intensive-early stocking heifers was depressed .31 lb for each pound of additional weight gained during the winter while weight gain of seasonlong grazing heifers was depressed .47 lb/lb of additional winter gain. Over the 150 day season, gain of the seasonlong grazing heifers was depressed .56 lb/lb of additional winter gain. As a result of poor performance in the early grazing season, the intensive-early stocking system did not produce more gain per acre than the seasonlong grazing system.

(Key Words: Grazing Systems, Rangeland, Compensatory Gain.)

Introduction

Many wintering programs for stocker cattle are intended to hold cattle at low rates of gain, therefore preparing them for compensatory gains on summer pastures. Although wintering at higher rates of gain may reduce subsequent summer performance, total weight gain and profitability may be improved by accelerated gains during the wintering phase.

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Limit-feeding high concentrate rations for a programmed rate of gain is a predictable means of improving winter performance. The relationship between rate of gain in the winter and gain in the grazing phase must be understood in order to project economies of different management programs. Results from a previous trial (McLean et al., 1990) indicated that for each additional pound of daily gain prior to grazing, daily gain on grass was depressed between .33 and .49 lb depending upon the length of the grazing season.

Intensive-early stocking is a grazing program which can increase weight gain per unit land area by 20-40% compared to seasonlong grazing. This is accomplished by shortening the summer grazing season by about one-half and increasing stocking density two or three times normal. Previous results indicate that plane of winter nutrition had a greater impact on daily gain during the intensive early stocking period than on gains over a full summer grazing season (McLean et al., 1990).

The current results are from the second year of a study conducted to determine the effects of accelerated winter gains on the performance of stocker cattle grazed under two different grazing programs. Subsequent feedlot performance was also monitored and is reported in accompanying reports.

Materials and Methods

One hundred sixty head of crossbred heifer calves (initial wt = 468 lb) were purchased in Georgia and transported to the Pawhuska Research Station in February, 1990. Following routine processing and a short receiving period, the heifers were allocated to two replications of four winter nutritional management programs. Replications were based on truckloads delivered to the station. One treatment group (DW) was placed on dormant tallgrass prairie rangeland and fed 2.0 lb/head/day of 38% CP range cubes. Salt/mineral mix was provided free-choice. The other three groups were confined in drylot and limit-fed a high concentrate diet (Table 1) in sufficient quantities to promote 1.0 (LG), 1.5 (MG), or 2.0 (HG) lb gain/head/day. Daily feed allowances were based on estimated NE_g content of the ration and energy requirements of the heifers. Feed allowances were adjusted every 14 days based on projected gains of the cattle. Feed was offered once daily between 9 a.m. and 10 a.m. All heifers were implanted with Synovex-H at the start of the winter period and reimplanted at 84-day intervals until trial completion.

After 42 days on the winter nutritional programs, the cattle were weighed following an overnight period without feed and water. Each winter treatment replication was then randomly allocated by weight to either

Table 1. Composition of limit-fed ration.

Ingredient	% As fed
Corn, #2 whole shelled	86.96
Supplement	13.04
Supplement composition	
Soybean meal	51.18
Cottonseed meal	29.83
Calcium carbonate	9.96
Potassium chloride	2.06
Salt	2.45
Dicalcium phosphate	.59
Urea	3.46
Tylan 40	.09
Vitamin A-30	.17
Vitamin E-50	.014
Rumensin 60	.19

intensive-early stocking (IES) or seasonlong stocking (SLS) for the summer grazing season. Seasonlong stocking is continuous grazing from May to late September at the recommended moderate stocking rate. Intensive-early stocking is defined as continuous grazing from May to mid July at a stock density (head/acre) twice that of the SLS but at a stocking rate (head•days/acre) similar to SLS. Four pastures, two IES and two SLS, were used for the grazing phase. Rangeland on the research station is typical of the Cross Timbers vegetation type with a mosaic of oak/hickory forests and tallgrass prairies.

On July 20, 80 days into the summer grazing season, all cattle were weighed following an overnight period without feed and water. The SLS cattle were returned to pasture and the IES groups were transported 310 miles to Goodwell, OK, to be finished. The SLS cattle were grazed for an additional 70 days (150 days total) before being shipped to the same location for finishing. Protein supplement (1.0 lb/head/day, 38% CP range cubes) was fed to the SLS cattle during the final 70 days of grazing. Weights were recorded prior to shipment in September.

Data were analyzed using GLM procedures of SAS. The model for the backgrounding phase and last 70 days of the SLS phase included winter treatment and replication. Comparisons for the first 80 days of the grazing season were made using a model containing winter treatment, grazing

treatment, replication, and the interaction of winter treatment and grazing treatment. Least significant difference procedures were used to separate means. Separate regression equations for the relationships of winter gain and grazing gain were developed for the IES cattle and SLS cattle during the first 80 days, and SLS cattle for the complete 150 days of grazing.

Results and Discussion

Winter nutritional management resulted in an 80 lb spread in average weights between the DW heifers and the HG heifers (Table 2). All the program fed heifers were more efficient than expected with the actual feed conversion being 21 percent better than expected at the MG feeding level. DW heifers gained less ($P<.05$) weight than the other groups. The previous year, DW heifers gained .95 lb/day during an 84-day winter period (McLean et al., 1990). The LG and HG groups performed relatively close to programmed levels of gain. The MG group gained .41 lb/day more than targeted and weight at the end of the winter phase was similar to weight of the HG heifers. During the previous winter trial, daily gains of all three

Table 2. Performance of heifers during the 42-day winter phase.

	Dormant range	Programmed gain, lb/day		
		1.0	1.5	2.0
	lb/head			
Initial weight	467	471	467	468
Final weight	479[a]	517[b]	547[c]	559[c]
Gain	11.3[a]	45.8[b]	80.1[c]	90.2[c]
Daily gain	.27[a]	1.09[b]	1.91[c]	2.15[c]
Feed intake (dry matter basis)		7.4	9.1	10.9
Feed/gain				
Theoretical	---	7.4	6.1	5.4
Actual	---	6.8	4.8	5.1

[a,b,c] Row means are different, $P<.05$.

limit-fed groups were about .50 lb/head/day greater than expected (McLean et al., 1990).

Weight gains on pasture were low relative to several previous years of research at this station. During the first 80 days of grazing, the heifers on IES gained less weight than heifers on SLS (Table 3). This depression indicates that stocking rates were too heavy. Pasture utilization was grossly surveyed in July. Use profiles on key grass species did not suggest overutilization. However, a canopy of lanceleaf ragweed was present in the pastures and may have inhibited grazing by cattle. Additionally, the spring of 1990 was relatively cool and dry and forage production was effectively delayed by three to four weeks.

Heifer performance during the initial 80 days of grazing is summarized in Table 3. No interactions among winter treatments and summer grazing

Table 3. Performance of heifers during the first 80 days of grazing.

	Dormant range	Programmed gain, lb/day		
		1.0	1.5	2.0
	lb/head			
Initial weight				
IES[d]	476	520	545	556
SLS[d]	481	513	550	561
80-day weight				
IES[d]	558	590	597	606
SLS[d]	595	606	620	622
MEAN	576[a]	598[b]	608[b]	615[b]
Gain				
IES[d]	82.3	69.9	52.7	50.9
SLS[d]	113.4	93.2	69.8	60.9
MEAN	97.9[a]	81.5[b]	61.2[c]	55.9[c]
Daily gain				
IES[d]	1.03	.87	.66	.64
SLS[d]	1.42	1.17	.87	.76
MEAN	1.22[a]	1.02[b]	.76[b]	.70[b]

[a,b,c] Row means are different, $P < .05$.
[d] IES = Intensive-early stocking; SLS = Seasonlong stocking.

programs were noted. Cattle from the DW treatment gained more ($P<.05$) weight than heifers from the programmed feeding groups. By the end of 80 days on pasture, the range in weights between the DW and HG heifers had narrowed from 80 lb/head to 50 lb/head on IES and 27 lb/head on SLS. Once again, the gains for the MG and HG heifers were similar. Performance of the LG heifers was intermediate to the DW group and the two higher levels of programmed gain.

Weight gain during the final 70 days of the SLS grazing period were similar for the four winter management groups (Table 4). In a previous trial (McLean et al., 1990), the DW and LG cattle tended ($P=.08$) to gain faster than the MG and HG cattle in the late summer. The current results failed to show such a trend ($P=.19$).

Heifers on IES gained less weight ($P<.05$) than heifers on SLS during the first 80 days of grazing (Table 3). Regression equations relating winter daily gain (X) to daily gain (ADG) during the first 80 days of grazing were: $ADG=1.02-.16X$ ($P<.0001$; $r^2=.25$) for IES heifers and $ADG=1.39-.25X$ ($P<.0001$; $r^2=.32$) for SLS heifers. Hence for IES heifers, each additional pound of daily gain in the winter depressed daily gain on pasture by .16 lb/day. On SLS, daily gain was depressed .25 lb/day. Similar equations relating total winter gain (X) to total gain (GAIN) in the first 80 days were: $GAIN=81.8-.31X$ for IES and $GAIN=111.1-.47X$ for SLS. This second set of equations is more useful and indicates that for every pound of additional gain in the winter, gain by the IES heifers was depressed .31 lb while gain was depressed almost .5 lb in the SLS heifers. In year 1, GAIN depression during the first 84 days of grazing was .49 lb/lb of additional winter gain (McLean et al., 1990).

The difference in gain suppression between IES and SLS indicates that heavy stocking reduced the ability of the DW and LG heifers to compensate as fully on IES as on SLS. This suggests that winter management programs

Table 4. Effects of winter growing program on performance of heifers during the last 70 days of summer grazing.

	Dormant range	Programmed gain, lb/day		
		1.0	1.5	2.0
	lb/head			
Final weight	663	677	678	682
Gain	68.0	70.9	57.5	60.2
Daily gain	.97	1.01	.82	.86

which accelerate gain will have less impact in operations that utilize grazing management programs that depress performance (i.e. heavier stocking or possibly intensive rotation) than in grazing programs which promote high cattle gains (i.e. continuous grazing at moderate stocking rates).

Regression analysis for the entire SLS grazing season yielded the equations ADG=1.20-.16X ($P<.0001$; $r^2=.32$) and GAIN=180.3-.56X. In year 1, SLS GAIN was depressed .60 lb/lb of winter gain.

SLS heifers were 87 lb heavier ($P<.05$) than IES heifers at the end of their respective grazing seasons (Table 5). Also, the spread between winter management groups was 49 lb/head and 19 lb/head for IES and SLS cattle, respectively.

In past research at this station (McCollum et al., 1990), IES produced about 20% more gain/acre than SLS grazing. However, due to poor performance during the early grazing season, IES yielded 14% less ($P<.05$) gain/acre than SLS in the current year (Table 5). No interaction between winter management and summer grazing system was detected. Gross differences between IES and SLS ranged from 17 to 25 lb gain/unit area for the winter management groups.

Table 5. Total gain/heifer, total gain/area, and weight off pasture.

	Dormant range	Programmed gain, lb/day 1.0	1.5	2.0
	lb/head			
Weight off pasture				
IES[d]	558	590	597	607
SLS[d]	663	677	678	682
Mean	610[a]	634[b]	637[b]	645[b]
Total gain/heifer				
IES[d]	82.3	69.9	52.6	50.9
SLS[d]	181.4	164.1	127.3	121.2
MEAN	131.9[a]	117.0[b]	89.9[b]	86.0[b]
Total gain/acre				
IES[d]	164.7	139.8	105.3	101.8
SLS[d]	181.4	164.6	127.2	121.1
MEAN	173.0[a]	151.9[b]	116.3[c]	111.5[c]

[a,b,c] Row means are different, $P<.05$.
[d] IES = Intensive-early stocking; SLS = Seasonlong stocking.

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EFFECTS OF TILMICOSIN OR CEFTIOFUR ON HEALTH AND PERFORMANCE OF SHIPPING STRESSED STOCKER CATTLE

R.A. Smith[1], M.T. Van Koevering[2], D.R. Gill[3] and R.L. Ball[4]

Story in Brief

One hundred twenty one head of cattle demonstrating clinical signs of bovine respiratory disease were selected from 213 head of shipping stressed heifer, steer and bull calves, weighing an average of 500 lbs. These cattle were used to determine the relative efficacy of Tilmicosin and Ceftiofur for the treatment of bovine respiratory disease. Tilmicosin produced a greater response (rectal temperature < 104.0° F and disappearance of clinical signs) to treatment (72.6 vs 55.9%); and with this treatment severity of illness scores (1.7 vs 2.2) were also lower. Rectal temperatures of calves treated with Tilmicosin were lower on day 4 than those treated with Ceftiofur (103.3 vs 104.0° F). Fewer cattle receiving Tilmicosin required treatment with a second drug following their initial treatment (24.1 vs 42.4%). Cattle treated with Tilmicosin had greater daily gains during the 28 day receiving period (0.63 vs -0.03 lbs).

(Key Words: Shipping Fever, Tilmicosin, Ceftiofur, Stressed Calves.)

Introduction

Transported stocker cattle, being under stress, are extremely susceptible to shipping fever, also known as the bovine respiratory disease complex (BRD). Drugs which decrease the incidence or severity of BRD of newly received stocker cattle are of great interest because mortality rates typically range from 2 to 5%. Tilmicosin is an experimental new drug that may improve cattle health and performance.

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Materials and Methods

Upon arrival at Pawhuska, OK, from either Kentucky or Georgia, 213 cattle were weighed individually, identified with an ear tag and allotted randomly to 10 pens for a nutrition study. On arrival cattle had free choice access to water and long stem grass hay. The following morning, all calves were processed as follows: vaccinated with IBR/PI3 (modified live virus; i.m.) and 7 way clostridial bacterin and injected with ivermectin. Calves were adapted to a 72% concentrate ration which was limit fed to allow gains up to 2 lb/day. Any calves showing signs of illness upon arrival were placed on a medication program and were not included in the comparative respiratory treatment study.

Starting on day 1, cattle showing visual signs of respiratory disease that had a rectal temperature of 104° F or higher were treated with Tilmicosin (Elanco Products, Division of Eli Lilly, Indianapolis, IN) (10 mg/kg) or Ceftiofur sodium (Upjohn Co., Kalamazoo, MI) (0.50 mg/lb). Alternate cattle received each treatment. Tilmicosin was administered as a single s.c. injection; Ceftiofur was administered once daily for 3 days. All cattle were assigned a severity of illness score (1 = normal; 2 = slight depression; 3 = moderate depression; 4 = severe depression, not moving; 5 = downer, dead) at the time of treatment. On day 4, body temperature was taken and severity of illness was scored. Cattle then were classified as responders (not requiring further treatment) or retreats which required additional treatment beyond the initial three days. Cattle initially treated with Tilmicosin and classified as a retreat were treated with another antibiotic and did not receive a second injection of Tilmicosin. Cattle initially treated with Ceftiofur and classified as a retreat received Ceftiofur for two more days or with another antibiotic if no improvement was noted on day 4. At the end of 28 days, bulls were castrated, horns were tipped, and cattle were weighed, branded, implanted and moved to pasture.

All data were analyzed using the general linear model of SAS with the main effects of drug and a combined effect of nutritional treatment and origin. F tests were used to identify significant effects of drug treatments.

Results and Discussion

Health response to Tilmicosin or Ceftiofur are shown in Table 1. Cattle receiving Tilmicosin showed a greater response ($P<.03$) to their first treatment (72.6 vs 55.9%); on day 4, their severity of illness was lower (1.7 vs 2.2) and rectal temperature was lower (103.3 vs 104.0). The incidence of retreats also was decreased ($P<.02$) and mortality was lower ($P<.05$) with Tilmicosin.

Table 1. Effect of Tilmicosin or Ceftiofur on animal health.

	Tilmicosin	Ceftiofur	Probability (P<)
Animals, Number	62	59	
Response, %	72.6	55.9	.03
Severity			
Day 1, score[a]	2.8	2.8	
Day 4	1.7	2.2	.01
Temperature			
Day 1, °F	105.2	105.4	
Day 4, °F	103.3	104.0	.01
Weight[b]			
Day 1, lb	506	508	
Day 4, lb	519	509	
Retreat, %	24.1	42.4	.02
Repull, %[c]	4.8	10.2	
Mortality, %	1.6	10.2	.05
Treatment days, number[d]	1.8	5.5	.01

[a] 1 = normal; 2 = slight depression; 3 = moderate depression; 4 = severe depression, not moving; 5 = downer, dead.
[b] Least squares means.
[c] Animals found sick more than once.
[d] Because Tilmicosin is a single injection treatment and Ceftiofur was administered a minimum of 3 days, a statistical bias exists.

Cattle performance is presented in Table 2. Cattle treated with Tilmicosin had greater (P<.07) final body weight and greater (P<.04) average daily gain during the 28 day study. This greater average daily gain may be a result of greater response by cattle to the initial treatment with Tilmicosin.

A higher percentage of calves treated with Ceftiofur needed retreatment with a second drug and were treated for more (P<.01) days (5.5 vs 1.8), which probably impaired performance.

A new antibiotic, Tilmicosin is being studied for the treatment of BRD. Administered as a single s.c. injection, it maintains a three day therapeutic level of antibiotic in the lung. In this study, Tilmicosin proved useful as an antibiotic for treatment of BRD.

Table 2. Effect of Tilmicosin or Ceftiofur on performance[a].

	Tilmicosin	Ceftiofur	Probability (P<)
Animals, number	62	59	
Weight			
Arrival	502	498	
Final	521	498	.07
Average daily gain, lb	0.63	-0.03	.04

[a]Least squares means.

THE EFFECTS OF ESCAPE PROTEIN ON HEALTH AND PERFORMANCE OF SHIPPING STRESSED CALVES

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Story in Brief

Four hundred and sixty six shipping-stressed steer, bull and heifer calves initially weighing an average of 490 pounds were received at the Pawhuska Research Station between October 1989 and April 1990. The objective of this study was to determine if proteins differing in type and quality can change animal health and performance. Calves were fed four protein supplements consisting of: soybean meal, soybean meal + bloodmeal, milo distillers dried grain plus solubles and milo distillers dried grain plus solubles + bloodmeal. All diets were formulated to be isocaloric (NEg 50 Mcal/cwt) and isonitrogenous (14.5% CP) while containing 28% roughage. Diets were limit fed for 28 days to produce a maximum daily gain of 2.0 pound. Daily gains overall and for sick cattle were not altered, but daily gains for cattle that were never treated for sickness were 19.5% greater (2.21 vs 1.78 pound) with diets containing soybean meal. Morbidity was similar (72%) for all treatments, but the percentage of cattle that recovered following treatment with the first drug was greater, incidence of being repulled for sickness was less, and the number of days calves required drug treatment declined with diets containing milo distillers dried grain plus solubles. Mortality tended to be less with supplemented bloodmeal in the diet. Increasing the percentage of escape protein in the receiving diet improved the health of shipping-stressed calves, but reduced the rate of gain of healthy calves.

(Key Words: Escape Protein, Shipping-Stress, Calves, Bloodmeal.)

Introduction

Transportation over long distances and the mixing of cattle in sale barns are both principal factors associated with the incidence of stress related disease. Newly received cattle are highly susceptible to shipping fever, otherwise known as bovine respiratory disease complex, which can lead to

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high rates of morbidity and mortality. Increasing the quantity of escape protein by feeding milo distillers dried grain plus solubles and improving the quality of amino acids reaching the lower gut by feeding bloodmeal may result in improved animal health and performance. The objective of this study was to determine if increasing the level of escape protein in receiving rations could improve animal health and performance.

Materials and Methods

Five truck loads of shipping-stressed steer, bull and heifer calves (n=466) weighing an average of 490 lbs were received at the Pawhuska Research Station between October 1989 and April 1990. After unloading, cattle were individually weighed, identified, and allowed free access to hay and water overnight. The following day all animals were vaccinated with IBR-PI3 (modified live virus; i.m.) and 7-way clostridial bacterin and dewormed with ivermectin.

After processing cattle were allotted to pens based on initial weights. Pens were then randomly allotted to one of four protein supplements. Protein supplements consisted of: soybean meal (SBM), SBM + bloodmeal (BM), milo distillers dried grain plus solubles (DDGS) and DDGS + BM. All diets (Table 1) were formulated to be isocaloric (NEg 50 Mcal/cwt) and isonitrogenous (14.5% CP) while containing 28% roughage. Cattle were adapted to diets over a 5-day period by sequentially decreasing the amount of hay fed. Diets were limit fed for 28 days to produce a maximum daily gain of 2.0 lb.

Cattle were visually monitored twice daily for signs of sickness. Animals displaying visual signs of depressed activity and feed intake were moved to the processing area where rectal temperatures and severity of illness was clinically appraised and recorded. Animals with rectal temperatures $>104^{O}F$ were considered sick. Sick animals were treated with antimicrobial drugs. If rectal temperature decreased within 48 hours, treatment was terminated. If no improvement in temperature or visual signs was apparent within 48 hours, a different antimicrobial drug was administered. This procedure was continued until a satisfactory improvement in health was observed.

Results and Discussion

The effects of escape protein on animal performance are illustrated in Table 2. Daily gains for all cattle and for cattle classified as sick were not altered by dietary treatment. However, daily gains of cattle that were never treated for sickness were greater ($P<.01$) with SBM diets. Waller et al.

Table 1. Composition of diets (dry matter basis).

Ingredient	SBM	SBM+BM	DDGS	DDGS+BM
Ration	----------	(%)	----------	
Corn, rolled	51.88	54.49	40.18	46.18
Alfalfa hay, pelleted	8.00	8.00	8.00	8.00
Cottonseed hulls	20.00	20.00	20.00	20.00
Molasses, cane	3.80	3.80	3.80	3.80
Pelleted supplement	16.32	13.71	28.02	22.02
Supplement				
Soybean meal	14.47	9.88	0.00	0.00
Milo distillers	0.00	0.00	26.29	18.04
Bloodmeal	0.00	2.30	0.00	2.30
Dicalcium phosphate	.24	.33	.06	.21
Calcium carbonate	1.16	.63	.99	.74
Potassium chloride	.08	.20	.30	.36
Salt	.30	.30	.30	.30
Bovatec 68	.02	.02	.02	.02
Trace mineral	.01	.01	.01	.01
Vitamin A	.02	.02	.02	.02
Vitamin E	.02	.02	.02	.02
Calculated escape protein	5.70	6.67	8.16	8.36

Average calculated composition of the ration:

Nutrients	Ration Composition DM %
NEm, Mcal/cwt	83.32
NEg, Mcal/cwt	50.00
Crude protein, %	14.50
Escape protein	7.22
Crude fiber, %	15.06
K, %	1.00
Ca, %	0.62
P, %	0.33

Table 2. Effect of escape protein on animal performance.[a]

Item	SBM	SBM+ BM	DDGS	DDGS+ BM	Significant (P<) SBM vs DDGS	BM vs 0
Animal, No.	117	114	119	116		
Pens	8	8	8	8		
Weights, lbs						
Arrival	497	490	484	489	.22	.90
Final[b]	542	530	517	528	.04	.97
Daily gains, lbs						
Overall	1.51	1.41	1.21	1.38	.16	.75
Never sick	2.33	2.09	1.78	1.78	.01	.43
Sick	1.04	.99	.95	1.30	.59	.38
Feed:Gain	6.3	7.1	7.8	6.5	.42	.69

[a]Expressed as least squares means.
[b]Significant interaction P<.10.

(1980) found, using a diet with equal amounts of corn silage and corn cobs, no difference in daily gains between SBM and DDGS diets. There was also no response in daily gains with the addition of urea to the DDGS diet. In a preliminary study comparing SBM and DDGS diets we found that ruminal ammonia was severely depressed with the DDGS diet which may have limited microbial protein synthesis.

The effects of escape protein on animal health parameters are presented in Table 3. Morbidity rate (the percentage of cattle becoming sick) was similar (72%) for all treatments. The percentage of cattle that recovered following treatment with the first drug was greater ($P<.02$), the incidence of cattle being repulled for sickness was less ($P<.01$), and the number of days cattle required drug treatment declined ($P<.04$) with diets containing DDGS. The lower daily gains with the DDGS diets were compensated for with significant increases in health parameters. The decreased number of repulls and sick days for cattle fed DDGS has definite advantages due to decreased drug and labor costs when compared to the 19.5% higher gains for a 28-day period with SBM diets. Mortality tended to be less with supplementation of BM in the diet.

Increasing the percentage of escape protein in the receiving diet improved the health of shipping-stressed calves. It can be suggested that the improvement in health observed in the DDGS diets is from increased amounts of dietary protein escaping rumen degradation and entering the small intestine where it may be utilized. Based on the ADG for calves that were never sick, the NEg value of DDGS appears to be lower than the 62 Mcal/cwt suggested by the 1984 Beef NRC. The decreased number of treatment days required by calves receiving DDGS diets and improved ADG with SBM diets would agree with findings by Lofgreen et al. (1975) if the energy levels of DDGS diets are lower then SBM rations. The addition of escape protein to receiving rations maybe a valuable tool for cattlemen who receive shipping-stressed calves.

Table 3. Effect of escape protein on animal health.

Item	SBM	SBM + BM	DDGS	DDGS + BM	Significant (P<) SBM vs DDGS	BM vs 0
Animal, No.	117	114	119	116		
Pens	8	8	8	8		
Morbidity, %	72.7	74.3	69.8	72.4	.48	.52
Mortality, %	3.0	.78	1.9	.69	.53	.09
Recovered, %	29.8	45.4	45.7	56.5	.02	.02
Repull, %	26.7	23.1	9.8	3.2	.01	.36
Retreat, %	37.0	21.9	27.0	26.5	.68	.26
Treatment days	6.1	5.5	5.0	5.0	.04	.41
Severity Score[a]						
First	2.61	2.63	2.68	2.68	.29	.92
Last	1.48	1.34	1.45	1.46	.50	.34
Average	2.02	1.91	1.95	1.89	.38	.08
Temperature						
First[b]	105.7	105.4	105.5	105.5	.47	.03
Last	102.9	103.0	102.7	102.8	.06	.13
Average	104.2	103.9	103.9	104.0	.12	.21

[a]First = day 1 of treatment; Last - final day of treatment.
[b]Significant interaction P<.10.

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MASS MEDICATION OF NEWLY ARRIVED STOCKER CATTLE TO IMPROVE HEALTH AND PERFORMANCE

M.T. Van Koevering[1], M.C. King[1], D.R. Gill[2] and R.L. Ball[3]

Story in Brief

The effectiveness of long acting oxytetracycline (LAO) and sustained release sulfadimethoxine (SRS) as a form of mass medication was studied in three hundred and twelve newly received steer, bull and heifer calves. Upon arrival calves were divided into two groups by alternately processing calves with either routine processing (control), or routine processing plus LAO and SRS. Morbidity was reduced from 5.13% in controls to .64% in calves receiving mass medication. Daily gains were improved 28% by mass medication (.82 vs .64 lb/head) during the 28 day trial.

(Key Words: Mass Medication, Newly Received Cattle, Shipping Fever.)

Introduction

Numerous cattle are shipped into the state of Oklahoma each year from all over the country. The stress related with transportation leads to high rates of morbidity and mortality, resulting primarily from shipping fever-bovine respiratory disease complex (BRD). Cattlemen receiving stressed cattle realize that preventing BRD is more economical than treating animals after they become ill. Administration of intramuscular oxytetracycline for three consecutive days to stressed calves entering the feedlot has been shown to reduce the incidence of BRD, but this treatment has the economic disadvantage of increased labor (Addis et al., 1976; Lofgreen, 1983). However, administration of long-acting antibiotics and sustained release drugs at processing could help prevent BRD from occurring and eliminate the need for daily drug treatments without the need for increased labor.

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Materials and Methods

Three truck loads of cattle originating in Florida arrived concurrently at the research station in Pawhuska, OK. Two trucks contained steer and bull calves while the third contained heifers for a total of 312 calves weighing an average of 452 lbs. After unloading, calves were individually weighed, identified and processed. All calves were routinely processed as follows: vaccinated with IBR-PI3 (modified live virus; i.m.) and 7 way clostridial bacterin and injected with ivermectin. Routine processing was considered to be the control, while the mass medication treatment consisted of routine processing plus long acting oxytetracycline (LAO) and sustained release sulfadimethozine (SRS) to alternating calves.

All calves were maintained in drylot pastures for 28 days while being adapted to a grain and long-stem prairie hay diet with ad libitum access to water. Calves were monitored daily for sickness (rectal temperature $>104^{\circ}F$, or visually depressed). Sick animals were treated daily with antibiotics until rectal temperature was $<104^{\circ}F$ for two consecutive days and visual signs disappeared. At the end of the 28-day study, cattle were held overnight without feed or water and weighed.

Results and Discussion

The effects of mass medication on animal health and performance are illustrated in Table 1. Calves medicated with LAO and SRS at the time of first processing had 28% ($P<.01$) greater daily gains (.82 vs .64 lb/head) than the routinely processed cattle during the 28-day trial. This increase in daily gains is similar to the findings of Gill et al. (1986). This increase in daily gains may have resulted from a decrease in the incidence of BRD complex in mass medicated cattle, allowing cattle to increase feed consumption faster.

Mass medication decreased ($P<.01$) the percentage of sick cattle from 5.13% in the controls to .64%. These data are consistent with the findings of Lofgreen (1983) and Gill et al. (1986) where significant decreases in morbidity were obtained with mass medication of LAO alone or in combination with SRS at processing.

Mass medication at processing can decrease the extensive labor cost of identification, separation, and treatment of sick calves. In addition, the improvement in daily gains from mass medication of cattle in receiving lots shall benefit them as they enter the next stage of production.

Animals, No.	106	101	105	156	156
Sex	Male	Female	Male		
Arrival wt, lb	454	457	446	451	454
Final wt, lb	477.94	471.99	471.07	469.13	477.04
Morbidity, %					

[a]Expressed as least squares means.
[b,c]Treatment means on same line with different superscripts differ P<.01.
[d,e]Pasture means on same line with different superscripts differ P<.01.

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EVALUATION OF WHEAT FORAGE IN WINTERING PROGRAMS FOR COW CALF OPERATIONS

K.L. Apple[1], K.S. Lusby[2], A.L. Hutson[3] and G.M. Provence[4]

Story in Brief

One hundred and sixty two Hereford and Hereford x Angus calves were used to compare (1) alternate day grazing of cows on wheat pasture, (2) dry wintering of cows on dormant bermuda/native pasture with calves having continuous access to wheat pasture, or (3) cows wintered the same as for Treatment 2 but calves fed dry creep feed limited to 2 lb/day. After removal from wheat pasture on March 8, all cattle were maintained on native range until weaning in July. Calves from Treatment 1 cows gained faster during the wheat pasture phase than calves from other treatments. Gains were similar for calves creep grazed on wheat and calves fed limited creep. Calves creep grazed on wheat forage gained less than calves from the other groups when removed from wheat pasture and grazed on native range until weaning. Treatment 1 had a $56.13 per cow advantage over Treatment 2 and a $45.34 per cow advantage over Treatment 3 when wintering costs and value of additional weaning weights were combined. Data from the first year of this study suggest that alternate day grazing of cows and permitting free access of their calves to wheat can be an economical method of wintering a cow herd.

(Key Words: Wheat Pasture, Beef Cows, Creep Feed, Winter.)

Introduction

Wheat pasture has long been recognized as an extremely high quality forage that will support rapid gain (1.5-2 lb/day) in stocker calves. It has been assumed that beef cows, having large daily forage intakes and lower nutrient requirements on a percentage basis, would waste much of the nutrient content of wheat forage if permitted to graze wheat pasture full time. As a result, programs such as limit-grazing of cows on wheat forage one day in two or three or only allowing calves access to wheat forage through creep gates have been suggested to improve efficiency of wheat

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forage utilization by cows. Unfortunately, many of these recommendations are not backed by controlled research. The objective of this study was to compare traditional wintering of fall calving cows and their calves on dormant native range with protein supplementation to alternate day grazing of wheat pasture or traditional wintering of cows with calves permitted access to wheat forage through creep gates.

Materials and Methods

One hundred and sixty two Hereford and Hereford x Angus calves were used to compare three wintering treatments. The study was conducted on a ranch near Duncan in south central Oklahoma. Cows calved from early September to late October. Treatments were: 1) cows alternately grazed one day on wheat pasture and one day on an adjacent dormant dry bermuda native pasture with free choice wheat straw in round bales. Calves of these cows had continuous access to wheat via creep gates; 2) cows were wintered on dormant bermuda native pasture and fed 4 lb/day of a 39% crude protein supplement. Calves had continuous access to wheat pasture via creep gates; and 3) cows were wintered the same as for Treatment 2 but calves had access to a creep ration fed in conventional creep feeders. The creep ration consisted of 65% corn, 30% soybean meal, 4% salt and 1% limestone. The salt was added to limit intake to a target level of 2 lb/day.

Cows were randomly allotted to treatments on September 1, before calving. Cows were then grazed on three similar native grass pastures during the calving season until the beginning of the study on November 13. Cows and calves were gathered off pasture and calves were individually identified with an ear tag, and weighed unshrunk on November 13, 1989. Cows were not weighed. Steer calves were implanted with Synovex C® (Syntex) on November 13 and again on March 8. All cattle were maintained on their respective treatment regimens until March 8, 1990 when calves were again weighed unshrunk. From March 8 until calves were weighed at weaning on July 10, all cattle were grazed together on native range.

Data were analyzed using the GLM procedure of SAS (1985). The final model included treatment, calf breed, calf sex, initial calf weight and two way interactions. Differences between treatment means were detected by LSD test.

Results and Discussion

Calves weighed about 165 lb at the start of the study on November 13 (Table 1). Although not individually weighed or scored for condition, cows

Table 1. Performance of calves wintered on wheat, creep grazed on wheat or wintered on dry grass with limit-fed creep.

	Treatments		
Cows	1 Wheat pasture alternate days	2 Native range	3 Native range
Calves	Wheat pasture continuous	Wheat pasture continuous	limit fed creep
No. of pairs	58	54	50
Calf wt, lb			
11/13/89	166	164	157
3/08/90	398[a]	369[b]	356[b]
7/10/90	582[a]	535[b]	546[b]
Calf daily gain, lb			
11/13/89 to 3/08/90	2.02[a]	1.79[b]	1.73[b]
3/08/90 to 7/10/90	1.50[a]	1.35[b]	1.54[a]
11/13/89 to 7/10/90	1.75[a]	1.56[b]	1.63[b]
Winter costs - 11/13/89 to 3/08/90, $[l]			
Native pasture	7.00[c]	26.66[f]	26.66[f]
Wheat straw, 80 bales	11.60[d]	--	--
Wheat pasture	60.00[e]	15.00[g]	--
39% Supplement	--	50.60[h]	50.60[h]
Creep feed	--	--	21.20[i]
Total winter cost, $	78.60	92.26	98.46
Additional wt gain, lb			
11/13 to 7/10[j]	45	0	18
Value of additional gain,[k] $	42.47	0	16.99

[a,b] Means on a line with different superscript letters differ (P<.05).
[c] Native pasture @ $10/acre, 1/2 time use.
[d] Wheat straw @ $10/bale.
[e] Wheat pasture @ $60/acre.
[f] Native pasture - 10 acres/cow @ $8/acre, 1/3 time use.
[g] 4 calves/acres @ $60/acre.
[h] 39% protein supplement @ $220/ton.
[i] Creep feed - 231 lb/calf @ $183/ton.
[j] Computed from lowest treatment to highest treatment.
[k] Average 500-600 lb steer and heifer price, medium frame #1, July, 1990, for Oklahoma City market.
[l] Winter maintenance costs based on original cow numbers carried throughout the trial. Performance figures exclude any calf losing an I.D. tag.

were estimated by trained observers to be in an average condition score of 5. The winter of 1989-90 was remarkable because of a period of extreme cold in late December, mild weather from January to March, and extremely cool temperatures in April and May. Wheat pasture was ample throughout the period of November 13 to March 8. However, native forage was very limited from March to June because of abnormally cool spring temperatures and record low rainfall in June.

As expected, calves from cows grazed alternate days on wheat pasture (Treatment 1) gained significantly faster during the winter wheat pasture phase than calves from the other treatments. Gains were similar for calves creep grazed on wheat and calves fed salt limited creep. Average daily intake of the limit fed creep was 2.01 lb/head/day. By March, Treatment 1 cows which grazed alternate days on wheat pasture had estimated body condition scores of 6 compared to 5 for Treatment 2 and 3 cows which grazed dormant forage. Based on observations of grazing behavior and wheat straw consumption, Treatment 1 cows apparently obtained a large proportion of their total intake from wheat pasture and consumed a minimal amount of low quality straw on alternate days off wheat pasture. However, even with alternate days on wheat straw, Treatment 1 cows wintered in greater body condition than was probably necessary for good milk production and reproduction.

Cows and calves were removed from wheat pasture in March because this procedure permitted grain to be harvested. An important finding in this study was that Treatment 2 calves, creep grazed on wheat forage, gained less ($P<.05$) than calves from the other groups when removed from wheat pasture and grazed on native range until weaning. It is likely that calves accustomed to free access to wheat forage found the native range much less palatable, particularly in late winter. We are not aware that this has been previously reported. If repeatable, poor calf performance after a change from wheat forage to lower quality forage would significantly affect the application and economics of creep grazing. During the period between removal from wheat pasture until weaning, calves previously fed salt limited creep on dry grass had similar gains as Treatment 1 calves. It is possible that limit fed creep calves were accustomed to consuming native forage and continued to do so after removal of the creep. Even if Treatment 1 calves consumed less native forage after removal from wheat pasture, it is likely that milk production of Treatment 1 cows was greater (based on higher body condition) than for Treatment 2 and 3 cows wintered on dry grass and protein supplements.

Wintering costs and weaning weights (Table 1) were improved with Treatment 1 compared to other treatments. Treatment 1 had a $56.13 per cow advantage over Treatment 2 and a $45.34 per cow advantage over Treatment 3 when wintering costs and value of additional weaning weights

were combined. The cost of wheat pasture was more than offset by the increased pasture requirements and supplement costs for wintering on native range. Treatment 3 improved marginal returns by $10.79 compared to Treatment 2 by increasing weaning weights, even though wintering costs were higher. The producer must realize that the decision must be evaluated each year based on expected calf prices and wintering costs. With only one year of data, it appears that returns can be increased for the cow-calf producer who has wheat pasture available as a winter feed source for cows and calves.

There are other issues that need to be addressed when using wheat pasture for wintering the cow herd. Although rebreeding performance was not evaluated in this study, less than 6% of cows failed to calve the following fall, suggesting that rebreeding efficiency was high for all treatment groups. Data from the first year of this study suggest that alternate day grazing of cows and permitting free access of their calves to wheat can be an economical method of wintering a cow herd.

CORN VS SOYBEAN HULL SUPPLEMENTS FOR BEEF COWS FED LOW QUALITY NATIVE GRASS HAY

W.W. Chan[1], C.A. Hibberd[2], R.R. Scott[1]
and K. Swenson[3]

Story in Brief

Five mature beef cows were supplemented with two levels of corn or soybean hulls to compare the effect of starch vs digestible fiber feeds on intake and site of digestion of low quality native grass hay. Cows had free choice access to coarsely chopped native grass hay (4.6% CP, 81.1% NDF). Supplements given daily included a control (.41 lb mineral plus molasses), low corn (3.3 lb corn), high corn (6.6 lb corn), low soybean hulls (3.3 lb soybean hulls) and high soybean hulls (6.6 lb soybean hulls). Compared to corn, soybean hull supplementation tended to increase hay OM intake. Compared to low corn, other treatments increased total tract OM disappearance. Ruminal and total tract NDF disappearance (lb/day) increased with soybean hull supplementation. Ruminal pH and ammonia concentrations generally were higher for soybean hulls than corn. Although TDN is much greater for corn than for soybean hulls (91 vs 64%), this study suggests that these supplements had similar effects on total energy intake.

(Key Words: Corn, Soybean Hulls, Grass Hay, Intake, Digestibility.)

Introduction

Beef cows grazing native range in winter require supplementation to meet their energy and protein requirements. Supplementation becomes more critical when environmental and physiological stresses also are considered. Energy supplementation may be necessary to reduce cow body weight loss and maintain an adequate calf growth rate. Supplements containing high levels of cereal grain decrease forage intake and digestibility due to the effects of starch (Chase and Hibberd, 1987). Under such circumstances, total energy intake of cows may not be increased.

High fiber feeds such as soybean hulls, being devoid of starch, may enhance forage utilization (Martin and Hibberd, 1990). Although performance

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studies suggest that soybean hulls are an effective alternative to corn (Trautman, 1987), few studies have compared soybean hulls with corn on the site and extent of digestion of low quality native grass hay. The objective of this study was to compare corn with soybean hull-based supplements on intake and on site and extent of digestion of low quality native grass hay by nonpregnant, nonlactating beef cows.

Materials and Methods

Five mature, nonpregnant Limousin x Hereford x Angus cows (average weight, 1,195 lb), each fitted with permanent ruminal, duodenal and ileal cannulas were allocated randomly to five treatments in a 5 x 5 latin square. Low quality native grass hay chopped through a 2-inch screen and fresh water were supplied free choice. Supplements included a control (minerals only) and two levels (3.3 or 6.6 lb) of either corn or soybean hulls with soybean meal added to provide a total of 1.35 lb supplemental crude protein/day (Table 1).

Twenty-one day experimental periods included 14 days of adaptation and 7 days of sampling. Quantities of hay offered and refused were recorded and sampled on days 16 through 19. Duodenal, ileal and fecal samples were collected eight times during days 16 through 19 to represent every three hours of a 24-hour day. Hay, hay refusal, supplement and digesta samples were analyzed for dry matter, ash, acid-insoluble ash, and neutral detergent fiber. Ruminal fluid was sampled on day 20 at 0, 2, 4, 6, 9, 12, 18 and 24 hour after supplement was fed. Ruminal pH was determined immediately. Ruminal samples were acidified and frozen for later ammonia analysis. Organic matter and NDF flows and digestibilities were calculated from acid-insoluble ash ratios in feed and digesta.

Intake, flow and digestibility data were subjected to least squares analysis of variance with period, animal, source (corn vs soybean hulls), level (3.3 vs 6.6 lb) and source x level included in the model. Orthogonal contrasts were designed to test: 1) Control, control vs all supplements, 2) Source, corn vs soybean hulls, 3) Level, 3.3 vs 6.6 lb/day, and 4) Source x Level interaction. If the source x level interaction was significant, differences among treatment means were detected by LSD. Ruminal data were analyzed by least squares with period, treatment, animal and hour included in the model.

Results and Discussion

Hay OM intake was increased (P=.006) by supplementation (Table 2). Although not significantly affected by level or source of supplement, hay OM intake tended (P=.13) to be higher with soybean hulls than with corn. In

Table 1. Supplement composition and nutrient supply.

	Control	Supplement			
		Low corn	High corn	Low SBH	High SBH
Supplement composition, % (DM basis)					
Corn		60.95	80.84		
Soybean hulls				62.55	83.66
Soybean meal		31.57	13.26	29.73	10.15
Dicalcium phosphate	32.12	2.28	1.51	2.34	1.56
Trace mineralized salt	25.81	1.83	1.21	1.88	1.25
Molasses	41.29	3.01	3.02	3.00	3.01
Sodium sulfate		.3	.12	.45	.32
Vitamin A (30,000 IU/g)	.79	.06	.04	.06	.04
Supplement intake, lb/day					
Dry matter[a]	.40	6.13	9.29	5.89	8.80
Corn		3.30	6.60		
Soybean hulls				3.30	6.60
Nutrient supply, lb/day					
Crude protein[a]	.00	1.33	1.34	1.36	1.39
TDN[b]	.11	4.56	7.10	3.55	5.07
Starch[c]		2.14	4.29		

[a] Actual analysis.
[b] Estimated from NRC, 1984.
[c] Starch content of corn estimated to be 65%.

Table 2. Organic matter (OM) and NDF intake, flow and digestion in beef cows fed low quality native grass hay supplemented with corn or soybean hulls.

		Corn		Soybean hulls			Probability[a]			
Item	Control	Low	High	Low	High	SE	Control	Source	Level	S x L
Intake, lb/day										
Supplement OM	.04	5.01	7.75	4.85	7.36					
Hay OM	12.04	14.68	14.23	16.74	14.83	.82	.006	.13	.18	.39
Total OM	12.08	19.69	21.98	21.59	22.19	.82	.006	.13	.18	.39
Total NDF	11.56	14.77	14.49	18.21	18.51	.76	.0001	.0004	.99	.71
Ruminal disappearance, lb/day										
OM[b]	5.01	9.74	11.19	11.39	11.76	.62	.0001	.10	.17	.40
NDF	7.01	9.20	8.77	12.18	12.55	.54	.0001	.0001	.96	.48
Ruminal digestibility, % of intake										
OM[b]	41.02	49.29	51.26	53.38	53.59	2.52	.002	.23	.67	.73
NDF	60.47	61.74	60.65	67.44	68.15	1.94	.09	.005	.92	.65
Total tract disappearance, lb/day										
OM	5.75[c]	11.31[d]	13.34[e]	12.55[de]	12.94[e]	.45	.0001	.37	.02	.09
NDF	6.98	8.94	8.63	11.97	12.22	.50	.0001	.0001	.96	.59
Total tract digestibility, % of intake										
OM	46.71	58.12	61.18	58.76	58.77	2.67	.001	.75	.58	.58
NDF	59.58	60.40	59.80	66.31	66.19	2.48	.22	.03	.89	.92

[a] Probability levels for orthogonal contrasts: Control = Control vs all Supplements, Source = Corn vs Soybean hulls, Level = 3.3 vs 6.6 lb/day, S x L = Source x Level interaction.

[b] OM disapperance uncorrected for microbial OM.

[c,d,e] Means within the same row with different superscripts differ ($P < .05$).

addition, compared to 3.3 lb/day, 6.6 lb/day tended (P=.18) to decrease hay OM intake.

Ruminal and total tract OM digestibilities (%) were not affected (P>.5) by source or level of supplement (Table 2). Ruminal OM disappearance (lb/day) tended to be higher (P=.10) with soybean hulls than with corn. In addition, 6.6 lb/day of supplement tended (P=.17) to increase ruminal OM disappearance. Level of supplementation had a greater effect on total tract OM disappearance with corn than soybean hulls (Source x Level, P=.09). Total tract OM disappearance was significantly higher for 6.6 than 3.3 lb/day of corn suggesting that feeding additional corn had a positive influence on energy intake. Total tract OM disappearance for both levels of soybean hulls were intermediate and not different (P>.05) from 6.6 lb corn. The TDN value is reported to be higher for corn than for soybean hulls (91 vs 64%). This difference in supplemental TDN was not reflected in total tract OM disappearance suggesting that the energy content of these two feeds is not as different as TDN values would suggest when used as components of a range supplement.

Compared to corn, soybean hulls increased (P=.03) ruminal and total tract NDF digestibility (%, Table 2). Soybean hulls increased (P<.0001) NDF disappearance (lb/day) both in the rumen and in the total tract. Corn supplementation has been suggested to reduce NDF digestion but differences in NDF digestibility between the control and corn supplements were not detected in this study suggesting that added starch did not reduce NDF digestion. Because soybean hulls contain a high concentration of unlignified NDF, the increased NDF digestion may be attributable to increased digestible NDF intake rather than negative associative effects.

Treatment differences in ruminal pH were dependent on sampling time (treatment x sampling time, P=.06, Figure 1). Ruminal pH was higher (P=.0001) for the control than for the mean of the other supplements at each sampling time. With soybean hull supplements, ruminal pH was lowest at 2 hour after feeding whereas the lowest pH with corn supplements was observed later (4 to 6 hour after feeding). Compared to soybean hulls, corn supplementation decreased ruminal pH at 4 (P=.005), 6 (P=.04), 9 (P=.03) and 24 (P=.03) hour postsupplementation. The higher supplement level (6.6 vs 3.3 lb/day) reduced (P=.01) ruminal pH only for the 18 hour sample.

Supplementation increased (P<.04) ruminal ammonia concentrations at all sampling times except at 9 hour (Figure 2). Compared to corn, soybean hulls increased ruminal ammonia at 2 (P=.05), 4 (P=.005) and 6 (P=.08) hour postfeeding. In addition to decreased ruminal pH, reduced ruminal ammonia concentrations with corn supplements may also contribute to decreased NDF digestion. Compared to 6.6 lb/day, feeding 3.3 lb/day resulted in higher ruminal ammonia at 2 (P=.05), 6 (P=.16), 9 (P=.006), 12 (P=.01) and 18 (P=.01) hour postsupplementation. Because the 3.3 lb/day

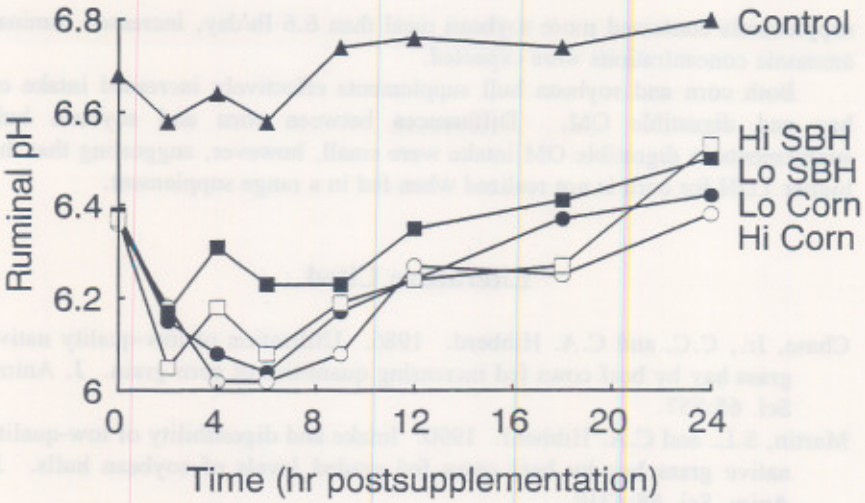


Figure 1. Changes in ruminal pH in beef cows fed low quality native grass hay supplemented with soybean hulls or corn.

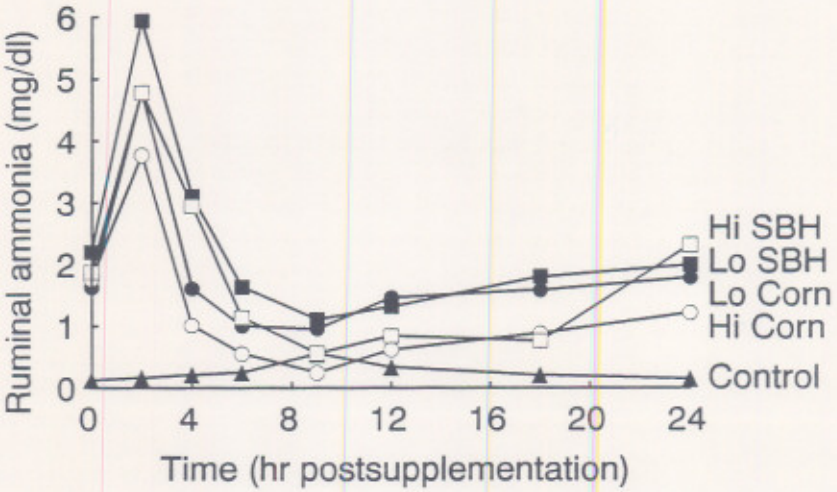


Figure 2. Changes in ruminal ammonia concentrations in beef cows fed low quality native grass hay supplemented with soybean hulls or corn.

supplements contained more soybean meal than 6.6 lb/day, increased ruminal ammonia concentrations were expected.

Both corn and soybean hull supplements effectively increased intake of hay and digestible OM. Differences between corn and soybean hull supplements in digestible OM intake were small, however, suggesting that the higher TDN for corn is not realized when fed in a range supplement.

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IN SITU DRY MATTER AND PROTEIN DISAPPEARANCE OF FEEDS IN BEEF COWS FED CONCENTRATE OR ROUGHAGE DIETS

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Story in Brief

The in situ technique was used to determine the effect of diet (80% concentrate vs roughage) on ruminal dry matter and protein degradability. Twelve feeds (3 cereal grains, 6 protein feeds and 3 roughage feeds) were ruminally incubated for 16 hours. Both dry matter and crude protein disappearance were lower for most feeds when incubated in the roughage-fed cow. The ranking of cereal grains and protein feeds was generally similar for both diets. For example, blood meal, feather meal and corn gluten meal had the lowest protein degradation of all protein feeds on both the concentrate and roughage diets. This study illustrates that the ruminal degradation of feeds is dependent on diet. Consequently, diet must be considered when formulating diets on the basis of ruminally degraded protein.

(Key Words: In Situ, Ruminal Degradable Protein, Concentrate, Roughage.)

Introduction

In addition to the total protein content of a feed, protein characteristics such as ruminal protein degradation are becoming more important. For example, range supplements must contain adequate quantities of ruminally degraded protein to stimulate fermentation of forage. If feeds high in bypass protein are used in range supplements, ruminal microbes may be starved for nitrogen. Under these conditions, forage fermentation and microbial protein synthesis may decline.

Ruminal degradation of feed protein varies widely among different feedstuffs. In addition, diet may alter ruminal protein degradation. Consequently, the objective of this study was to measure in situ dry matter and protein disappearance of selected feeds in beef cows fed concentrate or roughage diets.

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Materials and Methods

Two ruminally cannulated, mature crossbred beef cows were fed either a concentrate (Table 1) or a hay diet. The hay diet consisted of free choice, low quality native grass hay (4.5% CP) supplemented with 2 lb of a 40% CP supplement per day.

Feeds included cereal grains (wheat, corn, milo), protein feeds (soybean meal, cottonseed meal, whole cottonseeds, corn gluten meal, blood meal, feather meal) and roughage feeds (alfalfa hay, wheat midds, soybean hulls). Feeds were procured from the OSU Feedmill or from samples taken from various research projects. All feeds were ground through a 1-mm screen. Duplicate samples (.5 g) were placed in 2 x 4 inch dacron bags. These bags were tied in random order onto weighted strings. Bags were placed in the rumen of each cow for a 16 hour incubation period. Duplicate bags without sample were incubated in each cow. After incubation, the bags were removed and rinsed in lukewarm water. Bags then were washed by rotating between two large buckets of clean, lukewarm water until the wash water remained clear. The bags were removed from the strings, washed and dried at 105^{o} C for 24 hours. Kjeldahl protein content of the original feeds and of each bag was analyzed to calculate protein disappearance.

Feeds were grouped into classes of cereal grains, protein feeds and roughage feeds for statistical analysis. Data were subjected to least squares analysis of variance with feed class, diet and feed class x diet included in the model.

Table 1. Composition of concentrate diet.

Feed	% (as-is)
Sorghum grain, dry rolled	62.75
Cottonseed hulls	14.00
Soybean meal	10.00
Alfalfa, dehydrated	6.00
Cane molasses	5.00
Salt	.50
Limestone	.50
Dicalcium phosphate	.50
Aurofac-10	.15
Ammonium chloride	.50
Urea	.10

Results and Discussion

The protein content of the feeds used in this study (Table 2) generally was similar to reported values (NRC, 1982). The major discrepancy was noted for corn. The analyzed protein content of corn (8.86%) is typical of corn fed in Oklahoma during certain years.

In situ dry matter disappearance of two of three cereal grains, four of six protein feeds and two of four roughage feeds was higher for the cow fed the concentrate than the cow fed the roughage diet (Table 3). Ruminal microorganisms are probably more active on a concentrate diet and would be expected to ferment feeds more thoroughly. A significant feed class x diet interaction was observed, however, suggesting that the difference between diets was dependent on feed source. Within cereal grains, the difference due to diet was much greater for corn and sorghum grain compared to wheat. Both corn and sorghum grain contain protein that is known to be degraded less in the rumen than wheat protein. Perhaps protein shielding of starch granules was more limiting in corn and sorghum grain than in wheat. Within protein feeds, DM disappearance was lower on the roughage diet than on the concentrate except for whole cottonseed. Regardless of diet, feeds known to be slowly degraded in the rumen (blood meal, feather meal and corn gluten meal) were degraded to a lesser extent at 16 hours than feeds known to have greater ruminal degradation (soybean meal, cottonseed meal, whole cottonseeds).

Table 2. Protein content of feeds.

	Actual analysis	NRC (1982)
	----------% (DM basis)----------	
Cereal grains:		
Corn	8.86	10.9
Sorghum grain	12.24	12.4
Wheat	14.25	14.4
Protein feeds:		
Blood meal	94.14	93.3
Feather meal	87.86	91.3
Corn gluten meal	68.14	67.2
Soybean meal	48.80	49.9
Cottonseed meal	43.41	45.2
Whole cottonseeds	24.05	23.9
Roughage feeds:		
Alfalfa hay	21.77	19.0
Soybean hulls	14.40	12.1
Wheat midds	17.98	17.2

Table 3. Dry matter disappearance from dacron bags of selected feeds incubated in beef cows fed concentrate or roughage diets.

	Concentrate	Roughage
Cereal grains:[a]		
Corn[b]	84.8	38.8
Sorghum grain[b]	72.2	37.4
Wheat	89.8	86.6
Mean	82.3	54.3
Protein feeds:[a]		
Blood meal[b]	22.7	2.8
Feather meal	8.9	8.5
Corn gluten meal[b]	36.0	16.8
Soybean meal[b]	76.6	52.7
Cottonseed meal	50.5	48.4
Whole cottonseeds[b]	50.0	58.5
Mean	40.8	31.3
Roughage feeds:[a]		
Alfalfa hay[b]	51.1	55.9
Soybean hulls[b]	50.2	43.2
Wheat midds	72.2	70.8
Mean	57.8	56.6

[a] Feed x diet interaction ($P<.05$).
[b] Effect of diet ($P<.05$).

Protein disappearance from dacron bags was higher on the concentrate than roughage diet for all feeds except for whole cottonseed and alfalfa hay (Table 4). Within cereal grains, the rank in protein disappearance (wheat > corn > sorghum grain) was similar to DM disappearance. On the concentrate diet, blood meal, feather meal and corn gluten meal were degraded to a lesser extent than soybean meal and whole cottonseeds. On the roughage diet, rankings were similar although the protein degradation of soybean meal was extremely low (34%). Protein degradation of whole cottonseeds was increased on the roughage diet. Within roughage feeds, the roughage diet resulted in increased protein disappearance from alfalfa hay but it decreased protein disappearance from soybean hulls and wheat midds. The protein disappearance of all roughage feeds was extremely high on both diets suggesting that a major portion of their protein is degraded in the rumen.

Diet has an effect on ruminal dry matter and crude protein disappearance from feeds. These differences are important when formulating range supplements because feed selection will affect the quantity of ruminally degraded protein in a supplement which may affect ruminal fermentation of

Table 4. Protein disappearance from dacron bags of selected feeds incubated in beef cows fed concentrate or roughage diets.

	Concentrate	Roughage
Cereal grains:[a]		
Corn[b]	97.0	50.0
Sorghum grain[b]	74.1	36.7
Wheat[b]	104.5	84.0
Mean	91.9	56.9
Protein feeds:[a]		
Blood meal[b]	28.7	16.5
Feather meal	12.7	11.7
Corn gluten meal[b]	24.0	12.4
Soybean meal[b]	71.8	34.1
Cottonseed meal	57.1	50.4
Whole cottonseeds	88.6	93.4
Mean	47.1	36.4
Roughage feeds:[a]		
Alfalfa hay[b]	68.3	74.7
Soybean hulls[b]	75.3	65.4
Wheat midds[b]	98.1	84.0
Mean	79.9	74.7

[a] Feed x diet interaction ($P<.05$).
[b] Effect of diet ($P<.05$).

forage (Scott and Hibberd, 1990). In addition, including bypass proteins such as blood meal, feather meal and corn gluten meal in supplements may alter the quantity and quality of amino acid flow to the small intestine. This study suggests that the ruminal protein degradation of feeds should be determined with the diet that will be used.

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FEATHER MEAL IN WINTER SUPPLEMENTS FOR BEEF COWS

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Story in Brief

Seventy six spring calving and 65 fall calving Hereford and Hereford x Angus cows were blocked by age, breed, and weight within calving season and allotted to four groups to compare performance when 7.5 or 15% hydrolyzed feather meal replaced isonitrogenous amounts of soybean meal in winter supplements. Cows were maintained by calving group on native range and individually fed supplements in covered stalls 6 days/week. The supplementation period for spring calving cows was November 14 to April 17 and for fall calving cows was November 28 to March 20. Supplements, CP% and pounds CP/day were: (1) Negative control 23% CP, .69 pounds; (2) Soybean meal, 40% CP, 1.2 pounds; (3) 7.5% feather meal, 40% CP 1.2 pounds and (4) 15% feather meal, 40% CP 1.2 pounds. For spring calving cows, weight losses precalving and for the total winter period were less for soybean meal cows than for negative control cows. Precalving weight gains were similar for 15% feather meal and soybean meal. Cows fed 7.5% feather meal tended to gain less weight precalving compared to cows fed soybean meal or 15% feather meal. Fall calving cows fed feather meal tended to lose less weight than soybean meal fed cows when hay was fed but lost more weight when hay was not provided. Five percent of spring calving cows offered 7.5% feather meal and 10.5% of cows offered 15% feather meal refused to eat supplement and were removed from the study. Feather meal may be more appropriate for supplementing on hay than on dormant range.

(Key Words: Feather Meal, Soybean Meal, Protein, Beef Cow Supplements.)

Introduction

Hydrolyzed feather meal is a byproduct of the poultry industry. The American Association of Feed Control Officials in 1965 defined it as "the product resulting from the treatment under pressure of clean undecomposed

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feathers from slaughtered poultry, free of additives and/or accelerators. Not less than 75% of its crude protein shall consist of digestible protein by the pepsin digestibility method". The crude protein content of feather meal (FM) ranges from 80 to 90%, however most of this protein is undegradable within the rumen thus FM is considered a bypass or escape protein. Large variations exist in the quality of FM between sources. These variations are due to the processing techniques used and the amounts of blood and offal contained in the meal. The objective of this study was to evaluate the performance of spring and fall calving beef cows grazing dormant native range and receiving protein supplements containing FM.

Materials and Methods

The value of FM as a supplemental protein source for beef cows grazing winter range was evaluated in two trials. Supplements, CP% and lb CP/day were: 1) Negative control (NC), 23% CP, .69 lb; 2) Soybean meal (SBM), 40% CP, 1.2 lb; 3) 7.5% FM, 40% CP, 1.2 lb; and 4) 15% FM, 40% CP 1.2 lb. Supplements provided equal amounts of calcium, phosphorus, potassium, and Vitamin A. Complete supplement formulations are given in Table 1. Cows in each trial were maintained in the same pasture for the entire supplementation period. The trials were conducted at the Lake Carl Blackwell Range Cow Research Center approximately 12 miles west of Stillwater, OK. All cows were wintered on dormant standing range forage (2.5% CP) with big bluestem, little bluestem, indiangrass and switchgrass as the predominant species. Cows were gathered off pasture 6 day/week and individually fed 3 lb of pelleted supplement (3/16 in) in a covered stall barn.

Trial 1

Seventy-six spring calving Hereford and Hereford x Angus cows were fed protein supplements from November 14, 1989 until April 17, 1990. During the supplementation period cows were given access to prairie hay (6% CP) when snow or ice covered the ground or when extreme cold was encountered (29 days).

Cow weights were taken after overnight withdrawal from feed and water every 28 days until two weeks prior to the first expected parturition date (avg date March 5). Weights of cows and calves were then taken every 14 days until the end of supplementation. The closest weight prior to parturition was recorded as the final pregnant weight.

Cow body condition scores (BCS) were evaluated (score of 1 = very thin to 9 = very fat) every 56 days. After the end of the supplementation period, cow and calf weights were collected every 28 days until weaning

Table 1. Composition of supplements and daily feeding rates (DM basis) used in Trials 1 and 2.

			FM	
	NC	SBM	7.5%	15%
Ingredients, %				
Soybean meal	43.32	90.08	73.59	58.35
Feather meal			7.50	15.00
Milo	48.32	3.98	12.11	19.03
Molasses	4.19	4.18	4.19	4.21
Dicalcium phosphate	2.50	1.75	1.95	2.32
Potassium chloride	1.62		.56	1.07
Vitamin A[a]	.1	.1	.1	.1
CP, %	26.32	44.87	44.74	44.71
Feeding rates[b] lb/day	3.0	3.0	3.0	3.0
Daily CP supplied, lb	.69	1.2	1.2	1.2

[a]30,000 IU/g.
[b]7 day basis expressed as is.

(September 5) and cow BCS were taken every 56 days. On May 5, three Hereford x Angus bulls were placed with all cows for 74 days and pregnancy was determined by rectal palpation on October 18.

Estimates of milk production were obtained using the weigh suckle weigh technique on May 22 and July 17. Cows and calves were separated for two 12 hour periods. Calves were weighed, allowed to nurse until satisfied, then reweighed to determine pounds of milk produced per 12 hour period.

Trial 2

In the second study, 65 two to six year old Hereford and Hereford x Angus fall calving cows were fed protein supplements from November 28 to March 20. The average calving date for the fall calving cows was September 17. Cows and calves were weighed every 28 days and cow BCS was evaluated every 56 days for the entire supplementation period.

Ad libitum access to prairie hay (6% CP) was given from December 6 until January 15 and also in February and March when snow and ice cover restricted grazing or when extremely cold temperatures occurred.

Cows were bred by natural service from November 27 to February 1. Pregnancy was determined by rectal palpation on April 26. Date of conception was estimated by subtraction of 280 days from the subequent calving date.

A milk production estimate was conducted as described in Trial 1 on March 20. All calves were weaned from the cows on May 1.

Results and Discussion

Trial 1

Palatability problems were experienced and 1 out of 19 of the spring calving cows receiving 7.5% FM and 2 out of 19 of those receiving 15% FM refused to eat supplements. One cow in the 15% FM group which refused to eat would only smell the supplement. This suggests that an odor is detectable even when a small percentage of FM is included. All cows were given two weeks to become accustomed to protein supplements and the feeding program. After this period the cows refusing to eat were given access to the SBM supplement to determine if feed refusals were because of protein source or if it was an environmental effect due to feeding in individual stalls. All cows that refused FM readily accepted the SBM supplement so it was determined that refusals were the result of the FM additions.

Cows consuming the NC supplement lost significantly more weight (Table 2) to calving than did the SBM or 15% FM supplemented cows. Weight changes for the 7.5% FM group tended to be less ($P<.16$) than the NC group but were not statistically different than either the SBM or 15% FM supplemented cows. During the lactational phase of the trial, weight changes were not statistically different between supplemental groups.

For the entire winter supplementation period the NC cows lost significantly more weight than did the SBM group. The weight changes of the FM supplemented cows tended to be less than the NC cows ($P<.15$ and $P<.22$ for the 7.5% and 15% groups respectively). Cows fed FM and SBM performed similarly.

Rebreeding rates of cows were not statistically different between treatment groups. However, pregnancy rates ranged from 86 to 77% and were the least for the cows receiving FM.

Cow BCS changes tended to reflect cow weight changes during the pre and post calving periods. Milk production, calf birth weights, weaning weights and gains were not affected by the supplement fed to cows (Table 3).

Table 2. Weight and body condition changes and pregnancy rates of spring calving cows in Trial 1 (least squares means).

			FM	
	NC	SBM	7.5%	15%
Number of Cows				
Initial	19	19	19	19
Final	17	19	17	16
Initial Weight, lb				
11/14/89	1009	1012	1011	1007
Initial condition score	5.96	5.94	6.00	5.91
Precalving:				
Weight change, lb				
11/14/89 to calving	-10.3[a]	20[b]	9.8[ab]	18.5[b]
Condition change				
11/14/89 to calving	-.64	-.45	-.49	-.48
Postcalving:				
Weight change, lb				
Calving - 4/17/90	-141	-136	-139	-150
Condition change				
Calving - 4/17/90	-1.14[a]	-.83[b]	-1.01[ab]	-1.13[ab]
Winter weight change, lb				
11/14/89 - 4/17/90	-152[a]	-117[b]	-130[ab]	-132[ab]
Condition change				
11/14/89 - 4/17/90	-1.55[a]	-1.12[b]	-1.30[ab]	-1.33[ab]
Pregnancy rates %[c]	84	86	82	77

[a,b]Means on the same line with the same superscript do not differ significantly ($P < .05$).

[c]Includes data only from cows weaning a calf.

Table 3. Calf birth weights, weaning weights, gains and milk production of cows, Trials 1 and 2 (least squares means).

	NC	SBM	FM 7.5%	FM 15%
Trial 1				
Spring calving cows				
Calf				
Birth weight, lb	84.4	87.4	86.5	87.1
Gains, lbs				
Birth to 4/17/90	61.2	64.5	58.9	64.8
4/18/90 - 9/5/90	294.9	284.2	285.0	289.0
Weaning weight, lb	440.5	436.1	430.4	440.9
Cow				
Milk production, lb				
5/22/90	17.1	16.8	17.0	20.0
7/17/90	13.8	12.3	11.5	13.5
Trial 2				
Fall calving cows				
Calf				
Initial weight, lb	173.7	173.6	173.7	173.6
Gains, lbs				
11/28/89 to 3/20/90	92.4	100.2	88.3	101.6
3/21/90 - 5/01/90	48.4	43.8	47.9	48.7
Weaning weight, lbs	314.5	317.6	309.9	323.9
Cow				
Milk production, lb				
3/20/90	5.9	5.5	6.4	5.8

Trial 2

Fall calving cows fed NC lost significantly more weight while ad libitum access to hay was provided than did cows receiving either of the FM supplements and tended to lose more weight (Table 4) than the SBM fed cows ($P < .12$). Cows receiving 15% and 7.5% FM tended to gain faster than the SBM fed cows during this period ($P < .16$ and $P < .24$, respectively).

During the second period of this trial, when ad libitum access to hay was no longer provided, the SBM supplemented cows lost significantly less weight than cows fed any other supplement group. The weight changes for the 7.5% FM group tended to be less than the NC group ($P < .12$).

Total weight loss for the entire winter supplementation period was greatest for the NC supplemented cows. Thus protein was a limiting factor in the diet. Weight loss tended ($P < .07$) to be greater for the 15% FM than for the SBM supplemented cows. Weight loss for cows fed 7.5% FM was not different than that for cows fed 15% FM.

Rebreeding rates ranged from 99% to 70%. As in the first trial, type of protein supplement did not significantly influence cow rebreeding. However, mean pregnancy rates reflect the weight changes observed, with the cows losing the most weight having the lowest pregnancy rates.

Similar to the first trial, treatment did not affect calf weaning weight, gain or cow milk production (Table 4). Although treatment did not significaltly influence BCS, the BCS reflected weight losses that occurred during each period.

It is possible that supplements containing FM had too much protein bypass the rumen with insufficient nitrogen for ruminal needs. The FM used in these studies was only 61% pepsin digestible, suggesting that much of the bypass protein may have been indigestible. Variability between batches of FM may be an important factor in determining utilization.

Based on our studies, ruminal protein requirements should be considered if the forage is very low in degradable protein. Hydrolyzed feather meal may be more appropriate for supplementing on hay than on dormant range because of poor rumen degradability of some batches of feather meal.

Table 4. Weight and body condition changes and pregnancy rates of fall calving cows, Trial 2 (least squares means).

			FM	
	NC	SBM	7.5%	15%
Number of cows	16	16	17	16
Initial weight, lb 11/28/89	943	948	941	946
Initial condition score	5.0	5.4	5.3	5.4
Weight change, lb				
Hay, ad libitum 11/28/89 - 1/23/90	-16.5[a]	-.9[a]	10.6[ab]	13.4[ab]
Condition changes				
Hay, ad libitum 11/28/89 - 1/23/90	-.35	-.33	-.19	-.16
No hay 1/24/90 - 3/20/90	-91.5[a]	-57.6[b]	-76.8[a]	-88.2[a]
Condition changes 1/24/90 - 3/20/90	-.71	-.38	-.61	-.55
Total weight change:	-108[a]	-58.5[b]	-66.2[b]	-74.7[b]
Condition change: 11/28/89 - 3/20/90	-1.05	-.71	-.80	-.71
Pregnancy rates, %	79	99	70	77

[a,b]Means on the same line with the same superscript do not differ significantly ($P < .05$).

EFFECT OF SUPPLEMENTAL BYPASS PROTEIN ON INTAKE, DIGESTION AND DUODENAL PROTEIN FLOW OF LOW QUALITY NATIVE GRASS HAY IN BEEF COWS

R.R. Scott[1], C.A. Hibberd[2], W.W. Chan[1] and K.S. Swenson[3]

Story in Brief

Five mature beef cows fitted with ruminal, duodenal and ileal cannulae were utilized in a 5 x 5 latin square design to determine the effect of supplemental bypass protein on hay intake, site of digestion and duodenal crude protein flow. Cows were fed native grass hay (4.3% crude protein) free choice and blends of soybean hulls and soybean meal with or without bypass protein. Blood meal and corn gluten meal were used as the bypass protein feedstuffs. Supplements provided two levels of total protein (.9 or 1.3 pounds per day) and two levels of bypass protein (28% or 50% of total protein). Ruminal ammonia concentrations decreased when bypass protein composed 50% of the supplemental protein. Ruminal organic matter disappearance (percent of organic matter intake) was depressed relative to the unsupplemented control and was not affected by level or source of supplemental protein. Level of protein increased hay organic matter and digestible organic matter intakes. Bypass protein did not affect site or extent of digestion. Duodenal crude protein flow increased with added supplemental protein, but did not differ between levels of bypass protein. This study suggests that a blend of blood meal and corn gluten meal may be used in formulating low-starch/digestible fiber supplements for low quality forage diets without decreasing forage utilization, digestible organic matter intake or duodenal crude protein flow.

(Key Words: Beef Cattle, Grass Hay, Bypass Protein, Intake, Digestibility.)

Introduction

Fermentation of forage by ruminants yields microbial protein and volatile fatty acids. Microbial protein flowing to the small intestine supplies a

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Introduction

Fermentation of forage by ruminants yields microbial protein and volatile fatty acids. Microbial protein flowing to the small intestine supplies a portion of the protein requirement of ruminants. Fall calving beef cows grazing dormant native grass cannot satisfy their protein and energy requirements solely from fermentation of consumed forage. Although, supplemental protein increases forage fermentability (Scott and Hibberd, 1990), duodenal protein flow may still be inadequate. Under these circumstances, feed protein that escapes ruminal degradation (bypass protein) may supplement microbial protein flowing to the small intestine. Excess bypass protein, however, may limit forage utilization (Hibberd and Martin, 1990).

Previous studies have illustrated that bypass protein can replace a portion of the ruminally degradable protein fraction of supplements. Hibberd et al. (1988) increased performance of fall calving cows with supplements containing bypass protein. Cows receiving supplements containing .7 lb bypass protein lost less weight and produced more milk than cows supplemented with .4 lb bypass protein. Supplementation effects on forage utilization and intake, however, were not reported.

Scott and Hibberd (1990) fed increasing quantities of supplemental ruminal degradable protein (RDP) and determined that .9 lb supplemental RDP (1.3 lb total CP) maximized utilization and intake of low quality forage by mature beef cows. In addition, supplemental ruminal degradable protein increased ruminal ammonia concentrations and rate of digestion. Supplemental ruminal degradable protein was required at a rate of .65 lb/day (.9 lb total CP) to maintain ruminal ammonia concentrations above 1 mg/dl. If bypass protein can replace a portion of the ruminal degradable protein fraction of supplements without adversely affecting forage utilization, duodenal N and amino acid flows may be manipulated. The objective of this experiment was to determine the effect of supplementing low quality grass hay diets with two levels of total protein with or without bypass protein on forage intake, site of organic matter digestion and nitrogen flow to the small intestine.

Materials and Methods

Five mature beef cows (1,120 lb, average empty body weight) fitted with ruminal, duodenal and ileal cannulae were fed coarsely chopped (2-inch screen) native grass hay (4.3% CP, 75.2% NDF) and supplements containing two levels of total protein (.9 lb and 1.3 lb) and two levels of bypass protein (28% or 50% of total protein). The fifth treatment was an unsupplemented

control which was included to estimate the nutritional value of the native grass hay. Treatments and cows were arranged in a 5 x 5 latin square with pen randomized in each period. Supplements were formulated with blends of soybean meal and soybean hulls (Table 1). Soybean meal (50% CP) and soybean hulls (12% CP) differ markedly in protein concentration but appear to be similar in ruminal protein degradability (72%). A blend of blood meal and corn gluten meal was added to formulate the 50% bypass supplements. Blood meal (82% bypass CP) and corn gluten meal (55% bypass CP) were utilized because of their complementary amino acid profiles (NRC, 1985). Supplemental energy supply was equalized with soybean hulls to prevent confounding effects between supplemental protein and energy and to minimize negative associative effects (Table 2). All supplements provided 2.9 lb TDN and were fed at a rate of 4.0 lb DM/day. Scott and Hibberd (1990) illustrated that .9 lb RDP (1.3 lb CP) maximized digestion and intake of low quality hay. In this study, the 1.3 lb CP-28% bypass treatment is identical to the .9 lb RDP supplement formulated by Scott and Hibberd (1990).

Cows were adapted to supplements for two weeks followed by one week of intensive sampling. Supplements were fed once daily at 7:00 a.m. Hay intake was measured on days 16 through 19 as hay offered minus hay refused. Hay refusals were sampled and discarded and fresh hay was fed daily. Nutrient intake was calculated by subtracting total nutrients refused from

Table 1. Feed composition of supplements with differing levels and sources of protein.

		.9 lb CP		1.3 lb CP	
Feed, % (DM basis)	Control	28% BP[a]	50% BP	28% BP	50% BP
Soybean hulls		60.20	71.34	31.36	47.99
Soybean meal		29.40	4.14	58.07	20.36
Blood meal			7.30		10.90
Corn gluten meal			6.71		10.01
Molasses	35.13	4.00	4.00	4.00	4.00
Dicalcium phosphate	37.27	3.44	3.44	3.44	3.44
TM salt[b]	27.05	2.50	2.50	2.50	2.50
Sodium sulfate		.38	.49	.55	.71
Vitamin A (30,000 IU/g)	.54	.05	.05	.05	.05
Dairy flavors	.03	.03	.03	.03	.03

[a] BP = Bypass protein.

[b] Trace mineralized salt contained 92% NaCl, .25% Mn, .20% Fe, .033% Cu, .007% I, .005% Zn and .0025% Co.

Table 2. Nutrient composition and daily nutrient supply of supplements providing differing levels and sources of protein.

Item	Control	.9 lb CP		1.3 lb CP	
		28% BP[a]	50% BP	28% BP	50% BP
Nutrient, % DM					
Crude protein[b]	3.0	22.2	22.2	33.3	33.3
TDN[c]	22.2	73.9	72.0	75.8	72.9
Calcium[c]	12.64	1.37	1.37	1.37	1.37
Phosphorus[c]	11.09	.90	.90	1.14	.99
Feeding rate, lb DM/day	.34	3.95	3.95	3.95	3.95
Nutrient supply, lb DM/day					
Crude protein					
Total[b]	.02	.92	.89	1.33	1.32
RDP[cd]	.01	.66	.45	.96	.66
Bypass[ac]	.01	.26	.44	.37	.66
TDN[c]	.08	2.93	2.85	3.00	2.89

[a] BP = Bypass protein.
[b] Actual analysis.
[c] Estimated.
[d] RDP = Ruminal degradable protein.

total nutrients offered. Duodenal, ileal and fecal samples were obtained eight times over days 16 through 19 to represent every three hours of a 24 hour day. Acid insoluble ash was determined on hay, hay refusal and digesta samples to calculate nutrient flow and digestibility. Ruminal OM digestion was not corrected for contribution of microbial OM. Intensive ruminal sampling was performed on day 20 to measure ruminal ammonia concentrations.

All data were subjected to least squares analysis with a model that included period, animal and treatment. One cow, which became ill during period three, was replaced during subsequent periods and her data for period three was deleted. Orthogonal contrasts were used to compare the control vs all supplements, level of protein, level of bypass protein and protein level by bypass protein level interaction.

Results and Discussion

Treatment differences in ruminal ammonia concentrations were dependent on sampling time (time x treatment, P<.0001; Figure 1). Ruminal ammonia concentrations peaked two hours after supplementation and were higher (P<.0001) with 1.3 lb protein. Fifty percent bypass protein supplements reduced (P<.0001) concentrations of ruminal ammonia, verifying that the 28% bypass supplements supplied more ruminal degradable protein (RDP). Ruminal ammonia concentration of the control was below 1 mg/dl throughout the day. This response illustrates the low nitrogen content of mature grass hay and the need for supplemental protein. Ruminal ammonia concentrations remained below 1 mg/dl for the .9 lb CP supplements for most (18 hours) of the day. Ruminal ammonia concentrations of 1.3 lb CP-28% bypass supplement remained above 1.2 mg/dl for the entire day. The .9 lb CP-28% bypass and 1.3 lb CP-50% bypass supplements supplied the same quantity of RDP, however, ruminal ammonia concentrations of 1.3 lb CP-50% bypass supplement were higher.

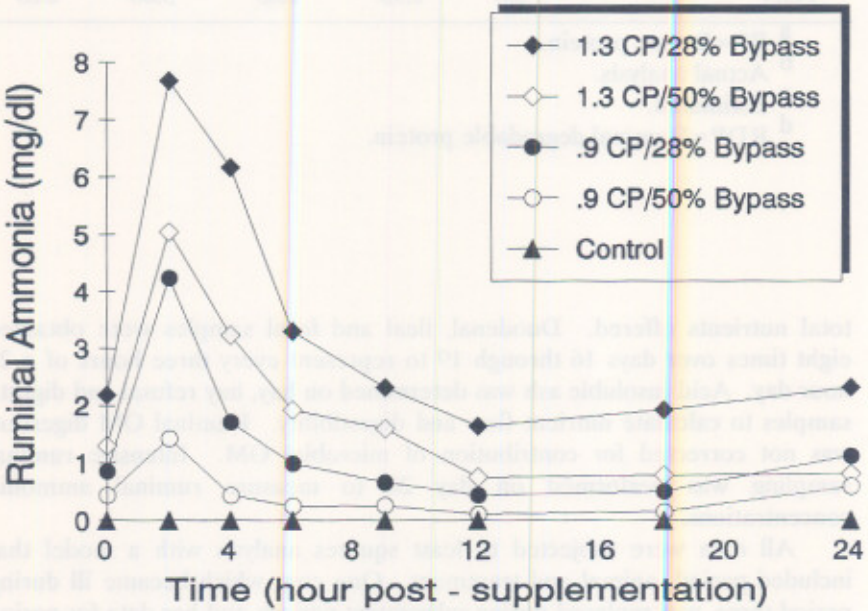


Figure 1. Diurnal changes in ruminal ammonia concentrations in beef cows fed low quality native grass hay supplemented with differing levels and sources of protein.

Higher ruminal ammonia concentrations of the 1.3 lb-50% bypass supplement may be the result of nitrogen recycling. Alternately, faster incorporation of feed protein into microbial protein may have reduced ruminal ammonia concentrations for .9 lb CP-28% bypass supplement. Ruminal pH values (Table 3) support the latter explanation, because rapid fermentation will decrease ruminal pH. Ruminal pH of the control was higher ($P<.0001$) than for protein supplements. Relatively high ruminal pH (6.61) coupled with low ruminal ammonia indicates a slow fermentation rate (Scott and Hibberd, 1990). Level of protein tended to decrease ($P<.07$) ruminal pH. Greater quantities of RDP in 28% bypass supplements may have stimulated fermentation rate and decreased ($P<.001$) ruminal pH compared to 50% bypass supplements.

Supplementation increased ($P<.0001$) hay organic matter (OM) and total OM intake (Table 3). Hay OM intake increased ($P<.01$) from 16.4 lb/day with .9 lb CP to 18.4 lb/day with 1.3 lb CP supplements. Bypass protein did not affect hay OM intake at either level of protein intake. Although 1.3 lb CP (.9 lb RDP) maximized the intake of low quality grass hay (Scott and Hibberd, 1990), these data suggest that bypass protein can supply 50% of total supplemental protein without decreasing hay intake.

Total tract OM digestibility was 58.7% for unsupplemented hay and increased ($P<.003$) with protein supplementation (Table 3). Level of supplemental protein did not affect ($P=.70$) total tract OM digestibility (%). High RDP supplements (28% bypass protein), however, tended ($P=.27$) to increase total tract digestibility. Total tract OM disappearance (digestible OM intake) increased (1.2 lb; $P<.003$) with 1.3 lb supplemental protein. These data are in agreement with Scott and Hibberd (1990) indicating that digestible organic matter intake of low quality hay diets is dependant upon the level of supplemental protein.

Ruminal OM digestion data have not been corrected for microbial OM (Table 3). Ruminal OM digestibility tended to decrease with supplementation. Longer ruminal retention time of unsupplemented forage for the control probably allowed more extensive microbial attack. Supplementation increased ($P<.0001$) the quantity of OM that disappeared in the rumen. Level of supplemental protein increased ($P=.012$) ruminal OM disappearance. Differences in ruminal OM disappearance are mainly due to differences in hay OM intake. The lack of treatment differences in ruminal OM digestibility (%) is probably the result of faster particulate passage rates (Scott and Hibberd, 1990). Supplements containing 28% bypass increased ruminal ammonia concentrations, which should stimulate the rate of forage fermentation. Scott and Hibberd (1990) attributed increased ruminal OM disappearance (lb) to increasing ruminal ammonia concentrations with added supplemental RDP. Although 28% bypass supplements increased ruminal ammonia concentrations, the quantity and

Table 3. Effect of supplemental level and source of protein and undegraded protein on intake and digestion of organic matter by beef cows fed low quality native grass hay.

	Control	.9 lb CP		1.3 lb CP		SE[b]
		28% BP[a]	50% BP	28% BP	50% BP	
Organic matter intake, lb/day						
Hay[de]	11.8	15.9	16.9	18.5	18.3	.71
Total[de]	12.0	19.4	20.4	22.0	21.8	.71
Site of organic matter disappearance[c]						
Rumen						
lb/day[de]	6.5	10.0	10.3	11.3	11.1	.42
Mouth to duodenum, %	54.8	52.1	51.2	52.4	51.9	1.79
Total tract						
lb/day[de]	7.0	12.0	12.3	13.7	13.3	.40
Mouth to anus, %[d]	58.7	62.7	61.2	63.0	61.8	1.28
Ruminal pH[fg]	6.61	6.26	6.39	6.24	6.35	.023

[a] BP = Bypass protein.
[b] Standard error of the mean.
[c] Uncorrected for microbial organic matter.
[d] Control vs all supplements ($P < .001$).
[e] Response to level of supplemental CP ($P < .01$).
[f] Response to level of supplemental CP ($P < .07$).
[g] Response to supplemental bypass protein ($P < .001$).

percentage of ruminal OM disappearance were similar (P>.10) between levels of bypass protein.

Supplemental protein increased (P<.0001) hay CP intake, total CP intake and duodenal CP flow above the control (Table 4). Compared to the control, duodenal CP flow was increased by 2.5 and 3-fold for the .9 and 1.3 lb protein supplements, respectively. The 1.3 lb protein supplements increased (P<.02) duodenal CP flow 24% above .9 lb protein supplements. Supplemental RDP should increase ruminal microbial growth and protein flow to the duodenum. Duodenal CP flow averaged 1.9 lb and 2.35 lb CP/day for the .9 lb and 1.3 lb levels of protein, respectively. Duodenal protein flows for .9 lb and 1.3 lb CP levels are 16% and 11% above the protein requirements for a 1,200 lb gestating or lactating beef cow (NRC, 1984), respectively. Bypass protein did not alter (P=.86) duodenal CP flow. Similar duodenal protein flows between levels of bypass protein may explain the lack of an intake response to bypass protein.

Supplemental protein increased (P<.0001) digestible OM intake (total tract OM disappearance, lb/d) compared to the control. Digestible OM intake was not affected (P=.89) by level of bypass protein. Level of protein further increased (P<.003) intake of digestible OM by 1.2 lb. Approximately one lb of TDN is required per 5 lb increase in milk production (NRC, 1984). Therefore, the high CP supplement should support 5 lb more milk per day than the low CP supplement. In addition, milk production should be stimulated by enhanced duodenal protein flow. Although duodenal protein

Table 4. Effect of supplemental level and source of protein on crude protein intake and flow to the duodenum.

		.9 lb CP		1.3 lb CP		
	Control	28% BP[a]	50% BP	28% BP	50% BP	SE[b]
CP intake, lb/day						
Total[cd]	.5	1.6	1.6	2.1	2.1	.04
Hay[cd]	.5	.7	.7	.8	.8	.04
Supplement[cd]	.0	.9	.9	1.3	1.3	.02
Duodenal CP flow lb/day[cd]	.8	1.9	1.9	2.3	2.4	.12

[a] BP = Bypass protein.
[b] Standard error of the mean.
[c] Control vs all supplements (P<.0001).
[d] Response to level of supplemental CP (P<.02).

flow was not affected by level of bypass, duodenal amino acid supply may have been altered by high bypass supplements. Altered duodenal amino acid flow may explain increased milk production of cows supplemented with bypass protein (Hibberd et al., 1988).

This study emphasizes the dramatic positive associative effect that supplemental protein has on the intake and utilization of low quality native grass hay. Increasing the quantity of supplemental CP from .9 to 1.3 lb/day increased CP and TDN intake by .52 and 1.2 lb/day, respectively. These additional nutrients should decrease body weight and condition losses while improving milk production of lactating cows grazing dormant native grass. In addition, bypass protein did not adversely affect digestible OM intake or duodenal CP flow. Consequently, bypass protein sources can be added to range supplements when economically justified.

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THE EFFECT OF MID-SUMMER DEWORMING ON WEIGHT GAIN OF COWS AND THEIR CALVES IN SOUTHEAST OKLAHOMA

S.C. Smith[1] and J.W. Kelley[2]

Story in Brief

The effect of a midsummer deworming following a spring deworming on performance of cows and their calves was evaluated in a herd of 41 cows and their calves in LeFlore County in southeastern Oklahoma. Midsummer deworming improved calf weight gains from treatment to October weaning by 24 pounds. During the same period, cow weight was also improved by 20 pounds.

(Key Words: Anthelmintics, Deworm.)

Introduction

The effect of routine treatment of cowherds with anthelmintics has been inconsistent. The response of a cow herd to deworming will depend on the level of infection, reinfestation, and the type of parasite involved. Research has shown the intestinal nematode Ostertagia ostertagi to potentially be the most economically damaging of the internal parasites. A 1987 southeast Oklahoma study with cows and their calves receiving a midsummer deworming resulted in a 21 lb. improvement in weaning weights and improved cow weight gain and body condition in weaning weights and improved cow weight gain and body condition score (Smith et al., 1987). In the 1987 trial the cattle had not received a previous spring treatment with an anthelmintic. The objective of this study was to evaluate the effect of a midsummer deworming as a follow up treatment to a spring deworming on the weight gain of cows and their calves.

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Materials and Methods

A total of 41 cows and their calves were used to evaluate the effect of midsummer treatment with ivermectin (Ivomec) on cow and calf weight gain. The trial was conducted on a ranch north of Poteau, Oklahoma. Calves ranged in weight from 120 to 500 lbs. at the beginning of the trial. On May 19, 1990, all cattle were gathered, individually identified, weighed and dewormed with fenbendazole (Safe-Guard) drench. Prior to midsummer (M/S) deworming calves were paired to their respective dams. On August 3, 1990, all cows and calves were again weighed. Cows were randomly allotted to treatment groups either receiving ivermectin or no treatment. Ivermectin was used as the midsummer anthelmintic due to its efficacy against the inhibited stage of Ostertagia at label dosage. Calves were identified when weighed, treated and allotted to the same treatment group as their respective dams. Throughout the trial all cattle grazed together in improved pastures. Treatment groups were not physically separated from one another. Cows and calves were again weighed at weaning on October 9, 1990. Data were analyzed by General Linear Models procedure.

Results and Discussion

Initial mean calf weights were similar for control and M/S groups (241 vs 238 lb, respectively). The midsummer deworming significantly improved August-October weight gains (119 vs 143 lb, $P<.04$). May-August and total calf weight gains were not statistically different. Lactating cows retreated with an anthelmintic in August tended to gain faster to weaning in October (49 vs 29 lb) then control cows.

The combination of results of this field trial and the 1987 study indicate that a midsummer deworming of commercial cows and their spring born calves should be considered by Oklahoma cattlemen. The effectiveness of an internal parasite control program is dependent on the type of parasite involved, the level of infection, the rate of reinfestation and the timing of the administration of appropriate anthelmintics. If application of an anthelmintic is necessary and economically effective in the spring, after which reinfestation can be quite rapid given the environment and grazing management employed in southeast Oklahoma herds, then a midsummer deworming will probably be warranted in terms of productivity and profitability. Reinfestation rates will be lessened in the hot, dry summer months. Although specific parasites involved in this and the previous study were not determined, any midsummer deworming in southeast Oklahoma should be with a product deemed effective against the inhibited stage of Ostertagia.

Table 1. Effect of midsummer deworming on cow and calf performance.[a]

Item	Control	Midsummer deworm
Number of animals:		
Cows	21	20
Calves	21	20
Cow Performance:		
Weight, lb; 5/19/90	894	897
Weight changes 5/19/90 to 8/3/90	20	23
Weight changes to 8/3/90 to 10/9/90	29	49
Total weight change	48	72
Calf Performance:		
Initial wt. 5/19/90 lb	241	238
Wt. gain 8/3/90	159	151
Wt. gain 8/3/90 to 10/9/90	119[b]	143[b]
Total wt. gain	278	294

[a] Least squares means.

[b,c] Means on same line with different superscripts differ significantly ($P<.04$).

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THE EFFECT OF DEWORMING ON PERFORMANCE OF FALL BORN BEEF CALVES

S.C. Smith[1]

Story in Brief

The effect of a single injection of ivermectin (Ivomec) was evaluated with fall born beef calves raised in Pittsburg County in southeastern Oklahoma. Treatment with ivermectin had no significant effect on weight gain of fall born calves when treated in December.

(Key Words: Beef Cattle, Parasites, Fall Born.)

Introduction

The need for deworming cattle in southeast Oklahoma has resulted in the routine treatment of cattle with anthelmintics. These treatments are usually in the spring or fall when cattle are normally processed. Fall calving herds are occasionally processed in December with cows receiving treatment for internal parasites resulting from infestations from the previous summer or fall. The need for treating fall born calves at this time is a question commonly asked by owners of these herds as the calves may not have experienced climatic or other conditions conducive to parasitic infestation. Pasture infestation levels are typically waning by late fall. The objective of this trial was to determine the effect of winter treatment with an anthelmintic on weaning weights of October/November born calves.

Materials and Methods

Forty fall born, mostly October and November, nursing calves were used to evaluate the effectiveness of a winter treatment with ivermectin (Ivomec) on weaning weight. The trial was conducted on a Polled Hereford ranch in Pittsburg County in southeastern Oklahoma. Cows and their calves were gathered December 8, 1989. Cows were routinely processed and all were treated with ivermectin. The necessity for this winter deworming had

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[1]Area Livestock Specialist

been previously determined by the ranch owner as evidenced by previous cow and calf performance. Cow body condition scores, rebreeding rates and calf weaning weights were improved with the incorporation of winter deworming in the herd health plan. Previously, calves did not receive a winter anthelmintic treatment. Calves were weighed, individually identified, blocked by sex, and randomly allotted by weight to one of two treatment groups; control or dewormed. Initial weights ranged from 105 to 230 lbs. The dewormed calves received an injection of ivermectin with dosage determined by weight.

All cows and their calves grazed dormant native grass pasture with hay and protein supplementation. Treatment groups were not physically separated. Calves were weighed when gathered for weaning and processing 151 days later on May 8, 1990. Data were analyzed using a model that included calf sex and weight gain. Treatment differences were evaluated by F-test.

Results and Discussion

Deworming treatment had no statistically significant effect on the weight gain of the calves (Table 1). Given the success of ivermectin as an anthelmintic, even against inhibited Ostertagia ostertagi, the lack of any weight gain advantage by treated calves would indicate a low or nonexistent level of internal parasite infestation in these calves. Given the predetermined need for deworming the dams of the trial calves, an apparent level of parasite infestation exists. Apparently, the prospect of fall born calves picking up a significant parasite load was low, at least in this instance, negating the need for a winter deworming.

Table 1. Effect of Ivermectin on fall born calf performance.[a]

Item	Control	Ivermectin
Number of calves	19	21
Average beginning wt, lb[b]	175	171
Average weight gain, lb[b]	270	242

[a]Least squares means.
[b]No significant treatment effect (P>.05).

EFFECTS OF RUMINAL CONTENTS ON B-VITAMIN STATUS IN CHICKS

P.L. Dubeski[1], F.N. Owens[2] and R.G. Teeter[2]

Story in Brief

Chick growth and survival were monitored as indices of the B-vitamins supplied by ruminal contents. Ten diets were formulated containing all, none, or all but one of each of the eight B-vitamins. These diets were fed alone or mixed with liquid ruminal contents to test the ability of the ruminal contents to meet the chick's requirement for each B-vitamin. Compared to requirements for chicks, ruminal contents of steers fed concentrate diets contained 37, 500, 160, 244, 309, 207, 15300 and 72% of the chick's total need for thiamin, riboflavin, B_6, niacin, pantothenate, folic acid, B_{12} and choline. This means that based on chick requirements, the supply from ruminal contents was low for thiamin and choline but adequate for all the other B-vitamins. Added ruminal contents increased gain and efficiency for each vitamin deficient diet as expected except for the B_{12} and pantothenate deficient diets. Growth rate of chicks fed the B_{12}-deficient diet was depressed by adding ruminal contents. Based on chick growth, supply of available B_{12} in ruminal contents appears low. Further investigation of the antagonism of B_{12}, of the less than anticipated response to pantothenic acid, and of the low ruminal concentration of thiamin is warranted.

(Key Words: Rumen Contents, B-Vitamins, Cattle.)

Introduction

Ruminal production and degradation of B-vitamins have been studied previously at Oklahoma State (Zinn et al., 1987). Those results indicated that ruminal output of pantothenic acid and folic acid were less than 10% of estimated requirements. In contrast, supply of other B-vitamins (thiamin, riboflavin, niacin, pyridoxine and vitamin B_{12}) exceeded estimated requirements at normal feed intake levels. Whether or not these vitamins were all present in a form available for animals and whether direct

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Table 1. Composition of complete diet.

Ingredient	Amount (grams)
Corn starch	54.35
Vitamin-free casein	26.40
Glista salts[a]	5.37
Solka-Floc (cellulose)	3.00
Citric acid[b]	1.00
Arginine	1.20
DL-Methionine	.40
Glycine	.20
Choline bitartrate	.31
Vitamin ADEK premix[c]	.10
Thiamine hydrochloride premix[d]	.33
Riboflavin premix[d]	.33
Niacinamide premix[d]	.33
Pyridoxine hydrochloride premix[d]	.33
Calcium D-pantothenate premix[d]	.33
Folic acid premix[d]	.33
Vitamin B_{12} premix[d]	.33
Biotin premix[e]	.33
Corn oil	5.00

[a] Glista Salts (TD#88178, Teklad Premier Laboratory Diets) provided 1.16% Ca, .64% P, .404% K, .35% Na, 600 ppm Mg, 212 ppm Mn, .1 ppm Se, 56 ppm Zn, 10 ppm Cu, 5 ppm I, 84 ppm Fe, 5350 ppm Cl, .058% S, and .2 ppm Co.

[b] Citric Acid (Anhydrous) at 1% of diet to prevent microbial growth.

[c] Vitamin ADEK Premix (Teklad) provided 10,000 IU Vitamin A, 2,500 IU Vitamin D_3, 50 IU Vitamin E and 2 mg menadione per kg.

[d] In the complete diet, added B-vitamins were supplied at 2.0 ppm thiamin, 6.6 ppm riboflavin, 33 ppm niacin, 3.96 ppm pyridoxine, 11 ppm pantothenic acid, 1.1 ppm folic acid, and .019 ppm B_{12}, and 1,750 ppm choline. Vitamin deficient diets were made by replacing the vitamin premix(es) with an equivalent amount of corn starch.

[e] Biotin was present in all diets at .35 ppm.

Table 2. Chick average daily gain, dry matter intake, gain/feed and survival.

Vitamin diet[a]	Rumen contents	ADG g/d	Intake g DM/d	Gain/ feed	Survival, % to end
Complete	+	27.0[b]	44.5[b]	.607[b]	100
Complete	-	20.5[c]	31.1[c]	.659[c]	97
Folic Acid	+	25.4[b]	42.2[b]	.601[b]	97
Folic Acid	-	19.1[c]	28.4[c]	.672[c]	97
Niacin	+	24.5[b]	42.3[b]	.578	100
Niacin	-	16.9[c]	27.0[c]	.624	95
Choline	+	15.1	27.6[b]	.549[b]	100
Choline	-	16.7	25.5[c]	.654[c]	97
Riboflavin	+	23.2[b]	39.6[b]	.586[b]	97
Riboflavin	-	7.1[c]	17.5[c]	.407[c]	100
Pyridoxine	+	19.8[b]	34.0[b]	.582[b]	87
Pyridoxine	-	7.2[c]	15.4[c]	.469[c]	93
Thiamin	+	15.1[b]	30.7[b]	.491[b]	97[a]
Thiamin	-	2.9[c]	11.1[c]	.257[c]	20[b]
B_{12}	+	0.1[b]	18.1	.004[b]	100
B_{12}	-	1.4[c]	14.7	.093[c]	100
Pantothenate	+	-1.3[b]	15.2[b]	-.086[b]	96
Pantothenate	-	-2.0[c]	9.7[c]	-.209[c]	94
Devoid	+	10.5[b]	23.4[b]	.448	100[a]
Devoid	-	3.3[c]	9.4[c]	.341	13[b]

[a] The vitamin treatment describes the complete and devoid diets and the diets in which specific B-vitamins were omitted.

[b,c] Means within a vitamin without a common superscript differ ($P < .05$).

Table 3. B-vitamin composition of ruminal contents compared to chick requirements.

Vitamin	Concentration in ruminal contents, ppm	Chick requirements[a] ppm	% Requirement supplied by ruminal contents
Thiamin	0.67	1.8	4.6
Riboflavin	18.0	3.6	62.0
Pyridoxine	4.8	3.0	19.8
Niacin	66.0	27.0	30.3
Pantothenate	30.9	10.0	38.6
Folic Acid	1.14	0.55	25.7
B_{12}	1.38	0.009	1900
Choline	933	1300	8.9

[a] 1984 Poultry NRC requirements for chicks 0-3 weeks old.

microbial B_{12} assay. Depressed ADG and G/F for RC+ compared to RC- suggests that ruminal contents exacerbated the B_{12} deficiency, even though survival was not affected. Survival on both B_{12} diets was high; compared to other B-vitamins B_{12} is retained tenaciously in the body.

Birds fed pantothenate-deficient diets, with or without ruminal contents, had low dry matter intakes and lost weight although survival was not affected. These birds remained alert and lively. Ruminal contents increased dry matter intake and G/F, and decreased weight loss. However, even though ruminal contents contributed 38.6% of pantothenic acid requirements, dry matter intake, ADG and G/F were poorer from both RC+ and RC- diets than from any other diets. The RC+ pantothenate-deficient diet was the only RC+ diet that resulted in weight loss. This poor performance could be related to the effect of rumen fluid on B_{12} status, since B_{12} has a sparing action on pantothenic acid requirements in poultry. Other nutritional interactions may also be important. For example, biotin included in a pantothenate-deficient diet prolongs survival, but precipitates a pantothenate deficiency in only half the time. Our diets all were high in biotin. Pantothenic acid requirements also are influenced by ascorbic acid, folic acid, fat and protein levels.

In conclusion, a 14-day chick bioassay was used in which chicks were fed vitamin deficient diets. The test was insensitive for folic acid, niacin and choline; dry matter intake, ADG or feed efficiency were not depressed. Single deficiencies of thiamin, riboflavin, B_6 and pantothenic acid reduced

DUODENALLY INFUSED CASEIN OR UREA-GLUCOSE FOR STEERS FED A HIGH CONCENTRATE DIET

J.D. Garza-F.[1], F.N. Owens[2] and S. Welty[3]

Story in Brief

The influence of post-ruminal protein on feed intake of eight crossbred steers (784 lb) with ruminal, duodenal and ileal (T-type) cannulas was studied. Steers received duodenal infusions (4 doses/day; 750 ml at 8:30 am, 12:30 pm, 4:30 pm and 8:30 pm) of either casein or urea-glucose solutions both mixed with a B-vitamin complex. Animals had free choice access to an 80% corn-soybean-cottonseed hull concentrate diet; feed intake was measured daily throughout the 57-day trial. Steers infused with the urea-glucose mixture, tended to eat more feed (17.3 vs 15.0 lb/day) drink more water (7.2 vs 6.3 gal/day) and have higher ruminal dry matter digestibility (52 vs 47%) than steers infused the casein. Composition of nutrients infused post-ruminally may alter ruminal function and site of digestion. Daily gain of steers also tended to be greater (3.3 vs 2.66 lb) with post-ruminal urea-glucose than post-ruminal casein. These results suggest that benefits attributed to increased escape protein with adequate protein diets may be due to an increased supply of glucogenic materials.

(Key Words: Beef Cattle, Duodenal Infusions, Protein.)

Introduction

Understanding the role that ingested nutrients play in controlling feed intake in ruminants under confined-feeding operations may improve economics of production. In general rate of gain increases as the level of feed intake increases; therefore if feed intake increases, rate and efficiency of gain are improved. Amino acid imbalance or B-vitamin deficiencies can reduce feed intake in non-ruminant animals. Effects of supplementation of these nutrients on feed intake in beef cattle fed high grain diets have not been examined. Most feed intake studies have been conducted with sheep or goats fed high or all-forage diets. Data presented by Egan and Moir (1965)

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Table 2. Composition of casein and urea-glucose solutions infused per duodenum to beef steers.

	Daily dose per animal (g DM)	
	Solutions	
Item	1	2
Casein	294.0	-
Urea	-	92.5
Glucose	-	319.7
DL methionine	3.0	-
Sodium bicarbonate	16.0	16.0
Water (liters)	3.0	3.0

Calculated analysis:

Item	Casein	Urea	Glucose
DM, %	91.0	99.0	95.0
N, %	14.2	46.0	-
CP, %	89.0	288.0	-
DE, Mcal/kg[b]	3.9	-	3.7

[a] Steers were dosed with 750 ml of either the casein or the urea-glucose solution four times daily.

[b] Estimated (Nurient requirements of swine, NRC 1988).

duodenal digesta and fecal grab samples were collected (8:00 am, 12:00 pm and 8:00 pm) on day 14 and 15 of each experimental period. Ruminal fluid pH was recorded immediately and individual samples were acidified for later ammonia-N (NH_3-N) analysis. Duodenal, fecal grab samples and an aliquot of ruminal fluid within each animal and period were composited, dried and ground prior to chromic oxide determinations.

Total ruminal contents were removed mechanically on day 16 of each period to measure total rumen liquid volume, ruminal dry matter and density of the fluid. Amounts of free liquid, and the association of the fluid with solids (bound liquid) in the rumen were calculated.

Data were analyzed including animal, period and treatment as variables. In addition, data from ruminal and duodenal pH and NH_3-N were analyzed as repeated measures using the treatment x animal x period interaction as the main plot error term. Means were compared using least squares procedures.

Table 4. Effect of duodenally infused casein or urea-glucose mixtures on feed and water intake and ruminal parameters in beef steers fed a high concentrate diet (n=8).

	Treatments		
	Casein	Urea-glucose	SE
Intake:			
Feed, lb DM/day	15.0[a]	17.3[b]	.64
Water, gallons/day	6.3[c]	7.2[d]	.32
Rumen contents:			
Total contents, lb	55.0	58.0	4.14
Ruminal DM, %	13.9[a]	16.7[b]	.54
pH	6.1	5.9	.02
Liquid:			
Total volume, gallons	5.7	5.8	.38
Free, gallons	4.4[a]	3.7[b]	.17
Bound to feed, gallons	1.3[c]	2.0[d]	.27
Solids:			
Total solids, lb	7.6	10.1	1.01

[a,b] Means in the same row with different superscript differ (P<.05).
[c,d] Means in the same row with different superscript differ (P<.10).

ruminal NH_3-N levels found in our study, suggest that microbial degradation of the soluble portion of the feed protein was large or that recycling was extensive.

Total tract DM digestibility was not altered by type of solution infused (69 vs 70%) but animals receiving the urea-glucose mixture had higher (52 vs 47%, P<.01) ruminal DM digestibility (Table 5). Results from this study indicate that post-ruminal infusions of urea-glucose increased voluntary feed intake more than infusions of casein. The urea-glucose mixture increased extent of ruminal digestion. The fact that intake was not greater with casein than urea plus glucose imply that postruminal supply of amino acids was not limiting feed intake with these steers gaining 2.9 lb/day when fed this diet. Steers consumed an average of 903 g daily of dietary crude protein compared to an estimated need (NRC, 1984) of 917 g, so the greater response to urea-glucose than casein is surprising. Benefits ascribed to increased escape protein with higher feed intake of a concentrate diet may be due to an increased supply of glucogenic material, not to the amino acids themselves.

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traditional growing programs have utilized ad libitum access of lower energy rations. While these rations provide the desired lower rate of gain during the growing period, the poor feed efficiency realized with full feed and reduced gain has limited the feasibility of such programs. While it has been known that providing the energy necessary for a reduced level of gain with a reduced amount of a high concentrate ration should be more economically and energetically efficient than the use of full fed high roughage rations, the potential management problems associated with limit feeding have limited adoption of the practice. With the advent of microcomputers, it is now possible to accurately predict the amount of a given ration needed to achieve a target weight gain. Further, feed additives such as monensin reduce the danger of overeating and acidosis associated with high energy rations. The objectives of this research were to determine the effect of limit feeding rations containing two energy levels on performance of weaned calves during the growing phase, and on subsequent finishing performance and carcass traits.

Methods and Materials

Seven hundred and sixty two spring born (March, April) Limousin x Hereford Angus calves from one ranch near Gordon, Nebraska were weaned and shipped to XIT Feeders, a division of Continental Grain Co. near Dalhart in the northwestern Texas panhandle. Calves arrived at the feedlot on November 2 and 3, 1989. On arrival, steers were randomly allotted to 8 pens and assigned by pen to one of 3 treatment groups (Table 1). Treatments were (1) limit feeding a ration containing 61 Mcal NEg/cwt of DM to gain 2.20 lb/day (3 pens); (2) limit feeding a ration containing 66 Mcal NEg/cwt to gain 2.20 lb/day (3 pens); or (3) ad libitum a ration containing 61 Mcal NEg/cwt until weight reached 750 lbs (2 pens). Approximately 95 calves were assigned to each pen and provided 12 in. of bunk space per calf. All pens were switched to full feeding of a ration containing 66 Mcal NEg/cwt when calves averaged 750 lbs. The first pen was slaughtered when visual conditions indicated that the majority of that pen would attain a choice quality grade. All other pens were then slaughtered so that all pens had equal days to slaughter from the end of the growing period.

All calves were initially implanted with Synovex-S®, vaccinated with Bovishield® 4 (Norden) and injected with Ivomec® (MSD Agvet). Cattle were revaccinated with Bovishield® 4 on day 10 after arrival. At 90 days post arrival, cattle were reimplanted with Synovex-S® (Syntex), revaccinated with Bovishield® 4 and injected with 7-way Clostridial vaccine (Affiliated Labs).

All calves were fed warm up rations ad libitum from arrival until November 23 by which time all pens demonstrated stable consumption. At

amount of limit fed rations was increased by 10%. Limit fed pens were fed once daily at 8 AM and full fed pens were fed 3 times per day. A check weight was taken on December 22, approximately 30 days into the growing period.

All pens regardless of treatment, were switched to full feeding of the finishing ration (Table 2) when individual pens weighed approximately 750 lbs. Pens were reweighed full at this time. At the end of the growing period, two feeder calf order buyers and one packer buyer scored all pens for body condition (scale of 1 = very thin to 9 = very fat). All calves were slaughtered at a commercial packing facility and carcass data were obtained from USDA graders. All weights from the time of arrival at the feedlot to slaughter were adjusted to a 4% shrunk basis.

Table 2. Final finishing ration for all pens.

Ingredient	% DM	Percent in ration, as fed
Corn silage	34.5	19.0
Flaked corn	79.0	32.5
Flaked milo	79.0	30.0
Wheats midds	88.0	10.0
Supp, finisher[a]	95.5	3.2
Fat	99.0	3.3
Beet molasses	73.0	2.0
Dry matter, %		72.5
Rumensin, g/ton		19.5
Tylan, g/ton		6.2
Nutrients, DM basis: %		
NEm, Mcal/cwt	99.7	
NEg, Mcal/cwt	66.5	
Crude protein, %	13.2	
Concentrate, %	92	
Crude fiber, %	5.9	
Potassium, %	0.7	
Calcium, %	0.65	
Phosphorus, %	0.36	
Magnesium, %	0.22	

[a] Finisher supp (%): 72 CP; 63 NPN; 13 Ca; .5 P; 1.1 K.

Table 4. Performance of steers during the growing period.

	Limit fed		Full fed
	Treatment[a] 1	Treatment 2	Treatment 3
Beginning wt, growing period	545	544	539
Growing days	87	89	78
Respiratory pulls, %	14.8[b]	11.6[c]	11.3[c]
Digestive pulls, %	1.0	.3	0
Respiratory deads, %	1.0	.3	0
Digestive deads, %	1.1	.7	.5
Daily gain, lb	2.36[b]	2.38[b]	2.79[c]
DM intake, lb	12.98[b]	11.9[b]	15.15[c]
Feed:gain	5.50[b]	5.02[c]	5.43[b]
Cost of Gain ($/cwt)	42.84	39.73	40.18
Condition score[d]	5.2[b]	5.2[b]	6.7[c]

[a] Treatments 1 & 3 = 61 Mcal/100 lb dry matter; Treatment 2 = 66 Mcal/100 lb dry matter.

[b,c] Means on row with different superscript letters differ ($P<.05$).

[d] Scale of 1 = very thin to 9 = very fat.

Gains of limit fed calves were slightly greater than the target gain of 2.20 lb/day. As expected, Treatment 2 calves fed the 66 Mcal ration were more efficient ($P<.05$) than Treatment 1 calves fed the 61 Mcal ration, although feed efficiency for both limit fed groups was excellent and comparable to or above that for full fed calves. Cost of gain was lowest for Treatment 2 and 3 calves during the growing period. Calves that were full fed during the growing period were fatter at the end of the growing period ($P<.05$) than limit fed calves. Condition scores for limit fed treatments were similar.

More calves from Treatment 1 were pulled during the growing period ($P<.05$) than from Treatments 2 and 3. Reasons for this difference are not apparent. The number of calves treated for respiratory or digestive disorders during the growing period was similar for all treatments. No bullers were observed in any pens during the entire study.

Limit fed calves received their feed allocation at one feeding daily at 8:00 AM. Early in the limit feeding period calves would consume all their

limit fed. Limit fed treatments tended to be heavier at slaughter than full fed calves, suggesting that limit feeding can increase slaughter weight of weaned calves when placed directly in the feedlot. The number of days from the time calves weighed about 750 lbs to slaughter was 122 days for all treatments.

The total feeding period was 11 days longer for limit fed calves than controls (Table 6). Daily gains were not significantly different, although overall average feed intake tended to be lowest for limit fed calves. Cost of gain tended to favor limit fed calves.

Carcass weight (Table 7) followed live weight with limit fed calves tending to have the heaviest carcasses. Dressing percent was similar for all groups. Quality grade was also similar for all treatments with Treatment 3 tending to have more choice and fewer standard grade carcasses. Yield grades were similar for all groups. More ($P<.05$) condemned livers were noted among limit fed treatments. Whether the greater incidence of condemned livers is related to eating behavior during the limit feeding period or during the subsequent finishing phase is not known and bears further study.

Table 6. Performance of steers during the total feeding period.

	Limit fed		Full fed
	Treatment[a] 1	Treatment 2	Treatment 3
Total days	210	210	199
Daily gain, lb	2.79	2.85	2.90
DM intake, lb	15.16	15.18	16.36
Feed:gain (DM)	5.43	5.34	5.65
Cost of Gain ($/cwt)	41.17	40.63	42.00

[a] Treatments 1 & 3 = 61 Mcal/100 lb dry matter; Treatment 2 = 66 Mcal/100 lb dry matter.

EFFECTS OF SUPEROXYGENATION OF DRINKING WATER ON PERFORMANCE AND CARCASS CHARACTERISTICS OF FEEDLOT STEERS

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Story in Brief

Three hundred seventy five number one Okie steers (840 pounds) were used to compare the effects of superoxygenation of drinking water on feedlot performance and carcass characteristics. The steers received standard feedlot processing on arrival and were individually weighed and tagged. The steers were fed the standard 62 Mcals/cwt NEg feedlot diet. Average daily dry matter feed consumption, average daily gain, feed conversion and cost of gain favored the control pens. The control pens also consumed less water. Cattle receiving ozone treated water had more outside fat cover; however fewer of these animals graded choice.

(Key Words: Ozonized Water, Feedlot Steers, Feedlot Performance.)

Introduction

Recently, there has been renewed interest in the superoxygenation of the drinking water of feedlot steers. In a recent trial, Lee (1989, unpublished data) showed improvement in feedlot rate of gain and a concomitant improvement in feed efficiency of a magnitude comparable to that seen by the addition of an ionophore to the diet of feedlot steers. This study was designed to study the efficacy of the superoxygenation system in the commercial feedlot environment.

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animals consumed more feed (21.04 vs 20.14 lb/hd/day), had a higher ADG (3.59 vs 3.39 lb/hd/day), and had a more efficient F/G (5.87 vs 5.94 lb feed/lb gain). The ADG and F/G data are in contrast with the findings of Lee (1989). The feedlot cost of gain favored the control animals (43.96 vs 46.36 $/cwt). The calculated metabolizable energy of the diet (Table 2), as determined from animal performance indicates a slight numerical advantage for the control animals. This result is expected considering the ADG and ADF data (Table 1)

When comparing carcass parameters (Table 2), the animals on the ozone treatment had a numerically greater dressing percentage, superior marbling score and yield grade. The KPH% of the treated animals averaged higher than the controls ($P<.09$). The ozone treated animals had more outside fat cover, which is similar to the findings of Lee (1989, unpublished data); however, there were 8% fewer animals grading choice in the treated group than for the controls. This is an apparent contradiction, recognizing that the treated animals averaged a higher marbling score. These anomalies may be attributed to biological variability within the treatment groups.

The data in Table 3 reflecting average daily air temperature depict an abnormally warm situation during the course of the experiment. The efficiency of superoxygenation of the drinking water may have been hampered by the high environmental temperatures. Other experiments cited were conducted during the winter months and environment may have contributed to conflicting results.

Superoxygenation of drinking water for feedlot steers had no significant impact on either performance or carcass parameters considered in this study.

Table 2. Carcass characteristics of feedlot steers.

	Control	Ozone	SE
Hot carcass wt., lb	779	762	5.89
Rib eye area, sq. in.	13.0	12.7	.09
KHP, %	2.18[a]	2.21[b]	.01
Fat thickness, in.	.57	.63	.02
Marbling score	443	447	9.43
Yield grade	3.36	3.17	.09
Choice, %	64	56	.008
Dressing percent	63.4	63.5	

[a,b]Means with different superscripts are different ($P<.09$).

Table 3. Average air temperature.

	Degrees Fahrenheit		
	High	Low	Mean
May	75.7	47.2	60.8
June	95.1	61.4	77.9
July	93.3	64.6	78.5
August	93.3	63.4	77.0
September	86.0	59.8	73.1

VIRGINIAMYCIN AND MONENSIN EFFECTS ON PERFORMANCE AND CARCASS CHARACTERISTICS OF FEEDLOT STEERS: A THREE TRIAL SUMMARY

M.T. Van Koevering[1], D.R. Gill[2], F.N. Owens[2], H.G. Dolezal[3] and J.A. Rogers[4]

Story in Brief

Effects of three levels of virginiamycin (10, 17.5 and 25 g/ton) on cattle performance and carcass characteristics were tested by comparison of diets with either no ionophore (control) or those containing monensin. Seven hundred and forty four steers, initially weighing 735 pound were fed approximately 123 days. Virginiamycin at the highest level slightly increased daily gains (2.4%) and feed conversion (3.2%). Feed intake was not different from controls, but it was higher with added virginiamycin than with added monensin. During the second period and over the entire trial, feed conversion increased linearly as virginiamycin was added. Increasing levels of virginiamycin also increased linearly the calculated energy content of the diet (2.9% at 25 g/ton). The percentage of cattle obtaining a yield grade of 4 or greater also increased linearly with virginiamycin supplementation. Virginiamycin appears to ease adaptation to feed, reduce liver abscess incidence, and improve feed efficiency of feedlot steers.

(Key Words: Virginiamycin, Monensin, Antibiotic, Steers.)

Introduction

The addition of certain feed additives, including antimicrobial agents like virginiamycin, to domestic livestock diets may enhance rate and efficiency of gain. Virginiamycin was tested recently by SmithKline Beecham Animal Health (SBAH) to obtain an FDA clearance for use in feedlot cattle. As part of this protocol, three feedlot trials were conducted with virginiamycin to determine the proper feeding level, its effect on gain, feed efficiency, and the incidence of liver abscesses, and to compare it to the established feed additive, monensin.

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Materials and Methods

Three previous trials involving a total of 744 yearling feedlot steers initially weighing 735 lb have been summarized (Gill et al., 1990; Gill et al., 1989; Smith et al., 1989). Steers were selected from larger groups of cattle for uniformity in type, size, and weight. All cattle were blocked by weight and randomly allotted to pens following routine feedlot processing with vaccinations of IBR-PI_3-Lepto and 4-way clostridial and dewormed with Ivermectin. In two of the studies, steers received anabolic implants; in the third, anabolic implants were not used.

Steers had ad libitum access to a high concentrate diet (Table 1) for the entire feeding period. Additional alfalfa hay and cottonseed hulls were

Table 1. Composition of diets on a dry matter basis.

Ingredient	Ration sequence 1	2	3	4	Final
	(%)				
Corn, steam flaked	39.52	49.52	59.52	69.52	81.52
Alfalfa hay	25.00	20.00	15.00	10.00	5.00
Cottonseed hulls	25.00	20.00	15.00	10.00	3.00
Cane molasses	3.75	3.75	3.75	3.75	3.75
Supplement[a]	6.73	6.73	6.73	6.73	6.73

Calculated composition of the final ration:

Nutrients	Ration composition DM %	As Fed %	Supplement composition DM %	As Fed %
NEm, Mcal/cwt	95.04	80.39	67.55	62.39
NEg, Mcal/cwt	61.56	52.07	44.85	41.42
Crude protein, %	12.25	10.36	51.33	47.41
Crude fiber, %	5.46	4.62	9.55	8.82
K, %	.69	.58	1.03	.95
Ca, %	.45	.38	4.73	4.37
P, %	.33	.28	1.11	1.02
Dry matter, %	100.00	85.00	100.00	92.26

[a] Supplement composition: Cottonseed meal 77.04%, calcium carbonate 11.03%, urea 5.60%, salt 4.24%, dicalcium phosphate .92%, trace mineral .18%, vitamin E .14%, vitamin A 30,000 IU .17% and virginiamycin premix (Stafac-10) or monensin (Rumensin 60) as required.

added to the initial rations to facilitate diet adaptation (Rations 1-4, Table 1). In all trials, virginiamycin was compared to diets containing no ionophore (control) and, in two studies, to diets containing monensin. Virginiamycin was fed at concentrations of 10, 17.5 and 25 g/ton whereas monensin was fed at 25 g/ton of feed.

Initial weights were obtained off the truck; other weights were taken without feed or water withdrawal. Gains and feed efficiency (Table 2) were calculated based on shrunk weights (96% of full weight). Cattle were fed for an average of 123 days (Period 1), after which all cattle were fed the control nonmedicated ration for six days prior to slaughter (Period 2). All cattle were trucked 60 miles to Booker, Texas for slaughter. Livers were examined for the presence of liver abscesses and flukes. Carcass data were collected (Table 3) 24 hours postmortem and yield and quality grades were determined (USDA, 1987).

The trials were combined and analyzed with the main effect of treatment, divided into four orthoginal contrasts consisting of monensin vs the average of the 3 virginiamycin levels, and linear, quadratic and cubic effects of virginiamycin.

Results and Discussion

Virginiamycin at the highest level (25 g/ton) slightly increased ADG (2.4%) and feed efficiency (3.2%). Feed intake with virginiamycin did not differ from the control diet but remained higher ($P<.01$) than with the monensin diet during all periods of the trial. Feed efficiency increased linearly during the second period ($P<.08$) and over the entire trial ($P<.07$) with added virginiamycin. Increasing levels of virginiamycin also linearly increased ($P<.05$) the calculated NEg of the diet (by 2.9% at 25 g/ton) demonstrating that the cattle utilized the dietary nutrients more efficiently. The percentage of yield grade 4 (YG4) cattle increased linearly ($P<.05$) with supplementation of virginiamycin suggesting that improvements in efficiency may have been greater had the cattle been killed at an equal body composition. Virginiamycin supplemented at the highest concentrations (17.5 g and 25 g/ton) tended to reduce the incidence of liver abscesses. No other carcass characteristics were changed by treatment.

Table 2. Effect of virginiamycin on steer performance.

	Control	Virginiamycin 10 g/ton	Virginiamycin 17.5 g/ton	Virginiamycin 25 g/ton	Monensin 25 g/ton	Sig.[a] Prob.
No. of head	174	216	134	80	135	
Pens	21	25	17	8	17	
Weight, lb						
Initial	736	735	735	735	736	
Final	1187	1189	1176	1203	1187	
Daily gains, lb						
Carcass basis[b]	3.63	3.66	3.67	3.73	3.62	
Daily feed, lb DM						
First period	21.83	21.78	21.64	22.01	21.24	M vs V (.05)
Second period	22.07	21.78	21.94	21.86	21.00	M vs V (.01)
0-Slaughter	21.83	21.69	21.73	21.79	21.03	M vs V (.01)
Feed/gain						
First period	5.72	5.65	5.67	5.61	5.62	
Second period	7.13	6.95	6.98	6.75	6.91	VL (.08)
0-Slaughter	6.01	5.92	5.91	5.82	5.80	VL (.07)

Table 2. (Continued)

	Control	Virginiamycin 10 g/ton	Virginiamycin 17.5 g/ton	Virginiamycin 25 g/ton	Monensin 25 g/ton	Sig.[a] Prob.
Metabolizable energy, Mcal/kg	3.16	3.19	3.19	3.23	3.24	VL (.06)
Net energy, Mcal/lb						
Maintenance	96.6	98.2	98.5	100.4	100.6	VL (.05)
Gain	63.5	64.3	64.5	65.4	65.6	VL (.06)

[a]M vs V: Monensin compared to the average of the three virginiamycin treatments. VL: virginiamycin linear effect.
[b]Final weight calculated as carcass weight/.64.

Table 3. Effect of virginiamycin on carcass characteristics

		Virginiamycin			
	Control	10 g/ton	17.5 g/ton	25 g/ton	Monensin 25 g/ton
Carcass wt, lb	749	751	753	758	749
Dressing %[a]	62.73	62.64	62.73	62.72	62.92
Rib eye area, sq in	12.84	12.68	12.87	12.91	12.69
KPH, %	1.99	2.04	2.05	2.04	2.04
Fat thickness, in	.49	.49	.49	.49	.53
Marbling score[b]	429	424	426	424	414
Percent choice	67.47	66.58	64.70	62.20	63.55
Percent YG 4[c]	1.62	9.83	10.10	10.10	8.57
Liver abscess:					
Incidence, %	18.89	19.56	14.76	14.76	20.99

[a] Calculated by dividing hot carcass weight by the gross final weight.
[b] 300-399 = slight; 400-499 = small (USDA, 1987).
[c] Linear effect of virginiamycin ($P<.05$).

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THE EFFECT OF LAIDLOMYCIN PROPIONATE AND TYLOSIN ON PERFORMANCE AND CARCASS CHARACTERISTICS OF FEEDLOT STEERS

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Story in Brief

One hundred and forty Angus and Hereford X Angus crossbred steers were used to evaluate the efficacy of laidlomycin propionate supplemented at 10 g/ton alone and in combination with tylosin (9 g/ton). Administration of laidlomycin propionate resulted in a heavier final live weight. Daily gains (live weight basis) during the first half of the trial were increased 8.3% by laidlomycin propionate. Tylosin alone increased daily gain 10.2% during the second half of the trial. Daily gains for the 111 day trial (live weight basis) were improved 8.1% by laidlomycin propionate and 7.3% by tylosin. Lack of a significant interaction would imply that these two drugs were additive, but examination of means revealed that adding tylosin to the laidlomycin propionate diet provided little if any benefit except for reducing the incidence of liver abscesses. Laidlomycin propionate increased the efficiency of feed utilization 9.0% during the first half of the trial and 8.9% over the entire trial. Tylosin also improved feed efficiency over the entire trial by 4.0% (6.9% with controls vs .85% with the laidlomycin propionate diet). Laidlomycin propionate did not increase marbling scores or quality grades nor were any differences noted in ribeye muscle cooking properties or tenderness among the treatment groups. This ionophore-antibiotic combination should be economically important for cattle producers.

(Key Words: Laidlomycin Propionate, Tylosin, Feedlot, Steers, Ionophore.)

Introduction

Laidlomycin propionate is a new ionophore that increases daily gain and improves feed conversion (Gill et al., 1987; Spires et al., 1990; Mader et al., 1991). The efficacy of feeding laidlomycin propionate alone or in

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combination with tylosin, an antibiotic already cleared to reduce liver abscesses, was studied in this trial. Laidlomycin propionate increases the concentration of propionate in rumen fluid (Spires and Algeo, 1983) allowing feedlot steers to utilize their diets more efficiently and may inhibit bacteria that produce lactic acid. Still under investigation for FDA approval, laidlomycin propionate is not yet available to the commercial producer.

Materials and Methods

One hundred and forty Angus and Hereford X Angus crossbred steers, originating from a single ranch in Nebraska, were selected from a larger group based on uniformity of size, weight and breed. Steers were blocked by initial weight and allotted to pens and treatments in a randomized block design. Five pens of seven steers each were allocated to each of four treatments. Dietary treatments consisted of controls (basal diet), laidlomycin propionate (10 g/ton), tylosin (9 g/ton) and the combination of laidlomycin propionate (10 g/ton) and tylosin (9 g/ton). Upon arrival, steers were individually weighed, identified, vaccinated with IBR-PI_3 (MLV) IM, Clostridia chauvoei, septicum, novyi, sordellii and perfingens types C and D bacterin, and dewormed with Ivermectin. Steers were not implanted. Steers were allowed free access to hay and water overnight after arrival.

Steers were given ad libitum access to high concentrate diets from self-feeders for the entire feeding period. Cottonseed hulls plus chopped alfalfa, used as roughage sources, were sequentially removed from the diet to aid in adaptation of cattle to the final diet (Table 1). Steers were allowed a 9-day adaptation period before the drug treatments were initiated. Steers were receiving their final ration by day 17 of the study. After obtaining the 111-day weight, all cattle were placed on the control ration for a drug withdrawal period of ten days prior to slaughter.

Initial weights were obtained directly off the truck. Following the 9-day adaptation period, cattle were shrunk (no feed or water) for 18 hours on two consecutive days in order to obtain an initial shrunk weight at the initiation of drug treatments. Gains and feed efficiency were calculated based on shrunk period weights (96% of full weight except for the initial and 111 day weight) to account for fill. Two steers were removed from the laidlomycin propionate treatment for reasons not associated with drug treatments. Cattle were trucked to Dodge City, Kansas for slaughter. At the time of slaughter, livers were examined for the presence and severity of liver abscesses. Carcass data were obtained 24 hour postmortem and yield and quality grades were determined (USDA, 1989). Approximately 8 inches of Longissimus muscle (ribeye) corresponding to the 9-12th rib section was removed from the left side of each carcass and vacuum packaged. Ribeye sections were

Table 1. Composition of diets (dry matter basis).

Ingredient	Diet Sequence 1	2	3	4	Final
			(%)		
Corn, rolled	38.08	48.08	58.08	68.08	79.58
Alfalfa hay, pelleted	30.00	25.00	18.75	12.50	4.50
Cottonseed hulls	20.00	15.00	11.25	7.50	4.00
Molasses, cane	3.75	3.75	3.75	3.75	3.75
Pelleted supplement[a]	8.17	8.17	8.17	8.17	8.17

Calculated Composition:

Nutrients	Diet DM %	Diet As Fed %	Supplement DM %	Supplement As Fed %
Dry matter, %	100.00	87.80	100.00	91.76
NEm, Mcal/cwt	92.26	81.00	65.47	60.07
NEg, Mcal/cwt	61.01	53.57	43.64	40.04
Crude protein, %	12.76	11.20	51.34	47.11
Crude fiber, %	5.92	5.19	10.07	9.24
K, %	.69	.60	1.21	1.11
Ca, %	.50	.44	4.48	4.11
P, %	.33	.29	.98	.90

[a] Supplement composition: Soybean meal 45.00%; cottonseed meal 34.18%; calcium carbonate 10.49%; urea 4.89%; salt 3.67%; dicalcium phosphate 1.46%; trace mineral mixture .16%; vitamin A (30,000 IU/g) .13%; Laidlomycin propionate premix 0 or .12%; Tylosin premix 0 or .14%.

aged for 10 days at 33°F before a one inch thick steak (12th rib end) was removed for broiling (medium degree of doneness). Cooking time, cooking shrinkage and shear force (tenderness) were determined for each steak. Data were analyzed on a pen basis using the general linear model of SAS with the main effects of weight block, laidlomycin propionate, tylosin and the interaction of laidlomycin propionate and tylosin included in the model. Least squares means are reported. When the interaction was not significant ($P>.10$), main effect means were contrasted statistically.

Results and Discussion

Effects of laidlomycin propionate and tylosin on cattle performance are reported in Table 2. Except for KPH percentage (Table 3), no interactions of these two drugs were detected ($P>.10$). Hence overall treatment means are presented and discussed. Cattle supplemented with laidlomycin propionate had greater ($P<.05$) weights at 111 days than control cattle. Daily gains of cattle supplemented with laidlomycin propionate averaged 8.3% higher ($P<.05$) during the first half of the trial; while daily gains during the second half were 10.2% greater ($P<.05$) with tylosin. Averaged over the 111 days, daily gains were increased 8.1% by laidlomycin propionate ($P<.05$) and by 7.3% with tylosin ($P<.10$). This increase in daily gain is similar to the findings of Spires et al. (1990) and Mader et al. (1991). Laidlomycin propionate may allow cattle to adapt to their high concentrate diets faster and thereby increase gain, because this ionophore has been reported to inhibit lactic acid production in the rumen. Tylosin may reduce digestive upsets occurring late in the feeding period as demonstrated by higher gains during this time. Improved liver health, discussed later, also might explain this benefit. Gains based on carcass weight, though tending to increase (4.8% with laidlomycin propionate and 3.6% with tylosin) were not significantly improved ($P<.19$, $P<.60$). The difference observed between live weight and carcass adjusted daily gains may be due to the 10-day withdrawal period required for laidlomycin propionate.

Although no differences in feed intake were detected, groups differed in efficiency. Supplementation with laidlomycin propionate to the diet improved ($P<.01$) the efficiency (9.0%) of feed utilization during the first half of the trial. Efficiency of feed utilization averaged across the 111 days was 8.9% greater ($P<.01$) with laidlomycin propionate and 8.1% greater ($P<.10$) with tylosin. Calculated metabolizable and net energy values for diets containing laidlomycin propionate were greater ($P<.05$) supporting the concept that energy utilization was improved. These data are consistent with earlier studies in which laidlomycin propionate improved feed conversion (Gill et al., 1987; Spires et al., 1990; Mader et al., 1991). Tylosin improved ($P<.10$) feed efficiency over the total trial by 4.0% based on live weights, but the 4.5% advantage in NEg with tylosin, based on hot carcass weight after the 10 day withdrawal was not significant ($P<.59$). The difference between live weight, feed efficiency and carcass adjusted NE_g maybe a result of the 10-day withdrawal period required for all drugs in this study.

Carcass characteristics were similar between treatments except for KPH, percent yield grade 4's or greater, and condemned livers. For KPH%, an interaction ($P<.06$) was detected. Administration of laidlomycin propionate or tylosin alone tended to increase KPH as compared to the combination of these two drugs. The increased percentage of yield grade 4's

Table 2. Effects of laidlomycin propionate or tylosin on steer performance.

Item	Laidlomycin Propionate	Tylosin	Treatment				SEM	Effect[ab]	
								Laidlomycin Propionate	Tylosin
No. of pens	0	0	5	5	5	5			
No. of steers			35	33	35	35			
Weight, lb:									
Initial			719	722	718	717	1.47		
111 days			1115	1149	1139	1146	7.77	*	
Daily Gains, lb:									
0-55			4.20	4.59	4.36	4.50	.10	*	
55-111			2.95	3.12	3.24	3.25	.09		*
0-111			3.57	3.85	3.79	3.87	.07	*	†
Carcass, ADG[c]			3.36	3.51	3.44	3.52	.09		
Daily feed, lb DM:									
0-55			22.75	22.63	22.38	22.13	.31		
55-111			23.06	22.38	22.97	22.88	.38		
0-111			22.91	22.50	22.68	22.51	.30		
0-slaughter			22.57	22.13	22.39	22.24	.29		

Table 2. (Continued)

Item	Laidlomycin Propionate	Tylosin	Treatment 0 0	+ 0	0 +	+ +	SEM	Effect[ab] Laidlomycin Propionate	Tylosin
Feed/gain									
0-55			5.43	4.95	5.14	4.93	.10	**	
55-111			7.83	7.21	7.12	7.07	.27		
0-111			6.42	5.87	5.98	5.82	.12	**	†
0-Slaughter			6.74	6.31	6.51	6.32	.15	†	
Metabolizable energy, Mcal/kg			2.88	3.01	2.94	2.99	.04	*	
Net energy, Mcal/cwt									
Maintenance			83.97	89.50	86.26	88.78	1.82	*	
Gain			55.77	59.50	57.47	59.14	1.22	*	

[a] † = P<.10, * = P<.05, ** = P<.01

[b] Interactions not significant (P>.10).

[c] Carcass average daily gain (carcass weight/.638)/121 days.

Table 3. Effects of laidlomycin or tylosin on carcass characteristics.

Item	Laidlomycin	Propionate	Tylosin	Treatment				SEM	Effect[ab]		
									Laidlomycin	Propionate	Tylosin
Carcass wt, lb.	0	0	0	718	732	724	730	6.55			
Dressing %[c]	0	0	+	64.4	63.7	63.5	63.6	.40			
Ribeye area, sq. in.	0	+	0	12.35	12.48	12.28	12.42	.16			
KPH, %[d]	0	+	+	2.23[e]	2.36[f]	2.36[f]	2.30[ef]	.04			
Fat thickness, in.	+	0	0	.51	.55	.48	.51	.03			
Marbling score[g]	+	0	+	463	463	448	460	13.99			
Maturity[h]	+	+	0	134.6	136.3	135.7	134.7	1.78			
Choice, %	+	+	+	85.7	76.0	80.0	88.6	8.14			
USDA Yield Grade				3.05	3.19	3.04	3.08	.10			
Percent YG4				0	5.71	0	8.57	2.86	*		
Condemned liver, %				22.9	21.1	11.4	0	5.96			*

Table 3. (Continued).

Item	Laidlomycin Propionate / Tylosin	Treatment				SEM	Effect[ab]	
		0 / 0	+ / 0	0 / +	+ / +		Laidlomycin Propionate	Tylosin
Raw, wt., oz		8.78	8.90	8.48	8.71	4.33		
Cooking time, min/3 oz		20.43	20.94	20.23	20.60	.62		
Cooking shrink, %		26.65	26.59	27.23	26.77	.48		
Shear force, lbs		7.82	8.15	8.02	8.06	.09		

[a] Significant effect of Laidlomycin propionate or Tylosin † = P < .10, * = P < .05, ** = P < .01.
[b] Interaction were not significant (P < .10) except for KPH.
[c] Calculated by dividing gross 111-day weight by carcass weight.
[d,e,f] Interaction significant (P < .10), means with different superscripts differ P < .10.
[g] 300-399, slight; 400-499, small.
[h] Calculated by averaging lean maturity and skeletal maturity.

or greater found with laidlomycin propionate feeding probably reflects the increased carcass weight or additive effect of heavier carcass weights, with slightly higher KPH. When hot carcass weight was included as a covariate Mader et al. (1991) also reported greater fat deposition in the form of KPH and marbling when cattle were supplemented with laidlomycin propionate. Tylosin, as previously reported (Strasia et al., 1987; Stock et al., 1986), decreased ($P<.05$) the percentage of cattle with condemned livers. However, considering healthy animals alone, tylosin feeding during the second half of the trial still increased ($P<.08$) ADG suggesting tylosin's effects on gain were not due to liver abscesses alone. No ($P>.10$) differences were noted for cooking time, cooking shrinkage or tenderness (shear force).

Supplementation of laidlomycin propionate and tylosin increased daily live weight gain, improved live feed conversion, and reduced the incidence of condemned livers. This ionophore-antibiotic combination should be economically useful for cattle producers.

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EFFECT OF DAILY ROTATION OF IONOPHORES ON RUMINAL FERMENTATION IN CATTLE FED CONCENTRATE DIETS

J. Zorrilla-Rios[1], J.D. Garza-F[1] and F.N. Owens[2]

Story in Brief

Eleven mature ruminally cannulated cattle were fed an 80% concentrate diet to examine ruminal fermentation changes in response to several different ionophore programs. Animals received their basal diet for 2 weeks. Starting with the third week, 4 different treatments were imposed: 1) control (no ionophores), 2) monensin-tylosin (300 mg/day) fed continuously, 3) lasalocid (300 mg/day) fed continuously and 4) daily rotation of 2 and 3. Ionophores were fed for 5 consecutive weeks, followed by a 3-week ionophore withdrawal period. Compared to the other treatments, monensin plus tylosin tended to be more effective at depressing total gas and methane production. In vitro ammonia concentration and ruminal pH were not altered by dietary treatments. No synergistic effects on ruminal microbial fermentation activity were apparent from the daily rotational ionophore program as compared to the mean of monensin-tylosin or lasalocid fed individually. In vitro batch culture procedures can rapidly screen ionophore feeding programs.

(Key Words: Ionophores, Fermentation, Beef Cattle.)

Introduction

The use of ionophores to improve feed efficiency in cattle is a common practice in the feedlot industry. However, individual ionophores differ in their effect on performance. Continuous feeding of monensin depresses feed intake with little effect on gain; in contrast, lasalocid fed continuously has limited effect on feed intake but increases rate of gain. Knowledge of such individual ionophore characteristics could be employed to enhance ionophore usefulness during the feeding cycle. Branine et al. (1989) suggested that feeding of monensin and lasalocid on alternate days to beef cattle enhanced feed efficiency and gain more than continuous use of either ionophore alone.

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[1]Research Associate [2]Regents Professor

In addition, daily rotation versus weekly ionophore rotation gave more consistent responses in feed efficiency and rate of gain. Mechanisms of these responses are not clear, but it has been suggested that bacteria are less likely to adapt to an ionophore when ionophores are fed on alternate days. The objectives of this study were to determine the effect of 3 different ionophore programs on in vitro ruminal fermentation changes and to develop procedures for in vitro measurements of total gas, methane and ammonia.

Materials and Methods

Eleven mature beef cattle with large rumen cannulas, were allotted randomly to individual pens and fed a 80% concentrate basal diet. Animals were fed twice daily (8:30 am and 4:30 pm) and water was available at all times during the 10-week trial. The first two weeks of the study served as a control period; the basal diet was fed without ionophores. From week 3 to 7, three different ionophore treatments were imposed. Treatments included additions of 1) control (no ionophore), 2) monensin-tylosin (300 mg/day) fed continuously, 3) lasalocid (300 mg/day) fed continuously, and 4) daily rotation of 2 and 3. For the last 3 weeks of the study, ionophores were withdrawn from the diet. Ruminal liquid samples were taken weekly during the entire trial at 2 h after the morning feeding. Samples were strained through four layers of cheese cloth and pH was recorded immediately. Ruminal fluid was transferred to the laboratory in a pre-warmed thermos for in vitro batch culture studies.

Hungate culture tubes (15 ml) with a screw cap and rubber septum were used to incubate 2.5 ml of strained ruminal fluid with 250 mg of ground corn. All tubes received 2.5 ml of McDougall's artificial saliva plus 200 ul of a glutamic acid solution. Prior to incubation, all culture tubes were bubbled with CO_2. Tubes were run in triplicate and incubated in a water bath at 38^{o}C for approximately 22 h. Total gas production was measured directly with a graduated syringe equipped with a 23 gauge needle. Thereafter, cultured tubes were maintained on ice for gas chromatographic analysis (methane). Ammonia-N (NH_3-N) was determined colorimetrically (Broderick and Kang, 1980).

Data were subjected to analysis of variance for a completely random design with a model including ionophore treatments as the main plot and sampling (weeks) in the subplot. Means were adjusted by analysis of covariance to pre-treatment measurements. Orthogonal contrasts were used to compare treatment effects.

Results and Discussion

In vitro fermentation measurements during the period of ionophore administration (week 3 through 7) are presented in Table 1. Ionophore treatments reduced total gas ($P<.001$) and methane production ($P<.01$). Likewise differences were apparent between individual ionophores. Monensin-tylosin were more effective (4.0 vs 5.1 ml; $P<.001$) decreasing total methane production than lasalocid, but similar (5.1 vs 4.5 ml) to the daily ionophore rotation program. Past in vivo and in vitro studies (Thornton and Owens, 1981; Salim, 1989) indicated that addition of ionophores to the diet may reduce methane production from 13 to 27%. In Thornton's study, addition of 200 mg/day of monensin to low, medium and high roughage diets decreased methane production by 16% and 24%, compared to 15.1% in this study. In addition, methane reduction may be greatest during the first 12 to 15 days of ionophore administration (Rumper et al., 1986; Salim, 1989). Total methane production in this study tended to drop during the first 21 days of the trial; thereafter, methane concentrations increased to pre treatment levels (Figure 1). However values were always lower with the monensin-tylosin treatment except during week 3 when the rotation program gave the lowest values.

Continuous or daily rotation of ionophores did not alter ruminal fluid ammonia concentration or pH (Table 1). Similar results have been reported

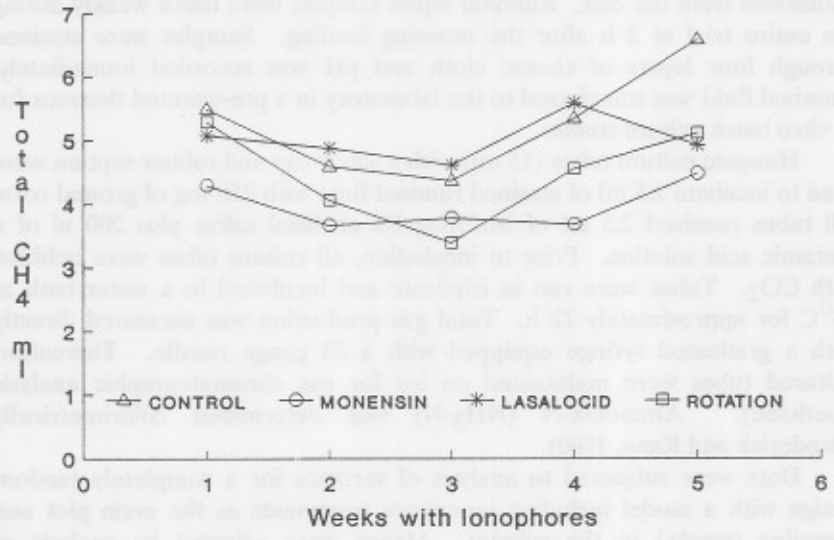


Figure 1. Weekly total methane production changes in beef cattle fed different ionophore programs.

Table 1. Effect of ionophore rotation program on ruminal fermentation.

	Treatments[a]					Orthogonal contrast[b]		
Variables	C	MT	L	DR	SE	C vs Others	MT vs L	DR vs MT,L
Gas, ml	27.3	22.0	22.8	22.6	0.73	.001	NS	NS
Total methane, ml	5.3	3.9	5.1	4.5	0.18	.01	.003	NS
Methane, % of total gas	19.3	18.1	20.8	19.8	0.67	NS	.02	NS
NH_3-N, mg/dl	9.0	8.5	8.1	9.1	0.89	NS	NS	NS
In vitro pH	5.1	5.2	5.2	5.1	0.03	NS	NS	NS

[a] C= Control; MT= Monensin-Tylosin; L= Lasalocid; DR= Daily rotation.
[b] Control vs others; Monensin-Tylosin vs Lasalocid; Daily rotation vs Monensin-Tylosin, Lasalocid.

(Salim, 1989) with steers receiving equivalent ionophore treatments and fed a 90% concentrate diet.

Analysis of values before and during administration of the 3 different ionophore treatments indicated that total gas production dropped (24.2 vs 22.5 ml; $P < .003$) during the treatment phase (Table 2).

Total methane production during the ionophore feeding fell by 15.1% compared to the control period although numerical values (5.3 vs 4.5 ml) showed no statistical differences. Ruminal ammonia concentrations were increased (6.8 vs 8.6 mg/dl) during ionophore inclusion (Table 2). In vivo depression in ruminal ammonia concentration are expected with monensin feeding (Schelling, 1984).

In conclusion, daily rotation of ionophores showed no advantage over a single continuous feeding of either monensin plus tylosin or lasalocid, on the measurements in this study. In addition, monensin-tylosin decreased methane production more than lasalocid. The daily ionophore rotation treatment gave intermediate methane production. Overall, the in vitro batch culture procedure may be a convenient method to evaluate ionophore feeding programs, and may be useful as a tool to test new ionophores.

Table 2. In vitro fermentation changes before and during administration of 3 different ionophore programs.

Variable	Before treatment	After treatment	P[a] Value
Gas, ml	24.2	22.5	.003
Total methane, ml	5.3	4.5	.20
Methane, % of total gas	23.0	19.6	.28
NH_3-N, mg/dl	6.3	8.6	.002
In vitro pH	5.1	5.2	.22

[a] Probability of adjusted means by covariance analysis.

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CONTROLLED RUMINAL INFUSION OF SODIUM BICARBONATE: II. INFLUENCE OF INFUSION INTERVAL ON THE RUMINAL CONDITIONS IN LACTATING COWS

M. Aslam[1], W.B. Tucker[2], J.F. Hogue[1], R.K. Vernon[1], and G.D. Adams[3]

Story in Brief

Four ruminally cannulated, lactating Holstein cows in a 4 x 4 Latin square were used to evaluate the effect of $NaHCO_3$ infusion on ruminal acid-base status. Treatments consisted of infusing water (3.8 liters) alone from 0 to 2 hour postfeeding or infusing 110 grams $NaHCO_3$ in 3.8 liters of water from 0 to 2, 2 to 4, or 4 to 6 hours postfeeding, twice daily. Diets contained sorghum silage and concentrate in a 35:65 ratio (dry matter basis) and were offered for 45 minutes twice daily. Ruminal fluid performance data was collected at feeding and every 30 minutes thereafter for 8 hours on the last day of each experimental period. Free proton concentration in fluid from the rumen was reduced and, with the exception of 2 to 4 hour infusion, buffering capacity increased with $NaHCO_3$ infusion. The acetate to propionate ratio tended to be reduced by $NaHCO_3$ infusion, whereas total VFA concentration was unchanged. Ruminal liquid volume tended to be increased by 0 to 2 hours infusion whereas ruminal outflow rate tended to be reduced by 2 to 4 hours $NaHCO_3$ infusion. Sodium bicarbonate infusion (approximately .73%) into cows receiving supplemental dietary $NaHCO_3$ (.5%) altered ruminal acid base status; however, these alterations were not accompanied by shifts in ruminal VFA patterns that previously have accompanied dietary buffer supplementation.

(Key Words: Sodium Bicarbonate, Ruminal pH, Buffering Capacity.)

Material and Methods

Four ruminally cannulated Holstein cows were arranged in a 4 x 4 Latin square with 1 week experimental periods. A total mixed diet containing .5% $NaHCO_3$ (DM basis; Table 1) with sorghum silage and concentrate in a 35:65 ratio being offered to the cows for 45 minutes, twice daily. Amounts of feed

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Table 1. Ingredient and nutrient composition of diet DM.

Ingredient:	%
Sorghum silage	35.01
Ground shelled corn	40.57
Soybean meal, 44% CP	21.64
Limestone	.92
Dicalcium phosphate	.54
Dynamate[1]	.36
Trace mineralized salt[2]	.46
Sodium bicarbonate	.50
Nutrient[3]:	
DM (as fed)	43.3
Crude protein	17.3
ADF	20.3
NDF	32.4
NE_l, Mcal/kg[4]	1.59
Ca	.57
P	.48
Mg	.33
K	1.39
Na	.39
S	.31
Cl	.42

[1] Double sulfate of K and Mg.
[2] Contained 92% NaCl, .250% Mn, .200% Fe, .033% Cu, .007% I, .005% Zn, and .0025% Co.
[3] Composition from laboratory analyses.
[4] Calculated from ADF.

consumed were recorded. Treatments consisted of infusion of water alone from 0 to 2 hours postfeeding (Ctrl) or infusion of $NaHCO_3$ for 2 hours beginning either at 0 (0-2bic), 2 (2-4bic) or 4 hours (4-6bic) postfeeding. The sodium bicarbonate solution was prepared by dissolving 110 grams $NaHCO_3$ in 3.8 liters of water. The infusion solution was allowed to flow by gravity into the rumen at a controlled rate.

On the morning of the last day of each experimental period, cows were intraruminally dosed with 550 mg Cr as Cr-EDTA immediately before feeding; thereafter, ruminal fluid samples were collected every 30 minutes from 0 to 8 hours postfeeding. Ruminal fluid pH was determined; ruminal fluid was filtered and two, 100 ml aliquots were collected in polyethylene vials and frozen for subsequent measurement of buffering capacity, VFA and Cr.

Buffering capacity was calculated as the amount of acid or base required to titrate ruminal fluid from pH 5 to pH 7, and was expressed as meq/L. Buffer value index (BVI; Hogue, 1991) was calculated utilizing the pH and buffering capacity of the ruminal fluid. A higher BVI indicates that ruminal fluid had greater acid-neutralizing power.

Results and Discussion

Dry Matter Intake, Milk Yield and Milk Composition

DM intake (Table 2) was not affected by any $NaHCO_3$ infusion intervals. Erdman et al. (1980) observed an increase in DM intake with dietary $NaHCO_3$ supplementation.

Milk yield was higher for Ctrl than for 4-6bic potentially a result of the tendency for lower DM intake with 4-6bic. Cows were released from the stanchions immediately following termination of their infusion interval; therefore, 4-6bic cows were confined for a longer interval than the other cows. This added stress may have reduced milk yield. Fat yield and protein yield were not affected by treatment. Milk protein yield, lactose yield, percentage SNF and SNF yield all were reduced for 4-6bic vs Ctrl, potentially a result of reduced intake or increased stress for that treatment.

Ruminal acid base status

Ruminal free proton concentration or acidity ($[H^+]$) tended to be lower for 0-2bic (solid line) than Ctrl (dotted line) at 1.5 but greater at 3.5 hours postfeeding (Figure 1a). The difference at 1.5 hour was during the period of $NaHCO_3$ infusion. Compared to Ctrl, mean ruminal $[H^+]$ from 0 to 8 hours postfeeding was lowered by 2-4bic and 4-6bic, but not affected by 0-2bic (Table 3). The rapid rise in $[H^+]$ during 2 to 4 hour postfeeding (Table 3) for Ctrl and 0-2bic indicated that, whether from dietary or exogenous origin, ruminal effects of this buffer dissipated rapidly.

Overall, ruminal infusion of $NaHCO_3$ tended to increase buffering capacity above that for the water infusion throughout the post feeding interval (Table 3), but the increases did not always correspond temporally to $NaHCO_3$

Table 2. Dry matter intake, milk yield and milk composition of cows receiving ruminal infusion of water from 0 to 2 h, or $NaHCO_3$ for 0 to 2, 2 to 4, or 4 to 6 h after feeding.

	Infusion interval						
	1 0-2 h Water	2 0-2 h $NaHCO_3$	3 2-4 h $NaHCO_3$	4 4-6 h $NaHCO_3$	SE	Effect	P Value
DM intake, kg/d	14.8	15.2	14.5	14.2	.5	NS[1]	
Milk:							
Yield, kg/d	21.2	20.0	21.2	19.1	.7	1 vs. 4	.073
Fat, %	3.39	3.54	3.40	3.45	.18	NS	
Fat yield, kg/d	0.71	.72	.71	.65	.04	NS	
Protein, %	3.00	3.03	2.97	2.98	.03	NS	
Protein yield, kg/d	.63	.61	.62	.56	.02	1 vs. 4	.063
Lactose, %	5.05	5.00	5.06	5.01	.02	1 vs. 2	.071
Lactose yield, kg/d	1.07	1.00	1.07	0.96	.03	1 vs. 4	.052
SNF, %	8.68	8.66	8.65	8.62	.02	1 vs. 4	.038
SNF yield, kg/d	1.84	1.73	1.83	1.64	.06	1 vs. 4	.054
SCC (1,000)	130	161	127	132	24	NS	

[1] Nonsignificant; $P > .15$.

(Figure is continued on pages 264 and 265)

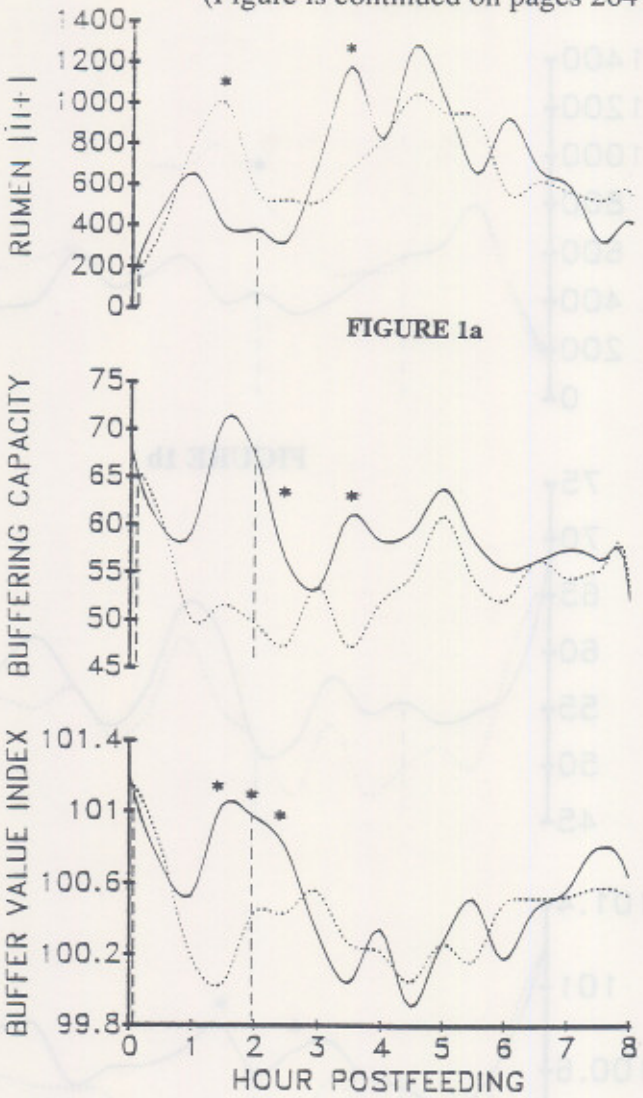


FIGURE 1a

Figure 1. Ruminal buffer value index, buffering capacity (Meq/L) and free proton concentration (neq/L) for Ctrl vs. 0 to 2 hour $NaHCO_3$ infusion, panel A; Ctrl vs. 2 to 4 hour $NaHCO_3$ infusion, panel B; and Ctrl vs. 4 to 6 hour $NaHCO_3$ infusion, panel C. Ctrl = (····); $NaHCO_3$ infusion = (----). Free proton concentration of 1,000 neq/L = a pH of 6; 316 neq/L = a pH of 6.5; and 100 neq/L = a pH of 7. Vertical, dashed lines represent beginning and end of $NaHCO_3$ infusion. * = probability that treatment means are not different ($P < .15$).

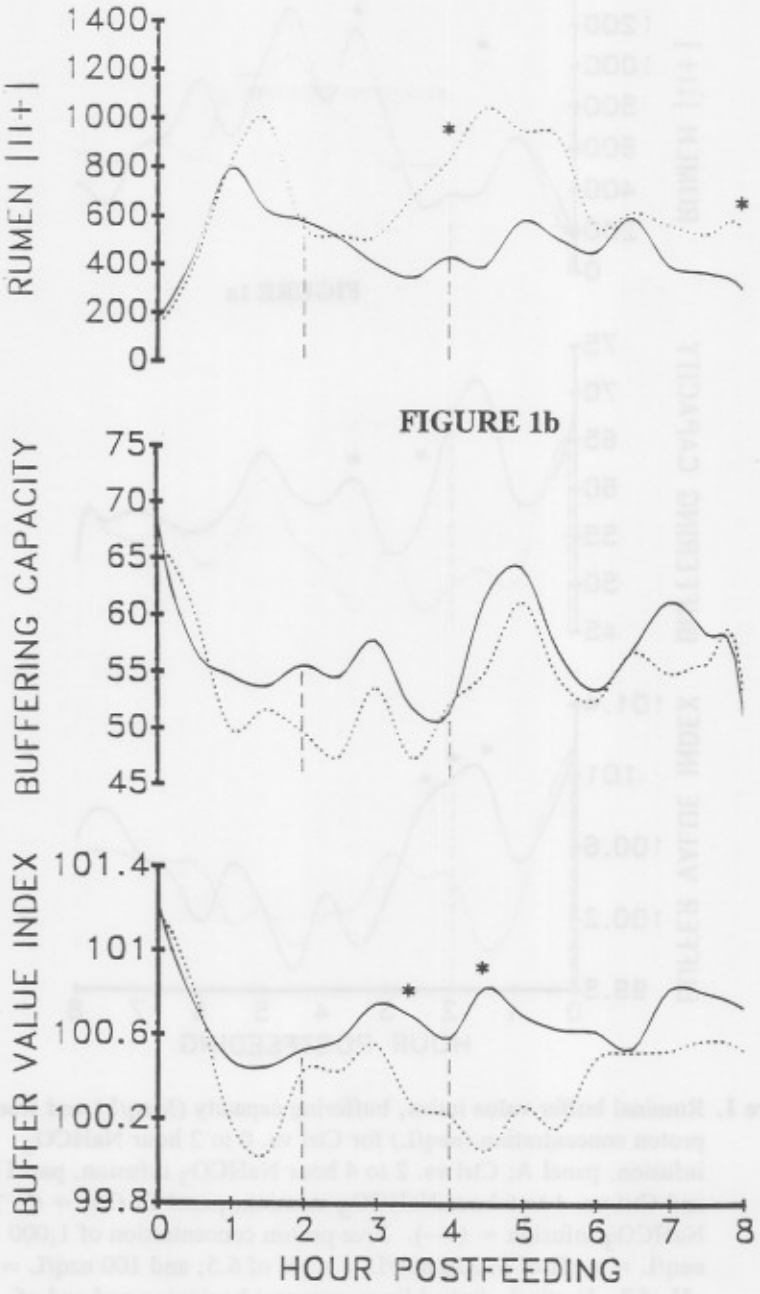

RUMEN (1+1)
1400
1200
1000
800
600
400
200
0
*
*
BUFFERING CAPACITY
75
70
65
60
55
50
45
BUFFER VALUE INDEX
101.4
101
100.6
100.2
99.8
*
*
0
1
2
3
4
5
6
7
8
HOUR POSTFEEDING

FIGURE 1b

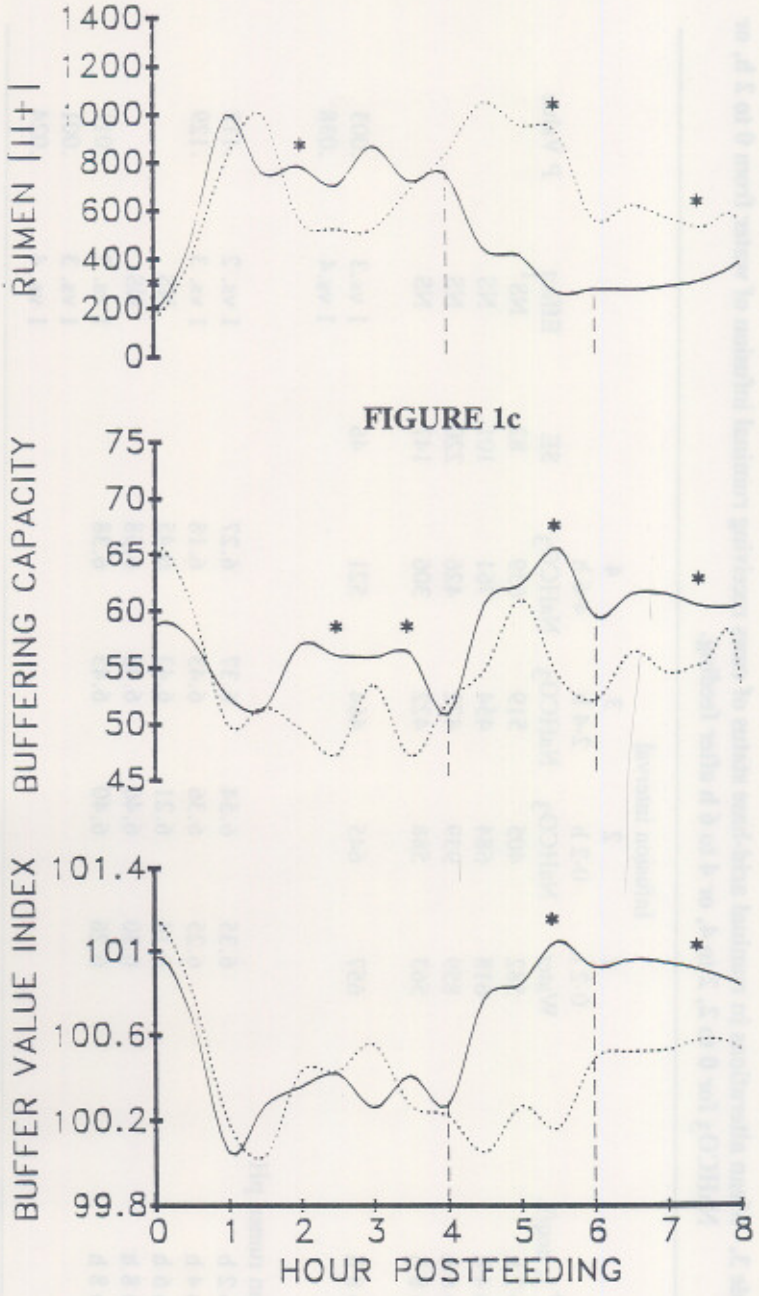

RUMEN [H+]
1400
1200
1000
800
600
400
200
0
BUFFERING CAPACITY
75
70
65
60
55
50
45
BUFFER VALUE INDEX
101.4
101
100.6
100.2
99.8
0 1 2 3 4 5 6 7 8
HOUR POSTFEEDING

FIGURE 1c

Table 3. Mean alterations in ruminal acid-base status of cows receiving ruminal infusion of water from 0 to 2 h, or $NaHCO_3$ for 0 to 2, 2 to 4, or 4 to 6 h after feeding.

	Infusion interval						
	1	2	3	4			
	0-2 h	0-2 h	2-4 h	4-6 h			
$[H^+]$, neq/L	Water	$NaHCO_3$	$NaHCO_3$	$NaHCO_3$	SE	Effect	P Value
0 to 2 h	582	405	519	639	82	NS[1]	
2 to 4 h	618	684	454	761	101	NS	
4 to 6 h	859	939	472	426	220	NS	
6 to 8 h	563	588	422	306	147	NS	
0 to 8 h	657	645	464	521	46	1 vs.3	.003
						1 vs.4	.038
Mean rumen pH							
0 to 2 h	6.35	6.54	6.37	6.27		1 vs. 2	.118
2 to 4 h	6.25	6.36	6.43	6.18		1 vs. 3	.129
4 to 6 h	6.14	6.21	6.43	6.45		NS	
6 to 8 h	6.30	6.46	6.46	6.58		NS	
0 to 8 h	6.26	6.40	6.43	6.38		1 vs. 2	.011
						1 vs. 3	.001
						1 vs. 4	.024

Table 3. (Continued)

Mean buffering capacity, meq/L							
0 to 2 h	55.5	65.1	56.6	55.4	5.4	NS	
2 to 4 h	50.0	59.3	54.2	55.3	2.3	1 vs. 2	.028
4 to 6 h	54.9	59.2	57.3	59.9	1.7	1 vs. 2	.129
						1 vs. 4	.088
6 to 8 h	54.6	55.9	56.2	60.8	2.2	1 vs. 4	.093
0 to 8 h	54.2	59.8	56.3	58.2	1.1	1 vs. 2	.005
						1 vs. 4	.012
Mean buffer value index							
0 to 2 h	100.54	100.90	100.60	100.47	.16	NS	
2 to 4 h	100.38	100.50	100.63	100.34	.13	NS	
4 to 6 h	100.24	100.24	100.67	100.77	.23	NS	
6 to 8 h	101.53	100.53	100.70	100.91	.18	NS	
0 to 8 h	100.43	100.55	100.67	100.64	.05	1 vs. 2	.117
						1 vs. 3	.002
						1 vs. 4	.006

[1] Nonsignificant; $P > .15$.

infusion. In contrast to the present study, Hogue et al. (1991) observed that ruminal fluid buffering capacity increased during $NaHCO_3$ infusion. In the current study, .5% $NaHCO_3$ infusion treatments were compared to a Ctrl cow receiving some $NaHCO_3$ via the diet. This presence of buffer in the diet may explain why buffering capacity did not increase during each $NaHCO_3$ infusion.

Mean BVI from 0 to 8 hours postfeeding was higher for each of the $NaHCO_3$ infusion treatments than for Ctrl (Table 3) such differences were not detected for each $NaHCO_3$ infusion treatment for buffering capacity and ruminal $[H^+]$ during this interval.

Ruminal volatile fatty acids

Total ruminal fluid VFA concentrations (Figure 2) generally were not affected, whereas the ruminal acetate to propionate ratio (A:P) tended to be reduced by $NaHCO_3$ infusion (Figure 3). Hogue et al. (1991) and other researchers reported that A:P increased with $NaHCO_3$ infusion and with dietary $NaHCO_3$. The reason for this discrepancy is not clear.

Ruminal Kinetics

To evaluate ruminal liquid kinetics, the natural logrithm of ruminal fluid Cr concentration was regressed upon time postfeeding. Mean r^2 for linearity of regression was .695 $\pm$ .239, n=16. Ruminal liquid volume (Table 4) was higher for 0-2bic than Ctrl. Liquid flow rate was lower for 2-4bic than for Ctrl and tended to be lower for 2-4bic than for other $NaHCO_3$ infusion intervals. This contrasts with results of Rogers et al. (1985) where supplementation of 1.4% dietary $NaHCO_3$ increased total daily ruminal fluid outflow in cows receiving either long-stemmed or chopped alfalfa hay.

Intra-ruminal infusion of $NaHCO_3$ into cows receiving supplemental dietary $NaHCO_3$ effected alterations in ruminal acid-base status; however, these alterations were not accompanied by shifts in ruminal VFA patterns or in milk composition. The effects of $NaHCO_3$ infused directly into the rumen may be different from those of dietary $NaHCO_3$.

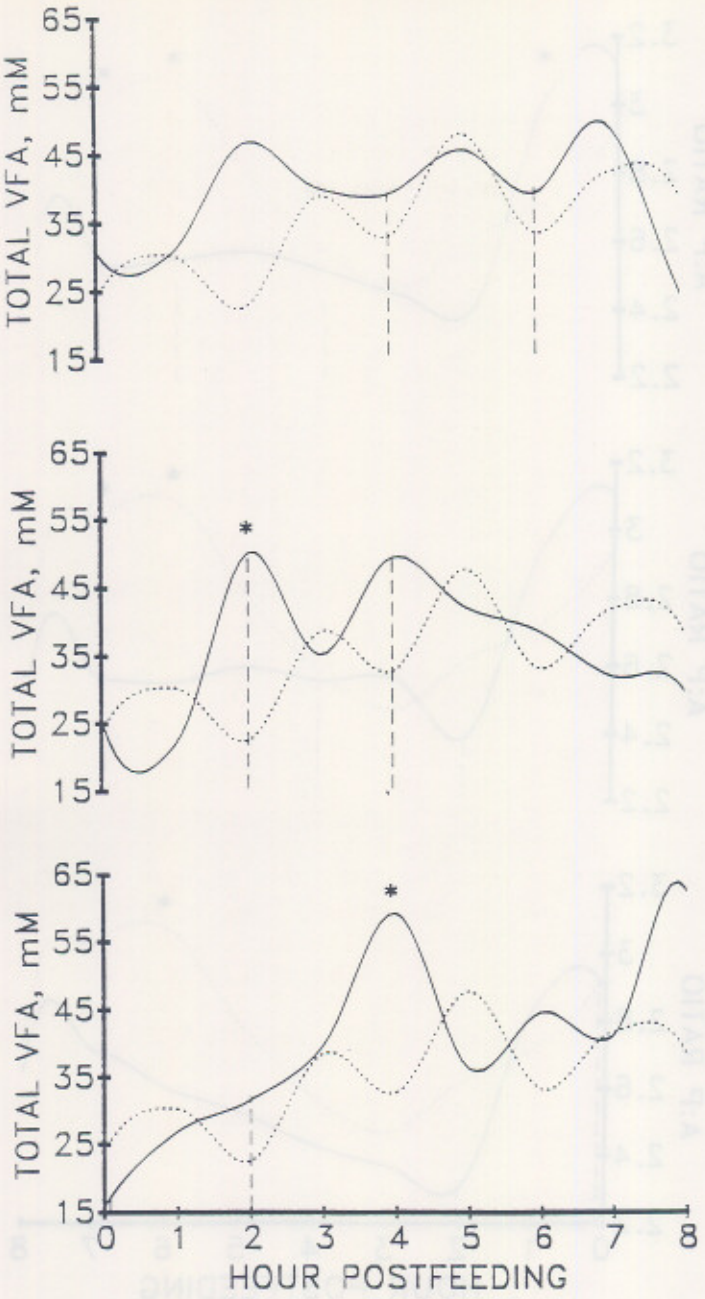


Figure 2. Total ruminal volatile fatty acids (mM) for Ctrl vs. 0 to 2 hour $NaHCO_3$ infusion, bottom panel; Ctrl vs. 2 to 4 hour $NaHCO_3$ infusion, middle panel; and Ctrl vs. 4 to 6 hour $NaHCO_3$ infusion, top panel. Ctrl = (....); $NaHCO_3$ infusion = (----). * = probability that treatment means are not different ($P < .15$).

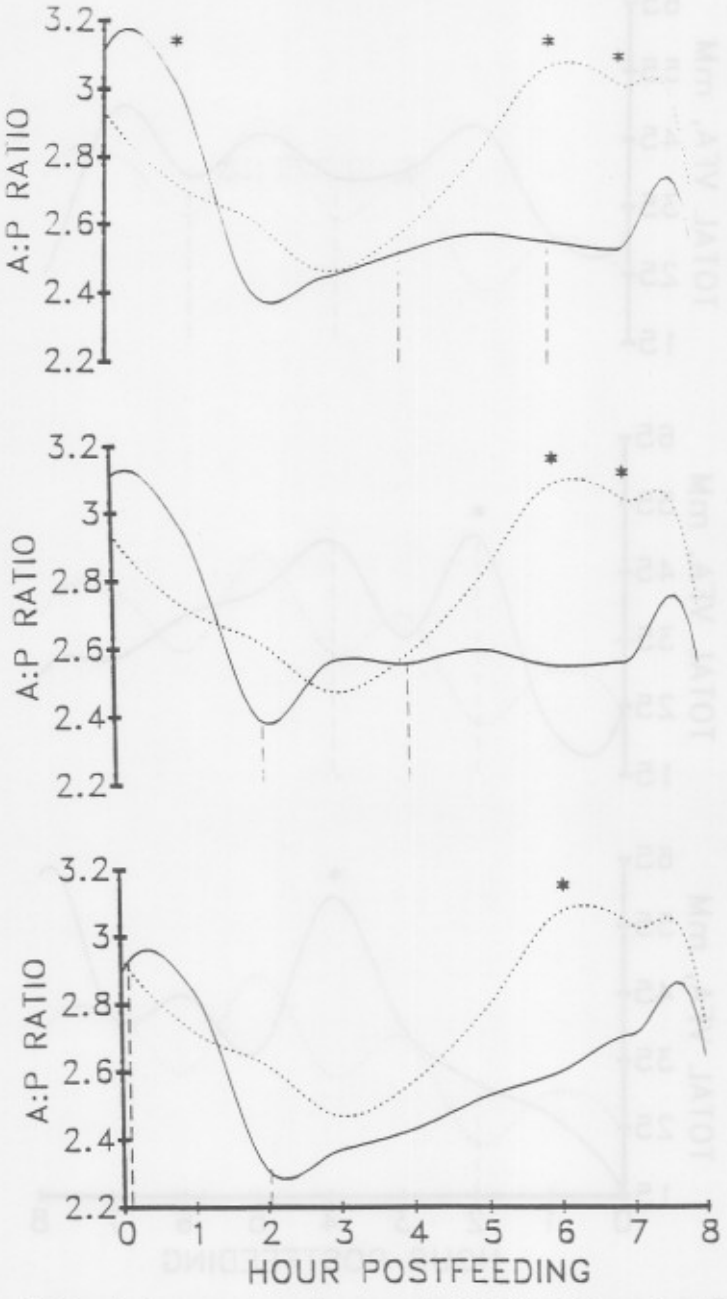


Figure 3. Ruminal acetate to propinoate ratio (A:P) for Ctrl vs. 0 to 2 hour $NaHCO_3$ infusion, bottom panel; Ctrl vs. 2 to 4 hour $NaHCO_3$ infusion, middle panel; and Ctrl vs. 4 to 6 hour $NaHCO_3$ infusion, top panel. Ctrl= (....); $NaHCO_3$ infusion= (----). * = probability that treatment means are not different ($P < .15$).

Table 4. Rumen kinetics of cows receiving ruminal infusion of water from 0 to 2 h, or $NaHCO_3$ for 0 to 2, 2 to 4, or 4 to 6 h after feeding.

	Infusion interval						
	1 0-2 h Water	2 0-2 h $NaHCO_3$	3 2-4 h $NaHCO_3$	4 4-6 h $NaHCO_3$	SE	Effect	P Value
Rumen:							
Liquid Volume, L	54.1	62.0	52.2	51.1	3.2	1 vs. 2	.129
Flow rate, L/h	5.97	4.37	3.62	5.44	1.00	1 vs. 3	.148
Liquid dilution rate, %/h	11.46	7.16	6.89	10.35	2.23	NS[1]	
Liquid turnover time, h	9.58	27.86	20.33	9.99	10.19	NS	

[1] Nonsignificant; P>.15.

Literature Cited

Erdman, R.A., et al. 1980. Effect of dietary sodium bicarbonate and magnesium oxide on production and physiology in early lactation. J. Dairy Sci. 63:923.

Hogue, J.F., et al. 1991. Controlled ruminal infusion of sodium bicarbonate: I. Influence of postfeeding infusion interval on ruminal milieu. J. Dairy Sci. (in press).

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CONTROLLED RUMINAL INFUSION OF SODIUM BICARBONATE: I. INFLUENCE OF POSTFEEDING INFUSION INTERVAL ON RUMINAL ACID-BASE STATUS

J.F. Hogue[1], W.B. Tucker[2], M.T. Van Koevering[1], R.K. Vernon[1], and G.D. Adams[3]

Story in Brief

Four ruminally cannulated, lactating Holstein cows were assigned to a 4 X 4 Latin square to monitor the effects of intra-ruminal sodium bicarbonate infusion on changes in the rumen environment. Sodium bicarbonate (110 g), dissolved in 3.8 L of water, was infused twice daily at a constant rate for 2 hours starting at 0, 2 or 4 hours postfeeding. All cows had access to their diet containing sorghum silage and concentrate in a 35:65 ratio (DM basis) for 45 minutes twice daily. Ruminal fluid was collected at feeding and every 30 minutes postfeeding for 12 hours on the last day of each 7-day period. Compared to the water infusion, the 2 to 4 hour sodium bicarbonate infusion most effectively prevented the postfeeding increase in ruminal free proton concentration. Based upon alternations in ruminal acid-base status, exogenous buffer ideally should be provided to the rumen at 2 to 4 hour postfeeding; however, our results indicate that the effectiveness of this regimen might be improved if combined with a rapidly released or unprotected dietary buffer.

(Key Words: Sodium Bicarbonate, Rumen pH, Buffering Capacity.)

Materials and Methods

Four pluriparous, ruminally cannulated Holstein cows were arranged in a 4x4 Latin square; each experimental period lasted 1 week. A total mixed diet (Table 1) of sorghum silage and concentrate (35:65 ratio; DM basis) was fed at 0300 and 1500 hours in an amount consumed within 45 minutes. Samples of this total mixed diet were collected weekly and composited at the end of the trial for nutrient analysis by a commercial laboratory. Dry matter composition of the sorghum silage was determined weekly and utilized to maintain a consistent ratio of ingredients in diet DM.

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Table 1. Ingredient and nutrient composition of experimental diet DM.

Ingredient:	%
Sorghum silage	35.03
Ground shelled corn	41.04
Soybean meal, 44% CP	21.66
Limestone	.92
Dicalcium phosphate	.54
Dynamate[1]	.36
Trace mineralized salt[2]	.46
Nutrient[3]:	
CP	16.8
ADF	19.7
NDF	30.2
NE_1[4], Mcal/kg	1.61
Ca	.66
P	.45
Mg	.28
K	1.20
Na	.23

1 Double sulfate of K and Mg.
2 Contained 92% NaCl, .250% Mn, .200% Fe, .033% Cu, .007% I, .005% Zn, and .0025% Co.
3 Composition from laboratory analyses.
4 Calculated from ADF.

Treatments consisted of infusion water from 0 to 2 hour (Ctrl), or sodium bicarbonate ($NaHCO_3$) for 2 hour intervals at 0 (0-2bic), 2 (2-4bic) or 4 hour (4-6bic) postfeeding, twice daily throughout the experimental period. Sodium bicarbonate solution was prepared for infusion at each feeding by dissolving 110 g $NaHCO_3$ in 3.8 L of water; this solution was allowed to flow by gravity at a controlled rate into the rumen. Although interval postfeeding at which infusions were initiated differed among treatments, the amount of $NaHCO_3$ (110 g) per infusion was constant across all treatments.

On the morning of the last day of each experimental period, ruminal fluid was collected every 30 minutes from 0 to 12 hours postfeeding. Ruminal fluid pH was measured (Model 950 pH/ion analyzer, Fisher Scientific, Pittsburgh, PA), and ruminal fluid was then strained through four layers of cheesecloth

and a 100-ml aliquot was collected in polyethylene vials, tightly capped and frozen for buffering capacity analysis.

Buffering capacity was determined by titrating a 30-ml aliquot of ruminal fluid with continuous stirring from its initial pH to a pH of 5 with HCl (.5 or 1.0N), and titrating an additional 30-ml aliquot from its initial pH to a pH of 7 with NaOH (.1 or 1.0N). All pH measurements were recorded following 30 s of equilibration. Total volume of base and acid added to each sample was summed and utilized to calculate buffering capacity. Buffering capacity was expressed as total milliequivalents free protons required to change 1 L of rumen fluid from pH 5 to pH 7.

A buffer value index (BVI) was calculated, which allowed evaluation of the combined effects of exogenous buffers on ruminal pH and buffering capacity.

Statistical analysis consisted of a linear model ANPVA for each sampling time for ruminal variables. Cow, period, treatment and residual error were included in the model. Contrasts were employed to compare Ctrl to 0-2bic, Ctrl to 2-4bic, and Ctrl to 4-6bic, with statistical significance declared at $P<.15$.

Results and Discussion

As contrasted with Ctrl, free proton concentration ($[H^+]$) in the rumen was reduced by 0-2bic and 2-4bic, and was numerically lower for 4-6bic during the periods of infusion, i.e., 0 to 2, 2 to 4, and 4 to 6 hours, respectively (Table 2). Response of ruminal $[H^+]$ to $NaHCO_3$ infusion was rapid; reductions were evident within .5 hour of infusion. Moreover, responses to cessation of infusion were equally rapid. Ruminal $[H^+]$ of cows receiving $NaHCO_3$ infusion rebounded and was similar to those of Ctrl cows within .5 hour after infusion ended. Hence, alterations in ruminal acid-base status effected by dietary $NaHCO_3$ were transient. Ruminal acid concentration is highest 4 to 6 hours postfeeding with twice per day feeding (Tucker et al., 1988); to be most effective in maintaining ruminal $[H^+]$ within a range which promotes fiber digestion, buffering capacity should be greatest immediately prior to this interval.

Ruminal $[H^+]$ was reduced consistently during the periods of $NaHCO_3$ infusion. However, beginning at 7 to 8 hours postfeeding, ruminal $[H^+]$ consistently was higher for each $NaHCO_3$ infusion treatment than for the Ctrl (Table 2). The reason for this response is not readily apparent, but it may relate to a feedback mechanism reducing salivary buffer flow in response to increased ruminal fluid pH for the cows receiving $NaHCO_3$ infusion. However, by 7 hours postfeeding, ruminal $[H^+]$ was low enough (i.e., pH

Table 2. Mean alterations in ruminal pH and hydrogen ion concentration of cows receiving ruminal infusions of water from 0 to 2 h, or $NaHCO_3$ for 0 to 2, 2 to 4, or 4 to 6 h after feeding.

	Infusion interval						
	1 0-2 h	2 0-2 h	3 2-4 h	4 4-6 h			
	Water	NaHCO3	NaHCO3	NaHCO3	SE	Effect	P Value
Mean rumen pH							
0 to 2 h	6.25	6.24	6.22	6.13		1 vs 2	.012
					1 vs 4	.102	
2 to 4 h	6.12	6.17	6.37	5.99	1 vs 3	.024	
4 to 6 h	6.07	6.03	6.24	6.29	NS		
6 to 12 h	6.36	6.43	6.42	6.48	1 vs 2	.038	
						1 vs 3	.031
						1 vs 4	.091
0 to 12 h	6.40	6.34	6.36	6.31		1 vs 4	.058
Mean [H+], neq/L							
0 to 2 h	736	485	772	956	107	NS[1]	
2 to 4 h	846	846	522	1127	107	1 vs 3	.077
4 to 6 h	1075	1144	803	648	208	NS	
6 to 12 h	305	553	552	403	63	1 vs 2	.032
						1 vs 3	.033
0 to 12 h	585	677	612	650	46	NS	

1 NS ($P > .15$).

was high enough) for all treatments so that fiber digestion should not have been affected by these differences.

Buffering capacity (Table 3) tended to be elevated during $NaHCO_3$ infusion at each infusion interval; this response was most dramatic for 2-4bic. This elevation continued for several hours after infusion ceased for 0-2bic and 2-4bic, but ended at 6 hours postfeeding for 4-6bic. In each case, buffering capacity fell below that of Ctrl at approximately 7 hours postfeeding, corresponding to the time frame for the elevated ruminal $[H^+]$ mentioned previously for the $NaHCO_3$ treatments. However, by 7 hour postfeeding, ruminal $[H^+]$ was low enough, and ruminal fermentation had subsided enough that the lack of buffering capacity for the $NaHCO_3$ treatments at this stage may not be biologically important.

Responses in BVI to $NaHCO_3$ infusion (Table 3) were similar to those of ruminal $[H^+]$ and buffering capacity; as $NaHCO_3$ was infused, BVI increased. This elevation also was transient; by 7 hours postfeeding, BVI was lower for all $NaHCO_3$ treatments. Buffer value index provided a more sensitive index of exogenous buffer-effected alterations in ruminal acid-base status than either ruminal $[H^+]$ or ruminal fluid buffering capacity alone. For example, ruminal $[H^+]$ was lower for 0-2bic than for Ctrl at .5 and 1 hour postfeeding, whereas buffering capacity was unaffected by $NaHCO_3$ infusion during this interval. Despite the absence of any effect on buffering capacity, the difference in ruminal $[H^+]$ was sharp enough that BVI was higher for 0-2bic than for Ctrl. The reverse occurred at 4.5 and 5 hours postfeeding for 4-6bic. Ruminal $[H^+]$ was unaffected, whereas buffering capacity was significantly higher for 4-6bic than Ctrl, resulting in a higher BVI for $NaHCO_3$ infusion during that interval.

Buffering capacity of feedstuffs varies depending upon their ion content (Jasaitis et al., 1987). This variation may affect the requirement for exogenous dietary buffers in practical diets. Identification of the pH and buffering capacity of specific feedstuffs would allow calculation of a BVI both for individual feeds and for any combination of feeds utilized in a diet. Moreover, ranges of total dietary BVI for which supplementation of buffers is justified could be identified.

Table 3. Mean alterations in ruminal buffering capacity and buffer value index of cows receiving ruminal infusions of water from 0 to 2 h, or NaHCO3 for 0 to 2, 2 to 4, or 4 to 6 h after feeding.

	Infusion interval						
	1 0-2 h	2 0-2 h	3 2-4 h	4 4-6 h			
	Water	NaHCO3	NaHCO3	NaHCO3	SE	Effect	P Value
Mean buffering capacity, meq/L							
0 to 2 h	66.0	70.5	63.9	67.1	2.9	NS	
2 to 4 h	59.7	63.5	66.1	63.0	2.8	NS	
4 to 6 h	57.6	61.3	66.9	63.5	1.6	1 vs 3	.007
						1 vs 4	.044
6 to 12 h	69.6	64.2	67.6	63.8	1.7	1 vs 2	.063
						1 vs 4	.050
0 to 12 h	65.9	65.2	66.6	64.1	1.0	NS	
Mean buffer value index							
0 to 2 h	100.58	100.93	100.51	100.39	.09	1 vs 2	.037
2 to 4 h	100.35	100.42	100.77	100.13	.15	1 vs 3	.086
4 to 6 h	100.08	100.08	100.53	100.62	.22	1 vs 4	.131
6 to 12 h	101.09	100.73	100.80	100.87	.07	1 vs 2	.013
						1 vs 3	.031
						1 vs 4	.084
0 to 12 h	100.73	100.63	100.71	100.63	.05	NS	

1 NS (P>.15).

Literature Cited

Jasaitis, D.K. et al. 1987. Influence of feed ion content on buffering capacity of ruminant feedstuffs in vitro. J. Dairy Sci. 70:1391.

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EFFECT OF DIETARY CATION-ANION BALANCE ON ACID-BASE STATUS IN HORSES

L. A. Baker[1], D.R. Topliff[2], D.W. Freeman[2], R.G. Teeter[3] and J.W. Breazile[3]

Story in Brief

Four mature, sedentary geldings were randomly assigned to one of four experimental treatments to evaluate the effects of varying dietary cation-anion balances on urine and blood pH and blood gasses. Dietary cation-anion balance is calculated as meq((Na + K) - Cl)/kg diet dry matter. Diets consisted of a base concentrate (corn, soybean meal and cottonseed hulls), fed with native prairie grass hay in a 60:40 ratio. Diets were formulated to provide cation-anion balances of -50 (L, low), +50 (ML, medium low), +150 (MH, medium high) and +250 (H, high). Urine pH was significantly lower for the low versus the high DCAB diets. Blood pH, pCO_2 and HCO_3^- values were also significantly lower for the low versus the high DCAB diets, in both arterial and venous samples. The results of this trial indicate that horses consuming diets with a cation-anion balance less than +150 meq/kg of DM may experience metabolic acidosis and increased urinary calcium and magnesium loss.

(Key Words: Equine, Nutrition, Acid-Base.)

Introduction

Currently, little research is available regarding dietary cation-anion balance (DCAB) effects in horses. However, this phenomenon has been studied extensively in dairy cattle, swine and poultry. The equation most commonly used to calculate DCAB is (meq (Na + K) - Cl)/kg dry matter. The equation takes into account only the monovalent elements sodium, potassium and chloride, as they are the most readily absorbed and appear to have the greatest metabolic impact. Sodium and chloride are both involved with osmotic fluid regulation, while potassium is involved with the maintenance of acid-base balance and osmotic pressure regulation. Because sodium and potassium are often absorbed from the gastrointestinal tract in

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exchange for a proton, and chloride is absorbed in exchange for a bicarbonate ion, any alteration in the relative amounts of these ions in the diet could be expected to have an effect on the acid-base balance in the animal. Tucker et al. (1988) showed that by increasing the level of DCAB from -10 to +20 meq/100g DM, milk yield in lactating Holsteins was increased by 8.6 percent. Tucker et al. (1988) demonstrated that altering the DCAB of the diet has marked effects on blood acid-base balance. High chloride diets have been shown to depress blood pH, bicarbonate and increase pCO_2 levels. Petito et al. (1984) showed that an increased ingestion of acid in rats increased urinary and fecal excretion of calcium. These rats also had decreased bone weight due to increased calcium mobilization from the bone without vitamin D action. Topliff et al. (1988) showed that there is a significant increase of calcium and chloride in the urine of horses consuming a diet with a DCAB of +6.5 meq/kg DM versus a diet of a DCAB of +150 meq/kg. Furthermore, these horses had higher concentrations of chloride in the urine. If prolonged, this situation could lead to developmental orthopedic disease in young growing horses, or to an osteoporosis weakening the skeleton in mature horses. The objective of this experiment was to study the effects of varying DCAB in mature sedentary horses.

Materials and Methods

Four mature, sedentary geldings were used in a 4x4 Latin square experiment to study the effects of DCAB on the acid-base status on non-exercised horse. Four diets providing -50 (L), +50 (ML), +150 (MH) and +250 (H) meq((Na + K) - Cl)/kg diet dry matter were rotated among the four experimental periods. Each period consisted of a 21 day adjustment period followed by a 72 hour collection period. Diets consisted of a concentrate and hay mixture in a 60:40 ratio, and were fed in amounts to maintain constant body weights. The concentrate was composed of corn, soybean meal and cottonseed hulls. To achieve the required DCAB levels, calcium chloride and ammonium chloride were added to the L and ML diets, while sodium bicarbonate and potassium citrate were added to the H diet. The MH diet (DCAB of +150) served as the basal diet, representative of a typical ration. Horses were exercised for thirty minutes daily on a hot walker, and were given required health care throughout the trial.

Both arterial and venous blood samples were drawn hourly, via indwelling catheters, for 12 hours post-feeding, and analyzed immediately for pH, pCO_2, tCO_2, HCO_3^-, base excess, standard bicarbonate and base excess extracellular fluid by way of a blood gas analyzer. Total urine production was collected every 4 hours post-feeding for 72 hours and samples analyzed immediately for pH. Fecal grab samples were obtained over 72 hours to

represent every 2 hours post-feeding. Composited urine and fecal samples were frozen and stored for later mineral analysis. All data were analyzed using a repeated measures model. Least squares means over time were then tested using the pdiff procedure and significance declared at a probability level of .05 (SAS, 1985).

Results and Discussion

The effect of treatment over time on urine pH is shown graphically in Figure 1. Horses consuming diet L had significantly lower urine pH values, ranging from 5.40 on diet L to 8.14 on diet H. The effect of treatment over time on arterial and venous blood pH is shown graphically in Figures 2 and 3. Arterial and venous blood pH values were significantly lower on diet L. Values ranged from 7.32 on diet L to 7.42 on diet H for arterial, and 7.31 on diet L to 7.41 on diet H for venous samples. The effect of treatment over time on blood pCO_2 is shown graphically in Figures 4 and 5. Arterial and venous blood pCO_2 was significantly lower on diet L, with arterial values ranging from 38.92 on diet L to 48.37 on diet H and venous values ranging from 45.36 on diet L to 53.70 mm/Hg on diet H. Treatment over time effects on blood HCO_3^- are shown in Figures 6 & 7. Arterial and venous blood HCO_3^- was significantly lower on diet L, with arterial values ranging from 22.53 on diet L to 29.30 on diet H and venous values ranging from 23.93 on diet L to 31.22 mmol/L on diet H .

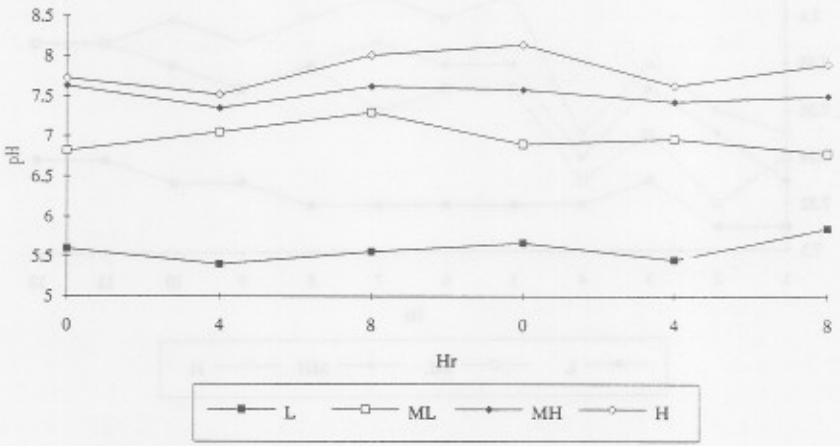


Figure 1. Effect of DCAB on urine pH post feeding.

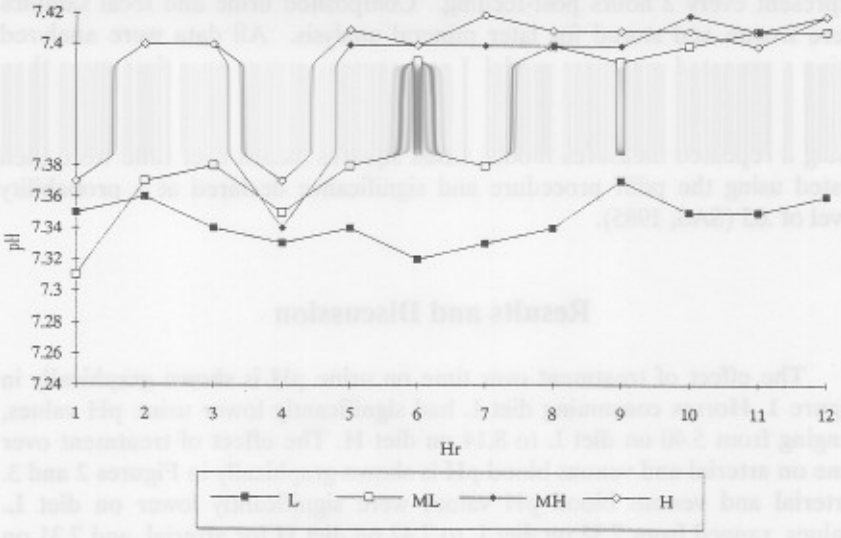


Figure 2. Effect of DCAB on arterial blood pH post feeding.

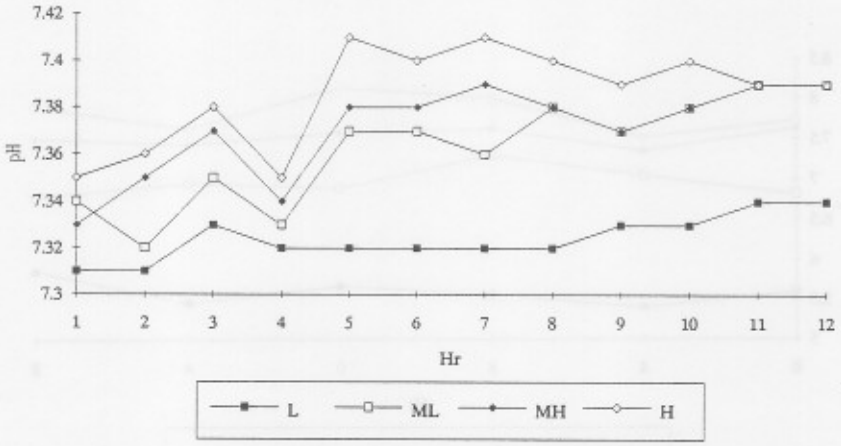


Figure 3. Effect of DCAB on venous blood pH post feeding.

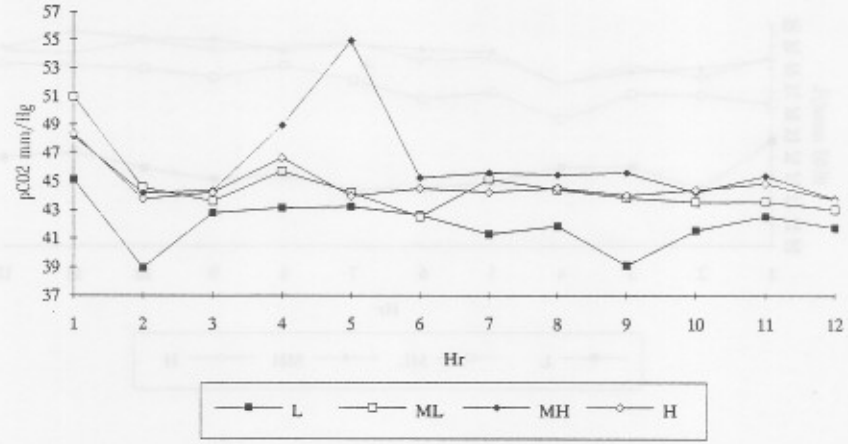


Figure 4. Effect of DCAB on arterial blood pCO_2 post feeding.

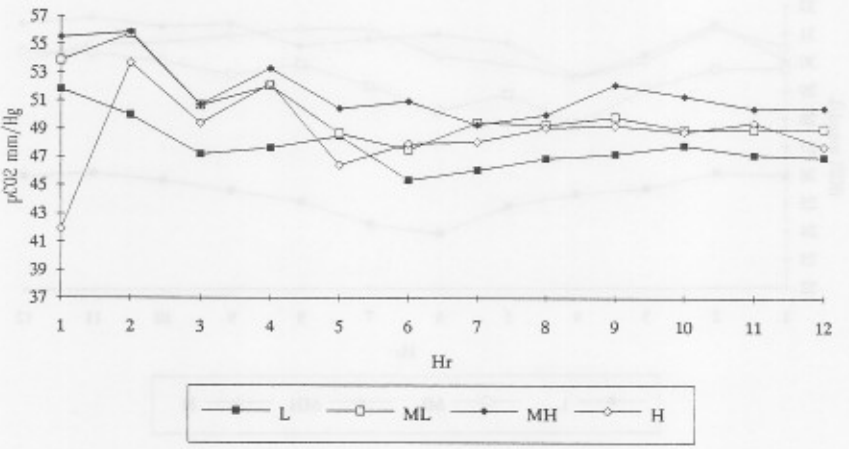


Figure 5. Effect of DCAB on venous blood pCO_2 post feeding.

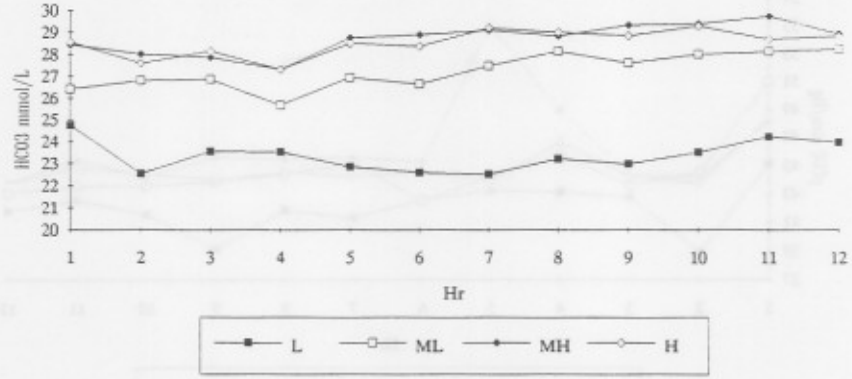


Figure 6. Effect of DCAB on arterial blood HCO_3 post feeding.

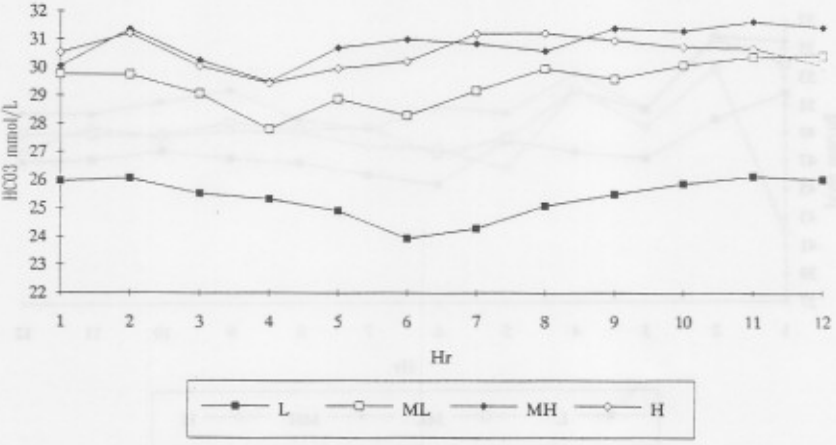


Figure 7. Effect of DCAB on venous blood HCO_3 post feeding.

Blood acid-base status is influenced by absorption of inorganic ions. The absorption of cations such as Na and K will increase the generation of base in the systemic system, and the absorption of anions, such as Cl, will increase acid generation. Data from this experiment agree with that of Tucker et al. (1988) in that diets with a low DCAB (high Cl concentration) decrease blood pH, bicarbonate and pCO_2 levels.

In summary, these data indicate that horses consuming diets providing a DCAB of less than +150 meq/kg of DM may experience a state of nutritionally induced metabolic acidosis. This acidosis may lead to increased urinary calcium excretion. Further research is needed to study the effects of DCAB on skeletal growth and soundness of young horses, as well as the mature performing horse.

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EFFECTS OF DIETARY CATION-ANION BALANCE ON BLOOD PARAMETERS AND MINERAL METABOLISM IN EXERCISING HORSES

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Story in Brief

Four geldings and four mares of primarily Thoroughbred and Quarter Horse breeding were grouped by sex and randomly assigned to one of four experimental treatments to test the effects of dietary cation-anion balance (DCAB) on exercising horses. Treatments were formed by supplementing the corn-soybean meal-cottonseed hull supplement to provide a DCAB of -50 (Low, L), +50 (Medium Low, ML), +150 (Medium High, MH) and +250 (High, H) meq((Na+K)-Cl)/kg diet dry matter. Calcium chloride and ammonium chloride were added to diet L and ML and sodium bicarbonate and potassium citrate were added to diet H to achieve the desired DCAB. Horses were subjected to a six week conditioning period, consisting of long slow distance (LSD) aerobic work. During the experimental periods horses were subjected to a combined exercise regimen alternating LSD with an interval training protocol 6 days/week. The effect of treatment was highly significant for acid base parameters in horses at rest, although acid-base parameters, heart rate and plasma glucose concentrations were not significantly different in horses performing anaerobic work. Horses consuming diet L excreted significantly more calcium and chloride and less sodium than those consuming diet H. Results of this trial suggest that DCAB has a significant effect on acid-base status and mineral excretion in resting horses, although the buffering effect of excess cations in the diet did not protect blood pH during the exercise bout itself.

(Key Words: Dietary Cation-Anion Balance, Horses, Exercise.)

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[1]Graduate Student [2]Associate Professor [3]Assistant Professor [4]Regents Professor and Head [5]Professor

Introduction

Little research pertaining to the effect of DCAB on the exercising horse is available. Potassium, sodium and chloride are the major ions involved with acid-base balance and the osmotic regulation of body fluids. The equation that is used to determine the DCAB is meq((Na+K)-Cl)/kg diet dry matter. The effects of DCAB on acid-base physiology have been investigated in many species. In dairy cattle it has been shown that increasing the level of DCAB from -10 to +20 meq/100g DM increased milk yield in lactating Holsteins by 8.6 percent (Tucker et al., 1988). Altering the DCAB of rations fed to swine and poultry has been shown to affect blood pH and calcium balance and suggests to predispose the development of bone disease (Austic, 1984; Patience et al. 1987). Low DCAB due to chloride has been shown to depress blood pH, bicarbonate and decrease pCO_2 levels (Tucker et al., 1988).

Horses performing extensive amounts of physical exercise may lose large quantities of some minerals from the body through sweat (Schryver et al., 1978; Kerr and Snow, 1983). Young et al. (1989) showed that horses fed a diet that contained 4.32 Mcal/d during the rest period and 7.93 Mcal/d during the exercise period to have increased fecal outputs of sodium, potassium, chloride, and phosphorus. There was also a decrease in the urinary output of all the above ions except potassium which increased 31.3 mg/kg body weight. Topliff et al. (1988) showed that there is a significant increase of calcium in urine ($p<.05$) of horses consuming a diet with a low DCAB. Those horses also had higher concentrations of chloride ($p<.05$) in the urine.

Sodium and potassium are frequently absorbed from the gastrointestinal tract in exchange for the secretion of a proton. Also, as chloride is absorbed from the gastrointestinal tract, a bicarbonate ion is secreted. Altering these ions in the diet may help to delay the onset of fatigue in performance horses. It was therefore the objective of this experiment to investigate the effect of varying levels of DCAB on blood acid-base status and mineral balance in horses performing strenuous work.

Materials and Methods

Four geldings and four mares of primarily Thoroughbred and Quarter Horse breeding were used in two simultaneous 4x4 Latin square experiments. Horses were subjected to a six week conditioning period, consisting of LSD aerobic work. During the experimental periods horses performed a combined exercise regimen alternating LSD with an interval training protocol consisting of alternating sprints with a slow gallop 6 days/wk. Four diets

(Table 1) with DCAB's (calculated as meq((Na+K)-Cl)/kg diet dry matter) of -50 (L), +50 (ML), +150 (MH) and +250 (H) were fed for a 21 day adjustment period followed by a 96 hour collection period. The concentrate was fed with bermuda grass hay in a 60:40 ratio in amounts required to maintain constant body weight. Calcium chloride and ammonium chloride were added to diet (L), calcium chloride was added to the diet (ML), and potassium citrate and sodium bicarbonate were added to the diet (H) to achieve the desired DCAB. The diet (MH) served as the basal diet. The horses were maintained in individual stalls with free access to water. The horses were immunized and dewormed prior to the initiation of the trial and received standard animal health care throughout the trial.

Beginning with the morning feeding on the 22nd day of each experimental period, venous blood samples were drawn hourly for 17 hours. The blood samples were analyzed immediately for blood pH and blood gases. A total urine collection was taken beginning at the same time for 72 hours on the geldings by urine collection harnesses and for 24 hours on the mares by catheterizing the bladder. Fecal grab samples were taken over 72 hours to represent every two hours during the post feeding interval. Composited urine and fecal samples were stored for later mineral analysis. The last day of each experimental period, horses were subjected to a standard exercise

Table 1. Composition of concentrate diets, DM basis.

	Diet			
Ingredient (%)	L	ML	MH	H
Ground Corn	33.2	33.2	33.2	33.2
Soybean Meal	6.9	6.9	6.9	6.9
Cottonseed Hulls	14.8	15.1	15.0	13.7
DiCal	.21	.21	.19	.20
Limestone	----	.22	.78	.78
Trace Mineral Salt	.55	.55	.55	.55
Calcium Chloride	.78	.54	----	----
Ammonimum Chloride	.30	----	----	----
Potassium Citrate	----	----	----	.89
Sodium Bicarbonate	----	----	----	.61
Liquid Cane Molasses	2.0	2.0	2.0	2.0
Bermuda Grass Hay	40	40	40	40
Total	100	100	100	100

test (SET) approximately two hours before the morning feeding. The SET consisted of a 1.6 km sprint at speeds sufficient to elicit a target heart rate of 200 beats/min. Blood samples were drawn via jugular venipuncture preexercise, at the end of exercise and at 1, 2, 3, 4, 5, 10, 20 and 30 minutes postexercise. Blood samples were analyzed immediately for blood pH, blood gases and plasma glucose concentration. Heart rates were recorded using an on board heart rate monitor. All data were analyzed using a general linear model procedure for repeated measures and least square means calculated for each parameter. The pDiff procedure was used to detect significant differences between means (SAS, 1985).

Results and Discussion

Least square means for blood pH and blood gases for horses at rest and exercising horses are shown in Figures 1-5. Blood pH (Figure 1) for horses at rest was reduced ($p<.001$) by the (L) diet versus the basal diet (MH). Effect of treatment was also significant for HCO_3 (26.95(L)-31.43(H)mmol/L) (Figure 2). These results are in agreement with Tucker et al. (1988) who reported a decrease in venous blood pH, bicarbonate and pCO_2 in dairy cows fed diets with low DCAB's.

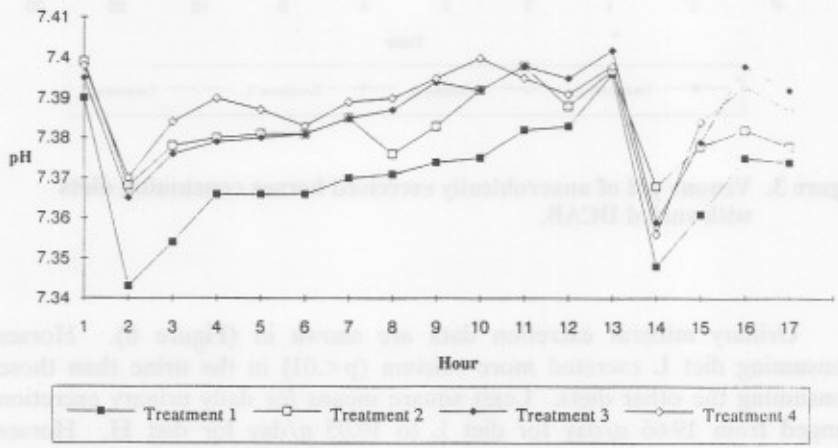


Figure 1. Venous blood pH in horses at rest consuming diets with varied DCAB.

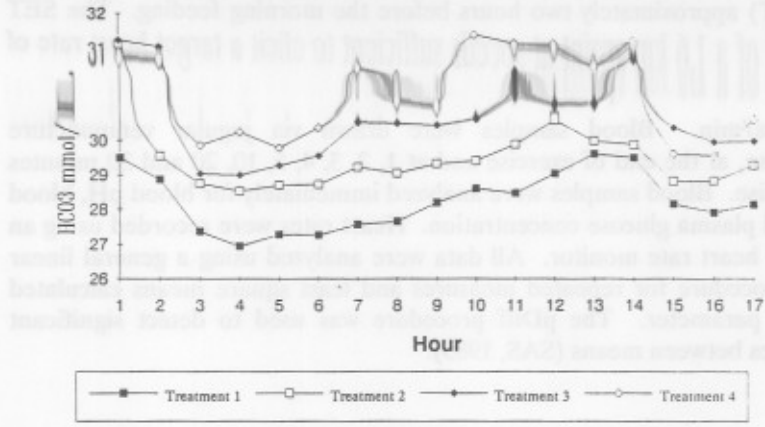


Figure 2. Venous bicarbonate in horses at rest consuming diets with varied DCAB.

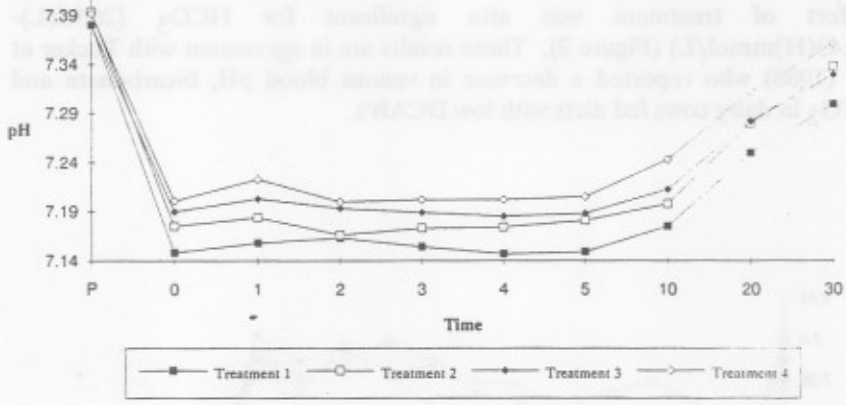


Figure 3. Venous pH of anaerobically exercised horses consuming diets with varied DCAB.

Urinary mineral excretion data are shown in (Figure 6). Horses consuming diet L excreted more calcium ($p<.01$) in the urine than those consuming the other diets. Least square means for daily urinary excretion ranged from 19.66 g/day for diet L to 10.05 g/day for diet H. Horses consuming diet L excreted more ($p<.01$) chloride (65.31 g/day) in the urine when compared to the other treatments (ML-48.51; MH-32.30; H-34.86 g/day). These results are in agreement with Topliff et al. (1989) who

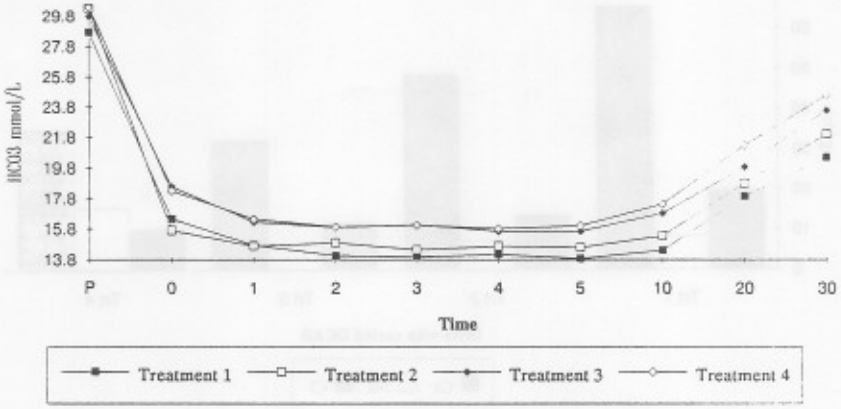


Figure 4. Venous bicarbonate in anaerobically exercised horses consuming diets with varied DCAB.

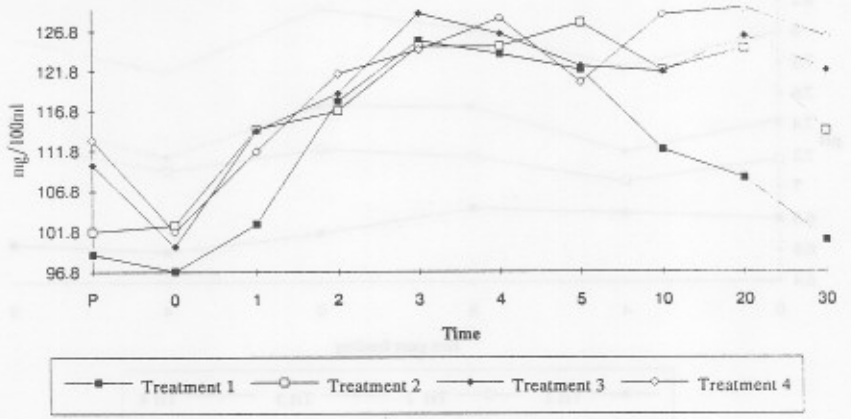


Figure 5. Plasma glucose in anaerobically exercised horses consuming diets with varied DCAB.

reported an increase in urinary calcium and chloride excretion in exercising horses consuming diets of low DCAB. Daily urinary sodium excretion (15.21 g/day) for horses consuming diet H was greater ($p < .01$) as compared to the other three diets (L-8.24; ML-7.25; MH-5.75). No significant differences were detected in daily urinary K, Mg, P, or S excretion. Urine pH data are shown in Figure 7. There was a significant Time x Treatment interaction with an average pH across time of 6.74, 7.18, 7.39 and 7.94 for diets L, ML,

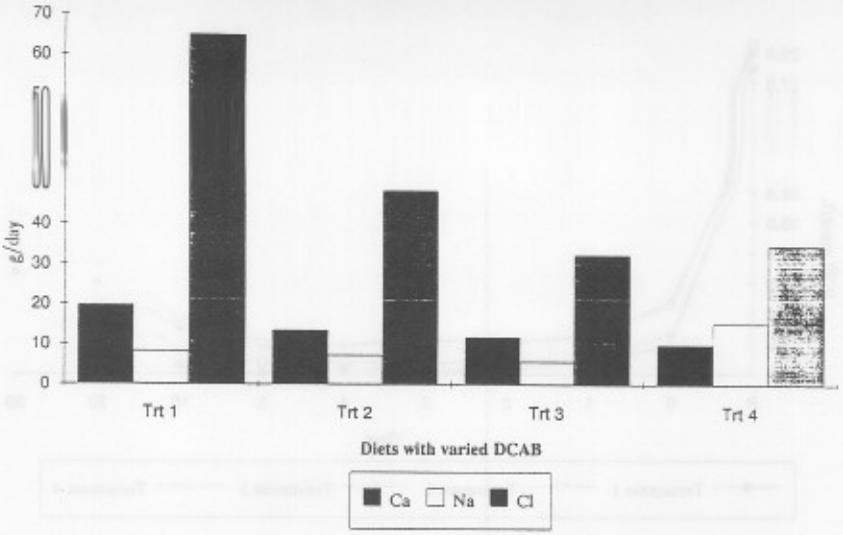


Figure 6. Urinary mineral excretion of exercising horses consuming diets with varied DCAB.

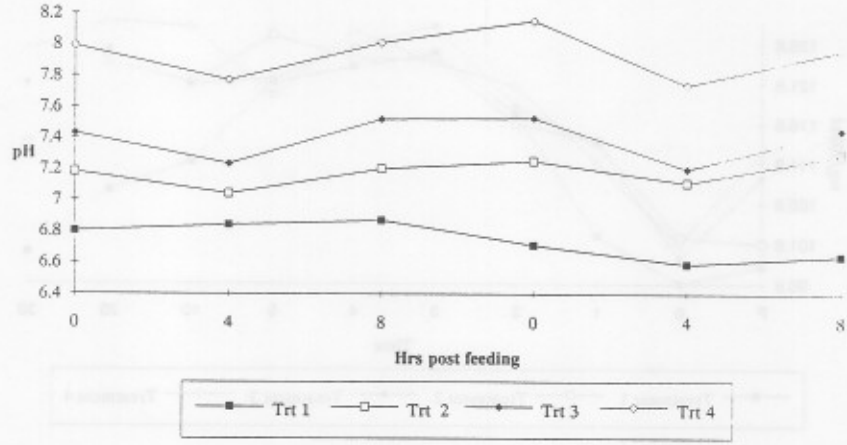


Figure 7. Urine pH of exercising horses consuming diets with varied DCAB.

MH and H respectively. Although the cause of the increased calcium excretion is not fully understood, these results indicate that exercising horses consuming diets of lower DCAB may be in a net negative calcium balance. Under prolonged situations, this could lead to an osteoporotic weakening of the skeletal system as seen in swine and poultry (Patience et al., 1987; Austic, 1984).

When cations such as Na^+ and K^+ are absorbed, systemic base generation will increase. In addition, when anions such as Cl^- are absorbed, acid generation will also increase. From this information the conclusion can be drawn that the ratio of cations to anions in the diet (DCAB) could influence blood acid-base status as previously shown by Tucker et al. (1988). Effects of treatment were not significant for the measures of acid-base status in horses performing anaerobic work. However, the data concerning exercise blood pH (Figure 3) and bicarbonate (Figure 4) demonstrate a trend toward a difference between treatment L and treatment H. During strenous exercise blood pH will drop due to respiratory and metabolic effects along with a concurrent drop in bicarbonate. Diets that are high in DCAB may buffer these responses. No difference was detected in heart rate during exercise or recovery. There were no significant differences in plasma glucose concentrations (Figure 5) in all four dietary treatments until 10 minutes post exercise, where there was a difference ($p<.05$) between diets L and H. At 20 minutes post exercise, there was a significant difference between diets L and ML, and diets MH and H. At 30 minutes post exercise, there were significant differences between the L diet and the ML, MH and H diets. These data indicate that horses consuming diets with a low DCAB may experience a metabolic acidosis. No buffering effect of diets MH and H was apparent post exercise. However, that may be attributed to the time exercise was performed in relation to feeding. In a pretrial study, we observed a buffering effect on blood pH in horses exercised within four hours post-feeding. Additional research is needed to clarify the effect of DCAB on acid-base status post-feeding.

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PLASMA GLUCOSE CONCENTRATIONS AND DIGESTIBILITY OF DRY MATTER, ENERGY AND CRUDE PROTEIN IN MATURE GELDINGS FED WHEAT AND OAT BASED DIETS

D.R. Topliff[1] and D.W. Freeman[1]

Story in Brief

Eight mature stock horse geldings were used in two simultaneous 4x4 Latin square experiments to determine the effect of feeding graded levels of wheat and oats on postprandial glucose concentrations and digestibility of dry matter, energy and crude protein. Experimental concentrate diets consisted of 100, 66, 33 and 0 percent wheat with the balance as oats. Concentrate diets were fed in a 60:40 ratio with prairie grass hay at equal dry matter intakes across treatments. The digestibility of dry matter and energy was greatest for the all wheat concentrate as compared to the 33 percent wheat and all oats concentrates. No significant differences were detected in total tract apparent protein digestibility. Plasma glucose concentrations were highest in geldings fed the all wheat concentrate beginning 90 min post feeding and remained elevated out to 4 h indicative of the higher starch content of wheat. No palatability or health problems associated with feeding of wheat were noted. These data indicate that wheat can successfully be included in rations for horses.

(Key Words: Equine, Nutrition, Wheat, Digestibility.)

Introduction

The high cost of oats due to drought conditions over the last two years have forced horse producers to look for alternative sources of concentrates. With the surplus of wheat in storage in the United States, wheat has been a good buy relative to oats and at times has been competitively priced against corn. However, little information on feeding wheat to horses is available. One experiment showed that wheat was less palatable than oats to ponies, but no digestibility data were derived in that study (Hawkes et al., 1985). Because of the lack of information, producers are reluctant to include wheat

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in diets for horses at any level. Many fear that the high gluten content will produce an impaction leading to colic and death. The objective of the present study was to determine the digestibility of dry matter (DM), energy (DE) and protein (CP) of wheat fed at graded levels to mature horses, and determine the effect on postprandial blood glucose concentrations.

Materials and Methods

Eight mature geldings were used in simultaneous 4x4 Latin square experiments to study the effects of feeding graded levels of wheat. Concentrate diets (Table 1) were fed in a 60:40 ratio with native prairie grass hay and consisted of 100 (W), 66 (WO), 33 (OW) or 0 (O) percent wheat with the balance as oats. The concentrate portion of each diet was mixed, ground and pelleted into a 3/8 inch pellet. Rations were fed at a constant dry matter intake across treatments (Table 2) in two equal feedings at 7 a.m. and 7 p.m. daily during a two week adjustment period and a one week collection period. Geldings were allowed 12 h to consume their ration at which time any feed refused was collected, weighed and recorded. All geldings were exercised daily on a mechanical walker for 20 min at a rate of approximately 15 miles/h in order to increase DE requirement and allow for feeding a greater amount of total ration. It was felt that if there were health problems associated with feeding wheat, a higher intake would disclose them.

In addition, chromic oxide was added as an indigestible marker to the concentrate portion of the diet at the rate of 5 g/feeding for 7 d prior to the start of collection to determine total fecal output. Fecal grab samples were taken over the last 72 h of each experimental period such that each two hours

Table 1. Composition of experimental diets, DM basis.

	Diet			
Ingredient (%)	W	WO	OW	O
Wheat	59.1	38.6	18.9	----
Oats	----	19.3	37.8	55.5
Salt	.3	.3	.3	.3
DiCal	.36	.33	.30	.27
Limestone	.24	.27	.30	.33
Soybean Meal	----	1.2	2.4	3.6
Prairie Hay	40	40	40	40

Table 2. Least squares mean dry matter and crude protein intake and digestibility of dry matter energy and crude protein.

Item	Diet W	WO	OW	O	SEM
DM Intake,lb	15.2[a]	15.2[a]	15.2[a]	15.3[a]	.30
CP Intake, lb	1.87[a]	1.81[a]	1.81[a]	1.81[a]	.09
DM Digestibility, %	69.6[a]	66.2[ab]	64.1[b]	65.1[b]	2.18
Apparent Protein Digestibility, %	71.7[a]	70.5[a]	70.5[a]	72.3[a]	2.06
Energy Digestibility, %	68.1[a]	65.1[ab]	63.6[b]	64.2[b]	2.08

[a,b] Means in the same row not sharing the same superscript are significantly different ($p<.05$).

post feeding was represented. All fecal samples were dried for 72 h and composited using equal weights of each sample. The composite was then ground, chromium content of the feces determined colorimetrically using a wet ash procedure (Fenton and Fenton, 1979) and total fecal output calculated assuming quantitative recovery of chromium fed. Energy content of feed and feces was determined by burning pelleted samples under 30 atm of oxygen in a bomb calorimeter (Parr, 1968). Nitrogen content of feed and feces was determined by standard Kjeldahl analysis (AOAC, 1975).

On the last day of each collection period, blood samples were drawn by venipuncture into heparinized vacuum tubes to represent each 30 minutes post feeding out to 4 hours and then hourly until the next feeding. Blood samples were immediately centrifuged and plasma harvested and frozen for subsequent analysis. Plasma glucose concentration was determined on duplicate samples colorimetrically at 430 nm on a Beckman DU spectrophotometer (Sigma, 1988).

Intake and digestibility data were analyzed by analysis of variance using a model that accounted for differences due to horse, period and treatment and least squares means tested using Tukey's W at the $p<.05$ level (SAS, 1985). Plasma glucose data were analyzed by repeated measures analysis of variance, again using horse, period and treatment as main effects and time as the repeated variable (SAS, 1985). Least squares means were calculated and polynomial response curves for plasma glucose concentrations over time compared by constructing orthogonal contrasts. Significance was declared if the F test for a particular contrast had a $p<.05$.

Results and Discussion

Least squares means for DM and CP intake and digestibility of DM, energy and CP are shown in Table 2. No significant differences were found for DM or CP intakes. Therefore, differences in nutrient digestibilities and plasma glucose concentrations observed in this trial were not effected by intake.

Apparent CP digestibility was similar across all treatments ($p>.05$). These values are in the normal range expected, given the ration contained 60 percent concentrate (NRC, 1989). Since crude protein intake was similar for all horses on each treatment, regression analyses to estimate the true protein digestibility of wheat was not possible.

Geldings that received W digested a higher proportion of dietary dry matter ($p<.05$) than geldings consuming either OW or O. Least squares mean dry matter digestibilities were 69.6, 66.2, 64.1 and 65.1 percent for treatments W, WO, OW and O, respectively. Those results were expected since the calculated fiber content of W was 15 percent as compared to 20 percent for O.

Geldings consuming the all wheat concentrate also digested a higher proportion ($p<.05$) of the energy when compared with the other three diets. Least squares mean digestibility coefficients for energy were 68.1, 65.1, 63.6 and 64.2 percent for treatments W, WO, OW and O, respectively. Applying those percentages to the gross energy determined for each diet yields DE concentrations of 1.29, 1.25, 1.21 and 1.25 Mcal/lb DM for the four diets, respectively (Table 3).

Further, in a separate digestion trial the DE content of the hay alone was determined to be .73 Mcal/lb DM (Table 3). Using by difference calculations, the DE (Mcal/lb DM) of the concentrate portion of each diet and wheat and oats can be estimated for comparative purposes. An assumption of no associative effects on energy digestibility between the concentrate and hay must be made. Certainly the potential for a negative associative effect of the concentrate portion of the diet on the neutral detergent fiber (NDF) fraction of the hay and oats exists. It has been shown that as starch intake increases, NDF digestibility decreases, presumably because of a pH depression in the hindgut (Thompson et al., 1981). However, using the calculated values for wheat and oats, a predicted total ration DE can be calculated and compared to the actual values obtained from the digestibility trial to indicate the existence and extent of such an effect.

The DE content of the concentrate portion of each diet was calculated by difference to be 1.66, 1.60, 1.52 and 1.57 Mcal/lb DM for W, WO, OW and O respectively (Table 3). Since wheat is the only energy source in W and

Table 3. Digestible energy of total rations, hay, and concentrates and calculated DE of wheat and oats.

Item	Diet W	WO	OW	O
Total Ration DE[a]	1.29	1.25	1.22	1.25
Hay DE[b]	.72	.72	.72	.72
Concentrate DE[c]	1.66	1.60	1.52	1.57
Wheat DE[c]	1.69	----	----	----
Oats DE[d]	----	----	----	1.47
Predicted Total Ration DE[e]	----	1.25	1.21	----

[a] Determined from digestibility data in this trial.
[b] Determined from digestibility data in a separate trial.
[c] Calculated by difference.
[d] Calculated by difference using the DE value for wheat and assuming a DE value of 1.6 Mcal/lb for soybean meal.
[e] Calculated using a DE value of 1.69 Mcal/lb for wheat, 1.47 Mcal/lb for oats, .72 Mcal/lb for hay, and 1.6 Mcal/lb for soybean meal.

constitutes 98.5 percent of the concentrate, the DE content is calculated to be 1.69 Mcal/lb DM. That compares favorably with published values of 1.74 (NRC, 1978) and 1.75 (NRC, 1989). Applying a value of 1.60 Mcal/lb for soybean meal NRC, 1989), which constitutes 6 percent of the concentrate, and the above assumptions, the calculated value of DE for oats in diet O is 1.48 Mcal/lb DM. That compares to published values of 1.51 (NRC, 1978) and 1.45 (NRC, 1989) Mcal/lb. Those values are calculated from a regression equation based on the acid detergent fiber (ADF) of the feedstuff as follows: DE (Mcal/lb) = 1.85 - 0.025(%ADF) (Fonnesbeck, 1981).

Using the derived DE values for wheat and oats, the predicted total ration DE for diets WO and OW are 1.25 and 1.21 Mcal/lb DM respectively. The actual values obtained from the digestion trial were 1.25 and 1.22 Mcal/lb for WO and OW respectively. That would suggest that if digestibility of the NDF fraction of oats is depressed by the starch content of wheat, it is a small amount.

Least squares mean plasma glucose concentrations are shown graphically in Figure 1. Plasma glucose response curves were best described by the fifth order polynomial ($p<.05$) and were similar for all treatments.

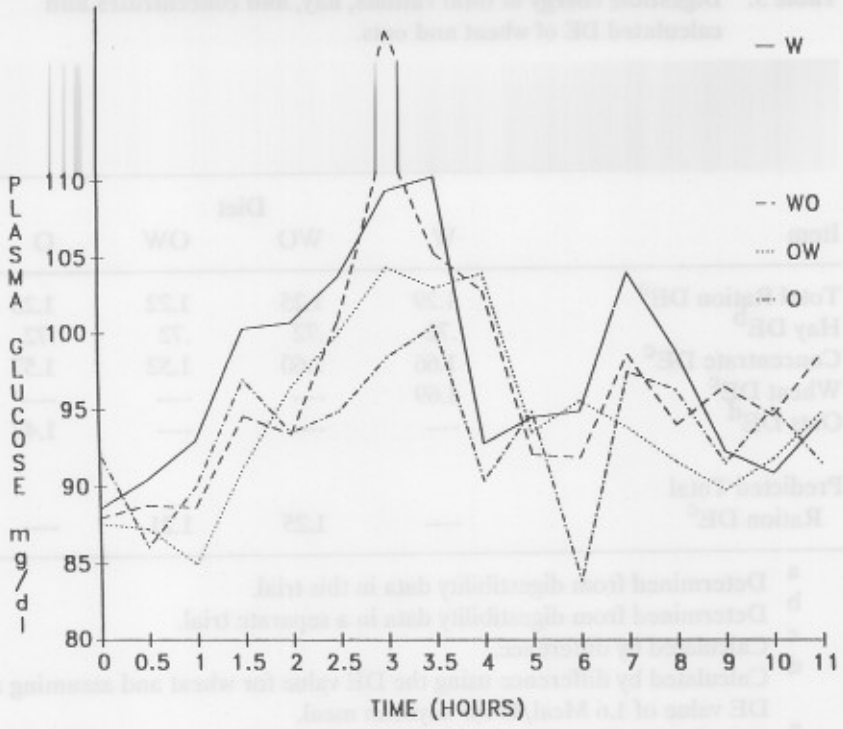


Figure 1. Least square mean plasma glucose concentrations in geldings fed wheat and oat based diets.

The postprandial peak occurred between 3 and 3.5 hr in all treatments, which suggests the insulin response was similar for all treatments, although plasma insulin concentrations were not measured in this experiment. Orthogonal contrasts of treatment response curves were significant for W versus O and the average of W and WO versus the average of OW and O. No difference ($p>.05$) was found between WO and OW. Therefore, plasma glucose concentrations apparently mirror the difference in starch content of the diet, suggesting that at these levels of intake, starch digestion in the small intestine remained at a constant percentage across treatments. That agrees with the findings of other experiments which found no difference in pre-cecal starch digestion with concentrate intakes up to 80 percent of diet (Hintz et al., 1971, Arnold et al., 1981, Hinkle et al., 1983).

Results of this study indicate that energy and DM digestibility of wheat are higher than oats while apparent protein digestibility is similar. The higher starch content of wheat is reflected in plasma glucose concentrations, indicating that a proportional amount of the additional starch was digested and absorbed in the small intestine. Further, the protein in wheat was digested at similar rates as that from oats, suggesting that concerns regarding the gluten being indigestible and a cause of impaction are unwarranted. No

palatability problems with any of the diets were observed, nor were there any short term health problems associated with the feeding of wheat. The authors conclude that wheat can be successfully incorporated into diets for horses, even though NDF digestibility may be slightly depressed when fed in combination with other grains that have a high NDF content such as oats or barley. More research is needed to determine the value of wheat in supporting productive functions such as growth and lactation and the effects of processing on site of digestion and feeding safety.

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EFFECT OF CLENBUTEROL ON LAMB PERFORMANCE AND CARCASS TRAITS

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Story in Brief

Twelve fall born Dorset wethers were used to compare the effects of 0.2 mg/hd/d clenbuterol on performance and carcass traits. Lambs were allotted to one of three groups with Treatments 2 and 3 receiving clenbuterol for 21 days. Following this period lambs in group 3 were given Lasix (1ml/hd/d) for 3 days. Lambs were then slaughtered at 6 or 13 days following clenbuterol removal. Significant differences ($P<.05$) were found among treatments, with treated lambs gaining faster than controls. For carcass characteristics, Treatment 3 had significantly ($P<.10$) larger loineye areas then Treatment 1. Adjusted fat thickness, leg conformation, and yield grade differed significantly ($P<.05$) for Treatment 3 versus Treatment 1, indicating clenbuterol treated lambs produced carcasses with a higher lean to fat ratio.

(Key Words: Clenbuterol, Lambs, Average Daily Gain, Carcass Traits)

Introduction

Production of excessively fat lambs has long been a concern of the packing industry. Thus, in 1986 the American Sheep Producers Council established a "certified lean lamb program" based on the following criteria: 1) external fat thickness of .1 to .25 inches, 2) leg conformation score of average choice or higher, 3) kidney and pelvic fat of 4.5% or less, 4) USDA quality grade of low choice or higher, and 5) no evidence of ram characteristics.

Tatum et al. (1986) reported that of over 6000 carcasses surveyed, over 60% failed to meet these requirements and the overwhelming reason was failure to fit the external fat requirement.

Clenbuterol is a ß-Agonist reported to increase muscle and decrease deposition of fat. It has also been associated with an increase in average daily gain.

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The objective of this study was to determine the effect of clenbuterol on lamb performance and carcass traits, particularly fat deposition.

Materials and Methods

Twelve fall born Dorset wethers were randomly allocated across three treatment (T) groups and clenbuterol was administered for 21 days as follows: T-1 = none, T-2 = 0.2mg/head/day, T-3 = same dosage as group 2 but these lambs were given Lasix at 1 ml/head for the first three days after withdrawal of clenbuterol, in conjunction with another trial testing residue clearance time in the urine. Lambs were fed a 16% crude protein commercial diet. While on trial, lambs were weighed on a weekly basis.

Two lambs from each treatment were slaughtered at day six post withdrawal, while the remainder of the lambs were slaughtered at day 13 post withdrawal. Lambs were delivered to the Oklahoma State University Meat Laboratory and after a twelve hour shrink they were weighed and slaughtered. At 24 hours post mortem, data for USDA quality and yield grade determinations (USDA, 1982) were obtained by trained university personnel.

Data were analyzed using treatment as a single main effect. For carcass traits, hot carcass weight was included as a covariate since many carcass parameters are highly weight dependent.

Results and Discussion

Performance trait means for the 21 day administration of clenbuterol are reported in Table 1. Since Treatments 2 and 3 were not treated differently during this trial period, they were grouped together for comparison to the

Table 1. Performance traits for control and clenbuterol-treated lambs.

Item	Control	Treated[a]
Initial weight, lb.	71.50	72.75
21 d. weight[b], lb.	83.25	90.63
Average daily gain, lb.	0.56[c]	0.85[d]

[a] Clenbuterol administered (mg/day/lamb): 1 = 4 lambs at 0.0 mg., 2 = 8 lambs at 0.2 mg.

[b] Weight at end of clenbuterol administration period.

[cd] Means with different superscript letters are significantly different ($P<.05$).

control group. Means for average daily gain were significantly different ($P < .05$) for the treated versus control lambs. This coincides with a results found by Baker et al. (1984) in which lambs receiving 3.53 mg/day clenbuterol in the diet gained significantly faster than control lambs given no clenbuterol. It is important to note for the present study that there were visual differences in the rate of loineye and leg muscling changes, with treated lambs increasing in muscularity at a greater rate then controls.

Least squares means for carcass traits are presented in Table 2. There was a tendency for decreased actual fat thickness as well as kidney and pelvic fat for the clenbuterol treatment groups versus control lambs, however the means were not significantly different. When comparing adjusted fat thickness

Table 2. Least squares means for carcass traits.

Item	Treatment[a] 1	2	3
Slaughter weight, lb.	83.84	83.56	82.60
Hot carcass weight, lb.	49.63	49.63	49.63
Dressing %	60.57	60.59	60.96
Skeletal maturity[b]	1.75	2.25	2.25
Lean maturity[b]	1.70	1.77	2.03
Overall maturity[b]	1.72	2.01	2.14
Prelim. quality grade[c]	11.88	11.44	11.72
Overall conformation[c]	11.35	11.21	10.94
Final quality grade[c]	12.16	12.69	13.41
Fat thickness, in.	0.15	0.12	0.11
Adj. fat thickness, in.	0.18[d]	0.15 [de]	0.13[e]
Ribeye area, sq.in.	2.05[f]	2.17[fg]	2.22[g]
Leg conformation[c]	11.82[d]	12.47[de]	13.46[e]
Kidney and pelvic fat, %	2.08	1.97	1.70
Yield Grade	2.79[d]	2.54[de]	2.27[e]

[a] Clenbuterol administered (mg/day/lamb) to 4 lambs per treatment: 1 = none (control); 2 = 0.1 with no Lasix upon withdrawal; 3 = 0.1 with 1ml/Lasix/lamb/day for the first 3 days of withdrawal.

[b] 1 = A minus; 2 = A avg.

[c] 10 = low Choice; 11 = avg. Choice; 12 = high Choice; 13 = low Prime.

[de] Means in same row with a different superscript letter are significantly different ($P<.05$).

[fg] Means in same row with a different superscript letter are significantly different ($P<.10$).

however, means for lambs in Treatments 3 were significantly lower than the means for Treatment 1 lambs. There were also significant differences when comparing Treatment 1 to 3 for the muscling traits of ribeye area and leg conformation score. This is consistent with previous work where clenbuterol treatments have increased ribeye area versus controls. Due to advantages in trimness and muscling, yield grades were also significantly different for Treatment 3 when compared to Treatment 1. The effect of clenbuterol on muscling traits increases the lean to fat ratio in the carcass.

Lean, skeletal, and overall maturity, while tending to be higher for Treatments 2 and 3 than for Treatment 1, were not significantly different ($P > .05$). This could be due to the young age of all lambs at slaughter and to the small sample size per treatment. There was less than a third of a quality grade (high choice to low prime) difference for the 3 treatment groups, indicating that clenbuterol did not reduce the deposition amount of flank streaking or intramuscular fat.

It may be that if all lambs had been slaughter at the end of the 21 day administration of clenbuterol without a withdrawal period, more significant differences might have been seen for control versus treated lambs in regards to fat thicknesses and muscling traits.

Implications

This trial helps show that ß-Agonists can help to increase muscle mass and thus lower the percent fat in lamb carcasses. This could be an important production tool with the "lean lamb certification program". Increasing muscularity of lambs while decreasing fat thickness will help increase the percentage of lambs meeting the "lean lamb criteria". With a fast paced society and increasing health concerns, production of a uniform trim product will continue to gain importance. This will be especially true in the lamb slaughtering industry where production of excessively fat carcasses is a wide spread, consistent problem, and one that must be solved by producers and packers together.

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THE EFFECT OF ISOLATED SOY PROTEIN SUBSTITUTION FOR MILK PROTEINS WITH AND WITHOUT MAINTAINING CONSTANT LACTOSE ON PERFORMANCE OF EARLY WEANED PIGS

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Story In Brief

Two hundred fifty two pigs (84 pigs in each of 3 Trials) weaned at approximately 23 days of age were used to determine the effect of isolated soy protein substitution for milk proteins, with and without constant lactose. Treatments were: 1) a basal pre-starter diet containing 10% dried skim milk and 20% whey; 2) and 3) 50 and 100% substitution, respectively, of both dried skim milk and whey with isolated soybean protein with constant lactose; 4) and 5) 50 and 100% replacement, respectively, of dried skim milk and whey with isolated soybean protein without lactose; 6) a corn-soybean meal diet with lactose; and 7) a corn-SBM diet without lactose. Trial duration was 2 weeks (Period 1) with gain and efficiency of gain obtained weekly. All pigs were fed a common 18.5% crude protein starter diet for an additional 3-week period (Period 2). During week 1, a quadratic response in average daily gain was observed in pigs fed increasing levels of isolated soy protein with lactose while no differences in gain were observed in pigs fed isolated soy protein without lactose. Pigs fed the corn-soybean meal diet without lactose had lower gains than those fed the basal pre-starter diet (Treatment 1). Gain:feed ratio in week 1 followed a similar pattern to that observed for gain. Treatment differences in gain and efficiency of gain during week 2 and for Period 1 were not significant. Performance during Period 2 was not affected by previous treatment. This study suggests that the lactose component of milk products may explain part of the response to milk protein observed in early weaned pigs.

(Key Words: Swine, Nutrition, Weaning, Protein Source, Lactose.)

Introduction

It has been well documented that growth rate and efficiency of feed utilization of early weaned pigs are superior with milk protein diets when

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compared to soybean protein diets (Hays et al., 1959; Coalson et al., 1972; Sheery et al., 1978; Wilson and Leibholz, 1981; Leibholz, 1982). Recently, however, two studies (Dietz et al., 1988; Geurin et al., 1988) indicate that sources of refined soybean protein offer a suitable replacement for milk protein in diets of early weaned pigs. It has also been reported that pigs fed isolated soy protein diets with added lactose had improved gain and efficiency of gain when compared to those receiving isolated soy protein diets without added lactose (Sewell and West, 1965; Giesting et al., 1985; Dietz et al., 1988).

The objective of this study was to evaluate the effect on performance of 50 and 100% substitution of dried skim milk (DSM) and whey with isolated soy protein, with and without maintaining constant lactose. The lactose effect on pigs fed a corn-soybean meal (SBM) diet was also investigated. All pigs were fed a common starter diet for an additional 3-week period to determine the effect of diet fed for the initial 2-week period on subsequent performance.

Materials and Methods

Two hundred fifty two Yorkshire, Hampshire and Yorkshire x Hampshire crossbred pigs (84 pigs in each of three replicates) were weaned at approximately 23 days of age (actual age 21 to 27 days). Pigs within replicate were blocked into two age groups with blocks consisting of seven pens. Forty two pigs per block (six pigs per pen) were stratified by sex, litter and weight to pens, and pens were randomly allotted to one of seven treatments.

Dietary treatments fed during the first 14 days (Period 1) consisted of the following (Table 1): 1) a basal pre-starter diet containing 10% dried skim milk and 20% of an edible grade of dried whey with limited use of 50% soybean meal; 2) and 3) 50 and 100% substitution, respectively, of dried skim milk and whey on an equal weight basis with isolated soy protein[4] with lactose maintained at the level present in the basal diet, 4) and 5) 50 and 100% substitution, respectively, of DSM and whey with isolated soy protein (Nurish 3000[5] replaced protein from Nurish 2000 on an equal crude protein basis) with no correction for differences in lactose; 6) a corn-SBM based diet with lactose maintained at the level present in the basal diet; and 7) the corn-SBM based diet of treatment 6 without lactose. All diets fed during Period 1 were formulated to contain 1.30% lysine, .90% Ca and .70% P. In the subsequent 21-day period (Period 2) all pigs were fed a common 18.5% crude protein corn-soybean meal starter diet (Table 2) to evaluate any carry-over effects on

[4]Nurish 2000; Protein Technologies International, St. Louis, MO
[5]Protein Technologies International, St. Louis, MO

Table 1. Composition of diets fed during Period 1 (2 Weeks)

Ingredient	Treatment[a] 1	2	3	4	5	6	7
Corn, US No 2	44.825	49.075	53.225	70.445	70.645	38.845	61.515
Soybean meal, 50%	13.80	7.00	.30	7.00	3.60	27.90	26.00
Casein	---	---	---	1.48	---	---	---
Nurish 2000[b]	---	15.00	30.00	---	---	---	---
Nurish 3000[b]	---	---	---	6.64	13.28	---	---
Dried skim milk	10.00	5.00	---	---	---	---	---
Whey protein isol.	---	---	---	1.89	---	---	---
Whey, dried isol.	20.00	10.00	---	---	---	---	---
Lactose, 97%	---	2.57	5.14	---	---	20.61	---
Fishmeal, Menhaden	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Soybean oil	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Lysine, HCL	.10	.10	.10	.10	.10	.10	.10
Ethoxyquin	.025	.025	.025	.025	.025	.025	.025
Methionine	---	---	---	---	---	.10	.05
Apraland[c]	.10	.10	.10	.10	.10	.10	.10
Calcium carbonate	.40	.37	.30	.75	.86	.61	.75
Dicalcium phosphate	.51	.52	.55	1.32	1.15	1.47	1.22
Vit. TM premix[d]	.94	.94	.94	.94	.94	.94	.94
Salt	.30	.30	.30	.30	.30	.30	.30
Tryptophan	---	---	.02	---	---	---	---

Table 1. (Continued).

Calculated composition of diet:							
ME, kcal/kg	3,454.61	3,456.81	3,461.22	3,452.40	3,448.00	3,452.40	3,47[illegible].86
Lactose, %	19.99	19.99	19.99	.00	.00	19.99	.00
Lysine, %	1.30	1.30	1.30	1.30	1.30	1.30	[illegible].30
Crude protein, %	19.90	19.73	19.64	21.49	22.68	20.07	[illegible].08
Threonine, %	.89	.83	.77	.89	.89	.80	.84
Tryptophan, %	.25	.24	.26	.26	.28	.25	.26
Met + Cys, %	.72	.74	.77	.83	.89	.76	.78
Calcium, %	.90	.90	.90	.90	.90	.90	.90
Phosphorus, %	.70	.70	.70	.70	.70	.70	.70

[a] As fed basis.
[b] Protein Technologies International, St. Louis, MO.
[c] Contains 150 g Apramycin per ton of complete feed.
[d] Supplies 8.800 IU vitamin A, 880 IU vitamin D, 37 IU vitamin E, 44 mg pantothenic acid, 59 mg niacin, 8[illegible] mg riboflavin, 7.3 mg menadione sodium bisulfate, .04 mg vitamin B12, 3 mg biotin, 6 mg pyridoxine, 2 mg f[illegible]ic acid, 10 mg thiamine, 880 mg choline chloride, .2 mg selenium, .06 g manganese, .2 g zinc, .2 g iron, .02 [illegible] copper, .2 g magnesium, 1 g potassium, and .4 mg iodine per kg of feed.

Table 2. Composition of diet fed during Period 2 (3 weeks)

Ingredient	% of Diet[a]
Yellow Corn	67.55
Soybean Meal	28.50
Dicalcium Phosphate	1.95
Calcium Carbonate	.90
Vit. TM Premix[b]	.375
Lysine	.15
Salt	.40
Copper Sulfate	.075
Apralan[c]	.10
Calculated Composition of Diet:	
ME, kcal/kg	3,150.62
Lysine, %	1.10
Crude Protein, %	18.48
Threonine, %	.75
Tryptophan, %	.22
Met + Cys, %	.61
Calcium, %	.85
Phosphorus, %	.70

[a] As fed basis.

[b] Supplies 6,600 IU vitamin A, 660 IU vitamin D, 28 IU vitamin E, 6.6 mg riboflavin, 33 mg pantothenic acid, 44 mg niacin, .03 mg vitamin B12, 5.5 mg menadione sodium bisulfate, 45 mg manganese, 150 mg iron, .15 mg selenium, .30 mg iodine, 15 mg copper, and 150 mg zinc per kg of feed.

[c] Contains 150 g Apramycin per ton of complete feed.

performance from diets fed during Period 1. Pigs had ad libitum access to both feed and water during Period 1 and Period 2.

The pigs were housed in an environmentally controlled nursery in pens measuring 3.8 by 5.0 feet on a raised, woven wire floor. A temperature of 84-86°F was maintained during the first week of the experiment and was decreased 2°F per week for the remainder of the trial.

Individual pig weights and pen feed intake was measured weekly, and pen feed efficiency was evaluated. Pen was used as the experimental unit to evaluate average daily gain, gain:feed ratio and average daily feed intake.

Results and Discussion

Results for average daily gain, gain:feed ratio and average daily feed intake are presented in Table 3. During week 1, a quadratic response ($P<.08$) in average daily gain was observed in pigs receiving increasing levels of isolated soy protein with lactose such that pigs fed diets containing 50% isolated soy protein substituted for milk proteins with lactose had improved average daily gain, followed by a decline in average daily gain in pigs fed the 100% isolated soy protein diet with lactose. A similar trend in gain:feed was observed for pigs receiving these diets. Pigs fed diets in which 50 and 100% of the dried skim milk and whey was replaced by isolated soy protein without lactose had similar gains, however, a linear decrease ($P<.05$) in gain:feed was observed during week 1. Gains of pigs fed the corn-soybean meal diet with lactose were similar to those fed the basal diet, while those fed the corn-soybean meal diet without lactose had lower ($P<.05$) gains than those receiving the basal diet. Efficiency of feed utilization for pigs fed the corn-soybean meal diets, with and without lactose, followed the same trend as average daily gain, however, these differences were not significant.

During week 2 similar gains were observed in pigs fed the basal diet and the isolated soy protein diet with lactose, while gain:feed was more variable as noted by a trial by treatment interaction ($P<.05$). A linear and quadratic response ($P<.05$) in gain:feed was observed in Trial 2 and Trial 3, respectively, during week 2 for pigs fed increasing levels of isolated soy protein with lactose. Pigs receiving the basal diet and the isolated soy protein diets without lactose had similar gain. A treatment by trial interaction ($P<.05$) was observed in gain:feed for pigs fed the isolated soy protein diets without lactose, but neither the linear nor the quadratic effects were significant. Average daily gain and gain:feed for pigs receiving the corn-soybean meal diets, with and without lactose, were similar to those observed in week 1, however, the differences during week 2 were not significant.

Average daily gain and gain:feed for Period 1, regardless of treatment, were not significant. However, a treatment by trial interaction ($P<.05$) for gain:feed was observed.

During Period 2 no differences in average daily gain or gain:feed due to previous treatment were observed. Average daily feed intake during week 1, week 2, Period 1 and Period 2 was not affected by treatment.

The results of this study support the findings of Dietz et al. (1988) and Geurin et al. (1988) who reported that pigs fed isolated soy protein diets had gains and efficiency of feed utilization that was equal to the performance of pigs fed milk protein based diets. Also, the performance of pigs fed lactose supplemented diets in this study supports the results of Sewell and West (1965), Giesting et al. (1985) and Dietz et al. (1988) who reported increased

Table 3. Effect of protein source and level of lactose on ADG (lb/d, feed efficiency (g:f) and average daily feed intake (lb/d).

Item	Time of Trial		(1) Basal Diet	(2) 50% ISP +LAC	(3) 100% ISP +LAC	(4) 50% ISP -LAC	(5) 100% ISP -LAC	(6) C-SBM +LAC	(7) C-SBM -LAC
ADG	Week 1[ab]		.34[h]	.38	.28	.35	.31	.31[h]	.23[i]
	Week 2		.45	.42	.52	.46	.39	.44	.43
	Period 1		.39	.40	.40	.40	.35	.37	.33
	Period 2		1.22	1.20	1.21	1.18	1.21	1.11	1.15
G:F	Week 1[c]		.80	.84	.63	.78	.62	.73	.48
	Week 2[de]	(Tr 1)	.33	.33	.32	.44	.29	.54	.44
		(Tr 2)[f]	.64	.74	.87	.79	.72	.72	.77
		(Tr 3)[g]	.38	.34	.46	.13	.27	.27	.17
	Period 1[de]	(Tr 1)	.44	.47	.35	.50	.37	.64	.45
		(Tr 2)	.69	.75	.81	.79	.66	.66	.64
		(Tr 3)	.58	.61	.59	.44	.52	.50	.42
	Period 2[de]	(Tr 1)	.61	.64	.65	.62	.61	.65	.61
		(Tr 2)	.62	.59	.61	.60	.63	.56	.54
		(Tr 3)	.58	.63	.55	.65	.61	.55	.63

Table 3. (Continued).

ADFI	Week 1	.42	.44	.43	.45	.47	.40	.40
	Week 2	.96	.87	.93	.94	.90	.85	.91
	Period 1	.69	.66	.68	.69	.68	.62	.66
	Period 2	2.04	1.95	2.02	1.90	1.96	1.89	1.93

[a] Treatment effect ($P < .05$).
[b] Quadratic response in ADG with increasing level of ISP with lactose ($P < .08$).
[c] Linear decrease in G:F with increasing level of ISP without lactose ($P < .05$).
[d] Treatment by trial interaction ($P < .05$).
[e] Trial effect ($P < .05$).
[f] Linear increase in G:F with increasing level of ISP with lactose ($P < .05$).
[g] Quadratic increase in G:F with increasing level of ISP with lactose ($P < .05$).
[h,i] Means in same row with different superscripts differ ($P < .05$).

average daily gain and improved feed efficiency in pigs fed lactose supplemented diets when compared to those consuming diets without lactose.

The greatest response to the lactose supplemented diets was observed in week 1 of the experiment. This is consistent with the results observed by Ekstrom et al. (1975) which indicate that the lactase activity in the small intestine of baby pigs increase from a low at 1 day of age to a maximum at 15 days of age before falling to a plateau level of 75% of maximum by 28 days of age. Furthermore, results by Turlington et al. (1989) indicate that improved performance in early weaned pigs fed lactose supplemented diets may be due to greater energy and nutrient digestibilities and reduced digesta flow rate.

For Period 1 of this experiment, average daily gain and gain:feed of pigs fed the diet where 50% of the milk proteins were substituted with isolated soy protein without lactose (Treatment 4) were lower than those reported by Decuypere et al. (1981) and Dietz et al. (1988). However, performance of pigs fed the diet in which 100% of the dried skim milk and whey was replaced with isolated soy protein without lactose (Treatment 5) was similar to that observed by Geurin et al. (1988), but was lower than values reported by Dietz et al. (1988). Higher average daily gain and gain:feed have been obtained by Mateo and Veum (1980) for pigs fed isolated soy protein diets with lactose than those reported here. Pigs consuming the corn-soybean meal diet with lactose (Treatment 6) and the corn-soybean meal diet without lactose in this study had lower average daily gain and gain:feed than those obtained by Dietz et al. (1988) and Wilson and Leibholz (1981), respectively.

The results of this study indicate that the lactose component of milk products may explain part of the response to milk protein observed in early weaned pigs, and that partial or total replacement of milk proteins with isolated soy protein with lactose addition will produce performance equivalent to that observed with milk protein.

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EFFECTS OF SUBSTITUTING YEAST PROTEIN FOR SOY PROTEIN ON GAIN, FEED EFFICIENCY AND INCIDENCE OF SCOURS IN EARLY WEANED PIGS

T.M. Fakler[1], K.S. Sohn[2] and C.V. Maxwell[3]

Story in Brief

A study involving sixty-six Yorkshire pigs (six each from 11 liters) was conducted to determine the effect of substituting yeast protein for soy protein in prestarter and starter diets. Pigs were weaned at approximately 21 days of age and randomly allotted within litter to six treatments. From day 1 to day 14 (Period 1), a complex prestarter diet (Positive control), a standard corn-soybean meal prestarter diet (Negative control) and four diets containing increasing levels of yeast protein were fed. From day 15 to day 35 (Period 2), pigs were fed a lower lysine (1.1%), less complex starter diet. Fecal consistency was subjectively evaluated at 2-day intervals by three independent evaluators during weeks 1 and 2 and at the end of weeks 3, 4 and 5, with an increasing fluidity of the stool corresponding to an increased score. Fecal samples were obtained and dry matter content determined at the end of weeks 1, 2 and 4. Increasing levels of dietary yeast at the expense of soy protein did not significantly affect average daily gain, average daily feed intake or feed efficiency during any time period. A linear increase in fecal evaluation scores was observed in pigs fed increasing levels of yeast protein (treatments 2 through 6) for days 8, 10, 12, 14 and 21. However, a linear decrease in fecal dry matter was observed only during week 1 in pigs fed increasing levels of yeast protein. Performance characteristics were similar for pigs fed the yeast protein diets and the complex industry standard diets (Positive control). These findings indicate that yeast protein can be substituted for soy protein in prestarter and starter swine diets without loss in performance.

(Key Words: Early Weaned Pig, Protein Source, Yeast Protein.)

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Introduction

The practice of early weaning pigs (18 to 21 days of age) is considered essential in modern pork production in order to maximize profits by shortening the breeding cycle and maximizing reproductive efficiency of the sow. One of the major problems with the practice of early weaning is the observed postweaning lag which lasts from 5 to 10 days and is characterized by low feed intake, little or no gain, diarrhea and increased mortality rates. It has been suggested that nutritional factors may also influence postweaning performance in early weaned pigs (Li et al., 1990).

Although the young pig can utilize a simple corn-soybean diet when weaned as early as 18 days of age, performance is improved by incorporating alternative sources of protein into the diet (Dietz et al., 1988). Increased usage of milk products, particularly dried skim milk and dried whey, has been shown to increase performance of early weaned pigs. Availability of large surpluses encouraged the use of these milk products as subsidized, low price by-products were a part of worldwide dairy product surpluses. More recently, these surpluses have diminished as a result of decreased incentives and subsidies. In addition, rapid advances in processing technology have changed the type of milk by-products available.

Protein sources which have the potential of replacing the more expensive milk proteins or the soy proteins in early weaned pig diets should be readily accepted by the swine industry. This study was conducted to determine the effects of substituting yeast proteins for soybean meal in prestarter and starter diets and to compare performance of pigs fed the yeast protein diets with performance of pigs fed a complex diet formulated to meet typical industry standards.

Materials and Methods

Sixty-six Yorkshire pigs (six each from 11 litters) were weaned at 20 to 22 days of age and allotted by sex and weight within litter to one of six dietary treatments providing a total of eleven pigs per treatment. During the first 14 days, pigs were assigned to one of six dietary treatments (Table 1): 1) control diet formulated to meet industry standards (Positive control); 2) standard corn-soybean meal prestarter diet (Negative control); 3, 4, 5 and 6) replaced

Table 1. Composition[a] of diets fed during period 1.

Ingredient	Positive control	Negative control	Provesteen-T 25%	Provesteen-T 50%	Provesteen-T 75%	Provesteen-T 100%
Corn	46.56	61.44	62.20	63.13	62.99	63.55
SBM, 50%	12.00	30.00	22.60	14.90	7.50	----
DSM	10.00	----	----	----	----	----
Whey	20.00	----	----	----	----	----
Fish meal	5.00	----	----	----	----	----
Provesteen-T	----	----	7.05	14.00	21.18	28.00
Fat	4.00	4.00	4.00	4.00	4.00	4.00
Lys	.17	.24	.24	.24	.24	.24
Apralan	.10	.10	.10	.10	.10	.10
$CaCO_3$	.42	1.03	1.76	2.19	2.48	2.54
Dical	.51	1.85	.66	----	----	----
Vit. TM	.94	.94	.94	.94	.94	.94
Salt	.30	.40	.40	.40	.40	.40
Met	----	----	.05	.10	.15	.20
Trp	----	----	----	----	.02	.03
Calculated composition of diet						
ME (Mcal/lb)	1.56	1.56	1.56	1.56	1.55	1.54
Lys (%)	1.30	1.30	1.30	1.30	1.30	1.30
CP (%)	19.10	19.77	20.15	20.33	20.72	20.91
Thr (%)	.86	.79	.82	.85	.88	.90
Trp (%)	.24	.26	.24	.23	.23	.23
Met + Cys (%)	.70	.67	.67	.67	.67	.67
Ca (%)	.90	.90	.90	.90	1.00	1.00
P (%)	.70	.70	.70	.79	1.01	1.21

[a] As fed basis.

soy protein with dried yeast protein[4] at levels of 25, 50, 75 and 100% respectively, on an equal lysine basis (1.3%). For days 15 to 35 (Period 2), diets were reformulated to a lower lysine (1.1%), less complex starter diet (Table 2). Pigs were housed in individual, elevated metal pens in an environmentally controlled room with ad libitum access to feed and water. Interim gain and efficiency estimates were obtained weekly. Fecal samples

Table 2. Composition[a] of diets fed during period 2.

Ingredient	Positive control	Negative control	Provesteen-T 25%	Provesteen-T 50%	Provesteen-T 75%	Provesteen-T 100%
Corn	60.13	68.73	70.13	71.51	72.31	73.28
SBM, 44%	20.00	27.40	20.50	13.60	6.80	----
Whey	10.00	----	----	----	----	----
Fish meal	3.00	----	----	----	----	----
Provesteen-T	----	----	5.81	11.62	17.42	23.00
Fat	4.00	----	----	----	----	----
Lys	.17	.17	.17	.17	.17	.17
Apralan	.10	.10	.10	.10	.10	.10
$CaCO_3$	.62	.92	1.52	2.05	2.21	2.40
Dical	1.30	1.80	.86	----	----	----
Vit. TM	.38	.38	.38	.38	.38	.38
Salt	.30	.50	.50	.50	.50	.50
Met	----	----	.03	.06	.09	.13
Trp	----	----	----	.01	.02	.04
ME (Mcal/lb)	1.55	1.47	1.48	1.49	1.49	1.49
Lys (%)	1.10	1.10	1.10	1.10	1.10	1.10
CP (%)	17.08	17.90	18.19	18.49	18.77	18.95
Thr (%)	.72	.71	.74	.77	.79	.82
Trp (%)	.22	.24	.22	.22	.22	.22
Met + Cys (%)	.60	.60	.60	.60	.60	.60
Ca (%)	.85	.85	.85	.85	.89	.95
P (%)	.70	.70	.70	.72	.89	1.06

[a] As fed basis.

[4] Provesteen[R]T, Provesta Corporation, Bartlesville, OK

were obtained and dry matter content determined at the end of weeks 1, 2 and 4. Fecal consistency was subjectively evaluated at 2-day intervals by three independent evaluators during weeks 1 and 2 and at the end of weeks 3, 4 and 5. Each fecal sample was scored 1, 2, 3, 4 or 5 corresponding to evaluations of firm, moderately form, moderately watery, watery and extremely watery respectively.

The data for each response criteria were analyzed by least squares analysis of variance with treatment, litter, sex and appropriate 2-way interactions in the model. Orthogonal contrasts were used to compare linear, quadratic and cubic response to level of Provesteen in the diet (Negative control to 100%). Dunnett's test for comparisons with controls was used to separate means for characteristics in which differences were significant.

Results and Discussion

The effect of protein source on average daily gain is presented in Table 3. During all weeks and within all periods, pigs fed the yeast protein diets grew as fast as pigs fed the corn-soy diet and the complex positive control diet. In addition, during week 5, average daily gain increased with increasing level of yeast protein ($P < .06$).

Average daily feed intake (Table 4) and feed efficiency values (Table 5) were similar during all weeks and within all periods. It is interesting to note however, that though not statistically significant, the efficiency of feed

Table 3. Least squares means for average daily gain (lb).

			Provesteen-T			
Period	Positive control	Negative control	25%	50%	75%	100%
Period 1	.58	.49	.55	.52	.55	.55
Week 1	.40	.29	.31	.27	.34	.31
Week 2	.75	.67	.79	.77	.76	.79
Period 2	1.21	1.21	1.29	1.31	1.34	1.34
Week 3	.82	.94	1.01	1.07	1.16	1.00
Week 4	1.31	1.26	1.33	1.35	1.26	1.37
Week 5[a]	1.48	1.43	1.52	1.51	1.59	1.64

[a] Linear effect ($P < .06$) for negative control through 100% diet.

Table 4. Least squares means for average daily feed intake (lb).

Period	Positive control	Negative control	Provesteen-T 25%	50%	75%	100%
Period 1	.83	.75	.75	.76	.73	.73
Week 1	.56	.51	.49	.48	.51	.45
Week 2	1.10	.99	1.02	1.03	.95	1.00
Period 2	2.08	2.04	2.17	2.21	2.22	2.08
Week 3	1.62	1.58	1.72	1.82	1.79	1.62
Week 4	1.93	1.96	2.18	2.14	2.04	2.06
Week 5	2.71	2.59	2.62	2.68	2.84	2.57

Table 5. Least squares means for feed efficiency (Gain/Feed).

Period	Positive control	Negative control	Provesteen-T 25%	50%	75%	100%
Period 1	.702	.631	.762	.699	.619	.734
Week 1	.696	.586	.726	.603	.591	.629
Week 2	.709	.675	.798	.794	.646	.839
Period 2	.489	.583	.653	.640	.671	.575
Week 3	.684	.617	.671	.668	.601	.669
Week 4	.571	.513	.590	.681	.570	.621
Week 5	.581	.571	.638	.663	.614	.622

utilization during week 5 and period 2 was improved with the feeding of the yeast protein.

Fecal dry matter values on day 7 (Table 6) for pigs fed treatments 4, 5 and 6 were lower ($P<.05$) than for pigs fed treatments 1, 2 and 3. On days 14 and 28, fecal dry matter values were similar . Fecal scores (Table 7) for days 2 through 14 did not differ. On days 21 and 28, pigs fed the 75% Provesteen-T diet had higher ($P<.05$) fecal scores than pigs fed all other diets. An increased fecal score was observed with increasing levels of yeast protein on days 8, 10, 12, 21 and 35. This linear increase, although statistically significant, was still within a reasonable range for pigs of this age.

Table 6. Least squares means for percentage fecal dry matter.

Day	Positive control	Negative control	Provesteen-T 25%	50%	75%	100%
Day 7[a]	30.0[b]	27.0[b]	29.6[b]	25.0[c]	25.6[c]	24.6[c]
Day 14	27.0	25.6	26.8	26.3	24.7	27.1
Day 28	27.8	26.8	27.6	27.0	26.2	28.6

[a] Linear Effect ($P < .05$) for negative control through 100% diet.
[b,c] Means with different superscripts differ ($P < .05$).

Table 7. Least squares means for fecal scores.

Day	Positive Control	Negative Control	Provesteen-T 25%	50%	75%	100%
Day 2	1.60	1.49	1.57	1.59	1.46	2.26
Day 4	1.93	1.79	1.80	1.66	1.87	1.73
Day 6	1.54	1.75	1.61	1.68	1.86	1.96
Day 8[a]	1.73	2.02	1.87	2.26	2.55	2.59
Day 10[a]	1.87	2.14	1.90	2.33	2.49	2.66
Day 12[ab]	1.97	2.24	1.97	2.32	2.52	2.48
Day 14	2.20	2.47	2.27	2.32	2.61	2.70
Day 21[ab]	2.17[c]	2.16[c]	2.20[c]	2.28[c]	2.67[d]	2.35[c]
Day 28	2.11[c]	2.20[c]	2.39[c]	2.33[c]	2.47[d]	2.36[c]
Day 35[e]	2.38	2.39	2.41	2.47	2.51	2.56

[a] Linear effect ($P < .01$) for negative control through 100%diet.
[b] Cubic effect ($P < .05$) for negative control through 100%diet.
[c,d] Means with different superscripts within rows differ ($P < .05$).
[e] Linear effect ($P < .06$) for negative control through 100%diet.

The search for alternate sources of protein for use in early weaned pig diets in order to increase performance and profits continues. This study indicates that the yeast protein can be effectively substituted for soy protein in prestarter and starter swine diets for early weaned pigs without loss in performance.

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NUTRIENT COMPOSITION OF OKLAHOMA YELLOW CORN

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Story in Brief

Thirty one yellow dent corn hybrids grown at four Oklahoma locations during three years were analyzed for dry matter, crude protein, lysine threonine, isoleucine and methionine + cystine. Significant differences among hybrids were observed for crude protein, lysine, threonine, isoleucine and methionine + cystine when expressed as percent of corn on a dry matter basis. Significant differences among hybrids were also observed for threonine, isoleucine and methionine + cystine when expressed as percent of crude protein. Significant differences among production locations were observed for dry matter, crude protein, lysine, threonine, isoleucine and methionine + cystine expressed as percent of corn on a dry matter basis. Significant location differences were also observed for threonine and methionine + cystine expressed as percent of crude protein. Early maturing hybrids had significantly higher levels of lysine and threonine when expressed as percent of dry matter or as a percent of crude protein than later maturing varieties. Hybrid production location and days to maturity influenced nutrient composition of Oklahoma produced yellow dent corn.

(Key Words: Corn Composition, Amino Acids, Protein, Dry Matter.)

Introduction

Corn production is a minor enterprise in Oklahoma compared to other cereal grains, yet 5 to 9 million bushels are produced annually. Much of this production is available to swine producers. However research is not available to evaluate yellow dent corn hybrids produced in Oklahoma for specific amino acids and is very limited for crude protein and dry matter. Thus, this study

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was conducted to determine the protein and essential amino acid composition of 31 yellow dent corn hybrids grown at four Oklahoma locations.

Materials and Methods

Yellow dent corn hybrids were grown in 1987, 1988 and 1989 at four different sites in Oklahoma as shown in Table 1. Note that only some of the varieties were grown within each year and location. Of the thirty one hybrids grown six were classified as early maturing (90-104 days), 15 medium maturing (105-119 days) and 10 late maturing (120-140 days).

All corn samples were analyzed on a dry matter basis for crude protein, lysine, threonine, isoleucine, methionine and cystine. Amino acid concentrations were determined from acid hydrolysates by ion exchange chromatography using a Beckman model 6300 amino acid analyzer. The hydrolysis procedure did not protect from potential loss of methionine and cystine. Therefore, concentrations of these two amino acids here will be lower than actual concentrations. Difference among varieties may or may not be relative. Values for methionine (an essential amino acid) and cystine (a nonessential amino acid) were combined in all the data reported since cystine can meet up to 50% of the methionine requirements of swine.

Date from a total of 164 samples from the 31 hybrids were statistically analyzed using a least squares procedure to estimate means. Adjustments were made for hybrid, location and year within location. Partial correlations of crude protein with each of the amino acids were calculated to measure the association between each of these.

Table 1. Number of hybrids grown by year and location.

	Location			
Year	Haskell[b]	Goodwell[a]	Bixby[b]	Colbert[b]
1987	14	--	16	15
1988	24	23	--	24
1989	12	10	14	12

[a] Irrigated.
[b] Nonirrigated.

Results and Discussion

Least squares means for dry matter and crude protein of each hybrid are shown in Table 2. Differences among hybrids for dry matter were not significant with a range of 90.47 to 91.69%. Crude protein values expressed on a dry matter basis differed ($P<.01$) among hybrids ranging in value from 9.14% for Pioneer 3184 to 10.98% for Pioneer 3906 hybrid varieties.

Least squares means for lysine, threonine, isoleucine and methionine + cystine expressed as percent of corn on a dry matter basis are shown in Table 3. Differences ($P<.01$) were observed among hybrids for threonine, isoleucine and methionine + cystine, and ($P<.05$) for lysine.

Least squares means for lysine, threonine, isoleucine and methionine + cystine expressed as a percent of crude protein are shown in Table 4. Differences among hybrids for isoleucine ($P<.01$) and for threonine and

Table 2. Effect of hybrid on dry matter and crude protein of yellow corn.[ab]

Hybrid variety		No. samples	Dry matter, %	Crude[c] protein, %
R.C. Young	0R0 150	8	90.49	9.73
R.C. Young	0R0 180	4	90.50	9.20
R.C. Young	0R0 190	7	90.99	9.70
R.C. Young	0R0 Exp. 801	4	90.48	9.83
Pioneer	3906	6	90.84	10.98
Pioneer	3475	6	90.89	9.49
Pioneer	3184	6	90.54	9.14
Pioneer	3343	7	90.97	10.10
Stauffer	S3306	6	90.78	9.95
Stauffer	S6210	6	91.69	10.68
Stauffer	S8656	6	90.84	10.22
Funks	G-4323	6	91.14	10.95
Funks	G-4616	6	90.85	10.48
Golden Acres	T-E 6920-A	6	90.91	10.21
Golden Acres	T-E 6994	6	90.91	9.32
Golden Acres	T-E 7317	6	90.72	10.66

(Table 2 continued on next page)

Table 2. (Continued).

Hybrid variety		No. samples	Dry matter, %	Crude[c] protein, %
Taylor Evans	T-E6988	6	90.91	9.60
Garst	8808	6	90.98	9.41
Garst	8108	6	90.97	10.01
Garst	8344	6	91.11	9.96
Seedtec	ST-7680	3	91.02	9.50
Seedtec	ST-7711	3	91.33	9.65
Hyperformer	HS-566	3	91.32	10.26
Hyperformer	HS-64	4	91.34	10.63
Hyperformer	HS-67	7	91.04	9.95
Hyperformer	HS-88	4	90.58	10.17
Warner	W-2160	4	90.65	9.83
Warner	W-2192	4	90.62	10.61
Warner	W-2192A	4	90.57	10.09
Seedco	SC-123	4	90.47	10.49
Seedco	SC-119	4	90.93	9.70

[a] Dry matter basis.
[b] Standard errors for dry matter and crude protein are .289 and .247, respectively.
[c] Significant differences among hybrids ($P < .01$).

methionine + cystine ($P < .05$) were observed. No significant difference ($P > .10$) was observed among varieties for lysine expressed as percent of crude protein.

The effect of production location on dry matter and crude protein content is shown in Table 5. Differences ($P < .05$) among locations were observed for both crude protein and dry matter. Location also had an effect ($P < .05$) on lysine, threonine, isoleucine and methionine + cystine expressed as percent of dry matter as shown in Table 6. When the same amino acids were expressed as percent of crude protein, significant differences ($P < .05$) were also observed for lysine, threonine and methionine + cystine but not for isoleucine (Table 7).

Table 3. Effect of hybrid on lysine, threonine, isoleucine and methionine + cystine content of yellow corn. [ab]

Hybrid variety[c]		Lysine[d] %	Threonine[e] %	Isoleucine[e] %	Methionine[e] + cystine %
R.C. Young	0R0 150	.32	.38	.31	.23
R.C. Young	0R0 180	.32	.34	.30	.18
R.C. Young	0R0 190	.30	.35	.31	.24
R.C. Young	0R0 Exp. 801	.32	.36	.33	.28
Pioneer	3906	.34	.41	.34	.26
Pioneer	3475	.29	.39	.31	.17
Pioneer	3184	.27	.31	.26	.22
Pioneer	3343	.30	.35	.30	.27
Stauffer	S3306	.34	.41	.35	.27
Stauffer	S6210	.30	.38	.35	.31
Stauffer	S8656	.31	.36	.31	.31
Funks	G-4323	.33	.37	.35	.31
Funks	G-4616	.30	.36	.32	.32
Golden Acres	T-E 6920-A	.31	.36	.32	.35
Golden Acres	T-E 6994	.29	.32	.29	.25
Golden Acres	T-E 7317	.31	.38	.34	.33
Taylor Evans	T-E 6988	.31	.35	.29	.27
Garst	8808	.30	.33	.28	.24
Garst	8108	.31	.34	.30	.30
Garst	8344	.32	.36	.31	.31
Seedtec	ST-7680	.26	.33	.30	.24
Seedtec	ST-7711	.29	.33	.29	.21
Hyperformer	HS-566	.30	.31	.25	.24
Hyperformer	HS-64	.29	.38	.35	.28
Hyperformer	HS-67	.30	.36	.31	.29
Hyperformer	HS-88	.30	.36	.29	.30

(Table 3 continued on next page)

Table 3. (Continued).

Hybrid variety[c]		Lysine[d] %	Threonine[e] %	Isoleucine[e] %	Methionine[e] + cystine %
Warner	W-2160	.32	.36	.34	.24
Warner	W-2192	.34	.42	.38	.37
Warner	W-2192A	.33	.38	.31	.29
Seedco	SC-123	.29	.38	.36	.32
Seedco	SC-119	.31	.36	.33	.20

[a] Dry matter basis.
[b] Standard errors for lysine, threonine, isoleucine and methionine + cystine are .015, .016, .018 and .029, respectively.
[c] See Table 2 for number samples analyzed of each hybrid.
[d] Significant differences among hybrids ($P < .05$).
[e] Significant differences among hybrids ($P < .01$).

Table 4. Effect of hybrid on lysine, threonine, isoleucine and methionine + cystine expressed as % of crude protein.[a]

Hybrid variety[b]		Lysine %	Threonine[c] %	Isoleucine[d] %	Methionine[d] + cystine %
R.C. Young	0R0 150	3.29	3.88	3.19	2.30
R.C. Young	0R0 180	3.44	3.72	3.30	1.91
R.C. Young	0R0 190	3.08	3.63	3.18	2.50
R.C. Young	0R0 Exp. 801	3.32	3.69	3.34	2.91
Pioneer	3906	3.14	3.70	3.09	2.39
Pioneer	3475	3.05	4.11	3.22	1.88
Pioneer	3184	3.02	3.45	2.88	2.46
Pioneer	3343	3.00	3.50	2.98	2.10

(Table 4 continued on next page)

Table 4. (Continued).

Hybrid variety[b]		Lysine %	Threonine[c] %	Isoleucine[d] %	Methionine[d] + cystine %
Stauffer	S3306	3.41	4.06	3.50	2.72
Stauffer	S6210	2.89	3.59	3.26	2.94
Stauffer	S8656	3.05	3.53	3.00	3.05
Funks	G-4323	3.02	3.42	3.17	2.83
Funks	G-4616	2.92	3.48	3.06	3.08
Golden Acres	T-E 6920-A	3.07	3.54	3.09	3.42
Golden Acres	T-E 6994	3.10	3.44	3.11	2.64
Golden Acres	T-E 7317	2.98	3.55	3.12	3.10
Taylor Evans	T-E 6988	3.20	3.70	3.04	2.81
Garst	8808	3.20	3.55	3.01	2.58
Garst	8108	3.17	3.42	3.00	2.94
Garst	8344	3.21	3.59	3.07	3.05
Seedtec	ST-7680	2.77	3.45	3.15	2.55
Seedtec	ST-7711	3.06	3.44	3.00	2.18
Hyperformer	HS-566	2.91	3.11	2.47	2.42
Hyperformer	HS-64	2.81	3.57	3.22	2.65
Hyperformer	HS-67	3.05	3.60	3.14	2.93
Hyperformer	HS-88	3.01	3.57	2.88	2.94
Warner	W-2160	3.34	3.71	3.47	2.48
Warner	W-2192	3.22	4.00	3.65	3.61
Warner	W-2192A	3.29	3.80	3.12	2.81
Seedco	SC-123	2.80	3.66	3.38	3.01
Seedco	SC-119	3.17	3.68	3.44	2.03

[a] Standard errors for lysine, threonine, isoleucine and methionine + cystine expressed as % of crude protein is .153, .150, .152 and .266, respectively.
[b] See Table 2 for number samples analyzed.
[c] Significant differences among hybrids ($P < .05$).
[d] Significant differences among hybrids ($P < .01$).

Table 5. Effect of location on dry matter and crude protein content of yellow corn.[ab]

Location	Dry matter[c] %	Crude protein[c] %
Haskell	90.14[d]	11.08[d]
Goodwell	91.71[e]	9.58[e]
Bixby	90.64[f]	10.00[f]
Colbert	90.86[f]	9.56[e]

[a] Dry matter basis.
[b] Standard errors for dry matter and crude protein are .104 and .116, respectively.
[c] Any two means in same column not sharing a common superscript are different ($P < .05$).

Table 6. Effect of location on lysine, threonine, isoleucine and methionine + cystine of yellow corn.[ab]

Location	Lysine[c] %	Threonine[c] %	Isoleucine[c] %	Methionine[c] + Cystine %
Haskell	.33[d]	.39[d]	.34[d]	.31[d]
Goodwell	.29[ef]	.36[e]	.30[e]	.25[e]
Bixby	.32[dg]	.37[e]	.31[e]	.32[d]
Colbert	.30[fg]	.35[e]	.30[e]	.21[f]

[a] Dry matter basis.
[b] Standard errors for lysine, threonine, isoleucine and methionine + cystine are .006, .007, .007 and .012, respectively.
[c] Any two means in same column not sharing a common superscript are different ($P < .05$).

Table 7. Effect of location on lysine, threonine, isoleucine and methionine + cystine expressed as % of crude protein.[a]

Location	Lysine[b] %	Threonine[b] %	Isoleucine %	Methionine[b] + Cystine %
Haskell	2.99[d]	3.52[d]	3.12	2.81[d]
Goodwell	3.07[de]	3.75[e]	3.18	2.66[d]
Bixby	3.17[e]	3.68[de]	3.19	3.24[e]
Colbert	3.23[e]	3.64[de]	3.17	2.22[f]

[a] Standard errors for lysine, threonine, isoleucine and methionine + cystine expressed as % of crude protein is .056, .058, .056 and .108, respectively.

[b] Any two means in same column not sharing a common superscript are different ($P < .05$).

The effect of relative maturity measured in number of days from planting to maturity for dry matter and crude protein is shown in Table 8. No significant differences ($P > .10$) were observed. Relative maturity had an effect ($P < .05$) on lysine and threonine expressed as percent of dry matter with the early maturing hybrids higher than the medium or late maturing hybrids (Table 9). No significant differences were observed in days to maturity for isoleucine or methionine + cystine.

Table 10 shows the effect of maturity on the levels of lysine, threonine, isoleucine and methionine + cystine expressed as percent of crude protein.

Table 8. Effect of maturity on dry matter and crude protein content of yellow corn.[abc]

Maturity/Days		Dry Matter %	Crude protein %
Early	90-104	90.76	10.20
Medium	105-119	90.90	9.91
Late	120-140	90.86	10.07

[a] Dry matter basis.

[b] Standard errors for dry matter and crude protein are .089 and .100, respectively.

[c] No significant differences among hybrids ($P > .10$).

Table 9. Effect of maturity on lysine, threonine, isoleucine and methionine + cystine content of yellow corn.[ab]

Maturity/Days		Lysine[c] %	Threonine[c] %	Isoleucine %	Methionine + Cystine %
Early	90-104	.33[d]	.38[d]	.33	.28
Medium	105-119	.31[e]	.36[e]	.32	.26
Late	120-140	.30[e]	.36[e]	.31	.29

[a] Dry matter basis.
[b] Standard errors for lysine, threonine, isoleucine and methionine + cystine are .005, .006, .006 and .011, respectively.
[c] Any two means in same column not sharing a common superscript are different ($P < .05$).

Table 10. Effect of maturity on lysine, threonine, isoleucine and methionine + cystine expressed as % of crude protein.[a]

Maturity/Days		Lysine[c] %	Threonine[c] %	Isoleucine %	Methionine + Cystine %
Early	90-104	3.22[d]	3.74[d]	3.23	2.70
Medium	105-119	3.12[c]	3.65[de]	3.20	2.65
Late	120-140	3.01[e]	3.56[e]	3.08	2.85

[a] Standard errors for lysine, threonine, isoleucine and methionine + cystine are .048, .050, .050 and .093, respectively.
[b] Any two means in same column not sharing a common superscript are different ($P < .05$).

The early maturing hybrids tended to be higher in lysine and threonine than the medium or late maturing hybrids with a significant difference ($P<.05$) between the early and late maturing hybrids. The same relationship was observed when the amino acids were expressed as a percent of dry matter. No differences again were observed for isoleucine or methionine + cystine ($P>.10$).

Year within location differences ($P<.05$) were found for dry matter, crude protein and all amino acids on both a percent of dry matter and as percent of protein except for threonine expressed as percent of crude protein. Means for year within location are not presented, however they indicate nutrient composition at a given location can be affected by the year in which they were grown.

Partial correlations of crude protein with lysine, threonine, isoleucine and methionine + cystine were .40, .74, .76 and .47 respectively. This indicates that there is a relatively strong association between crude protein and either threonine or isoleucine as compared to lysine and methionine + cystine. These results suggest that significant nutrient composition differences occur among yellow dent corn hybrids grown in Oklahoma. Significant nutrient composition differences also occurred among production locations and days to maturity. Early maturing hybrids were higher in lysine and threonine than medium or late maturing hybrids even though no significant differences were observed for crude protein.

PERFORMANCE OF GESTATING GILTS FED WHEAT VS SORGHUM GRAIN

W.G. Luce[1], C.V. Maxwell[2], A.C. Clutter[3], M.D. Woltmann[4] and R. Vencl[5]

Story in Brief

A study was conducted to compare diets of hard red winter wheat vs sorghum grain for bred gilts. A total of 156 gilts were allotted from two seasons to the two dietary treatments. No significant differences were found between treatment means for litter size at birth, 21 days and 42 days; individual pig weight at birth, 21 days and 42 days; litter weight at birth, 21 days and 42 days; gestation gain and lactation loss. This study indicated that hard red winter wheat can be used successfully as a grain source for bred gilts.

(Key Words: Wheat, Sorghum Grain, Gestation, Swine.)

Introduction

Wheat in recent years has often been competitively priced with other cereal grains to justify its use as a livestock feed. Thus interest in feeding wheat is especially high in Oklahoma, a major wheat producing state with yields of 150 to 225 million bushels annually. Previous research conducted at Oklahoma State University (Luce et al., 1990) indicated that bred gilts fed hard red winter wheat had reduced reproduction performance as compared to those fed sorghum grain. Thus, this study was conducted to reevaluate wheat as an energy source in gilt gestation diets.

Materials and Methods

A total of 156 crossbred gilts mated to crossbred boars (Fall, 1989 and Spring, 1990) were randomly allotted within four lines to two dietary treatments.

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[1]Regents Professor [2]Professor [3]Assistant Professor [4]Graduate Student [5]Herd Manager

The four composite lines represented were as follows: 1) Unselected control; 2) Selection of boars for fast average daily gain under ad libitum conditions; 3) Selection of boars for fast average daily gain at 83% of predicted ad libitum; 4) Selection of boars for slow average daily gain under ad libitum conditions.

A sorghum grain-soybean meal diet and a hard red winter wheat-(TAM-105 variety) soybean meal diet was fed in both seasons (Table 1). The diets were formulated to be equal in lysine, calcium and phosphorus. Metabolizable energy and other nutrients were similar in both diets.

Table 1. Composition of experimental diets.

Ingredients, %	Gestation diets		Lactation diet
	Sorghum	Wheat	
Sorghum grain	81.20	---	77.80
Wheat, hard red winter	---	85.30	---
Soybean meal, 44% CP	14.40	10.40	17.80
Dicalcium phosphate	1.75	1.55	1.70
Calcium carbonate	1.05	1.15	1.10
Salt	.35	.35	.35
Vitamin-trace mineral mix[a]	.25	.25	.25
Chlorotetracycline	1.00	1.00	1.00
Total	100.00	100.00	100.00
Calculated composition			
Metabolizable energy, kcal/lb	1370	1411	1371
Protein, %	13.65	14.98	14.83
Lysine, %	.62	.62	.72
Calcium, %	.85	.85	.85
Phosphorus, %	.65	.65	.65

[a]Supplied 800,000 IU Vitamin A, 80,000 IU Vitamin D, 3,400 IU Vitamin E, 4,000 mg d-pantothenic acid, 5,400 mg niacin, 800 mg riboflavin, 660 mg menadione, 4mg Vitamin B12, 80,000 mg choline chloride, 18 mg selenium, 5 g manganese, 18 g zinc, 18 g iron, 2 g copper and 36 mg iodine per lb of premix.

[b]Supplied 200 g chlorotetracycline per ton of feed.

In all seasons, gilts were housed outside in dirt lots during gestation and group fed five pounds of feed per head per day. At day 110 of pregnancy, gilts were moved to individual confinement farrowing crates and litters were penned separately 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/day until farrowing. After farrowing, the gilts were self-fed the lactation diet for the duration of the 42 day lactation. Pigs had access to creep feed from 21 to 42 days of age.

Results and Discussion

Dietary treatment effect on litter size at birth, 21 days and 42 days; individual pig weight at birth, 21 and 42 days; litter weight at birth, 21 days and 42 days and gestation gain and lactation loss are presented in Table 2.

Table 2. Effect of grain source on reproductive performance of gestating gilts.[a]

Item	Sorghum grain gestation diet	Wheat gestation diet
No. litters	74	82
Litter size		
Birth	9.64	9.51
21 days[b]	8.08	7.79
42 days[b]	7.89	7.76
Pig weight, lb		
Birth	3.38	3.31
21 days	11.56	11.55
42 days	22.19	22.37
Litter weight, lb		
Birth	32.25	31.02
21 days[b]	92.09	88.61
42 days[b]	173.10	171.11
Gestation gain, lb	113.31	103.64
Lactation loss, lb	-2.61	-4.49

[a]No significant differences between treatment means.
[b]Significant diet x line interaction. See Table 3.

No significant differences between treatment means were found for any of the traits measured, but diet x line interactions were observed for litter size at 21 days ($P<.04$), litter size at 42 days ($P<.05$) and litter weight at 42 days ($P<.02$). Thus, these means are presented within line in Table 3.

Decreases ($P<.05$) in litter size at 42 days and litter weight at 21 and 42 days were observed for gilts fed sorghum grain diets as compared to those fed wheat in line 1. In contrast, litter weight at 21 and 42 days was less ($P<.05$) for gilts fed wheat in line 2 as compared to gilts fed sorghum grain. In line 3, litter size and weight at 42 days was also smaller ($P<.05$) for gilts fed wheat as compared to those fed sorghum grain. No significant differences were noted between gilts fed sorghum grain and wheat in line 4.

These trials indicated that hard red winter wheat can be used very successfully as a grain source for bred gilts, but specific recommendations may depend on genetic type of the sow herd. Results for line 1 were in contrast to research reported by Luce et al. (1990) when bred gilts fed TAM 101-variety hard red winter wheat had decreased reproductive performance as measured by litter size at birth and weaning, litter weight at birth and weaning and individual pig weights at weaning as compared to those gilts fed sorghum grain. The differences between these two experiments could be because of differences in wheat varieties or quality of the wheat used.

It should be noted that the wheat based diet contained 80 lb less soybean meal per ton than the sorghum grain based diet to achieve an aqual dietary lysine content. This 28% reduction in soybean meal should be considered when comparing the cost of wheat vs sorghum grain based sow diets.

Table 3. The effect of grain source on performance of gestating gilts within line.

	Line[a]							
	1		2		3		4	
Item	Sorghum	Wheat	Sorghum	Wheat	Sorghum	Wheat	Sorghum	Wheat
Litter size								
21 days	7.29	8.55	8.16	7.39	8.88[b]	7.34[c]	7.99	7.90
42 days	7.04[b]	8.47[c]	8.08	7.28	8.62	7.49	7.80	7.79
Litter weight, lb								
21 days	85.59[b]	101.34[c]	96.05[b]	79.66[c]	98.55[b]	83.70[c]	88.17	89.74
42 days	162.40[b]	197.69[c]	182.18[b]	153.16[c]	180.46	167.25	167.36	166.34

[a]1 = Unselected control. 2 = Selected for fast average daily gain under ad libitum conditions. 3 = Selected for fast average daily gain at 83% of predicted ad libitum. 4 = Selected for slow average daily gain under ad libitum conditions.

[b,c]Means in a row with different superscript within line differ ($P < .05$).

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SPRAY DRIED PLASMA PROTEIN AS A PROTEIN SOURCE FOR EARLY WEANED PIGS

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Story in Brief

A study involving 144 pigs (72 pigs in each of two trials) weaned at approximately 24 days of age (20-28 days), was conducted to determine the effect of replacing dried skim milk in complex prestarter diets with plasma protein (AP-820) or spray-dried fresh whole blood (AP-300) on performance of early weaned pigs. Treatments were: 1) a control complex prestarter diet containing 10% dried skim milk; 2) and 3) dried skim milk was replaced on an equal lysine basis with 4% AP-820 or 2.75% AP-300, respectively. All diets were formulated to contain 1.4% lysine and 20% dried whey. Treatments were applied for a 2-week period (Period 1) followed by a 3-week period (Period 2) when all pigs were fed a common 18% crude protein starter diet. Gain and efficiency were measured weekly. During week 1, week 2 and for the overall-2 week period, pigs fed AP-820 or AP-300 grew faster and consumed more feed than those fed dried skim milk. Pigs fed AP-820 had higher average daily gain and average daily feed intake than those fed AP-300. Feed efficiency during Period 1 was not affected by dietary treatments. Pigs fed AP-820 or AP-300 continued to have improved gain and efficiency during a subsequent 3-week period when pigs from all treatments were fed a common starter diet. These results suggest that spray dried plasma proteins are effective alternatives to dried skim milk in a complex prestarter diet for early weaned pigs and improve performance when compared to dried skim milk.

(**Key Words:** Swine, Nutrition, Weaning, Plasma Protein, Spray Dried Whole Blood.)

Introduction

Milk proteins have been used in the prestarter diet to minimize the effect of the 5 to 10 day postweaning lag period and their contribution to

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improved performance has been reported (Wilson and Leibholz, 1981; Walker et al., 1986). Recently, however, four papers (Dietz et al., 1988; Sohn et al., 1990 a,b; Geurin et al., 1988) indicate that some sources of refined soy protein will support performance similar to that observed in pigs fed milk proteins in complex prestarter diets.

Recently, Gatnau and Zimmerman (1990) indicated that spray dried porcine plasma as a protein source supported performance better than isolated soy protein or dried skim milk diets. Hansen et al. (1990) produced similar results with spray dried plasma protein replacing dried skim milk in a high nutrient dense diet with lactose maintained constant. Drew et al. (1990) found that either porcine or bovine immunoglobulins provided adequate local immune protection in the intestine when included in the diet of neonatal pigs.

Blood meal made from blood of pigs and cattle collected at slaughter is high in protein and lysine. Its lack of use in swine diets is due primarily to the poor avalability of lysine as a result of the extended high temperatures used during the batch drying process or lack of quality control prior to processing. Blood meal that has been flash dried by the ring or drum process has been shown to have a high available lysine. Miller and Parsons (1981) reported the bioavailable lysine in ring-dried pig and cattle blood and steam-drum dried cattle blood to be 6.5 to 7.0% on an as fed basis. Blood meal produced from blood refrigerated immediately after collection and spray dried using a low temperature drying process has not been tested.

This study was conducted to determine the effect of replacing dried skim milk in complex prestarter diets with plasma proteins or blood meal in early weaned pigs.

Materials and Methods

One hundred forty four Yorkshire, Hampshire and Yorkshire x Hampshire crossbred pigs (72 pigs in each of two trials) were weaned at approximately 24 days of age (actual age 20-28 days). Pigs within trial were blocked by weight into two groups with blocks consisting of six pens. Thirty six pigs per block (six pigs per pen) were stratified by litter and weight to six pens, and two pens within each block were randomly allotted to one of three experimental diets. Dietary treatments (TRT) during the first 14 days postweaning (Period 1) consisted of the following (Table 1: TRT 1) a control complex prestarter diet containing 10% dried skim milk (DSM) and devoid of soybean meal; TRT 2) and 3) dried skim milk was replaced with 4% AP-820 and 2.75% AP-300, respectively. Substitutions were made on an equal lysine basis and diets were formulated to contain a constant lactose level. AP-820 is one of nature's unique proteins, composed of active albumin and

globulin proteins. AP-300 is the fresh whole blood produced from bovine and swine processing plants by spray drying at low temperatures. All diets were formulated to contain 1.4% lysine and 20% of an edible grade of dried whey. Treatments were applied for 2 weeks (Period 1) and all pigs were fed a common 18% crude protein starter diet (Table 1) for an additional 3- week period (Period 2) to evaluate any carry-over effects on performance from diets fed during Period 1. Pigs had ad libitum access to both feed and water during Period 1 and Period 2. Pigs were housed in an environmentally controlled nursery in pens measuring 3.8 by 5.0 feet on a raised, woven wire floor. A temperature of 84 to 86°F was maintained during the first week of the experiment and was decreased 2°F per week for the remainder of the trial.

The data for each response criteria were analyzed by least squares analysis of variance. The models for average daily gain, average daily feed intake and feed efficiency included the main effects of trial, treatment, litter within trial and appropriate 2-way interactions. Individual pig weight and pen feed intake were measured weekly to determine average daily gain, average daily feed intake and gain to feed ratio. Pen was used as the experimental unit.

Results and Discussion

No block x treatment interactions ($P > .2$) were observed indicating that the response of both weight groups to dietary treatment was similar. Therefore, data from both blocks were combined in the results.

During the first week postweaning, pigs fed AP-820 or AP-300 grew faster ($P<.05$) than those fed dried skim milk (Table 2). The magnitude of response ranged from a 32.6% increase in average daily gain in pigs fed the AP-820 diet to a 19.5% increase in average daily gain in pigs fed the AP-300 when compared to gain of pigs fed the dried skim milk control diet (DSM). During the second week, pigs fed AP-820 or AP-300 continued to grow faster ($P<.05$) than those fed DSM. During the entire 14-day period, average daily gain was higher ($P<.05$) in pigs fed AP-820 or AP-300 when compared to pigs fed DSM. During the first week, the second week and for the entire 14-day period, pigs fed AP-820 grew faster than those fed AP-300.

Average daily feed intake during the first week was lower ($P<.05$) in pigs fed DSM compared to pigs fed AP-820 or AP-300 (Table 2). The largest difference in feed intake was observed during week 1 when pigs fed AP-820 and AP-300 consumed 28.3% and 15.2% more feed per day, respectively. During the second week on trial and for the entire 2-week

Table 1. Composition of Experimental Diets.

	Diets[ab]			
	Period 1			Period 2
Ingredient	DSM	AP-820	AP-300	
AP-820[c]	-	4.0	-	-
AP-300[d]	-	-	2.75	-
Dried skim milk	10.0	-	-	-
Whey, dehydrate	20.0	20.0	20.0	-
Steam rolled oats	26.9	26.9	26.9	-
Provesteen[e]	8.0	8.0	8.0	-
Pro-88[f]	5.0	5.0	5.0	-
Lactose	-	5.26	5.26	-
Corn, yellow	16.575	16.795	18.007	66.65
Soybean oil	6.0	6.0	6.0	-
Lysine, HCl	.35	.35	.35	.15
Soybean meal,44%	-	-	-	28.5
Fishmeal, menhaden	3.0	3.0	3.0	-
Ethoxyquin	.025	.025	.025	-
FOA 390[g]	1.0	1.0	1.0	1.0
Flavor, berry	.1	.1	.1	-
Novasil[h]	.5	.5	.5	-
Coli-mix[i]	.5	.5	.5	-
Copper sulfate	.1	.1	.1	.075
Dicalcium phosphate-	.53	.52	1.95	
Calcium carbonate	1.05	1.02	1.02	.90
DL-Methionine	.16	.18	.228	-
Vit. min. premix[j]	.74	.74	.74	.375
Salt	-	-	-	.40
Calculate analysis, %				
ME (Kcal/lb)	1585	1574	1574	1453
Crude protein	20.37	19.60	19.43	18.32
Calcium	.96	.96	.96	.88
Phosphorus	.87	.87	.87	.74
Lysine	1.40	1.40	1.40	1.11
Threonine	.86	.87	.82	.72
Tryptophan	.23	.24	.23	.24
Met+Cys	.76	.76	.76	.61

(Table 1 continued on next page)

Table 1. (Continued).

[a] As fed basis.
[b] DSM: dried skim milk diet; AP-820: active albumin and globulin protein diet; AP-300: fresh whole blood protein diet.
[c] AP-820, American Protein Corporation, Ames, Iowa.
[d] AP-300, American Protein Corporation, Ames, Iowa.
[e] Provesteen, Provesta Corporation, Bartlesville, OK.
[f] Pro-88, Morgan, Mfg. Co., Inc. Paris, IL.
[g] Contained 10g Furazolidone, 5g Oxytetracycline, 4.5g Arsanilic acid per lb of diet.
[h] Novasil, Engelhard Corporation, St. Charles, IL.
[i] Coli-mix, Central Biologics, Inc, Raleigh, NC.
[j] Supplied 4,160 IU vitamin A, 416 IU vitamin D, 18 IU vitamin E, 20 mg pantothenic acid, 28 mg niacin, 4.0 mg riboflavin, .02 mg vitamin B_{12}, 1.3 mg biotin, .6 mg pyridoxine, .9 mg folic acid, 3.9 mg thiamin, 267 mg choline, .1 mg selenium, .03 g manganese, .1 g zinc, .1 g iron, .01 g copper, .43 g potassium and .2 mg iodine, per lb. of feed in Period 1 and 3,000 IU vitamin A, 300 IU vitamin D, 12.8 IU vitamin E, 15 mg pantothenic acid, 20.3 mg niacin, 3.0 mg riboflavin, .01 mg vitamin B_{12}, 193 mg choline, .07 mg selenium, .02 g manganese, .07 g zinc, .07 g iron, .07 g copper, .17 mg iodine, per lb of feed in Period 2.

period, average daily feed intake was higher ($P<.05$) in pigs fed AP-820 or AP-300 when compared to pigs fed DSM.

Feed efficiency (G:F) during the first week, the second week and for the overall 14- day period was not affected by dietary treatments.

Average daily gain and average daily feed intake during Period 2 continued to be higher ($P<.1$) in pigs previously fed AP-820 or AP-300 in Period 1 when compared to pigs previously fed DSM, even though pigs from all treatment groups were fed a common corn-soybean meal diet in Period 2. Feed efficiency, however, was similar among pigs fed the three dietary treatments (Table 2) during the subsequent 3-week period (Period 2). Average daily gain and average daily feed intake in Period 2 of pigs previously fed AP-820 as the supplemental protein source were similar to those of pigs previously fed AP-300.

Table 2. The effect of plasma protein on performance of early weaned pigs[a].

Item	Diet			SE
	DSM	AP-820	AP-300	
Average daily gain, lb				
Week 1	.46[b]	.61[c]	.55[d]	.02
Week 2	.77[b]	.97[c]	.88[d]	.02
Period 1	.62[b]	.79[c]	.72[d]	.02
Period 2	1.16[e]	1.21[f]	1.25[f]	.02
Average daily feed intake, lb				
Week 1	.46[b]	.59[c]	.53[d]	.02
Week 2	.97[e]	1.21[f]	1.08[g]	.02
Period 1	.72[e]	.90[f]	.81[g]	.02
Period 2	2.09[e]	2.17[f]	2.19[f]	.02
Feed efficiency (G:F)				
Week 1	.97	1.02	1.08	.06
Week 2	.86	.83	.84	.02
Period 1	.89	.90	.91	.02
Period 2	.56	.56	.57	.01

[a] Least squares means.
[b,c,d] Means in the same row with different superscript differ ($P < .05$).
[e,f] Means in the same row with different superscript differ ($P < .1$).

Initial pig weight (Table 3) averaged 15.90, 15.90 and 15.87 lb for pigs fed DSM, AP-820 and AP-300, respectively. After week 1, due to inferior gains by pigs fed dried skim milk, dietary protein source affected pig weight ($P < .05$) and by the end of week 2, pigs fed DSM weighed 9.7 and 4.9% less than pigs fed the AP-820 and AP-300, respectively. Differences in pig weight continued throughout the 3-week carryover period when pigs were fed a common starter diet.

It should be noted that the substantial improved performance in pigs fed plasma proteins was exhibited even though performance of pigs fed the

Table 3. The effect of plasma protein on pig weight (lb)[a].

Item	Diet			SE
	DSM	AP-820	AP-300	
No of pigs	24	24	24	
Initial wt	15.90	15.90	15.87	
Week 1	19.14[b]	20.17[c]	19.72[d]	.15
Week 2	24.64[b]	27.02[c]	25.86[d]	.33
Week 3	31.15[b]	33.88[c]	33.15[c]	.55
Week 4	39.27[b]	42.11[c]	41.56[c]	.57
Week 5	49.06[b]	52.43[c]	52.05[c]	.59

[a] Least squares means.
[b,c,d] Means in the same row with different superscripts differ ($P < .05$).

complex control diet devoid of soybean meal was excellent and considerably better than performance during week 1 and week 2 of similar trials conducted in our facilities (Coffey et al., 1990, Sohn et al, 1990a). This study suggests that the plasma proteins offer a unique dietary protein source for pigs immediately after weaning.

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THE EFFECT OF CREEP FEEDING ON POSTWEANING PERFORMANCE IN EARLY WEANED PIGS

K.S. Sohn[1]., T.M. Fakler[2] and C.V. Maxwell[3]

Story in Brief

A study involving 144 pigs weaned at approximately 24 days of age was conducted to determine the effect of creep feeding on postweaning performance in early weaned pigs. Pigs from litters offered creep feed for one week prior to weaning and pigs from litters not offered creep feed were blocked by weight into two groups (heavy and light weight) and fed a common prestarter diet for the first two week period (Period 1) and a common starter diet from day 15 to 35 postweaning (Period 2). During week 1 and for Period 1, average daily gain was similar between heavy pigs from both the creep fed and non-creep fed groups but average daily gain of light weight pigs was greater in pigs previously fed creep feed. Average daily gain was similar for all pigs during week 2. During week 1 average daily feed intake was similar for heavy pigs and for light pigs between treatments. During week 1 and for Period 1, smaller pigs previously fed creep feed had improved feed efficiency when compared to those not offered creep, however feed efficiency of heavy weight pigs was similar between the two groups. During Period 2 average daily gain and average daily feed intake of heavy pigs were improved in the creep fed group when compared to non-creep fed group. Feed efficiency during Period 2 was similar between the two treatments. This study suggests that creep feeding influences subsequent performance of early weaned pigs.

(Key Words: Early Weaned Pig, Weaning, Creep Feeding Period.)

Introduction

In order to shorten the breeding cycle and maximize reproductive efficiency of the sow herd, many swine producers have started routinely weaning pigs at 3 to 4 weeks of age. The practice of creep feeding was originally introduced for older pigs whose increasing energy requirement could not be met with decreasing sow milk production after 3 to 4 weeks of

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lactation, and its benefits were well established (Krider et al., 1950; Terrill et al., 1952). In contrast, data regarding the benefits of creep feeding in situations where piglets are weaned at 3 to 4 weeks of age are much less conclusive. Lucas and Lodge (1961) have suggested that even a little creep feed intake may cause digestive enzyme induction and gut flora modifications that may prepare the young pig for the dry diets offered postweaning. The gut immune system may also have a period of hypersensitivity to dietary proteins in pigs not fed sufficient quantities of dietary protein to allow the developement of oral tolerance. This may be of particular significance to the early weaned pig because of the limited intake. English (1981) reported that creep feed intakes of 1.32 lb before weaning results in a mature gut and minimize postweaning diarrhea. Miller et al. (1984) suggested that substantial amount of creep feed before weaning may cause the animal to become tolerant to the dietary antigens, thus when the pigs are weaned the immune response is suppressed with little resulting gut changes. In contrast, insufficient preweaning feed intake, which commonly occurs when the pigs are weaned at three weeks or less, results in the immune system being primed to the dietary antigens. This leads to a gut damaging hypersensitivity response when piglets are weaned and may predispose early weaned pigs to postweaning diarrhea. This study was conducted to evaluate the effectiveness of creep feeding for early weaned pigs

Materials and Methods

One hundred forty four Yorkshire, Hampshire and Yorkshire x Hampshire crossbred pigs (72 pigs in each of two trials) were weaned at approximately 24 days of age (20-28 day). Each trial was composed of thirty six pigs from six litters previously offered a creep feed (Table 1) for 1 week prior to weaning and thirty-six pigs from five litters which were not offered creep feed. The creep diet was formulated to be highly palatable and to contain a high percentage of postweaning protein sources. After weaning, pigs within preweaning treatment were blocked by weight into two groups (heavy and light) and fed a common prestarter and starter diet. The average age at weaning of pigs in the heavy group was 24.4 days and for the light group was 23.7 days. The postweaning prestarter diet contained 10% dried skim milk (Table 2) and was formulated to contain 1.4% lysine and 20% of an edible grade of dried whey. The prestarter diet was fed to both the creep fed and non-creep fed pigs for 2 weeks (Period 1) with weekly gain and efficiency data obtained. All pigs were fed a common 18% crude protein starter diet (Table 2) for an additional 3 week period (Period 2). Pigs had ad libitum access to both feed and water during Periods 1 and 2. Pigs were housed in an environmentally controlled nursery in pens measuring 3.8 by 5.0

Table 1. Diet fed during one week prior to weaning[a].

Ingredient	%
Sunflower seed	25.0
Dried skim milk	20.0
Whey,dehydrate	16.5
Isolated soy protein	10.0
Provesteen[b]	10.0
Fish meal, menhaden	8.0
Rolled steamed oats	5.0
Corn, ground	5.0
Flavor 792[c]	.5

[a] As fed basis.
[b] Provesta Corporation, Bartlesville, OK.
[c] Flavor Hut Corporation, St. Charles, IL.

Table 2. Composition of diets fed during periods 1 and 2.

	Diet[a]	
Ingredient	Period 1	Period 2
Dried skim milk	10.0	-
Whey, dehydrate	20.0	-
Isolated soy protein	3.0	-
Soybean meal, 44%	-	28.5
Steamed rolled oats	26.9	-
Provesteen[b]	8.0	-
Corn, ground	11.52	66.65
Soybean oil	8.0	-
Lysine, HCl	.24	.15
Fish meal, menhaden	3.0	-
Ethoxyquin	.025	-
Pment sugar[c]	5.0	-
Dicalcium phosphate	-	1.95
Calcium carbonate	1.0	.9
FOA 390[d]	1.0	1.0
Flavor 792[e]	.1	-

(Table 2 continued on next page)

Table 2. (Continued).

Novasil[f]	.5	-
Coli-mix[g]	.5	-
Copper sulfate	.1	.075
DL-Methionine	.075	-
Vit-min-mix[h]	.74	.375
Salt	.30	.40
Calculated analysis		
ME, Kcal/lb	1592.7	1453.6
CP, %	20.7	18.3
Ca, %	.9	.88
P, %	.81	.74
Lys, %	1.40	1.11
Trp, %	.24	.24
Thr, %	.87	.72
Met+Cys, %	.64	.61

[a] As fed basis.
[b] Provesta Corporation, Bartlesville, OK.
[c] Pment sugar, Bob's Candy Co., Albany, GA.
[d] Contains 10g Furazolidone, 5g Oxytetracycline, 4.5g Arsanilic acid per lb.
[e] Flavor 792, Flavor Hut Corporation, St. Charles, IL.
[f] Novasil, Engelhard Corporation, Cleveland, OH.
[g] Coli-mix, Central Biologics, Inc., Raleigh, NC.
[h] Supplied 4,160 IU vitamin A, 416 IU vitamin D, 18 IU vitamin E, 20 mg pantothenic acid, 28 mg niacin, 4.0 mg riboflavin, .02 mg vitamin B_{12}, 1.3 mg biotin, 2.7 mg pyridoxine, .9 mg folic acid, 3.9 mg thiamin, 267 mg choline, .1 mg selenium, .03 g manganese, .1 g zinc, .1 g iron, .1 g copper, .1 g magnesium, .43 g potassium and .2 mg iodine, per lb of feed in Period 1 and 3,000 IU vitamin A, 300 IU vitamin D, 12.8 IU vitamin E, 15 mg pantothenic acid, 20.3 mg niacin, 3.0 mg riboflavin, .01 mg vitamin B_{12}, 193 mg choline, .07 mg selenium, .02 g manganese, .07 g zinc, .07 g iron, .07 g copper, .17 mg iodine, per lb of feed in Period 2.

feet on a raised, woven wire floor. A temperature of 84 to 86°F was maintained during the first week of the experiment and was decreased 2°F per week for the remainder of the trial. Incidence of scours was observed twice daily during the first two weeks and once a day for the last three weeks of the study. Individual pig weight and pen feed intake were measured weekly to determine average daily gain, average daily feed intake and feed efficiency. Pen was used as the experimental unit to evaluate performance criteria.

Results and Discussion

The amount of total feed intake in the pre-weaning period was .62 lb/pig for the week prior to weaning (Table 3). Creep feed did not significantly affect weaning weight. Performance differences between the older, heavier pigs and younger, smaller pigs were observed resulting in a block x treatment interaction ($P<.05$). Therefore, data will be presented on a within block basis.

During the first week postweaning, average daily gain was similar between heavy weight, older (24.4 days of age) pigs from both the creep fed and non-creep fed groups but average daily gain of younger (23.7 days), light weight pigs from litters previously fed creep diet was higher ($P<.05$) than that of light weight pigs from litters not offered a creep diet (Table 4). During the second week, feeding creep feed prior to weaning did not affect average daily gain in either the heavy or light pigs. Light weight pigs from litters fed the creep grew faster ($P<.05$) than those from litters not offered

Table 3. Creep-feed intake in the pre-weaning period.

Item	Treatment	
	Creep	No creep
No of litters	11	10
No of pigs	82	76
Avg birth wt, lb	2.90	2.93
Avg weaning wt, lb	13.75	13.64
Total feed intake		
Days 17-24, lb/pig	.62	0
Avg daily feed intake		
Days 17-24, lb/pig	.09	0

Table 4. The effect of creep feeding on average daily gain, average daily feed intake and feed efficiency of early weaned pigs[a].

	Treatment				
	Creep		No creep		
Item	Heavy	Light	Heavy	Light	SE
Weaning age, d	24.4	23.7	24.3	23.6	
	Average daily gain, lb				
Week 1[g]	.46[d]	.48[d]	.48[d]	.33[e]	.04
Week 2	.81	.79	.84	.68	.07
Period 1[g]	.64[d]	.64[d]	.66[d]	.51[e]	.04
Period 2[g]	1.39[b]	1.28[c]	1.25[c]	1.23[c]	.02
	Average daily feed intake, lb				
Week 1	.55	.57	.57	.51	.02
Week 2	1.03[d]	.88[ef]	.99[de]	.81[f]	.04
Period 1	.79[d]	.73[de]	.79[d]	.66[e]	.02
Period 2	2.46[b]	2.20[c]	2.24[c]	2.17[c]	.04
	Feed efficiency (G:F)				
Week 1[g]	.83[d]	.88[d]	.86[d]	.67[e]	.05
Week 2	.79[d]	.88[e]	.83[de]	.85[de]	.03
Period 1[g]	.81[de]	.88[d]	.84[de]	.76[e]	.03
Period 2	.57	.58	.56	.57	.01

[a] Least squares means.
[b,c] Means in the same row with different superscripts differ ($P < .01$).
[d,e,f] Means in the same row with different superscripts differ ($P < .05$).
[g] Block x treatment interaction ($P < .05$).

creep feed postweaning during Period 2 but average daily gain between heavy pigs was similar. One of the advantages of creep feeding is to provide additional feed for suckling pigs in situations where milk intake may be insufficient for normal growth and development; especially light weight pigs. The higher ($P<.05$) average daily gain observed in light weight pigs from litters previously creep fed as compared to light weight pigs from litters not offered creep during week 1 and for Period 1 suggests that creep feeding may be more important in gut developement in lighter, younger pigs.

Average daily feed intake during the first week on trial was similar among the treatments. During the second week and for the entire 14 day prestarter period (Period 1), no significant differences were observed between heavy weight pigs from litters fed creep feed and those not receiving the creep feed but lighter pigs from litters offered the creep diet tended to have higher average daily feed intake than lighter pigs from litters not offered creep diet although no significant differences were observed. During the first week, feed efficiency (gain/feed) was similar between heavy weight pigs from the creep fed and non-creep fed groups, but light weight pigs from litters fed the creep diet had improved ($P<.05$) feed efficiency when compared to those from litters not previously fed the creep diet. During the second week, feed efficiency was not affected by creep feeding in either heavy pigs or light weight pigs. During the entire 14 day period, heavier pigs fed creep feed and those not offered creep feed had similar feed efficiency but light weight pigs from litters previously fed the creep diet had improved efficiency ($P<.05$) when compared to those from litters not fed the creep diet. During Period 2, average daily gain and average daily feed intake continued to be affected by preweaning treatment in the heavy weight pigs. Heavy weight pigs previously fed creep feed had higher ($P<.05$) average daily gain and average daily feed intake when compared to heavy pigs from litters not offered the creep diet. Conversely, light weight pigs from the preweaning treatments had similar average daily gain and average daily feed intake. No significant difference in feed efficiency between the two groups was observed during period 2 for either heavy or light weight pigs.

Initial weight of heavy pigs (Table 5) averaged 17.64 and 17.56 lb while initial weight of light pigs averaged 12.06 and 12.10 lb for pigs from litters previously fed the creep diet or not offered the creep diet, respectively. After week 1, due to inferior gains by light weight pigs from litters not offered the creep diet, creep feeding affected pig weight ($P<.05$) and by the end of week 2, light weight pigs from litters not offered the creep diet weighed 7.3% less than light weight pigs previously fed the creep diet prior to weaning. Differences in pig weight continued throughout the 3 week carryover period when pigs were fed a common starter diet. Light weight pigs from litters not offered the creep diet weighed 5.5% less at the

Table 5. The effect of creep feeding on pig weight (lb)[a].

	Treatment				
	Creep		No creep		
Item	Heavy	Light	Heavy	Light	SE
No of pigs	36	36	36	36	
Initial wt	17.64	12.06	17.56	12.10	
Week 1[g]	20.83[d]	15.51[e]	20.97[d]	14.45[f]	.31
Week 2[g]	26.49[d]	21.01[e]	26.86[d]	19.25[f]	.62
Week 3	35.18[d]	29.02[e]	34.63[d]	26.88[e]	.77
Week 4	45.72[d]	37.80[e]	43.65[d]	35.31[e]	.95
Week 5	55.77[d]	47.72[e]	53.33[d]	45.23[e]	1.08

[a] Least squares means.
[d,e,f] Means in the same row with different superscripts differ ($P < .05$).
[g] Block x treatment interaction ($P < .05$).

completion of the trial when compared to those from litters previously fed creep diet although these differences were not significant. There was no significant difference in incidence of scours (16 vs 18 pigs) in pigs between litters previously fed the creep diet and those not offered the creep diet during Period 1 (Table 6).

Table 6. The effect of creep feeding on incidence of scours in early weaned pigs.

	Treatment			
	Creep		No creep	
Item	Heavy	Light	Heavy	Light
No of pigs	36	36	36	36
Week 1	7	2	2	6
Week 2	2	5	3	7
Period 1	9	7	5	13
Period 2	0	0	1	0

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ALTERNATIVE PROTEIN SOURCES FOR MILK PROTEIN IN EARLY WEANED PIG DIETS

K. S. Sohn[1] and C. V. Maxwell[2]

Story in Brief

A study involving 144 pigs weaned at approximately 24 days of age, was conducted to determine the effect of two dried skim milk substitutes on performance. Treatments were: 1) a control complex prestarter diet containing 10% dried skim milk; 2) and 3) dried skim milk was replaced with a cheese by-product or an isolated soy protein based dried skim milk substitute, respectively. Trial duration was for a 2 week period (Period 1) followed by a 3 week period (Period 2) when all pigs were fed a common 18% crude protein starter diet. During week 1 and Period 1, average daily gain in pigs fed either the cheese by-product or isolated soy protein diet was similar to that observed in pigs fed the dried skim milk diet. During week 2, average daily gain was similar in Trial 1 among the treatments but pigs fed the control diet had lower average daily gain in Trial 2 when compared to pigs fed the isolated soy protein diet (Trial x treatment interaction). During week 1 and Period 1, average daily feed intake was higher in pigs fed the isolated soy protein diet than in those fed the other diets. Feed efficiency during Period 1 was not affected by dietary treatments although a trial x treatment interaction was observed in week 2 and Period 1. Performance during Period 2 was not affected by dietary treatments. These results suggest that a selected cheese by-product and an isolated soy protein based dried skim milk substitute can be used to effectively replace dried skim milk in a complex prestarter diet for early weaned pigs.

(Key Words: Swine, Nutrition, Weaning, Cheese By-product, Isolated Soy Protein.)

Introduction

It has become commonplace for swine producers to wean pigs at early ages. Weaning as early as three weeks has been accomplished by the use of

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diets containing high levels of milk products, especially dried skim milk and dried whey. Although performance of pigs fed these milk based diets is superior to that observed in pigs fed simple corn-soybean meal diets, the milk product diets are more expensive. Thus, other feed ingredients need to be evaluated as replacements for all or part of the dried skim milk. The ability of utilizing the protein from isolated soy protein or cheese by-product could reduce the inclusion rate of more expensive milk protein in the diet of early weaned pigs. The feasibillity of the protein from a cheese by-product in early weaned pig diets as an alternative protein source for milk protein has not been tested. Recently, two studies (Sohn et al., 1990a,b; Coffey et al., 1990) indicated that isolated soy protein adequately replaces the proteins of dried skim milk for three week old weaned pigs, however, a product containing whey and isolated soy protein developed to replace dried skim milk had not been tested. This study was conducted to determine the effect of two dried skim milk substitutes on performance of early weaned pigs.

Materials and Methods

One hundred forty four Yorkshire, Hampshire and Yorkshire x Hampshire crossbred pigs (72 pigs in each of two trials) were used in this experiment. Pigs were weaned at approximately 24 days of age (actual age 20-28 day). Pigs within trial were blocked by weight into two groups with blocks consisting of six pens. Thirty six pigs per block (six pigs per pen) were stratified by litter and weight to six pens, and two pens within each block were randomly allotted to one of three experimental diets. Dietary treatments (TRT) during the first 14 days (Period 1) consisted of the following (Table 1): 1) a control complex prestarter diet containing 10% dried skim milk (DSM); TRT 2) and 3) DSM was replaced with PRO-88 or NURISH-2000, respectively. PRO-88 (cheese by-product) was made from the rejected cheese from the human retail sector with several varieties of cheese used in the manufacturing process. NURISH-2000 (isolated soy protein based milk protein substitute) was developed to provide a protein source that is very similar in nutrient composition to dried skim milk and is a mixture of isolated soy protein, dried skim milk and dried whey. All diets were formulated to contain 1.4% lysine and 20% of an edible grade of dried whey. Trial duration was 2 weeks (Period 1) with weekly gain and efficiency estimates obtained. All pigs were fed a common 18% crude protein starter diet (Table 1) for an additional 3 week period (Period 2) to evaluate any carry-over effects on performance from the diet fed during Period 1. Pigs had ad libitum access to both feed and water during Periods 1 and 2. Pigs were housed in an environmentally controlled nursery in pens measuring 3.8 by 5.0 feet on a raised, woven wire floor. A temperature of 84 to 86°F was

Table 1. Composition of experimental diets.

	Diets[a,b]			
	Period 1			Period 2
Ingredient	DSM	PRO-88	NURISH-2000	
Isol. soy protein	3.0	3.0	3.0	-
Dried skim milk	10.0	-	-	-
Whey, dehydrate	20.0	20.0	20.0	-
Steam rolled oats	26.9	26.9	26.9	-
Provesteen[c]	8.0	8.0	8.0	-
Pro-88[d]	-	10.0	-	-
Nurish-2000[e]	-	-	10.0	-
Corn, yellow	11.52	13.63	11.33	66.65
Soybean oil	8.0	5.7	8.0	-
Lysine, HCl	.24	.32	.32	.15
Soybean meal,44%	-	-	-	28.5
Fishmeal, menhaden	3.0	3.0	3.0	-
Ethoxyquin	.025	.025	.025	-
Pment Sugar[f]	5.0	5.0	5.0	-
FOA 390[g]	1.0	1.0	1.0	1.0
Flavor 792[h]	.1	.1	.1	-
Novasil[i]	.5	.5	.5	-
Coli-mix[j]	.5	.5	.5	-
Copper sulfate	.1	.1	.1	.075
Dicalcium phosphate	-	-	-	1.95
Calcium carbonate	1.0	1.1	1.1	.90
DL-Methionine	.075	0.085	.085	-
Vit. min. premix[k]	.74	.74	.74	.375
Salt	.30	.30	.30	.40
Calculated analysis				
ME (Kcal/lb)	1595	1593	1596	1453
Crude protein, %	20.71	20.87	20.59	18.32
Calcium, %	.90	.91	.91	.88
Phosphorus, %	.81	.86	.82	.74
Lysine, %	1.40	1.40	1.40	1.11
Threonine, %	.87	.87	.86	.72
Tryptophan, %	.24	.25	.25	.24
Met+Cys, %	.64	.64	.65	.61

Table 1. (Continued).

[a] As fed basis.
[b] DSM: dried skim milk diet; PRO-88: cheese by-product diet; NURISH-2000: isolated soy protein based dried skim milk substitute diet.
[c] Provesteen, Provesta Corporation, Bartlesville, OK.
[d] Pro-88, Morgan Mfg. Co., Inc, Paris, IL.
[e] Nurish-2000, Protein Technologies International, St Louis, MO.
[f] Pment sugar, Bob's Candy Co., Albany, GA.
[g] Contained 10g Furazolidone, 5g Oxytetracycline, 4.5 g Arsanilic acid per lb of diet.
[h] Flavor 792, Flavor Hut Corp. St. Charles, IL.
[i] Novasil, Engelhard Corp. Cleveland, OH.
[j] Coli-mix, Central Biologics, Inc. Raleigh, NC.
[k] Supplied 4160 IU vitamin A, 416 IU vitamin D, 18 IU vitamin E, 20 mg pantothenic acid, 28 mg niacin, 4.0 mg riboflavin, .02 mg vitamin B_{12}, 1.3 mg biotin, 2.7 mg pyridoxine, .9 mg folic acid, 3.9 mg thiamin, 267 mg choline, .1 mg selenium, .03 g manganese, .1 g zinc, .1 g iron, .1 g copper, .43 g potassium and .2 mg iodine, per lb of feed in Period 1 and 3,000 IU vitamin A, 300 IU vitamin D, 12.8 IU vitamin E, 15 mg pantothenic acid, 20.3 mg niacin, 3.0 mg riboflavin, .01 mg vitamin B_{12}, 193 mg choline, .07 g selenium, .02 g manganese, .07 g zinc, .07 g iron, .07 g copper, .17 mg iodine, per lb of feed in Period 2.

maintained during the first week of the experiment and was decreased 2°F per week for the remainder of the trial. Individual pig weight and pen feed intake were measured weekly to determine average daily gain, average daily feed intake and gain to feed ratio. Pen was used as the experimental unit.

Results and Discussion

During the first week and Period 1, average daily gain in pigs fed either the cheese by-product (PRO-88) or the isolated soy based dried skim milk substitute (NURISH-2000) was similar to that observed in pigs fed the control diet (Table 2). During the second week average daily gain was similar in Trial 1 among the treatments but pigs fed the control diet had

Table 2. The effect of protein source on average daily gain, average daily feed intake and feed efficiency of young pigs in period 1[a].

Item	Diet[b]			SE
	DSM	PRO-88	NURISH-2000	
	Average daily gain, lb/day			
Week 1	.48	.53	.55	.02
Week 2[e] (Trial 1)	.95	.79	.86	.02
(Trial 2)	.81[c]	.88[cd]	.97[d]	.02
Mean	.88	.84	.92	.02
Period 1	.68	.68	.73	.02
Period 2	1.23	1.25	1.28	.02
	Average daily feed intake, lb/day			
Week 1	.51[c]	.51[c]	.57[d]	.02
Week 2	1.03	1.03	1.12	.02
Period 1	.77[c]	.77[c]	.85[d]	.02
Period 2	2.11	2.16	2.18	.07
	Gain:feed ratio			
Week 1	.94	1.01	.95	.03
Week 2[e] (Trial 1)	.83[c]	.70[d]	.72[d]	.02
(Trial 2)	.87	.91	.92	.02
Mean	.85	.81	.82	.02
Period 1[e] (Trial 1)	.88[c]	.84[cd]	.82[d]	.01
(Trial 2)	.87	.91	.91	.01
Mean	.87	.87	.86	.01
Period2	.58	.58	.59	.01

[a] Least squares means.
[b] See Table 1 for explanation of diet code names.
[c,d] Means in the same row with different superscript differ ($P < .05$).
[e] Trial x treatment interaction ($P < .05$).

lower (P<.05) gain in Trial 2 when compared to pigs fed the isolated soy based dried skim milk substitute (trial x treatment interaction, P<.05). Performance of pigs fed PRO-88 was intermediate. Average daily feed intake during the first week was highest (P<.05) in pigs fed NURISH-2000 when compared to pigs fed PRO-88 or the control diet. During the first week pigs fed the NURISH-2000 diet consumed 11.5% more feed per day than those fed the PRO-88 or the control diet. During the second week on trial, average daily feed intake among the dietary treatments was similar. During the overall two week period, average daily feed intake was higher (P<.05) in pigs fed NURISH-2000 than in those fed the other diets. The effect of dietary protein source on feed efficiency was similar to that observed for average daily gain. Treatment differences in feed efficiency in week 1 were not significant. During the second week, pigs fed the control diet had improved feed efficiency (P<.05) in Trial 1 and similar feed efficiency in Trial 2 when compared to pigs fed NURISH-2000 or PRO-88 resulting in a trial x treatment interaction (P<.05). No significant differences were observed, however, in efficiency between pigs fed NURISH-2000 or PRO-88. Average dailly gain, average daily feed intake and feed efficiency were similar among pigs fed the three dietary treatments during the subsequent 3 week period (Table 2). These results are similar to the findings of Sohn et al. (1990a,b) who reported that pigs fed an isolated soy protein diet in individual pens had gains and feed efficiency that were similar to those observed in pigs fed a dried skim milk based diet. This study confirms the efficiency of isolated soy proteins in a pen feeding system which more closely simulates eommercial production systems.

Initial pig weight (Table 3) averaged 14.76, 14.76 and 14.78 lb for pigs fed the control, PRO-88 and NURISH-2000 diets, respectively. Pigs fed the control diet had lower weights (P<.05) at the end of weeks 3 and 4 postweaning when compared to pigs fed NURISH-2000. A similar trend was evident at the completion of the trial (week 5) although differences were not significant. Geurin et al. (1988) and Coffey et al. (1990) reported that pigs fed an isolated soy protein diet had a similar average daily gain and feed efficiency when compared to those fed a milk protein diet. Also, Dietz et al .(1988) and Decuypere et al. (1981) suggested that partial or total replacement of milk proteins with isolated soy protein could produce performance equivalent to that observed in pigs fed dried skim milk.

When whole milk is used for cheese manufacture, a starter culture and enzyme preparation are added to the heated whole milk. The bacteria cultures and enzymes react with the lactose and casein, respectively, and produce lactic acid and casein is precipitated as a curd. The curd is then separated from the whey and pressed into cheese. Thus, PRO-88, which contains casein should be a highly digestible protein source for baby pigs. Kies et al. (1983) suggested that when lactic casein is manufactured under

Table 3. The effect of protein source on pig weight (lb)[a].

Item	Diet			SE
	DSM	PRO-88	NURISH-2000	
No of pigs	48	48	48	
Initial wt	14.76	14.76	14.78	
Week 1	18.15[b]	18.48[bc]	18.63[c]	.13
Week 2	24.44	24.42	25.12	.22
Week 3	32.41[b]	32.87[bc]	33.68[c]	.31
Week 4	40.63[b]	41.43[bc]	42.44[c]	.46
Week 5	50.34	51.08	51.99	.64

[a] Least squares menas.
[b,c] Means in the same row with different superscript differ ($P < .05$).

controlled conditions, its protein or in particular the essential amino acid component, is virtually completely digested and absorbed at the terminal ileum of the growing pigs. Mclaughlin et al. (1983) reported that addition of cheese flavor improved feed intake and weight gain relative to those obtained with pigs fed a diet containing a commercial flavor; during week 1 pigs fed diets containing a cheese flavor ate more (.42 lb vs .30 lb/day) and gained more (.18 lb vs .06 lb/day) than pigs fed a diets containing no flavor. Our results suggest that a selected cheese by-product (PRO-88) and an isolated soy protein based dried skim milk substitute (NURISH-2000) can be used to effectively replace dried skim milk in a complex prestarter diet for early weaned pigs.

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TABLE OF EQUIVALENTS

U.S. Metric

Length:

1 inch	= 2.54 centimeters	1 millimeter	= 0.03937 inch
1 foot	= 30.48 centimeters	1 centimeter	= 0.3937 inch
	= 0.3048 meters	1 meter	= 39.37 inches
1 yard	= 0.9144 meters		= 3.281 feet
1 mile	= 1609.34 meters		= 1.094 yards
	= 1.609 kilometers	1 kilometer	= 0.6214 mile

Area:

1 square inch	= 6.452 sq. centimeters	1 sq. centimeter	= 0.155 sq. inch
		1 sq. meter	= 1.196 sq. yards
1 sq. foot	= 0.0929 sq. meter		= 10.764 sq. feet
1 sq. yard	= 0.8361 sq meter	1 hectare	= 2.471 acres
1 acre	= 0.4047 hectare	1 sq. kilometer	= 0.386 sq. mile
1 sq. mile	= 259.0 hectares		= 247.1 acres

Volume:

1 cubic inch	= 16.387 cu. centimeters	1 cu. centimeter	= 0.061 cu. inch
		1 cu. meter	= 35.135 cu. feet
1 cu. foot	= 0.0283 cu. meter		= 1.308 cu. yards
1 cu. yard	= 0.7646 cu. meter	1 milliliter	= 0.0338 ounce
1 fluid ounce	= 29.573 milliliters	1 liter	= 33.81 ounces
1 pint	= 0.4732 liter		= 2.1134 pints
1 quart	= 0.9463 liter		= 1.057 quarts
1 gallon	= 3.7853 liters		= 0.2642 gallon
		1 kiloliter	= 264.18 gallons

Weight:

1 ounce	= 28.50 grams	1 gram	= 0.03527 ounce
1 pound	= 453.592 grams	1 kilogram	= 35.274 ounces
	= 0.4536 kilogram		= 2.205 pounds
1 ton	= 907.2 kilograms	1 metric ton (1,000 kg)	= 2204.6 pounds

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