Oklahoma State University

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To: Clientele in Animal Agriculture

Re: 1989 Animal Science Research Report

U.S. agriculture represents one of the greatest success stories ever, providing U.S. consumers with an abundance of high quality food at an extraordinarily low price. Much additional food is exported.

However, challenges remain. Profitability has not always come easily in recent years. Emphasis has necessarily shifted from maximum production to efficient production. And now, more than ever before, we find ourselves operating in a global agricultural economy.

How can we meet today's challenges? The answer to this question remains the same. Profitability and competitiveness in Animal Agriculture will be achieved only by the maximum use of available technology. A continuing and high priority mission of the OSU Animal Science Department is to develop, through its research programs, as much useful technology as possible with the resources at our disposal.

One of our goals is to provide results of our research to our clientele as quickly as possible. This Animal Science Research Report is important in facilitating that goal. We trust that the 53 research articles in this report, from research of the past year, will help animal agriculture meet its challenges.

Yours truly,

Bob Totusek

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

CENTENNIAL
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Celebrating the Past . . . Preparing for the Future

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Confidence in Research Results

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

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

In some articles there are 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 studied and is an estimate of the mean of the larger group of animals from which the sample came. The .5 is called the standard error and is a measure of the precision of the estimation procedure. This means that the probability is .68 that the value being estimated by the sample mean is within one standard error of the estimate.

Some papers report "correlation" coefficients. These are measures of positive or negative relationships between traits or variables. Positive relationships mean that when one variable is higher than average the other variable tends to also be higher than average. Negative correlations mean that larger than average values in one trait are associated with smaller than average values of the other trait. Correlations range from -1 for negative to +1 for positive relationships. The nearer the values are to 1 or -1 the stronger the relationship. When a correlation is statistically insignificant there is strong evidence that the relationship found was not due to chance. Correlations 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 subject to peer review for scientific merit, adequacy of experimental procedures and correctness of interpretation. Mention of a trademark, proprietary produce or vendor does not constitute a guarantee or warranty of the produce nor does it imply its approval or disapproval to the exclusion of other products of vendors that may also be available.

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

Research report committee

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A PRELIMINARY EVALUATION OF THE SALERS BREED IN A COMMERCIAL BEEF HERD

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Story in Brief

The Salers breed has been recently introduced into North America. In an effort to evaluate the breed as a component of a commercial cow herd a study was initiated comparing Salers x Hereford females to Hereford x Angus and Hereford females. Fifty females from each breed group were identified for use in the study at a large commercial ranch in Wyoming. Two-year old Salers x Hereford females had substantially heavier calves at weaning than two-year old females from the other breed groups. Calving difficulty in the three groups showed the Salers x Hereford females in the middle. Despite fairly low average body condition at weaning all Salers x Hereford females were diagnosed as pregnant to calve as three-year old cows. These results provide preliminary evidence that the Salers breed should be considered for use in the commercial beef industry as a component of a crossbred cow herd.

(Key Words: Crossbreeding, Salers, Birth Weight, Weaning Weight.)

Introduction

Numerous breeds of beef cattle have been introduced into North America in the last three decades. As each has been introduced careful consideration of its general merits has been important in establishing appropriate use in the commercial beef industry. A relatively recent import has been the Salers (pronounced Sah-lairs) from France. It is a dark red breed that was formed in a mountainous region where conditions are relatively severe. The breed has been studied as a terminal sire (Tinker et al., 1988), but little information to date has been reported on its utility as a component of a commercial cow herd.

This study was initiated to investigate the efficiency of Salers crossbred cows in a relatively harsh location (northwest Wyoming).

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Materials and Methods

Pregnant females representing three breed groups were set aside from the herd at the Pitchfork Ranch near Meteetsee in northwest Wyoming. Fifty females each of Hereford, Hereford x Angus and Salers x Hereford were identified for this study and were managed together. Calves were sired by Salers and Angus bulls. The year in which results for this report were obtained was characterized by low rainfall which was a common problem throughout much of the Northern Plains during 1988. All Salers x Hereford females were two years of age while some of the females in the other groups were three- or four-years old and had calved previously.

Calves were born in January, February and March. 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 8 months of age. A weaning weight was obtained and all weights were adjusted to 205 days. At weaning, pregnancy status of each cow was determined and cow condition score was evaluated (1 = emaciated to 9 = obese).

Data were analyzed by ordinary least squares procedures with breed of female, sire breed, sex, age of the dam and appropriate two way interactions in the model.

This study will be continued through three years. Open cows will be culled according to the usual management procedures followed in this herd.

Results and Discussion

The results of this study are shown in Table 1. The primary comparisons of interest are between the Salers x Hereford females and the two-year old females from the other two breed groups. Salers x Hereford and Hereford x Angus cows had their calves earlier in the calving season than did Hereford cows ($P<.05$). Salers x Hereford cows had calves that were heavier ($P<.05$) and resulted in more calving difficulty ($P<.05$) than Hereford x Angus two-year old females. Differences with the Hereford females for birth weight and calving difficulty were not significant. Salers x Hereford cows weaned much heavier calves ($P<.01$) than two-year old cows from the other two breed groups. Calves from Salers x Hereford two-year old cows were similar in size to calves out of older cows from the other breed groups.

Two-year old Hereford x Angus cows had higher ($P<.05$) body conditions scores at weaning than either two-year old Hereford or Salers x Hereford cows. Despite the lower average body condition score and the heavy calves at weaning all of the Salers x Hereford cows were diagnosed as pregnant.

Table 1. Performance of cows (and their calves) representing three breed groups.

Breed of dam	Age of dam	N	Birth date[a]	Birth weight	Calving ease score	Weaning weight	Cow condition score	% Pregnant
Hereford x Angus	2	29	35.3	59.5	1.2	362.5	5.6	90
Hereford x Angus	3	21	39.6	68.5	1.1	413.8	5.0	100
Hereford	2	29	48.5	65.5	1.8	354.4	4.5	97
Hereford	3	12	57.9	72.2	1.2	401.5	5.2	100
Hereford	4	9	66.2	68.9	.9	393.4	5.4	100
Salers x Hereford	2	50	33.6	66.0	1.5	400.2	4.7	100

[a]Birth dates calculated as days from January 1.

These preliminary results suggest that the Salers may have a role in the commercial beef cattle industry as a component of a crossbred cow herd. They weaned heavy calves as two-year olds and had little apparent trouble establishing a new pregnancy. Additional data from this study will yield important information pertaining to the continued productivity of these females.

Literature Cited

Tinker, E.D. et al. 1988. Limousin vs Salers as a terminal sire: Birth and weaning characteristics. Okla. Agr. Exp. Sta. Res. Rep. MP-125:7.

different environments may make herd sire selection very difficult. One method of decreasing some of the variation among bulls, especially during the post-weaning phase, is central bull testing. Central bull test stations provide both purebred and commercial cattlemen an opportunity to compare and evaluate bulls managed under common nutritional and environmental conditions.

In light of the current selection trends in the beef cattle industry toward larger framed cattle with greater growth potential, buyers need to understand relationships among performance measurements of growth and other economically important traits as they evaluate bulls for their particular breeding program. In addition, it may be helpful for potential buyers to know the extent to which various performance traits have contributed to selling price in the past.

The objectives of this study were to evaluate the relationships among measurements of growth and other performance traits as well as to determine the influence of performance measurements on the selling price of performance tested beef bulls.

Materials and Methods

Performance data were collected on 1183 Angus, 519 Hereford and 601 Polled Hereford bulls completing the 140 day test at Oklahoma Beef, Inc. during the period from 1981 to 1987. The bulls, approximately 7 to 8 months of age upon delivery to the test station, were allowed a two-week warm-up prior to starting the official gain test. Initial measurements of hip height, weight and scrotal circumference were taken on all bulls. Upon completion of the 140-day test, final measurements of hip height, weight, scrotal circumference, rib fat thickness and ribeye area were obtained. Ribeye fat thickness and ribeye area were estimated with a scanogram manufactured by the Ithaca Company, Ithaca, New York. Hip height growth rates and average daily gains were calculated by using on-test and off-test measurements.

Performance records were correlated with sale prices of 448 bulls that sold from 1983 to 1987 to determine the influence of various performance traits on the selling price of performance tested beef bulls. Variables included were off-test measurements of hip height, weight, average daily gain, rib fat, ribeye area and scrotal circumference along with the sale price of 208 Angus, 94 Hereford and 146 Polled Hereford bulls that sold in eight Oklahoma Beef, Inc. All Breed Performance Tested Bull Sales from 1983 to 1987.

Sale catalogs were available to buyers prior to each sale. The catalogs included identification of each bull, a two-generation pedigree, birth date and owner. Since the fall sale of 1985, expected progeny differences of each bull's sire were also available if reported within the respective breed sire summary. Performance data reported in each catalog were: on-test weight, off-test weight, adjusted yearling weight, adjusted yearling height, scanogram measurements of ribeye area and ribeye fat, scrotal circumference, average daily gain and weight per day of age. In addition, the number of bulls within each test group as well as an index of on-test performance were included. The index was a composite score with basically three traits considered: average daily gain, weight per day of age and adjusted yearling weight.

The relationship among selling price and performance traits were evaluated by calculating the correlation between price and performance traits. Contributions of each trait to selling price for each breed were independently evaluated by using a multiple regression procedure to obtain partial regression of price on each performance trait. These regressions were obtained simultaneously for all the traits after accounting for variation due to year. The trait that contributed the least in each breed was removed from consideration and the analyses were repeated until only those traits that made significant contributions to selling price remained. In this way traits were ranked by magnitude of effect.

Table 1. Correlation coefficients among various performance traits.

Trait		1	2	3	4	5	6	7	8	9
On-test height	(1)	1.00								
On-test weight	(2)	** .75	1.00							
Off-test height	(3)	** .86	** .56	1.00						
Off-test weight	(4)	** .72	** .80.	** 67	1.00					
Average daily gain	(5)	** .17	-.04	** .35	** .57	1.00				
Height daily growth	(6)	** -.30	** -.37	** .22	** -.11	** .33	1.00			
Scrotal circumference	(7)	** .22	** .26	** .20	** .33	** .20	-.04	1.00		
Ribeye area	(8)	** .56	** .53	** .57	** .71	** .45	-.01	** .30	1.00	
Rib fat	(9)	** .04	.16	** .01	** .22	** .14	** -.10	** .10	.05	1.00

**Significance level (P<.01).

Results and Discussion

Phenotypic correlation coefficients associated with the performance traits measured during the study are presented in Table 1. On-test height and on-test weight were strongly and positively related to off-test height and off-test weight, indicating that taller, heavier bulls at the beginning of the test were also taller, heavier bulls at the end of test. However, average daily gain during the test was weakly correlated with on-test height and on-test weight. Taller, heavier bulls at the beginning of the test tended to grow at a slower rate in hip height than smaller framed bulls, as indicated by a negative correlation of -.30. Average daily gain was most highly associated with off-test weight (r =.57).

Ribeye area or muscling was strongly correlated to all weight traits, especially off-test weight (r =.71). However, degree of fatness as indicated by ribeye fat thickness was not strongly correlated to any trait.

Scrotal circumference was also positively correlated to all growth traits. Even though the correlations were small, heavier and taller bulls tended to have larger scrotal circumference measurements.

Table 2. Angus least squares means by year.

	1981	1982	1983	1984	1985	1986	1987
Number of bulls	212	221	235	190	134	118	73
On-test height (in)	43.6	43.9	44.2	44.6	45.2	45.9	46.0
Off-test height (in)	48.2	48.7	48.9	49.5	50.2	50.8	51.1
On-test weight (lb)	600	601	623	632	644	672	694
Off-test weight (lb)	1119	1135	1139	1183	1173	1226	1269
Average daily gain (lb)	3.70	3.81	3.67	3.94	3.78	3.96	4.11
Height daily growth (in)	.032	.034	.034	.035	.036	.035	.036
Scrotal circumference (cm)	----	37.26	37.29	38.1	37.44	37.70	38.86
Ribeye area (sq in)	13.2	13.1	13.8	13.4	13.5	14.1	----
Rib fat (in)	.42	.42	.43	.44	.41	.41	.24

The least squares means for Angus, Hereford and Polled Hereford bulls are presented in Tables 2, 3 and 4, respectively. From 1981 through 1987, the height and weight of bulls entered in the OBI Test Station in all three breeds increased appreciably, indicating an emphasis by breeders entering bulls in the test toward larger bulls. Off-test hip height increased over 2.5 in in all three breeds, while off-test weight increased over 139 lb. Average daily gain tended to increase slightly over the seven years; however, ribeye area and ribeye fat remained relatively constant. A slight trend for increased ribeye area during the later years of the study was noted. The hip height growth rates noted in all three breeds were similar to recommended adjustment factors by Beef Improvement Federation.

Correlations among the various off-test performance traits and selling price are presented in Table 5. With the exception of rib fat, all were significant and of favorable direction. Measures of off-test weight and height had the strongest correlation to selling price, although only moderate in value at .49 and .47, respectively. Relationship of rib fat and scrotal circumference to selling price was extremely weak. Moderate to low correlations between

Table 3. Hereford bulls least squares means by year.

	1981	1982	1983	1984	1985	1986	1987
Number of bulls	147	123	65	72	58	49	5
On-test height (in)	44.1	44.6	45.3	45.2	45.9	45.7	45.8
Off-test height (in)	48.7	49.3	49.7	49.9	50.8	50.5	51.2
On-test weight (lb)	634	648	662	680	709	701	687
Off-test weight (lb)	1093	1136	1173	1178	1247	1220	1242
Average daily gain (lb)	3.28	3.48	3.65	3.54	3.85	3.72	3.96
Height daily growth (in)	.032	.033	.032	.033	.035	.034	.038
Scrotal circumference (cm)	35.77	35.99	36.51	36.41	36.48	36.58	37.24
Ribeye area (sq in)	12.6	13.1	13.9	13.5	13.6	13.9	-----
Rib fat (in)	.31	.31	.28	.39	.44	.43	.44

Table 4. Polled Hereford bulls least squares means by year.

	1981	1982	1983	1984	1985	1986	1987
Number of bulls	123	117	115	77	63	46	60
On-test height (in)	42.9	44.0	44.9	44.9	45.8	46.4	45.4
Off-test height (in)	47.8	48.7	49.5	49.9	50.6	51.1	50.5
On-test weight (lb)	538	615	641	639	688	686	641
Off-test weight (lb)	1037	1113	1150	1165	1205	1237	1176
Average daily gain (lb)	3.56	3.56	3.63	3.76	3.70	3.94	3.83
Height daily growth (in)	.035	.033	.033	.036	.034	.033	.037
Scrotal circumference (cm)	----	34.96	35.55	36.33	36.62	35.87	36.07
Ribeye area (sq in)	12.4	12.7	13.4	13.4	13.8	13.9	-----
Rib fat (in)	.43	.43	.43	.40	.39	.41	.30

Table 5. Correlation coefficients between sales price and off-test traits.

	Price
Weight	.49**
Height	.47**
Ribeye area	.37**
Rib fat	.05
Scrotal circumference	.10*
Average daily gain	.32**

*Significance level: (P < .05).
**Significance level: (P < .01).

ribeye area and average daily gain with selling price were .37 and .32, respectively. Since the larger framed, heavier bulls tended to sell for the higher prices, breeders readily recognized the importance of frame and height. Therefore, the trend by breeders to emphasize on-test height and weight when entering bulls in the test station can be easily explained by the association of these two traits and subsequent selling price.

Table 6 presents the impact that a per unit change in each trait had on selling price. Only off-test weight and off-test height made significant contributions to selling price in the Angus and Hereford bulls, while average daily gain also contributed significantly in the Polled Hereford breed. Ribeye area, ribeye fat and scrotal circumference did not significantly contribute toward the variation in selling price in any breed. A 100 lb differential in off-test weight was associated with a $233, $258 and $172 difference in selling price in the Angus, Hereford and Polled Hereford bulls, respectively. Even more pronounced was the importance of height. A one inch change in final height off-test was associated with a change in selling price of $182, $176 and $195 in Angus, Hereford and Polled Hereford, respectively. The row headed

Table 6. Partial regressions of sale price on off-test traits.

Number	Angus 208	Hereford 94	Polled Hereford 146
Weight ($/lb)	2.33**	2.58**	1.72*
Height ($/in)	182.00**	175.56**	194.51**
Ribeye area ($/sq in)			
Rib fat ($/in)			
Scrotal circumference ($/cm)			
Average daily gain ($/lb)			285.53*
R^{2b}	.37	.38	.40

[a]Change in price per unit change indicated for each trait.
[b]Proportion of variation in price accounted for by traits having coefficients for that breed.
*Significance level: (P < .05).
**Significance level: (P < .01).

R^2 indicates the proportion of the variation in selling price that can be attributed to the performance traits indicated. In this study, only 40% of the selling price variation in the Polled Hereford breed could be accounted for by off-test height, off-test weight and average daily gain. Off-test height and off-test weight accounted for 38% and 37% of variation in selling prices of the Angus and Hereford bulls, respectively. The additions of other factors into the model did not increase the percentage of the variation accounted for by the various performance traits.

A simple ranking of the traits obtained through these analyses is given in Table 7. These rankings indicate that measures of growth, most notably off-test height and weight generally had the greatest effect on selling price. Frame size has been a trait of major economic importance, primarily due to demand for larger, heavier, more efficient cattle. Breeders realized the significant impact of frame on selling price and simply tested larger framed, heavier bulls each year.

It is important to note that both sale order and the physical appearance of the bulls on sale day may have had a profound effect on these results. Certain bulls have phenotypic characteristics which may lead to an increase or decrease in price on sale day. The extent to which visual appraisal is used to determine price is unknown but may be quite large. In addition, certain pedigrees and bloodlines as well as expected progeny difference values of a bull's sire may have a significant impact on the selling price of performance tested beef bulls. The reputation of the breeder and his/her business relationships with potential customers may also have a significant bearing on selling price.

Table 7. Ranking of off-test traits in order of importance as contributors to sales price.

	Angus	Hereford	Polled Hereford
Number	208	94	146
Weight	2	2	2
Height	1	1	1
Ribeye area	6	4	4
Rib fat	5	6	6
Scrotal circumference	4	5	5
Average daily gain	3	3	3

OVERALL PRODUCTIVITY OF YOUNG CROSSBRED COWS CONTAINING 0, 1/4 OR 1/2 BRAHMAN BREEDING IN SPRING VERSUS FALL CALVING SYSTEMS

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L.W. Knori[3] and J.W. Castree[1]

Story in Brief

Productivity of two- to six-year old crossbred cows with 0, 1/4 or 1/2 Brahman breeding was evaluated using 201 records on spring calving and 172 records on fall calving cows collected from 1983 to 1987. Significant genotype (crossbred cow group) x environment (season of calving) interactions were found for age at first calf, lifetime percentage weaned, average adjusted weaning weight and weight weaned per year. Angus x Hereford in both seasons and Hereford x Angus in the fall group tended to calve earlier than the other groups. All spring calving groups calved first at an earlier age than did their respective fall calving counterparts. Average calving interval was 389 days, with no differences attributable to effects included in model. All groups weaned higher percentages in the spring than in fall. Spring and fall calving cows within each crossbred group tended to have similar average adjusted weaning weights. Weight weaned per year tended to be greater for spring calving groups than for fall calving groups. Spring calving Angus x Hereford dams had the lowest average adjusted weaning weight (345 lb) and fall calving Brahman x Angus tended to have the highest (475 lb). Spring calving Brahman-Hereford x Angus tended to wean the most weight per year (438 lb), while fall calving Brahman x Hereford tended to wean the least weight per year (273 lb). These results show that spring calving has some advantages to fall calving and Brahman breeding can be used to increase some aspects of cow productivity.

(Key Words: Crossbreeding, Beef Cattle, Brahman, Lifetime Productivity, Genotype x Environment Interaction.)

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

Introduction

Crossbreeding is used by commercial producers in an attempt to increase production efficiency. However, different environments may have varying effects on different genetic types (genotype x environment interactions). Evaluation of this genotype (crossbred cow group) x environment (season of calving) interaction is the purpose of a study currently being conducted by the Oklahoma Agricultural Experiment Station. This project was designed to evaluate the effects of crossbred cow group, season of calving and the interaction between the two using crossbred cows with different proportions of Brahman, Angus and Hereford breeding, managed in spring or fall calving systems. The objective of this portion of the study was to evaluate productivity of young (two- to six-year old) cows. The traits analyzed were age at first calf, average calving interval, lifetime weaning percentage, average adjusted weaning weight of calves weaned and weight weaned per year.

Materials and Methods

Cows for this project were produced by assigning Angus and Hereford dams at random to spring and fall calving groups. The cows were then mated to Angus, Hereford, Brahman, Brahman x Angus and Brahman x Hereford sires to produce calves with 0 Brahman (Hereford x Angus and Angus x Hereford), 1/4 Brahman (1/4 Brahman-1/4 Hereford-1/2 Angus and 1/4 Brahman-1/4 Angus-1/2 Hereford) and 1/2 Brahman (Brahman x Angus and Brahman x Hereford). The mating system, origin of foundation breeding stock and growth and performance of crossbred calves were presented by Bolton et al. (1986). Productivity and milk production of these cows was presented by McCarter et al. (1987a,b, 1988). Cows were maintained at the Southwestern Livestock and Forage Research Laboratory, El Reno, Oklahoma, for production of 1983 through 1986 calf crops on native tallgrass pastures. After weaning the 1986 calf crop, cows were moved to the range north of Lake Carl Blackwell in Stillwater, Oklahoma. Cows were exposed to Limousin bulls, in single sire pastures, for a 75 day breeding season to produce 1983 and 1984 calf crops. For 1985 and 1986 calf crops, cows were synchronized and bred once artificially to Limousin sires before being placed in single sire pastures with Limousin bulls for a total breeding season of 75 days. The calf crop in 1987 was produced by artificially breeding cows to Limousin and Salers bulls, then placing these in single sire pastures with Limousin bulls for a total breeding season of 75 days. Spring calving groups were bred to calve in February, March and April and fall calving cows were bred to calve in September, October and November. Spring and fall born calves were weaned at an average age of 205 and 240 days, respectively. Fall-born calves were weaned at an older age, a common practice of Oklahoma producers.

Age at first calf was computed in days using dam's birth date and her first calving date. Calving interval was computed using first and last calving dates and the total number of calves produced. Lifetime weaning percentage was computed by dividing the parity of the dam by the total number of possible calvings. Average age adjusted weaning weight, adjusted to 205- and 240-day basis for spring and fall groups, respectively, was computed by dividing the total weight weaned by a dam by the total number of calves produced. Weight weaned per year was computed by dividing the total weight weaned by the age of dam (in years) minus one. The distribution of records used in this analysis are presented in Table 1 by crossbred cow group and season of calving. Data were analyzed using least squares procedures to determine the effect of crossbred cow group, season of calving and the interaction of crossbred cow group with season of calving.

Table 1. Distribution of records by crossbred group and season of calving.

Crossbred cow group[a]	Season of calving		
	Spring	Fall	Total
0 Brahman:			
HxA	24	25	49
AxH	12	13	25
1/4 Brahman:			
1/4 B-1/4 H-1/2 A	48	40	88
1/4 B-1/4 A-1/2 H	38	28	66
1/2 Brahman:			
BxA	42	38	80
BxH	37	28	65
Total	201	172	373

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

Results and Discussion

Age at first calf was significantly affected by the interaction between crossbred cow group and season of calving (Table 2). Within the spring calving group, Angus x Hereford calved earlier ($P < .01$) than all other spring calving groups. Within the fall calving group, the two groups of 0 Brahman cows tended to calve earlier than 1/4 or 1/2 Brahman cows. Cows out of

Table 2. Least squares means for age at first calf in days by crossbred cow group x season of calving interaction.

Crossbred cow group[a]	Season of calving	
	Spring	Fall
0 Brahman:		
HxA	815[b]	1123[de]
AxH	629[c]	1057[d]
1/4 Brahman:		
1/4 B-1/4 H-1/2A	769[b]	1173[ef]
1/4 B-1/4 A-1/2H	793[b]	1216[f]
1/2 Brahman:		
BxA	784[b]	1191[ef]
BxH	795[b]	1370[g]

[a]H=Hereford, A=Angus and B=Brahman.
[b,c,d,e,f,g]Means not sharing at least one common superscript differ (P<.05).

Angus dams tended to calve earlier than those out of Hereford dams. Due to the fact that no fall calving two-year old Brahman x Hereford cows weaned a calf, this group gave birth to their first calf later (P<.01) than all other groups. Spring calving cows in all breed groups calved first at an earlier (P<.05) age than their fall calving counterparts.

Average calving interval was 389 days. No factors included in the model significantly affected this trait.

Lifetime weaning percentage was significantly affected by the interaction between crossbred cow group and season of calving (Table 3). All crossbred groups, with the exception of Angus x Hereford, weaned a higher (P<.05) percentage of calves in the spring than in the fall. Within

Table 3. Least squares means for lifetime percentage weaned by crossbred cow group x season of calving interaction.

Crossbred cow group[a]	Season of calving	
	Spring	Fall
0 Brahman:		
HxA	90.2[bc]	78.3[de]
AxH	71.4[df]	76.4[cdf]
1/4 Brahman:		
1/4 B-1/4 H-1/2 A	92.8[b]	67.5[ef]
1/4 B-1/4 A-1/2 H	78.4[d]	64.0[f]
1/2 Brahman:		
BxA	80.5[cd]	67.7[ef]
BxH	73.6[df]	51.3[g]

[a]H=Hereford, A=Angus and B=Brahman.
[b,c,d,e,f,g]Means not sharing at least one common superscript differ (P<.05).

each proportion Brahman, cows out of Angus dams tended to wean higher percentages than those out of Hereford dams. Within the spring calving group, 1/4 Brahman-1/4 Hereford-1/2 Angus and Hereford x Angus cows were similar and were superior (P<.05) to Angus x Hereford, 1/4 Brahman-1/4 Angus-1/2 Hereford and Brahman x Hereford. Within the fall calving group, groups were similar with the exceptions that Hereford x Angus weaned a higher (P<.05) percentage than did 1/4 Brahman-1/4 Angus-1/2 Hereford and Brahman x Hereford weaned the lowest (P<.05) percentage.

The interaction between crossbred cow group and season of calving was significant for average adjusted weaning weight (Table 4). Within the spring group, Angus x Hereford and Brahman x Hereford tended to wean the lightest calves with the remaining four breed groups being similar. No differences existed between the breed groups in the fall calving herd. All breed groups produced calves of similar weights across seasons with the exception of Angus x Hereford which produced heavier (P<.01) calves in the fall than in the spring.

Weight weaned per year was significantly affected by the crossbred cow group x season of calving interaction (Table 5). Weight weaned per year combines reproductive performance with mothering ability of the dam to give a more precise estimate of a cow's total productivity. Within the spring group, 1/4 Brahman-1/4 Hereford-1/2 Angus, Brahman x Angus and Hereford x Angus were similar with only 1/4 Brahman-1/4 Hereford-1/2 Angus producing more (P<.05) weight per year than Angus x Hereford, 1/4 Brahman-1/4 Angus-1/2 Hereford and Brahman x Hereford. Angus x Hereford produced less (P<.05) weight per year than all breed groups except Brahman x Hereford. Within the fall calving group, 0 and 1/4 Brahman and

Table 4. Least squares means for average adjusted weaning weight for calves weaned[a] by crossbred cow group x season of calving interaction.

Crossbred cow group[b]	Season of calving	
	Spring	Fall
0 Brahman:		
HxA	207.3[cd]	209.4[cd]
AxH	156.4[e]	211.1[cd]
1/4 Brahman:		
1/4 B-1/4 H-1/2 A	211.1[c]	206.1[cd]
1/4 B-1/4 A-1/2 H	212.6[c]	211.2[cd]
1/2 Brahman:		
BxA	205.1[cd]	215.5[c]
BxH	190.7[d]	212.4[cd]

[a]Total weight weaned during lifetime divided by number of calves weaned, in lb.
[b]H=Hereford, A=Angus and B=Brahman.
[c,d,e]Means not sharing at least one common superscript differ (P<.05).

Table 5. Least squares means for weight weaned per year[a] by crossbred cow group x season of calving interaction.

Crossbred cow group[b]	Season of calving	
	Spring	Fall
0 Brahman:		
HxA	184.7[cde]	163.1[df]
AxH	141.6[fg]	153.6[dfg]
1/4 Brahman:		
1/4 B-1/4 H-1/2 A	198.5[c]	143.5[fg]
1/4 B-1/4 A-1/2 H	175.5[de]	142.8[fg]
1/2 Brahman:		
BxA	181.4[cde]	160.5[df]
BxH	166.8[ef]	123.7[g]

[a]Total adjusted weight weaned divided by age of dam in years minus one, in lb.

[b]H=Hereford, A=Angus and B=Brahman.

[c,d,e,f,g]Means not sharing at least one common superscript differ ($P<.05$).

Brahman x Angus were similar and tended to be superior to Brahman x Hereford. Only Hereford x Angus and Brahman x Angus were significantly superior to Brahman x Hereford. Only the 1/4 Brahman groups differed across seasons as the spring calving 1/4 Brahman groups weaned more ($P<.05$) weight per year than their fall calving counterparts. As in lifetime weaning percentage, cows out of Angus dams tended to be superior to those out of Hereford dams within the same proportion Brahman.

In summary, spring calving was advantageous to fall calving for all crossbred groups except Angus x Hereford. Cows with Angus dams tended to be more productive than those out of Hereford dams within the same proportion Brahman group. Overall, spring calving 1/4 Brahman-1/4 Hereford-1/2 Angus tended to be the most productive indicating that Brahman breeding can be incorporated into a commercial crossbreeding system to increase production efficiency. Due to genotype x environment interactions, environment and management systems need to be considered when selecting breeds for use in a crossbreeding system.

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SOME FACTORS AFFECTING WEANING RATE OF YOUNG CROSSBRED COWS CONTAINING 0, 1/4 AND 1/2 BRAHMAN BREEDING IN SPRING OR FALL CALVING SYSTEMS

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Story in Brief

Weaning rate was calculated as the proportion of cows exposed to breeding that weaned a calf and was evaluated using 1060 records on crossbred cows (three- to six-years old) containing 0, 1/4 or 1/2 Brahman breeding. Season of calving, lactational status at breeding, prebreeding weight and condition score significantly affected weaning rate. Interactions affecting weaning rate include crossbred cow group x lactational status, crossbred cow group x condition score, crossbred cow group x weight, season of calving x weight and year of calving x age of dam. Angus x Hereford, 1/4 Brahman-1/4 Angus-1/2 Hereford and Brahman x Angus dams lactating at breeding weaned lower percentages than those cows of similar breeding that were dry at breeding. Angus x Hereford cows receiving a condition score of 5 tended to wean a higher percentage of calves than cows of similar breeding receiving other scores whereas a score of 6 resulted in the higher weaning rate for 1/4 Brahman-1/4 Hereford-1/2 Angus. More calves were weaned by 1/4 Brahman-1/4 Angus-1/2 Hereford dams receiving a score of 3, with weaning rate decreasing as condition score increased. No 0 Brahman cows weighing less than 660 lb at breeding weaned a calf. As proportion of Brahman breeding increased, the effect of weight on weaning rate decreased. Across all calving groups, weaning rate increased as weight increased.

(Key Words: Crossbreeding, Beef Cattle, Brahman, Weaning Rate.)

Introduction

Crossbreeding is a recommended management technique for increasing the efficiceny of commercial beef production. Successful crossbreeding

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requires the choice of breeds appropriate for the production environment. Brahman-cross cows have been widely evaluated in the Gulf Coast region of the United States. However, few studies outside of this region have involved Brahman breeding and information concerning lactational status, prebreeding score and prebreeding weight and their effects on weaning rate in Brahman-cross dams is limited. The data used for this study come from a project by the Oklahoma Agricultural Experiment Station designed to evaluate the effects of genotype (crossbred cow group), environment (season of calving) and the interaction between genotype and environment. The purpose of this portion of the study was to determine the effects of crossbred cow group, season of calving, lactational status, prebreeding condition score and prebreeding weight on weaning rate of crossbred cows containing 0, 1/4 or 1/2 Brahman, Angus and Hereford breeding in spring or fall calving systems.

Materials and Methods

Angus and Hereford dams were assigned at random to spring and fall calving groups and mated to Angus, Hereford, Brahman, Brahman x Angus and Brahman x Hereford sires to produce crossbred calves that were 0 Brahman (Angus x Hereford and Hereford x Angus), 1/4 Brahman (1/4 Brahman-1/4 Hereford-1/2 Angus and 1/4 Brahman-1/4 Angus-1/2 Hereford) and 1/2 Brahman (Brahman x Angus and Brahman x Hereford). The mating system, origin of foundation breeding stock and growth and performance of crossbred calves were presented by Bolton et al. (1986). Productivity and milk production of these cows was presented by McCarter et al. (1987a,b, 1988). Lifetime productivity of young cows was presented by McCarter et al. (1989). Cows were maintained at the Southwestern Livestock and Forage research Laboratory, El Reno, Oklahoma for production of 1983 through 1986 calf crops. After weaning the 1986 calf crop, cows were moved to the North Lake Carl Blackwell Range, Stillwater, Oklahoma. Pastures were typical tallgrass pastures with some bermudagrass. Cows were exposed to Limousin bulls, in single sire pastures, for a breeding period of 75 days to produce the 1984 calf crop. For 1985 and 1986 calf crops, cows were synchronized and bred artifically to Limousin sires and then placed in single sire pastures with Limousin sires for a total breeding period of 75 days. The calf crop in 1987 was produced by breeding cows artifically to Limousin and Salers sires, twice if necessary, before being placed in single sire pastures with Limousin sires. Spring calving cows were bred to calve in February, March and April and fall calving cows were bred to calve in September, October and November.

Records of two-year old dams were deleted from the analysis so that all cows had the opportunity to produce a calf and be lactating at the onset of this study. Weaning rate was analyzed as the proportion of cows exposed to breeding that weaned a calf. Values of 0 and 1 were assigned to cows not weaning a calf and to cows weaning a calf, respectively. Data were analyzed using least squares procedures to determine the effects of crossbred cow group, season of calving, lactational status, conditon score, weight and all two factor interactions on weaning rate.

Results and Discussion

All main effects, with the exception of crossbred cow group, significantly affected weaning rate. The amount of variation attributable to crossbred cow group was reduced by the addition of condition score and weight to the model as differences did exist between crossbred groups. Two way interactions found to be significant were crossbred cow group x lactational status, crossbred cow group x condition score, crossbred cow group x weight, season of calving x weight and year x age of dam. Subclass least squares means are presented for these significant interactions.

Table 1 contains the least squares means for weaning rate by crossbred cow group x lactational status. No differences were found between dry and lactating Hereford x Angus, 1/4 Brahman-1/4 Hereford-1/2 Angus and Brahman x Hereford. For the remaining three groups, Angus x Hereford, 1/4 Brahman-1/4 Angus-1/2 Hereford and Brahman x Angus, weaning rates for lactating cows were lower ($P<.05$) than for dry cows.

Least squares means for weaning rate by crossbred cow group x condition score are presented in Table 2. Weaning rates for Hereford x

Table 1. Least squares means for weaning rate by crossbred cow group x lactational status.

Crossbred cow group[a]	Lactational status: Dry	Lactational status: Lactating
0 Brahman:		
HxA	77.6^{bcd}	67.8^{bc}
AxH	86.7^{bd}	53.7^{c}
1/4 Brahman:		
1/4 B-1/4 H-1/2 A	89.9^{bd}	81.8^{be}
1/4 B-1/4 A-1/2 H	111.6^{f}	78.1^{be}
1/2 Brahman:		
BxA	100.0^{df}	83.7^{be}
BxH	94.5^{def}	86.7^{bd}

[a]H=Hereford, A=Angus and B=Brahman.
[b,c,d,e,f]Means not sharing at least one superscript differ ($P<.05$).

Table 2. Least squares means for weaning rate by crossbred cow group x prebreeding condition score.

Crossbred cow group[a]	Prebreeding condition score				
	3	4	5	6	7+
0 Brahman:					
HxA	74.7^{b}	66.0^{b}	78.8^{b}	76.3^{b}	67.4^{b}
AxH	77.7^{bc}	74.0^{bc}	92.8^{b}	53.0^{c}	53.4^{c}
1/4 Brahman:					
1/4 B-1/4 H-1/2 A	86.3^{bc}	76.7^{b}	88.4^{c}	89.6^{bc}	88.4^{bc}
1/4 B-1/4 A-1/2 H	111.8^{bc}	109.7^{b}	90.6^{d}	74.9^{e}	87.4^{cde}
1/2 Brahman:					
BxA	96.9^{b}	88.6^{b}	99.1^{b}	90.0^{b}	84.8^{b}
BxH	101.8^{b}	91.7^{b}	83.6^{b}	83.7^{b}	92.1^{b}

[a]H=Hereford, A=Angus and B=Brahman.
[b,c,d,e]Means not sharing at least one superscript differ ($P<.05$).

Table 3. Least squares means for weaning rate by crossbred cow group x prebreeding cow weight.

Weight class[a], lb	Crossbred cow group[b]					
	HA	AH	BHA	BAH	BA	BH
≤660	--	--	62.1	81.0	77.1	90.2
661 - 770	97.3	63.2	98.1	74.0	98.1	87.8
771 - 880	93.2	66.4	80.0	83.1	78.9	85.3
881 - 990	83.7	94.6	89.2	87.4	92.7	90.0
991 - 1100	77.1	80.9	89.5	90.4	94.4	82.7
1101 - 1210	97.1	91.8	80.0	113.9	88.8	94.0
>1210	68.5	104.2	102.3	134.3	112.8	104.3

[a]Cows were group by increments of 110 lb.

Angus, Brahman x Angus and Brahman x Hereford were not affected by condition score. Angus x Hereford cows receiving a condition score of 5 tended to wean more calves than those receiving other scores. Cows receiving scores of 3 or 4 tended to have higher weaning rates than those receiving scores of 6 or more. For 1/4 Brahman-1/4 Hereford-1/2 Angus dams, those receiving scores of 3, 5, 6 or 7 were similar (P>.10). The only difference (P<.05) for this group occurred between those receiving condition scores of 5 (88.4%) and 4 (76.7%). For 1/4 Brahman-1/4 Angus-1/2 Hereford, weaning rate tended to decrease as condition score increased.

Table 3 contains the least squares means for weaning rate by crossbred cow group x weight. For all groups, weaning rate tended to increase as weight increased. Zero Brahman cows were more affected by low weights than were 1/4 and 1/2 Brahman cows as no 0 Brahman cows weighing 660 lb or less at breeding weaned a calf. As proportion of Brahman increased, the effect of weight decreased.

Least squares means for weaning rate by season of calving x weight are presented in Table 4. No differences were found between the two seasons for those weight classes below 1100 lb. Spring calving cows weighing more than 1100 lb had higher (P<.05) weaning rates than did fall calving cows with similar weights. With the exception of the 660 lb and less weight class, spring calving cows tended to have higher weaning rates than fall calving cows of similar weights.

Least squares means are presented in Table 5 by the year x age of dam interaction. Due to the age distribution of the herd and the limited amount of data available, few differences were found between the age groups present in each year. For 1985, weaning rates for three- and four-year old dams were similar (P>.15). The same was true for three-, four- and five-year olds in 1986. In 1987, four- and five-year olds were similar and four-year olds had a

Table 4. Least squares means for weaning rate by season of calving x prebreeding cow weight.

Weight class[a], lb	Season of calving: Spring	Fall
≤660	35.1[b]	62.4[bcd]
661 - 770	87.9[cde]	84.9[cd]
771 - 880	86.8[cd]	75.5[d]
881 - 990	94.1[ce]	85.0[cd]
991 - 1100	89.6[cf]	82.0[df]
1101 - 1210	102.3[e]	86.2[cd]
>1210	125.7[g]	83.1[cd]

[a]Cows were grouped into increments of 110 lb.
[b,c,d,e,f,g]Means not sharing at least one common superscript differ (P<.05).

Table 5. Least squares means for weaning rate by year x age of dam.

Year	Age of dam 3	4	5	6
1984	84.5[ab]			
1985	91.0[ac]	94.1[c]		
1986	91.2[ac]	94.5[c]	93.9[ac]	
1987		70.4[d]	76.4[bde]	63.2[e]

[a,b,c,d,e]Means not sharing at least one superscript differ ($P<.05$).

higher ($P<.05$) weaning rate than did six-year olds, 70.4 and 63.2%, respectively.

In summary, Brahman x British crossbred cows were affected by lactational status at breeding in a manner similar to British crosses. However, condition score and weight had less effect on Brahman x British crossbred dams than British crosses. Thus, the condition scoring system developed for British and British cross cows may be of less use for evaluation of Brahman and Brahman x British crossbred cows.

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LIMOUSIN VERSUS SALERS AS A TERMINAL SIRE: POSTWEANING AND CARCASS TRAITS

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

Story in Brief

Limousin and Salers sires were used in this study to compare the usefulness of these breeds as a terminal sire. Twelve different sires were used each year. These consisted of six sires from the Limousin breed and six sires from the Salers breed. Carcass data were collected on 289 calves. The Limousin sires were represented with 152 calves and the Salers sires were represented with 137 calves. There were small advantages for Limousin-sired calves relative to Salers for days on feed (199 vs 204 days) and slaughter age (409 vs 415 days). Carcass weight per day of age was the same for the two sire breeds (1.79 lb/day of age). Feedlot daily gains for the two sire breeds were very similar (approximately 2.9 lb/day). There were no substantial differences in carcass characteristics between the breed groups. These results indicate that the Salers breed can be as useful as the Limousin breed for serving the purposes of a terminal sire in order to produce calves for use in a feedlot and for slaughter.

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

Introduction

The beef cattle industry is constantly concerned with meeting consumer demands. As consumer demand shifts toward a leaner product use of a "terminal sire" breed in a breeding program becomes important. The terminal sire serves as one way in which the producer can change the product which he or she wants to put on the market to the consumer.

A producer must be concerned with producing a product as efficiently as possible as well as meeting consumer demands. The choice of terminal sires in a program becomes important. Selection of an appropriate terminal sire should enhance growth rates and carcass merit of calves.

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Selection of the appropriate sire breed to implement in a crossbreeding system is a very important decision to the producer. As new beef breeds have arrived in the United States it has become important to evaluate them for use in a terminal sire crossbreeding system. The Limousin breed is known for its benefits to a terminal crossbreeding system. This study was established to compare the usefulness of Salers as a terminal sire in comparison with the Limousin.

Materials and Methods

Two different cow herds were used in this study. Calves born in 1986 were from 11-, 12-, and 13-year old cows from eight different breed groups: Hereford x Angus, Angus x Hereford, Simmental x Angus, Simmental x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus and Jersey x Hereford.

The 1987-born calves were produced by 4-, 5- and 6-year old crossbred cows of six different breed groups. These different crossbred cow groups consisted of Hereford x Angus, Angus x Hereford, Brahman x Angus, Brahman x Hereford, 1/4 Brahman-1/4 Hereford-1/2 Angus and 1/4 Brahman-1/4 Angus-1/2 Hereford.

The bulls used in this study were selected by the North American Limousin Foundation and the American Salers Association. The semen was donated by the owners of the bulls. A total of 12 bulls were used each year. Within each year there were six different bulls from each breed. Bulls were randomly assigned to each cow group with approximately an equal representation of each bull within each cow group. Birth and weaning characteristics have been reported by Tinker et al. (1988).

The 1986-born calves were shipped to the feedlot operation with the on-test weight recorded approximately 24 hours after arrival. The 1987-born calves received a pencil shrink of 4% off the actual weaning weights. Calves received a grower-type ration in the early part of the feeding period and were shifted to a high concentrate ration later in the feeding period.

Carcass information obtained on these calves included rib eye area, yield grade, quality grade, marbling score, rib fat thickness, adjusted fat thickness and hot carcass weight. Other postweaning traits included feedlot daily gain, days on feed, and days birth to slaughter.

Calves were taken out of the feedlot when trained personnel working for the feedlot decided that the calves were at a desired endpoint in terms of weight and carcass grade.

Results and Discussion

A total of 289 calves were evaluated in this study for carcass and postweaning traits. Sire breed means were averaged over years, crossbred dam groups and sexes (Table 1). Among the traits evaluated in this study only days on feed and slaughter age had a tendency ($P<.10$) to be different for the two breeds. The Limousin-sired calves averaged 199 days on feed while the Salers-sired calves averaged 204 days on feed. Slaughter age for the Limousin-sired calves averaged 409 days while the Salers-sired calves averaged 415 days. The remaining traits included on-test weight, slaughter weight, feedlot daily gain, hot carcass weight, carcass weight per day of age, dressing percentage, rib fat thickness, adjusted fat thickness, kidney, pelvic and heart fat percentage, yield grade, ribeye area, marbling score and quality grade. The two sire breeds did not exhibit any significant differences ($P>.10$) for these traits.

These results provide preliminary indication that Salers-sired calves provide similar carcass and postweaning merit in comparison with the Limousin-sired calves. However, more research is needed to clarify the usefulness of Salers in a breeding program. This study suggests that the Salers breed has potential as a terminal sire breed.

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

Trait	Breed of sire[a]	
	Limousin	Salers
Number of animals	152	137
On test weight,lb	528	541
Slaughter weight,lb	1107	1127
Days on feed*	199	204
Slaughter age,d*	409	415
Feedlot daily gain,lb/day	2.91	2.88
Hot carcass weight,lb	729	741
Carcass wt. per day of age,lb/day	1.79	1.79
Dressing percentage	65.9	65.8
Rib fat thickness/in	.42	.41
Adjusted fat thickness/in	.48	.48
Kidney, pelvic and heart fat,%	2.16	2.11
Yield grade	2.34	2.47
Ribeye area,sq in	14.3	14.0
Marbling score[b]	470	486
Quality grade[c]	8.59	8.95

[a]Least squares means with adjustments for years, crossbred dam groups and sexes.
[b]Marbling score: 400=slight, 500=small.
[c]Quality grade: 8=Se^0, 9=Se^+.
*$P<.10$.

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EFFECT OF COW TYPE AND BODY CONDITION SCORE ON POSTPARTUM CYCLICITY OF VARIOUS TWO-BREED-CROSS COWS

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Story in Brief

The effect of body condition score on reproductive performance was evaluated with two-breed-cross cows representing various biological types. The study consisted of 188 aged crossbred cows nursing calves from single births. Cows were bled twice, 7 days apart, at an average of 85 days after calving and body condition scores were assigned at time of blood sampling during one of the two weeks. Blood plasma was analyzed for progesterone concentration by radioimmunoassay to determine luteal activity. Body condition score at time of sampling did have an effect on the percentage of cows with luteal activity at 85 days postpartum. Crossbred group did affect the percentage of cows with luteal activity but no crossbred group x body condition score interaction was detected. Jersey-cross cows had a greater percentage of cows with luteal activity than Simmental-cross, Brown Swiss-cross and Hereford x Angus cows. This provides evidence that the desired body condition score to enhance reproductive performance may be different for cows of differing breeds and biological types.

(Key Words: Body Condition Score, Crossbred Cows.)

Introduction

Many studies have shown the importance of adequate body condition in beef cows to ensure rebreeding early in the ensuing breeding season. Much of this work has been conducted with cows of a single breed type. Whether cows of different breeds or breed combinations, and thus biological types, will perform the same reproductively while at a similar body condition score (BCS) remains to be addressed. If response varies by cow type, it would be appropriate to have different BCS recommendations for the different types.

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

Therefore the purpose of this research was to determine reproductive performance of cows of various types and breed combinations at similar BCS.

Materials and Methods

The cow herd used in this study was composed of eight crossbred cow groups produced by mating Hereford, Angus, Simmental, Brown Swiss and Jersey bulls to Angus and Hereford cows. The 188 cows were 11, 12 and 13 years old when they calved during the spring of 1986 at the Lake Carl Blackwell Research Range west of Stillwater. 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. BCS was assigned to each cow at the time of blood sampling during one of the two weeks that a blood sample was collected. A panel of four people familiar with the 1 - 9 scoring system (1 = emaciated, 9 = very obese) assigned the scores to cows. Average BCS was determined for the panel and utilized in the analysis. Cows were assigned to one of three groups based on condition score, with groups consisting of cows with a BCS of 4 or less, BCS 5 and BCS 6 or greater. Progesterone concentrations of blood samples were measured by radioimmunoassay to identify those cows with luteal activity (LA), which indicates those cows which have initiated cyclic ovarian activity since calving. Data were analyzed to determine the percentage of cows cycling in each crossbred cow group, BCS and crossbred cow group x BCS combination.

Results and Discussion

Body condition score at time of blood sampling had an effect on percentage of cows with LA. Only 42% of cows with a BCS 4 or less had LA whereas cows with BCS 5 and those with BCS 6 or greater had 71% and 87% cows cycling, respectively. The eight crossbred cow groups were separated into breed of cows' sire and breed of cows' dam for evaluation. The Hereford x Angus reciprocal cross cows were omitted from the breed of dam analysis and grouped together to make comparisons with the other breed of sire groups. No difference was found for breed of cows' dam (Angus vs Hereford) but breed of cows' sire did have an effect. Least squares means for the crossbred groups are listed in Table 1. A greater percentage of cows from Jersey sires had LA than cows of the other three crossbred groups.

No interaction was present between crossbred group and BCS but comparisons within a BCS show differences in LA between some crossbred groups. Least squares means for these subgroups are also presented in Table

Table 1. Least squares means for percentage of cows with luteal activity 85 days postpartum for crossbred groups and crossbred groups x body condition score subgroups[a].

Crossbred group	Body condition score ≤4	5	≥6	Group average
Hereford x Angus	10.1[b] (3)	61.3[b](28)	77.0(18)	55.7[b](49)
Simmental-sired	36.4[bc](8)	65.1[b](27)	82.8 (9)	61.4[b](44)
Brown Swiss-sired	51.4[bc](9)	59.6[b](26)	57.6 (2)	59.5[b](37)
Jersey-sired	62.5[c](43)	98.6[c](15)	--- (0)	89.0[c](58)

[a]Number of cows in each group or subgroup is shown in parentheses next to the mean.

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

1. The number of cows classified in each subgroup is given in parentheses after each mean. There were no Jersey-sired cows with a BCS 6 or greater to establish a mean for that subgroup. At BCS 4 or lower more cows from Jersey sires had LA than Hereford x Angus cows, with cows from Simmental and Brown Swiss sires intermediate and not different from Jersey-sired or Hereford x Angus cows. More Jersey-sired cows had LA than cows of the other three crossbred groups at BCS 5. There were no differences between Simmental-sired, Brown Swiss-sired and Hereford x Angus cows at BCS 6 or greater and there were no Jersey-sired cows with this degree of body condition.

This research reinforces that BCS does have an effect on percentage of cows returning to estrous by 85 days after calving. Crossbred group did affect percentage of cows with LA but there was no interaction between crossbred cow group and BCS. A greater percentage of the Jersey-cross cows exhibited LA than the other two-breed combinations. Since cows of this breed type do not need to be in as high a BCS as other types of crossbred cows in order to cycle 85 days after calving, they would not need to be fed to the same body condition. Thus money could be saved due to reduced feed costs while attaining a desirable level of reproductive performance. Therefore some refinements of the BCS recommendations for enhancing reproductive performance may need to be investigated for cows of various breed combinations and biological types.

CHARACTERISTICS OF PIGS SELECTED FOR RAPID OR SLOW GAIN AND FED AD LIBITUM OR LIMITED RATIONS

M.D. Woltmann[1], A.C. Clutter[2], D.S. Buchanan[3], H.G. Dolezal[4] and R. Vencl[5]

Story in Brief

Two lines of pigs selected for divergent growth rate were evaluated on either ad libitum or restricted diets. A total of 180 barrows from the second, third and fourth generations of selection in a spring-farrowing replicate and 36 barrows from the third generation in a fall-farrowing replicate were either fed individually or as littermate pairs. Carcass data were collected from an additional littermate barrow at the start of each test to allow estimation of lean tissue growth rate of tested barrows. Complete carcass separation data were collected after barrows were removed from test. Barrows from a rapid growth line were faster growing, consumed more feed and deposited more fat than slow growth line barrows when both lines were fed ad libitum. Restricted feeding decreased gain and deposition of fat and improved total body weight feed efficiency of rapid growth line barrows relative to slow growth line barrows.

(Key Words: Swine, Selection, Gain, Intake, Composition.)

Introduction

The primary goal of the swine industry should be to produce each unit of pork as efficiently as possible. With increasing emphasis on lean pork, this goal needs to be modified to an ultimate goal of improving the efficiency of lean tissue production. A number of preweaning and postweaning traits determine the overall efficiency of swine production. Selection for gain, backfat and efficiency has been shown to be successful. However, single-trait selection for one of these traits often results in undesirable changes in one or more other traits.

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The purpose of this study was to evaluate the effect of selection for divergent postweaning growth rate on lean tissue growth rate, lean tissue feed conversion and other growth and carcass traits. Divergent lines were evaluated under ad libitum and restricted intake to determine the role of feed intake in response to selection for growth rate.

Materials and Methods

Lines of pigs selected for rapid (RGL) and slow (SGL) postweaning growth rate were established from litters born during 1981 at the Southwest Livestock and Forage Research Station. Boars purchased from central test stations were mated to a crossbred population of gilts to begin the lines. The tested boars were ranked on an index that gave primary emphasis to increased gain and decreased fat and were puchased in pairs (one high-indexing and one low-indexing boar in each pair). The RGL was initiated by mass selection for rapid gain in pigs sired by high-indexing boars and the SGL was established by mass selection for slow gain among pigs sired by low-indexing boars. Each line was represented in spring- and fall-farrowing replicates. The lines were closed at this point and divergent selection for growth rate continued on both males and females.

Barrows representing two, three and four generations of selection in spring-born litters (n=180 barrows) and three generations of selection in fall-born litters (n=36 barrows) were fed individually or in littermate pairs starting at approximately 80 lb. Barrows from the RGL and SGL were evaluated on either an ad libitum ration or a ration restricted to 83% of predicted ad libitum intake. Ad libitum intake was predicted using an equation based on live weight. This 2 X 2 factorial arrangement of line and ration was blocked nine times per trial. Each test was designed to end when the average weight of the block was 230 lb. Feed intake and weight were measured weekly throughout the test and ultrasonic backfat probes at the first rib, last rib, and last lumbar vertebra were taken weekly starting at approximately 150 lb. Upon removal from test, barrows were slaughtered and carcasses were separated into lean, bone and fat. Carcass backfat, loin eye area and length were also measured. The same carcass data were collected on an additional littermate barrow at on-test weight to establish initial composition of the lines and allow estimation of lean tissue growth rate of the tested barrows.

Results and Discussion

An earlier study of these lines following four generations of divergent selection showed that the RGL gained faster and were more efficient (total feed/total body weight gain) from nine weeks of age through 220 lb and had more backfat at 230 lb (Clutter et al., 1988) than the SGL. Growth and performance traits for the spring replicate of the current study are presented in Table 1. The line x ration interaction was significant (P<.05) for average daily gain (ADG). The RGL gained faster than the SGL on the ad libitum ration (P<.05), but there was no difference in gain between the lines when feed was restricted. The line x ration interaction was also significant (P<.05) for average daily feed intake, feed efficiency on a total body weight basis (FE) and average probed backfat (BF). The lines were not significantly different for feed efficiency under ad libitum conditions, but the RGL was more efficient (P<.05) than the SGL when intake was restricted. On ad libitum intake, the RGL consumed more feed and were fatter than the SGL (P<.05), however differences between lines for these traits were not significant when feed was restricted. It appears that a difference in intake was responsible for a large portion of the difference in gain between the two lines and that much of the additional feed consumed by the RGL under ad libitum conditions was used to produce fat. Even though selection in both lines had been under ad libitum conditions, the RGL pigs were able to gain body weight more efficiently than pigs from the SGL when feed was restricted.

The line x ration interaction was not significant for any of the traits in the fall replicate (Table 2). The difference in gain between the lines was not significant, but the RGL was fatter, less efficient and had a higher feed intake than the SGL (P<.05). Barrows on limited intake gained more slowly, were

Table 1. Least-squares means for growth and performance traits in the spring replicate.

	Line-ration[a]			
	RGL-AL	RGL-LIM	SGL-AL	SGL-LIM
ADG (lb/day)[c]	1.87	1.76	1.76	1.74
FE (feed/gain)[c]	3.50	3.19	3.48	3.37
Intake (lb/day)[c]	6.47	5.58	6.11	5.88
BF (in)[bc]	1.23	1.11	1.17	1.13
LTGR[d]	.457	.447	.451	.442
LTFC[ce]	.068	.080	.075	.076

[a]RGL=rapid growth line, SGL=slow growth line, AL=ad libitum ration and LIM=limited to 83% of ad libitum.
[b]Average backfat in an average of three probed measurements at the first rib, last rib and last lumbar vertebra adjusted for final weight.
[c]Significant (P<.05) for line by ration interaction.
[d]LTGR=lean gain/day.
[e]LTFC=lean gain/feed consumed.

Table 2. Least-squares means for growth and performance traits in the fall replicate.

	Line or ration[a]			
	RGL	SGL	AL	LIM
ADG (lb/day)[d]	1.84	1.86	1.98	1.72
FE (feed/gain)[cd]	3.59	3.40	3.55	3.45
Intake (lb/day)[c]	6.60	6.35	7.03	5.91
BF (in)[bcd]	1.15	1.08	1.20	1.03

[a]RGL=rapid growth line, SGL=slow growth line, AL=ad libitum ration and LIM=limited to 83% of ad libitum.
[b]Average backfat in an average of three probed measurements at the first rib, last rib and last lumbar vertebra adjusted for final weight.
[c]Significant (P<.05) for line.
[d]Significant (P<.05) for ration.

more efficient and deposited less fat than barrows allowed ad libitum intake (P<.05).

Lean tissue growth rate (LTGR) and lean tissue feed conversion (LTFC) was defined as the daily lean gain and the lean gain per feed consumed, respectively. Initial lean content was predicted from littermate barrows slaughtered at on-test weight (80 to 100 lb). Total lean gain was estimated by the difference between total dissected lean and predicted initial composition of lean. Estimates of LTGR and LTFC are not presented for the fall replicate due to the small numbers of barrows and the subsequent error associated with estimating these traits. The line x ration interaction was significant (P<.05) for LTFC in the spring replicate. The SGL tended to be more efficient than the RGL in converting feed to lean when fed ad libitum, with only small differences when the lines were restricted. These results also indicated that the additional feed consumed by the RGL was used for the deposition of fat, with no improvement in lean gain.

In the spring replicate, the line x ration interaction was significant (P<.05) for dissected lean and dissected fat, each expressed as a percent of the chilled carcass weight (Table 3). The RGL had a lower percentage lean and a greater percentage fat than the SGL when feed intake was not limited (P<.05), but line differences for these traits were not significant when feed was limited. Differences in percent bone were not significant. In the fall replicate (Table 4) the RGL had a larger percentage fat and bone (P<.05) and tended to have a smaller percentage lean (P<.10) than the SGL. Differences between rations for percentage fat and loin eye area were also significant (P<.05). In both replicates, means for average carcass backfat were consistent with those for probed backfat on the live pig.

Table 3. Least-squares means for carcass traits in the spring replicate.

	Line-ration[a]			
	RGL-AL	RGL-LIM	SGL-AL	SGL-LIM
% Lean[bc]	58.71	63.32	62.76	63.29
& Fat[bc]	29.22	24.40	25.67	25.37
% Bone[c]	12.07	12.28	11.57	11.34
Length (in)	31.8	31.9	31.5	31.3
Loin eye area(in^2)[b]	4.43	4.73	4.45	4.33
Average backfat[b]	1.22	1.03	1.12	1.08

[a]RGL=rapid growth line, SGL=slow growth line, AL=ad libitum ration and LIM=limited to 83% of ad libitum.
[b]Significant (P<.05) for line by ration interaction.
[c]Expressed as percent of chilled carcass weight.

Table 4. Least-squares means for carcass traits in the fall replicate.

	Line-ration[a]			
	RGL	SGL	AL	LIM
% Lean[bef]	58.92	61.47	58.27	62.11
& Fat[bcd]	29.60	25.93	30.33	25.30
% Bone[bc]	11.48	12.61	11.51	12.58
Length(in)	30.0	31.1	31.0	30.8
Loin eye area(in^2)[d]	4.20	4.32	4.57	3.95
Average backfat[c]	1.12	.98	1.10	1.00

[a]RGL=rapid growth line, SGL=slow growth line, AL=ad libitum ration and LIM=limited to 83% of ad libitum.
[b]Expressed as percent of chilled carcass weight.
[c]Significant (P<.05) for line.
[d]Significant (P<.05) for ration.
[e]Significant (P<.10) for line.
[f]Significant (P<.10) for ration.

Growth curves for the spring replicate, estimated by regressing weight on age, are presented by line x ration subclass for each of the three generations of selection (Figures 1a, 1b and 1c). In all generations, curves for the RGL ad libitum pigs tended to have the steepest slope. The curves of the SGL for both rations were very similar for all three generations. This indicates that SGL pigs were limited less than the RGL by the restricted

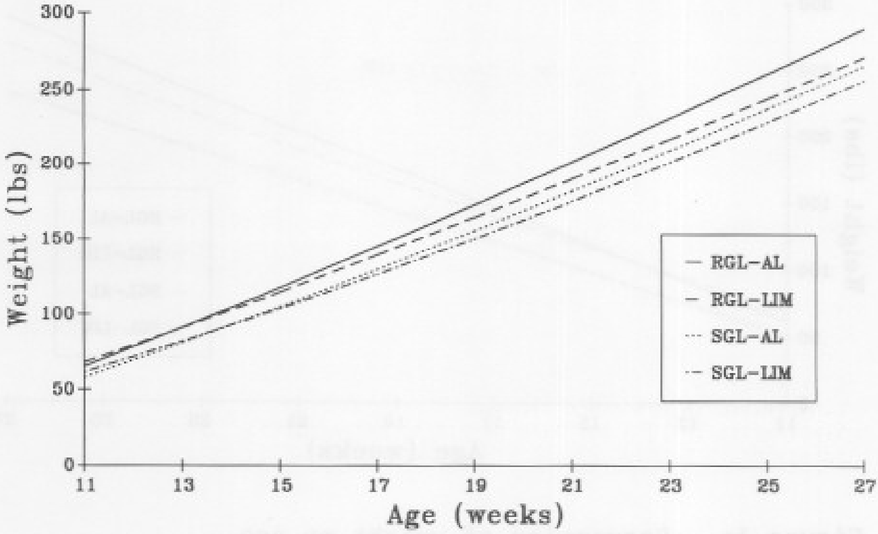

Figure 1a. Regression of weight on age. Generation 2: Spring replicate.

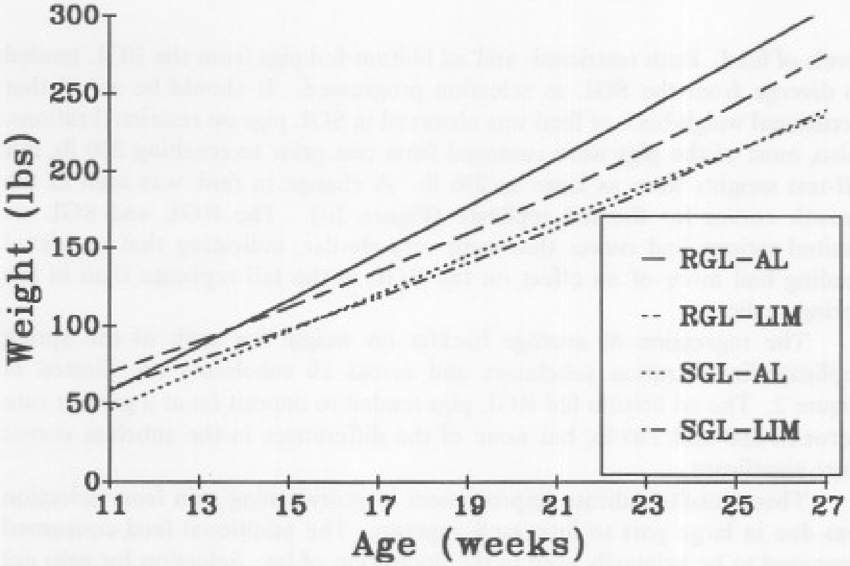

Figure 1b. Regression of weight on age. Generation 3: Spring replicate.

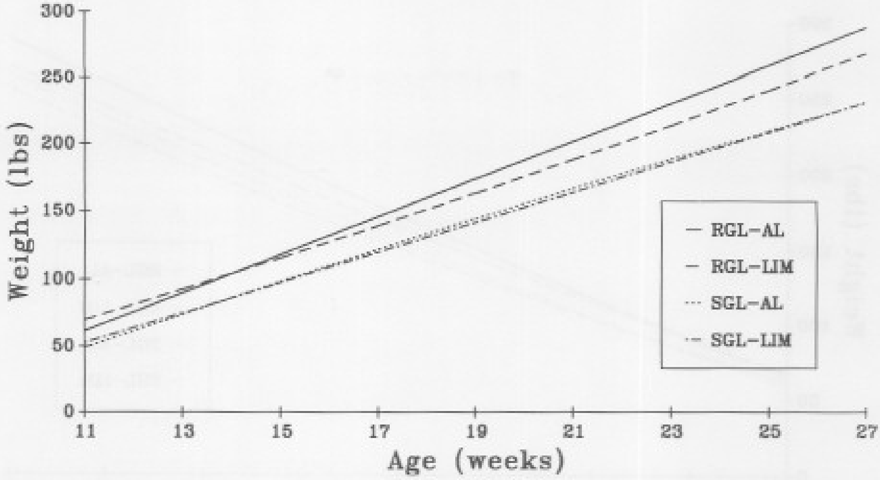

Figure 1c. Regression of weight on age.
Generation 4: Spring replicate.

levels of feed. Both restricted- and ad libitum-fed pigs from the RGL tended to diverge from the SGL as selection progressed. It should be noted that occasional weigh-back of feed was observed in SGL pigs on restricted rations. Also, most of the pigs were removed from test prior to reaching 250 lb, but off-test weights were as large as 296 lb. A change in rank was seen in the growth curves for the fall replicate (Figure 1d). The RGL and SGL on limited rations had curves that were very similar, indicating that restricted feeding had more of an effect on the RGL in the fall replicate than in the spring replicate.

The regression of average backfat on weight for each of the spring replicate line x ration subclasses and across all subclasses are plotted in Figure 2. The ad libitum fed RGL pigs tended to deposit fat at a greater rate between 180 and 240 lb, but none of the differences in the subclass curves were significant.

These results indicate improvement in postweaning gain from selection was due in large part to increased appetite. The additional feed consumed appeared to be primarily used in the deposition of fat. Selection for gain did not appear to change LTGR and tended to decrease LTFC. Restriction of feed in the RGL resulted in a 5.9% decrease in gain, an 8.9% improvement

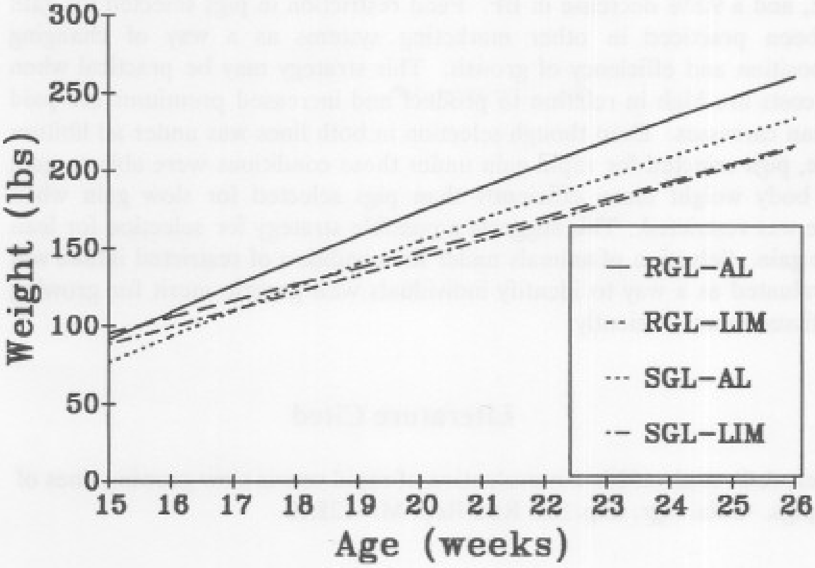

Figure 1d. Regression of weight on age.
Fall replicate.

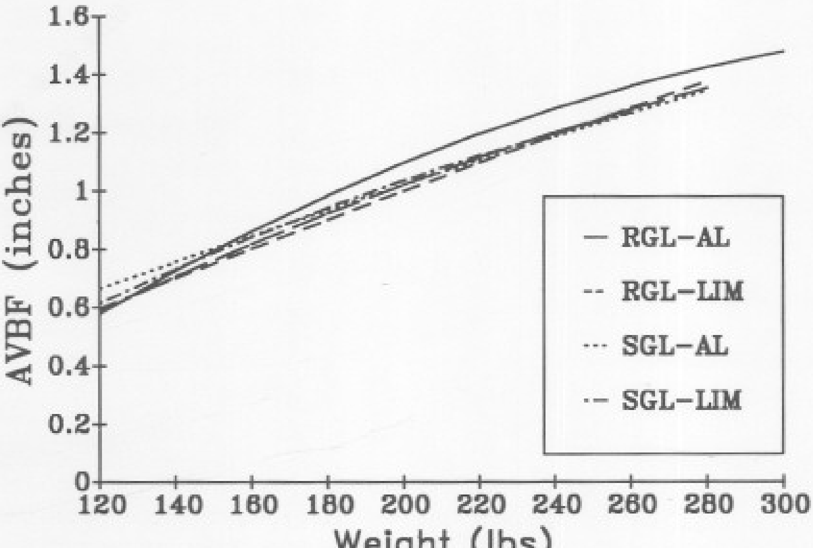

Figure 2. Regression of average backfat on weight.
Spring replicate: Across generation.

in FE, and a 9.8% decrease in BF. Feed restriction in pigs selected for gain has been practiced in other marketing systems as a way of changing composition and efficiency of growth. This strategy may be practical when feed costs are high in relation to product and increased premiums are paid for lean carcasses. Even though selection in both lines was under ad libitum intake, pigs selected for rapid gain under these conditions were able to gain total body weight more efficiently than pigs selected for slow gain when intake was restricted. This suggests a possible strategy for selection for lean tissue gain. Selection of animals under the condition of restricted intake will be evaluated as a way to identify individuals with genetic merit for growing lean tissue more efficiently.

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WHEAT MIDDLINGS VERSUS SOYBEAN MEAL AND TWO WHEAT MIDDLINGS/SOYBEAN MEAL SUPPLEMENTS FOR WINTERING SPRING CALVING BEEF COWS

D.A. Cox[1], K.H. Ovenell[1], K.S. Lusby[2] and R.P. Wettemann[3]

Story in Brief

Eighty-eight spring calving Hereford and Hereford x Angus cows and heifers wintered on dormant native tallgrass range were fed supplements to provide equal daily amounts of crude protein. The supplements consisted of soybean meal (40% crude protein), soybean meal and wheat middlings (32% crude protein), wheat middlings and soybean meal (24% crude protein) and wheat middlings (16% crude protein). Each supplement was fed to provide .8 lb of protein per day from November 5 to December 9, 1987 and 1.2 lb of protein per day from December 9, 1987 to May 4, 1988. Cow weight changes from November 5 to calving were 50, 68, 89 and 125 lb for 40, 32, 24 and 16% protein supplements, respectively. Winter weight changes, including calving weight losses, were -110, -79, -84 and -62 lb for the same treatments. Cows on treatments with the greatest weight and body condition gains before calving tended to lose more weight from calving until spring. Weaning weights and cow rebreeding rates were not significantly affected by treatments. Linear increases in precalving cow weight changes with increased levels of wheat middlings indicate that protein from wheat middlings is efficiently utilized and that wheat middlings are a good source of supplemental energy for beef cows. However, weight responses to different supplements may be different for nonlactating vs lactating cows.

(Key Words: Beef Cows, Energy, Protein, Soybean Meal, Wheat Middlings, Winter.)

Introduction

Wheat middlings are the offal of the wheat kernel after the milling process for removal of flour and germ. Over 140,000 tons per year are

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available for use in livestock feeds in Oklahoma. Wheat middlings contain about 16% crude protein (CP), but are discounted for their relatively high (8%) crude fiber content. Fiber from bran-type feeds has been shown to be highly digestible and to be an excellent energy source for grazing cattle. Lusby and Wettemann (1988) found that spring calving cows performed similarly when fed supplements containing 16% protein from either wheat middlings or mixtures of corn and soybean meal. The objective of this study was to compare winter performance of spring calving beef cows and their calves when supplemented with soybean meal, wheat middlings or two mixtures of soybean meal and wheat middlings.

Materials and Methods

Eighty-eight two- to five-year old spring calving Hereford and Hereford x Angus cows wintered on dormant native tallgrass range were fed supplements to provide equal daily amounts of crude protein (CP). Supplements consisted of soybean meal (40% CP), soybean meal and wheat middlings (32% CP), wheat middlings and soybean meal (24% CP) and wheat middlings (16% CP). Each supplement was fed to provide .8 lb of protein per day from November 5 to December 9, 1987 and 1.2 lb of protein per day from December 9, 1987 to May 4, 1988. Supplements were formulated to provide equal daily amounts of calcium, phosphorus and potassium. Composition of supplements and daily amounts fed are summarized in Table 1.

Table 1. Composition of supplements and daily feeding rates.

	Treatments (% crude protein)			
	40% SBM[a]	32% SBM/MIDDS	24% MIDDS/SBM	16% MIDDS
Ingredients, %				
Soybean meal	94.45	63.4	31.05	
Wheat middlings		31.95	66.85	98.35
Dicalcium phosphate	5.0	3.0		
Limestone	.5	.5	2.1	1.6
Vit A (30)[b]	.05	.05	.03	.025
Crude protein,				
90% DM basis, %	44.4	35.6	26.7	17.8
Feeding rates per day, lb[c]				
11/05/87 to 12/09/87	2.0	2.5	3.3	5.0
12/09/87 to 5/04/88	3.0	3.75	5.0	7.5

[a]SBM is soybean meal and MIDDS is wheat middlings.
[b]30,000 IU/lb.
[c]7-day basis.

All cows grazed a single pasture and were gathered six mornings each week for supplement feeding in individual covered stalls. Supplement amounts were prorated for 6-day per week feeding. Cows were weighed and body condition determined (1 = very thin, 5 = moderate, and 9 = very fat) at 28-day intervals until early February, after which time cows were weighed and scored at 14-day intervals. The last weight and condition score prior to calving was used to estimate final pregnant weight and condition score. All weights were taken after overnight withdrawal from feed and water. Hay was fed during periods of extreme cold, snow and ice, and in April when adequate forage was unavailable. Calves were weaned on September 13, about 30 days earlier than normal because of extreme drought conditions.

Cows were exposed to Hereford bulls for natural service from April 28 to June 29, 1988 (62 days). Cows were vaccinated on January 5 and January 28, 1988 with Calf Guard (Norden Laboratories) to prevent calf scours. All cows and calves were treated with Ivermectin on May 4. Pregnancy was determined by rectal palpation at weaning. Calf weaning weights were adjusted for sex, age of calf and age of dam. Birth weights were similarly adjusted for calf sex and age of dam.

Results and Discussion

Cow weight and condition changes are summarized in Table 2. Cows fed wheat middlings gained more weight ($P<.01$) from November to calving than cows fed soybean meal (125 vs 50 lb). Precalving responses to wheat middlings/soybean meal mixtures at 24 and 32% protein were similar and intermediate between soybean meal and wheat middlings (+68 and +89 lb). Precalving cow weight gains increased linearly with amount of wheat middlings in the diet ($P<.001$).

Feeding wheat middlings also reduced cow weight losses ($P<.01$) through the entire supplementation period compared to feeding soybean meal (-62 vs -110 lb). Weight changes for cows fed 24 and 32% protein supplements were intermediate between soybean meal and wheat middlings (-79 and -84 lb). Cow body condition changes reflected weight changes.

While feeding increased amounts of wheat middlings significantly increased cow weight before calving, weight changes from calving to the end of the supplementation period were similar for all treatments. There was, in fact, a trend for cows on treatments with the greatest body condition at calving to lose more weight after calving. In a companion study (Ovenell et al., 1989), weight changes of lactating, fall calving cows fed these same diets were not different during the winter. This suggests that weight change responses of cows to supplements may depend on stage of production.

Table 2. Weight and body condition changes and rebreeding rates of cows fed soybean meal (SBM) and wheat middlings (MIDDS) supplements (least squares means).

	Treatments (% crude protein)			
	40% SBM	32% SBM/MIDDS	24% MIDDS/SBM	16% MIDDS
No. of cows	22	22	22	22
Initial wt, Nov. 5, 1987	929	931	938	944
Initial cond. score^e	5.6	5.7	5.5	5.5
Weight Changes, lb				
precalving				
Nov 5 to Dec 3	39^a	50^{ab}	56^b	55^b
Dec 3 to Jan 5	-2	2	-14	5
Jan 5 to Jan 28	0^a	14^{ac}	23^{bc}	24^{cd}
Jan 28 to Feb 12	23	24	28	31
Nov 5 to Precalving	50^a	68^{ab}	89^b	125^c
Postcalving^f				
Precalving to Apr 5	-194	-178	-220	-274
Apr 5 to May 4	33	31	47	87
Precalving to May 4	-160	-147	-173	-187
Winter wt change				
Nov 5 to May 4	-110^a	-79^b	-84^b	-62^b
Body condition changes				
Nov 5 to Preg cond.	$-.3^a$	$-.7^b$	$-.1^a$	0^a
Preg cond. to May 4	-.8	-.3	-.6	-.5
Nov 5 to May 4	-1.0^a	-1.0^{ab}	$-.8^{abc}$	$-.4^c$
Rebreeding rate^f	75	84	81	68

^{a,b,c,d}Means on the same line with different superscripts differ (P<.05).

^{e}Body condition scale: 1 = very thin, 5 = moderate, 9 = very fat.

^{f}Includes data only from those cows weaning a calf.

Calf birth weights (Table 3) tended to be greater for calves of cows fed greater amounts of supplement. Calf weight gains from birth to May 4, 1988, which should indicate level of milk production, also tended to be greater for calves of cows fed higher levels of daily supplements. Similarly, weaning weights also tended to be greater for calves of cows that received greater amounts of wheat middlings during winter supplementation (450, 445, 473 and 469 lb for 40, 32, 24 and 16% protein supplements).

Table 3. Calf birth weights, weight gains and weaning weights (least squares means).

	Treatments (% crude protein)			
	40% SBM[a]	32% SBM/MIDDS	24% MIDDS/SBM	16% MIDDS
Avg calving date	3/02/88	3/04/88	2/27/88	3/06/88
Calf birth weights, lb	83	83	86	87
Calf gain, lb				
Birth to May 4	83	83	91	91
Weaning weight, lb	450	445	473	469

[a]SBM is soybean meal, MIDDS is wheat middlings.

Rebreeding rates were not significantly different among treatments (Table 2). Considering the good body condition of all cows at calving, fewer cows than expected became pregnant. Greater than expected weight and condition losses from calving through breeding occurred because of drought conditions which severely reduced spring forage growth. These weight and condition losses, coupled with a high percentage of first and second calf females and only a 62-day breeding season, probably are related to the poorer than expected rebreeding rates.

In conclusion, precalving cow weight gains increased linearly ($P < .001$) as supplements containing greater amounts of wheat middlings were fed. This suggests that the protein value of wheat middlings is similar to that of soybean meal and(or) energy deficiencies are met with the additional middlings. After calving, additional amounts of supplement did not increase cow weight, demonstrating that increases in cow weight and condition must be achieved before calving. Wheat middlings can be effectively used as a protein and(or) energy source for wintering beef cows in Oklahoma.

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WHEAT MIDDLINGS VERSUS SOYBEAN MEAL AND TWO WHEAT MIDDLINGS/SOYBEAN MEAL SUPPLEMENTS FOR WINTERING FALL CALVING BEEF COWS

K.H. Ovenell[1], D.A. Cox[1], K.S. Lusby[2] and R.P. Wettemann[3]

Story in Brief

Fifty-eight mature fall calving Hereford, Hereford x Angus and Limousin x Angus beef cows wintered on native tallgrass range were allotted to four supplemental feed treatments to provide equal daily amounts of crude protein. The supplements consisted of soybean meal (40% Crude Protein), soybean meal and wheat middlings (32% Crude Protein), wheat middlings and soybean meal (24% Crude Protein) and wheat middlings (16% Crude Protein). Each supplement was fed to provide .8 lb of protein per day from November 29 to December 9, 1987 and 1.2 lb of protein per day from December 9, 1987 to March 15, 1988. There were no significant differences in cow weight or condition score changes between the four supplemental treatments. No significant differences were noted in calf weight gains or weaning weights. Additionally, rebreeding rates of cows were not affected by the treatments.

(Key Words: Beef Cows, Soybean Meal, Wheat Middlings, Native Tallgrass Range, Winter.)

Introduction

Wheat middlings are the offal of the wheat kernel after the milling process for removal of flour and germ. Over 140,000 tons per year are available for use in livestock feeds in Oklahoma. Wheat middlings contain about 16% CP but are discounted for their relatively high (8%) crude fiber content. Fiber from bran-type feeds has been shown to be highly digestible and is an excellent energy source for grazing cattle. A previous study, Lusby and Wettemann, 1988b) demonstrated that spring calving cows wintered on wheat middlings performed similarly to cows fed 16% protein supplements of

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corn and soybean meal. A companion study (Lusby and Wettemann, 1988a), however, suggested that while increased supplemental energy increased body weight in spring calving cows before calving, weight was not increased with lactating fall calving cows. The objective of this study was to compare winter performance of lactating, fall calving beef cows and their calves when supplemented with soybean meal, wheat middlings or one of two mixtures of soybean meal and wheat middlings fed at rates to provide the same amount of daily protein.

Materials and Methods

Fifty-eight mature fall calving Hereford, Hereford x Angus and Limousin x Angus cows were allotted by breed and body weight to four supplemental feed treatments to provide equal daily amounts of crude protein (CP). Supplements consisted of soybean meal (40% CP), soybean meal and wheat middlings (32% CP), wheat middlings and soybean meal (24% CP) and wheat middlings (16% CP). Each supplement was fed to provide .8 lb CP/head/day from November 29 to December 22, 1987 and 1.2 lb CP/head/day from December 22, 1987 to March 15, 1988. Supplements were formulated to provide equal daily amounts of calcium, phosphorus and potassium. Composition of supplements and daily amounts fed are shown in Table 1.

Table 1. Composition of supplements and daily amounts fed.

	Treatments (% crude protein)			
	40% SBM[a]	32% SBM/MIDDS	24% MIDDS/SBM	16% MIDDS
Ingredients, %				
Soybean meal	94.45	63.4	31.05	
Wheat middlingss		31.95	66.85	98.35
Dicalcium phosphate	5.0	3.0		
Limestone	.5	.5	2.05	1.625
Vit A (30)[b]	.05	.05	.03	.025
Crude protein, 90% DM basis, %	44.4	35.6	26.7	17.8
Feeding rates/day, lb[c]				
11/29/87 to 12/22/87	2.0	2.5	3.3	5.0
12/22/87 to 3/15/88	3.0	3.75	5.0	7.5

[a]SBM is soybean meal, MIDDS is wheat middlings.
[b]30,000 IU/lb.
[c]7-day basis.

All cows were grazed in a single pasture of native tallgrass range and were gathered 6 days each week for supplement feeding in individual covered stalls. Supplement amounts were prorated for 6-day per week feeding. Cows and their calves were weighed at 28 day intervals after overnight withdrawal from feed and water. Cows were also scored visually for body condition (scale of 1 = very thin, 5 = moderate and 9 = very fat) at each weigh period. All cows were treated with Ivermectin on September 25, 1987. Prairie hay was fed during 27 days when snow or ice covered standing forage or when extremely cold temperatures were encountered. All calves were born from August 29 to November 2, 1987. Cows were exposed by natural service to Hereford bulls from November 30, 1987 to January 20, 1988 (a 51-day breeding season). Calves were weaned on May 17, 1988. Pregnancy was determined by rectal palpation on May 24, 1988. Weaning weights were adjusted for sex, age of calf and age of dam.

Results and Discussion

Cow weight and condition changes over the total trial were not significantly different for the four treatments (Table 2). In contrast, spring calving cows fed these same supplemental diets had increased weight gains to calving with increasing amounts of wheat middlings (Cox et al., 1989). Calf gains tended to be greater during the supplementation period for calves of cows fed greater daily amounts of middlings. Weaning weights in May reflected the slight increases in gain made during the supplementation period. The small increases in calf gains, however, suggest that milk production of the cows was not greatly improved by feeding additional energy in the form of wheat middlings. Rebreeding rates were high and similar for all treatments, ranging from 87 to 96%.

The amount of wheat middlings fed and lack of significant improvements in cow and calf weight changes strongly suggests that forage intake and(or) digestibility was reduced as the amount of energy in the form of wheat middlings was increased. Forage supply was adequate during the trial period. Because pregnant, nonlactating cows fed the same supplements (Cox et al., 1989) responded differently, these results suggest that stage of production can affect performance responses to supplements. The excellent rebreeding rates for all treatments indicate that body condition and nutrition were adequate and supplemental protein requirements were met. In agreement with a previous experiment (Rakestraw et al., 1986), if fall calving cows are in good body condition at the start of breeding (BCS =55) and lose a minimal amount of weight during the breeding season (approximately 50 lb), a high percentage of cows will become pregnant (>90%).

Table 2. Effects of supplement treatments on lactating, fall calving cow and calf performance.

	Treatments (% crude protein)			
	40% SBM[a]	32% SBM/MIDDS	24% MIDDS/SBM	16% MIDDS
No. of cows	14	15	15	14
Initial wt 11/29/87	1009	1011	1000	1001
Initial cond. score[b]	5.5	5.4	5.4	5.3
Weight changes, lb				
Nov 29 to Dec 22	-59	-50	-54	-55
Dec 22 to Jan 20	15	4	1	8
Jan 20 to Feb 16	0	-15	-1	-4
Feb 16 to Mar 15	-70	-58	-42	-51
Nov 29 to Mar 15	-114	-118	-96	-102
Mar 15 to May 24	176	183	154	177
Nov 29 to May 24	61	64	58	75
Body condition changes				
Nov 29 to Mar 15	-.8	-.8	-.9	-.7
Mar 15 to May 24	1.3	1.2	1.2	1.4
Nov 29 to May 24	.5	.4	.3	.7
Rebreeding rate, %	87	96	90	93
Calf data				
Weight gains, lb				
Nov 29 to Mar 15	98	109	113	113
Nov 29 to weaning	207	215	224	223
Weaning weights, lb	367	387	393	384

[a]SBM is soybean meal, MIDDS is wheat middlings.
[b]Body condition scale: 1 = very thin, 5 = moderate, 9 = very fat.

In conclusion, when fall calving beef cows are in good body condition, have adequate forage and are provided hay during conditions of extreme cold and snow cover, performance may not be improved by feeding additional energy supplements after protein needs have been met. The effects of protein or energy supplements on cow weight and condition change are apparently influenced by stage of production.

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THE EFFECT OF DECCOX ON WEIGHT GAIN OF NEWLY-WEANED BEEF CALVES

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Story in Brief

The effect of the addition of Deccox, a coccidiostat, to the supplement of 199 newly-weaned beef calves was evaluated in two separate trials in Pittsburg and McCurtain counties in southeastern Oklahoma. Deccox improved weight gains of the Deccox-fed calves by 15 lb in Trial 1. Weight gains were also improved by 3.5 lb in Trial 2. No illness was observed in either treatment groups of both trials. These studies suggest that weaned calves retained on the ranch are subject to subclinical coccidiosis and respond to a coccidiostat.

(Key Words: Coccidiosis, Decoquinate, Wheat Pasture, Beef Cattle, Weaning.)

Introduction

Coccidiosis is a parasitic disease commonly found in newly-received stocker cattle. Symptoms include dehydration, anemia, loss of condition, and bloody scours. Economic losses result from reduced cattle performance, increased medication and labor costs, increased susceptibility to other diseases, and death loss. Coccidiosis is caused by coccidia commonly found in the intestine of cattle. The incidence of coccidiosis is mostly prevalent in spring and fall. The addition of Deccox, a coccidiostat, to the receiving ration of newly-arrived stocker cattle has been shown to increase average daily gain and reduce illness in numerous trials in Oklahoma (Barnes et al., 1985). These trials, demonstrating the incidence of subclinical coccidiosis in stressed stocker cattle, raise the question of whether the stress of weaning could predispose young calves to the effects of the parasite. The following trials

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were conducted to determine the effects of the addition of Deccox to a supplement for newly-weaned calves retained on the ranch.

Materials and Methods

A total of 199 newly-weaned calves were used to evaluate the effects of the addition of Deccox to a supplement fed post weaning. The trials were conducted in southeastern Oklahoma.

In Trial 1, one hundred heifers in Pittsburg County, primarily of Angus breeding, weighing an average of 457 lb, were weaned seven days prior to the beginning of the trial period, December 3, 1987. At the start of the trial the calves were vaccinated for blackleg and brucellosis, implanted, treated with ivermectin, weighed and randomly assigned to equal control and treatment groups of 50 head. Each group was moved to adjacent, similar native grass pastures and fed 2 lb/day of a 41% crude protein cottonseed meal supplement. One group received 125 mg Deccox/day in their supplement. The cattle were then weighed again at 32 days with the final weight taken at 60 days after initial weighing and processing.

In Trial 2, ninety-nine spring born Brahman x English crossbreed steers and heifers weighing 544 lb were sorted off their dams east of Broken Bow in McCurtain County, October 5, 1987. They were immediately weighed, eartagged, vaccinated for IBR, BVD, blackleg, lepto and vibrio, implanted, treated with ivermectin and gate cut into a control group of 49 head and a Deccox treatment group of 50 head. The cattle were then moved to adjacent 4 acre traps and offered medium-good quality bermuda grass hay ad libitum and 2 lb/head/day of a cottonseed meal supplement. One group received Deccox at a rate of 125 mg/day. The cattle were weighed at the end of 28 days.

Results and Discussion

In Trial 1, the Deccox-fed cattle gained an average 1.32 lb/day (Table 1) compared to 1.07 lb/day for the calves of the control group ($P<.01$). Weight gains during Period 1 (32 days) were .81 and .65 lbs/day ($P<.15$) for the Deccox and control groups, respectively. Second period gains were 1.91 and 1.56 lb/day ($P<.05$) for the Deccox and control groups, respectively. Weather during Period 1 was wet with cool, variable temperatures. Period 2 weather consisted of prolonged periods of extreme cold with snow.

In the first 28 days of Trial 2, the Deccox-fed cattle gained 5.1 lb (.18 lb/day) (Table 2) with the control group gaining an average of 1.6 lb (.06

Table 1. Effect of Deccox on weight gains of newly-weaned calves. (Trial 1)[a]

	Control	Deccox	Prob.[b]
Number of calves	50	50	
Avg beginning wt, lb	459	456	
Period 1 wt, lb	480	482	
Period 1 gain, lb	20.8	26.0	<.12
Period 1 ADG, lb/day	.65	.81	<.12
Period 2 wt, lb	523	545	
Period 2 gain, lb	43.6	53.3	<.20
Period 2 ADG, lb/day	1.56	1.90	<.20
Total gain, lb	64.3	79.4	<.01
Total ADG, lb/day	1.07	1.32	<.01

[a]Least squares means.
[b]Probability that the difference between means could occur by chance.

Table 2. Effect of Deccox of weight gains of newly-weaned calves. (Trial 2)[a]

	Control	Deccox	Prob.[b]
Period 1			
Number of calves	49	50	
Avg beginning wt, lb	542	545	
End wt, lb	544	550	
Total gain, lb	1.6	5.1	<.09
ADG, lb/day	.06	.18	<.09

[a]Least squares means.
[b]Probability that the difference between means could occur by chance.

lb/day) ($P<.10$). There was no evidence of bloody scours or other disease. Low apparent weight gains may be explained in that all calves in the trial were weighed immediately after sorting off the cows without shrink. Other weights were taken in the morning before cattle were allowed to feed. Cattle may also have lost weight in the first days of the trial due to the stress of weaning.

The additional weight gains achieved by the Deccox-fed calves in these two trials would indicate that the stress of weaning could predispose calves to subclinical coccidiosis and that supplements containing a coccidiostat would economically benefit producers retaining these calves in a backgrounding or stockering program. Increased gains of 15 lb, valued at $95/cwt would yield a gross return of $14.25. Also, although there were no signs of illness in any of the cattle involved in these two trials, previous trials with stocker cattle have shown that cattle supplemented with Deccox have fewer sick animals and shorter periods of required medication.

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THE EFFECT OF YEAST CULTURE ON CALF PERFORMANCE

Jorge Quinonez[1], D.G. Wagner[2] and L.J. Bush[3]

Story in Brief

The effect of supplementing corn or wheat based rations with yeast culture (*Saccharomyces cerevisiae*, YEA-SACC[4]) on dry matter intake and weight gain and on ruminal pH was evaluated in a 70 day trial using 48 Holstein calves approximately 3 weeks of age (24 bulls, initial weight 109 lb and 24 heifers, 99 lb). Calves were randomly assigned to either corn or 30% wheat-based high concentrate diets containing 15% dehydrated alfalfa pellets, with or without added yeast culture. Yeast culture was added at the rate of 2 lb/ton to those diets containing yeast. Additionally, calves were fed whole milk (8%/body weight$^{.75}$) during the first 2 weeks of the experimental period. The average dry matter intake for days 1 to 70 was similar, being 4.39, 4.01, 3.99 and 4.11 lb per day for corn, corn-yeast, wheat and wheat-yeast treatments, respectively. Live weight gains were 1.89, 1.74, 1.56 and 1.67 lb/day for the same treatments, respectively. Improved daily gain (1.82 vs 1.62 lb/day) and feed efficiency (2.3 vs 2.5 lb feed/lb gain) were noted for animals fed corn based diets compared to those diets containing wheat. Neither feed intake, weight gain nor pH of the ruminal fluid was affected by the addition of yeast.

(Key Words: Corn, Wheat, Yeast, Calves.)

Introduction

Feeding and managing dairy calves is an important phase of dairy production. The need to develop good dairy replacement animals and to properly feed young, male dairy calves not to be sold for veal (e.g. dairy stocker and feedlot steers) and the need to divert less milk to calf feeding has led to many changes in calf feeding practices. Proper feeding of very young,

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early weaned beef calves also is becoming increasingly important in some beef operations.

Grains such as corn or wheat provide an excellent source of dietary energy in the rearing of calves. However, it has been suggested that young calves may lack adequate salivary amylases and other carbohydrate digesting enzymes for proper starch utilization (Rose, 1970). The inclusion of yeast culture in the concentrate rations for dairy calves has been proposed as a potential means to improve digestion. According to Lyons (1987), yeast contains both protein (proteases) and starch digesting (amylases) enzymes and supplies protein, vitamins and other nutrients in the diet. Some have suggested that yeast may improve diet digestibility. Few reports exist on supplementing dairy calf rations with yeast cultures. This experiment was conducted, therefore, to determine the effect of adding yeast culture to corn and wheat based rations for dairy calves.

Materials and Methods

Twenty-four Holstein bull calves (109 lb) and 24 Holstein heifer calves (99 lb) were blocked according to sex, then randomly assigned at 3 wk of age to the following treatments: a) Control, consisting of a corn based diet (C); b) C plus 2 lb of yeast (*Saccharomyces cerevisiae*, YEA-SACC)/ton (CY); c) 30% wheat based diet (W); and d) W plus yeast (WY). Diets contained 15% dehydrated alfalfa pellets (Table 1) and were formulated to meet NRC (1978) requirements for growing dairy calves. Diets were calculated to be isonitrogenous and approximately equal in energy content. Calves were fed whole milk (8%/body weight$^{.75}$) during the first two weeks of the trial. Animals were individually penned. Feed and water were available at all times. Feed orts were removed and weighed weekly. Feed samples were taken weekly for analyses. Calves were weighed weekly. During the fourth and ninth weeks, ruminal samples were obtained by stomach tube to determine ruminal pH. Ruminal fluid pH was measured immediately, and rumen fluid was strained through a double layer of cheesecloth. Fifty milliliters of strained rumen fluid were mixed with 0.5 ml of saturated mercuric chloride and then frozen for later volatile fatty acid (VFA) determination. Data were analyzed as a 2 x 2 factorial experiment with a randomized, complete block design with sex as the blocking factor (Steel and Torrie, 1980). The adjusted treatment means were compared using pre-planned orthogonal contrasts as follows: corn-wheat; yeast-no yeast; and grain x yeast.

Table 1. Composition of diets.

	Corn	Corn & yeast	Wheat	Wheat & yeast
Ingredients, % as fed				
Corn	30.0	30.0	----	----
Wheat[a]	----	----	30.0	30.0
Sorghum grain	17.5	17.5	20.0	20.0
Soybean meal, solv.	20.0	20.0	16.5	16.5
Oats	7.0	7.0	8.0	8.0
Fixed portion[b]	25.5	25.5	25.5	25.5
Yeast culture (YEA-SACC)[c]	-	+	-	+
Nutrient analyses:				
Net energy, Mcal NE_g/100 lb[d]	49.8	49.8	49.2	49.2
Total protein, %	17.0	17.0	17.0	17.0
Rumen undegradable protein, %	7.14	7.14	5.78	5.78
Calcium, %	.56	.56	.55	.55
Phosphorus, %	.51	.51	.51	.51

[a]Hard red winter wheat, No. 2 grade.
[b]Fixed portion of concentrate mix: Alfalfa dehy pellets, 15.0, molasses liquid 5.0, dicalcium phosphate 1.0, salt .5, sodium bicarbonate 4.0%.
[c]Product produced by ALLTECH, Nicholasville, KY; included in mix at a level of 2.0 lb/ton.
[d]Calculated

Results and Discussion

Feed intake was similar (P>.05) on all treatments, averaging 4.39, 4.01, 3.99 and 4.11 lb per day on the C, CY, W and WY treatments, respectively (Table 2). Calves fed corn based diets had slightly greater feed intake than those fed 30% wheat, but the differences were not significant (P>.05). These results are in agreement with previous Oklahoma observations with lactating dairy cows. Wheat starch is generally more readily fermented in the rumen than corn starch (Axe et al., 1987), which may reduce intake. However, no differences in ruminal fluid pH were noted in this study, averaging 5.7 on both corn and wheat treatments. Since feed was available at all times, frequent consumption may have moderated feed intake at any one time and thus any potential changes in pH.

Calves fed corn rations gained more (1.81 lb/day, P<.02) than animals fed wheat rations (1.61 lb/day). This is in agreement with results of Oklahoma studies in which lactating dairy cows produced more milk on corn than on wheat based diets. Increased gain on corn diets is probably,in part, a

Table 2. **Feed intake and liveweight gains by dairy calves.**

	Corn	Corn & yeast	Wheat	Wheat & yeast	Statistical significance: Grain type	Yeast	Inter-action	SE
Number of animals	10	12	9	12	--	--	--	--
Initial body weight, lb	106	106	99	105	--	--	--	--
Final body weight, lb	240	229	209	223	--	--	--	--
Liveweight gain, lb/day	1.89	1.74	1.56	1.67	P<.02	NS	NS	.12
Dry matter intake, lb/day	4.39	4.01	3.99	4.11	NS	NS	NS	.22
Feed conversion, lb feed/lb gain	2.31	2.29	2.54	2.44	P<.001	NS	NS	.05
Ruminal fluid pH	5.7	5.7	5.6	5.8	NS	NS	NS	.09

NS = Not significant (P>.05).

Table 3. Effect of diet on total concentration and molar proportion of ruminal VFA of dairy calves.

	Corn	Corn & yeast	Wheat	Wheat & yeast	Statistical significance: Grain type	Statistical significance: Yeast	Statistical significance: Inter-action	SE
Total conc., mmol/l	408	370	363	369	NS	NS	NS	39.7
Molar %								
Acetic	50.7	49.4	51.8	54.7	P<.04	NS	NS	1.51
Propionic	36.4	37.3	38.4	35.7	NS	NS	NS	1.12
Butyric	7.8	8.7	6.0	6.0	P<.002	NS	NS	.67
Isovaleric	.65	.36	.44	.76	NS	NS	NS	.15
Valeric	4.36	4.20	3.37	2.73	P<.004	NS	NS	.39

NS = Not significant (P>.05)

consequence of improved feed intake. Feed efficiency also was improved ($P<.001$) on corn over wheat diets (2.3 vs 2.5 lb feed/lb gain). Though not significant, feed intake, daily gain and feed efficiency tended to show a slight improvement when the wheat based diet was supplemented with yeast. The inclusion of yeast had no effect on either the total concentration of VFA or the molar proportion of individual fatty acids (Table 3). Under the conditions of this trial, inclusion of yeast (YEA-SACC) in either corn or wheat based diets for calves did not improve performance.

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EFFECT OF YEAST CULTURE ON INTAKE AND PRODUCTION OF DAIRY COWS FED CORN OR WHEAT BASED CONCENTRATE MIXTURES

Jorge Quinonez[1], D.G. Wagner[2] and L.J. Bush[3]

Story in Brief

The effect of supplementing corn or wheat based concentrate mixtures with yeast culture (*Saccharomyces cerevisiae*, YEA-SACC[4]) on feed intake and milk yield was evaluated using 24 Holstein cows. Treatments included feeding either corn or 60% wheat based concentrate mixtures, with or without added yeast culture. Yeast culture was added at the rate of 3.0 lb/ton of concentrate mixture to the two yeast containing treatments. Concentrate mixtures were calculated to be isonitrogenous and approximately equal in energy content. Alfalfa hay (50:50) and the concentrate mixture were each fed separately in individual stanchions twice each day at about 12 hour intervals. Dry matter intake by cows fed corn was higher (corn, 52.6; corn-yeast, 51.9 lb/day) than for cows fed wheat (wheat, 48.0; wheat-yeast 47.3 lb/day). Additionally, average milk yield was higher for cows fed corn than for cows fed wheat based concentrate mixtures (69.5 vs 67.0 lb/day) as was butterfat test (3.42 vs 3.19%) and fat corrected milk yield (63.6 vs 59.2 lb/day). Dry matter intake and milk yield were unaffected by the addition of yeast. Ruminal pH was higher (6.20 vs 5.94) in cows fed corn than in those fed wheat.

(Key Words: Corn, Wheat, Yeast, Milk Production, Dairy Cows.)

Introduction

In many areas of the United States, periodically wheat is competitively priced with other feed grains as a potential energy source for use in concentrate mixtures for dairy cows. In recent Oklahoma studies (Faldet et al., 1986), feed intake and milk yield were reduced, however, when cows were fed isonitrogenous concentrate mixtures in which hard red winter wheat

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replaced 0, 40, 60 or 80% of the corn and some protein supplement. Little research on supplementing ruminant rations with yeast cultures has been reported during the last two decades, although some nutritionists recommend the inclusion of yeast in rations for high producing dairy cows (McCullough, 1986). Therefore, this study was conducted to explore the effects of adding yeast culture to corn or wheat based concentrate mixtures on feed intake, milk production, ruminal fluid pH and volatile fatty acid (VFA) production in lactating dairy cows.

Materials and Methods

Twenty-four Holstein cows were allotted to four treatments: a) Control, consisting of a corn based concentrate mixture (C), b) C plus yeast (CY), c) 60% wheat-based concentrate mixture (W), and d) W plus yeast (WY). Yeast (YEA-SACC) was added at the rate of 3.0 lb/ton of grain mixture. Yeast levels were those suggested by the manufacturer. The concentrate mixtures and alfalfa hay were fed individually in a 50:50 ratio (Table 1). Cows were fed the experimental rations in a switchback design

Table 1. Composition of concentrate mixtures.

	Corn	Corn & yeast	Wheat	Wheat & yeast
Ingredients, % as fed				
Corn	65	65	18	18
Wheat[a]	--	--	60	60
Sorghum grain	6	6	--	--
Cottonseed meal, solv, ext.-	9.5	9.5	2.5	2.5
Fixed portion[b]	19.5	19.5	19.5	19.5
Yeast culture (YEA-SACC)[c]	-	+	-	+
Calculated analysis:				
Net energy, Mcal NE_L/100 lb	75.5	75.5	76.8	76.8
Total protein, %	·12.0	12.0	12.0	12.0
Rumen undegradable protein, %	5.8	5.8	3.3	3.3
Crude fiber	7.9	7.9	7.7	7.7

[a]Hard red winter wheat, No. 2 grade.
[b]Fixed portion of concentrate mix: soybean hulls 15, dicalcium phosphate 2.0, salt .75, sodium bicarbonate 1.25, and magnesium oxide 0.5%
[c]Product produced by ALLTECH, Nicholasville, KY; included in concentrate mix at a level of 3.0 lb/ton.

with three 4-week periods (Lucas, 1956). The first two weeks of each period were allowed for adjustment to rations with data from the final two weeks being used for treatment comparisons. Cows were assigned by calving date to treatment sequences. The concentrate and forage were fed in individual stanchions in two equal portions twice daily at approximately 12 hour intervals. The hay was fed separately from the concentrate mixture approximately 4 hours after feeding of the concentrate mixture. Feed intake was recorded daily. Feed orts or weighbacks for each cow were composited on a weekly basis and analyzed for dry matter (DM) and crude protein (CP). Milk yield was recorded twice daily, and samples were taken at four consecutive milkings each week to determine fat and protein content. Each cow was weighed on two consecutive days prior to the trial and on the first and last day of each period. Cows were weighed just prior to milking, with milk weight being deducted from the respective body weights.

During the last week of each period, a rumen fluid sample was taken from each cow by stomach tube 3 to 4 hours after feeding concentrate. A minimum of 300 ml of rumen fluid was strained through a double layer of cheese cloth, and pH was measured immediately. Two hundred ml of rumen fluid was then acidified with 8 ml of 50% hydrochloric acid and frozen for later ruminal fluid ammonia-nitrogen (NH_3-N) analyses, and 100 ml of strained rumen fluid was mixed with 1 ml of saturated mercuric chloride and frozen for volatile fatty acid analyses. At the same time rumen fluid samples were taken, blood samples were taken from the media caudal vein for subsequent plasma urea nitrogen determination. However, data for NH_3-N and plasma urea-N are not included herein.

Statistical analysis was conducted by summarizing response variables on a per period basis. Analysis of variance (Lucas, 1956) was performed with block, period, cow and treatment included in the model. The adjusted treatment means were compared using pre-planned orthogonal contrasts as follows: corn-wheat; yeast-no yeast; and grain x yeast.

Results and Discussion

Dry matter feed intake on wheat diets (avg 47.6 lb/day) was lower ($P<.001$) than on corn diets (52.1 lb) (Table 2). Since hay and the concentrate mix were fed in a fixed ratio, intake of both hay and grain were reduced on wheat diets. Wheat starch is more readily fermented in the rumen than corn starch (Axe et al., 1987). Decreased feed intake by cows fed wheat based diets may have been due to altered ruminal fermentation. Ruminal pH was lower ($P<.01$) in cows fed wheat (5.93) than in cows fed corn (6.22) diets. Feeding concentrates more frequently than twice daily may have reduced the differences in ruminal pH and may have increased feed

Table 2. Feed intake, milk yield and ruminal pH.

	Corn	Corn & yeast	Wheat	Wheat & yeast	Statistical significance			
					Grain type	Yeast	Inter-action	SE
Dry matter intake, lb/day								
Concentrate mix	26.6	26.2	24.6	24.0	P<.001	NS	NS	1.08
Alfalfa hay	26.0	25.7	23.3	23.3	P<.001	NS	NS	1.03
Total	52.3	51.9	47.9	47.3	P<.001	NS	NS	1.91
Protein intake,, lb/day								
Concentrate mix	3.41	3.32	3.45	3.45	NS	NS	NS	.132
Alfalfa hay	5.39	5.39	4.93	4.88	P<.001	NS	NS	.198
Total	8.80	8.71	8.38	3.34	P<.02	NS	NS	.286
Milk yield								
Milk, lb/day	70.4	68.6	67.1	66.9	P<.003	NS	NS	1.50
Fat test, %	3.36	3.48	3.17	3.22	P<.009	NS	NS	.07
FCM, lb/day	63.8	63.4	59.2	59.2	P<.001	NS	NS	2.27
Protein, %	2.99	3.01	3.00	3.02	NS	NS	NS	.02
Gross feed efficiency (Milk/total DM intake)	1.35	1.33	1.41	1.43	P<.01	NS	NS	.02
Ruminal pH	6.18	6.27	5.86	6.01	P<.01	NS	NS	.09

NS = Not significant (P>.05).

intake on the wheat based diets. The inclusion of yeast, however, had no effect on pH. Faldet et al. (1986) also noticed a decrease in both concentrate and hay intake when cows were fed rations containing increasing levels of wheat. However, McPherson and Waldern (1969) reported similar DM intakes when soft white wheat replaced barley at up to 93% of the concentrate mixture.

Intake of DM tended to be lower (P>.3) for cows fed rations containing yeast culture than for those fed rations without yeast; however, the differences were relatively small (.5 lb/day). Several authors (Fallon and Harte, 1987; Hughes, 1987; Lyons, 1986; Gomez-Alarcon et al., 1987) have suggested increased DM intakes by ruminants fed yeast cultures which were attributed to buffering effects of the additive. Lassiter et al. (1958), however, observed no effect of yeast culture on feed intake by dairy cows.

Milk yield of cows fed corn-based concentrate mixtures was higher (P<.03) than for cows fed grain mixtures containing 60% wheat (69.5 vs 67.0 lb/day) which could be attributed to a higher DM intake of cows fed the corn based grain mixture. Since wheat is higher in protein than corn and the diets were formulated to be isonitrogenous, the wheat based grain mixes contained 7.0% less cottonseed meal than did the corn based diets and also were lower in rumen undegradable protein. In what ways these items may have contributed to reduced intake and milk yield on wheat based diets are not known but need further study. Milk fat test of cows fed the corn based mixture (3.42%) was higher (P<.01) than for those fed wheat (3.19%), resulting in an advantage in 4% fat corrected milk (FCM) of 4.5 lb/day for cows fed corn instead of wheat (Table 2). Milk yield and fat content, however, were not affected by the inclusion of yeast culture (P>.05). Neither grain type nor the addition of yeast culture affected milk protein content.

The total concentration of VFA was greater (P<.03) when cows were fed wheat compared to being fed corn based diets. The molar percentage of acetic acid in the ruminal fluid was higher (65.4 vs 60.9%, P<.007) and propionic acid was lower (21.9 vs 26.6%, P<.004) for cows fed corn based grain mixtures (Table 3), which was consistent with the observed difference in milk fat content. No significant differences in either total VFA concentration or in proportions of VFA were observed by the inclusion of yeast culture.

In summary, the addition of yeast culture to concentrate mixtures for dairy cows fed either corn or wheat as the principal energy source in the grain mixture did not affect performance under the conditions of this trial. Yeast had no effect on feed intake, milk yield and composition, pH of the ruminal fluid or VFA.

Table 3. Effect of diet on molar proportion of ruminal VFA.

	Corn	Corn & yeast	Wheat	Wheat & yeast	Statistical significance: Grain type	Yeast	Inter-action	SE
Total conc., mm/l	450.2	335.8	470.4	472.1	P<.03	NS	NS	32.05
Molar %								
Acetic	65.60	65.10	60.94	60.90	P<.007	NS	NS	1.37
Propionic	22.00	21.82	26.60	26.60	P<.004	NS	NS	1.32
Isobutyric	.35	.45	.35	.33	NS	NS	NS	.08
Butyric	10.03	10.23	9.46	9.61	NS	NS	NS	.67
Isovaleric	1.02	1.22	.86	.86	P<.03	NS	NS	.09
Valeric	1.0	11.18	1.79	1.73	P<.001	NS	NS	.11

NS = Not significant (P>.05).

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EFFECTS OF DIET ON RUMINAL LIQUID AND ON BLOOD SERUM OSMOLALITY AND HEMATOCRIT IN FEEDLOT HEIFERS

J.D. Garza F.[1], F.N. Owens[2] and J.E. Breazile[3]

Story in Brief

Eight ruminally cannulated beef heifers were used in a crossover experiment to examine osmolality changes in ruminal liquid and blood serum. Blood hematocrit and ruminal pH also were examined. Heifers were adapted for 20 days to ad libitum intake of either a concentrate or a hay diet. After the adaptation period, ruminal and blood samples were obtained for three consecutive days at -2, 1, 2, 4 and 6 hours after feeding. Ruminal pH varied with diet and post-prandial time, being higher prefeeding than post-feeding. Ruminal osmolality peaked 1 and 2 hours post-feeding for the hay and concentrate diet at 265 and 296 mOsm/kg, respectively. Serum osmolality was consistently higher than ruminal osmolality. Hematocrit was higher for heifers fed hay than for heifers fed concentrate but post-prandial changes were minor. Ruminal liquid and serum osmolality ranged within normal physiological values indicating that drastic changes in these parameters may occur only under special dietary conditions, and that peak values can be expected between 2 to 4 hours post-feeding.

(Key Words: Ruminal Osmolality, Serum Osmolality, Hematocrit, Beef Cattle.)

Introduction

Dietary constituents and metabolites markedly influence the ruminal environment. Ruminal pH has been studied extensively because of its special importance to ruminal fermentation and volatile fatty acid utilization. Other important variables within the rumen, which might influence rumen fermentations, such as osmotic pressure have received less attention. Previous experiments have demonstrated that osmotic pressure in the rumen is important. (Warner and Stacy, 1965; Ternouth and Beattie, 1971; Bergen,

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1972; Warner and Stacy, 1977; Phillip et al., 1981). Although most of these studies have been conducted with sheep, they generally agree that ruminal fluid hypertonicity limits feed intake and causes an influx of water from blood into the rumen. After feeding, ruminal liquid normally is thought to be hypotonic to blood, but it rises (350-380 mOsmol/l) soon after feeding. According to Phillip et al. (1981), high ruminal osmolalities (525 mOsm/kg) depressed feed intake of ruminally cannulated lambs within 30 min after feeding. Based on these findings the authors concluded that ruminal osmolality inhibited short term feed intake. The purpose of this experiment was to measure changes in osmolality in ruminal liquid and blood serum with time after feeding in cattle fed two different types of diets. Packed red cell volume (hematocrit) and ruminal pH also were monitored.

Materials and Methods

Eight crossbred beef heifers averaging 1210 lb body weight, each fitted with a rumen cannula (10 cm ID), were used in two 23-day experimental periods. Animals were randomly assigned to individual pens and received a concentrate diet (Table 1) or chopped Prairie hay plus 1.5 kg daily of a 50% protein concentrate in a crossover experiment. During the first 20 days of each period, animals were adapted to ad libitum intake of the experimental diets. Feed intake was recorded daily. Fresh feed was provided twice daily at 8:30 a.m. and 4:30 p.m. during the entire trial at 120% of the previous days intake. After day 20, intake was restricted to 90% of the mean intake of days 14 to 19. Water and mineral premix were available ad libitum. Ruminal and blood samples were collected sequentially during the last 3 days of each experimental period, at -2, 1 , 2, 4 and 6 hours after the 8:30 a.m. feeding. A

Table 1. Diet composition (dry matter basis).

Ingredients		Concentrate %
Dry rolled corn		63.06
Dehydrated alfalfa pellets		6.03
Cottonseed hulls		14.07
Soybean meal (44%)		10.05
Cane molasses		5.03
Salt (trace mineralized)		.50
Ground limestone		.50
Dicalcium phosphate		.50
Aurofac-10		.15
Urea (42% N)		.10
	total	100.00

30 ml blood sample was withdrawn at each time via jugular venipuncture. Blood was placed in siliconized tubes to harvest serum. Immediately after collection, 10 ml of blood were transferred into heparinized tubes for microhematocrit determination. Blood plasma samples were frozen at -20°C until osmolality was analyzed. Aliquots from heparinized blood samples were transferred to microhematocrit capillary tubes. Hematocrit was determined in triplicate soon after blood sampling.

Ruminal liquid samples were taken prior to each blood sample. Approximately 250 ml of fluid were withdrawn from the ventral ruminal sac with a suction flask and a manual pump. This ruminal fluid was filtered through two layers of cheesecloth and pH was determined immediately with a glass electrode. Thereafter, the samples were centrifuged at 10,000 g for 15 min; aliquots of the supernatant fluid were frozen and stored at -70°C until analyzed. At the time of analysis the serum and the ruminal samples were thawed and osmolalities were determined in duplicate in an osmometer using the freezing point depression procedure. Data were analyzed using the general linear model procedure.

Results and Discussion

Ruminal pH was altered ($P<.05$) by diet (Table 2). Heifers fed the high concentrate diet had lower ruminal pH. Ruminal pH at -2 hours was higher ($P<.0001$) than the mean pH post-feeding (Figure 1). Post-feeding, linear quadratic, cubic terms revealed quadratic ($P<.04$) effects of time on pH. Mean values for ruminal pH were in the range expected for concentrate (5.5 and 6.5), and roughage (6.2 and 7.0) diets suggested by Owens and Goetsch (1988). These authors indicated that pH usually is lowest between 1/2 and 4

Table 2. Effect of diet on ruminal pH, hematocrit, ruminal liquid and serum osmolalities of heifers fed hay or concentrate diets.

Parameter	Diets		SE
	Concentrate	Hay	
Ruminal pH	6.2^b	6.7^a	.09
Hematocrit %	34.4^b	37.0^a	.43
	--------- osmolality (mOsmol/kg)--------		
Ruminal liquid	284.0	250.4	13.60
Serum	303.0	296.0	4.61

[a,b]Mean values in a row with different superscripts are significantly different (P<.05).
SE=Standard error of the mean.

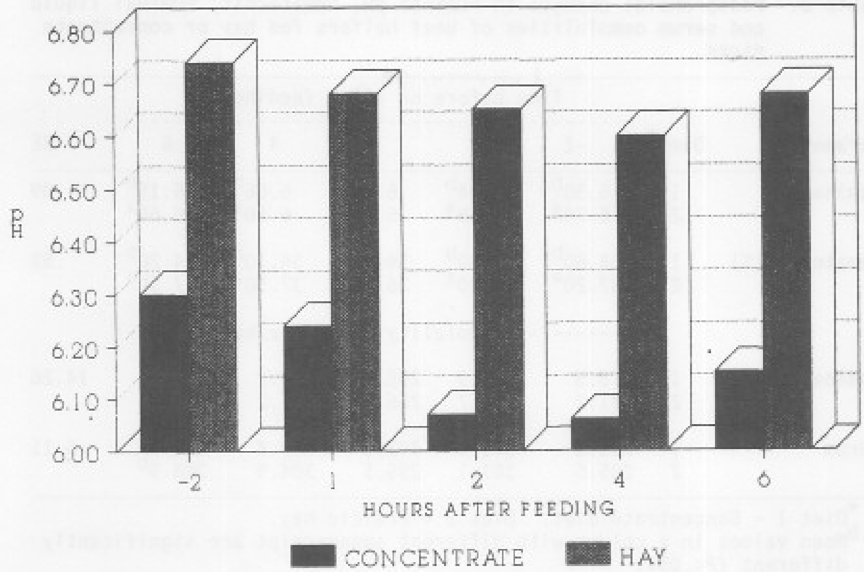

Figure 1. Ruminal pH versus time in beef heifers fed concentrate and hay diets.

hours after a meal, which agrees with our concentrate diets. In this study pH was lowest two hours after feeding for the concentrate diet versus 4 hour post-feeding for the hay diet (Figure 1).

Osmolalities for ruminal liquid and serum are presented in Tables 2 and 3. Post-prandial values for both materials were higher ($P<.05$) than before feeding. Peak values never reached those reported by other authors (Phillip et al., 1981; Engelhardt, 1975; Ternouth, 1967; Warner and Stacy, 1965). One explanation for these differences in our results may be attributed to the type of animal and diet composition. Most of the above studies measured osmolality in sheep which had been deprived of food or water for a certain period of time and in some studies salt loads were infused into the rumen. Such experimental procedures would dramatically alter ruminal liquid osmolality. Presumably, the preprandial osmolality values in the range of 200 to 280 mOsmol/kg as we observed, are more physiological. Postprandial ruminal osmolality values, however, can vary considerably depending on the concentration of either the dissolved substances in the feed or the products of microbial activity. Lower ruminal osmolality values for the roughage diet presumably are due to lower production of solutes and greater dilution of these solutes (VFA and mineral salts) by saliva. Intraruminal

Table 3. Postprandial changes in ruminal pH, hematocrit, ruminal liquid and serum osmolalities of beef heifers fed hay or concentrate diets.

Parameter	Diet*	Time before or after feeding (h) -2	1	2	4	6	SE
Ruminal pH	1	6.30[b]	6.24[b]	6.07[b]	6.06[b]	6.15[b]	.09
	2	6.74[a]	6.68[a]	6.65[a]	6.60[a]	6.68[a]	
Hematocrit(%)	1	34.80[b]	34.80[b]	34.00[b]	34.10[b]	34.20[b]	.53
	2	37.20[a]	36.70[a]	36.80[a]	37.50[a]	37.00[a]	
		osmolality (mOsmoles/kg)					
Ruminal Liq	1	278.5	288.9	296.0	280.2	277.8	14.26
	2	241.2	264.7	256.9	247.2	241.9	
Serum	1	296.5	302.5	303.9	304.4	308.7[a]	6.11
	2	285.6	301.1	299.5	304.9	288.9[b]	

*Diet 1 = Concentrate diet. Diet 2 = Prairie hay.
a,b Mean values in a column with different superscript are significantly different (P<.05).
SE=Standard error of the mean.

infusions of water or hypertonic solutions altered the osmotic pressure of the rumen liquid and blood (Warner and Stacy, 1977). If the rumen becomes hyperosmolar as a result of feeding, direct addition of water to the rumen will lower the ruminal osmolality (Ternouth, 1967). Yet Engelhardt (1969) stated that hypotonicity of the rumen contents cannot be explained either by the inflow of saliva or by influx of water into the rumen. He concluded that a major cause of ruminal liquid hypotonicity was due to absorption of VFA through the ruminal epithelium. Similarly Ternouth (1967) indicated that 2 hours after feeding, VFA concentration and osmolality dropped simultaneously, and that ruminal osmolality always remained higher than normal serum levels. Serum osmolality (Figure 2) increased after feeding and remained elevated for up to 4 hours. Thereafter osmolality decreased slightly to return to their preprandial level. Serum osmolality values never were lower than the ruminal fluid osmolalities as suggested by Ternouth (1967). Thus, VFA uptake or influx of water across the rumen wall cannot explain the difference between rumen and serum values.

Whether changes in salivary flow were associated with the low osmolality of rumen contents of heifers fed the hay diet is not known. Further studies should consider both how saliva production alters osmotic status of the rumen and the converse, how osmolality of serum alters salivary flow. Packed red cell volume (hematocrit) was higher (P<.004) for heifers

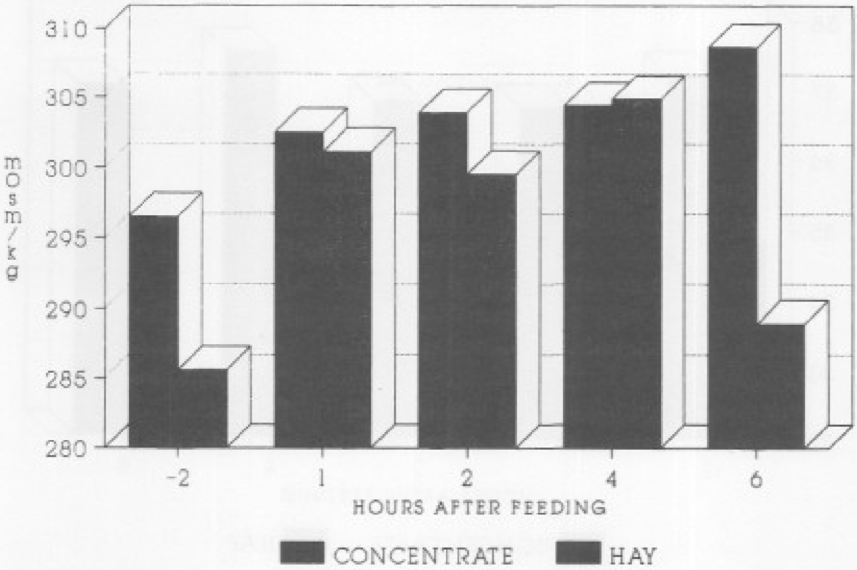

Figure 2. Serum osmolality versus time in beef heifers fed concentrate and hay diets.

fed hay than for heifers fed concentrate (Figure 3). No difference between preprandial and postprandial times or between postprandial times proved significant. Hematocrits were close to the normal physiological values (32 to 35) reported in the literature (Swenson, 1984). Published information on the effects of different types of diets on hematocrit is limited. Warner and Stacy (1965) indicated that high ruminal osmolalities (near 400 mOsmol/kg) were accompanied by hemoconcentration in sheep. They attributed these changes to transfer of body water from the blood into the rumen. Similarly, Ternouth (1967) with Merino ewes observed that packed cell volume and serum proteins in blood increased during the first hour post-feeding. Unfortunately neither of these reports presented absolute hematocrit changes to compare with the values obtained in our study. As ruminal osmolality averaged about 240 mOsm/kg with the roughage diet, water should be absorbed from, not diffuse into the rumen. This would decrease hematocrit, not increase it as we observed.

Ruminal liquid osmolalities in our study never attained the high values reported by Warner and Stacy (1965). One interesting finding was the higher ($P<.05$) (Table 2 and Figure 4) hematocrit and the lower ruminal osmolality (250.4 mOsm/kg) of the heifers fed the hay diet. Serum osmolality remained constant for both diets. Hence, hematocrit changes may

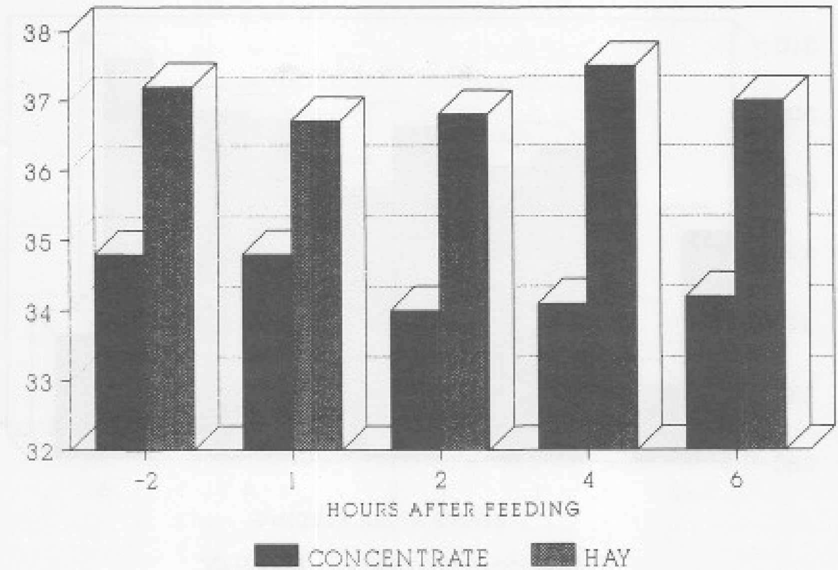

Figure 3. Hematocrit versus time in beef heifers fed concentrate and hay diets.

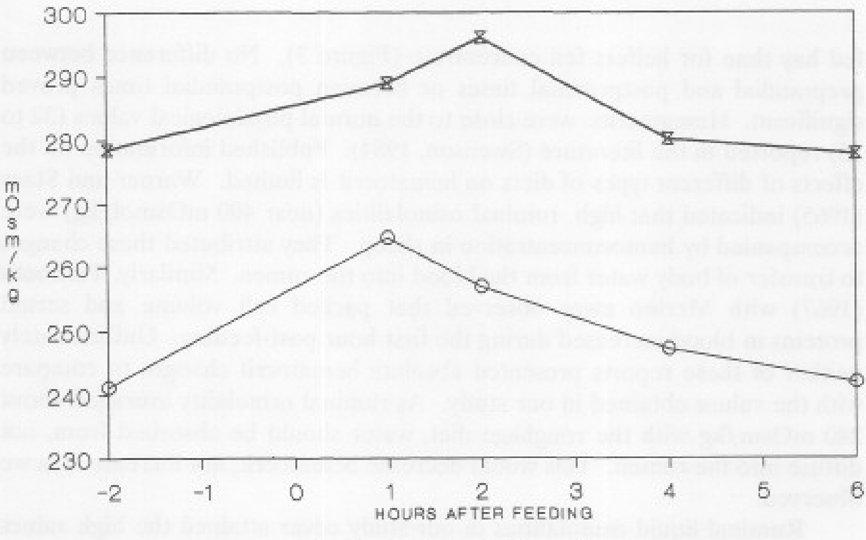

Figure 4. Rumen osmolality versus time in beef heifers fed concentrate and hay diets.

be due to differences in saliva production. Warner and Stacy (1977) indicated that salivary flow was affected by the osmotic status of the animal. When water was infused into the rumen of sheep, rate of saliva flow decreased. When rumen contents were hypotonic due to the addition of water to the rumen, a clear decrease in salivary flow was observed. These findings would be opposite to our results, because the animals consuming hay had lower ruminal osmolality and presumably had greater saliva flow.

As indicated previously, little water moves across the rumen wall when rumen osmotic pressure is isotonic (260 to 340 mOsmol/kg). If true, one cannot attribute our higher hematocrits to net transfer of water from blood into the rumen. Red blood cell size variation also alters hematocrit. Increased serum osmolality would shrink red blood cells (RBC) and decrease hematocrit. As diet did not alter serum osmolality, altered size of RBC would be unlikely as an explanation for the change in hematocrit. Nevertheless this assumption deserves study.

In conclusion, our results suggest that osmolality values of rumen contents are maximum between 1 to 2 hours after feeding, and are higher with grain than low quality forage. Serum osmolality peaked later (4 to 6 hours after feeding). Increased hematocrits with the low quality forage diet were not expected and have not been reported previously. Differences between diets and post feeding changes in osmolality of the blood serum and ruminal fluid do not support the idea that flux of water across the rumen wall is extensive under normal feeding conditions. Flux may be more evident with restriction of water or salt feeding or infusion into the rumen. High hematocrit and low ruminal osmolality may reduce salivary flow; whether such changes depress forage intake deserves study.

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EFFECT OF DIET AND LEVEL OF INTAKE ON RUMEN LIQUID AND SOLID VOLUMES, PASSAGE RATES, AND WATER CONSUMPTION OF BEEF CATTLE

J. D. Garza F.[1] and F. N. Owens[2]

Story in Brief

Twelve Hereford x Angus heifers (1330 lb) fitted with large rumen cannulas were used to determine the effect of diet and feed intake level on rumen liquid and solid volumes. Animals were adapted to either concentrate or hay diets and fed once daily at one of three levels of intake (1.0, 1.4, 1.8% of body weight) for a minimum of 14 days. Rumen contents were evacuated and screened to separate solids from free liquid. Water intake tended to be greater with the hay diet. Rumen liquid volumes were higher for hay diets (71.3 liters vs 46.5 liters). Liquid outflow was higher with the hay than the concentrate diet (132 vs 75 liters/day). As dry matter intake was increased, water intake doubled and total solids in the rumen increased. Ruminal liquid volumes were not altered by feed intake but outflow increased linearly with intake. Blood hematocrit declined as feed and water intake increased.

(Key Words: Liquid Passage Rate, Rumen Evacuation, Water Intake.)

Introduction

More knowledge about the interactions between level of feed intake, diet quality and ruminal digestion should aid in developing nutrition programs to improve the efficiency of livestock production. Level of feed intake presumably is one of the major factors regulating rumen turnover. Increased dry matter consumption, increasing turnover rate of both fluid and particulate digesta from the rumen, should shift site of digestion from the rumen to the intestines. Physical characteristics of the diet (bulk, particle size) also have an impact on rumen volume and gut fill, affecting not only ruminal turnover, but also mastication and rumination which in turn can increase saliva production. Both salivary secretion and water consumption can be affected by the nature of the diet, and might be expected to promote

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greater washout of smaller particles and soluble substances from the rumen. The objectives of this study were to determine the effect of diet type (concentrate vs hay) and three different levels of intake on water consumption, rate of passage and rumen liquid and solid volumes measured directly by ruminal evacuation.

Materials and Methods

Twelve Hereford x Angus beef heifers (1330 lb) fitted with large ruminal and T-type duodenal cannulas were fed a concentrate diet or an 60% alfalfa: 40% prairie hay diet at three intake levels (1.0, 1.4, 1.8% of individual body weight daily). Animals were housed in individuals pens, adapted to their diets for a minimum of 14 days, and fed once daily at 8 a.m.; water intakes were recorded daily. Each animal received three levels of intake but remained on the same diet throughout the experiment. Blood and ruminal liquid samples were collected two hours after feeding, three days before ruminal evacuation for pH and hematocrit determination. At 21 h prior to ruminal evacuation, cobalt EDTA was administered into the rumen (CoEDTA acetate containing 1g of Co) of each animal. An equal volume of tap water was used to rinse residual marker left in the graduated cylinder and funnel. Total rumen contents were removed mechanically using a vacuum device at the end of each experimental period 21 h after the cobalt was dosed. Ruminal contents were screened twice (1/4 x 1/4 inch square pores) manually to separate the particulate solids from the liquid phase; each phase was weighed separately and representative samples were collected and frozen for subsequent chemical analysis. The remaining ruminal contents were returned to the rumen. All ruminal samples were analyzed for dry matter. Data were analyzed using general lineal model procedures and orthogonal contrasts were used to separate treatment means.

Results and Discussion

Daily water intake tended to be greater (22%) with the hay diets (Figure 1) and increased ($P<.001$) with levels of feed intake for both the concentrate and the hay diets. Although information on water consumption by cattle under normal commercial management is scarce, Hicks et al. (1988) indicated that feedlot cattle fed during the summer consumed an average of 38 liters of water per day. They concluded that water intake was influenced by both dry matter intake and environmental temperature. Differences between the average water intake observed in our study and in Hicks'

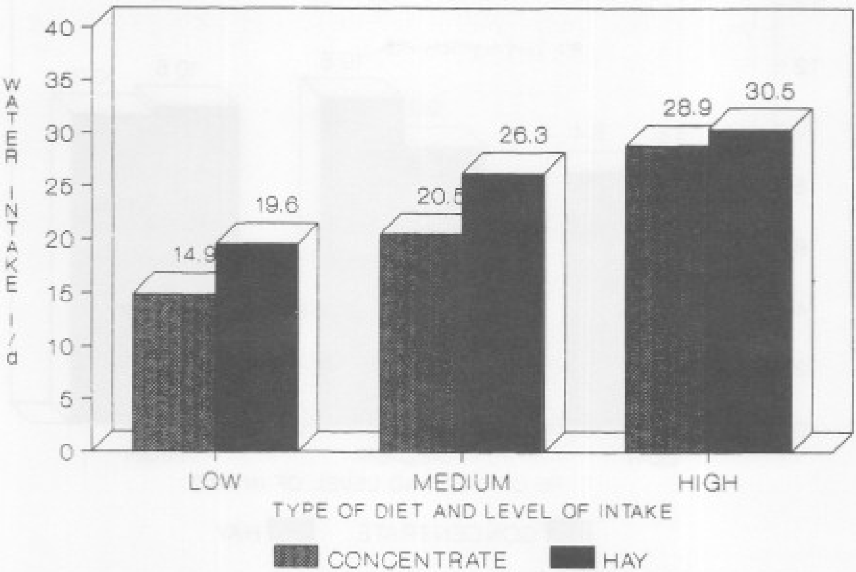

Figure 1. Daily water consumption in beef heifers fed concentrate vs. hay diets.

experiment can be explained, not only by lack of heat stress and lower level of feed intake in our study, but also by the fact that our observed daily water intakes were made on an individual basis while their intakes were determined as total water disappearance for pens of 16 animals.

Weights of dry matter in the rumen are shown in Figure 2. No differences ($P>.05$) were observed between the concentrate and the hay diet, however as level of intake increased, total weight of solids in the rumen increased.

Ruminal liquid volumes were much larger ($P<.001$) for the hay than the concentrate (71 vs. 46 liters; Figure 3), indicating that intake of fibrous materials increased rumen liquid volume markedly. This may increase residence time for more extensive microbial fermentation (Owens and Goetsch, 1988). However, level of feed intake did not affect rumen liquid volume ($P>.05$). Total outflow (Figure 4) from the rumen was estimated by the recovery of CoEDTA 21 hours after dosing. Water outflow was much higher for the hay than for the concentrate diet (132 vs 75 liters/day), similar to values reported by Owens and Goetsch (1988).

Ruminal liquid pH was lower ($P<.01$) with the concentrate than with the hay diet (6.0 vs 6.5; Figure 5). Differences in pH due to level of intake were not detected.

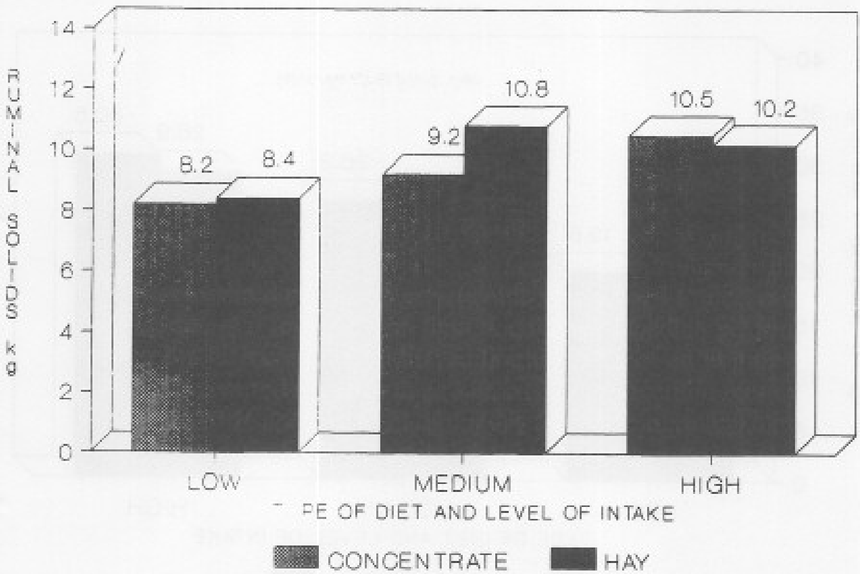

Figure 2. Total ruminal solids, kg dry matter.

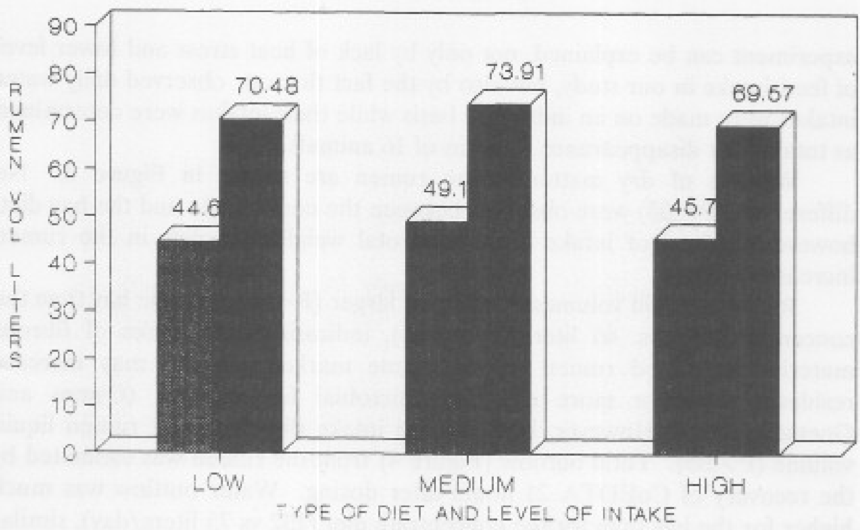

Figure 3. Rumen liquid volume in heifers fed concentrate vs. hay diets.

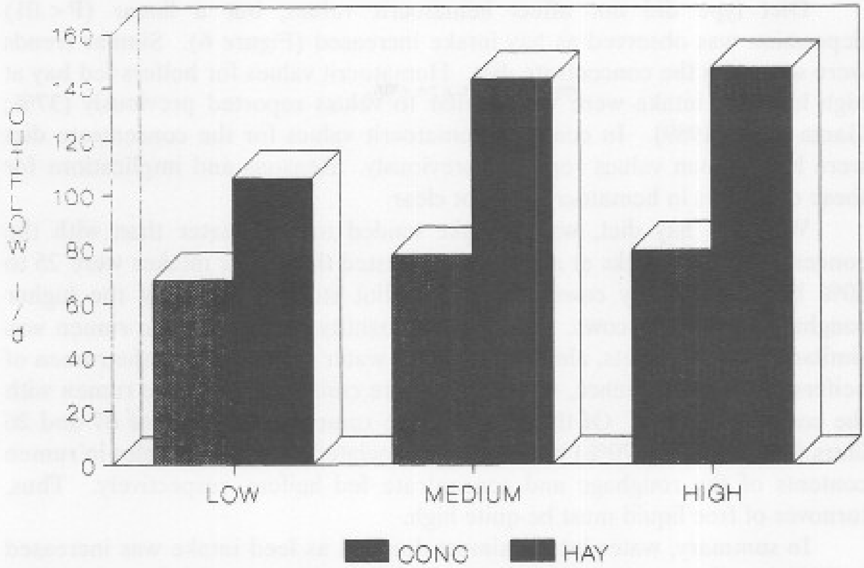

Figure 4. Rumen water outflow (l/d).

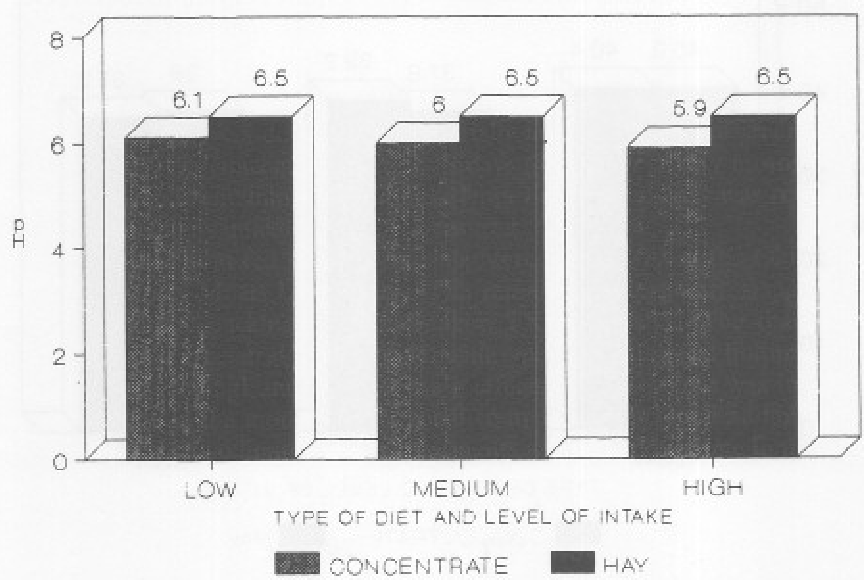

Figure 5. Ruminal liquid pH in heifers fed concentrate vs. hay diets.

Diet type did not affect hematocrit values, but a linear ($P<.01$) depression was observed as hay intake increased (Figure 6). Similar trends were seen with the concentrate diet. Hematocrit values for heifers fed hay at high levels of intake were very similar to values reported previously (37%; Garza et al., 1989). In contrast, hematocrit values for the concentrate diet were higher than values reported previously. Reasons and implications for these decreases in hematocrit are not clear.

With the hay diet, water intake tended to be greater than with the concentrate diet. Hicks et al. (1988) suggested that water intakes were 25 to 50% higher for dairy cows than for feedlot steers because of the higher roughage diet fed to cows. Though the quantity of solids in the rumen was similar for the two diets, almost 50% more water was present in the rumen of heifers fed forage. Hence, solids were more concentrated in the rumen with the concentrate diet. Of this liquid in the rumen, an average of 67 and 26 liters (over 90% and 70%) were closely associated with the particles in rumen contents of the roughage and concentrate fed heifers, respectively. Thus, turnover of free liquid must be quite high.

In summary, water intake almost doubled as feed intake was increased by 80% but changes in ruminal volume and dilution rate with increased feed and water intake were small. Ruminal solids tended to increase as feed and

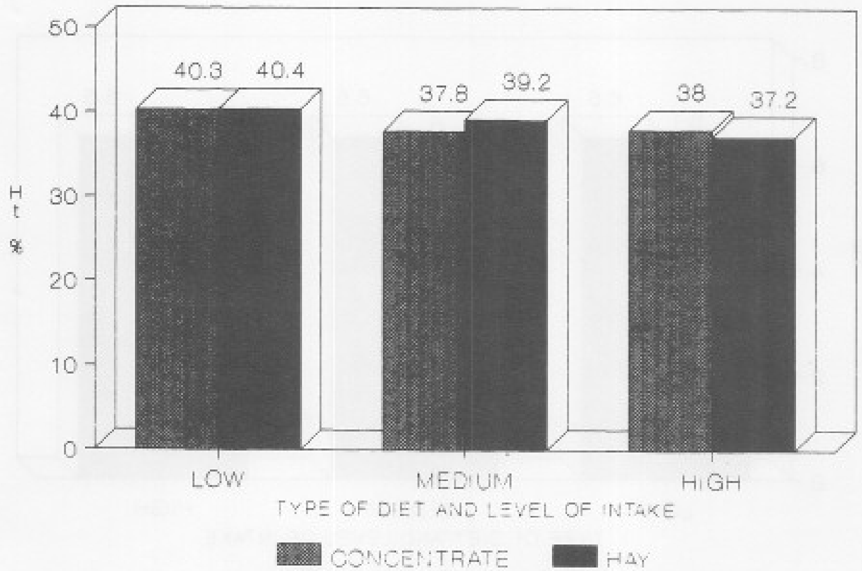

Figure 6. Hematocrit of heifers fed concentrate vs. hay diets.

water intake increased. Drops in hematocrit could reflect direct escape of drinking water or fluid absorption through the rumen wall. How flux of water in and out of the rumen changes with intake needs more study, as salivary flow and influx through the rumen wall would be expected to be altered by ruminal conditions which affect rumination and osmolarity.

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QUANTITATIVE ORIGIN OF RUMINAL LIQUID WITH VARIOUS DIETS AND FEED INTAKES

J. D. Garza F.[1] and F. N. Owens[2]

Story in Brief

Heifers fed hay diets drank more water (25.6 liters/day) than heifers fed concentrate (21.5 liters/day). As level of feed intake was increased, daily water consumption increased linearly. The amount of drinking water which entered the rumen was higher for the roughage than the concentrate diet (9 liters/day vs 4 liters/day). Percent of ruminal water from drinking water was greater for the hay diet (7.5%) than for the concentrate diet (5.3%). It was estimated from this study that 92 to 96% of ruminal fluid originates from saliva and water flux through the rumen wall, and not from drinking water. Type of diet and level of intake did not alter ruminal osmolality, but it influenced serum osmolality. Of drinking water consumed, 60 to 80% bypassed the rumen. Thus, drinking water may be an ideal vehicle to permit compounds (electrolytes, amino acids, vitamins, glucose) to evade ruminal fermentation.

(Key Words: Water Intake, Ruminal Water Origin, Beef Cattle.)

Introduction

Fluid in the rumen may originate from feed, drinking water, saliva and diffusion through the rumen wall. Feeding forages will increase the amount of time spent masticating and ruminating, both of which increase saliva production. Saliva is an important source of water in the rumen for buffering and for flushing fluid through the rumen.

Saliva and solutes such as volatile fatty acids (VFA) and salts in the rumen create osmotic gradients that can affect water absorption from the rumen into the blood. If the rumen contents are highly concentrated (salts, and VFA) water from blood diffuses into the rumen. Such fluxes of water are difficult to quantify because of the constant turnover of material. Digesta (liquids and solids) rate of passage techniques have evolved, but how water

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moves in and out of the rumen still is not clearly defined. When lactating cows were given water after several hours of water deprivation in one previous study (Woodford et al., 1984) up to 18% of the consumed water bypassed the rumen. The objective of this study was to assess quantitatively the origin of ruminal water by using an external liquid marker.

Materials and Methods

Two diets composed of either concentrate or hay (60% alfalfa, 40% prairie) were fed to 1320 lb heifers in two 3x3 Latin squares. Feeding methods are described in a companion paper by Garza and Owens (1989). Starting three days before ruminal evacuation polyethylene glycol (PEG) was added at a rate of 10 g per gallon of drinking water for each animal. The polyethylene glycol concentrations in drinking water and ruminal samples were determined by a turbidimetric method. Ruminal liquid and serum osmolalities were determined by the freezing point depressing procedure. Total PEG intake (g/day) was calculated by multiplying PEG concentration in the drinking water times daily water intake. Amount of PEG leaving the rumen (g/day) (PEG outflow) was calculated by multiplying PEG concentration in ruminal liquid times rumen volume times the liquid dilution rate. Liquid dilution rate was calculated from cobalt dosage and cobalt concentration in ruminal fluid 21 h later when the rumen was evacuated.

Results and Discussion

Results are presented in Table 1. As discussed previously, water intake, rumen volume, particle-associated liquid and liquid outflow were greater with the hay than with the concentrate diet. Also, as DM intake increased, water intake and ruminal dilution rate increased in a stepwise fashion. However, ruminal liquid volume did not increase as feed (and water) intake increased.

Amount of consumed water which entered the rumen with the roughage diet was more than double ($P<.01$) that with the concentrate. Yet based on PEG concentrations only 4.5 to 8.4% of ruminal liquid was obtained from consumed water. The remaining 90% presumably was derived from saliva and diffusion from blood. Some diffusion from blood would be expected when ruminal fluid osmolality is greater than blood serum osmolality. But in this study, differences in osmotic pressure between blood serum and ruminal fluids were quite small (Figure 1), so net influx of ruminal liquid from blood presumably would be minor.

Based on PEG analysis the percentage of drinking water which did not mix with rumen contents and thereby evade the rumen was greater ($P<.05$)

Table 1. Origin of ruminal liquid in beef heifers fed hay and concentrate diets.

	Diets										
	Hay			Concentrate				Hay		Conc	
Intake of DM, % wt/day	1.0	1.4	1.8	1.0	1.4	1.8	Diet	L	Q	L	Q
Water intake, l/day	19.6	26.3	30.5	15.0	20.5	29.0	.10	.001	NS	.001	.001
Rumen outflow, l/day	106.1	143.0	147.3	68.3	77.3	79.3	.001	.001	NS	NS	NS
Rumen outflow, %/h	6.1	8.1	8.8	6.4	6.6	7.4	NS	.001	NS	.06	NS
Rumen volume, l	70.5	74.0	69.5	44.6	49.1	45.7	.001	NS	NS	NS	NS
Free liquid, l	45.3	40.6	36.3	34.2	36.8	32.0	NS	.008	NS	NS	NS
Bound liquid, l	25.0	32.7	32.9	10.3	12.0	13.4	.001	.003	.02	NS	NS
Rumen water from drinking water.											
Drinking water entering the rumen, l/day	9.0	9.3	11.4	3.0	4.0	5.0	.002	NS	NS	NS	NS
% from drinking	8.4	6.3	8.0	4.5	5.0	6.3	.08	NS	NS	NS	NS
Bypass of drinking water, l/day	10.6	16.5	22.0	13.2	17.0	24.1	NS	.001	NS	.001	NS
% of consumed	54.1	64.6	66.6	81.4	79.7	82.2	.002	NS	NS	NS	NS

L = Linear effect of level (treatment).
Q = Quadratic effect of level (treatment).
NS = No significance.

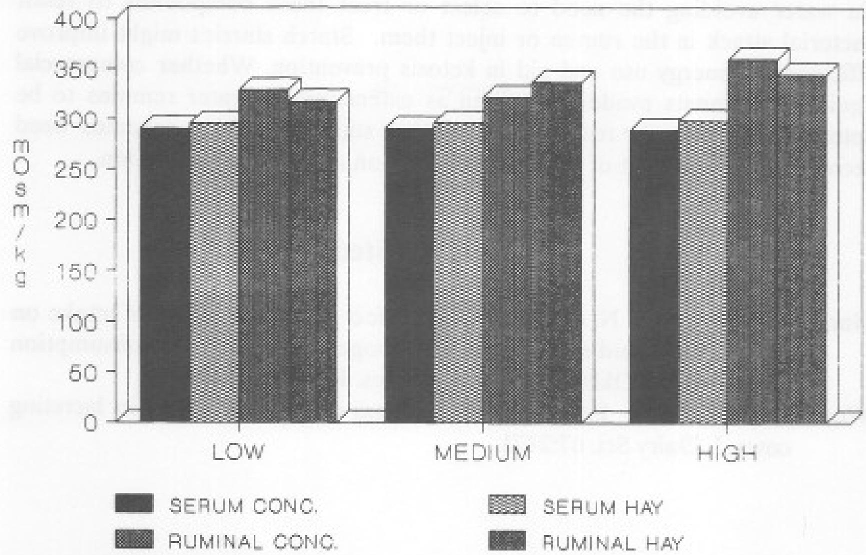

Figure 1. Ruminal liquid and serum osmolality changes in heifers fed concentrate vs. hay diets.

with the concentrate than the roughage diet (81.0 vs 60.4%), values much higher than following water deprivation (Woodford et al., 1984). This water presumably was flushed through the rumen due to the proximity of entry and exit points. Such a high level of water evasion has a number of nutritional and health implications.

First, if all drinking water entered the rumen, it would cause drastic shifts in volume, osmotic pressure and, in some cases, temperature. Such changes would be detrimental to the microbial population and disrupt the fermentation process. Thus, extensive bypass will prevent disturbance of ruminal function.

Secondly, high bypass means that the amount of drinking water consumed will not alter turnover or dilution of ruminal contents. Hence, feeding salt or compounds to increase water intake might not be expected to increase ruminal turnover and thereby improve efficiency of microbial growth in the rumen.

Third, high bypass of drinking water can provide a vehicle to increase flow of selected nutrients to the intestines for digestion and absorption. For shipping stressed cattle, electrolytes, amino acids and B vitamins in water should escape fermentation and potentially could improve health status. Soluble protein, amino acids, vitamins or electrolytes might be supplemented via water avoiding the need to select or treat these compounds to resist bacterial attack in the rumen or inject them. Starch slurries might improve efficiency of energy use and aid in ketosis prevention. Whether commercial liquid supplements evade the rumen as extensively as water remains to be determined. Overall, results indicate that supplementation schemes need reconsideration in light of this new information about ruminal evasion.

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VIRGINIAMYCIN VERSUS MONENSIN FOR FEEDLOT STEERS

D.R. Gill[1], C.A. Strasia[2], J.J. Martin[3], F.N. Owens[1] and H.G Dolezal[4]

Story in Brief

Two hundred yearling feedlot steers were used to compare virginiamycin (an antibiotic under preliminary evaluation) at 10/grams per ton to diets containing either no feed additives or monensin at 25/grams per ton. Virginiamycin tended to increase rate of gain (.22 lb/day) as compared to the control cattle and .25 lb as compared to steers fed monensin. The cattle receiving 10 grams of virginiamycin tended to consume more feed, especially during the first 28 days on feed. Feed efficiency was improved 5.27% by virginiamycin compared to the control and by 2.10% compared to monensin fed steers. No difference in carcass traits were detected although severity of liver abscesses was reduced by feeding virginiamycin.

(Key Words: Virginiamycin, Monensin, Feedlot, Antibiotic, Steers.)

Introduction

Improvements in the efficiency and safety of beef production are necessary to keep beef competitive in the market. The development of safe and more effective additives is a continual process. Virginiamycin is an antibiotic which may improve rate and efficiency of feedlot gains. This trial is one of a series of tests to determine its proper feeding level, effects on gain, feed efficiency, and the incidence of liver abscesses, and to compare it to the established feed additive, monensin.

Virginiamycin is currently being tested by SmithKline Animal Health Products to obtain an FDA clearance for use in feedlot cattle. In vitro studies (Nagaraja et al., 1987) have shown virginiamycin inhibits lactic acid production. Volatile fatty acid concentrations within the rumen varies with concentration of virginiamycin. This and other test data suggest

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virginiamycin may improve feedlot performance. **However, virginiamycin is not cleared for feeding to cattle.**

Materials and Methods

Two hundred yearling steers were selected for uniform size and weight from a group of 800 cattle. Steers were Hereford x Angus cattle from western Nebraska. The cattle were processed on October 15 at a commercial feedlot near Guymon, Oklahoma. Processing consisted of IBR-PI3-Lepto, 4-way clostridial vaccination and deworming with Ivermectin. Steers were implanted with Synovex-S at the start of the study. The cattle were fed a receiving ration over the weekend, then trucked approximately 10 miles to the trial site at Goodwell, Oklahoma on October 18, 1988. Upon arrival, steers were individually weighed and divided into four weight blocks of 50 head each (5 pens of 10 steers). Within each weight block, one pen was designated as control whereas two pens were fed supplemental virginiamycin (10 grams per ton) and two pens were fed supplemental monensin (25 grams per ton).

Steers were allowed ad libitum access to a high concentrate diet (Table 1) for the entire feeding period. Chopped alfalfa hay and cottonseed hulls were used to dilute the ration to 50% concentrate (Ration 1 of Table 1) in order to facilitate starting the cattle on feed. Roughage level was decreased sequentially in four steps until cattle were receiving the final ration by day 15 of the trial.

Initial weights were obtained off the truck, whereas unshrunk period weights were taken on all cattle. Gains and feed efficiency were calculated based on shrunk weights (96% of each weight except the initial weight) to account for fill. The feeding trial lasted 118 days. Due to the drug withdrawal requirement for virginiamycin, all cattle were fed the nonmedicated control ration for six days (days 113 to 118) prior to slaughter. They were then trucked to Booker, Texas (75 miles) for slaughter. At slaughter, livers were examined for presence of liver abscesses and flukes. Carcass data was obtained 24 hours post-mortem. Because only half as many pens received the control as the test diets, data were analyzed using least squares procedures. Least squares means were separated using the least significant difference procedure protected by an initial F-test.

Results and Discussion

Effects of feeding monensin or virginiamycin on cattle performance are presented in Table 2. Cattle supplemented with 10 grams virginiamycin per

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 %	Ration composition As Fed %	Supplement composition DM %	Supplement composition 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
Phos, %	.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%, 30,000 IU vitamin A .17% and virginiamycin premix (Stafac-10) or monensin (Rumensin 60) as required. Calculated NEg = 44.85.

ton of feed consumed more feed, particularly during the first 56 days, and gained (P<.05) at a higher rate. In the first 28 days of the test, the virginiamycin cattle gained .71 lb more weight per day (P<.01) than the control cattle (4.25 vs 3.54 lb/day). Many cattle feeders have stated that ionophore feeding allows cattle to be fed higher concentrate diets sooner. In this test, the monensin cattle did outgain the controls (4.09 vs 3.54 lb/day, P<.05) during the first 28 days on feed. These test cattle were purposely fed concentrate diets earlier. These data suggest that virginiamycin may make it possible to adapt cattle to a concentrate diet rapidly even though there were no signs of distress in the control or monensin cattle. Feed efficiency over the total trial was improved 5.36% with virginiamycin and 3.33% with monensin (live weight basis). On a carcass adjusted weight basis, these differences were 4.11% for virginiamycin and 4.59% for monensin.

Virginiamycin at 10 grams per ton tended to improve feed efficiency and gain partly by increasing feed intake. The calculated energy values of the test rations were not different among diets, although values from both additives were about 3% above the control. Carcass traits (Table 3) were not altered

Table 2. Effects of Virginiamycin or Monensin on steer performance.

	Control	Virginiamycin 10 g.	Monensin 25 g.
No. of pens	4	8	8
No of head	40	80	80
Weight, lb:			
Initial	771	771	771
56 days	1036^a	1062^b	1044^{ab}
112 days	1230^a	1255^b	1227^a
Daily gains, lb:			
0-56	3.98^a	4.44^b	4.13^{ab}
57-112	3.33	3.31	3.12
0-112	3.66^a	3.87^b	3.63^a
Carcass,ADG[1]	3.95^a	4.15^b	3.99^{ab}
Daily Feed, lb DM:			
0-56	24.62	25.52	24.39
57-112	25.63^a	25.06^{ab}	23.94^b
0-112	25.14	25.29	24.17
0-Slaughter	24.98	25.15	24.06
Feed/gain			
0-56	6.23	5.76	5.91
57-112	7.74	7.59	7.75
0-112	6.90	6.53	6.67
0-Slaughter	6.33	6.07	6.04
Metabolizable energy, Mcal/kg	3.07	3.16	3.17
Net energy, Mcal/cwt.			
Maintenance	92.53	96.92	97.28
Gain	61.14	63.58	63.84

[1]Carcass average daily gain (carcass weight/.62).
[a,b]Means in the same row with different subscripts differ (P<.05).

Table 3. Effect of Virginiamycin or Monensin on carcass characteristics.

Item	Control	Virginiamycin	Monensin
Carcass wt, lb	767.20	781.78	769.78
Dressing %[1]	62.36	62.25	62.76
Ribeye area, sq in	12.91	12.75	12.81
KPH, %	1.94	2.04	1.98
Fat thickness, in	.47	.49	.48
Marbling score[2]	438	441	433
Percent choice	82.50	76.25	80.00
Percent YG 4	5.00	6.25	6.25
USDA yield grade	2.96	3.12	3.02
Liver abscess:			
Incidence, %	25.00	27.50	26.25
Severity3	1.96	1.43	1.57

[1]Calculated by dividing gross 112-day weight by carcass weight.
[2]300-399, slight; 400-499, small.
[3]0=no abscesses; 1=one or two small, well organized, inactive abscesses; 2=two to four well organized abscesses without inflammation; 3=one or more active abscesses with inflammation, only among cattle with abscesses.

by treatment. Liver abscesses were detected in 53 of the 200 cattle. No differences in abscess incidence was detected but virginiamycin tended to decrease the liver severity score ($P < .10$) compared to the control steers.

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BEHAVIORAL PATTERNS OF FEEDLOT STEERS

R.B. Hicks[1], F.N. Owens[2] and D.R. Gill [2]

Story in Brief

Ninety three crossbred yearling steers were observed at 30-minute intervals for 24 hours on day 40 of a 138 day feeding trial to examine the diurnal patterns and individual differences in eating, ruminating and lying times. These steers spent 6.6, 15.5 and 54.4% of their time eating, ruminating, and lying, respectively. Peak eating times occurred at 0650 (47.3% of steers eating) and 1700 (36.8% eating) which corresponds to times of addition of fresh feed with another small peak at 2100 (17.9% eating). Ruminating and lying peaks during the day occurred at times inverse to eating. Individual animals with highest eating times had highest rumination and lying times. Steers which spent more time eating or ruminating tended to gain more rapidly. Daily gains increased by .02 lb/day for each 1% increase in lying time. Results of this trial suggest that the frequencies of eating, ruminating and lying are correlated with animal performance.

(Key Words: Feedlot Cattle, Behavior Pattern, Diurnal Patterns.)

Introduction

The pattern of feeding behavior by cattle is highly repeatable. A review by Hancock (1953) reported that grazing peaks occur at dawn and dusk with the majority of grazing occurring during the day. Diurnal activity patterns of feedlot cattle also have been reported in several studies. Stricklin (1987) in a review of feeding patterns of feedlot cattle in Saskatchewan, Canada (Gonyou and Stricklin, 1981 and 1984) reported that cattle exhibited three periods of eating activity during a 24-hour day. Major peaks occurred during the morning and afternoon which were associated closely with time of sunrise and sunset. A third period occurred in the middle of the night. Stricklin suggested that cattle divide their day into three 8-hour periods of eating. Ray and Roubicek (1971) reported on the diurnal behavior of feedlot steers in an Arizona feedlot during winter and summer and noted that in both seasons

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eating activity was greatest immediately following sunrise and prior to sunset. Similar eating patterns were noted in Iowa feedlot trials (Hoffman and Self, 1973), Maryland studies (Putnam and Davis, 1963; Putnam et al., 1967 and 1968) and Oklahoma feedlot trials (Arp et al., 1983; Doran, 1985). The objective of this study was to examine the diurnal behavior of feedlot steers and to determine if time spent eating, ruminating and lying down were correlated with performance of individual animals.

Materials and Methods

Ninety six crossbred (primarily British crosses) yearling steers which had been wintered on wheat pasture near Dalhart, Texas were trucked to Goodwell, Oklahoma on June 3, 1987. On arrival, all cattle were individually weighed, ear tagged, implanted with Synovex-S, and injected with ivermectin and a BRSV vaccine. These steers were predominantly Herefords (78 head) of small to medium frame size. The steers were divided into twelve pens of eight head each and four feed treatments were assigned randomly to the pens. Steers were fed a cracked corn high concentrate ration twice daily (approximately 0700 and 1600) for the 138-day trial. The ration was 80% cracked corn, 11% chopped alfalfa, 3.9% cane molasses and 5.1% pelleted supplement.

On days 40 and 41 of the trial (July 13 and 14), the behavior of each steer was noted and recorded at 30-minute intervals for 24 hours (2000 to 1950 hours, 48 observations per steer) to monitor the amount of time each animal spent eating, standing, lying, standing and ruminating, or lying and ruminating. Ambient temperature peaked at 78°F, on July 14 which is low for July. A thunderstorm occurred at 1550 hour (day 41) which altered normal behavioral patterns. These data were used to examine the diurnal patterns of eating, ruminating and lying. Because eating and ruminating behavior may alter performance (Owens and Ferrell, 1983), performance measurements were regressed against the frequency of eating, ruminating, and lying to examine these relationships.

Results and Discussion

The eating time pattern for these steers is illustrated in Figure 1. Between 2200 and 0600, less than 3.2% of the steers were eating. Eating peaked from 0650 to 0750 with 47.3% of the steers eating at 0650, and again from 1650 to 1700 with 36.8% eating at 1700. These peak eating times coincided with the feeding times (0700 and 1600); the presence of fresh feed

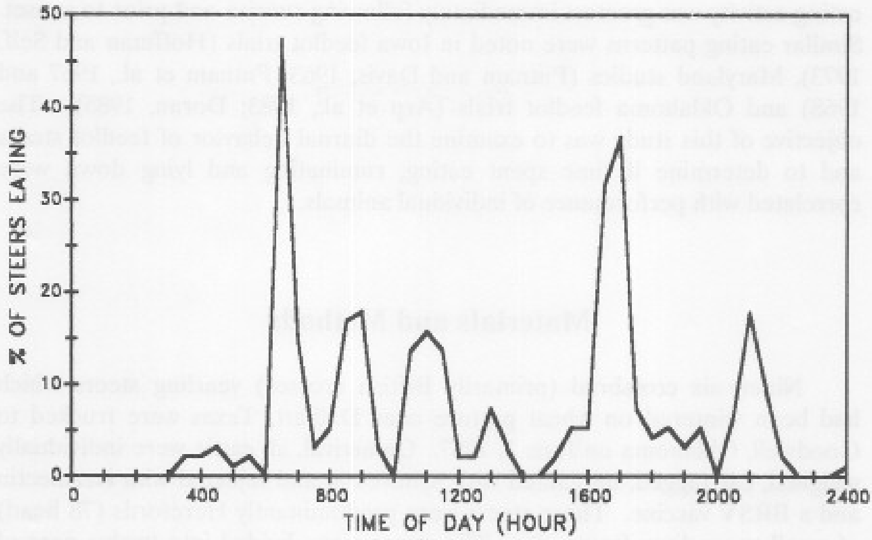

Figure 1. Eating pattern of feedlot steers.

stimulated eating. Gonyou and Stricklin (1981) also observed that peak eating times coincided with feeding times. In the period of time between feedings, the percentage of steers eating oscillated between 0 and 17.9%. Another peak in eating occurred at 2100 (sunset) with 17.9% of the steers eating. Similar diurnal eating behavior has been reported by several workers previously (Putnam and Davis, 1963; Putnam et al., 1967, 1968; Ray and Roubicek, 1971; Hoffman and Self, 1973; Arp et al., 1983; Doran, 1985; Stricklin, 1987).

Ruminating incidence (Figure 2) tended to be the inverse of eating. Between 2200 to 0600, 13.7 to 33.7% of the steers were ruminating. Lowest rumination incidence times occurred at 0650 (3.2%), 1700 (0%) and 2150 (2.1%) which correspond with the peak eating times. Doran (1985) noted similar ruminating patterns in feedlot steers.

Lying time (Figure 3) also varied inversely to eating time as was previously noted by Doran (1985). From 2250 to 0600, 56.8 to 100% of the steers were lying down. During the day (0750 to 1500) 31.6 to 88.4% of the steers were lying down which may reflect the warm temperature. From 1550 to 1800, most of the steers were standing; this corresponds to feeding time and occurrence of the thunderstorm. The steers generally were more active during the hours of 1550 to 2150 as temperature decreased.

Correlations between time spent eating, ruminating and lying and steer performance are presented in Table 1. Behavior of the steers grouped by

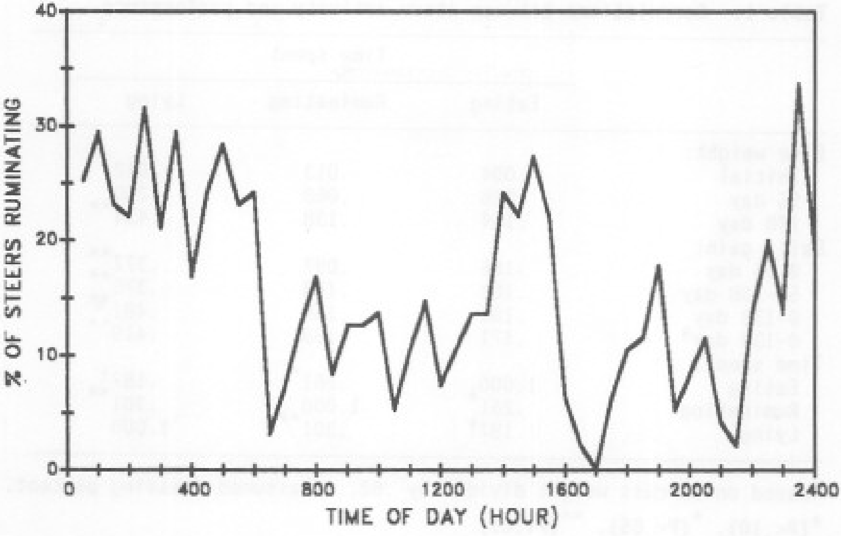

Figure 2. Ruminating pattern of feedlot steers.

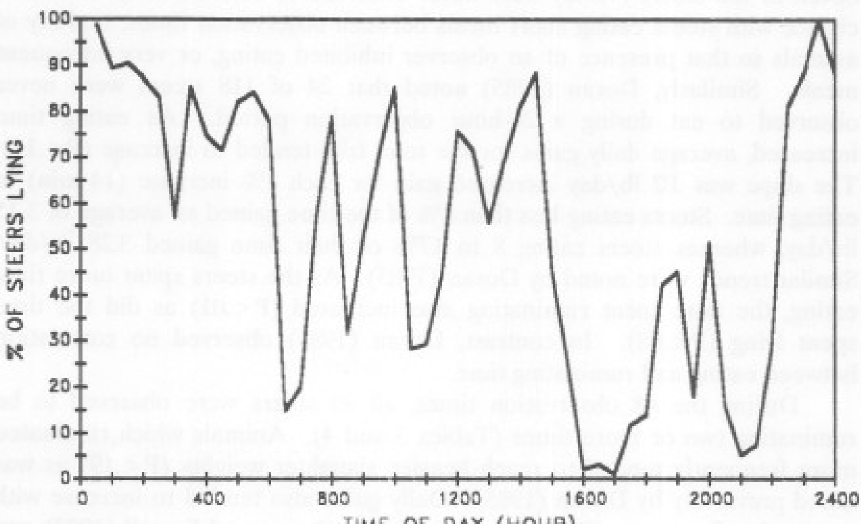

Figure 3. Lying pattern of feedlot steers.

Table 1. Correlations between steer activity and performance.

	Time spent		
	Eating	Ruminating	Lying
Live weight:			
Initial	.004	-.013	-.012
56 day	.126	.068	.290**
138 day	.154	.138	.434**
Daily gain:			
0-56 day	.156	.097	.377**
57-138 day	.102	.153	.376**
0-138 day	.166	.158	.481**
0-139 day[a]	.171	.168	.419**
Time spent:			
Eating	1.000	.261*	.187+
Ruminating	.261*	1.000	.301**
Lying	.187+	.301**	1.000

[a]Based on carcass weight divided by .62, an assumed dressing percent.
+(P<.10), *(P<.05), **(P<.01)

fraction of time spent eating is presented in Table 2. During the 24-hour observation, 82% of the steers spent between 2 and 10% of their time eating. Seven of the steers (7.5%) were never observed to eat; this may be due to chance with steers eating short meals between observation times, timidity of animals so that presence of an observer inhibited eating, or very infrequent meals. Similarly, Doran (1985) noted that 24 of 118 steers were never observed to eat during a 24-hour observation period. As eating time increased, average daily gains for the total trial tended to increase (P<.11). The slope was .02 lb/day increased gain for each 1% increase (14 min) in eating time. Steers eating less than 8% of the time gained an average of 3.15 lb/day, whereas steers eating 8 to 17% of their time gained 3.28 lb/day. Similar trends were noted by Doran (1985). As the steers spent more time eating, the time spent ruminating also increased (P<.01) as did the time spent lying (P<.08). In contrast, Doran (1985) observed no correlation between eating and ruminating time.

During the 48 observation times, all 93 steers were observed to be ruminating two or more times (Tables 3 and 4). Animals which ruminated more frequently tended to reach heavier slaughter weights (P<.19) as was noted previously by Doran (1985). Daily gains also tended to increase with rumination frequency (P<.11) as reported by Owens and Ferrell (1983) and Doran (1985). In this trial, daily gains appeared to plateau once rumination exceeded 17% of the time. As steers spent more time ruminating, time spent lying also increased (P<.003).

Table 2. Performance of steers versus percentage of time spent eating.

Item	Percentage of time spent eating									Linear slope	Prob.
	0	2	3	6	8	10	13	15	17		
No. of steers	7	14	11	17	22	12	7	2	1		
Live wt, lb:											
Initial	647	638	640	649	656	638	638	625	671	0	.970
56 day	818	821	825	840	845	854	816	803	878	1.5	.228
138 day	1041	1034	1045	1082	1076	1087	1027	1065	1098	2.6	.140
Daily gain, lb:											
0-56 day	2.46	2.66	2.71	2.84	2.77	3.26	2.60	2.60	3.08	.026	.136
57-138 day	2.60	2.51	2.55	2.82	2.68	2.73	2.46	3.08	2.57	.011	.328
0-138 day	2.55	2.57	2.62	2.84	2.73	2.95	2.53	2.88	2.77	.017	.112
0-139 day[a]	3.06	3.04	3.10	3.30	3.23	3.50	2.95	3.32	3.52	.022	.101
Time spent, %:											
Ruminating	13.4	12.4	16.3	14.2	17.6	16.0	19.3	17.7	20.8	.461	.012
Lying	47.6	49.4	59.5	54.0	55.5	58.5	52.7	55.2	52.1	.470	.073

[a]Based on carcass weight divided by .62, an assumed dressing percent.

Table 3. Performance of steers versus percentage of time spent ruminating (Part 1).

Item	Percentage of time spent ruminating										
	4	6	8	10	13	15	17	19	21	23	25
No. of steers	4	2	10	13	11	10	12	7	9	2	6
Live wt, lb:											
Initial	625	671	658	651	623	651	638	638	656	671	667
56 day	794	843	840	836	818	851	845	794	851	880	840
138 day	1012	1023	1060	1060	1067	1065	1074	1008	1089	1098	1074
Daily gain, lb:											
0-56 day	2.49	2.44	2.64	2.71	2.90	2.95	3.10	2.20	2.88	3.12	2.51
57-138 day	2.53	2.11	2.60	2.62	2.93	2.51	2.68	2.51	2.77	2.53	2.75
0-138 day	2.51	2.24	2.62	2.66	2.93	2.68	2.86	2.38	2.82	2.77	2.64
0-139 day[a]	2.99	2.75	3.08	3.12	3.32	3.30	3.37	2.79	3.34	3.43	3.08
Time spent, %:											
Eating	5.2	1.0	5.6	6.4	5.3	7.5	7.6	6.5	9.0	2.1	6.9
Lying	46.4	52.1	50.2	54.0	52.8	53.5	56.2	53.9	55.6	57.3	57.3

[a]Based on carcass weight divided by.62, an assumed dressing percent.

Table 4. Performance of steers versus percentage of time spent ruminating (Part 2).

Item	Percentage of time spent ruminating				Linear slope	Prob.
	27	29	33	38		
No. of steers	4	3	1	1		
Live wt, lb:						
Initial	636	620	678	583	0	.902
56 day	834	832	849	805	.4	.519
138 day	1074	1076	1091	1056	1.3	.186
Daily gain, lb:						
0-56 day	2.93	3.17	2.44	3.41	.011	3.55
57-138 day	2.82	2.84	2.84	2.93	.011	.144
0-138 day	2.86	2.97	2.68	3.12	.011	.130
0-139 day[a]	3.26	3.48	3.30	3.78	.011	.108
Time spent, %:						
Eating	9.4	7.6	8.3	12.5	.148	.012
Lying	58.3	63.9	60.4	62.5	.431	.003

[a]Based on carcass weight divided by .62, an assumed dressing percent.

Table 5. Performance of steers versus percentage of time spent lying (Part 1).

Item	Percentage of time spent lying										
	19	21	25	33	38	42	44	46	48	50	52
No. of steers	1	1	1	2	1	4	1	4	7	3	8
Live wt, lb:											
Initial	620	636	581	660	697	636	618	662	656	623	660
56 day	724	777	708	849	832	821	779	836	838	796	847
138 day	920	1012	849	1049	1034	1025	986	1045	1063	1034	1060
Daily gain, lb:											
0-56 day	1.34	1.96	1.76	2.77	1.78	2.71	2.31	2.53	2.66	2.53	2.75
57-138 day	2.29	2.77	1.65	2.31	2.40	2.40	2.42	2.42	2.64	2.75	2.51
0-138 day	1.91	2.44	1.69	2.51	2.13	2.53	2.38	2.46	2.64	2.66	2.60
0-139 day[a]	2.46	2.97	2.11	3.10	2.51	3.01	2.97	2.97	3.08	3.08	3.08
Time spent, %:											
Eating	2.1	0.0	6.3	1.0	6.3	8.9	2.1	6.8	6.5	8.3	7.6
Ruminating	4.2	12.5	10.4	9.4	8.3	13.5	14.6	16.7	11.9	14.6	18.8

[a]Based on carcass weight divided by .62, an assumed dressing percent.

Table 6. Performance of steers versus percentage of time spent lying (Part 2).

Item	Performance of time spent lying								Linear slope	Prob.
	54	56	58	60	63	65	67	77		
No. of steers	6	14	13	8	5	11	2	1		
Live wt, lb:										
Initial	631	660	642	656	605	638	649	645	0	.907
56 day	818	836	847	851	838	845	854	801	1.5	.005
138 day	1034	1065	1085	1067	1096	1102	1080	1049	2.9	.0001
Daily gain, lb:										
0-56 day	2.75	2.55	3.04	2.90	3.56	3.10	3.04	2.22	.026	.0002
57-138 day	2.53	2.66	2.77	2.51	2.99	3.04	2.66	2.90	.018	.0002
0-138 day	2.62	2.64	2.88	2.66	3.23	3.06	2.82	2.64	.022	.0001
0-139 day[a]	3.12	3.08	3.39	3.21	3.85	3.52	3.37	2.90	.020	.0001
Time spent, %:										
Eating	7.6	6.5	5.8	6.3	8.8	7.6	8.3	4.2	.074	.073
Ruminating	12.2	15.9	14.7	18.2	22.1	19.1	13.5	10.4	.211	.003

[a]Based on carcass weight divided by .62, an assumed dressing percent.

Over 83% of the steers spent more than 46% of their time lying down (Tables 5 and 6). Time spent lying was positively correlated with live weight at 56 and 138 days ($P<.01$). Daily gains for the first half of the trial, last half of the trial and total trial all increased as time spent lying increased ($P<.001$). Similarly, the NRC (1981) reported that mud, rain or storms (conditions causing lack of suitable bedding area) decrease feed intake by cattle which in turn should decrease performance. Those steers spending less than 57% of their time lying (53 head) gained 3.04 lb/day while those spending greater than 57% of the time lying (40 head) gained 3.43 lb/day. Doran (1985) reported that gains tended to increase as lying time increased up to 71% of the time ($P<.10$).

In summary, these feedlot steers exhibited diurnal behavior as has been noted by other workers. Results also suggest that the frequencies of eating, ruminating and lying were correlated with animal performance, but the mechanisms of the relationships remain to be defined. As frequency of eating, ruminating and lying increased, daily gains also increased. Presumably, increased feed intake would increase all of these factors whereas timidity or nervousness should decrease all three. Altering roughage level or source would be expected to alter eating and rumination time. If greater eating and ruminating times increase both particle size reduction and salivary flow to buffer the rumen and increase ruminal outflow, increases in rumination and eating times may improve efficiency of feed utilization and reduce acidosis. No information on efficiency of feed use of individual animals was available from this study. Selection for rapid eating, as practiced with dairy cattle, would reduce chewing time and potentially decrease digestibility of poorly processed grains. This could explain why shelled corn diets are often poorly utilized by Holstein steers. Whether feed supply, roughage level, feeding frequency or feed additives alter patterns or total time spent feeding and ruminating time needs study. No effect of limit feeding on these measurements was apparent here though Doran (1985) suggested that supplemental potassium tended to increase rumination time.

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EFFECT OF INDIVIDUAL OR GROUP PENNING ON PERFORMANCE OF FEEDLOT STEERS

R.B. Hicks[1], F.N. Owens[2] and D.R. Gill[2]

Story in Brief

Seventeen crossbred yearling steers were fed either individually (4 steers) or in groups of three or four head per pen (13 steers). Daily gains were reduced only slightly (6.3%) with individual feeding (4.57 vs. 4.88 lb/day) and feed intake was reduced slightly also (22.53 vs. 23.87 lb/day), while feed efficiency was reduced by only 2% (4.98 vs 4.88 lb feed/lb gain). Considerable day to day fluctuation in intake was apparent for both individually and group fed steers. Individual feeding appeared to reduce daily gain but these steers still performed exceptionally well.

(Key Words: Feedlot Steers, Group Fed, Individually Fed, Cyclic Intake.)

Introduction

Little information is published concerning the effect of individual or group penning on the performance of feedlot cattle. Garrett (1987) reported that individually fed steers in two trials had 7.4% higher daily gains despite 6.3% greater dry matter intakes than group fed steers. Feed efficiency was improved by 1% by individual feeding. Garrett also noted that the maintenance requirement of individually fed steers was reduced by 1.7%. This lower maintenance requirement possibly is the result of less activity which could be due to lack of competition, no drive or need to establish a peck order or other environmental factors associated with differences between pen types (Garrett, 1987). Perhaps other environmental differences existed as well. If individual feeding does not alter animal performance, fewer head could be used in feeding trials without loss in statistical precision. The objective of this experiment was to compare the performance of individually fed steers and group fed steers.

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[1]Graduate Student [2]Regents Professor

Materials and Methods

A group of 17 English crossbred yearling steers were weighed individually and implanted with Synovex-S on October 28, 1987. Four of the steers were fed individually in 30 x 8 feet pens. The remaining steers were divided into three pens of three head and one pen of four head and fed in 30 x 8 feet pens. One steer in one of the pens of three was removed from the experiment at 50 days due to injury. Each pen had slatted floors and was partially covered.

All steers were ad libitum fed a dry rolled corn concentrate ration twice daily for the entire 85-day trial. The amount of feed offered was not allowed to increase by more than 2 lb/head each day to avoid acidosis. Roughage content of the diet (dehydrated alfalfa pellets and cottonseed hulls) was decreased sequentially in four steps until steers were on the final 91% concentrate diet at 28 days (Table 1). Every morning the amount of residual feed in the bunks from the previous day was weighed so that daily intakes could be calculated.

The individually fed steers were slaughtered on day 83 at the Oklahoma State University Meats Laboratory. Group fed steers were slaughtered at a

Table 1. Ration composition, dry matter basis.[a]

Ingredient	Ration sequence 1	2	3	4	5[a]
			%		
Corn, dry rolled	39.3	49.7	59.5	69.7	80.9
Cottonseed hulls	25.4	20.3	15.3	10.2	5.0
Alfalfa, dehy-pellets	25.4	20.3	15.3	10.2	4.0
Cane molasses	3.5	3.5	3.5	3.5	3.5
Pelleted supplement	6.5	6.5	6.5	6.5	6.5
		Supplement composition, % of DM			
Cottonseed meal			2.01		
Soybean meal			2.85		
Calcium carbonate			.80		
Salt			.30		
Urea			.40		
Dicalcium phosphate			.07		
Vitamin A, 30000 IU/g			.01		
Vitamin E			.01		
Monensin, 60 g/lb			.02		
Tylan, 40 g/lb			.01		
Trace mineral			.01		

[a]Formulated to contain 94.7 mcal NEm/cwt, 61.0 mcal NEg/cwt, 12.3% crude protein, .69% potassium, .45% calcium and .31% phosphorus.

commercial packing plant in Booker, TX on day 85. The data were analyzed using a general linear model with type of feeding (individual vs. group) as a main effect. Initial weight was included as a covariate in the model.

Results and Discussion

Gains and performance of both individual and group fed steers were excellent (Table 2). Daily gains were greater for group fed steers throughout the feeding period. Daily gains over the entire trial were reduced slightly (6.3%) with individual feeding (4.57 vs. 4.88 lb/day, P=.22). Daily dry matter intake was 5.6% lower with individual feeding (22.5 vs. 23.9 lb/day, P=.14). Feed efficiency was reduced by only 2% with individual feeding (4.98 vs. 4.88 lb DM/lb gain, P=.72). The poorer performance of the individually fed steers could possibly be due to lack of competition, although results of my study are not conslusive due to the low number of animals. We anticipated much lower intakes and gain for animals in a non-competitive environment.

Carcass characteristics of these steers are presented in Table 3. Fat thickness over the twelfth rib (P<.10) and marbling scores (P<.05) were greater for individually fed steers. While rib eye area (P=.10), USDA yield grade (P<.05) and cutability (P<.05) were greater for group fed steers. All

Table 2. Effect of group feeding on performance (Least squares means).

Item	Individual	Group
No. of pens	4	4
No. of head	4	13
Weight, lb		
Initial (actual pen means)	886	850
Initial	868	868
Day 42	1083	1102
Final[a]	1258	1300
Daily gain, lb		
0-42 days	4.90	5.34
43-slaughter	4.21	4.43
0-slaugher	4.57	4.88
DM intake, lb/day		
0-42 days	20.70	21.17
43-slaughter	23.16	24.80
0-slaughter	22.53	23.87
Feed/gain		
0-42 days	4.23	3.95
43-slaughter	5.60	5.59
0-slaughter	4.98	4.88

[a]83 days for individuals and 85 days for group fed.

Table 3. Effect of group feeding on carcass characteristics (Least squares means).

Item	Individual	Group
Carcass weight, lb	756	769
Dressing percent	62.88	61.57
Rib eye area, sq in	12.04	13.39
KPH, %	2.06	1.77
Fat thickness, in	.50[d]	.38[c]
Marbling score	16.18[b]	12.46[a]
Percent choice	100.0	64.6
USDA yield grade	3.20[b]	2.45[a]
Cutability, %	49.34[a]	51.07[b]

[a,b]Means in the same row with different superscripts differ ($P<.05$).
[c,d]Means in the same row with different superscripts differ ($P<.10$).

of the individually fed steers graded choice, whereas only 65% (8 head) of the group fed steers graded choice. With this limited number of animals, it is difficult to draw conclusions regarding carcass characteristics, but performance and intake patterns remain of interest.

Plots of dry matter intake vs days on feed for individually and group fed animals are illustrated in Figures 1 and 2. Considerable day to day fluctuation in intake was apparent for both individual and group fed steers. Coefficients of variation (CV) for daily feed intake for the individually fed steers were 18.9, 23.4 23.4 and 28.9%. Whereas, for the group fed steers pen CV were 14.7, 15.1, 11.9 and 20.5%. Mean CV for individually and group fed steers were 23.6 and 15.6% ($P=.07$). In typical feeding trials with eight to ten head per pen, variation generally is much less. With more head per pen, day to day variation presumably is reduced because different animals are on different points of a cyclic intake pattern (Stroup et al., 1987). An extreme drop in intake occurred at about day 50 (Dec. 16) in individually fed steers which can be attributed to cold, snowy weather. In contrast, intakes of the group fed pens were not appreciably altered at this time. With both individually and group fed steers, intake often climbed continuously for about 10 days followed by a decline for about five days and then was followed by another climbing period. This slow increase may be due to our imposed limits on increases in intake to no more than 2 lb/day. Hence, intake might have shown less day to day variation if animals would have had unlimited access to feed at all times. More cyclic intake patterns may be due partially to subacute acidosis (Britton and Stock, 1987).

Presumably, a constant energy intake would lead to more efficient production because the waste of fluctuating metabolism would be reduced. Fluctating energy intake also would be expected to increase the likelihood of

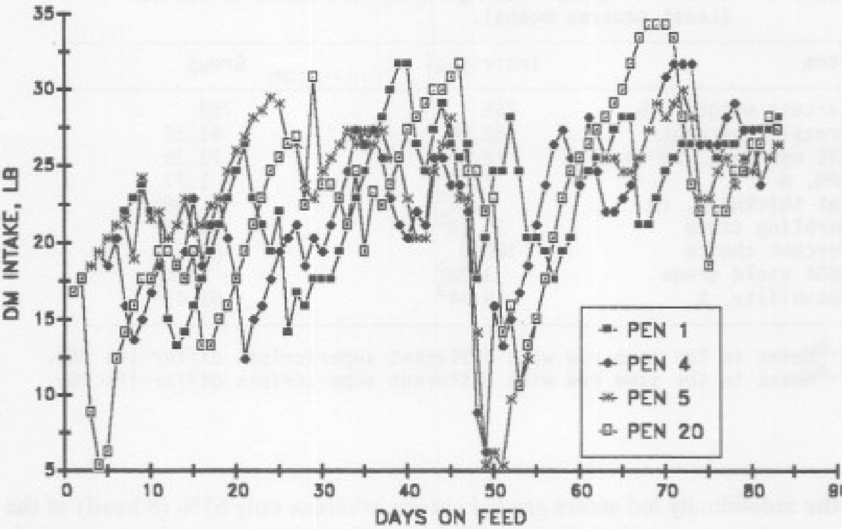

Figure 1. Dry matter intake versus days on feed for individually fed steers.

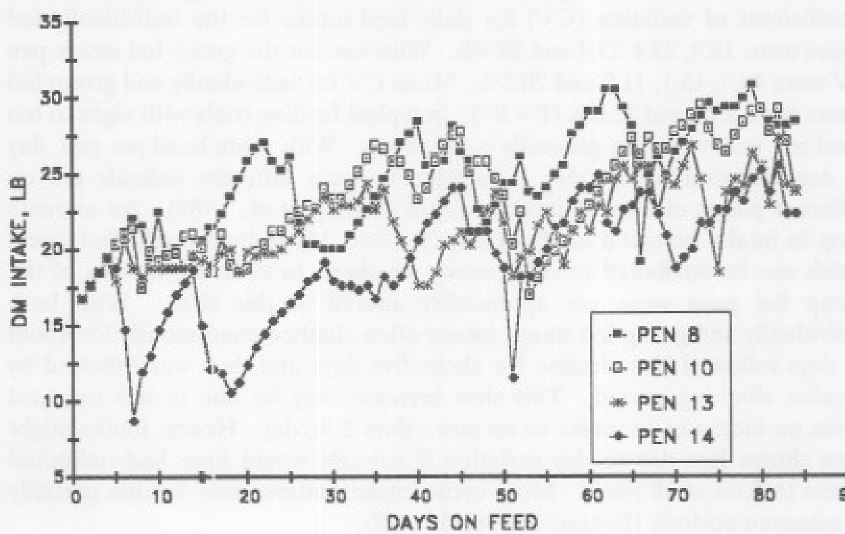

Figure 2. Dry matter intake versus days on feed for group fed steers.

acidosis and metabolic disorders. Regular feeding practices, as noted with limit feeding, may increase energetic efficiency by reducing these fluctuations.

In conclusion, lack of competition or companionship among steers in a pen did not markedly reduce gain or feed intake matching results from one previous study (Garrett, 1987). These results disagree with the concept that most workers stress that competition in the feedlot has large practical importance in feeding trials with cattle (Maynard and Loosli, 1969). Day to day variation in intake of steers was 16 to 24% with one to four steers per pen. These values are larger than would be observed in feedlot pens due to the low number of animals, but similar individual variation might be expected. If daily variation were reduced, efficiency of gain and marbling score might increase and external fat might decrease. Comparison of carcass characteristions of cattle with constant versus fluctuating fixed intake levels requires further study.

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EFFECT OF LIMIT FEEDING ON PERFORMANCE OF FEEDLOT STEERS

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Story in Brief

Twelve crossbred yearling steers (877 lb) were used to determine the effect of two different methods of limit feeding on feedlot performance. Steers were fed a high corn diet either ad libitum, 95% of ad libitum or had limited time of access to feed each day (2 hours). Daily feed intakes over the 85 day trial were 23.16, 22.65 and 21.50 lb/day for ad libitum, 95% and time limited steers, respectively. Daily gains and feed efficiency were not altered with either method of limit feeding. The percentage of steers grading choice was reduced from 100% to 50% with limit feeding. Dressing percentage and carcass weight were also reduced with limit feeding (63.1 vs 59.6% and 773 vs 737 lb). Steers with limited time of access to feed never adjusted to the feeding regime and exhibited considerable day to day fluctuation in feed intake over the entire trial.

(Key Words: Feedlot Steers, Limit Feeding, Individually Fed, Feed Intake.)

Introduction

Several recent studies have reported that feed efficiency of feedlot cattle can be improved by controlling or limiting feed intake. Most of these studies have controlled intake by feeding certain pens of cattle a specific percentage of the feed consumed by pens of cattle with ad libitum access to feed. This approach to controlled feeding has been shown to increase feed efficiency by around 5% (Lofgreen, 1969; Plegge et al., 1985, 1986; Hicks et al., 1987) in several trials, whereas in other trials efficiency was not altered or was decreased by approximately 1% (Davis et al., 1973; Lofgreen et al., 1983). The optimum level of restriction appears to be in the range of 90 to 95% of ad libitum. Another approach to controlled feeding is to limit time of access to feed. Garrett (1979) limited time of access to feed to a 16 hour period which reduced feed intake by 6.7%, daily gain by 7.6% and feed efficiency by

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1.3% as compared to ad libitum access to feed. The objective of this experiment was to determine the effect of limiting intake by pair feeding and by limiting time of access to feed on the performance of individually fed steers. An additional objective was to determine if steers could be trained to finish their feed in a short period of time.

Materials and Methods

A group of 12 English crossbred yearling steers were weighed individually and implanted with Synovex-S on October 28, 1987. All steers were individually fed in 30 x 8 feet pens. All steers were ad libitum fed twice daily for the first 14 days of the trial. After 14 days, the steers were divided into four blocks of three pens each based on average daily feed intake over the 14 day period. The following three treatments were then randomly assigned to pens: 1) fed ad libitum (AL), 2) pair fed at 95% of ad libitum (LF) and 3) limited time of access to feed to 2 hour/day (TF). In the ad libitum fed pens, intakes were not allowed to increase by more than 2 lb/day. Amounts of feed being offered to cattle being restricted were adjusted weekly based on the previous week's intake of the ad libitum fed pen in that block. Cattle having limited time of access to feed were initially allowed 2 hours access to feed at the morning feeding. However, after 2 weeks this was changed, because of low intakes (failure of steers to adapt to program), to 1 hour of access at both morning and evening feedings.

All steers were fed a dry rolled corn high concentrate ration for the 83 to 85 day trial. Roughage content of the diet (dehydrated alfalfa pellets and cottonseed hulls) was decreased sequentially in four steps until steers were on the final 91% concentrate diet at 28 days (Table 1). Every morning the amount of feed remaining in the bunks from the previous day was recorded so that actual daily intakes could be measured.

The ad libitum fed steers were slaughtered on day 83 at the Oklahoma State University Meats Laboratory. The remaining steers were slaughtered at a commercial packing plant in Booker, TX on day 85. The data were analyzed using a general linear model with type of feeding (ad libitum, limit fed or timed feeding) and block as main effects. Initial weight was included as a covariate in the model. Orthogonal comparisons included ad libitum vs the mean of the two limited intake treatments and pair fed vs time limited.

Results and Discussion

The effects of limit feeding on steer performance are reported in Table 2. Daily gains over the entire trial were similar for all treatment groups

Table 1. Ration composition, dry matter basis.[a]

Ingredient	Ration sequence 1	2	3	4	5[a]
	---------------------	---------	%	---------	---------------------
Corn, dry rolled	39.3	49.7	59.5	69.7	80.9
Cottonseed hulls	25.4	20.3	15.3	10.2	5.0
Alfalfa, dehy-pellets	25.4	20.3	15.3	10.2	4.0
Cane molasses	3.5	3.5	3.5	3.5	3.5
Pelleted supplement	6.5	6.5	6.50	6.5	6.5
		Supplement composition, % of DM			
Cottonseed meal			2.01		
Soybean meal			2.85		
Calcium carbonate			.80		
Salt			.30		
Urea			.40		
Dicalcium phosphate			.07		
Vitamin A, 30000 IU/g			.01		
Vitamin E			.01		
Monensin, 60 g/lb			.02		
Tylan, 40 g/lb			.01		
Trace mineral			.01		

[a]Formulated to contain 94.7 mcal NEm/cwt, 61.0 mcal NEg/cwt, 12.3% crude protein, .69% potassium, .45% calcium and .31% phosphorus.

Table 2. Effect of limit feeding on performance (Least square means).

Item	Ad lib	Limit fed	Timed
No. of pens	4	4	4
Weight, lb			
Initial (raw means)	886	858	886
Initial	877	877	877
Final[a]	1277	1286	1296
Daily gain, lb			
0-42 days	5.17	4.71	4.63
43-slaughter	4.20	4.54	4.84
14-slaughter	5.06	4.52	4.54
0-slaugher	4.69	4.63	4.74
DM intake, lb/day			
0-42 days	21.69[c]	19.91[b]	17.19[a]
43-slaughter	23.40	23.96	23.67
14-slaughter	24.18	23.49	21.89
0-slaughter	23.16	22.65	21.50
Feed/gain			
0-42 days	4.18[b]	4.40[b]	3.49[a]
43-slaughter	5.69	5.31	4.96
14-slaughter	4.85	5.25	4.86
0-slaughter	4.97	4.92	4.48

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

(4.69, 4.63 and 4.74 lb/day for AL, LF and TF groups, respectively). However, over the actual restricted period of the trial (14 day to slaughter) gains were reduced by 10.5% by limit feeding (5.06, 4.52 and 4.54 lb/day for AL, LF and TF, respectively). Daily dry matter intake over the entire trial was 97.8% of ad libitum for the LF group and 92.8% of ad libitum for the TF group. Feed efficiency over the entire trial was unaltered in the LF group but was improved by 9.9% by limiting time of access to feed (4.97, 4.92 and 4.48 lb DM/lb gain for AL, LF and TF, respectively). Zinn (1987) postulated that limit feeding improves feed efficiency by minimizing day to day variation in feed intake. Reducing day to day variation in intake conceivably could reduce the incidence of lactic acidosis. Day to day variation in intake was reduced with pair feeding but was increased with limited time of access to feed. The coefficients of variation for mean daily feed intake were 23.50%, 15.69% and 30.97% for AL, LF and TF groups, respectively.

Plots of dry matter intake vs days on feed for AL, LF and TF steers are illustrated in Figures 1, 2 and 3. The steers with limited time of access to feed never adjusted to this feeding regime as is illustrated by the considerable day to day fluctuation in intake. This might partially be attributed to subacute acidosis (Britton and Stock, 1987). The day to day fluctuation was obviously less with pair feeding but these steers still showed some fluctuation since they failed to consume their allotted amounts of feed at times.

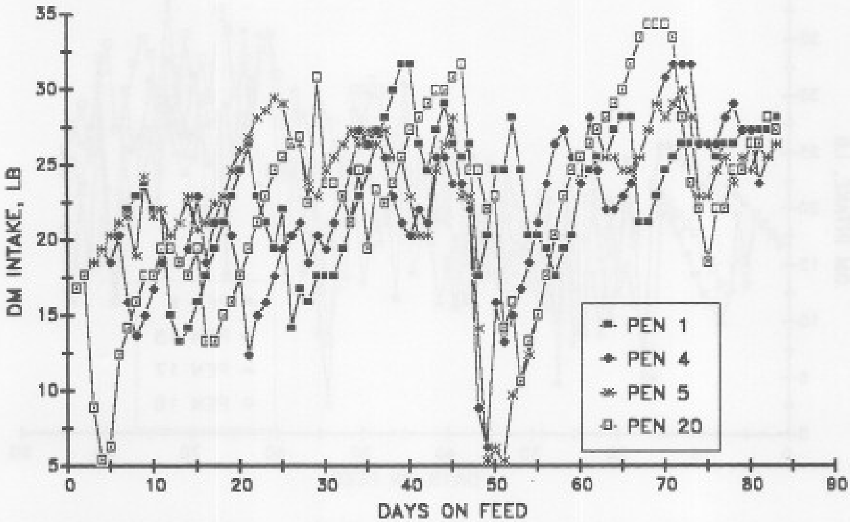

Figure 1. Dry matter intake vs days on feed for ad libiutm fed steers.

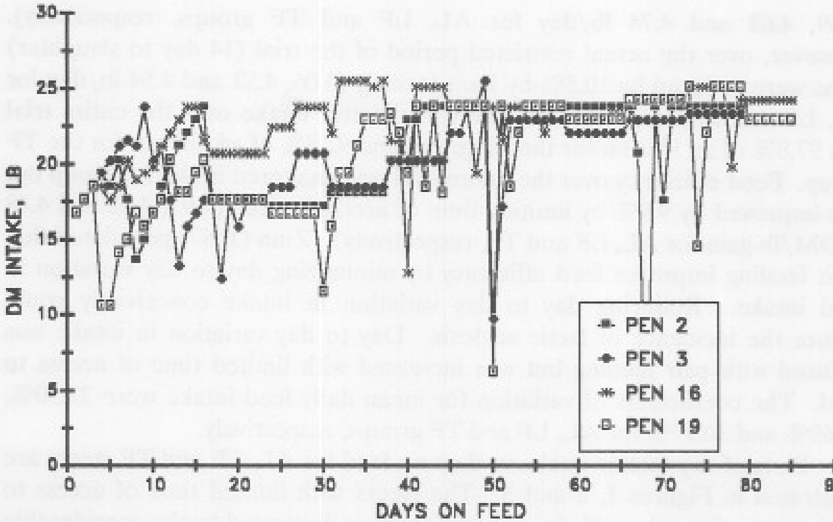

Figure 2. Dry matter intake vs days on feed for steers fed 95% of ad libitum.

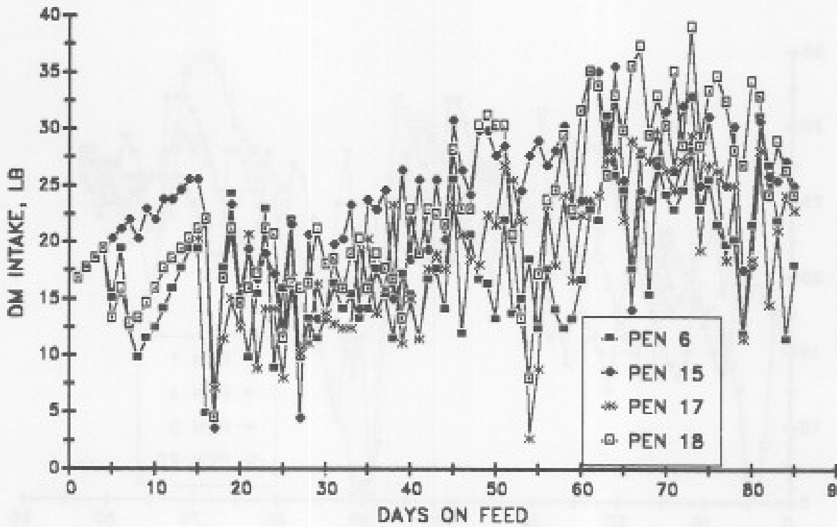

Figure 3. Dry matter intake vs days on feed for steers with limited time of access to feed.

Information showing the variation which occurred in intake for each steer is presented in Table 3.

Carcass characteristics of these steers are presented in Table 4. Carcass weight was reduced with limit feeding (773 vs 737 lb, P=.11). Dressing percentage also was reduced with limit feeding (63.1 vs 59.6%, P=.07). The percentage of steers grading choice was reduced with limit feeding from 100% to 50% (P=.07). Similar trends with limit feeding also were noted in earlier Oklahoma trials (Hicks et al., 1987, 1988).

Table 3. Maximum, minimum, means and standard deviations for daily intake for individual steers.

Steer group	Minimum[a]	Maximum[a]	Mean[a]	Std.dev.[a]	CV[b]
Ad libitum fed steers:					
Pen 1	13.18	31.64	22.85	4.31	18.86
Pen 4	6.15	31.64	21.83	5.10	23.36
Pen 5	5.27	29.88	22.91	5.35	23.35
Pen 20	5.27	34.28	22.48	6.50	28.91
Pair fed steers:					
Pen 2	2.64	24.17	20.87	3.64	17.44
Pen 3	9.67	25.49	20.61	2.94	14.26
Pen 16	12.74	25.49	22.64	2.40	10.60
Pen 19	6.15	25.05	20.33	3.96	19.48
Time limited steers:					
Pen 6	4.39	31.20	17.43	5.56	31.90
Pen 15	3.52	35.60	23.17	6.12	26.41
Pen 17	2.64	29.88	19.17	6.38	33.28
Pen 18	4.39	39.11	22.81	7.48	32.79

[a]Pounds of dry matter.
[b]Coefficient of variation.

Table 4. Effect of limit feeding on carcass characteristics (Least square means).

Item	Ad lib	Limit fed	Timed
Carcass weight, lb	773	742	732
Dressing percent	63.1	60.2	58.9
Rib eye area, sq in	12.18	13.15	12.28
KPH, %	1.96	1.90	1.90
Fat thickness, in	.44	.52	.31
Marbling score	17.60	12.64	12.13
Percent choice	100.0	75.0	25.0
USDA yield grade	3.14	2.82	2.53
Cutability, %	49.69	50.32	51.03

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EFFECT OF SEASON ON THE MAINTENANCE ENERGY REQUIREMENTS OF FEEDLOT STEERS

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Story in Brief

Apparent daily maintenance energy requirements for feedlot steers received in the Oklahoma Panhandle in the spring, summer, fall and winter seasons were 45.2, 49.2, 49.8 and 47.4 kcal/weight,lb$^{.75}$, respectively. Both heat and cold stress appeared to cause an increase in maintenance energy requirements.

(Key Words: Feedlot, Steers, Maintenance Requirements, Climate.)

Introduction

Climate (season, temperature) influences maintenance energy requirements of cattle (NRC, 1981). The maintenance energy requirement most consistently relates to impact from cold (Johnson, 1986). Field studies generally indicate that maintenance energy requirements increase from 1 to 1.5% per effective ambient temperature (EAT) unit below approximately 20°C (Johnson, 1986). The NRC (1976, 1984) estimates the maintenance requirement as: NEm (kcal/day) = 42.6 (mean weight, lb)$^{.75}$. Johnson (1986) reviewed feedlot data from Canada, Colorado, Iowa and Minnesota and suggested the following adjustment for cold temperatures: NEm = [42.6 + .637(20 - °C)]$W_{lb}^{.75}$. The purpose of this study was to look at the effect of climate or season on maintenance energy requirements of feedlot steers fed in western Oklahoma.

Materials and Methods

Weekly dry matter intake (DMI) records were obtained from a large feedlot in western Oklahoma for all pens of cattle marketed between January, 1983, and December, 1985. Excluding dairy steers and beef heifers,

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this represented 2,051 pens of steers. These were primarily steers of British breeding, usually crossbred with a small portion of steers with detectable Brahman breeding (238 pens). Most cattle had been purchased from western Oklahoma and the Texas Panhandle. Most were yearlings when started on feed and were fed for 114 to 165 days. DMI for this three year period are based on a total of 296,367 cattle or a mean of 145 steers per pen.

Data available for each set of cattle included feedlot purchase weight, initial feedlot arrival weight, final weight and number of days on feed. The data was divided into the following four receiving seasons (season that cattle were received in yard) such that each season would have a nearly equal number of days: January 29 through April 30 (92 days), May 1 through July 30 (91 days), July 31 through October 29 (91 days) and October 30 through January 28 (91 days). The number of pens received in each of these seasons were 604 (90,972 hd), 416 (56,543 hd), 585 (84,855 hd) and 445 (63,997 hd). Mean monthly temperatures for this three year period (1983-1985) were obtained from the weather station at Hooker, OK.

Since daily gain was known for each pen, it was possible to calculate the net energy for gain requirements (NEg) for each pen. The amount of daily feed intake used in meeting the NEg requirement was then calculated. By difference, the amount of feed left to meet maintenance requirements was determined. Assuming the net energy gain equations are correct, apparent NEm requirements for each season were then calculated. Apparent NEm requirements (kcal/$W_{lb}^{.75}$) were calculated using both the 1976 and 1984 NRC NEg equations. For steers weighing less than 574 lb the 1976 NRC steer calf equation or the 1984 NRC medium-frame calf equation were used. For steers weighing more than 574 lb, the yearling steer equation of Lofgreen (1977) or the 1984 NRC large-frame yearling equation were used.

Results and Discussion

The effects of season or climate on maintenance energy requirements are shown in Table 1. In all seasons, apparent maintenance energy requirement was greater than the base of 42.6 kcal/W,$lb^{.75}$ suggested by the NRC (1976, 1984). The maintenance requirements for steers fed over the spring, summer, fall and winter months were 45.2, 49.2, 49.8 and 47.4 kcal/weight,$lb^{.75}$, respectively using the NRC (1976) equations. This analysis indicates little effect of season on maintenance energy requirements. Maintenance energy requirements tended to be greatest for steers fed during the summer months and fall months. This data suggests that both cold and heat stress cause maintenance requirements to increase. Differences in apparent maintenance energy requirements between seasons in this Oklahoma feedlot and those suggested by Johnson (1986) could possibly be

Table 1. Effect of season on maintenance energy requirements.

Season received	Average period fed[a]	Initial wt, lb	Avg. temp, °F	Avg. range temp, °F	DMI lb	ADG lb	Apparent NEm[b]			
							76	std.err.	84	86
Jan 29 - Apr 30	Mar 15 - Aug 3	693	66.2	32.1 - 59.9	20.31	3.17	45.2	.565	47.6	43.3
May 01 - Jul 30	Jun 15 - Nov 4	706	72.0	58.3 - 87.4	20.31	3.04	49.2	.563	50.9	41.2
Jul 31 - Oct 29	Sep 15 - Feb 1	697	45.3	54.3 - 82.9	20.57	2.95	49.8	.564	50.9	50.6
Oct 30 - Jan 28	Dec 15 - May 5	693	42.8	24.0 - 49.8	20.13	2.97	47.4	.567	49.3	51.5

[a]140 days

[b]76: Calculated using NRC (1976) and Lofgreen (1977) NEg equations.
84: Calculated using NRC (1984) NEg equations.
86: Calculated using Johnson (1986) equation which adjust NEm requirement based on temperature.

attributed to hotter summers and moderate winters in Oklahoma as opposed to the data base from which Johnson developed his equation (Canada, Colorado, Iowa and Minnesota).

There are two major ways by which season or climate influences maintenance energy requirements of cattle: first, that due to acclimatization as a consequence of prolonged exposure to a thermal environment, and second, that due to an immediate increase in heat production necessary for maintenance of homeothermy when the animal is exposed to an acute heat or cold stress. Season could also influence maintenance energy requirements by altering animal activity or behavior. However, it is doubtful that animal activity was altered to any degree by season. Hoffman and Self (1973) in an Iowa study reported no difference in time spent eating or lying for feedlot steers fed in summer or winter. However, time spent drinking tended to be greater in summer than winter. Similar effects of season on behavior of feedlot cattle was also noted by Ray and Roubicek (1971).

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IMPACT OF LIVER FLUKES ON THE PERFORMANCE OF FEEDLOT STEERS

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Story in Brief

In a recent feeding trial, 101 out of 317 steers were found at slaughter to have liver flukes. Steers with liver flukes gained 5.9% slower than steers without flukes over a 135 day feeding period (3.39 vs 3.19 lb/day). Regression equations to predict daily gain, dry matter intake and feed efficiency utilizing initial weight and incidence of flukes (% of steers/pen with flukes) as input factors were developed. For each 10% increase in incidence of flukes, daily gain decreased by .028 lb/day and dry matter intake decreased by .151 lb/day. However, feed efficiency was not altered by the presence of flukes.

(Key Words: Feedlot, Steers, Liver Flukes.)

Introduction

Liver flukes are being detected at slaughter in a sizeable number of feedlot cattle fed in high plains feedlots. In a private study done for the Hitch Feedlots in 1984 and 1985, 1,045 of 31,817 head had evidence of fluke infection present at slaughter (3.28%). The incidence in different lots ranged from 0 to 34%. In a recent Oklahoma experiment, flukes were detected in 26 out of 140 head (Hicks et al., 1987). Steers with flukes gained 8.8% slower than steers without flukes over a 119 day period in this experiment. Australian workers (Chick et al., 1980) reported that gains were reduced by 14.4% in grazing steers artificially injected with flukes. This paper on liver flukes resulted from the detection of flukes in 32% of the cattle in a feeding trial. With this proportion of cattle harboring flukes, it was possible to statistically analyze the effect of liver flukes on the performance of feedlot steers.

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Materials and Methods

Liver flukes were discovered at slaughter in 101 of 317 feedlot steers used in the evaluation of virginiamycin. Because of individual identification, it was possible to analyze for effects of flukes. Livers were examined for abscesses and presence of liver flukes at slaughter and carcass data obtained 24 hours postmortem. The data was analyzed using a general linear model with treatment, fluke, and weight replicate as main effects.

Results and Discussion

The presence of liver flukes reduced daily gains during all phases of the feeding period (Table 1). This contrasts with the results of the previous study (Hicks et al., 1987) in which steers with flukes appeared to make compensatory gains during the last 28 days on feed. On a carcass adjusted basis, daily gains were reduced by 5.9% (P<.001) in steers with flukes (3.39 vs 3.19 lb).

Mean carcass weight was 19 lb lower (P<.001) in steers with flukes (Table 2) as would be expected due to the reduction in gain. Ribeye area

Table 1. Effect of liver flukes on steer performance.

	Absence	Presence
Number of steers	216	101
Weight, lb*		
Starting	690	690
56 days	935[b]	917[a]
Daily gains, lb*		
0-28	3.80[d]	3.46[c]
29-56	3.44[d]	3.19[c]
57-84	3.12[f]	2.96[e]
85-112	2.95[d]	2.77[c]
113-slaughter	2.48[d]	2.18[c]
0-56	3.63[b]	3.32[a]
57-slaughter	2.95[b]	2.75[a]
0-slaughter, live	3.21[b]	2.97[a]
0-slaughter, carcass[g]	3.39[b]	3.19[c]

*Expressed as least square means.
[a,b]Means with different superscripts differ (P<.001).
[c,d]Means with different superscripts differ (P<.05).
[e,f]Means with different superscripts differ (P<.10).
[g]Based on carcass weight divided by .6332, actual mean dressing percent.

Table 2. Effect of liver flukes on carcass parameters.*

	Absence	Presence
Carcass wt, lb	736[b]	717[a]
Dressing %	63.2[c]	63.5[d]
Rib eye area, sq in	12.23[d]	11.99[c]
KHP, %	1.94	1.97
Fat thickness, in	.55	.53
Marbling score	435	452
Percent choice	69.3	76.9
Yield grade	3.25	3.25
Percent YG 4	15.7	11.1

*All values expressed as least square means.
a,b Means with different superscripts differ (P<.001).
c,d Means with different superscripts differ (P<.10).

was also reduced (P<.10) in steers with flukes (11.23 vs 11.99 sq in). However, steers with flukes tended to have a greater degree of marbling (P=.104) with more carcasses grading choice (76.9 vs 69.3%, P=.17). Similar trends were noted in the previous trial (Hicks et al., 1987).

These data show that the presence of liver flukes can severely reduce performance of feedlot cattle. However, there are no data available on the effect of flukes on feed efficiency. In this experiment, the incidence of steers with flukes in each of the 40 pens ranged from 0 to 75%. Thus it was possible to develop regression equations to predict daily gain, dry matter intake and feed efficiency utilizing initial weight and incidence of flukes as input factors. As expected, pen daily gains were reduced as incidence of flukes increased (P<.05). For each 10% increase in incidence of flukes, daily gain decreased by .028 lb/day. DM intake also decreased as incidence of flukes increased (P<.05). For each 10% increase in incidence of flukes, DM intake decreased by .151 lb/day. However, feed efficiency was not altered by the presence of flukes.

In Table 3, predicted daily gain, DM intake and feed efficiency for steers initially weighing 690 lb with different incidences of steers with flukes (0 to 100%) are shown. Returns per head are also shown. The following assumptions were made in calculating returns: purchase cost of $81/cwt; fed 135 days; feed cost of $124/ton DM; yardage fee and feed mark-up of 35 cents/day and selling price of $70/cwt. Predicted gains for 0 and 100% incidence of flukes/pen steers (3.41 and 3.13 lb/day) agree well with observed gains for steers without and with flukes (3.41 and 3.15 lb/day). It would appear that fluke infection reduces returns by about $14/head.

In summary, flukes reduce DM intake causing a reduction in gains without altering feed efficiency.

Table 3. Effect of level of infection on performance.

Incidence of flukes per pen, %	Daily gain, lb[a]	DM intake, lb[b]	Feed/ gain[c]	Return per head, $
0	3.41	19.49	5.70	36.36
12.5	3.38	19.31	5.70	34.62
25	3.34	19.12	5.71	32.89
37.5	3.31	18.93	5.71	31.15
50	3.27	18.74	5.72	29.42
62.5	3.24	18.55	5.72	27.68
75	3.20	18.36	5.72	25.95
87.5	3.17	18.18	5.73	24.21
100	3.13	17.99	5.73	22.48

[a]Predicted by model (R^2=.71).
[b]Predicted by model (R^2=.89).
[c]Calculated from DM intake and daily gain.

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ULTRASOUND AND VISUAL APPRAISAL AS METHODS TO ACCOUNT FOR VARIATION IN PERFORMANCE AND CARCASS PARAMETERS IN FEEDLOT STEERS

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Story in Brief

Ninety six yearling steers of various breed types and initial weights (569 to 820 lb) were used to determine the effectiveness of initial ultrasound measurements and live animal evaluation in explaining variation in feedlot performance over 135- and 149-day feeding periods. Experienced evaluators subjectively scored each steer for condition, capacity, muscle, frame and quality. Backfat and ribeye area were determined by ultrasound at the initiation of the feeding trial. Initial weight, breed type, ultrasound and visual appraisal were used to estimate average daily gain, ribeye area, backfat, marbling and yield grade. In general, subjective evaluation accounted for the least variation in measurements of interest, while the combination of breed, initial weight and ultrasound data explained the most. These result suggest that ultrasonic measurements of initial backfat and ribeye can be useful as a tool to improve the capacity to predict several carcass parameters.

(Key Words: Ultrasound, Visual Appraisal, Feedlot Steers.)

Introduction

As the beef industry moves toward production to meet specifications, the need for more accurate prediction of performance and more uniform products from feedlot cattle increases. Accurate estimates of these characteristics would allow producers to sort cattle into outcome groups to feed to reach a desired endpoint, which ultimately would improve feedlot profitability. Ultrasound technology may be a useful sorting tool. Recent Kansas research suggests that sorting incoming feedlot cattle by hip height and ultrasonic backfat measurement permits one to group cattle for uniform feeding and marketing and to reduce time on feed (Houghton, personal

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communication). In this Kansas study, steers had a uniform genetic makeup and origin. By industry standards, uniformity of incoming feedlot steers is the exception rather than the rule. Therefore, the objective of this study was to determine if ultrasonic measurement of back fat and rib eye area could be used to detect differences in feedlot performance and carcass parameters of typical feedlot steers.

Materials and Methods

The 96 yearling steers of various breeds used in this experiment were part of a feeding trial conducted to determine the effects of virginiamycin, a feed-grade antibiotic, on performance and carcass characteristics of feedlot steers (Smith et al., 1989a). Three weight blocks were used for this study with mean initial weights of 600, 730 and 790 lb. Initial back fat thickness and ribeye area were determined for each steer using real-time ultrasound. Steers were scanned between the twelfth and thirteenth rib with an Aloka 210DX equipped with a 3 megahertz probe. After steers were allocated to pen, two trained evaluators visually appraised each animal for the following parameters: frame, muscle, condition, body capacity and quality. Scores for all parameters were on a scale from one to nine; the mean of these two scores was used for analysis. Muscle score was an estimate of thickness and muscle volume (1=thin, 9=heavy), condition was an assessment of fatness (1=thin, 9=fat), and capacity was an evaluation of potential feed consumption. Frame scores represented an estimate of hip height in relation to age. Each evaluator also scored the steers on overall quality of the individual as a feedlot animal. Ultrasound measurements were missed inadvertently on one steer initially and a second steer was removed during the trial due to injury; therefore, performance and carcass measurements were available for 94 head.

The cattle were slaughtered in two groups; therefore, analysis was conducted within slaughter group. Steers in the two heavier weight blocks were fed a total of 135 days (Kill 1) and those in the lightest weight block (600 lb initial weight) were fed for 149 days (Kill 2). General linear models were developed to account for variation in the following parameters: average daily gain (live and carcass basis), marbling, fat thickness, ribeye area and yield grade. Included in the models were: initial weight (W), breed (B), subjective scores (S) and ultrasonic measurements (U) of back fat and ribeye area. Quadratic terms for continuous variables were also included. Interactions were included in all models except for those with subjective variables. Because only a small number of animals were in the second slaughter group, some models for Kill 2 were not valid due to insufficient degrees of freedom associated with the error term and therefore, results are not presented. Regression equations were generated for each parameter in the two slaughter groups using initial weight with either back fat or ribeye area as independent variables.

Results and Discussion

The models developed were able to account for a fair amount of variation in performance traits. Among steers in slaughter group 1, initial weight and breed (WB), ultrasound (U) or subjective (S) measurements used independent of one another accounted for 15, 6, and 11% of the variation in average daily gain (live basis) respectively (Figure 1). However, when initial weight, breed and ultrasound were used together in the model (WBU), 36% of the variation in average daily gain could be explained. When subjective measures were added (WBUS), 44% of the variation could be explained. When evaluating daily gain on a carcass adjusted basis (Figure 2) similar

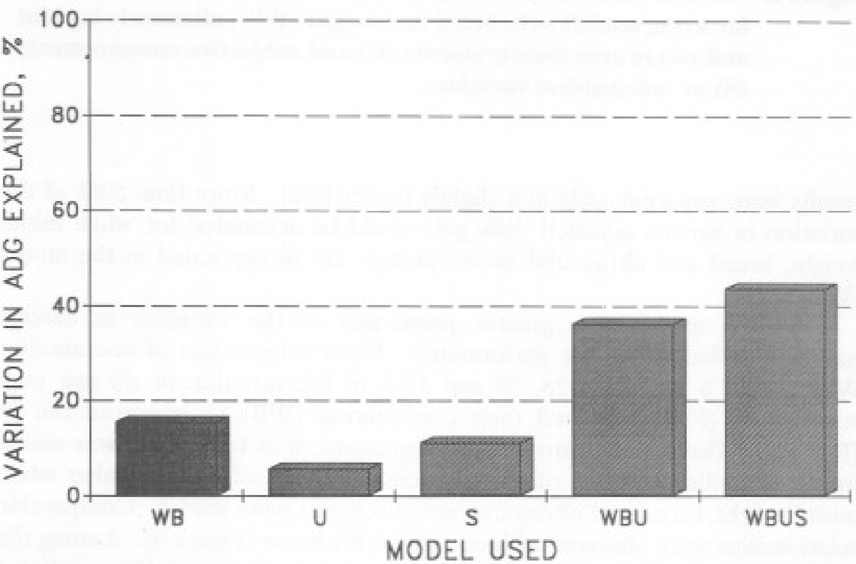

Figure 1. Variation in feedlot average daily gain accounted for using models with breed and weight (WB), ultrasonic backfat and ribeye area measurements (U) and subjective measurements (S) as independent variables.

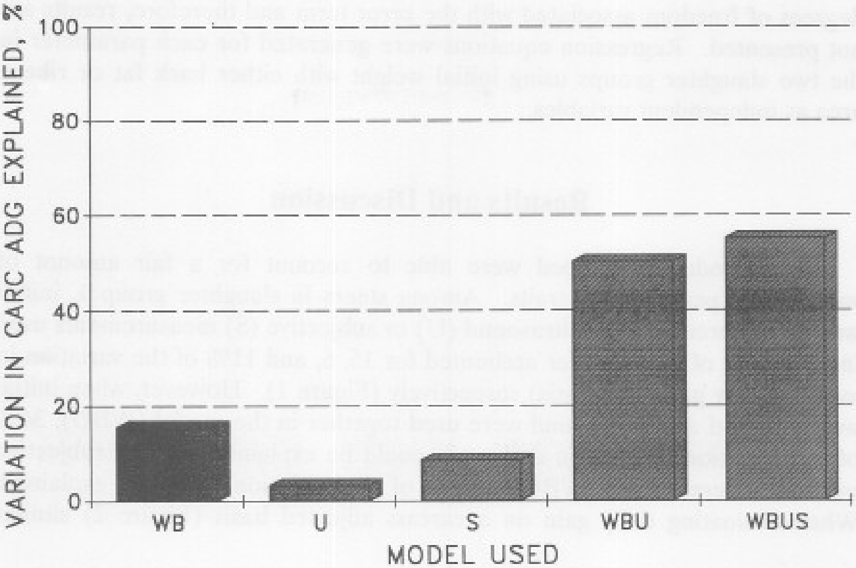

Figure 2. Variation in feedlot average daily gain (carcass basis) accounted for using models with breed and weight (WB), ultrasonic backfat and ribeye area measurements (U) and subjective measurements (S) as independent variables.

results were apparent, only at a slightly higher level. More than 50% of the variation in carcass adjusted daily gain could be accounted for when initial weight, breed and ultrasound measurements are incorporated in the model (WBU).

Models explained a greater proportion of the variation in carcass parameters than in feedlot performance. Used independent of one another WB, U and S explained 28, 30 and 11% of the variation in rib eye area respectively (Figure 3), and their combination (WBUS) improved the fit (R^2=.62). There was relatively little improvement in R^2 when S was added to WBU, indicating that subjective measures were of limited value when initial weight, breed and ultrasound measurements were known. Comparable relationships were observed with carcass fat thickness (Figure 4). Among the individual sources of information, ultrasound measurements (U) predicted carcass fat thickness best (R^2=.45). Similar relationships were observed with numerical yield grade (Figure 5) as fat thickness has the largest impact in estimating cutability. Using all available information (WBUS), 70% of the variation in yield grade was accounted for. Of particular interest is the

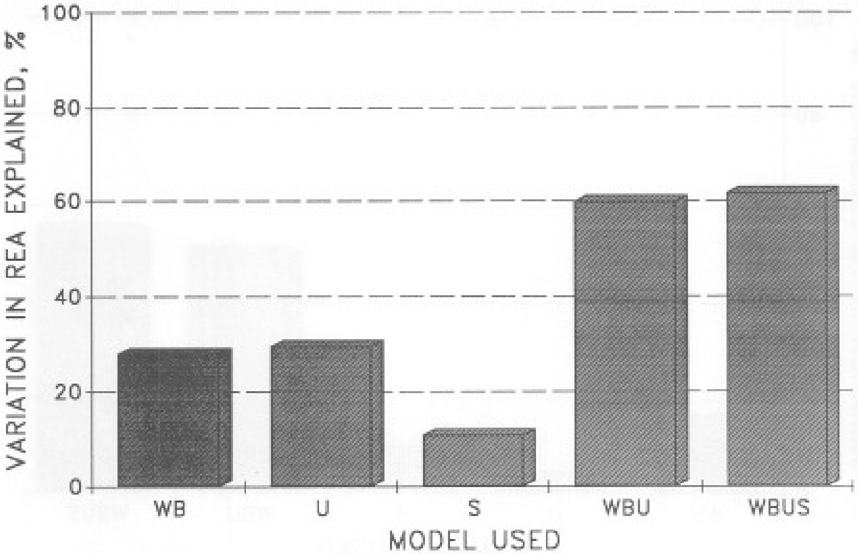

Figure 3. Variation in carcass ribeye area accounted for using models with breed and weight (WB), ultrasonic backfat and ribeye area measurements (U) and subjective measurements (S) as independent variables.

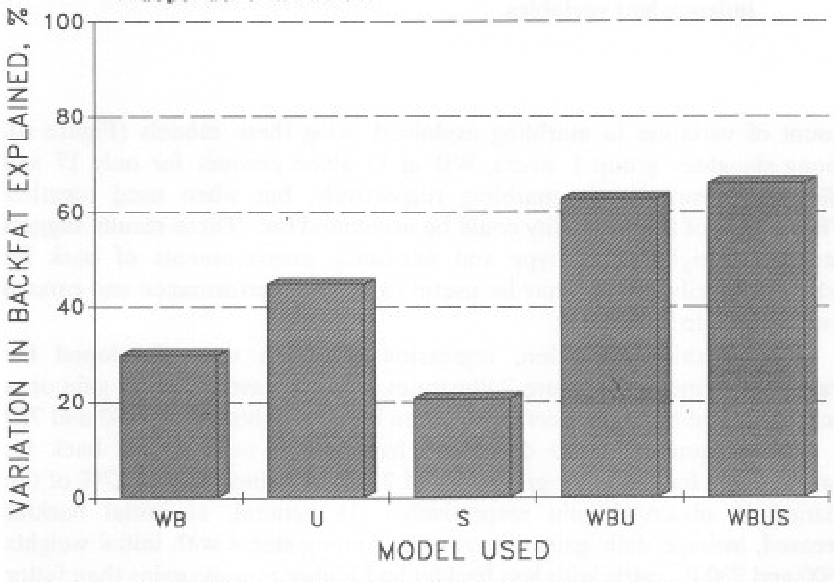

Figure 4. Variation in carcass fat thickness accounted for using models with breed and weight (WB), ultrasonic backfat and ribeye area measurements (U) and subjective measurements (S) as independent variables.

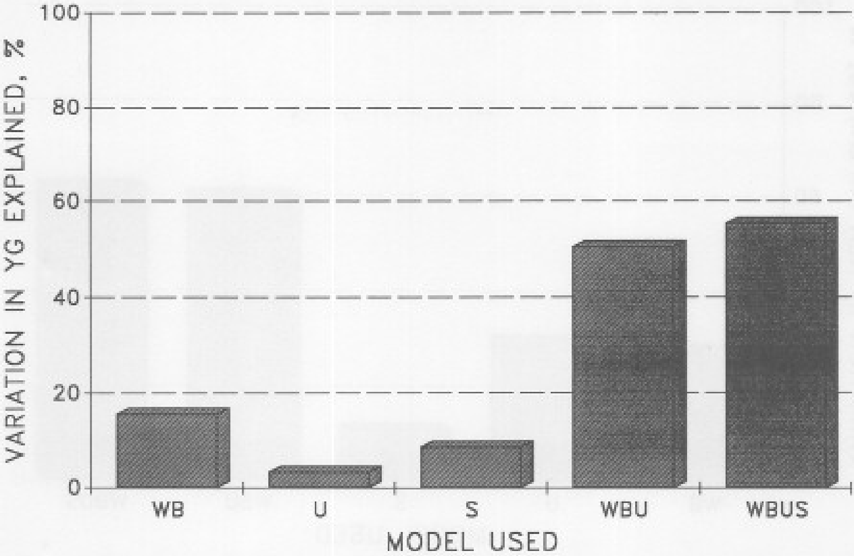

Figure 5. Variation in carcass yield grade accounted for using models with breed and weight (WB), ultrasonic backfat and ribeye area measurements (U) and subjective measurements (S) as independent variables.

amount of variation in marbling explained using these models (Figure 6). Among slaughter group 1 steers, WB or U alone account for only 17 and 14% of the variation in marbling respectively, but when used together (WBU), 58% of the variability could be accounted for. These results suggest that initial weight, breed type and ultrasonic measurements of back fat thickness and ribeye area may be useful to predict performance and carcass parameters of feedlot steers.

To test this assumption, regression equations were developed for parameters of interest. Figure 7 illustrates predicted average daily gain on a carcass adjusted basis for steers with mean initial weights of 600, 730 and 790 lb. These equations were developed from initial weights and back fat measurements for slaughter groups 1 and 2 and explained 15 and 17% of the variation in observed gain respectively. In general, as initial backfat increased, average daily gains decreased. Among steers with initial weights of 600 and 730 lb, cattle with less backfat had higher average gains than fatter animals, suggesting that ultrasonic backfat measurements may be useful in identifying animals with compensatory gain potential or with larger frame size and growth potential.

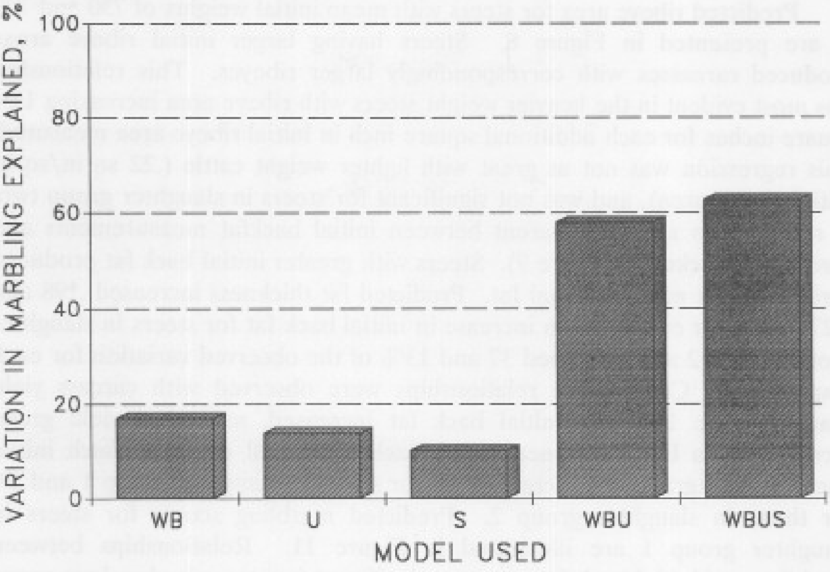

Figure 6. Variation in marbling score accounted for using models with breed and weight (WB), ultrasonic backfat and ribeye area measurements (U) and subjective measurements (S) as independent variables.

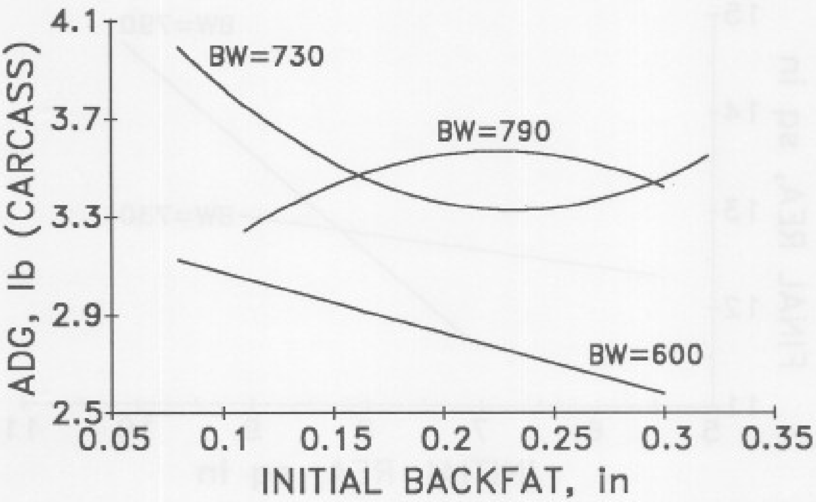

Figure 7. Predicted average daily gain (carcass adjusted basis) versus ultrasonic backfat measurements for steers with mean initial weights of 600, 730 and 790 lb.

Predicted ribeye area for steers with mean initial weights of 730 and 790 lb are presented in Figure 8. Steers having larger initial ribeye areas produced carcasses with correspondingly larger ribeyes. This relationship was most evident in the heavier weight steers with ribeye area increasing 1.04 square inches for each additional square inch in initial ribeye area measured. This regression was not as great with lighter weight cattle (.22 sq in/sq in initial ribeye area), and was not significant for steers in slaughter group two. A relationship also is apparent between initial backfat measurements and carcass fat thickness (Figure 9). Steers with greater initial back fat produced carcasses with more external fat. Predicted fat thickness increased .198 and .127 inches for every .1 inch increase in initial back fat for steers in slaughter groups 1 and 2 and explained 37 and 13% of the observed variation for each respectively. Comparable relationships were observed with carcass yield grade (Figure 10). As initial back fat increased, numerical yield grade increased in a linear manner. With each additional one-tenth inch initial backfat, yield grade was increased .70 for steers in slaughter group 1 and .39 for those in slaughter group 2. Predicted marbling scores for steers in slaughter group 1 are illustrated in Figure 11. Relationships between marbling and initial back fat were not significant for steers in slaughter group 2. In slaughter group 1, however, initial backfat was the only significant variable used in the equation; it accounted for 12% of the variation in

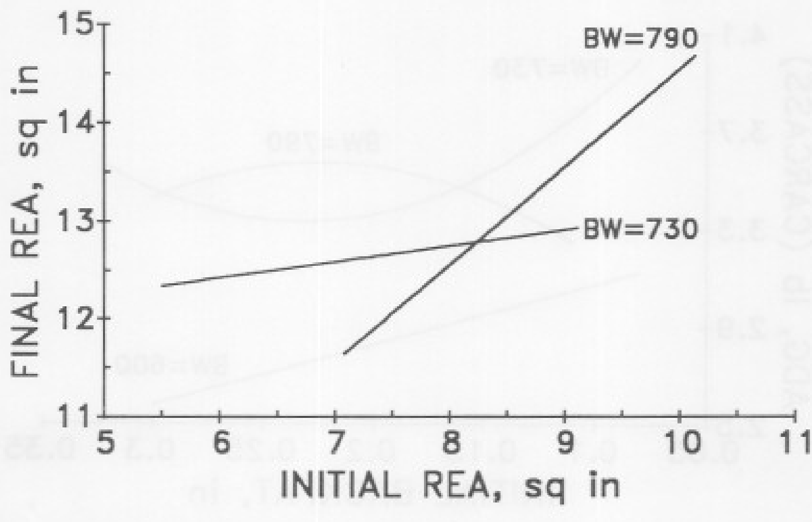

Figure 8. Relationship between predicted carcass ribeye area and ultrasonic ribeye area measurements for steers with mean initial weights of 730 and 790 lb.

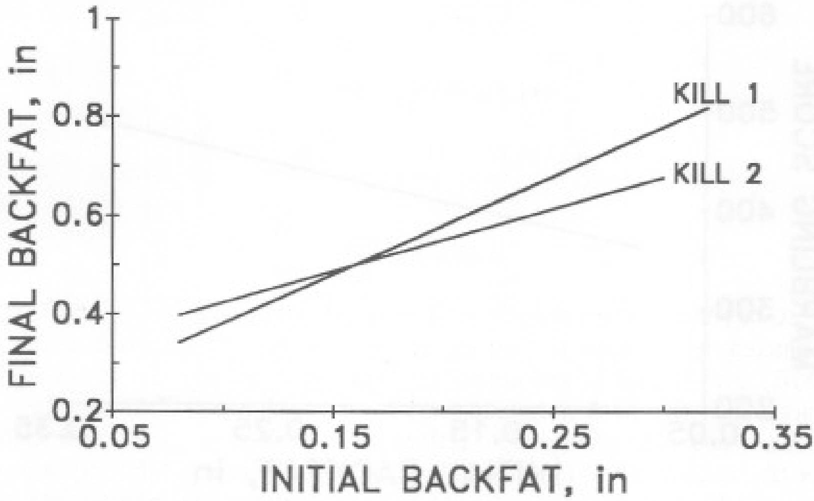

Figure 9. Relationship between predicted carcass fat thickness and ultrasonic backfat measurements for steers fed 135 (Kill 1) and 149 days (Kill 2).

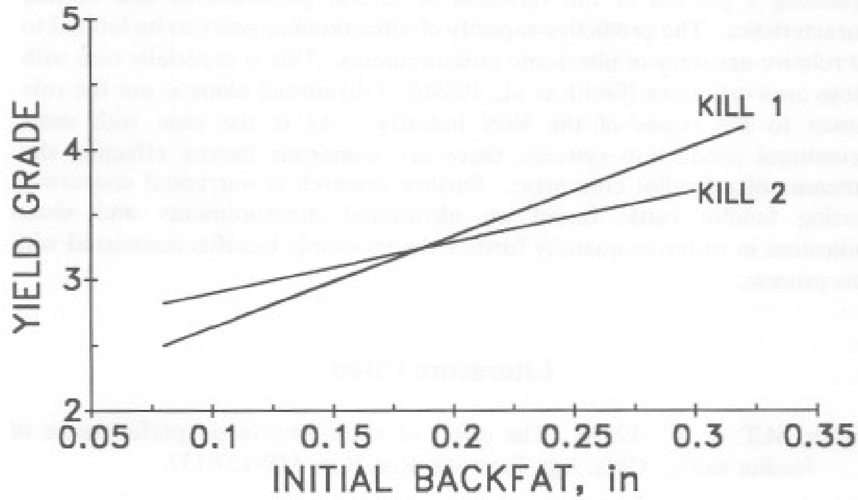

Figure 10. Predicted carcass yield grade versus ultrasonic backfat measuremenfpts for steers fed 135 (Kill 1) and 149 days (Kill 2).

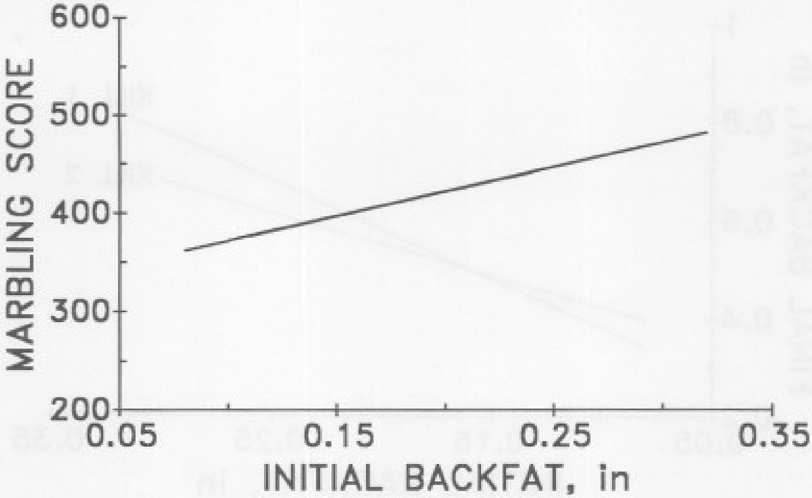

Figure 11. Predicted marbling score versus ultrasonic backfat measurements for steers fed 135 days (Kill 1).

observed marbling score. For this data set, the average steer with greater than .16 of an inch initial backfat graded choice (400 = Small^{00}).

Results of this study demonstrate that ultrasonic measurements of backfat and ribeye area made at the onset of a feeding period are useful in explaining a portion of the variation in several performance and carcass characteristics. The predictive capacity of ultrasound appears to be limited to the relative accuracy of ultrasonic measurements. This is especially true with ribeye area estimates (Smith et al., 1989b). Ultrasound alone is not the sole answer to the needs of the beef industry. As is the case with most agricultural production systems, there are numerous factors effecting the outcome of a feedlot enterprise. Further research is warranted concerning sorting feedlot cattle based on ultrasound measurements and visual indicators in order to quantify further the economic benefits associated with this process.

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THE EFFECT OF VIRGINIAMYCIN ON PERFORMANCE OF FEEDLOT CATTLE

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Story in Brief

Three hundred twenty yearling steers (686 lb) were fed virginiamycin at levels of 0, 10, 17.5 or 25 grams per ton in a feedlot trial. Regardless of level of use, virginiamycin did not alter rate of gain or feed intake. Virginiamycin fed at the 25 gram level improved feed efficiency (2.6%) and tended to decrease the incidence of liver abscesses when compared to steers fed the control ration (9 vs 15%). Virginiamycin tended to increase numerical yield grade of steers slaughtered at similar days on feed. Further testing of this product appears necessary to identify appropriate conditions for its use and optimal feeding level.

(Key Words: Virginiamycin, Feedlot Steers, Antibiotics.)

Introduction

It is widely accepted that the addition of several antimicrobial feed additives to the diets of domestic livestock enhances growth rate and improves feed efficiency. Virginiamycin is currently being tested for commercial use in feedlot cattle. In vitro studies (Nagaraja et al., 1987) have shown virginiamycin to effectively inhibit ruminal lactic acid production. Volatile fatty acid production varied, however, with concentration of virginiamycin. This suggests virginiamycin may be beneficial in improving feedlot performance. Therefore, our objective was to evaluate the performance of feedlot steers fed increasing levels of virginiamycin to determine effectiveness and optimal level of use.

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Materials and Methods

Three hundred twenty head of yearling steers were selected for uniform size and weight from a group of 500 cattle removed from "grazeout" wheat near Dalhart, Texas. Steers were of various breed type and crosses thereof. The cattle were processed April 30 at a commercial feedlot near Dalhart. Processing consisted of IBR-PI3-Lepto, 4-way clostridial vaccination and deworming with Ivermectin. No anabolic implants were administered. The cattle were fed a receiving ration for two days and then trucked approximately 75 miles to the trial site at Goodwell, Oklahoma. Upon arrival, all cattle were individually weighed and offered grass hay and water. The following day, steers were divided into 10 weight blocks of 32 head each. Within each weight block, steers were randomly assigned to one of four treatments (4 pens of 8 steers). A trained evaluator subjectively classified the steers as one of six breed categories (Table 1) and breed type was equalized across treatment. Treatments were virginiamycin (Stafac 10) at levels of 0 (controls) 10, 17.5 and 25 grams/ton. Steers in weight blocks one to seven (224 head) were fed in a separate barn than those in weight blocks eight to ten (96 head).

Steers were allowed ad libitum access to a high concentrate diet (Table 2) for the entire feeding period. Chopped alfalfa hay and cottonseed hulls were used to dilute the ration to 50 percent concentrate in order to facilitate starting the cattle on feed. These roughages were decreased sequentially in four steps until cattle were receiving the final ration by 28 days on feed.

Initial weights were those obtained upon arrival at Goodwell, whereas period weights were taken full on all cattle. Steers in weight blocks one to seven were weighed on days 29, 57, 85 and 113. Remaining steers were weighed the following day. The off test weight for steers in blocks four to ten was day 129. Steers in weight blocks one to three were fed an additional two

Table 1. Breed type classification[a].

Class	Description	Number of steers	Example
1	Straight-bred British	63	Hereford
2	Cross-bred British	73	Hereford X Angus
3	British X Continental	52	Hereford X Limousin
4	British X <= 3/8 Brahman	86	Brangus
5	British X > 3/8 Brahman	33	Hereford-Brahman X Brahman
6	Straight-bred Continental or Continental X Brahman	11	Simmental / Simbrah

[a]Classification determined using color, conformation, muscle pattern, ear length and hump development.

Table 2. Composition of diets on a dry matter basis.

Ingredient	Ration sequence 1	2	3	4	Final
	(%)				
Corn, steam rolled	39.94	49.94	59.94	69.94	81.94
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]	6.31	6.31	6.31	6.31	6.31

Calculated composition of the final ration:

Nutrients	Ration composition DM %	Ration composition As fed %	Supplement DM %	Supplement As fed %
NEm, mcal/cwt	95.22	80.50	68.06	62.70
NEg, mcal/cwt	61.70	52.16	45.65	42.06
Crude protein, %	12.25	10.36	54.17	49.90
Crude fiber, %	5.26	4.45	6.85	6.31
K, %	0.70	0.59	1.30	1.20
Ca, %	0.45	0.38	5.05	4.65
P, %	0.33	0.28	1.16	1.07
Dry matter, %	100.00	84.54	100.00	92.13

[a]Supplement composition: Cottonseed meal 40.16%, soybean meal 33.91%, calcium carbonate 10.95%, urea 5.96%, salt 4.52%, dicalcium phosphate 2.27%, trace mineral .19%, vitamin E .04%, 30,000 IU vitamin A .18% and virginiamycin premix (Stafac-10) as required.

weeks and therefore had a final live weight taken on day 143. In this report, all full weights were reduced 4% to account for digestive tract fill. Due to a drug withdrawal requirement for virginiamycin, all cattle were fed a non-medicated control ration for 6 additional days before slaughter at Booker, Texas. Total feeding time before slaughter was 135 days for steers in weight blocks four to ten (224 head) and 149 days for steers in weight blocks one to three (96 head). Livers were examined for abscesses and presence of flukes (Hicks et al., 1989) and carcass data obtained 24 hours postmortem. During the course of the study one, steer was removed due to injury and another due to rectal prolapse. In addition, one steer died after the feeding trial (during the drug withdrawal period). His data, however, were included in the live performance analysis. Cause of death appeared unrelated to treatment. All data were analyzed using a general linear model with treatment, breed and weight block as main effects. Interactions deemed non-significant (P>.30) were deleted from the model for each respective variable.

Results and Discussion

No significant differences in average daily gain or feed intake among the different treatment groups were observed (Table 3). However, feed efficiency over the entire trial was improved with increasing level of virginiamycin (linear effect, P<.01). Virginiamycin fed at the 25 gram level improved feed efficiency (P<.05) by 2.6% when compared to steers fed either the control ration or the 10 gram level of treatment.

Carcass characteristics were generally not altered by virginiamycin (Table 4) with the exception of yield grade and percent yield grade 4 carcasses. Steers fed virginiamycin at 10 g/ton had greater numerical yield grades than control steers (P<.05) and the percentage of yield grade 4 carcasses for virginiamycin-fed cattle was higher than for the controls (P<.05). It is difficult to explain how the percent of yield grade 4 carcasses increased without a corresponding rise in hot carcass weight, fat thickness and percent KPH or a decrease in ribeye area. Distribution in any one of the variables used in calculating yield grade or an additive effect among these variables may be responsible. Incidence of liver abscesses tended to decrease with virginiamycin use (9 vs 15%), however, this reduction was not statistically significant.

Table 3. The effect of virginiamycin on cattle performance.

	Virginiamycin level (grams/ton)			
Item	0	10	17.5	25
Steers, number	79	80	79	80
Weight, lb:				
Starting[d]	683	687	692	684
Starting	690	690	690	690
Day 129[d]	1105	1096	1097	1108
Day 129	1100	1094	1097	1108
Final[cd]	1155	1155	1142	1162
Final[c]	1152	1147	1137	1161
Daily gains, lb:				
0-129[d]	3.19	3.11	3.16	3.22
0-129	3.12	3.09	3.13	3.19
0-slaughter[cd]	3.36	3.33	3.35	3.39
0-slaughter[c]	3.31	3.29	3.33	3.39
Daily feed, lb DM				
0-129	19.16	19.03	19.06	19.13
0-slaughter[c]	19.09	18.97	19.02	19.06
Feed/gain:				
0-129	6.13[ab]	6.15[a]	6.07[ab]	5.98[b]
0-slaughter[c]	5.76[a]	5.76[a]	5.70[ab]	5.62[b]

[a,b]Means with different superscripts differ (P<.05).
[c]Based on carcass weight divided by .63, (mean dressing percent).
[d]Least squares means.

Table 4. The effect of virginiamycin on carcass parameters[d].

Item	Virginiamycin level (grams/ton)			
	0	10	17.5	25
Carcass weight, lb	730	730	732	736
Dressing percentage	63.14	63.33	63.16	63.25
Ribeye area, in^2	12.2	12.0	12.2	12.2
Fat thickness, in	.52	.55	.55	.55
KPH, %	1.87	1.92	1.94	1.92
Marbling score[c]	430.89	429.17	412.69	432.64
Percent choice	67.03	68.58	67.65	64.34
Yield grade	3.08[a]	3.42[b]	3.21[ab]	3.24[ab]
Percent YG 4	7.66[a]	21.15[b]	18.67[b]	22.14[b]
Liver abscesses, %	15.35	11.80	7.82	9.07
Liver flukes, %	26.85	26.11	40.36	31.38

[a,b]Means with different superscripts differ (P<.05).
[c]300-399, slight; 400-499, small.
[d]Least squares means.

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METHANE FERMENTER RESIDUE AS A PARTIAL ROUGHAGE SUBSTITUTE FOR FEEDLOT CATTLE

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Story in Brief

Two hundred forty feedlot steers were fed steam flaked corn-ground alfalfa-supplement diets, containing either 0 or 4.26% of a methane fermenter residue, Beef-Up, as a replacement for 4.26% DM as alfalfa hay. Average daily gain was not changed by the addition of the methane fermenter residue to the ration, however, feed consumption was increased by about 3% (27.2 lb/day vs 28.2 lb/day). The calculated metabolizable energy values were determined from animal performance. The control group produced calculated metabolizable energy values of 1.29 mcal/lb while the values for the treated animals were 1.27 mcal/lb. The apparent NEm, NEg and calculated metabolizable energy values for the methane fermenter residue as determined from animal performance were .345, -.292 and .518 mcal/lb, respectively. These data indicate that methane fermenter residue may be used in beef cattle feedlot rations as a nutrient source. However, its value may be in its contribution of macro and micro minerals, rather than energy. The two factors influencing the incorporation of methane fermenter residue into beef cattle finishing rations are nutrient composition and cost.

(Key Words: Methane Fermenter Residue, Feedlot Cattle.)

Introduction

The production of methane from beef cattle feedlot waste yields a final product, methane fermenter residue (MFR), which has received intermittent interest as a ration ingredient in feedlot diets. The MFR product has received consideration as an energy source (Prokop, 1980), however, more recent interest stems from the potential to replace a portion of the dietary

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roughage (Martin et al., 1984) and as a potential source of macro and micro mineral elements.

The proximate analysis of this MFR (Beef-Up) indicates the following approximate nutrient content: crude protein, 14%; crude fiber 17%; 5.75% calcium; 1.6% phosphorus and 1.1% potassium. These values would suggest that this MFR might be substituted for roughage in feedlot finishing rations. Previous work (Zinn et al., 1979; Prokop, 1980) suggests that the digestibility of the protein and dry matter was quite low. The objective of this study was to determine the efficacy of substituting MFR for approximately half the alfalfa hay in a feedlot finishing ration.

Materials and Methods

Two hundred forty Angus and Angus-cross steers (734 lb) were sorted for uniformity by size and color from approximately 1100 steers on one pasture and trucked approximately 20 miles to Goodwell, Oklahoma, September 2, 1987. The animals were individually identified, implanted with Synovex-S and administered with IBR, BVD, PI3, Leptospirosis, 7-Way Clostridial Vaccine, Ivermectin, Vitamin A and 60 mg copper as cupric glycinate upon initiation of the trial. The animals were randomized into twelve pens with six weight blocks. One pen from each weight block was selected at random to receive the MFR while the remaining pen in each block received the control diet. Initially, all animals in the test were fed the normal feedlot step-up rations and MFR was not included in the diet until the final ration was fed. The animals adapted well to confinement. There was virtually no sickness and the steers were placed on the final ration on day 27. Approximately 4.5% DM of the alfalfa hay in the treatment ration was replaced by 4.5% MFR which was incorporated into the ration supplement and manufactured into a three-sixteenth inch pellet. The basic ration was trucked from the H.C. Hitch Feedlot daily and either 4.5% DM alfalfa hay plus supplement or 4.5% DM MFR in the supplement was added to the ration and mixed on site.

Cattle were weighed off the trucks, then weighed full on day 27 when the test period began. Subsequent full weights were taken on days 55 and 83. These weights were shrunk 4%. Final weights were taken the day before slaughter on days 105, 115, 120, 122, 123 and 124. Replicate pens were slaughtered on the same day. Slaughter order was heavy block to light block. For slaughter, the animals were trucked approximately 50 miles to Liberal, Kansas where carcass data were obtained.

Results and Discussion

Feed efficiency was significantly altered by the addition of MFR to the finishing diet of beef steers ($P<.10$) Table 1. The steers which received the MFR product consumed more feed as they also did during the step-up phase and were consistently less efficient than the animals which received the control diet. The rates of gain and feed conversion values reflect the days on feed and the degree of finish that the steers had reached. With the serial slaughter model of Hicks et al., 1987, the average optimum slaughter date for this set of steers was about 115 days after being placed on feed. The cost of gain on a pay to pay feedlot basis was $34.97/cwt for the control and $35.97/cwt for MFR fed cattle (Table 1).

All carcass parameters (Table 2) were similar for both the MFR treated steers and the control animals. The differences in KPH, marbling score and percent Certified Angus Beef (CAB) were not significantly different from the control group ($P<.05$). Any difference in marbling score and CAB that there

Table 1. Steer performance.

	Control	Beef-Up
Weights, lb		
Initial	734	734
27 days	877	880
55 days	997	1003
83 days	1103	1106
Final	1202	1206
Daily gain, lb		
0-27 days	3.86	3.97
28-55 days	4.23	4.36
56-83 days	3.63	3.56
84-Final	3.40	3.37
27-Final	3.75	3.76
Daily feed lb/day		
0-27 days	30.60	31.97
28-55 days	28.67	29.70
56-83 days	27.74	28.80
84-Final	25.32	25.56
27-Final	27.24	28.20
Feed/Gain		
0-27 days	7.97	8.08
28-55 days	6.81	6.80
56-83 days	7.71	8.08
84-Final	7.54	7.74
27-Final	7.28[a]	7.50[b]
Cost of gain		
27-Final	34.97[c]	35.97

[a,b]Row means with different superscripts differ statistically ($P<.10$).
[c]Expressed in dollars per cwt.

Table 2. Carcass parameters.

	Control	Beef-Up
Carcass weight, lb	751	758
Dressing percent	65.53	65.56
Fat thickness, in.	.56	.55
Rib Eye Area, sq in	13.64	13.46
KPH, percent	2.13	1.87
Marbling score[a]	445	448
Choice, %	68	69
Certified Angus Beef, %	23	32
Yield Grade	2.83	2.83
Cutability,%[b]	50.2	50.2

[a]400 = Choice minus; 500 = average Choice.
[b]Closely trimmed lean cuts.

Table 3. Relationship of days on feed to calculated ration energy (mcal/lb).

Days	Treatment	CME	CNEm	CNEg
105				
	Control	1.29	.823	.547
	Beef-Up	1.27	.800	.530
115				
	Control	1.22	.755	.493
	Beef-Up	1.16	.711	.452
120				
	Control	1.20	.746	.485
	Beef-Up	1.20	.739	.479
122				
	Control	1.16	.710	.451
	Beef-Up	1.14	.695	.436
123				
	Control	1.17	.720	.461
	Beef-Up	1.15	.696	.437
124				
	Control	1.14	.691	.431
	Beef-Up	1.13	.682	.422
Mean				
	Control	1.20	.741	.478
	Beef-Up	1.17	.720	.459
Beef-Up[a]		.52	.345	-.292

[a]Values determined by the method of Owens and Gill, 1980.

may have been early were dampened by the results produced from the longer fed cattle.

As the number of days on feed increased, feed consumption declined, rate of gain declined, and feed conversion was depressed (Table 1). Calculated metabolizable energy (ME) reflected these results showing a drop of 12% from day 105 to day 124 (Table 3). In addition to the energy depressing action of greater degrees of finish in the longer fed cattle, the animals fed longer than 105 days experienced approximately two weeks of severe snow and cold. These environmental stress factors were apparent in higher dressing percentages on two kill dates.

The calculated ME, NEm and NEg values for Beef-Up, the MFR product, were estimated based on calculating the ME of both rations based on feed intake and animal performance (Owens and Gill, 1980). The ME of the replaced feeds is then deducted from the ME of the control ration. The difference between the control and the test diet remaining is assumed to be due to the test ingredient. Since the MFR was included in this ration at approximately 4.50%, it is assumed that the ME differences between treatments may be attributable to this fraction of the ration. Using this method, values for ME, NEm, and NEg of .52, .34 and -.29 mcal/lb, respectively, are calculated. These values are in close agreement with the values calculated by Martin et al., 1984. These interpretations are made, recognizing that small differences are difficult to detect when dealing with biologically variable systems even with well replicated studies.

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THE RELATIONSHIP OF VISUAL APPRAISAL TO ANIMAL PERFORMANCE AND CARCASS PARAMETERS

C.A. Strasia[1], K.S. Lusby[2] G.W. Horn[2], D.R. Gill[3], R.B. Hicks[4] and S.M. Hininger[5]

Story in Brief

One hundred eight feeder steers averaging 834 lb were visually scored (scores of 1 being undesirable and 3 being desirable) at feedlot processing for frame size, body capacity, fatness and health to estimate subsequent animal performance parameters. Stocker and feeder cattle are evaluated by these parameters. Prices are based on how "tall", how "thick", how "fleshy" or how "fresh" cattle appear. This trade jargon translates to the parameters of frame size, body capacity, fatness and health, respectively. The carcass value and frame size correlation of .39 was the only relationship which showed any potential to predict animal performance. All other correlations were less. The correlation between visual appearance and the economically important traits in beef feeder cattle of average daily gain, feed conversion and carcass quality is quite low.

(Key Words: Feedlot, Visual Appraisal, Performance, Carcass Parameters.)

Introduction

The pricing of beef cattle functions on average values. Feeder cattle prices are established within a relatively broad range based on visual appeal and body weight. These price ranges may be as much as $15 per hundred weight and vary with geographic area of the United States. The $15 per hundred weight price spread noted in feeder cattle is narrowed to a $1-$2 per hundred weight spread on slaughter steers. Slaughter cattle are also merchandised on averages. The finish feeding period upgrades the perceived value of the feeder animal and this animal is now merchandised on estimated carcass yield and estimated percent of Choice grade animals in a lot.

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There are large variations in feedlot performance in each pen of cattle. These differences occur in lots of animals from all geographic origins and genetic backgrounds. The purpose of this study was to attempt to correlate commonly used visual appraisal terms of feeder animals with subsequent economically important feedlot performance and carcass parameters.

Materials and Methods

One hundred eight steers of Angus, Brahman x Angus, Angus x Brahman-Angus and Simmental x Brahman-Angus ancestry weighing 834 lb were removed from fescue pastures that were either endophyte infected, clover mixes or endophyte free and shipped approximately 435 miles to the H.C. Hitch feedlot, Guymon, Oklahoma. The cattle were shipped at night to minimize the heat stress effects of the endophyte infected fescue. The cattle were rested 24 hours, individually weighed and routinely processed into the feedlot. The steers were visually scored at random by three individuals as they were released from the processing chute. The parameters used were frame size (small-1, medium-2 and large-3), body capacity (small-1, medium-2 and large-3), health score (sick-1, stressed-2, healthy-3), and fleshing score(thin-1, average-2, fleshy-3).

The steers were moved through the standard step-up ration program used in the H.C. Hitch feedlot. Final weights were taken on day 117 and were shrunk 4%. The steers were then trucked approximately 60 miles from the feedlot to Booker Custom Pack, Booker, Texas for slaughter. Carcass data were obtained at slaughter, and final wieghts (carcass adjusted) were carcass weight/.62..

The r and r^2 values resulting from the statistical analysis of the relationship between the visually determined parameters and performance parameters are shown in Tables 1 and 2. The steers were scored for the parameters of frame, body capacity, fleshing and health by three individuals. The data were analyzed individually, then combined. Frame (FR) was scored on the basis of the animal being small, medium or large framed. The body capacity (BC) parameter involved the evaluation of thickness and depth as an indicator of the ability of an animal to consume feed. This assumes that a deep thick animal will have the capability to consume more feed than a shallow thin animal. Fleshing score (FS) is based on the observation that an animal showing signs of fat will be less efficient than a thin animal with a large frame, commonly called a "green" animal. Health score (HS) ranged from healthy to sick. The latter category would include animals that appeared to be stressed and presumed to be a health problem.

Table 1. Correlation coefficients (r) of visual appraisal with performance parameters[a].

	Evaluator			
	1	2	3	combined
ADG X FR[b]	.11	.21	.10	.18
ADG X BC[c]	-.16	.08	-.09	-.10
ADG X FL[d]	-.10	-.25	-.28	-.32
ADG X HS[e]	-.05	-.07	.04	-.05
CADG X FR	.26	.28	.11	.29
CADG X BC	-.24	.17	-.13	-.13
CADG X FL	-.21	-.21	-.19	-.32
CADG X HS	-.08	.09	.10	.05
PRICE X FR	-.14	-.20	-.21	-.24
PRICE X BC	.12	-.21	-.03	-.06
PRICE X FL	.11	-.06	-.08	.07
PRICE X HS	-.04	-.02	-.03	-.04
VALUE X FR	.35	.41	.11	.39
VALUE X BC	-.07	.34	.07	.16
VALUE X FL	-.13	.06	.23	.08
VALUE X HS	.08	.32	.23	.32

[a]ADG is average daily gain based on final weight, CADG is average daily gain based on carcass adjusted final weight, PRICE is value/cwt and VALUE is total carcass value.
[b]Frame Score.
[c]Body Capacity.
[d]Fleshing Score.
[e]Health Score.

Table 2. Coefficients of determination (r^2) relationships with performance parameters[a].

	Evaluator			
	1	2	3	combined
ADG	BC[c] .0255	FS-FR[b] .1122	FS[d] .0775	FS .1021
CADG	FR-BC .0954	FR-FS .1299	FS .0378	FS-FR .1565
VALUE	FR .1202	FR-HS[e] .2059	HS-FR .0977	FR-HS-BC .2444

[a]ADG is average daily gain based on final weight, CADG is average daily gain based on carcass adjusted final weight, PRICE is value/cwt and VALUE is total carcass value.
[b]Frame Score.
[c]Body Capacity.
[d]Fleshing Score.
[e]Health Score.

Results and Discussion

The combined correlations for gain with BC, FR, FS and HS are, -.10, .18, -.32 and -.05, respectively (Table 1). When average daily gain is expressed on a carcass determined basis, these same parameters produce correlations of -.13, .29, -.32 and .05, respectively. All these correlations are so low that the differences in performance are either not influenced by the parameters which were estimated or the scoring system used was not sufficiently precise to detect differences.

When price (value per cwt) or carcass value are related to the parameters of body capacity, frame, flesh score and health score, correlations of -.06, -.24, .07 and -.04 with price, respectively, and correlations of .15, .39, .08 and .32 with carcass value, respectively, were observed. These values suggest a frame size, carcass value interaction. Carcasses weighing over 900 lb and under 500 lb are discounted in the beef trade. The economic consequence of this relationship may be negative under current market conditions.

When the evaluator scores were combined, there was a r^2 of .24 between the parameter of carcass value and frame score, health score and body capacity (Table 2).

These data were obtained from a group of cattle from a pasture study in which there had been statistically significant differences in animal performance, (Lusby et al., 1988). Compensatory feedlot gain and the need for a 1 to 9 rather than a 1 to 3 evaluation scale may have contributed to low correlations.

Literature Cited

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CORRELATION OF ULTRASOUND AND MEASURED FAT THICKNESS IN FEEDLOT HEIFERS

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Story in Brief

One hundred twenty three feeder heifers were weighed upon arrival in a commercial feedyard, and again at 60 days and 110 days. At 110 days heifers were scanned with ultrasound for fat thickness. Forty two animals were selected for slaughter at day 110 based on a live weight of 1000 lb and ultrasound subcutaneous fat measurements of .5 inches. The remainder of the animals were fed to 145 days. Subcutaneous fat thickness was measured with ultrasound prior to slaughter and actual fat thickness was measured post slaughter. The r^2 value was .3 for ultrasound vs measured back fat thickness. Accuracy within $\pm$ .10 inches of measured were achieved 36.4% of the time and $\pm$ .20 inches were recorded 65.3% of the time. Carcass parameters indicate that although both groups of heifers were identical in backfat thickness, days on feed was a more reliable indicator of carcass quality, 35.7% choice and 54.4% choice, respectively, than ultrasound fat thickness determination.

(Key Words: Heifers, Ultrasound, Fat Thickness.)

Introduction

The accurate measurement of subcutaneous fat thickness and ribeye area in the live animal would allow more precise estimation of ideal slaughter time. Technology has improved rapidly and ultrasonic equipment advances appear to have evolved where scanning large numbers of animals in a commercial feedlot may be feasible. Implementation of this technique could reduce feeding time and identify both overdone and high performance

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animals. Economic return for superior genetics may be maximized when practical, precise methods of identifying these animals are developed.

Materials and Methods

One hundred twenty three feeder heifers were weighed upon arrival in a commercial feedyard. The animals were fed a 64 mcal/cwt NE_g ration. The heifers were again weighed at 60 days and 110 days on feed. At day 110, heifers were scanned with ultrasound for fat thickness and 42 heifers were selected for slaughter. The average initial weight of these 42 animals was 673 lb. Animals were selected that would produce a minimum of 600 lb of carcass weight with an ultrasound measurement of .5 inches subcutaneous fat at the 12^{th} rib. The remaining animals were fed to 145 days, weighed and scanned with ultrasound for fat cover. The average initial weight of these seventy-nine was 589 lb. Both groups of animals were shipped approximately 60 miles by truck to Booker, Texas for slaughter. Hot carcass weight, 12th rib fat thickness and ribeye area were measured. Kidney, heart and pelvic fat and quality grade was estimated by the same individual. Correlation coefficients were determined for ultrasound fat thickness and actual manually measured fat thickness at the 12th rib.

Results and Discussion

The data on individual animals indicate that ultrasound fat thickness determinations performed under practical industry conditions are not of acceptable precision. Accuracy within $\pm$ .10 inches of measured were achieved 36.4% of the time and $\pm$ .20 inches were recorded 65.3% of the time (Table 1). Subcutaneous fat is not uniformly deposited over the carcass. Consequently, if measurements are not taken in precisely the same location, different values may occur.

The parameters of subcutaneous fat thickness and quality grade are not highly correlated (Table 2). The occurrence of .5 inches of subcutaneous fat does not assure that a particular animal will quality grade choice. Conversely, when the parameters of weight and fat thickness are used to determine the feeding end point, we appear to be sorting off the higher performing, more efficient and profitable animals. The average daily gains of 2.86 lb/day for short fed cattle and 2.45 lb/day for long fed cattle (Table 2) represents a 14% decrease in gain. Also, the most profitable animals in this study were slaughtered first. Pricing in the beef cattle industry currently functions on averages. Consequently, problems are created for the

Table 1. Accuracy and correlation of ultrasound to measured fat thickness.

	Residual fat thickness, in		
Fat thickness	+/-.10	+/-.20	>+/-.20
Number of animals	44	79	42
Percent	36.4	65.3	34.7
r^2, all animals	.36		

Table 2. Carcass characteristics of finished heifers.

Days on feed	110	145
No. of animals	42	79
In weight, lb.	673	589
Final weight, lb.	977	945
ADG, lb/d	2.86	2.45
Hot Carcass Weight, lb.	626	614
KPH, %	2.1	2.1
Fat thickness, in.	.50	.50
Ribeye area, sq in.	11.9	11.9
Marbling Score[a]	392	412
Percent choice	35.7	54.4
Yield grade	2.73	2.76

[a] 400 = Sm^{00}

commercial feedlot when underweight, low performance fat cattle are removed from an "average" pen. Additional time is required to get these animals to a marketable weight. The financial gain realized from the high performance animals may be largely negated by excessively fat, poor performing and lower yield grade cattle.

Literature Cited

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COMPARISON OF SITE AND EXTENT OF NITROGEN DIGESTION OF CORN AND FOUR SORGHUM GRAIN HYBRIDS IN BEEF STEERS

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Story in Brief

To compare the effect of corn and sorghum grain hybrids on site and extent of nitrogen digestion, four currently available sorghum grain hybrids (pure yellow, cream, hetero-yellow and red) and a commercially obtained corn were dry rolled and fed in an 85% grain diet to Angus x Hereford steers (531 lb) equipped with large ruminal and double L duodenal and ileal cannulae. Diets were fed at 2% of body weight (dry matter basis) in a 5x5 latin square. Ruminal escape of feed nitrogen was greater for red than other grains, with corn having less ruminal escape of feed nitrogen than the sorghum grain hybrids. Pre-cecal non-ammonia nitrogen digestibility was not altered by grain type; however, non-ammonia nitrogen flow to the cecum was greater for red than other grains. Disappearance and digestibility in the small intestine tended not to be affected by grain type; although, nitrogen in corn appeared to be slightly more digestible than nitrogen in sorghum hybrids, particularly yellow and red. Nitrogen from corn and the sorghum grain hybrids was not digested equally at all sites. Lower ruminal feed nitrogen digestion for sorghum grains compared to corn may decrease the supply of essential amino acids to the small intestine for steers fed sorghum if less microbial protein is synthesized.

(Key Words: Sorghum Grain, Corn, Nitrogen, Digestion, Beef Steers.)

Introduction

Cereal grains represent the major sources of energy and protein in feedlot diets. Nationally, corn is the most prominent grain fed, but sorghum grain is extensively used in some regions. Sorghum grain generally is regarded as being more variable in quality and less digestible than corn. However, improvement in sorghum grain hybrid strains may make sorghum

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more competitive with corn. Currently, available sorghum hybrids have not been compared to corn to determine the potential improvement in nutritional quality of sorghum relative to corn. Therefore, the objective of this study was to assess differences in site and extent of nitrogen (N) digestion of corn and four currently available sorghum grain hybrids.

Materials and Methods

Four sorghum grain hybrids (Table 1), representing a pure yellow (homozygous yellow endosperm, yellow seed coat, denoted as Yel), cream (heterozygous yellow endosperm, white seed coat), hetero-yellow (heterozygous yellow endosperm, red seed coat, denoted as Het-Yel) and red (homozygous white endosperm, red seed coat), were grown under dryland conditions in southeast Kansas during the summer of 1986. Rainfall was evenly distributed throughout the growing season and totaled 15 inches. Corn was obtained commercially. All grains were dry rolled before feeding in an 85% grain diet (Table 2). Molasses was included in the diet (3% of DM) to reduce dust. Urea was used as the sole source of supplemental N to enhance the estimation of feed N digestion in the rumen. Chromic oxide (.2% DM) was used as a digestibility marker.

Diets were fed three times daily to 531 lb Angus x Hereford steers surgically equipped, while under local anesthesia, with permanent ruminal and double L duodenal and ileal cannulae. Daily dry matter intake was restricted to 2% (DM basis) of steer weight to ensure uniform consumption within a 5x5 latin square. Experimental periods lasted 14 days with days 1 through 11 for diet adaptation and 12 through 14 for feed, digesta and fecal sampling. Samples were collected at 1200, 1600 and 2400 on day 12, 0600, 1500 and 2100 on day 13 and 0300 and 0900 on day 14. Ruminal fluid was collected at 1500 and 2100 on day 13 and 0300 and 0900 on day 14. Ruminal fluid was acidified after pH determination. Digesta and fecal samples were composited across day and time within each period, lyophilized and ground through a 1 mm screen. Ruminal fluid was also collected at 1400 h during

Table 1. Descriptive characteristics of sorghum grain hybrids.

Sorghum hybrid	Seed coat color	Endosperm color	Endosperm cross
Yellow	yellow	yellow	yellow x yellow
Cream	white	yellow	white x yellow
Hetero-yellow	red	yellow	white x yellow
Red	red	white	white x white

Table 2. Ingredient composition of experimental diets.

Ingredient[a]	% of dry matter
Grain	85.0
Cottonseed hulls	8.0
Molasses	3.0
Supplement	
Urea	1.20
Dicalcium phosphate	.44
Calcium carbonate	.93
Potassium chloride	.57
Sodium sulfate	.36
Trace mineralized salt	.25
Chromic oxide	.20

[a]Vitamin A was included at a level of 2200 IU/kg.

periods 2, 3, 4 and 5 for determination of microbial nitrogen flow to the small intestine.

Grain, feed, duodenal, ileal, fecal and microbial samples were analyzed for dry matter, ash, crude protein, ammonia-N, purine-N (RNA basis) and chromic oxide. Grain samples also were analyzed for sodium chloride soluble protein (NaCl-N) and pepsin insoluble N (PIN). Nitrogen digestibility was determined by chromic oxide ratio, while purine-N was utilized to distinguish feed protein from microbial protein escaping the rumen. Volume of sorghum grain berries was determined by measuring the volume of toluene that was displaced by 100 berries randomly selected from each hybrid. Least squares means were separated by a protected least significant difference.

Results and Discussion

The red sorghum grain hybrid contained more ($P<.05$) crude protein (CP) than cream, Het-Yel and Yel, while corn contained an intermediate amount of CP (Table 3). Corn and Yel contained more NaCl-N than red, while cream was intermediate, with all other grains being greater ($P<.10$) than Het-Yel. PIN was similar for all grains, averaging 12.2% of CP N. Among sorghum hybrids, Het-Yel had larger ($P<.05$) berries (g/100 berries) than other sorghum grain types, while Yel and red had larger ($P<.05$) berries than cream. The volume of individual berries was greater ($P<.10$) for Het-Yel than Yel and cream with Yel greater than cream. Red berries were intermediate in volume to Het-Yel and Yel. If all hybrids contained the same proportion of corneous and floury endosperm, larger berries should

Table 3. Chemical composition of corn and sorghum grain hybrids and complete mixed feeds (DM basis).

Item	Corn	Yellow	Cream	Hetero-yellow	Red
Grain					
CP	10.0[ab]	9.5[b]	9.7[b]	9.6[b]	10.4[a]
Starch	72.2	78.7	78.3	72.9	79.6
ADF	7.7	7.3	9.6	9.0	8.5
NaCl soluble protein, % of total N	30.9[x]	30.8[x]	27.6[xy]	21.4[z]	26.5[y]
Pepsin insoluble nitrogen, % of total N	12.4	11.1	12.5	12.2	12.8
Berry size, g/100 berries	--	2.22[b]	1.98[c]	2.53[a]	2.27[b]
Berry volume, µl/berry	--	18.0[y]	15.5[z]	20.5[x]	19.0[xy]
Density, g/ml	--	1.24	1.28	1.24	1.20
Feed					
CP	12.1[c]	12.6[b]	12.5[b]	12.6[b]	13.5[a]
Starch	64.7	65.1	62.6	66.4	65.2
ADF	5.4	5.6	6.5	5.7	5.6
Grain particle size					
Geometric mean, µm	3316[a]	785[bc]	684[c]	903[b]	695[c]
>4000 µm, %	76.0[a]	.2[b]	.2[b]	.2[b]	.2[b]
3999-2000 µm, %	22.0[w]	3.4[yz]	1.8[x]	7.1[x]	4.6[y]
1999-1000 µm, %	1.4[z]	75.8[x]	65.2[y]	79.8[x]	64.0[x]
999-500 µm, %	.2[c]	9.3[b]	13.0[a]	7.3[b]	15.2[a]
499-250 µm, %	.1	4.3	7.8	1.8	5.6
<250 µm, %	.2[z]	7.0[xy]	11.9[x]	3.8[yz]	10.6[x]

a,b,c Means in the same row with different superscripts differ ($P<.05$).
w,x,y,z Means in the same row with different superscripts differ ($P<.10$).

result in a smaller average geometric mean diameter of particles when rolled. However, the berries of greatest size and volume, Het-Yel, resulted in a larger ($P<.05$) geometric mean diameter of particles than did cream and red, with Yel being intermediate to Het-Yel and red. This may suggest that Het-Yel and Yel contain a larger proportion of the endosperm as less digestible corneous endosperm than do cream and red.

Steers fed the red sorghum hybrid consumed more N than when fed Het-Yel, Yel and cream, with corn being lower than all sorghum hybrids (Table 4). With all diets, a net gain in the amount of N reaching the duodenum above actual N intake levels was observed. A gain in N through the rumen indicates nitrogen recycling to the rumen. Ruminal feed N (excluding urea) digestibility was greater for corn ($P<.10$) than for sorghum grain hybrids, with pure yellow (Yel) and partial yellow endosperm hybrids (cream and Het-Yel) being more ($P<.10$) digestible than the white endosperm red sorghum. Pre-cecal non-ammonia N (NAN) digestibility was

Table 4. Comparison of site and extent of nitrogen digestion of corn and four sorghum grain hybrids.

Item	Corn	Yellow	Cream	Hetero-yellow	Red
Ruminal NH_3 N, mg/dl	7.60	10.02	7.81	9.45	8.36
Nitrogen intake, g/d					
Total feed N	93.8	97.7	97.3	98.0	103.9
Feed N(excluding urea N)	67.1	71.1	70.5	71.3	77.3
Duodenal non-NH_3 N, g/d	101	100	101	102	115
Microbial N	66.1	53.7	54.4	52.9	52.8
Feed N	35.1^{c}	46.7^{b}	46.8^{b}	49.3^{b}	61.9^{a}
Pre-cecal non-NH_3 N, g/d	34.8^{b}	39.9^{b}	36.2^{b}	36.9^{b}	46.0^{a}
Fecal on-NH_3 N, g/d	36.0^{z}	41.0^{yz}	39.7^{yz}	41.5^{y}	46.7^{x}
Nitrogen digestibility, % of intake					
Feed N(excluding urea N)	46.4^{x}	33.9^{y}	33.5^{y}	30.8^{y}	20.1^{z}
Ruminal escape feed N, %	53.6^{z}	66.1^{y}	66.5^{y}	69.2^{y}	79.9^{x}
Pre-cecal non-NH_3 N	62.4	59.3	62.6	62.2	55.8
Total tract non-NH_3 N	61.0	58.1	59.1	57.6	55.1
Non-ammonia N digestibility in the small intestine disappearance, g/d	66.4	60.5	65.0	65.2	68.7
% of entry	65.4	59.8	63.5	63.7	59.5
% of intake	71.8	62.1	66.4	66.5	65.9

^{a,b,c}Means in the same row with different superscripts differ ($P<.05$).
^{x,y,z}Means in the same row with different superscripts differ ($P<.10$).

similar for all grains, averaging 60.5%; however, NAN flowing out of the ileum was greater ($P<.05$) for red than other grains.

Digestibility of NAN in the small intestine, as proportion of intake, also was similar for all grains, averaging 66.5% of N intake. When digestibility was expressed as a percentage of NAN flow to the small intestine, corn appeared ($P>.10$) to be slightly more digestible than sorghum hybrids, particularly Yel and red.

Total tract NAN digestibility was only slightly greater ($P>.10$) for corn than for sorghum grain hybrids. Among sorghum hybrids the Yel and partial yellow endosperm (cream and het-yel) hybrids appeared to be slightly more digestible than the white endosperm (red) hybrid.

Corn protein may be more digestible or degradable in the rumen than sorghum protein because of differences in protein solubility and because larger corn particles are possibly retained in the rumen longer than smaller sorghum particles. However, due to greater surface area, the smaller sorghum particles may need a shorter retention period to be digested. Lower ruminal digestibility for sorghum protein could also result from a greater proportion of peripheral endosperm, containing more poorly extractable protein, compared to corn. Likewise, differences observed among sorghum hybrids may be the result of variation in peripheral endosperm, but also cross linking of prolamine protein fractions within the peripheral endosperm.

The site and extent of nitrogen digestibility was affected by corn and sorghum grain hybrid. Differences in ruminal digestibility may influence the quality of protein available for digestion and absorption in the small intestine. Although, specific amino acid requirements are not defined for beef cattle, differences in the quality of protein (feed versus microbial) digested in the small intestine could impact performance of feedlot cattle.

EVALUATION OF THE FIVE-DAY POSTHATCHING HEAT DISTRESS ACCLIMATION TECHNIQUE

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Story in Brief

In one study birds were exposed to 85, 95, 105 and 110°F for 24 hours at five days posthatching followed by housing at 85°F for 23 days and subsequent heat distress exposure to test a proposed new acclimation procedure. In addition, one group of birds was allowed to self regulate their ambient temperature under brooders. On day 28 posthatching the chicks were placed in two environmental chambers with 16 replicates of 6 chicks each per treatment. One chamber was maintained at 79°F while the other was cycled between 79 and 99°F for 2 weeks. A cubic acclimation effect on survival was detected during the growth phase with heat stressed broilers. Survival (%) and live weight gain (lb) in the cool and (hot) chambers during the growing phase for the 85, 95, 105, 110°F and the self regulated groups averaged 100, 2.23 (84, 1.39); 99, 2.20, (90, 1.45); 98, 2.27, (77, 1.42); 100, 2.29, (93, 1.43); 100, 2.20, (85, 1.37), respectively. In the thermoneutral chamber acclimation reduced gain at 28, but not 37 days posthatching. Further studies are needed to judge the efficacy of the procedure to counter heat distress consequences.

(Key Words: Acclimation, Heat Distress, Broilers, Mortality.)

Introduction

Heat distress in broilers is age dependent with the greatest susceptibility occurring four weeks posthatching and thereafter. Acclimation, the process by which birds adjust to the heat insult, increases broiler heat tolerance, but it depends on breed, age, climate and nutrition (Meltzer, 1987). Reece et al. (1972), reported that acclimating male broiler chicks from four to eight weeks was effective in reducing mortality when exposed to high temperature up to 105°F at eight weeks of age. Arjona et al. (1988) reported that mortality resulting from heat stress at 44 and 45 days of age was significantly

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reduced in broilers exposed to elevated environmental temperatures for 24 hours at just five days of age. They also indicated that under heat stress conditions the acclimatized broilers had a significantly improved feed efficiency compared to the unacclimatized group.

The metabolic basis for short-term acclimation to heat exposure is unknown. May et al. (1986) exposed broilers to moderate, constant and high-cyclic temperature for three days in a long term study and reported that neither acclimation nor constantly severe heat exposure 106°F impacted triiodothyronine (T3) or thyroxine (T4) concentration. Meltzer (1987), reported that the rise of body temperature in an acclimatized fowl is less than in the unacclimatized, and suggested that acclimatization occurs due to either a increased heat loss or decreased heat production. Teeter and Smith (1988) determined that 52% of the hypothermic effect of acclimation could be attributed to reduced feed intake leaving 48% of the response independent of feed consumption.

If the 5-day acclimation procedure is effective at increasing the broiler's heat tolerance then it may offer a means for the consequences of heat distress to be minimized. The objective of this trial was to evaluate the 5-day acclimation procedure on the performance of broilers subsequently exposed to heat distress.

Materials and Methods

Arbor Acre x Vantress broiler chicks were housed on rice hull litter in a partitioned brooder house. At five days posthatching, chicks were divided into five groups of 250 chicks each. Each group was assigned at random to one of five partitioned areas within the broiler house. Four groups of chicks were under controlled temperatures of 85, 95, 105 and 110°F for 24 hours while the other group was left to control their comfort zone by altering their position under the brooder. During days 6 through 28 all chicks were wing banded and placed in a common pen where the temperature was maintained at 85°F initially and gradually reduced to the birds ideal growing temperature of 70°F at 21 days posthatching. On day 28 chicks were identified by acclimation groups and distributed within two environmental chambers with one maintained at 79°F while the other cycled between 79 and 99°F. Relative humidity in both chambers was maintained between 50 to 55%. Feed (Table 1) and water were available for ad libitum consumption throughout the study. Upon completion of the 2-week experimental period body weight gain, survivability and feed efficiency were determined and analyzed by general linear model.

Table 1. Composition of basal diet.

Ingredient	Percent
Ground corn	56.8
Soybean meal	36.0
Fat	3.0
Dical. phosphate	2.35
Calcium carbonate	.90
Salt	.50
Vitamin Mix	.25
Trace Mineral	.10
DL-Methionine	.10
Total	100.00

Results and Discussion

Body weight at 28 days of age was significantly (P<.05) decreased by all artificial acclimation treatments (Table 2). The 4 week body weight of broilers acclimated at 95°F was decreased (P<.05) compared to those acclimated at 85, 105 or 110°F. However, no significant differences in body weight were detected at 43 days of age, suggesting that compensatory gain occurred. Indeed, body weight gain during the growth phase within the hot environmental chamber tended (P<.1) to increase among the acclimated groups. The desirability of this acclimation effect must be questioned as a greater growth rate is also associated with increased heat production.

Broiler survivability was significantly (P<.05) impacted in the heat stress environment by the acclimation technique. However, a significant (P<.05) cubic effect was detected making interpretation uncertain. Birds acclimated at 105°F had a significantly (P<.05) lower survivability compared to controls or those acclimated at 95 or 110°F. Feed efficiency, unadjusted for mortality, was numerically improved (64) in the 95 and 110°F acclimation groups and depressed (74) in the 105°F group. Further studies are needed so that the acclimation response may be adequately defined.

Table 2. The effect of 5-day posthatching heat distress acclimation on body weight, survivability, body weight gain and feed efficiency.

5-Day acclimation temperature (°F)	Body wt (lb) 28 days	Environment (growth phase): Thermoneutral % Survival[2]	Gain (lb)	FE[3]	Heat Distress % Survival	Gain (lb)	FE
Control[1]	1.28[a]	100[a]	2.20[a]	.51[a]	85[b]	1.37[b]	.40[ab]
85	1.23[b]	100[a]	2.23[a]	.52[a]	84[bc]	1.39[b]	.39[ab]
95	1.18[c]	99[a]	2.20[a]	.52[a]	90[bd]	1.45[b]	.43[a]
105	1.24[b]	98[a]	2.27[a]	.52[a]	77[c]	1.42[b]	.37[b]
110	1.23[b]	100[a]	2.29[a]	.53[a]	93[d]	1.43[b]	.43[a]

[a,b,c,d] Means within a column with different superscript differ ($P<.05$).
[1] Control = broilers allowed to seek comfort zone.
[2] Survivability.
[3] Feed efficiency.

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MAXIBAN EFFECTS ON HEAT DISTRESSED BROILERS

C.J. Wiernusz[1] and R.G. Teeter[2]

Story in Brief

A study utilizing 192 male broilers was conducted to evaluate the effects of Maxiban on the heat distressed broiler. During the 21-day trial, conducted four to seven weeks posthatching parameters monitored and results for control and treated birds respectfully, included: live weight gain (1.95, 1.91 lb); percent survival (87.5, 69.8%); and feed efficiency (.29, .21). Maxiban significantly reduced both percent survival and feed efficiency during the heat stressed period. The reduced feed efficiency was a result of the lower bird survival.

(Key Words: Maxiban, Nicarbazin, Broilers, Heat Distress.)

Introduction

Maxiban[3], a new drug combination consisting of Narasin (40 ppm) and Nicarbazin (40 ppm) has been suggested to provide a means for reducing Nicarbazin toxicity during heat distress. Reportedly, this drug combination may be utilized throughout the growing period. Long (1988) fed birds housed in a thermoneutral environment the Narasin/Nicarbazin combination from 10 to 50 ppm each along with nicarbazin fed alone at 125 ppm. His results indicated that birds performed better when given a mixture of Nicarbazin and Narasin of 10 to 40 ppm each than birds fed Nicarbazin alone at 125 ppm. Long also subjected birds to a 108°F heat stress and found that birds given a 50-50 mixture had a higher survivability than birds fed Nicarbazin at 125 ppm. Dose titration studies conducted in our laboratory however, indicate that Nicarbazin toxicity, as measured by bird mortality increases linearly with its inclusion level. The following study was conducted to evaluate Maxiban toxicity in male broilers during simulated summer heat distress.

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Materials and Methods

One hundred and ninety two Vantress X Arbor Acre male broilers were randomly allotted to 32 experimental units within the Oklahoma State University environmental chamber. Birds were allotted such that chamber position effects were blocked and that treatments consisted of 16 replicates of six chicks each. The environment was cycled between 77°F and 97°F with relative humidity maintained at 50%. At experiment initiation birds were 28 days old. Both feed (Table 1) and water were available for ad libitum consumption. Parameters monitored included live weight gain, feed consumption, feed efficiency and percent survival. Feed efficiency was calculated as:

Feed Efficiency = (average gain x percent survival)/feed consumption.

Table 1. Composition of basal diet.

Ingredient	Percent
Ground corn	56.8
Soybean meal	36.0
Fat	3.0
Dical. phosphate	2.35
Calcium carbonate	.90
Salt	.50
Vitamin mix	.25
Trace mineral	.10
DL-Methionine	.10
Total	100.00

Results and Discussion

Untreated broilers exposed to the cycling temperature heat distress (Table 2) exhibited reduced ($P<.01$) live body weight gain (27%), feed efficiency (31%) and survival (13%) when compared to the thermoneutral controls. Supplementing the rations of heat stressed broilers with Maxiban had no significant impact upon weight gain though it was numerically depressed (2.2%). However, Maxiban supplementation significantly depressed ($P<.01$) broiler survival from a mean of 87.5 to just 69.8%. Primarily as a result of the reduced number of birds surviving the trial, feed efficiency was also reduced ($P<.01$) from a mean of .29 to just .21. These data suggest that the new drug combination Maxiban does not eliminate the problems encountered with Nicarbazin use during high ambient temperature-relative humidity stress.

Table 2. Effects of 40 ppm narasin and 40 ppm nicarbazin on weight gain, feed efficiency and survivability.

Treatment	Weight gain (lb)	Feed efficiency	Survivability (%)
Control	1.97	.3293	87.50
Narasin/nicarb	1.91	.2991	69.79

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Long, P.L. et al. 1988. Anticoccidial activity of combinations of narasin and nicarbazin. Poultry Sci. 67:248.

EVALUATION OF TEN WHEAT VARIETIES FOR TME_n, CRUDE PROTEIN AND AMINO ACID CONTENT

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Story in Brief

One study utilizing 8-week old Vantress x Arbor Acre male broilers was conducted to estimate the nitrogen corrected true metabolizable energy (TME_n), crude protein and amino acid content of five soft red winter wheat varieties and five hard red winter wheat varieties. Mean TME_n values for the hard and soft wheat classifications were similar at 1513.7 and 1506.1 Kcal/lb, respectively. However, there were significant TME_n differences among individual varieties. Crude protein content was higher, with the exception of Chisholm, for the hard red winter wheats. Amino acid content expressed as a percent of total protein was similar for the two classifications.

(Key Words: Wheat, TME_n, Broiler, Protein, Amino Acids.)

Introduction

Wheat is commonly produced in Oklahoma as a cash crop for human consumption, but can also be utilized as a livestock feed. Wheat is higher in crude protein than corn or milo, possesses a higher dry matter content and contains more pounds per bushel. In addition, the lysine and methionine content of wheat averages .35 and .17% respectively, which is higher than other feed grains.

Least cost ration formulation requires feed composition data describing bioavailable nutrient content. Metabolizable energy (ME) can be expressed as either apparent (AME) or true (TME) metabolizable energy (Harris, 1966). Since Sibbald (1976) developed the TME bioassay, considerable amount of research has been conducted to determine feed TME_n values as these have the advantage of being corrected for endogenous loss.

The number of wheat varieties available for production increases each year as more are developed. In order for this increasing number of wheat varieties to be utilized efficiently as livestock feeds, they must be evaluated

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for nutrient content. The objective of this study was to determine the bioavailable energy, crude protein and amino acid content of five wheat varieties within the hard and soft wheats.

Materials and Methods

Eighty eight 8-week post hatching Vantress x Arbor Acre male broilers were utilized in a two-period study. All birds were individually housed in 10 x 18 x 17-inch wire cages within a thermostatically controlled room maintained at 75°F under constant florescent lighting. Water was provided ad libitum throughout the assay period.

Wheat varieties (Table 1) utilized in this study classified as either soft red winter or hard red winter, were provided by the Oklahoma Wheat Commission Company. Varieties classified as soft red winter included Hart, Caldwell, Arthur, Pike and Delange while the hard red winter wheat varieties included Triumph, Chisholm, Mustang, Payne and Tam 101.

The TME_n assay was conducted according to the method of Sibbald (1986), with modifications. As suggested by Sibbald, feed was withheld for 24 hr prior to initiating the assay. However, precision feeding was performed according to Teeter et al. (1984). Feed was administered on an air dry basis at 1.5% of initial body weight. Following feed administration a harness fitted with polyethylene bag was placed on the bird to commonly collect fecal and urine excretion for 48 hr (Sibbald et al., 1986). All excreta were frozen till subsequent analysis. Several observations were discarded as result of feed regurgitation and/or bag leakage. Due to the number of discarded observations, a second period was performed in a similar fashion to increase the number of observations per treatment group.

Table 1. Nutrient composition of winter wheat varieties expressed as a percent dry matter of the feed.

Wheat variety	DM	Ash	CP	Fat	ADF
Soft Red Winter					
Hart	86.65	1.62	12.91	1.27	2.82
Caldwell	87.01	1.53	11.20	1.22	2.69
Arthur	86.46	1.60	13.87	1.53	2.37
Pike	86.81	1.71	13.32	1.16	2.68
Delange	87.87	1.62	14.19	1.04	2.72
Hard Red Winter					
Triumph	88.42	1.32	15.76	.99	3.04
Chisholm	88.38	1.49	14.07	1.17	1.19
Mustang	88.69	1.45	15.39	1.27	.67
Payne	88.44	1.90	19.13	1.33	2.74
Tam 101	88.66	1.39	15.62	1.14	.73

Wheat samples were analyzed for gross energy using a Parr 1261 calorimeter, dry matter, fat as ether extract, protein (N x 6.25), ash (Association of Official Analytical Chemists, 1970), and acid detergent fiber (Van Soest, 1962). Amino acid concentrations were determined from acid hydrolysates by ion exchange chromatography using an automatic amino acid analyzer according to the methods outlined in the manufacturer's instruction manual 121-1M-1A April 1970. All data were subjected to analysis of variance. Duncan's multiple range test was used to determine differences ($P<.05$) between means when a significant F statistic effect was indicated by the analysis of variance (Steel and Torrie, 1960).

Results and Discussion

Results of crude protein and amino acid analysis are reported in Tables 2 and 3, respectively. The hard red winter wheat varieties were higher ($P<.05$) in crude protein and amino acid content similar to Poultry NRC (1984) values. Significant variation in crude protein and amino acid content or amino acid content expressed as a percent of crude protein were evident among wheat varieties. Wheat has been reported to vary in crude protein from 9.0 to 19.3% (Biely et al., 1970). This wide variation in protein content has been ascribed to both cultivar and cultural factors. Results of this study concur with that conclusion.

True metabolizable energy values corrected to zero nitrogen balance (TME_n) for the 10 wheat varieties are presented in Table 4. No significant differences were detected due to period and values reported are therefore averaged over period. The TME_n energy values, averaged across varieties within the hard and soft classification were similar ($P=.86$) at 1513.7 and 1506.1 Kcal/lb, respectively. However, variety differences within a wheat classification were detected ($P<.05$). Within the soft red winter wheat classification TME_n was depressed ($P<.05$) for the Delange and Hart varieties. Within the hard red winter wheat classification energy values were depressed ($P<.05$) for the Mustang variety and tended to be lower ($P<.1$) with the Chisholm and Tam 101 varieties. Reported values in the literature for TME_n (Sibbald, 1986; Salmon et al., 1987; Boldaji et al., 1986; Salmon, 1984) are similar range to the values obtained within this study. However, these values are for the spring and not the winter wheat classification.

Data reported therein suggest that greater variation occurs within a wheat classification than between the overall groups. Therefore, the producer must possess nutritional information specific for the variety utilized in order to maximize its utility as a livestock feed.

Table 2. Crude protein and amino acid composition of soft red winter wheat varieties.

	Hart	Caldwell	Arthur	Pike	Delange
% Protein (DM)	12.91	11.19	13.86	13.32	14.20
AA Composition as a % of feed					
Lysine	.37(2.86)[a]	.35(3.13)	.38(2.74)	.35(2.63)	---[b]
Histidine	.28(2.17)	.24(2.14)	.28(2.02)	.25(1.88)	.31(2.18)
Arginine	.63(4.88)	.61(5.45)	.65(4.69)	.59(4.43)	.69(4.86)
Aspartic Acid	.63(4.88)	.59(5.27)	.65(4.69)	.65(4.88)	.68(4.79)
Threonine	.33(2.57)	.31(2.77)	.36(2.59)	.34(2.55)	.39(2.75)
Serine	.53(4.10)	.48(4.29)	.57(4.11)	.53(3.98)	.62(4.37)
Glutamic Acid	3.49(27.0)	2.97(26.5)	3 85(27.8)	3.67(27.5)	4.15(29.2)
Proline	1.01(7.82)	.85(7.59)	1.11(8.01)	1.02(7.66)	1.22(8.59)
Glycine	.52(4.03)	.48(4.28)	.52(3.75)	.53(3.98)	.58(4.08)
Alanine	.45(3.48)	.39(3.48)	.45(3.25)	.43(3.23)	.48(3.38)
Valine	.55(4.26)	.50(4.47)	.57(4.11)	.53(3.98)	.51(4.01)
Methionine	.21(1.63)	.19(1.69)	.22(1.59)	.11(.83)	.22(1.55)
Isoleucine	.41(3.17)	.36(3.22)	.44(3.17)	.41(3.08)	.47(3.31)
Leucine	.82(6.35)	.72(6.43)	.86(6.20)	.82(6.16)	.92(6.48)
Tyrosine	.40(3.10)	.34(3.04)	.40(2.89)	.39(2.93)	.42(2.96)
Phenylalanine	.52(4.03)	.46(4.11)	.58(4.18)	.56(4.10)	.64(4.51)

[a]Numbers in parentheses represent amino acid concentrations as a % of the feed protein (DM basis).
[b]Value was not detected.

Table 3. Crude protein and amino acid composition of hard red winter wheat varieties.

	Triumph	Chisholm	Mustang	Payne	Tam
% Protein (DM)	15.76	14.07	15.39	19.13	15.63
AA Composition as a % of feed					
Lysine	.41(2.60)[a]	.40(2.84)	.36(2.34)	.49(2.56)	.34(2.17)
Histidine	.34(2.16)	.31(2.20)	.31(2.01)	.42(2.20)	.34(2.17)
Arginine	.75(4.76)	.70(4.97)	.64(4.16)	.92(4.81)	.74(4.73)
Aspartic Acid	.79(5.01)	.70(4.97)	.77(5.00)	.94(4.92)	.70(4.48)
Threonine	.41(2.60)	.35(2.49)	.40(2.60)	.47(2.46)	.37(2.37)
Serine	.65(4.12)	.60(4.26)	.65(4.22)	.89(4.65)	.62(3.97)
Glutamic Acid	4.65(29.5)	4.14(29.4)	5 08(33.0)	6.36(33.3)	4.50(28.8)
Proline	1.41(8.95)	1.12(7.96)	1.51(9.81)	1.67(8.73)	1.19(7.61)
Glycine	.62(3.93)	.54(3.84)	.58(3.77)	.75(3.92)	.58(3.71)
Alanine	.51(3.24)	.45(3.20)	.45(2.92)	.61(3.19)	.44(2.81)
Valine	.61(3.87)	.55(3.91)	.52(3.38)	.79(4.13)	.58(3.71)
Methionine	.25(1.59)	.20(1.42)	.18(1.17)	.27(1.41)	.20(1.28)
Isoleucine	.51(3.24)	.48(3.41)	.48(3.12)	.66(3.45)	.50(3.20)
Leucine	1.01(6.41)	.93(6.61)	.93(6.04)	1.30(6.80)	.98(6.27)
Tyrosine	.47(2.98)	.42(2.98)	.45(2.92)	.65(3.46)	.47(3.01)
Phenylalanine	.69(4.38)	.62(4.41)	.63(4.09)	.92(4.81)	.66(4.22)

[a]Numbers in parentheses represent amino acid concentrations as a % of the feed protein (DM basis).

Table 4. True metabolizable energy (TME) and N-corrected true metabolizable energy (TMEn) of different varieties of wheat.

Wheat variety	TME_n (Kcal/lb)	Standard Error[a] LMS
Soft Red Winter		
Caldwell	1595.1	56.4
Pike	1595.1	57.5
Arthur	1551.7	61.8
Hart	1388.9	48.8
Delange	1334.6	86.8
Mean value of Soft Red Winter	1506.1	29.5
Hard Red Winter		
Payne	1616.8	67.3
Triumph	1551.7	64.0
Tam 101	1508.3	90.1
Chisholm	1497.4	57.5
Mustang	1388.9	67.3
Mean value of Hard Red Winter	1513.7	32.7

[a]Standard error least squares means.

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THE EFFECTS OF DECCOX ON WEIGHT GAINS OF STOCKER CATTLE GRAZING WHEAT PASTURE

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M.D. Jamison[3] and K.S. Lusby[4]

Story in Brief

One hundred and ninety nine heifers were utilized to determine the effect of Deccox (decoquinate), a coccidiostat, on weight gain of stocker cattle grazing wheat pasture. The trial was conducted from December 2, 1987 to January 29, 1988 (58 days) in Okmulgee County in East central Oklahoma. Heifers had been raised on the ranch or were purchased cattle that had been received 4 to 6 weeks before initiation of the trial. During the first 28 days Deccox-fed cattle gained 40 lb compared to 31 lb for control cattle not fed Deccox. Gains for the second period were 28 and 31 lb, respectively, for Deccox and control cattle. Daily gains for the total trial, 68 lb for Deccox-fed cattle and 61 lb for controls, were not statistically different. Heifers may have been suffering from a low-level infection of coccidiosis during the first month of the trial but the effect apparently disappeared during the second month of grazing high quality forage. No sickness was observed.

(Key Words: Coccidiosis, Decoquinate, Wheat Pasture, Beef Cattle.)

Introduction

Coccidiosis is a common occurrence among newly received stocker cattle in Oklahoma. However, most winter stockers are moved to high quality small grain forages after recovery from the stresses of shipping and receiving. The question frequently arises about the need to continue feeding coccidiostats after the period of stress has ended and the level of nutrition is very high. This study was conducted to study the effect of feeding a

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coccidiostat to healthy stocker cattle grazing wheat pasture in December and January.

Materials and Methods

One hundred and ninety nine heifers weighing about 450 lb were randomly allotted to two treatments, (control, no Deccox and Deccox, 100 mg/day). Heifers grazed wheat forage in two pastures that provided ample and approximately equal amounts of forage. Both groups were fed the same amount of a commercial grain supplement daily throughout the trial in amounts ranging from 2 to 4 lb/day depending on forage availability. Deccox was administered with the supplement.

The trial was conducted at a ranch near Okmulgee in east central Oklahoma from December 2, 1987 to January 29, 1988 (58 days). Heifers had been raised on the ranch or were purchased cattle that had been received 4 to 6 weeks before the trial period so that the trial did not involve a receiving period. All cattle had been processed, including deworming, by November 6. All heifers were grazed on wheat pasture from November 5 to December 2, the start of the trial. Heifers were allotted to treatments based on origin (ranch raised or purchased) and weight. All cattle weights were taken without shrink.

Pastures were about 100 acres each resulting in a stocking rate of one heifer per acre. Grass hay was offered in equal amounts to each group during 10 days when snow covered all or part of the wheat forage.

Data for total weight gain and gain for Period 1 were analyzed using a model which included treatment, initial weight and the interaction term. The model for weight gain for Period 2 included treatment, second weight and the interaction. Second weight was used as a covariable to remove the effect of heavier weights of Deccox cattle at the end of Period 1.

Results and Discussion

Supplements were readily consumed by groups throughout the trial. Weights and gains are presented in Table 1. During the first 28 days, Deccox-fed cattle gained 40 lb compared to 31 lb for control cattle ($P<.03$). The increased gains of the Deccox group during the first 28 days of the study suggests that a low level of coccidiosis may have been present. Deccox has not been shown to have growth promotive effects exclusive from benefits of reducing coccidiosis.

Table 1. Performance of heifers grazing wheat pasture with or without Deccox.

	Control	Deccox	Prob.
No. heifers	99	100	
Initial wt (Dec 2), lb	447	452	
Weight gains, lb			
Dec 2-Dec 30	31	40	.03
Dec 30-Jan 29	31	28	.90
Total	62	68	.64
Final weight, lb	509	520	
No. pulled for sickness	0	0	

Gains for the second period were 28 and 31 lb (P>.5) for Deccox and control cattle. Daily gains for the total trial were 68 lb for Deccox-fed cattle compared to 61 lb for controls but were not statistically different. Heifers may have been suffering from a low level infection of coccidiosis during the first month of the trial but the effects apparently disappeared during the second month of grazing high quality forage. No sickness was observed. Cattle not affected by coccidiosis and maintained on high quality forage will probably not benefit from feeding coccidiostats.

RUMINAL FERMENTATION AND INTESTINAL NUTRIENT FLOWS IN STEERS GRAZING RANGELAND IN THE SUMMER

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

Story in Brief

Fistulated beef steers grazing tallgrass rangeland were used to monitor intake, ruminal fermentation and nutrient flows to the small intestine during four trials in both the 1986 and 1987 grazing seasons (May-September). Intakes in 1986 remained around 2.1% of body weight throughout the first three trials and decreased to 1.9% in late September, whereas 1987 intakes declined throughout the season, from 1.8% body weight in mid-May to 1.4% in late September. Nitrogen intake declined with advancing season both years. Duodenal flow of nitrogen exceeded nitrogen intake in all 1986 trials and in two 1987 trials. True ruminal digestion of organic matter remained fairly stable throughout the 1986 season, and ruminal ammonia nitrogen (mg/100ml) ranged from 7.1 in May to 2.6 in late September. In 1987, true ruminal digestion declined the latter half of the summer, and ruminal ammonia levels ranged from 3.8 in May to 1.4 in August. Microbial efficiency (g microbial nitrogen/kg organic matter truly fermented) did not change across trials in either year. Although no significant differences occurred, microbial efficiency tended to be lower in mid-season of both years suggesting an imbalance of ruminal substrates for microbial synthesis.

(Key Words: Ruminal Fermentation, Duodenal Flow, Rangeland, Microbial Efficiency, Intake.)

Introduction

The influence of advancing season on growth and nutritive value of range plants in relation to daily requirements of grazing animals is well noted. However, information concerning the relationship between diet quality, ruminal environment and nutrient utilization in grazing cattle is quite limited. A more complete understanding of these relationships will aid the

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development of nutrition and grazing management programs that will improve the efficiency of livestock production from forages.

Studies were conducted in 1986 and 1987 to investigate the seasonal changes in diet quality, forage intake and nutrient utilization that occur on tallgrass prairie rangeland in central Oklahoma. Portions of these studies are discussed in this report.

Materials and Methods

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

Four 10-day trials were conducted both years: mid May, late June, mid August and late September. Diet samples were collected from esophageally fistulated steers during each trial. The procedures are reported in another article in this publication (Campbell and McCollum, 1989). Six ruminally and duodenally cannulated beef steers (Angus x Hereford and Limousin x Hereford) were used to estimate intake and monitor ruminal fermentation in 1986. Eight ruminally and duodenally cannulated beef steers (Angus x Hereford, Limousin x Hereford and Hereford) were used in 1987. Chromic oxide powder was used as an external marker to estimate fecal output and duodenal flow. Purine content of digesta was utilized to estimate microbial contribution to duodenal flow. Intakes were calculated by fecal output/(1-in vitro organic matter digestibility). Fecal samples began after five days continuous dosage of chromic oxide and consisted of five samples over a three day period. Samples were composited within steer, dried in a forced air oven at 50°C and ground through a 1 mm screen. Duodenal digesta was collected at 1600 hours on day 7, 0200, 1200 and 2000 hours on day 8 and 0800 hours on day 9 of each trial. Digesta was composited across sampling times for each steer and lypholized. Fecal and duodenal samples were analyzed for ash, kjeldahl nitrogen, purines and chromium. Ruminal fluid was collected at 0800, 1400 and 2000 hours on day 9, and 0200 and 0800 hours on day 10 of each trial. Fluid was strained through cheesecloth, acidified and immediately frozen in plastic whirlpaks until analyzed for ammonia nitrogen. Addition fluid was collected and composited across steers for bacterial pellet isolation. The fluid was preserved with formaldehyde, centrifuged, and the resulting bacterial pellet washed and lypholized. Analysis included kjeldahl nitrogen and purine concentration.

Years were analyzed separately due to a significant year x trial interaction. Data from 1986 were analyzed by least squares procedures with a model containing trial and steer. In 1987, steers were blocked according to weight, resulting in a model containing trial, block and steer within block.

Results and Discussion

Intakes when expressed as percent of body weight, remained fairly stable throughout the first three trials of 1986 and then declined (P<.05) in late September (Table 1). Intakes in the last two trials of 1987 were lower (P<.05) compared to May and June trials (Table 1). Intake is influenced by advancing maturity of forage and the accompanied increase in fiber content. In 1986, diet ADF tended to increase as the summer progressed, changing from 42.9% in May to 44.9% in August and 47.6% in September (Campbell and McCollum, 1988). Intakes reflected this change. Intakes in 1987 also reflected the ADF content of the diets, which increased from mid-May through mid-August and stabilized through late September (Campbell and McCollum, 1989).

In 1987, a significant block effect occurred for intake expressed as percent of body weight. Forage intake by steers in the heavy block (average wt. 1400 lb), averaged over the summer, were 21.1% lower than the smaller steers (average wt 1005 lb). When the heavier steers were excluded, intakes

Table 1. Organic matter intake and flow to the small intestine.

Component	Year	Trial: Mid May	Late June	Mid August	Late September
Steer wt, lb	86	603	708	777	840
	87	1122	1166	1241	1274
Intake, g/d	86	5620[a]	6784[b]	7394[c]	7146[bc]
	87	8910[a]	8914[a]	8505[a]	7894[b]
Intake, % of body wt	86	2.05[ab]	2.11[a]	2.09[a]	1.88[b]
	87	1.80[a]	1.73[a]	1.53[b]	1.38[b]
Passage, g/d					
Duodenal	86	3002[a]	3578[ab]	4217[bc]	4449[c]
	87	5273	5313	5620	5488
Forage	86	2364[a]	2778[ab]	3421[bc]	3627[c]
	87	4248[a]	4485[ab]	4927[c]	4670[bc]
Microbial	86	638[a]	800[b]	796[b]	822[b]
	87	1025[a]	828[b]	693[c]	818[b]
Digestion, % of intake					
Ruminal, apparent	86	46.1	47.2	43.0	37.7
	87	40.5[a]	40.4[a]	33.6[b]	30.3[b]
Ruminal, true	86	57.6	59.0	53.8	49.2
	87	52.1[a]	49.7[a]	41.9[b]	40.7[b]

[a,b,c]Row means with different superscripts are different (P<.05).

were 2.1, 1.9, 1.7 and 1.5% body weight in mid May, late June, mid August and late September, respectively. Steers in the heavy block were obese Herefords. Therefore, lack of productive function and high body fat levels resulted in lower intake as a function of body weight.

Nitrogen intake declined with advancing season both years (Table 2). In 1986, nitrogen intake declined 28.6%, from 119.9 g/day in mid May to 85.6 g/day in late September. A decrease of 51.6% in nitrogen intake was noted in 1987, declining from 191 g/day in mid May to 92.5 g/day in mid August. Differences in total nitrogen intake (g/day) between years is not only due to differences in nitrogen concentration in the diet, but also to differences in total organic matter intake (g/day). In 1986, total organic matter intake increased as the season advanced as a result of weight gain by the steers. Also, steers used in 1987 were larger than steers utilized in 1986, therefore total intake was higher in 1987.

Nitrogen reaching the small intestine exceeded nitrogen intake in all 1986 trials, and during the last two trials of 1987. Forages containing less than 2 to 2.5% nitrogen are normally associated with a net gain of nitrogen reaching the duodenum relative to ingested nitrogen. This gain is the result of nitrogen recycling into the rumen. Microbial growth is dependent on the amount of fermentable organic matter and nitrogen available in the rumen. Previous research has suggested that ruminal microbes require between 2

Table 2. Nitrogen intake and flow to the small intestine.

		Trial			
Component	Year	Mid May	Late June	Mid August	Late September
Intake	86	119.9[a]	99.8[b]	90.2[bc]	85.6[c]
	87	191.0[a]	151.4[b]	92.5[c]	101.3[c]
Passage, g/d					
Duodenal	86	155.2	154.0	168.7	142.3
	87	215.1[a]	198.5[a]	165.1[b]	161.5[b]
Forage	86	92.3[ab]	87.1[ab]	99.7[a]	80.3[b]
	87	190.2[a]	175.8[a]	149.9[b]	144.0[b]
Bacterial	86	58.4	62.6	63.5	57.1
	87	99.3[a]	80.6[b]	63.0[c]	72.2[bc]
Digestion, % of intake					
Ruminal, apparent	86	-31.2[a]	-54.8[ab]	-86.8[c]	-65.2[bc]
	87	-13.2[a]	-31.6[b]	-79.2[d]	-59.7[c]
Ruminal, true	86	22.0[a]	12.6[ab]	-10.4[c]	6.5[b]
	87	42.1[a]	25.7[b]	- 6.0[c]	17.4[b]
Microbial Eff., g microbial N/kg OM truly fermented	86	18.4	15.8	16.0	19.1
	87	21.6	18.3	18.4	23.0

[a,b,c,d]Row means with different superscripts are different (P<.05).

and 5 mg NH_3-N/100 ml rumen fluid. True ruminal organic matter digestion did not change significantly throughout the 1986 season (Table 1), and ruminal ammonia-N levels remained above 2 mg/100 ml (Figure 1). Microbial efficiency values did not change ($P>.05$) across the 1986 season (Table 2). In 1987, true ruminal digestion of organic matter declined the last two trials. However, differences in microbial efficiency were only noted in mid August, during the same trial in which ammonia-N levels dropped below 2 mg/100 ml.

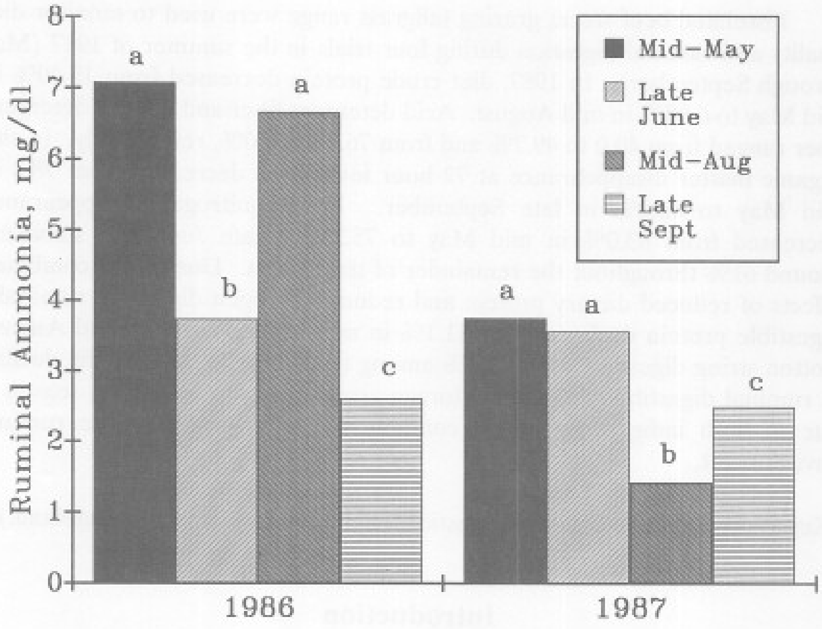

Figure 1. Ruminal ammonia-N concentration, mg/100 ml. [a,b,c,d]Means within a year with different superscripts are different ($P<.05$).

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DIET COMPOSITION AND DIGESTION IN STEERS GRAZING RANGELAND IN THE SUMMER

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

Story in Brief

Fistulated beef steers grazing tallgrass range were used to monitor diet quality and ruminal digestion during four trials in the summer of 1987 (May through September). In 1987, diet crude protein decreased from 13.40% in mid May to 6.80% in mid August. Acid detergent fiber and neutral detergent fiber ranged from 40.0 to 49.7% and from 76.7 to 83.0%, respectively. In situ organic matter disappearance at 72 hour incubation decreased from 78.2 in mid May to 66.0% in late September. In situ nitrogen disappearance decreased from 83.0% in mid May to 75.2% in late June and stabilized around 61% throughout the remainder of the season. Due to the combined effects of reduced dietary protein and reduced nitrogen digestion, ruminally digestible protein declined from 11.1% in mid May to 4.0% in mid August. Cotton string digestion varied 9.5% among trials, suggesting that the decline in ruminal digestibility of grazed forage associated with advancing season is due to both indigestible forage components and changes in the ruminal environment.

(Key Words: Forage Quality, Digestion, in situ Disappearance, Rangeland.)

Introduction

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

Studies were conducted in 1986 and 1987 to investigate the seasonal changes in diet quality, forage intake and nutrient utilization that occur on

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tallgrass prairie rangeland in central Oklahoma. The diet quality portion of the 1987 study is discussed in this report. Diet quality and ruminal digestion results for 1986 were reported earlier (Campbell and McCollum, 1988).

Materials and Methods

Cattle were grazed on moderately stocked tallgrass prairie rangeland located 12 miles southwest of Stillwater. Range condition on the area was high fair to low excellent. The dominant grasses were big bluestem and indiangrass, little bluestem, and switchgrass.

Four 10-day trials were conducted: mid May, late June, mid August and late September. Diet samples were obtained from esophageally fistulated steers the first two days of each trial. Masticate samples were dried in a forced air oven at 50°C, ground through a 2mm screen and stored for analysis of ash, crude protein (CP), acid detergent fiber (ADF) neutral detergent fiber (NDF) and in vitro organic matter digestibility (IVOMD).

Eight ruminally cannulated beef steers (Angus X Hereford, Limousin X Hereford and Hereford) were used to monitor ruminal fermentation. Ruminal organic matter disappearance (OMD) and nitrogen disappearance (ND) were estimated by suspending duplicate dacron bags containing 2g esophageal masticate in the rumen for intervals of 72, 48, 36, 24, 18, 12 and 6 hours. Duplicate bags containing .5g of cotton string were also incubated for 72, 48, 36 and 24 hours to monitor ruminal cotton string cellulose disappearance. All bags were removed simultaneously, washed with water until effluent ran clear and dried at 55°C for 48 hours. Residual forage was removed from the bags and analyzed for ash and kjeldahl nitrogen. Strings were removed from bags, washed clean, placed in foil pans, dried at 105°C and weighed to determine disappearance.

Four steers were used to collect diet data in one trial, and three steers were used in all others, resulting in 13 observations. Diet data were analyzed by least squares procedures as a completely randomized design with trial in the model. In situ data were collected from eight steers in all four trials. Data were analyzed within incubation period by least squares procedures as a completely randomized design with trial and steer in the model.

Results and Discussion

Diet crude protein was different ($P<.05$) among trials, declining from 13.40% in mid May to 6.80% in mid August, and increasing to 8.03% in late September. Cell wall constituents in the diets increased from mid May to late June and then declined between mid August and late September. Acid detergent fiber, representing the less digestible cell wall constituents, increased ($P<.05$) from mid May to mid August and remained relatively stable through late September. In situ organic matter disappearance reflected changes in both fiber fractions. Potential disappearance (72 h in situ bags) declined ($P<.05$) from 78.2% in mid May to 67.9% in mid August, and remained around 66% through late September (Table 2). Rate of organic matter disappearance, as indicated by short term disappearance values (6, 12 and 18 h) was slower for the mid August trial. A similar trend was noted for nitrogen disappearance. Potential nitrogen disappearance (72 h in situ bags) was lowest in mid August and late September. Potentially digestible nitrogen varied 28.4%, ranging from 83.0% in mid May to 59.4% in mid August. Combining values for diet protein (Table 1) with values for 72 hour nitrogen disappearance (Table 3) yielded ruminally digestible protein

Table 1. Nutrient composition of esophageal masticate.

Component[a]	Trial: Mid May	Late June	Mid August	Late September
	--------------% of organic matter------------			
CP	13.40[b]	10.59[c]	6.80[d]	8.03[d]
ADF	40.01[b]	44.08[c]	49.72[d]	47.89[d]
NDF	76.72[b]	82.35[c]	83.03[c]	80.53[b]
IVOMD	56.32[b]	54.78[b]	49.40[c]	44.20[d]

[a]CP is crude protein, ADF is acid detergent fiber, NDF is neutral detergent fiber and IVOMD is in vitro organic matter digestibility.
[b,c,d]Means with different superscripts are different ($P<.05$).

Table 2. In situ disappearance of organic matter in esophageal masticate samples.

Hours of incubation	Trial: Mid May	Late June	Mid August	Late September
6	25.17[a]	21.92[b]	15.49[c]	26.26[a]
12	38.21[a]	36.05[ab]	27.24[c]	34.77[b]
18	47.15[a]	43.05[a]	37.64[b]	45.23[a]
24	56.95[a]	53.78[ab]	44.80[c]	49.92[bc]
36	68.80[a]	62.39[b]	57.09[b]	58.84[b]
48	74.39[a]	70.26[b]	61.74[c]	63.68[c]
72	78.19[a]	75.34[b]	67.91[c]	66.02[c]

[a,b,c]Row means with different superscripts are different ($P<.05$).

Table 3. In situ disappearance of nitrogen in esophageal masticate samples.

Hours of incubation	Trial			
	Mid May	Late June	Mid August	Late September
6	22.70[bc]	25.28[b]	20.77[c]	34.57[a]
12	40.14[b]	34.51[bc]	31.43[c]	49.64[a]
18	49.85[a]	40.87[b]	38.17[b]	48.79[a]
24	60.67[a]	49.68[bc]	43.69[c]	52.28[b]
36	73.18[a]	62.44[b]	56.79[bc]	53.33[c]
48	79.53[a]	69.09[b]	57.00[c]	61.34[c]
72	83.01[a]	75.25[b]	59.43[c]	62.90[c]

[a,b,c]Row means with different superscripts are different (P<.05).

estimates of 11.1% in mid May, 8.0% in late June, 4.0% in mid August and 5.1% in late September.

In 1986, in situ dry matter disappearance and nitrogen disappearance at 72 h incubation decreased from 74.5 and 72.6% in mid May to 57.6 and 39.1% in late September. However, no differences (P>.05) were noted among trials for cotton string cellulose disappearance. Results from this portion of the 1987 study tend to agree with 1986 data, however, there was a tendency for string disappearance to decline with season (Table 4).

Table 4. In situ disappearance of cotton string cellulose.

Hours of incubation	Trial			
	Mid May	Late June	Mid August	Late September
24	26.09[bc]	29.43[ab]	21.62[c]	31.95[a]
36	53.22[ab]	39.34[b]	47.26[b]	63.75[a]
48	71.10[ab]	64.53[b]	69.24[b]	79.85[a]
72	95.44[a]	96.95[a]	92.47[ab]	87.71[b]

[a,b,c]Row means with different superscripts are different (P<.05).

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FEEDLOT PERFORMANCE OF STEERS GRAZED AS STOCKERS ON FESCUE: A 2-YEAR STUDY

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Story in Brief

A total of 114 Angus, Brahman x Angus, Angus x Brahman-Angus, and Simmental x Brahman-Angus steers, 13 to 19 months old, were used. Steers had been grazed from November to May on: (1) Kentucky 31 fescue (76% endophyte infected), (2) Kentucky 31 (74% infected) interseeded with clovers, or (3) Low endophyte Kentucky 31 fescue (.7% infected). Steers were removed from fescue pastures on May 21, held for 6 days on bermuda-ryegrass pastures, shipped to a feedlot in western Oklahoma, and fed for 117 or 113 days (Years 1 and 2). Steers from high endophyte fescue weighed 101 pounds less than steers from low endophyte pastures at the end of grazing but gained 68 pounds more during the feedlot phase. High endophyte steers gained faster during a 6-day holding period, tended to lose less weight in transit to the feedlot, and gained faster during the first 48 to 49 days in the feedlot. Because of slightly greater gains on pasture and in the feedlot, and greater gains during the 6-day holding period, interseeded clover steers had heavier slaughter and carcass weights than low endophyte steers. Rectal temperature was greater for high versus low endophyte steers at the end of fescue grazing and after the 6-day holding period with interseeded clover steers intermediate. No difference in rectal temperatures was noted at the feedlot. Carcass weights were lighter and quality grade tended to be lower for high endophyte steers. Steers with fescue toxicosis can compensate for up to 67% of reduced grazing gains.

(Key Words: Fescue, Endophyte, Feedlot, Finishing, Steers.)

Introduction

A number of trials have shown reduced pasture performance of cattle grazing endophyte infected fescue. Because thousands of these cattle are

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shipped to high plains feedlots for finishing, information about carryover effects of the endophyte toxin on subsequent performance in the feedlot is extremely important. The objective of this study was to evaluate feedlot performance and carcass characteristics of steers with large differences in previous pasture performance due to endophyte infection from grazing fescue pastures and pastures interseeded with clovers.

Materials and Methods

Steers from the second and third year of the fescue grazing study were shipped to a commercial feedlot in the Oklahoma panhandle. A total of 114 Angus, Brahman x Angus, Angus x Brahman-Angus, and Simmental x Brahman-Angus were used. The steers were from 13 to 19 months old when placed on feed. Steers had been grazed from November to May on Kentucky 31 fescue (76% endophyte infected), (2) Kentucky 31 (74% infected) interseeded with a mixture of clovers, or (3) low endophyte Kentucky 31 fescue (.7% infected). The grazing phase of the study was conducted at the Kerr Center, Inc. near Poteau in eastern Oklahoma.

Steers were removed from fescue pastures on May 21, 1987 (year 1) and May 19, 1988 (year 2), and hauled three miles to a bermudagrass-ryegrass pasture adjacent to shipping facilities and held for 6 days before shipment. At the time of shipment, steers were weighed directly off the bermudagrass-ryegrass pasture at 5 p.m., loaded onto trucks, and shipped 450 miles during the night to the Henry C. Hitch Feedyard near Guymon in western Oklahoma. The 6-day holding period on bermudagrass-ryegrass and night time shipping were used to minimize heat stress of steers from endophyte infected pastures.

On arrival at the feedyard, steers were placed in their pen and rested until the following morning when they were individually weighed full on electronic scales, had rectal temperatures taken and were given routine processing procedures for incoming cattle. Processing consisted of IBR-BVD-Leptospirosis, BRSV, 7-way Clostridial, injections of Vitamin A and copper, implanting with Synovex-S and deworming with ivermectin.

Steers were then fed for 117 days in year 1 and 113 days in year 2 on a 90% concentrate finishing ration with high moisture corn, steam flaked corn and steam flaked wheat. The ration contained approximately .97 Mcal NE_m/lb, .62 Mcal NE_g/lb and 12.65% crude protein on a dry matter basis. All steers were slaughtered at a commercial packing facility about 50 miles from the feedlot.

Steer weights at the end of the fescue grazing phase were taken after overnight withdrawal from feed and water. All other weights were full.

Steers were weighed individually at about 49 days into the feeding period, and again the day before slaughter. Steers were slaughtered on September 22, 1987 and September 15, 1988 and were graded about 24 hours after slaughter. Calculations of weight gains were based on 4% shrinks (actual full weights multiplied by .96) of live weights.

Results and Discussion

At the end of approximately 197 days of fescue grazing in late May, high endophyte steers showed typical clinical signs of fescue toxicosis including reduced gains (Table 1), increased rectal temperatures and rough hair coats.

During the 6-day period when cattle were held on bermudagrass-ryegrass pasture, steers previously grazing high endophyte and interseeded clover pastures gained faster (P<.05) than those previously on low endophyte pastures (35 and 44 vs 22 lb,respectively). Because the shipping weight was taken without shrink, results suggest that high endophyte steers took on more

Table 1. Weight gains and body temperatures of steers during the preshipment holding period and the feedlot.[a]

	Treatments			
	Endophyte infected fescue	Infected fescue & clover	Endophyte free fescue	SE
No. steers	41	34	39	
Weight off fescue pasture, lb	768[c]	878[b]	869[b]	12.1
Weight changes, lb				
6-day holding period	35[b]	44[b]	22[c]	5.5
Transit to feedlot	-22	-33	-35	6.2
Weight gains in feedlot, lb				
First 48-49 days on feed	222	200	196	9.0
July to finish, 65-68 days	231	227	218	7.5
Off fescue to slaughter	466[c]	440[bc]	400[b]	15.6
Total, pasture plus feedlot, 315-319 days	713[a]	792[c]	748[b]	12.1
Final finish weight, lb	1236[b]	1313[d]	1269[c]	12.3
Rectal temperature, F				
At time of shipping[e]	103.4[c]	103.1[c]	102.8[b]	.15
At processing in feedlot	102.2	102.0	101.8	.20
In feedlot, July	104.1	103.9	104.0	.17

[a]Two years data.
[bcd]Means on the same line with different superscripts differ P<.05).
[e]Second year only.

fill and(or) began gaining more rapidly than low endophyte steers when offered non-endophyte infected forage.

In other studies, reduced forage intake has been shown to be a major factor in poor performance of cattle grazing endophyte infected fescue. In the present study, high endophyte steers appeared gaunt at the end of the grazing study and the heavy forage accumulation in the endophyte infected pastures suggested reduced intake of endophyte infected fescue. The rapid gain of steers grazing interseeded clover during the 6-day holding period was unexpected because of the similar pasture gains of interseeded clover and low endophyte steers during the fescue grazing period. Weight losses during transit to the feedlot were similar for all three groups.

During the first 48 to 49 days on feed, steers from high endophyte pastures gained 222 compared to 200 lb for interseeded clover and 196 lb for low endophyte steers ($P<.09$). The increased rate of gain during the first part of the finishing period, together with more rapid gain during the 6-day holding period suggests that effects of the endophyte in this study were not permanent and that compensatory gain and(or) fill began almost immediately after removal from the infected fescue. Our results agree with recent research in which steers that had grazed fescue in Georgia were shipped to Texas for finishing during summer and early fall (Cole et al., 1987). In the Georgia-Texas studies, cattle that had grazed high endophyte fescue made more rapid gains, especially during the first 28 days in the feedlot, than cattle from low endophyte fescue.

In Arkansas trials (Piper et al., 1987), steers were moved from fescue pastures to feedlot pens in Arkansas. Steers previously grazing endophyte infected pastures made greater gains than steers from endophyte free pastures when steers were moved to the feedlot in October but not in July. These studies strongly suggest that environmental temperature at the time cattle are removed from endophyte infected pastures and shipped to finishing programs can affect the time required for cattle to begin compensating for poorer pasture performance.

Gains during the second half of the finishing period were similar for all three groups, suggesting that most of the compensatory growth occurred relatively early in the feeding period. Total weight gains from the time of removal from fescue grazing to slaughter were significantly greater for high endophyte (466 lb) compared to low endophyte steers (440 lb) with interseeded clover intermediate (400 lb).

A slight advantage in weight gain for interseeded clover steers compared to low endophyte steers in every phase of the study resulted in a significantly increased total gain from the onset of fescue grazing to slaughter (792 vs 748 lb) and a greater final finish weight (1313 vs 1269 lb). Although an explanation for this difference is not apparent, these findings are both interesting and consistent.

Rectal temperatures at the time of removal from fescue were significantly affected by pasture treatment. Following the 6-day holding period, temperatures were still higher for high endophyte steers than for low endophyte steers (103.4° vs 102.8°F) with interseeded clover intermediate (103.1°F). The rectal temperature of one high endophyte steer was 107.3°F at the time of removal from pasture. This steer exhibited extreme distress and was not shipped to the feedlot because it was felt he would not survive the stress of transportation. Heat stress is the major risk factor in handling cattle from endophyte infected fescue.

Rectal temperatures at the time of processing at the feedlot were similar and within normal ranges for all groups. Environmental temperatures in Poteau on mornings that steers were weighed after the end of fescue grazing ranged from about 80° to near 90°F for 1987 and 1988 with high humidity, while temperatures in Guymon the mornings steers were processed into the feedlot were about 58° to 65°F with low humidity. Kentucky research (Hemken et al., 1981) has shown that the effects of fescue toxicosis were more pronounced with environmental temperatures above 88°F. Elevated temperature in endophyte infected cattle is apparently caused by a failure of the body temperature regulatory mechanism under heat stress. While affected steers could not maintain body temperature in the hot, humid eastern Oklahoma climate, they had little difficulty in the cooler, dryer climate of the Oklahoma panhandle.

Rectal temperatures at 48 to 49 days on feed were again similar for steers on all treatments (Table 1). All temperatures were higher than "normal" for cattle but were probably not atypical for steers on a full feed of a high concentrate diet. One steer each year died in the feedlot. However, neither death was believed related to previous pasture treatment nor was the steer from the high endophyte treatment. Sickness was minimal throughout the study.

Carcass characteristics are shown in Table 2. Carcass weights reflected final live weights and were significantly lighter for high endophyte steers compared to low endophyte and interseeded clover steers (794 vs 821 and 849 lb). Fat thickness over the 12th rib and yield grades were similar for steers on all treatments. High endophyte steers tended to have lower quality grades, and smaller ribeye areas than low endophyte or interseeded clover steers. A summary of quality grades by percent of steers in each grade showed that all standard carcasses were from the high endophyte treatment. High endophyte steers also had the fewest choice carcasses. The lower quality grades of the high endophyte steers probably reflect their lighter weights and poorer body condition going on feed.

In conclusion, steers previously grazing high endophyte pastures weighed 101 lb less than steers from low endophyte pastures at the end of fescue grazing. There was considerable compensatory gain following

Table 2. Carcass characteristics of steers previously grazed on fescue pastures.[a]

	Treatments			
	Endophyte infected fescue	Infected fescue & clover	Endophyte free fescue	SE
Slaughter				
KHP[b], %	2.2	2.1	2.2	.05
Quality grade[c]	10.8	11.4	11.2	.21
Hot carcass weight, lb	794[d]	849[f]	821[e]	7.43
Ribeye area, sq in	13.1	13.6	13.6	.24
Fat thickness, in	.45	.47	46	.02
USDA yield grade	2.86	2.95	2.85	.08
Dressing percent	64.2	64.7	64.7	.42
USDA quality grade, %				
Standard	15	--	--	
Select	60	50	60	
Choice	25	50	40	

[a]Two years data.
[b]Kidney, heart and pelvic fat.
[c]11=Select+, 12=Choice-, etc.
[def]Means on a line with different superscript letters differ ($P<.05$).

removal from high endophyte pastures and continuing through the first 48 to 49 days of the finishing period. By the end of the feedlot phase, high endophyte steers weighed only 33 lb less than low endophyte steers. Interseeding clover appears to be an effective means of partially offsetting the undesirable effects of fescue endophyte. Steers from interseeded clover pastures gained slightly faster than low endophyte fescue steers both during grazing and in the feedlot, and were significantly heavier than low endophyte or high endophyte steers at the time of slaughter. If heat stress can be minimized during shipment to the feedlot and during the first few weeks of finishing, cattle previously exposed to fescue endophyte can perform very well in the feedlot and can compensate for some of the reduced performance during grazing.

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EARLY SUMMER SUPPLEMENTS FOR WEANED FALL-BORN CALVES GRAZING TALLGRASS PRAIRIE

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Story in Brief

Weaned, fall-born calves were used in a trial lasting from late May to mid July. A control group received no supplement, a second group received 1 lb/day of a 38% crude protein supplement and a third group received 3 lb/day of a 15.5% crude protein supplement for the first 28 days and then received 3 lb/day of a 25% crude protein supplement for the final 28 days. Both supplemented groups gained more weight (91.4 lb on average) than the unsupplemented calves (70.4 lb). Performance was similar for the two supplemented groups (94.3 and 88.5 lb). The efficiency of supplement conversion to additional gain (lb supplement/lb added gain) was 2.3 for the 38% crude protein and 9.2 for energy supplement. If the 38% crude protein supplement cost $225/ton, the other supplement must cost less than $56/ton to be competitive. This study suggests that young, light weight calves will respond to supplemental protein earlier in the summer than previously believed.

(Key Words: Calves, Rangeland, Supplementation.)

Introduction

Previous studies have demonstrated the benefits of feeding high protein supplements to stocker cattle in the last half of the summer grazing season. In general, the supplements are converted to gain at an efficiency of 2 to 3 lb supplement/lb added gain.

Supplementation during the early portion of the grazing season (May through June) has not been studied in depth. Kansas researchers have fed low rates of sorghum supplements containing ionophores and improved average daily gain of stocker cattle on early summer pasture about .1 to .15 lb/day with an efficiency of 8 to 10 lb sorghum/lb of added gain. Weight gains of weaned calves grazing tallgrass prairie in May, June and July were

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improved by feeding a low rate of soybean meal (Scott et al., 1987) at an observed efficiency of 1.7 to 4 lb supplement/lb added gain.

A potential problem with energy supplements is an imbalance in protein levels in the total diet. In the current study, calves were supplemented with low levels of a high protein supplement or with higher levels of an energy supplement. Protein levels of the energy supplement were adjusted every four weeks to account for the decline in forage protein.

Materials and Methods

Forty nine fall-born Hereford and Hereford x Angus calves that had been weaned in April were used in a 56-day supplementation trial. The trial began May 23 and ended July 19, 1987. On May 23 the calves were weighed (Table 1) and sorted into three treatment groups based on breed and sex. The treatment groups were maintained on three separate pastures. The pastures were stocked lightly to eliminate potential pasture differences. One treatment group acted as a control and received no supplemental feed during the trial. The second group was fed 1 lb/day of a 38% crude protein (CP) supplement (Table 2). The third group was fed 3 lb/day of an energy supplement containing 15.5% CP from May 23 until June 21. From June 21 to July 19, the third group was switched to an energy supplement containing 25% CP. The energy supplements were formulated and fed in an effort to provide supplemental energy, but balance protein intake with the estimated decline in forage protein. Wheat middlings were the primary energy source (other than oilseed meals) in the supplements. All supplements contained Bovatec and were fed in prorated amounts Monday through Friday. A free choice salt/mineral supplement (12% Ca, 7% P) was also provided. The

Table 1. Weights and performance of calves.

	Supplement group		
	Control	High protein	Energy
Initial wt, lb (5/23)	376	375	374
Gain, lb/head			
5/23 - 6/21	43.5[a]	56.3[b]	53.8[b]
6/21 - 7/19	26.7[a]	38.0[b]	34.7[b]
5/23 - 7/19	70.2[a]	94.3[b]	88.5[b]
Efficiency of supplement conversion, lb/lb added gain			
5/23 - 6/21	---	2.2	8.2
6/21 - 7/19	---	2.5	10.5
5/23 - 7/19	---	2.3	9.2

[a,b]Means are different, P<.05.

Table 2. Supplement composition (% as-is).

	High protein	Energy 15.5%	Energy 25%
Wheat midds	6.9	90.9	57.5
Cottonseed meal	61.0	3.0	18.9
Soybean meal	26.7	--	18.0
Molasses	2.5	2.5	2.5
Limestone	2.1	3.0	3.0
Dicalcium phosphate	.06	--	--
Potassium chloride	--	.5	--
Bovatec 68	.3	.07	.07
NEg (Mcal/lb)	48.3	43.1	45.0
Crude protein	38.3	15.5	24.8
Calcium	1.1	1.2	1.3
Phosphorus	.9	.8	.8
Potassium	1.3	1.3	1.2

calves were weighed following overnight shrink on May 23, June 21 and July 19.

For analysis, effects of supplement, breed and sex were included in the model. Breed and sex effects were not significant (P>.05).

Results and Discussion

Drought conditions existed in 1987. Therefore, the response to supplements may be biased due to relatively unusual forage conditions. The unsupplemented cattle gained approximately 1.25 lb/day from May to July (Table 1). During the first 28 days, the cattle gained 1.55 lb/day; gains decreased to .95 lb/day during the final 28 days.

Supplementing with 1 lb/day of the 38% CP feed increased average daily gain .43 lb/day (Table 1). This response is very similar to the gain response observed with growing cattle in July, August and September. The gain response was consistent over the entire 56 days.

Weight gains of the cattle receiving the energy supplement were slightly lower, but not different (P>.05) from the high protein group (Table 1).

The efficiency of supplement conversion to additional gain (lb supplement/lb added gain) was 2.3 for the high protein supplement and 9.2 for the energy group (Table 1). If the 38% CP supplement could be purchased for $225/ton, then the energy supplement would not be competitive unless priced less than $56/ton.

The efficient conversion of the high protein supplement can be attributed to two factors. First, young, lightweight calves require more protein than heavier, aged stockers. Scott et al. (1987) reported efficient conversion of high protein supplement in weaned fall-born calves grazing from May to August. Second, poor forage growing conditions may have enhanced response to the high protein supplement. Therefore, the response to high protein supplement might have been different if: 1) older or heavier cattle had been tested, and 2) drought conditions had not existed. However, the studies of Scott et al. (1987) were conducted during years with precipitation that exceeded long-term averages.

Response to the energy supplements was also consistent with previous observations. On average, energy supplements are converted to gain at an efficiency of 8 to 10 lb supplement/lb added gain unless forage availability is limiting performance. Based on supplemental energy intake, an efficiency of 9:1 suggests that supplement was substituting for forage, thereby reducing forage intake. Care was taken to utilize a low starch energy source in an effort to reduce negative impacts on forage digestion and intake. Once again, the size of cattle may have influenced these results. Average supplement intake was 3 lb/day, but the calves were actually fed 4.2 lb, 5 days per week. This level is equal to .9 to 1.1% of body weight in a calf ranging from 374 to 463 lb. This level of intake was probably great enough to limit intake and possibly hamper daily grazing behavior regardless of the influence of supplement on forage digestion.

It is questionable whether feeding energy supplements at high intakes (i.e., 3 lb/day) will ever prove to be economical unless forage availability is lacking. However, feeding lower amounts (i.e., 1 lb/day) has not been thoroughly investigated. The results of this trial and those of Scott et al. (1987) would suggest that light weight calves will economically respond to protein supplements in the early summer.

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EFFECTS OF FESCUE ENDOPHYTE AND INTERSEEDED CLOVER ON STEER PERFORMANCE ON KENTUCKY 31 TALL FESCUE

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Story in Brief

A total of 173 Angus, Brahman x Angus, and Simmental x Brahman-Angus steers (7 to 12 months old) were used in a 3-year study on the effects of fescue endophyte and clover on performance of stocker cattle grazing Kentucky 31 Tall Fescue. Steers of all breeds gained faster on interseeded clover and low endophyte pastures than on high endophyte fescue. However, the effect of the endophyte was not the same for all breeds. Brahman x Angus steers gained faster than Angus on all three pasture treatments, but Brahman x Angus steers had a greater advantage over Angus on high endophyte pasture (.62 lb/day), than on interseeded clover (.48 lb/day) or low endophyte fescue (.19 lb/day). Gains of Simmental x Brahman-Angus steers were similar to gains of Angus steers. The endophyte caused increases in body temperature only in late May, although the effect was not the same for all breeds. Temperatures of Brahman x Angus steers were not increased by grazing endophyte infected fescue but Angus and Simmental x Brahman-Angus had increased temperatures. Higher body temperatures were also seen with steers grazed on interseeded clover-fescue pastures although temperatures were not as elevated as on endophyte infected fescue alone. This study shows that interseeding clover with endophyte infected tall fescue can help overcome the detrimental effects of the endophyte on cattle gains. Breeds of cattle apparently differ in their ability to tolerate the toxic effects of the endophyte.

(Key Words: Fescue, Endophyte, Grazing, Clover.)

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Materials and Methods

A total of 173 Angus, Brahman x Angus and Simmental x Brahman-Angus, 7- to 12-month old steers were used to study effects of grazing tall fescue on weight gains and rectal temperature. The study was initiated in the fall of 1985 at the Kerr Center, Inc. near Poteau in Eastern Oklahoma. All steers originated from the cow herd at the Kerr Center. The three pasture treatments were: (1) high endophyte (76% infected); (2) high endophyte (74% infected) interseeded with clover, and (3) low endophyte (.7% infected).

Three pastures of each forage treatment (total of nine pastures) were randomly arranged in a wagon wheel design around a set of working and weighing facilities. Pasture sizes varied from 11 to 14 acres. The soil is Neff silt loam. Endophyte infection rate was determined from seed samples taken throughout the pastures in early June of 1985, 1986, and 1988. Seed samples were analyzed by the Fescue Toxicity Diagnostic Center, Auburn University, Auburn, AL.

The entire area had an old established stand of Kentucky 31 tall fescue. Low endophyte pastures were established by spraying three times with Paraquat beginning in the spring of 1984 to prevent seed production, followed with moldboard plowing, and seeding with one year old Kentucky 31 tall fescue testing 0% live endophyte. Soil pH, P, and K were maintained according to soil test recommendations. The interseeded clover treatment received no N fertilizer, but both the high and low endophyte treatments received 246 lb N fertilizer per acre each September. The interseeded clover pastures were overseeded each September with Redland red clover, Regal ladino clover, and Yuchi arrowleaf clover. Red clover became the dominant clover.

All steers were implanted with Ralgro each year at the beginning of grazing study and again at the March weighing. Average beginning steer weights were 484, 497, and 541 lb for 1985-87, respectively. Grazing began about November 6 and ended about May 20 for a 196-day period. Weights were taken after overnight withdrawal from feed and water at 42-day intervals except for the final period which lasted 28 days. Supplemental bermudagrass hay was fed when snow and ice occurred although only an average of 99 lb/steer was fed each year. Stocking rates were adjusted by adding or removing extra steers in order to equalize forage availability between pastures and also to better utilize the spring growth. Only data from steers maintained on the pastures throughout the season were used for analysis.

Rectal temperatures were taken with an electronic digital thermometer on the final weigh date the first year and at every weigh date during years 2 and 3. Weighing was completed before 10:00 a.m. and the order in which pasture groups were weighed was arranged to minimize bias because of the natural rise in body temperature during the day.

Results and Discussion

Average daily gains for each weighing period are shown in Table 1. Steers of all three breeds gained faster for the total grazing period on low endophyte and interseeded pastures than for high endophyte pastures ($P<.01$). However, the effect of pasture treatments was not the same for all steer breeds, and daily gains are shown for each breed and pasture treatment combination. The interaction between treatment and steer breed for daily gain was significant for the total grazing period and for the 2nd, 4th and 5th grazing periods. A breed x treatment interaction means that all breeds did not respond the same to the different pasture treatments. Brahman x Angus steers gained faster ($P<.05$) than Angus on all three pasture treatments but Brahman x Angus steers exhibited a greater advantage over Angus steers on the high endophyte pasture (.62 lb/day) than on interseeded (.48 lb/day) or

Table 1. Daily gains (lb) for Angus (AN), Brahman x Angus (BA) or Simmental x Brahman-Angus (SxBA) steers grazing high endophyte (HE), low endophyte (LE) or high endophyte fescue interseeded with clover (IS)[a].

		Grazing period ending date[b]					
Treatment	Breed	18Dec	29Jan	12Mar	23Apr	20May	Total
HE	AN	1.96^{cd}	$.95^{c}$	$.66^{c}$	1.32^{c}	$.73^{c}$	1.14^{c}
HE	BA	2.46^{e}	1.39^{ef}	1.08^{ef}	2.09^{d}	1.89^{ef}	1.76^{de}
HE	SxBA	1.62^{c}	$.90^{c}$	$.86^{cd}$	1.45^{c}	1.21^{d}	1.21^{c}
IS	AN	2.42^{e}	1.43^{ef}	1.23^{ef}	2.22^{d}	1.68^{de}	1.78^{e}
IS	BA	2.88^{f}	1.66^{f}	1.50^{f}	2.63^{e}	2.72^{h}	2.26^{g}
IS	SxBA	1.71^{c}	$.86^{c}$	1.28^{ef}	2.26^{c}	2.11^{fg}	1.61^{d}
LE	AN	2.90^{f}	1.25^{def}	$.81^{d}$	2.09^{d}	2.46^{fg}	1.87^{e}
LE	BA	3.01^{f}	1.47^{de}	1.10^{e}	2.11^{d}	2.81^{h}	2.04^{f}
LE	SxBA	2.06^{d}	$.99^{cd}$	$.79^{d}$	2.22^{d}	2.44^{gh}	1.65^{d}
Significance[i]							
Treatment		*	NS	*	**	**	**
Breed		**	**	**	**	**	**
Treatment x Breed		NS	*	NS	**	*	**

[a]3-year means.
[b]Grazing periods were 42 days except the last, which was 28 days.
[c,d,e,f,g,h]Means in a column with different superscripts differ ($P<.05$).
[i]*,**Indicate significance at the .05 and .01 probability levels, respectively, NS = not significant.

low endophyte pastures (.17 lb/day). Compared to Angus steers, daily gains of Simmental x Brahman-Angus steers for the total grazing period tended to be greater on the high endophyte pastures (.07 lb/day) but were less (P<.05) on interseeded and low endophyte pastures (-.17 and -.22 lb/day, respectively).

In general, steers grazing low endophyte and interseeded clover pastures gained faster in each intermediate period than high endophyte steers. The greatest differences were observed during the periods from mid March to late May (P<.01). Smaller differences in favor of low endophyte and interseeded clover treatments compared to high endophyte were seen during the November to mid December and mid January to mid March periods (P<.05). Pasture treatment differences were not different during the mid December to late January period. These observations strongly suggest that season and(or) temperature influenced the effects of endophyte toxins in these tall fescue pastures. The relative gain advantage for Brahman x Angus compared to Angus and Simmental x Brahman-Angus steers was greater on high endophyte and interseeded clover pastures than on low endophyte pastures.

Body temperatures for the different pasture treatments and cattle breeds are shown in Table 2. No differences in body temperature were detected at mid December to late April weigh dates (P>.30). However, on May 20, presence of the endophyte caused significant increases in body temperature for Angus and Simmental x Brahman-Angus steers.

Table 2. Rectal temperatures (F) on May 20 for Angus (AN), Brahman x Angus (BA) and Simmental x Brahman-Angus (SxBA) steers grazing high endophyte (HE), low endophyte (LE) or high endophyte fescue interseeded with clover (IS)[a].

	Breed		
	AN	BA	SxBA
Treatment			
HE	104.2[e]	102.7[c]	103.3[d]
IS	103.6[d]	102.8[c]	102.7[c]
LE	102.0[b]	102.5[bc]	102.4[bc]
Significance[e]			
Treatment	P<.01		
Breed	P<.01		
Treatment x Breed	P<.01		

[a]3-year means.
[b,c,d]Means on a line or column with different superscripts differ (P<.05).
[e]*,**Indicate significance at the .05 and .01 probability levels, respectively, NS = not significant.

Temperatures of Angus and Simmental x Brahman-Angus steers were higher ($P<.05$) from high endophyte pastures than for low endophyte pastures with interseeded clover steers intermediate. Rectal temperatures of Brahman x Angus steers were not affected by pasture treatment. A number of Angus and Simmental x Brahman-Angus steers exhibited rectal temperatures above 106°F with the highest being 107.3°F for one Simmental x Brahman-Angus steer in 1987.

Although elevated body temperatures occurred only at final weigh date on May 20, reduced steer gains caused by the high endophyte occurred on 4 of 5 weigh dates. Thus, while elevated body temperature is a symptom of fescue toxicosis, gains can be reduced by the endophyte without body temperature being affected. Highest gains were seen with interseeded clover steers although their body temperatures were intermediate between high and low endophyte.

It appears that elevated body temperatures occur only when environmental temperatures begin to exceed 80°F in May and that the effect of the endophyte is in restricting the body's ability to control body temperature. That is to say that these cattle did not have a true fever, but rather could not control their body temperature when the environmental temperature was high. Research at other universities has also shown the effect of the fescue endophyte to be temperature dependent.

It is important to note that the Brahman x Angus steers did not have elevated body temperatures which were characteristic in the Angus and Simmental x Brahman-Angus steers in May. This suggests that the heat tolerance and(or) characteristics of Brahman cattle may somehow permit these cattle to overcome the detrimental effects of the endophyte toxins.

Stocking rates were determined following visual appraisals of quantity of forage available. High endophyte pastures had the highest stocking rates and still had excess forage in the spring. The presence of excess forage in spring for the high endophyte pasture should not, however, necessarily be interpreted as meaning that high endophyte fescue produced more forage than low endophyte fescue. A number of studies have shown that the presence of endophyte in fescue reduces forage intake. Further, the degree of intake depression is greater when cattle are exposed to warmer temperatures.

An excellent stand of red clover was maintained in the interseeded clover pastures, and while individual steer gains were similar to those on the low endophyte, stocking rates were less on interseeded clover until mid April. This is because nitrogen fertilization could not be used in the fall with clover present in the pastures. Mean stocking rates were .82, .67 and .74 steers per acre for the high endophyte, interseeded clover, and low endophyte, respectively. This would give an estimated 232, 252, and 277 lb/acre gain for the high endophyte, interseeded clover, and low endophyte, respectively.

Grazing was terminated each year about May 20 because: (1) the cattle from high endophyte gained poorly during the last weigh period and were visibly affected by fescue toxicosis, (2) many of the other cattle were weighing over 880 lb and were ready for the feedlot, and (3) growth rate and quality of the pastures were deteriorating. No visible evidence of stand deterioration was noted in the low endophyte pastures throughout and at the end of the study.

In conclusion, Brahman x Angus steers gained faster on high endophyte and interseeded clover pastures than the Angus steers, and the advantage of Brahman x Angus steers was less on low endophyte pasture. Steer gains were similar on interseeded clover and low endophyte. Thus, the clover had a very positive effect in reducing the effect of the endophyte. Elevated body temperature did not occur in the Brahman x Angus steers, but did occur in Angus and Simmental x Brahman-Angus steers only in May, indicating that environmental temperature influenced body temperature. Reduced steer gains from high endophyte, however, occurred throughout much of the grazing season without elevated body temperatures. Therefore indicating that the endophyte affects physiological processes other than temperature control. Also, the other processes appear to be influenced by breed type.

SAMPLE SIZE DETERMINATION FOR ESTIMATING AMOUNTS OF AVAILABLE WHEAT FORAGE

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Story in Brief

Data from six years of wheat pasture grazing studies were used to develop a model describing the sampling variation of amounts of available forage dry matter. The model was used to determine the sample size required to achieve a maximum relative error in the estimate of forage dry matter availability. The variation among samples from a pasture had a coefficient of variation that was constant across pastures, years and sampling dates. The model developed used normality and a constant coefficient of variation of .3. Based on this model, a maximum 10% relative error of the estimated pasture mean could be achieved with a 50% chance from a sample size of four. A sample size of 36 would be required to increase this chance to 95%.

(Key Words: Sampling Variability, Coefficient of Variation.)

Introduction

The evaluation of performance of grazing animals in nutrition trials frequently requires estimates of the quantity of available forage. To this end, forage samples are collected during the course of the research. It would be useful to know how much sampling effort is required. This is the standard "sample size" question that should be addressed in planning an experiment. Answering this question requires selection of a criterion to be met with the sample and knowledge of the magnitude of sampling variation.

In this report, we consider the problem of sample size determination for estimating the amount of forage dry matter (DM) of wheat pasture. Using data collected on forage samples, we attempt to identify a reasonable model describing variation in samples of forage DM availability from wheat pasture.

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We then use this model, and the criterion of maximum relative error, to determine a sample size requirement.

Materials and Methods

The data set used in this report is from stocker cattle grazing studies on wheat pasture that were conducted at the Forage and Livestock Research Laboratory (USDA/ARS), El Reno, Oklahoma from 1981 to 1988 (Vogel, 1985 and 1988). Data from forage samples were available to us for each year except the 1984-85 pasture season. Eight pastures were used in each season except in 1982-83 when there were four pastures. Pasture size was approximately 10 ha. Usually, three samples were taken from each pasture on each sampling date. Sampling dates, three to five per pasture season, were chosen from different growing periods of the pasture season. Details of the data source are presented in Table 1. There were a total of 164 samples (pasture-date) available.

A sample consisted of forage in a .5 m^2 circular area, removed by hand clipping at ground level. Each sample was oven-dried, after which dry weight was measured. In this report, the units of dry matter are $g \cdot .5m^{-2}$. Multiplication by 20 converts this to $kg \cdot ha^{-1}$.

In the following analysis, we treat each pasture-date as a population from which we have a random sample of dry weights. Populations are expected to have different amounts of dry matter per unit area. The within-population variance is not assumed to be constant.

Results and Discussion

The practical objective of forage sampling is to estimate the forage dry matter per unit area in a pasture. The quality of this estimate depends on the magnitude of sampling variation and the sample size (number of forage samples observed). Assessing this quality depends on the combination of these factors and the form of the distribution of the estimate. Because of the

Table 1. Source of forage dry weight data used for analysis.

	Pasture-Season					
	1981-1982	1982-1983	1983-1984	1985-1986	1986-1987	1987-1988
No. of pastures	8	4	8	8	8	8
No. of sampling dates	4	3	5	3	4	3
Sample size	3	5	3	3	3	2,3

Central Limit theorem, the distribution of the sample mean may be approximated by the Normal distribution, even for small sample sizes if the population distribution is symmetric. Our approach was to assume normality unless the data indicated extreme skewness. When the sample size is small, it is not possible to have much opportunity to identify a distribution form. Therefore, our attempt to use the data proceeded in the following way. Using only the 155 samples of size 3 or more, the mean and standard deviation were obtained. The first value in each sample was standardized and the resulting 155 values were used to look for skewness. A histogram (Figure 1) of the distribution appeared quite symmetric and the measure of skewness was nearly 0. On this basis, we chose to retain the normality assumption.

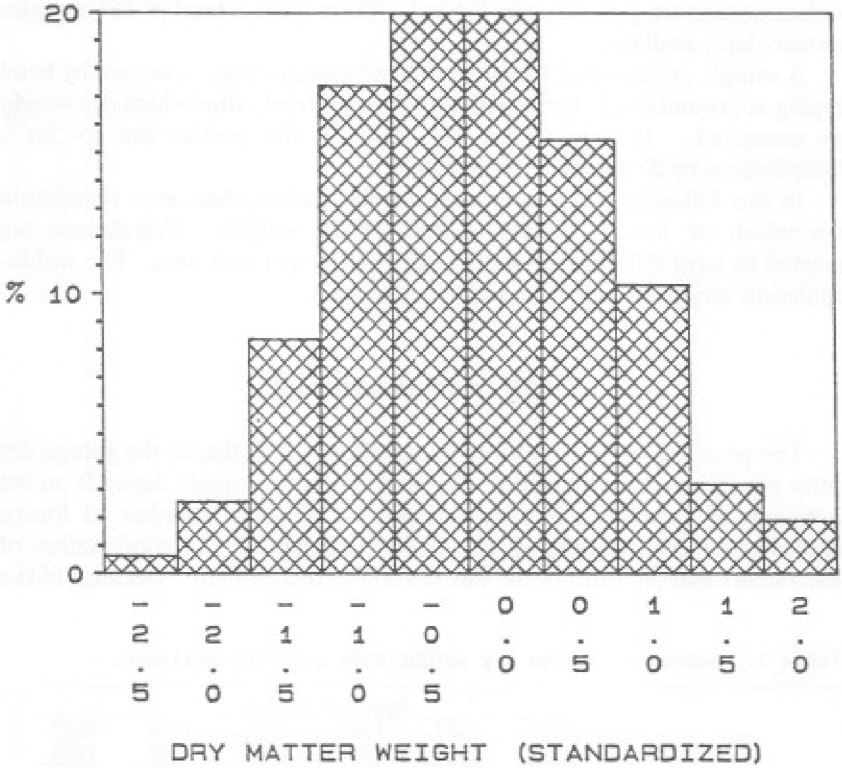

Figure 1. Distribution of the standardized forage dry matter weights ($g \cdot .5m^{-2}$) from 155 samples.

The standard deviations from the samples were observed to be quite variable. One might expect that the magnitude of the sample variation will increase as the mean level of forage dry matter increases. The plot (Figure 2) of the sample standard deviation against the sample mean supports this anticipated pattern. Furthermore, this plot suggests a linear relationship between the standard deviation and the mean, and that this linear relation extends through the origin. This pattern is consistent with a constant coefficient of variation (CV: ratio of standard deviation to mean). The straight line through the scatter plot in Figure 2 is the regression line with zero intercept, the fitting being done by ordinary least squares. The slope of this line is an estimate of the constant coefficient of variation.

Additional methods of checking for a constant CV and of estimating its value were attempted. These included other least squares fits, examination

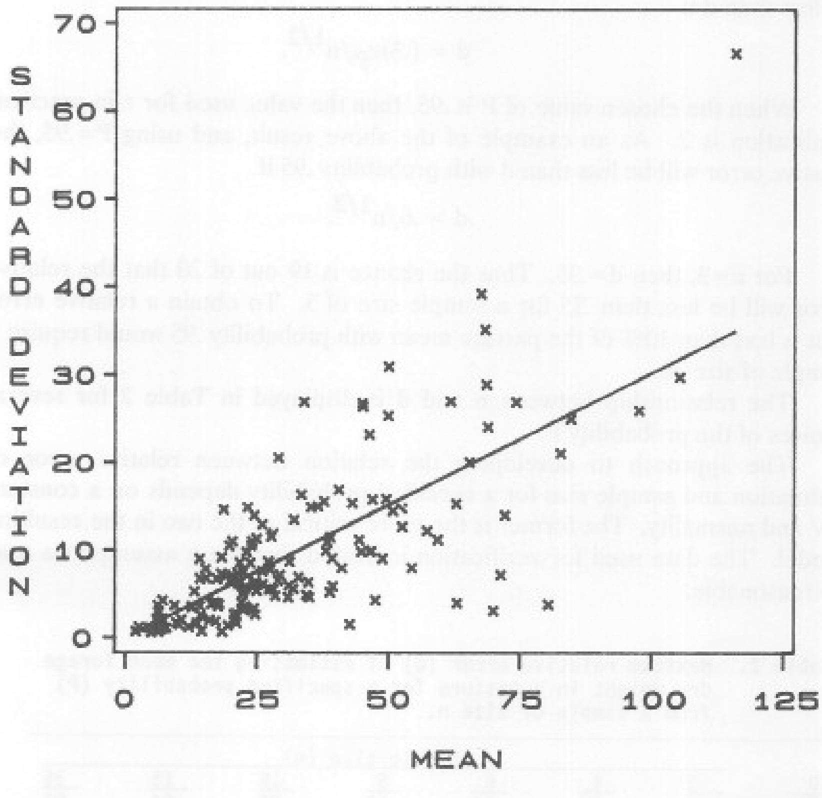

Figure 2. Plot of the standard deviation against the mean of forage dry weights ($g \cdot .5m^{-2}$) from 164 samples.

of residuals and maximum likelihood estimation. The results did not indicate a serious error in the assumption of a constant CV. The range of estimates from the different methods was .28 to .32.

The above analysis led us to the following model: The CV for sample variation is constant and the distribution of the sample mean is normal. In numerical evaluations to follow, we use CV=.30. From this model, we can obtain the relation between sample size and a desired precision by which the same mean estimates the mean dry weight ($g \cdot .5m^{-2}$) for the entire pasture. The pattern of this development is similar to that in Snedecor and Cochran (1980, pp. 441-442). The term relative error will refer to the absolute error of estimating the population mean as a fraction of the population mean. For a probability P, let z_p denote the 100(1+P)/2 percentile of the standard normal distribution. Then, for a sample of size n from a pasture, the probability is P that the relative error of an estimate of the pasture mean will be less than d if

$$d = (.3)z_P/n^{1/2}.$$

When the chosen value of P is .95, then the value used for z in practical application is 2. As an example of the above result, and using P=.95, the relative error will be less than d with probability .95 if

$$d = .6/n^{1/2}.$$

For n=3, then d=.35. Thus the chance is 19 out of 20 that the relative error will be less than .35 for a sample size of 3. To obtain a relative error that is less than 10% of the pasture mean with probability .95 would require a sample of size 36.

The relationship between n and d is displayed in Table 2 for several choices of the probability P.

The approach to developing the relation between relative error of estimation and sample size for a specified probability depends on a constant CV and normality. The former is the more critical of the two in the resulting model. The data used for verification indicated that these assumptions may be reasonable.

Table 2. Maximum relative error (d) of estimating the mean forage dry weight in a pasture for a specified probability (P) from a sample of size n.

	Sample size (n)						
P	3	4	6	9	16	25	36
.50	.12	.10	.08	.07	.05	.04	.03
.75	.18	.16	.13	.10	.08	.06	.05
.90	.29	.25	.20	.16	.12	.10	.08
.95	.35	.30	.25	.20	.15	.12	.10

The results are most useful when interest lies in relative error rather than absolute error. They permit determination of the sample size for achieving an upper limit to the relative error for a specified probability. They can also be used to evaluate the likely relative error for a chosen sample size.

If one wishes to have at most a 10% relative error in the estimate, then there is a 1 in 2 chance of achieving this when a sample size of 4 is used. With larger sample sizes of 9, 25, and 36, the chances increase to 3 in 4, 9 in 10, and 19 in 20, respectively.

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EFFECTS OF SUPPLEMENTAL PROTEIN ON PERFORMANCE OF STOCKER CATTLE GRAZING WHEAT PASTURE

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Story in Brief

A three-year study using 256 fall-weaned steers or heifers (483 lb average weight) was conducted to evaluate the effects of supplemental protein on performance of stocker cattle grazing wheat pasture. Cattle grazed wheat pasture and received no supplement or were fed 2 lb/day of either a corn-based energy supplement that contained (dry matter basis) about 8.4% crude protein or protein supplements that contained 18 to 25% meat meal (or meat and bone meal in year 3) or 22 to 33% cottonseed meal. All supplements provided 130 to 150 mg monensin/head. Supplements containing more than 16.6% (as-fed) meat meal or meat and bone meal were not fully consumed by the cattle. Irrespective of type of supplement, supplementation increased weight gains of the cattle about .22 lb/day. The meat meal, meat and bone meal or cottonseed meal supplements did not increase gains as compared with the energy supplement.

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

Introduction

Wheat forage commonly contains 20 to 30% crude protein on a dry matter basis. However, large amounts of soluble nitrogen (N) and soluble nonprotein N (NPN) are present in the crude protein fraction. Because of the rapid rate of degradation of wheat forage N in the rumen and loss of ammonia-N that is not incorporated into microbial protein, performance of rapidly growing cattle on wheat pasture may be limited by inadequate amounts of protein reaching the small intestine. The objective of this study

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was to determine the effect of feeding additional supplemental protein of low ruminal degradability on weight gains of stocker cattle grazing wheat pasture.

Materials and Methods

Eighty heifers in year 1 (1985-86), 96 steers in year 2 (1986-87) and 80 steers in year 3 (1987-88) were used. The trial in year 1 was conducted in cooperation with Panhandle State University (Goodwell, Oklahoma), and the trials in years 2 and 3 were conducted at the Forage and Livestock Research Laboratory (USDA/ARS, El Reno, Oklahoma). Description of the cattle, their mean initial weights and lengths of the trials are summarized in Table 1. Mean initial weight was 483 lb and the trials were approximately 111 days in length. In years 1 and 2 the heifers and steers were randomly allotted by weight within breed groups to four treatments in a randomized complete block design with two replications. Cattle of Treatment 1 received no supplement (other than free-choice access to a commercial mineral mixture[6]) while those of Treatments 2, 3 and 4 were fed daily 2 lb of a corn-based energy supplement or supplements that provided additional protein from meat meal (meat and bone meal in year 3) or cottonseed meal. In year 3, because of constraints on available wheat pasture only three treatments (i.e., 3 supplement groups) were assigned to replication 1 while five treatments (i.e., 2 nonsupplemented and 3 supplement groups) were assigned to replication 2 in an incomplete block design. Because of a shortage of wheat pasture in year 2, 1 replication was deleted due to large differences in forage availability among treatments. Therefore, data of 5 replications were included in this report.

In year 1 initial stocking density on wheat pasture was approximately 2.1 acres/heifer. Replication 1 consisted of a volunteer wheat pasture that was fertilized with 50 lb N/acre in late October. Replication 2 consisted of an irrigated wheat pasture that was planted late and was not ready for grazing at the onset of the experiment. Consequently, all cattle were placed by treatment on the volunteer wheat pasture until the irrigated wheat pasture was ready. In years 2 and 3, initial stocking densities were 1.85 and 2.6 acres/steer, respectively, with the wheat pasture being fertilized with approximately 80 lb N/acre.

Because of snow and ice cover, heifers in replications 1 and 2 in year 1 were removed from pasture and placed in drylot for 8 and 18 days,

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[6]Wheat Gainer Mineral No. 2. Farmland Industries. Guaranteed Analysis: Ca 15-17%, P 4.0%, Mg 10.0% and salt 19-21%.

Table 1. Number and description of cattle and length of trials of each year.

Year		No.	Description of Cattle			Length of trials	
			Sex	Mean initial wt, lb	Breed	Dates	Days
1	1985-86	80	Heifers	477	Hereford x Angus x Limousin and 1/8 or 1/4 Brahman crossbred	12/8 to 3/20	103
2	1986-87	96	Steers	513	Hereford x Angus x Limousin and 1/8 or 1/4 Brahman crossbred	11/14 to 3/19	125
3	1987-88	80	Steers	458	Hereford, Angus or Hereford x Angus	12/10 to 3/25	106

respectively. During this time they received their respective supplements, limited amounts of sorghum silage and haygrazer hay. In years 2 and 3, old world bluestem hay was fed on pasture during periods of snow and(or) ice cover. Hay was fed (i.e., approximately 6.1 lb/day) for 6 and 21 days in years 2 and 3, respectively.

Composition of the supplements is shown in Tables 2, 3 and 4. Supplements consisted of a corn-based energy supplement that contained (DM basis) about 8.4% crude protein (CP) or 16 to 20% CP supplements that contained 18 to 25% meat meal[7] (or meat and bone meal[8] in year 3) or 22 to 33% cottonseed meal[9]. The supplements were isocaloric and

Table 2. Ingredient composition and nutrient content of supplements (% of DM, Year 1).

Supplement	Corn	Meat meal[a]	Cottonseed meal[b]
Ingredient			
Corn	79.0	67.1	62.8
Meat meal		17.7(16.6)[c]	
Cottonseed meal			21.8(21.5)[c]
Cottonseed hulls	9.0	9.1	4.0
Molasses	4.4	4.4	4.4
Limestone	2.0		2.1
Dicalcium phosphate	3.5		2.9
Magnesium oxide	.6	.3	.45
Salt	1.2	1.2	1.2
Trace mineral salt	.30	.30	.30
Rumensin 60 Premix[d]	.11	.11	.11
Nutrient content			
NE_G (Mcal/cwt)	56	56	56
Crude protein			
Calculated	8.1	16.3	16.3
Actual	8.3	16.1	15.4
Calcium			
Calculated	1.57	1.56	1.51
Actual	1.28	1.25	1.32
Phosphorus			
Calculated	.94	.96	1.03
Actual	1.14	1.07	1.00
Magnesium			
Calculated	.48	.49	.50
Actual	.38	.36	.39

[a]Obtained from IBP, Inc. Slaughter Plant. West Point, NE.
[b]Method of processing unknown.
[c]Values in parentheses represent % as-fed.
[d]Added to supply 65 mg monensin/lb (as-fed) of supplement.

[7]Obtained from IBP, Inc. West Point, NE Slaughter Plant.
[8]Obtained from Cargill Nutrena Feed division, McPherson, KS.
[9]Unknown origin in year 1. Obtained from Traders Oil Mill (mechanical process) in years 2 and 3, Fort Worth, TX.

Table 3. Ingredient composition and nutrient content of supplements (% of DM, Year 2).

Supplement	Corn	Meat meal[a]	Cottonseed meal[b]
Ingredient			
Corn	79.3	62.2	51.1
Meat meal		25.4(23.9)[c]	
Cottonseed meal			32.6(32.0)[c]
Cottonseed hulls	3.8	3.8	.4
Diamond V yeast culture	3.0	3.0	3.0
Molasses	4.2	4.2	4.2
Limestone	2.71		3.48
Dicalcium phosphate	5.2		3.6
Magnesium oxide	.68	.23	.42
Salt	.70	.70	.70
Trace mineral salt	.30	.30	.30
Rumensin 60 Premix[d]	.14	.14	.14
Nutrient content			
NE_G (Mcal/cwt)	57	57	55
Crude protein			
Calculated	8.4	20.2	20.2
Actual	8.6	21.5	19.9
Calcium			
Calculated	2.20	2.20	2.20
Actual	2.25	2.25	2.05
Phosphorus			
Calculated	1.25	1.25	1.25
Actual	1.43	1.08	1.35
Magnesium			
Calculated	.55	.55	.58
Actual	.56	.40	.58

[a]Obtained from IBP, Inc. Slaughter Plant. West Point, NE.
[b]Produced by Mechanical Process; Traders Oil Mill, Fort Worth, TX.
[c]Values in parentheses represent % as-fed.
[d]Added to supply 75 mg monensin/lb (as-fed) of supplement.

contained, with the exception of year 3, similar amounts of calcium, phosphorus and magnesium. In year 3 the calcium and phosphorus contents of the energy and cottonseed meal supplements were slightly decreased (as compared with the meat and bone meal supplement) in order to decrease the amounts of dicalcium phosphate and calcium carbonate in the supplements because of concerns of high mineral content of the supplements on palatability and intake. Monensin was included in the supplements to supply 130 to 150 mg/head/day. In years 2 and 3, respectively, Diamond V Yeast Culture or ground alfalfa hay was included in all the supplements at a level of 3 to 4% in an attempt to improve the palatability of the meat meal or meat and bone meal supplements.

Animals were group fed supplements daily, with samples being taken weekly and composited across weeks within months for analyses. In years 2

Table 4. Ingredient composition and nutrient content of supplements (% of DM, Year 3).

Supplement	Corn	Meat and bone meal[a]	Cottonseed meal[b]
Ingredient			
Corn	77.8	61.4	53.1
Meat meal		24.6(23.2)[c]	
Cottonseed meal			31.4(30.8)[c]
Cottonseed hulls	6.0	4.9	.4
Alfalfa hay, ground	4.0	4.0	4.0
Molasses	4.2	4.2	4.2
Limestone	2.74		3.51
Dicalcium phosphate	3.95		2.37
Magnesium oxide	.43		.18
Salt	.45	.45	.45
Trace mineral salt	.30	.30	.30
Rumensin 60 Premix[d]	.13	.13	.13
Nutrient content			
NE_G (Mcal/cwt)	56	56	56
Crude protein			
Calculated	8.6	20.2	20.2
Actual	8.5	16.7	18.0
Calcium			
Calculated	2.00	2.71	2.00
Actual	1.68	2.51	2.02
Phosphorus			
Calculated	1.00	1.52	1.00
Actual	1.50	1.70	1.28
Magnesium			
Calculated	.39	.39	.39
Actual	.48	.43	.55

[a]Obtained from Cargill Nutrena Feed Division, McPherson, KS.
[b]Produced by Mechanical Process; Traders Oil Mill, Fort Worth, TX.
[c]Values in parentheses represent % as-fed.
[d]Added to supply 75 mg monensin/lb (as-fed) of supplement.

and 3, supplement refusals were weighed, sampled and dried and discarded weekly to provide estimates of daily DM consumption.

In years 2 and 3, hand clipped wheat forage samples were obtained to characterize forage composition at selected times to coincide with major changes in climatic growing condition for wheat. Hand clipped forage samples were frozen immediately after clipping by suspension over liquid N, and subsequently lyophilized. Lyophilized wheat forage samples were ground through a 2 mm mesh screen in a Wiley mill and analyzed for total N by the Kjeldahl procedure. Soluble N was determined following a 1 hour incubation at 39°C in a shaking water bath using the mineral mixture (2% v/v; pH 6.5) of the "Ohio" buffer in vitro fermentation media (Johnson, 1969). Non-protein nitrogen (NPN) was determined using 25 ml of the filtrate of the soluble N procedure by sodium tungstate precipitation with 5 ml of 1.07 N

H_2SO_4 and 5 ml of 11.2% sodium tungstate. Samples were also analyzed for soluble carbohydrates by the procedure of Balwani (1965) and in vitro organic matter disappearance (IVOMD) using a modification of the Tilley and Terry (1963) procedure.

Data were analyzed by least squares analysis of variance. Orthogonal contrasts were conducted to test for the following effects: 1) control vs supplementation, 2) energy vs protein supplementation and 3) meat meal vs cottonseed meal supplementation.

Results and Discussion

Chemical composition of the wheat forage in years 2 and 3 is shown in Tables 5 and 6, respectively. Crude protein content and IVOMD averaged 23% of DM and 80.2%, respectively. Thirty-one to 43% of total forage N was present as soluble N, and NPN accounted for 13 to 29% of total N. Total soluble carbohydrate content of the forage ranged from about 15 to 35% of DM. Beever et al. (1976) observed a significant negative relationship ($r = -.98, P < .001$) between the amount of N flowing to the small intestine of sheep and solubility of perennial ryegrass N.

Table 5. Chemical composition (DM basis) of wheat forage (Year 2).

Sampling date:	Nov 14	Dec 18	Jan 15	Mar 19	SEM
IVOMD[a], %	91.6	78.5	71.5	91.4	2.40
Crude protein, %	27.7	23.2	21.5	22.4	1.09
Soluble N					
% of total N	31.0	35.2	31.3	42.6	1.96
Non-protein nitrogen					
% of total N	17.8	23.0	22.1	27.7	.96
Soluble carbohydrates, %	20.2	16.4	15.6	15.2	1.20

[a]In vitro organic matter digestibility.

Table 6. Chemical composition (DM basis) of wheat forage (Year 3).

Sampling date:	Dec 10	Jan 26	Mar 25	SEM
IVOMD[a], %	77.6	75.4	75.1	.62
Crude protein, %	24.3	19.9	22.0	.77
Soluble N				
% of total N	32.1	32.1	37.6	.97
Non-protein nitrogen				
% of total N	13.2	16.7	28.6	.93
Soluble carbohydrates, %	32.3	35.0	21.6	1.47

[a]In vitro organic matter digestibility.

Supplement consumption, mean initial and final weights and daily gains of the cattle are shown in Table 7. Mean supplement consumption of the energy, meat meal and cottonseed meal supplements were 1.76, 1.58 and 1.78 lb DM/day.

Cattle completely consumed the supplements in year 1 up until March 4 at which time consumption decreased because of increasing amounts of available forage. In years 2 and 3, the meat meal (or meal and bone meal) content of the supplements was increased from 16.6% to about 23.5% (as-fed) in order to increase the amount of protein provided by the supplements. This decreased consumption of these supplements. Mean consumption of the energy, meat meal (or meat and bone meal) and cottonseed supplements was 1.63, 1.52 and 1.65 lb DM/day (year 2) and 1.69, 1.36 and 1.78 lb DM/day (year 3).

Daily gains of the cattle were increased ($P<.03$) about .22 lb by the overall effects of supplementation. The meat meal, meat and bone meal or cottonseed meal supplements did not increase ($P>.30$) gains as compared with the corn-based energy supplement. Calculated efficiency of supplement use was 11.4, 7.2 and 6.2 lb of supplement per lb of increased gain for cattle fed the energy, meat meal or cottonseed meal supplements, respectively. Differences among supplements were not significant. The efficiency of use of the energy supplement is similar to that of 9.4 and 10.3 reported by Elder (1967) and Gulbransen (1976).

Lee (1985) reported that weight gains of calves grazing wheat pasture and fed 1.5 lb/day of a supplement containing 15% meat meal were increased .20 lb/day as compared with a control, hominy feed-based

Table 7. Performance of cattle grazing wheat pasture during the protein supplementation trials.

	Treatment				
	Control	Corn	Meat meal	Cottonseed meal	SEM
Number of cattle	52	52	52	51	
Supplement consumption[a], lb DM/head/day	---	1.76	1.58	1.78	.07
Initial weight, lb	474	476	483	479	2.5
Final weight[b], lb	667	684	697	703	8.4
Daily gain[b], lb	1.78	1.93	1.99	2.06	.07
Efficiency of supplement use[c]	---	11.4	7.2	6.2	4.5

[a]Meat meal vs cottonseed meal supplementation ($P<.10$).
[b]No supplement vs supplementation ($P<.05$).
[c]Lb of supplement per lb of increased weight gain.

supplement. Anderson et al. (1987) reported a similar gain response by stocker cattle grazing wheat pasture fed 1.5 lb/day of a supplement that contained 11.5% feather meal and 19.4% meat and bone meal. Cattle received monensin in the studies reported by both Lee (1985) and Anderson et al. (1987). Our results are not in agreement with these studies. Differences in amounts of available wheat forage, the number of days of snow and(or) ice cover and the amounts of other supplemental feeds that were fed may account for part of the discrepancy of results. In the study of Anderson et al. (1987), cattle had free-choice access to wheat hay throughout the 79 days of grazing wheat pasture and free-choice access to corn silage during 21 days of the trial when snow cover "inhibited grazing". This fairly high level of supplementation with wheat hay and corn silage would favor a response to additional supplemental protein.

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ALTERNATIVE PROTEIN SOURCES FOR THE EARLY WEANED PIG

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Story in Brief

Seventy two Yorkshire pigs weaned at 21 days of age were allotted to one of four treatments differing in the type of protein supplying the lysine source: an all milk protein based diet with dried skim milk as the primary lysine source, a diet with isolated soy protein (PP500E, Protein Technologies International) as the primary lysine source, a diet with dried skim milk and isolated soy protein providing equal amounts of lysine or a diet with 50% soybean meal as the primary lysine source. All diets were formulated to contain 1.50% lysine and 40% whey. Pigs were housed individually in an environmentally controlled room in elevated metal pens. Temperature was maintained at 92 and 90° F for weeks 1 and 2, respectively. Trials were 14 days in length. Gain and efficiency of gain estimates were obtained weekly. All pigs were fed a common 18% crude protein starter diet for an additional three-week period to evaluate post-treatment effects on gain and efficiency of gain. Performance of pigs fed isolated soy protein as the supplemental protein source was equal to or exceeded the performance of those fed dried skim milk. Average daily gain during the subsequent three-week period was not affected by treatment. These findings indicate that isolated soy protein can be used with whey to replace dried skim milk as the protein source for pigs from three to five weeks of age.

(Key Words: Swine, Early Weaned Pigs, Isolated Soy Protein.)

Introduction

Weaning pigs at 18 to 21 days of age is often economically advantageous to swine producers. This practice will shorten the reproductive cycle of the sow herd and allow placement of females back into productivity sooner with

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

the expectation of rearing more pigs per sow per year, thus maximizing profit.

Subjecting a three week old pig to the distresses associated with weaning commonly results in a reduction of feed intake, little or no weight gain and diarrhea. It is also common to observe a longer postweaning growth depression and a higher incidence of mortality in early weaned pigs when compared to those weaned at an older age.

It has been well documented that young pigs' performance is greater when fed diets containing high levels of milk protein as compared to soybean protein. However, the use of the more complex diets has been questioned because of high cost and because pigs are capable of compensatory gain that results in little change in days to market weight.

The etiology of lower performance of young pigs fed soybean protein has not been determined clearly but possible explanations include: 1) lower amino acid availability in soybean protein than in milk protein; 2) substance or substances present in soybean protein may be detrimental to the health of the intestinal villi; and 3) protease or disaccharidase levels may be insufficient for optimal utilization of non-milk protein or energy.

The objective of this study was to compare gain, efficiency of gain and feed intake of early weaned pigs fed an all milk protein based diet using dried skim milk as the primary source of lysine compared to two sources of soybean protein. All pigs were fed a common starter diet for a three-week period after the trial to determine the effect of diet fed for a two-week period on subsequent performance.

Material and Methods

Seventy-two Yorkshire pigs were used to study the effect of dietary protein source on performance of early weaned pigs. Twenty-four pigs in each of three replicates were allotted by sex, litter and weight to one of four dietary treatments providing 18 pigs per treatment. Pigs began the trial after being weaned at approximately 21 days of age. These pigs were individually housed in metabolism crates measuring 1.54 ft by 2.49 ft in an environmentally controlled room at a temperature of 92^{O} to 82^{O} F for a period of 35 days. During the first 14 days (Period 1) the pigs were assigned to one of four dietary treatments (Table 1): dried skim milk as the primary lysine source (MP), a diet where isolated soy protein replaced dried skim milk as the primary lysine source (IS), a diet where dried skim milk and isolated soy protein provided equal amounts of lysine (MPIS), or a diet where 48% soybean meal served as the primary lysine source (SBM). Pigs had ad libitum access to feed and water. Calculated analysis of each diet is presented in Table 2.

Table 1. Composition of diets fed during period 1 (2 wk).

Ingredient	Diets[a,b] MP	IS	MPIS	SBM
Soybean meal	----	----	----	24.12
Isolated soy protein[c]	----	20.29	10.15	----
Dried skim milk	40.00	----	23.25	----
Whey, dried whole	40.00	40.00	40.00	40.00
Lactose	----	20.62	8.63	20.62
Cerelose	7.01	4.52	4.55	----
Soybean oil	10.00	10.00	10.00	10.00
Lysine, HCl	.21	----	----	.45
DL Methionine	.085	.115	.08	.17
Cystine	.085	.115	.08	.17
Tryptophan	----	----	----	.03
Threonine	----	----	----	.09
Lecithin	1.00	1.00	1.00	1.00
ASP 250	.25	.25	.25	.25
Calcium carbonate	.12	.70	.42	.49
Dicalcium phosphate	----	1.15	.35	1.37
Vit. TM premix[d]	.94	.94	.94	.94
Salt	.30	.30	.30	.30
	100.00	100.00	100.00	100.00

[a]As fed basis.
[b]MP: milk protein diet; IS: isolated soybean diet; MPIS: milk protein isolated soybean diet; SBM: soybean meal diet.
[c]Product PP500E, Protein Tech. Int., St. Louis, MO.
[d]Supplies 4,000 IU vitamin A, 400 IU vitamin D, 17 IU vitamin E, 20 mg panothenic acid, 27 mg niacin, 4 mg riboflavin, 3.3 mg menadione, .02 mg vitamin B_{12}, 400 mg choline chloride, .2 mg selenium, .06 g manganese, .2 g zinc, .1 g iron, .01 g copper, .2 mg iodine, per lb of feed.

Table 2. Calculated analysis of diets fed during period 1 (2 wk).

Ingredient	Diets[ab] MP	IS	MPIS	SBM
Lysine	1.50	1.50	1.50	1.50
Crude protein	20.09	23.46	22.81	17.91
Calcium	.90	.90	.90	.90
Phosphorus	.71	.70	.70	.71
M.E. (Kcal/kg)	1628.50	1611.10	1625.80	1603.30
Tryptophan	.25	.33	.30	.26
Threonine	.92	1.04	1.02	.90
Met + Cys	.88	.88	.89	.88

[a]As fed basis.
[b]MP: milk protein diet; IS: isolated soybean diet; MPIS: milk protein isolated soybean diet; SBM: soybean meal diet.

In the subsequent 21-day period all pigs were fed a common 18% crude protein starter diet to test for carry over effects from Period 1.

During the 5-week trial, individual pig weight was recorded weekly, feed intake was estimated, and feed efficiency (gain to feed ratio) was evaluated.

Results and Discussion

The effect of dietary protein source on average daily gain, average daily feed intake and feed efficiency during the 14-day experimental period is shown in Table 3. Pigs fed the IS diet grew 51 (P<.01) and 27% faster than those fed the SBM or MP diets, respectively. Similarly, pigs fed the MPIS diet grew 44 (P<.01) and 16% faster than those fed the SBM or MP diets, respectively. Differences observed in average daily gain were primarily the result of differences that occurred during week 1 of the trial when pigs fed the IS diet out performed those fed the SBM (P<.01) and MP diets by .34 and .14 lb/day, respectively. Pigs fed the MPIS diet during week 1 grew .31 (P<.05) and .11 lb/day faster than those fed the SBM and MP diets, respectively.

Table 3. The effect of protein source on piglet performance in period 1[a].

Item	Diet				
	MP	IS	MPIS	SBM	SEM
			Average daily gain, lb		
d 0 - 7	.27[bc]	.41[b]	.38[b]	.07[c]	.05
d 7 - 14	.88	.97	.92	.81	.07
d 0 - 14	.56[bc]	.68[b]	.65[b]	.45[c]	.05
			Feed efficiency lb gain/lb feed		
d 0-7	.40[fg]	1.27[f]	2.60[f]	-9.83[g]	4.93
d 7-14	.60	.99	1.16	.60	.34
d 0-14	.84	.93	1.09	.70	.16
			Average daily feed intake, lb		
d 0-7	.32[de]	.38[d]	.38[d]	.25[e]	.05
d 7-14	.83[c]	1.06[b]	.92[bc]	.72[c]	.07
d 0-14	.58[bc]	.72[b]	.65[b]	.47[c]	.05

[a]Least squares means, MP: milk protein diet; IS: isolated soybean diet; MPIS: milk protein isolated soybean diet; SBM: soybean meal diet.
[b,c]Means in the same row with different superscripts differ (P<.01).
[d,e]Means in the same row with different superscripts differ (P<.05).
[f,g]Means in the same row with different superscripts differ (P<.10).

The effect of dietary protein source on the efficiency of feed utilization was similar to the effect on average daily gain. Pigs fed the IS and MPIS diets had a higher (P<.10) gain to feed ratio during the first week on trial than those fed the SBM diet. Also during week 1, pigs fed the SBM diet exhibited a negative gain to feed ratio even though feed intake and weight gain were positive. This may be explained as several pigs lost large amounts of body weight, largely due to dehydration, in proportion to the amount of feed consumed causing the average of the G:F ratios to be negative. Perhaps a more meaningful approach would be to use the ratio of the means which were .84, 1.08, 1.00 and .28 lb gain/lb feed for pigs fed the MP, IS, MPIS and SBM diets, respectively. The efficiency of feed utilization was similar (P>.49) among the dietary protein sources during the entire 14 day period even though pigs fed the MPIS diet gained 56% more per lb of feed than those fed the SBM diet.

Average daily feed intake during Period 1 was larger (P<.01) for pigs fed IS and MPIS diets than for those fed the SBM diet. The largest difference was observed during week 2. Pigs fed the IS diet consumed 15%, 28% and 47% more per day than those fed the MPIS, MP, and SBM (P<.01) diets, respectively.

Average daily gain was similar (P>.30) among all treatments (Table 4) during the subsequent 3 weeks although pigs fed the SBM and MP diets

Table 4. The effect of protein source on piglet performance in period 2[a].

Item	Diet				
	MP	IS	MPIS	SBM	SEM
			Average daily gain, lb		
d 14-21	.97	.99	1.17	1.01	.09
d 14-35	1.26	1.31	1.35	1.26	.02
			Feed efficiency lb gain/lb feed		
d 14-21	.68[bc]	.61[c]	1.00[b]	.79[bc]	.10
d 14-35	.67[de]	.63[d]	.69[de]	.70[e]	.02
			Average daily feed intake, lb		
d 14-21	1.37[bc]	1.53[b]	1.49[bc]	1.28[c]	.07
d 14-35[f]	1.89[de]	2.05[d]	1.96[de]	1.80[e]	.05

[a]Least squares means, MP: milk protein diet; IS: isolated soybean diet; MPIS: milk protein isolated soybean diet; SBM: soybean meal diet.
[b,c]Means in the same row with different superscripts differ (P<.05).
[d,e]Means in the same row with different superscripts differ (P<.01).
[f]Means for MP and SBM treatments differ (P<.05).

during period 1 continued to show reduced gains when compared to pigs fed the IS and MPIS diets.

During week 3, pigs fed the MPIS diet exhibited a gain to feed ratio that was 64%, 47% and 27% higher than those fed the IS, MP and SBM diets, respectively. However, this difference was significant only for those fed the IS diet. During the combined 3-week period, the magnitude of the differences decreased and the gain to feed ratios for the MP, MPIS and SBM diets were only 6%, 9% and 10% higher than those observed in pigs fed the IS diet. During the subsequent twenty-one day period, pigs fed the IS diet ate more ($P<.01$) than those fed the SBM diet and the MP diet ($P<.05$) but was similar to pigs that received the MPIS diet.

Initial pig weights (Table 5) averaged 13.70, 13.84, 13.79 and 13.68 lb for MP, IS, MPIS and SBM treatments, respectively when placed on trial. After week 1, due to superior gains by pigs fed the IS and MPIS diets, dietary protein source affected pig weights ($P<.01$) and by the end of week 2, pigs fed the SBM diet weighed 8%, 15% and 14% less than pigs fed the MP, IS and MPIS diets, respectively. Less weight variation between treatments was evident during the 3 week carryover period although pigs previously fed the IS diet weighed more at the end of week 3 and 4 ($P<.05$) than those fed the SBM diet. Pigs fed the SBM diet weighed less at the completion of the trial when compared to other dietary treatments although differences tended to be significant ($P<.06$) only for those fed the IS diet.

Tight supplies of milk products combined with increasing demand usually cause higher prices for milk proteins and has resulted in a search for sources of protein that can nutritionally replace milk. The results of this study indicate that selected isolated soy protein will produce performance equivalent to that observed with milk protein and may be used to replace milk protein when economic circumstances allow.

Table 5. The effect of protein source on pig weight (lb)[a].

Item	Diet				
	MP	IS	MPIS	SBM	SEM
Initial Wgt.	13.70	13.84	13.79	13.68	.38
Week 1	15.53[bc]	16.72[b]	16.50[b]	14.22[c]	.50
Week 2	21.75[bc]	23.46[b]	22.99[b]	19.90[c]	.74
Week 3	28.42[de]	30.34[d]	30.70[d]	27.09[e]	1.10
Week 4	36.70[de]	39.40[d]	38.21[de]	35.39[e]	1.33
Week 5	47.90	50.90	49.50	46.73	1.56

[a]Least squares means, MP: milk protein diet; IS: isolated soybean diet; MPIS: milk protein isolated soybean diet; SBM: soybean meal diet.
[b,c]Means in the same row with different superscripts differ ($P<.01$).
[d,e]Means in the same row with different superscripts differ ($P<.05$).

NUTRIENT COMPOSITION OF NINE VARIETIES OF HARD RED WINTER WHEAT

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Story in Brief

Nine varieties of hard red winter wheat grown at four Oklahoma locations for two years were analyzed for dry matter, crude protein, lysine, threonine, isoleucine and methionine + cystine. Significant differences among varieties were observed for crude protein and isoleucine when expressed as percent of wheat on a dry matter basis. Nonsignificant differences were observed for dry matter, lysine, threonine and methionine + cystine among the varieties tested. Little difference among varieties was found for any of the amino acids analyzed 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 wheat on a dry matter basis. Significant differences between years were observed for dry matter, crude protein, threonine and isoleucine expressed as percent of wheat on a dry matter basis and methionine + cystine expressed as percent of crude protein. Significant year x location interactions were observed for crude protein, dry matter, threonine, isoleucine and methionine + cystine expressed as percent of wheat on a dry matter basis and methionine + cystine expressed as percent of crude protein. Non-hybrid varieties were significantly higher in crude protein and lysine than hybrids. Differences between hybrids and non-hybrids among other nutrients analyzed were not significant.

(Key Words: Wheat Composition, Amino Acids, Protein, Dry Matter.)

Introduction

There have often been periods in recent years when hard red winter wheat has been competitively priced with other cereal grains, justifying its use in swine rations. When wheat becomes competitively priced with other

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

cereal grains, it becomes especially attractive to Oklahoma pork producers since Oklahoma is a major wheat producing state. Wheat production in the state ranges from 130 to 225 million bushels annually.

Since wheat is normally higher in crude protein and essential amino acids than corn, its relative nutritional value to corn is often greater. However, many varieties of wheat are grown in Oklahoma and the variability in protein and amino acid composition has not been determined. This study was conducted to determine the protein and essential amino acid composition of nine varieties of wheat grown in four different locations.

Materials and Methods

All hard red winter wheat varieties were grown in 1984 and 1985 performance trials at four different Oklahoma Agricultural Experiment Stations located at Altus, Goodwell, Lahoma and Stillwater. All wheat 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 121 automatic amino acid analyzer. Values for methionine (an essential amino acid) and cystine (a non-essential amino acid) were combined in all the data reported since cystine can meet up to 50% of the methionine requirements of swine.

Results and Discussion

Least squares means for dry matter and crude protein for each variety are shown in Table 1. Differences among varieties for dry matter were not significant with a range of only 90.30 to 90.91%. Crude protein values expressed on a dry matter basis differed significantly ($P<.05$) among varieties with Payne, Triumph 64, Newton, TAM-101 and TAM-105 being higher than the other varieties.

Least squares means for lysine, threonine, isoleucine and methionine + cystine expressed as percent of wheat on a dry matter basis are shown in Table 2. Significant differences among varieties for isoleucine ($P<.05$) were observed. No significant differences ($P>.10$) were observed for the other amino acids analyzed although differences in lysine approached significance ($P<.11$). Least squares means for lysine, threonine, isoleucine and methionine + cystine expressed as a percent of crude protein are shown in Table 3 with no significant differences ($P>.10$) observed among varieties. Partial correlations between crude protein and lysine, threonine, isoleucine

Table 1. Effect of variety on dry matter and crude protein content of hard red winter wheat[ab].

Variety	Dry matter,%	Crude[c] protein,%
Bounty 100	90.69	16.08[efg]
Chisholm	90.91	15.91[fg]
HW 1010	90.69	16.00[efg]
Newton	90.54	17.24[def]
Payne	90.67	17.56[d]
TAM-101	90.30	16.88[defg]
TAM-105	90.65	16.82[defg]
Triumph 64	90.83	17.28[de]
Vona	90.44	15.79[g]

[a]Dry matter basis.
[b]Standard errors for dry matter and crude protein are .139 and .257, respectively.
[c]Any two means in the same column not sharing a common superscript are different (P<.05).

Table 2. Effect of variety on lysine, threonine, isoleucine and methionine + cystine content of hard red winter wheat[ab].

Variety	Lysine %	Threonine %	Isoleucine[c] %	Methionine + cystine %
Bounty 100	.40	.44	.52[de]	.50
Chisholm	.44	.43	.50[e]	.48
HW 1010	.44	.46	.55[de]	.54
Newton	.48	.47	.56[de]	.48
Payne	.44	.46	.57[d]	.53
TAM-101	.43	.45	.53[de]	.51
TAM-105	.47	.46	.52[de]	.49
Triumph 64	.43	.47	.56[de]	.58
Vona	.43	.45	.53[de]	.53

[a]Dry matter basis.
[b]Standard errors for lysine, threonine, isoleucine and methionine + cystine are .015, .011, .015 and .025, respectively.
[c]Any two means in the same column not sharing a common superscript are different (P<.05).

and methionine + cystine were .27 (P<.05), .45 (P<.01), .50 (P<.01) and .11 respectively. However, the relationship between crude protein and amino acids varied greatly within location and year.

The effect of production location on dry matter and crude protein content is shown in Table 4. Significant differences (P<.05) among locations were observed for both crude protein and dry matter. Location also had a significant effect (P<.01) for lysine, threonine, isoleucine and methionine +

Table 3. Effect of variety on lysine, threonine, isoleucine and methionine + cystine expressed as % of crude protein[a].

Variety	Lysine[bc] %	Threonine[bc] %	Isoleucine[bc] %	Methionine[bc] + cystine %
Bounty 100	2.51	2.72	3.23	3.12
Chisholm	2.77	2.72	3.13	3.64
HW 1010	2.77	2.90	3.45	3.37
Newton	2.76	2.72	3.24	2.79
Payne	2.49	2.63	3.26	3.04
TAM-101	2.57	2.69	3.19	3.02
TAM-105	2.79	2.74	3.08	2.95
Triumph 64	2.50	2.73	3.23	3.24
Vona	2.76	2.86	3.32	3.36

[a]Dry matter basis.
[b]No significant differences among varieties (P>.10).
[c]Standard errors for lysine, threonine, isoleucine and methionine + cystine are .107, .067, .088 and .157, respectively.

Table 4. Effect of location on dry matter and crude protein content of hard red winter wheat[ab].

Location	Dry matter[c] %	Crude protein[c] %
Stillwater	90.39^{e}	15.64^{f}
Goodwell	90.87^{d}	16.57^{e}
Lahoma	90.72^{de}	15.93^{ef}
Altus	90.56^{de}	18.33^{d}

[a]Dry matter basis.
[b]Standard errors for dry matter and crude protein are .09 and .17, respectively.
[c]Any two means in the same column not sharing a common superscript are different (P<.05).

cystine expressed as percent of wheat on a dry matter basis as shown in Table 5. However, when these same amino acids were expressed as percent of crude protein, significant differences across locations were only observed for isoleucine ($P<.05$) as shown in Table 6.

The effect of year grown (1984 or 1985) on the nutrient content of hard red winter wheat is shown in Table 7. Significant differences among years were observed for dry matter ($P<.01$), crude protein ($P<.01$), threonine expressed as percent of wheat on a dry matter basis ($P<.01$), isoleucine expressed as percent of wheat on a dry matter basis ($P<.05$) and methionine

Table 5. Effect of location on lysine, threonine, isoleucine and methionine + cystine content of hard red winter wheat[ab].

Location	Lysine[c] %	Threonine[c] %	Isoleucine[c] %	Methionine[c] + cystine %
Stillwater	.42[b]	.43[a]	.51[a]	.46[f]
Goodwell	.46[a]	.46[a]	.51[a]	.55[d]
Lahoma	.42[ab]	.44[a]	.52[a]	.49[ef]
Altus	.46[ab]	.49[b]	.61[b]	.54[de]

[a]Dry matter basis.
[b]Standard errors for lysine, threonine, isoleucine and methionine + cystine are .010, .007, .010 and .017, respectively.
[c]Any two means in the same column not sharing a common superscript are different (P<.05).

Table 6. Effect of location on lysine, threonine, isoleucine and methionine + cystine expressed as % of crude protein[ab].

Location	Lysine %	Threonine %	Isoleucine[c] %	Methionine + cystine %
Stillwater	2.67	2.76	3.29[de]	2.95
Goodwell	2.77	2.77	3.06[e]	3.34
Lahoma	2.66	2.77	3.30[d]	3.11
Altus	2.54	2.68	3.31[d]	3.06

[a]Dry matter basis.
[b]Standard errors for lysine, threonine, isoleucine and methionine + cystine are .071, .045, .059 and .105, respectively.
[c]Any two means in the same column not sharing a common superscript are different (P<.05).

+ cystine expressed as percent of crude protein on a dry matter basis (P<.10). A significant (P<.01) year x location interaction was observed for dry matter, crude protein and threonine, isoleucine and methionine + cystine expressed as percent of wheat on a dry matter basis. A significant (P<.05) year x location interaction was also observed for methionine + cystine expressed as percent of crude protein. A partial explanation for the interaction may have been the severe drought conditions occurring in 1984 at Altus and Lahoma. This may have had an effect on nutrient composition for the wheat produced at these two sites. A significant (P<.05) year x variety interaction was observed for isoleucine expressed as percent of crude protein.

Table 7. Effect of year on nutrient content of hard red winter wheat[a].

Nutrient[a]	1984	1985	SE[b]	Significance
	%	%		
Dry matter[c]	91.68	89.58	.066	P<.01
Crude protein (CP)[c]	16.96	16.27	.121	P<.01
Lysine, % of wheat	.44	.44	.007	
Lysine, % of CP	2.63	2.69	.050	
Threonine, % of wheat[c]	.47	.44	.005	P<.01
Threonine, % of CP	2.77	2.72	.032	
Isoleucine, % of wheat[c]	.55	.53	.007	P<.05
Isoleucine, % of CP[d]	3.24	3.24	.041	
Methionine + cystine				
% of wheat[c]	.51	.52	.012	
% of CP[e]	3.01	3.22	.074	P<.10

[a]Dry matter basis.
[b]Standard error of means.
[c]Significant (P<.01) year x location interaction.
[d]Significant (P<.05) year x variety interaction.
[e]Significant (P<.05) year x location interaction.

Table 8. Nutrient content of hybrid versus non-hybrid hard red winter wheat[a].

Nutrient[a]	Hybrid[b]	Non-hybrid[c]	SE[d]	Significance
Dry matter	90.69	90.62	.086	
Crude protein (CP)	16.04	16.78	.195	P<.05
Lysine, % of wheat	.42	.44	.010	P<.10
Lysine, % of CP	2.64	2.67	.064	
Threonine, % of wheat	.45	.46	.006	
Threonine, % of CP	2.81	2.73	.040	
Isoleucine, % of wheat	.54	.54	.010	
Isoleucine, % of CP	3.34	3.21	.055	
Methionine + cystine				
% of wheat	.52	.51	.014	
% of CP	3.25	3.08	.088	

[a]Dry matter basis
[b]Hybrids are Bounty 100 and HW1010
[c]Non-hybrid varieties are Chisholm, Newton, Payne, TAM-101, TAM-105, Triumph 64 and Vona.
[d]Standard error of means.

Two of the nine wheat varieties grown, Bounty 100 and HW1010, were hybrids while Chisholm, Newton, Payne, TAM-101, TAM-105, Triumph 65 and Vona were non-hybrids. Table 8 presents least squares means for the nutrients evaluated. Non-hybrids were higher in crude protein ($P<.05$) and lysine expressed as percent of wheat on a dry matter basis ($P<.10$) than hybrids. Values observed among other nutrients were similar.

More differences occurred in nutrient composition of hard red winter wheat in relation to location and year grown than among varieties. However, significant differences did occur among varieties for crude protein and isoleucine. Non-hybrid varieties tended to be higher in crude protein and lysine than hybrid varieties.

RAW MUNG BEANS AS A PROTEIN SOURCE FOR GROWING-FINISHING SWINE

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Story in Brief

Four growing and three finishing trials were conducted to determine the value of mung beans as a replacement for soybean meal in swine diets. A control corn-soybean meal diet was fed in each trial along with levels of mung beans supplying from 10 to 67% of the supplemental lysine during the growing period and from 20 to 75% of the supplemental lysine in the finishing period. During the growing period, feeding mung beans up to 30% of the supplemental lysine (10.2% of the ration) resulted in gain and efficiency of gain similar to that observed in pigs fed the corn-soybean meal control diet. Feeding higher levels generally decreased performance. During the finishing phase, feeding increasing levels of mung beans resulted in a small but linear decrease in daily gain and a quadratic increase in feed required per unit of gain. This study indicates that mung beans can be used to replace up to 60% of the supplemental lysine (16.2% mung beans) in finishing pig diets with little effect on performance.

(Key Words: Growing-Finishing Swine, Mung Bean.)

Introduction

The mung bean is a large seeded legume that is an important source of dietary protein in tropical and subtropical countries. Oklahoma is the leading state in mung bean production in the U.S. with 50,000 to 70,000 acres in production. In the canning industry, undersized or split beans are of no economic value and have traditionally been utilized in livestock feeds.

Mung beans represent a potential protein source for swine since they contain 22 to 28% crude protein and are high in the limiting amino acid,

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lysine. However, mung beans may contain a trypsin inhibitor (Gupta and Wagle, 1978) which may limit their use in swine diets. Preliminary chick studies indicated that mung beans could be used to supply up to 40% of the supplemental lysine without affecting performance. A comprehensive study involving four trials with growing (40 to 120 lb) and three trials with finishing (120 lb to market) swine have been conducted to determine the level of raw mung beans which can be included in growing-finishing swine diets without affecting performance.

Materials and Methods

A total of four trials involving 984 pigs during the growing phase and three trials involving 777 pigs during the finishing phase were conducted at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma. A common control corn-soybean meal diet was fed in each trial (Tables 1, 2). During the growing phase, pigs received diets in Treatments 1, 4, and 8 in Trial 1, Treatments 1, 6 and 7 in Trial 2, Treatments 1, 6 and 9 in Trial 3 and Treatments 1, 2, 3 and 5 in Trial 4. During the finishing phase, pigs received diets in Treatments 1, 3 and 6 in Trial 1, Treatments 1, 4 and 8 in Trial 2 and Treatments 1, 2, 5 and 7 in Trial 3. All diets were calculated to provide an increasing percentage of the supplemental lysine from mung beans at the expense of soybean meal. The percentage of lysine from soybean meal replaced by mung beans ranged from 0 to 67% during the growing phase and from 0 to 75% during the finishing phase. All diets were formulated on an equivalent lysine basis of .75% lysine for the growing phase and .62% lysine during the finishing phase. Two sources of mung beans were used during these trials. Mung beans used in Trials 1, 2 and 3 during the growing phase and Trials 1 and 2 during the finishing phase contained 1.86% lysine and mung beans used in Trial 4 of the growing phase and Trial 3 of the finishing phase contained 1.63% lysine. Diets were formulated using the analyzed lysine values.

Statistical analysis procedures were used which effectively combined analyses for the separate trials. Since Treatment 1 was common in each trial, comparison of the additional treatments could be made indirectly by using the comparison to Treatment 1. This technique to combine information from different experiments is similar to that employed by Tyler et al. (1983) and Luce et al. (1989).

Results and Discussions

Results of the combined trials are presented in this report. Graphic representation of responses are illustrated only in cases in which an effect ($P<.05$) of mung bean level was observed over all trials.

Table 1. Composition of experimental rations fed during the growing phase.

Ingredients	Treatments 1 Control	2 MB-10[a]	3 MB-20[a]	4 MB-25[a]	5 MB-30[a]	6 MB-34[a]	7 MB-42[a]	8 MB-50[a]	9 MB-67[a]
Corn, yellow	76.86	74.88	73.38	73.94	72.06	73.27	72.05	71.30	69.05
Soybean meal, 44%	19.53	17.66	15.82	14.88	13.98	12.89	11.44	10.00	6.59
Mung beans	--	3.73	7.06	7.50	10.20	10.15	12.83	15.50	20.65
Calcium carbonate	.82	.75	.75	.80	.72	.80	.76	.78	.75
Salt	.40	.40	.40	.40	.40	.40	.40	.40	.40
Vitamin -TM,mx[b]	.25	.25	.25	.25	.25	.25	.25	.25	.25
Tylan 10	.50	.50	.50	.50	.50	.50	.50	.50	.50
Calculated composition									
Lysine	.75	.75	.75	.75	.75	.75	.75	.75	.75
Calcium	.75	.75	.75	.75	.75	.75	.75	.75	.75
Phosphorus	.65	.65	.65	.65	.65	.65	.65	.65	.65

[a]Indicate the percentage of supplemental lysine supplied by mung beans. Mung beans containing 1.86% lysine were used in trials where Treatments 4, 6, 7, 8 and 9 were compared and mung beans containing 1.63% lysine were used in trials where Treatments 2, 3 and 5 were compared.

[b]Supplied 4,000,000 IU Vitamin A, 3,000,000 IU Vitamin D, 4 g riboflavin, 20 g pantothenic acid, 30 g niacin, 800 g choline chloride, 15 mg Vitamin B_{12}, 10,000 I.U. Vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.

Table 2. Composition of experimental rations fed during the finishing phase.

Ingredients	Treatments 1 Control	2 MB-20[a]	3 MB-25[a]	4 MB-38[a]	5 MB-40[a]	6 MB-50[a]	7 MB-60[a]	8 MB-75[a]
Corn, yellow	82.32	79.55	79.96	79.21	76.97	77.60	74.56	75.22
Soybean meal, 44%	14.61	11.99	11.33	9.09	9.09	7.63	5.99	3.75
Mung beans	--	5.29	5.63	8.59	10.74	11.75	16.23	17.88
Dical	1.50	1.67	1.53	1.58	1.70	1.58	1.75	1.65
Calcium carbonate	.82	.75	.80	.78	.75	.80	.72	.75
Salt	.40	.40	.40	.40	.40	.40	.40	.40
Vitamin -TM m x[b]	.25	.25	.25	.25	.25	.25	.25	.25
Tylan 10	.10	.10	.10	.10	.10	.10	.10	.10
Calculated composition								
Lysine	.62	.62	.62	.62	.62	.62	.62	.62
Calcium	.70	.70	.70	.70	.70	.70	.70	.70
Phosphorus	.60	.60	.60	.60	.60	.60	.60	.60

[a]Indicates the percentage of supplemental lysine supplied by mung beans. Mung beans containing 1.86% lysine was used in trials when Treatments 3, 4, 6 and 8 were compared and mung beans containing 1.63% lysine was used in trials where Treatments 2, 5 and 7 were compared.

[b]Supplied 4,000,000 IU Vitamin A, 3,000,000 IU Vitamin D, 4 g riboflavin, 20 g pantothenic acid, 30 g niacin, 800 g choline chloride, 15 mg Vitamin B_{12}, 10,000 I.U. vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.

During the growing phase, average daily gain decreased with increasing levels of mung beans in the diet (Figure 1; Quadratic effect, $P<.05$). These results indicate that the level of mung beans had little effect on gain at lower levels in the diet but affected gain more dramatically at higher levels. Average daily gain was similar in pigs on Treatments 1 to 5 but was reduced ($P<.01$) when mung beans in the diet were increased to more than 30% of the supplemental protein (Treatment 6). Pigs fed diets with higher levels than 30% of the supplemental lysine from mung beans (Treatment 7, 8 and 9) grew more slowly than those fed the control diet although difference were significant only at the two highest levels of mung beans (Treatment 8 and 9, $P<.01$). Least squares means for average daily gain for Treatment 1 to 9 were 1.49, 1.50, 1.53, 1.46, 1.56, 1.37, 1.44, 1.38 and 1.36 lb/day, respectively. Feed required per unit of gain followed a pattern similar to that observed for gain with pigs requiring more feed per unit of gain as mung beans in the diet increased (Figure 2; Quadratic effect, $P<.01$). As was observed for gain, level of mung beans in the diet had little effect on feed efficiency at lower

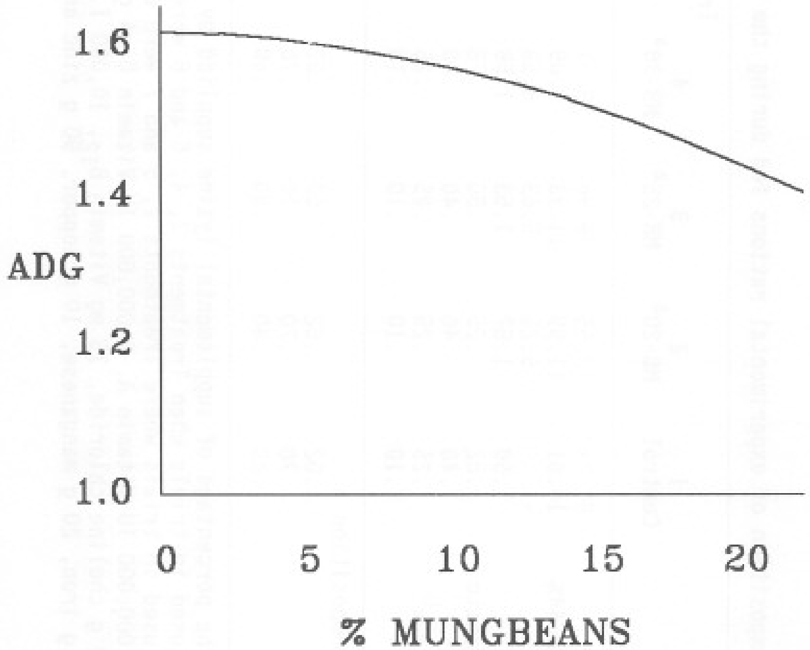

Figure 1. Effect of level of mung beans in the diet on average daily gain (ADG, lb) during the growing period.

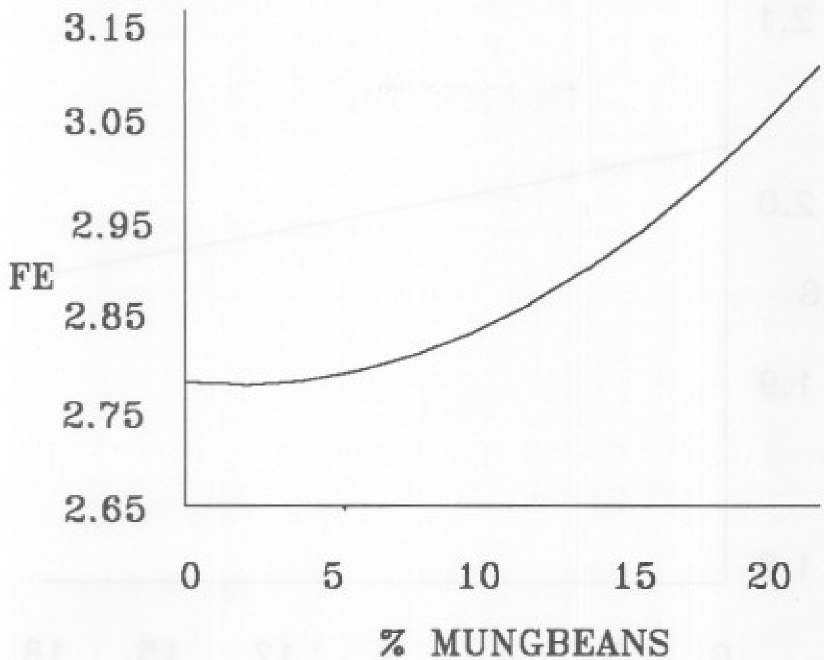

Figure 2. Effect of level of mung beans in the diet on feed efficiency (FE, lb feed/lb gain) during the growing phase .

levels in the diet but resulted in increased feed required per unit of gain at higher levels. Feed efficiency was similar in pigs fed up to 30% of the supplemental lysine from mung beans (Treatments 1 to 5). Least squares means were 2.78, 2.77, 2.78, 2.82, 2.79, 2.86, 2.83, 2.87 and 3.06 lb feed/lb gain for Treatments 1 through 9, respectively. It should be noted that feed required per unit of gain did not increase greatly until mung beans replaced 67% of the supplemental lysine where feed required per unit of gain was 10.1% higher than in pigs fed the control diet (Treatment 1 vs Treatment 9, $P<.01$). Increases in feed required per unit of gain in pigs on Treatments 6 and 8 approached signigicance ($P<.1$) when compared to pigs fed the control diet (Treatment 1). Average daily feed intake was similar among all levels of mung beans. This study suggests that mung beans can effectively replace up to 30% of the supplemental lysine (10.2% of the ration) in the diet of growing pigs without significantly affecting performance.

During the finishing period, average daily gain decreased linearly ($P<.01$) with increasing level of mung beans in the diet (Figure 3). Although the effect of increasing mung beans resulted in a linear reduction in gain over all levels, it should be noted that the magnitude of the reduction overall was

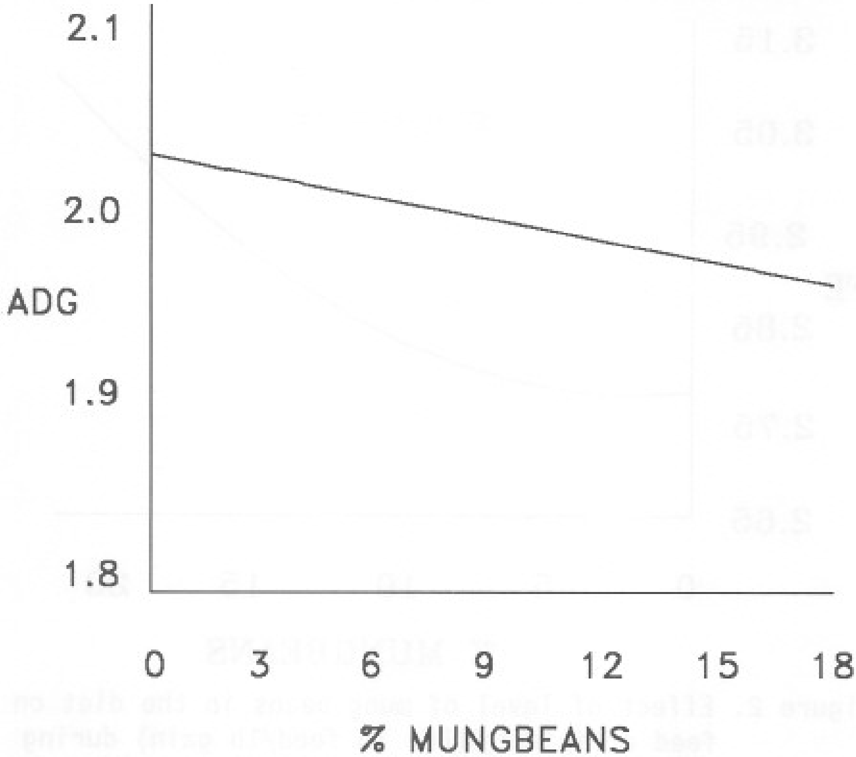

Figure 3. Effect of level of mung beans in the diet on average daily gain (ADG, lb) during the finishing period.

small. In fact, only in pigs fed diets containing 38 and 75% of the supplemental lysine from mung beans (Treatment 4 and 8) did the reduction in gain approach significance ($P<.07$ and $P<.06$, respectively) when the difference among the means were compared with pigs fed the control diet (Treatment 1). Gain in pigs fed other levels of mung beans was similar. Least square means for average daily gain for Treatment 1 through 8 were 2.00, 2.02, 2.10, 1.89, 1.99, 2.01, 2.07 and 1.90 lb/day, respectively. Feed required per unit of gain increased (Figure 4, Quadratic effect $P<.01$) with increasing level of mung beans. As was observed with the growing pig, feed efficiency of pigs fed the lower levels of mung beans was similar and feed required per unit of gain was increased ($P<.01$) only in pigs fed the highest level of mung bean supplementation (Treatment 1 vs Treatment 8). Least squares means for feed required per unit of gain for Treatment 1 through Treatment 8 were 3.58, 3.56, 3.39, 3.44, 3.53, 3.37, 3.64, 3.81, respectively. Average daily feed intake and adjusted backfat thickness was similar among

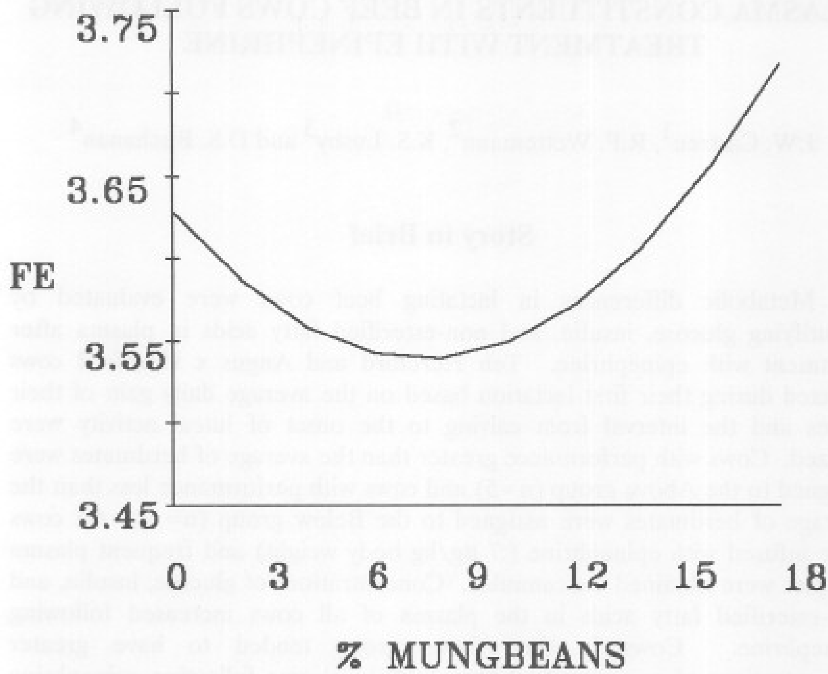

Figure 4. Effect of level of mung beans in the diet on feed efficiency (FE, lb feed/lb gain) during the finishing period.

all levels of mung beans. This study indicates that mung beans can be used to replace up to 60% of the supplemental lysine (16.2% mung beans) in finishing pigs with minimal effects on performance.

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PLASMA CONSTITUENTS IN BEEF COWS FOLLOWING TREATMENT WITH EPINEPHRINE

J.W. Castree[1], R.P. Wettemann[2], K.S. Lusby[3] and D.S. Buchanan[4]

Story in Brief

Metabolic differences in lactating beef cows were evaluated by quantifying glucose, insulin, and non-esterified fatty acids in plasma after treatment with epinephrine. Ten Hereford and Angus x Hereford cows selected during their first lactation based on the average daily gain of their calves and the interval from calving to the onset of luteal activity were utilized. Cows with performance greater than the average of herdmates were assigned to the Above group (n=5) and cows with performance less than the average of herdmates were assigned to the Below group (n=5). All cows were infused with epinephrine (.7 μg/kg body weight) and frequent plasma samples were obtained via cannulae. Concentrations of glucose, insulin, and non-esterified fatty acids in the plasma of all cows increased following epinephrine. Cows in the Above group tended to have greater concentrations of non-esterified fatty acids in plasma following epinephrine than cows in the Below group. Insulin in the plasma after epinephrine was less in Above than Below cows. Concentrations of glucose in plasma were not different between cow groups. An epinephrine challenge may be useful to evaluate fat mobilization and plasma concentrations of non-esterified fatty acids and insulin in lactating beef cows.

(Key Words: Beef Cow, Epinephrine, Glucose, Insulin, NEFA.)

Introduction

The interval from calving to the onset of luteal activity and the average daily gain of the calf are two important criteria when evaluating beef cow performance. A cow must rebreed within 82 days following calving to maintain a yearly calving interval. Sixty percent of a calf's 205-day weaning weight is dependent on maternal lactation. Nutrient intake and the body energy reserves of a cow influence milk production and the ability to rebreed.

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Richards et al. (1987) suggests that reduced concentrations of glucose and insulin in plasma are associated with nutritional anestrus. Concentrations of non-esterified fatty acids (NEFA) in plasma of cows are an indication of the rate of fat mobilization and may be useful to evaluate the energy status of the postpartum cow (Garmendia et al., 1986). The objective of this study was to evaluate the effect of epinephrine on concentrations of glucose, insulin, and NEFA in the plasma of lactating beef cows with above average or below average calf growth and reproductive performance.

Materials and Methods

Ten mature Hereford and Angus x Hereford cows were ranked during their first lactation based on average daily gain (ADG) of their calf and the interval from calving to the onset of luteal activity. Five cows with performance greater than the average of herdmates were assigned to the Above group and 5 cows with performance less than the average of herdmates were assigned to the Below group. At approximately 60 days post partum during the third or fourth lactation, cows were maintained in individual stanchions with their calves present and fed to NRC requirements. Cows were in moderate body condition [BCS = 4.6 .3 (1=emanciated and 9=obese) weight=956 lb]. Cows were infused with .7 μg/kg BW of epinephrine via an indwelling jugular cannulae. Frequent plasma samples were obtained via cannulae from 30 minutes before epinephrine infusion until 3 hours after infusion. Concentrations of glucose, insulin, and NEFA in plasma were quantified.

Results and Discussion

Production traits of cows and calves from the Above and Below groups (Table 1) were not significantly influenced by cow groups during the third or fourth lactation. However, the cows in the Above group tended to wean heavier calves and to initiate ovarian function sooner after calving.

Table 1. Least-squares means of production traits.

Trait	Group: Above	Group: Below
Weaning weight, lb	499.4	464.8
Average daily gain of calves, lb.	2.46	2.10
Onset luteal activity, d	57.8	66.6

Concentrations of glucose, insulin, and NEFA in the plasma of all cows increased following epinephrine infusion and attained maximum concentrations within 10 to 15 minutes following treatment. This increase in the concentration of all plasma constituents indicates that the dose of epinephrine was sufficient to elicit a response.

Below cows tended to have greater concentrations of insulin in plasma than Above cows ($P<.10$) following epinephrine treatment (Figure 1). Concentrations of NEFA in the plasma of Above cows were greater than that for Below cows ($P<.05$) after treatment with epinephrine (Figure 2). The increased NEFA in Above cows indicate a greater mobilization of body fat following treatment. There were no significant differences in the concentrations of glucose in the plasma of Above and Below cows following epinephrine infusion (Figure 3).

The mean concentrations of NEFA in the plasma of all cows after treatment with epinephrine were correlated with ADG of the calves ($r=.89$) and weaning weights ($r=.94$). Cows with a greater ability to mobilize body energy stores may have an increased potential for milk production which can result in greater ADG and heavier weaning weights of calves.

We conclude that an epinephrine infusion may be useful to evaluate fat mobilization and plasma concentrations of NEFA and insulin in lactating beef cows.

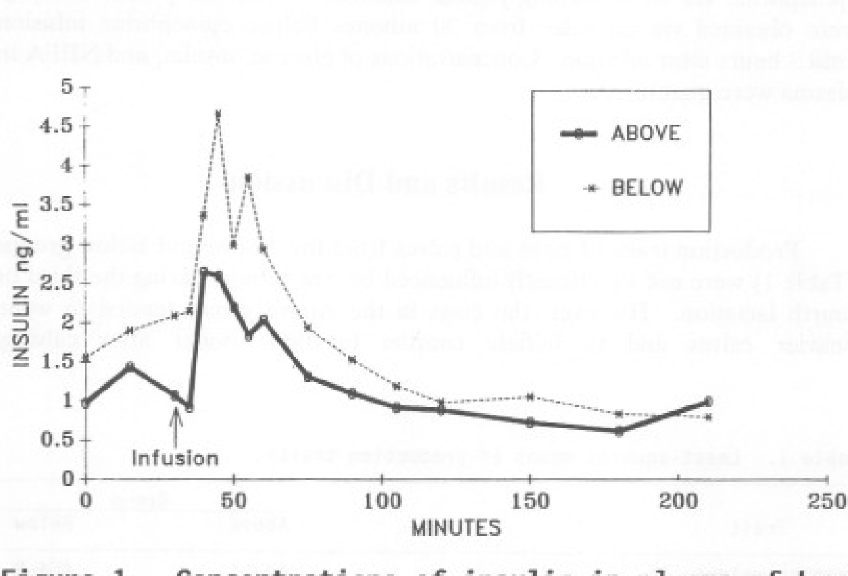

Figure 1. Concentrations of insulin in plasma of beef cows after epinephrine.

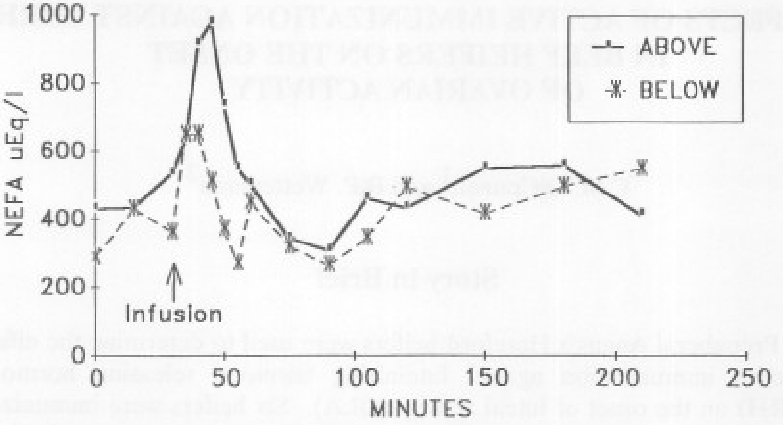

Figure 2. Concentrations of NEFA in plasma of beef cows after epinephrine.

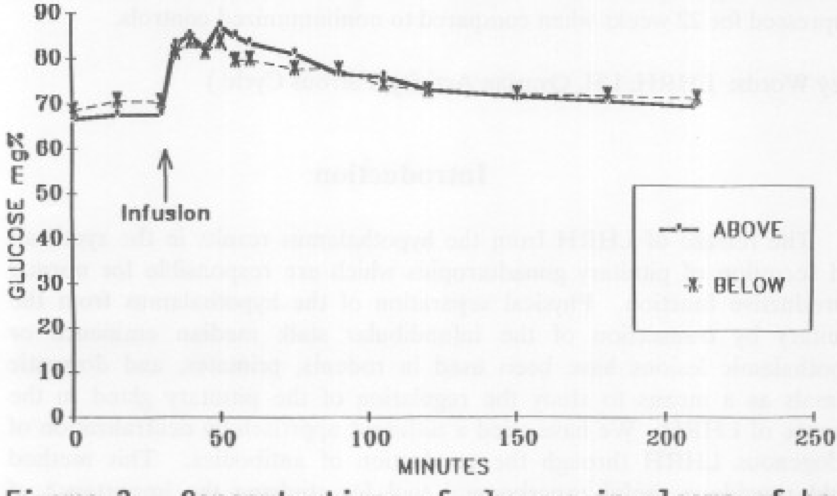

Figure 3. Concentrations of glucose in plasma of beef cows after epinephrine.

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EFFECTS OF ACTIVE IMMUNIZATION AGAINST LHRH IN BEEF HEIFERS ON THE ONSET OF OVARIAN ACTIVITY

C.M. O'Connell[1] and R.P. Wettemann[2]

Story in Brief

Prepuberal Angus x Hereford heifers were used to determine the effect of active immunization against luteinizing hormone releasing hormone (LHRH) on the onset of luteal activity (OLA). Six heifers were immunized at 13 months of age against LHRH and six heifers were maintained as controls. Treated heifers received a booster injection 45 days after the initial immunization. All heifers responded to immunization with the production of antibodies against LHRH. Luteal activity in immunized heifers was suppressed for 22 weeks when compared to nonimmunized controls.

(Key Words: LHRH, LH, Ovarian Activity, Estrous Cycle.)

Introduction

The release of LHRH from the hypothalamus results in the synthesis and secretion of pituitary gonadotropins which are responsible for normal reproductive function. Physical separation of the hypothalamus from the pituitary by transection of the infundibular stalk median eminence or hypothalamic lesions have been used in rodents, primates, and domestic animals as a means to study the regulation of the pituitary gland in the absence of LHRH. We have tried a different approach by neutralization of endogenous LHRH through the production of antibodies. This method could provide a useful experimental tool for studying the importance of LHRH in reproduction as well as an effective means to prevent pregnancy in heifers.

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Materials and Methods

Twelve prepuberal Angus x Hereford heifers at approximately 13 months of age were used to evaluate the effects of immunization against LHRH. Preparation of the antigen consisted of conjugating LHRH to Human Serum Albumin (HSA) by the carbodimide reaction. Six heifers received a primary injection of LHRH-HSA conjugate emulsified in Complete Freunds adjuvant (day 0). The imulsion was injected intradermally and subcutaneously at 6 sites in the mammary gland.

On day 45 a booster immunization of conjugate in Incomplete Freunds Adjuvant was given in the same manner as the initial injection.

Blood serum and plasma were obtained weekly for 36 weeks by jugular venipuncture. Concentrations of progesterone in plasma were quantified by radioimmunoassay and used to determine the onset of OLA. Antibody titers were determined in the serum and expressed as the $\%^{125}$I LHRH bound in the serum at a dilution of 1:100.

Results and Discussion

Luteal activity occurred at 51 and 274 weeks after the initial immunization for control and treated heifers respectively. Antibody production against LHRH as evident by increased binding of ^{125}I-LHRH in

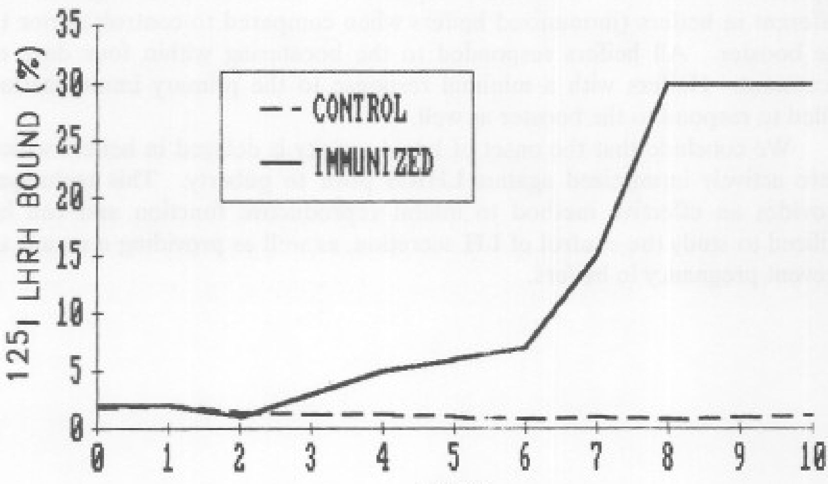

Figure 1. Binding of ^{125}I-LHRH to serum (1:100) from control heifers and heifers immunized against LHRH.

Table 1. Antisera titers in heifers before and after (days) booster immunization against LHRH.

Heifer	Treatment[a]	Binding (%) of ^{125}I-LHRH to antisera (1:100)		
		-3 d	+4 d	+11 d
531	I	1	5	7
257	I	1	7	5
581	I	2	4	19
580	I	2	21	62
552	I	7	16	40
930	I	28	37	48
All	C	<2	<2	<2

I=immunized against LHRH and C=control

the serum occurred in response to the primary immunization by 2 to 3 weeks after treatment, with a gradual increase in titer until week 6 (Figure 1). Immunized heifers received a booster between weeks 6 and 7 and this resulted in a rapid increase in titer by week 8.

At week 10, all immunized heifers had antisera titers against LHRH and titer was not directly related to the week of onset of OLA. For example, of two heifers with the lowest titers against LHRH at week 10 , one exhibited estrus at 14 weeks as opposed to 35 weeks in the other heifer.

The responses of individual heifers to booster treatment with LHRH is depicted in Table 1. With the exception of two heifers, binding was not different in heifers (immunized heifers when compared to controls) prior to the booster. All heifers responded to the boostering within four days of treatment. Heifers with a minimal response to the primary immunization failed to respond to the booster as well.

We conclude that the onset of luteal activity is delayed in heifers which were actively immunized against LHRH prior to puberty. This technique provides an effective method to inhibit reproductive function and can be utilized to study the control of LH secretion, as well as providing a means to prevent pregnancy in heifers.

SEXUAL BEHAVIOR AND TESTICULAR FUNCTION AFTER TREATMENT OF PREPUBERAL BOARS WITH TESTOSTERONE

R.P. Wettemann[1], D.K. Bishop[2], J.W. Castree[2], C.M. O'Connell[2], S. Welty[3] and C.V. Maxwell[4]

Story in Brief

Ten groups of three littermate purebred Hampshire and Yorkshire boars were used to determine the influence of supplemental testosterone on testicular function and sexual behavior. Boars were born between November and May. At three months of age, one boar from each litter was assigned to control, low testosterone or high testosterone treatment, once weekly between 3 and 6 months of age. Between 6 and 7 months, boars were exposed to an estrous gilt for 15 minutes each week and sexual behavior was evaluated. At 7 months, boars were castrated and weights and sperm numbers in the testes and epididymides were quantified. Body weight gain was not influenced by treatment. Testicular weights of control boars were greater than weights of boars on the high testosterone treatments. Sexual behavior was not influenced by treatment. After 4 weeks of sexual behavior evaluation, 70% of the control boars, 50% of the low testosterone and 80% of the high testosterone boars had completed successful matings. We conclude that weekly treatment of prepubertal boars with sufficient testosterone to influence testes weights did not alter sexual behavior.

Introduction

Much variation exists in sexual behavior of boars. The male hormone, testosterone, causes libido in boars. Removal of testosterone by castration or immunization to reduce testosterone in plasma reduces sexual interest of boars, and treatment with testosterone will restore sexual behavior. However, concentrations of testosterone in plasma of mature boars are not related to sexual aggressiveness.

Testicular weights increase very rapidly between 3 and 6 months of age in boars and the testes secrete increasing amounts of testosterone. This is

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also a time when boars and gilts attain the ability to respond differently to hormonal activation of mating behavior. The lack of female mating behavior in boars is associated with increased secretion of testosterone before puberty. Inadequate testosterone secretion during pubertal development may result in boars that have reduced libido.

The objective of this study is to determine the influence of supplemental testosterone before puberty on development of sexual behavior and testicular function of boars.

Materials and Methods

Ten groups of three littermate, purebred Hampshire and Yorkshire boars were used. At three months of age, one boar from each litter was assigned to each of the treatments: control; (LTP) .5 mg/kg of testosterone propionate (TP) once weekly, or (HTP) 2 mg/kg of TP once weekly. Testosterone propionate was in a solution (40 mg/ml) of 60% propylene glycol, 30% ethyl alcohol and 10% benzyl alcohol. Boars were treated between 3 and 6 months of age and weighed every 2 weeks. Boars were maintained in an enclosed barn and exposed to ambient temperatures between 60 and 86F and natural photoperiod.

Between 6 and 7 months of age, sexual behavior was observed, at weekly intervals, during 15 minute mating tests. Individual boars were exposed to a single estrous gilt in an isolated 4x4m pen. Mating traits monitored were ano-genital sniffs, nose-to-nose contact, nosing the flanks, proper rear mounts and improper head or side mounts. Copulatory performance was evaluated as the number, total time ejaculating and average reaction time to first mount.

At 7 months of age, boars were anesthetized and castrated. Weights of the testes and epididymides were determined and samples of testicular parenchymae and complete capita-corpora and caudal epididymides were homogenized and numbers of sperm in the tissues was quantified.

Results and Discussion

Body weight gain was not influenced by treatment. Testicular weights of control boars at seven months of age were greater than the weights of HTP boars. Total sperm numbers in the testes were significantly reduced in HTP compared to control boars (Table 1). The weights of the epididymides and numbers of sperm in the epididymides were also significantly reduced for HTP compared to control boars. The reduced testicular growth and function

Table 1. Influence of testosterone treatment on body weight and testicular characteristics.[a]

Characteristic	Treatment			SE
	Control	Low TP	High TP	
Boars, no	8	8	8	
Initial weight, lb	78.9	81.1	78.2	4.0
Final weight, lb	234.2	240.5	229.9	8.5
Testicular weight, g	330.0[b]	286.8[b]	223.8[c]	21.2
Total testicular sperm, X10^9	38.0[b]	28.6[bc]	22.6[c]	4.7
C-C[d] weights, g	33.9[b]	31.1[b]	24.5[c]	2.4
C-C spermatozoa, X10^9	28.4[b]	23.1[b]	12.8[c]	4.8
C[e] weights, g	33.4[b]	33.8[b]	26.9[c]	2.1
C spermatozoa, X10^9	44.2[b]	42.2[b]	21.7[c]	6.5

[a]Values for one testicle per boar.
[b,c]Means in a row with different superscripts differ ($P<.05$).
[d]Capita-corpora epididymides.
[e]Caudae epididymides.

of treated boars is probably caused by reduced secretion of gonadotropins from the pituitary due to the negative feedback of the exogenous testosterone.

Sexual behavior of the eight littermate groups was not influenced by treatment with testosterone (Table 2). The percentage of proper mounts and erections were not different for boars on the three treatments. After 4 weeks of sexual behavior evaluation, 70% of the control boars, 50% of the LTP and 80% of the HTP boars had completed successful matings.

Season of puberty tended to influence sexual behavior (Table 3). The month during which boars attained 6 months of age was used to classify boars as to the season of puberty. The percentage of boars exhibiting successful mating was greatest when the boars attained six months of age (puberty) during January to June and least for boars attaining six months during July through September. Previous studies have indicated that heat stress does not influence sexual behavior of sexually active boars or estrous cycles of cyclic

Table 2. Influence of testosterone treatment on reproductive behavior.

Characteristic	Treatment		
	Control	Low TP	High TP
Boars, no	10	10	10
Boars that exhibited:			
Proper mounts %	100	80	90
Erections %	80	90	90
Successful mating %	70	50	80

Table 3. Influence of season at puberty on the incidence of successful mating.

Season when boars attained 6 months of age	Number of Boars Total	Successful Matings	%
Jan - Mar	6	6	100
April - June	6	5	83
July - Sept	12	5	42
Oct - Dec	6	4	67

gilts. However, heat stress will delay puberty in gilts. Our results suggest the puberty may be delayed in boars during the summer months in Oklahoma.

Testicular characteristics and reproductive behavior are extremely variable traits. This study is continuing to increase the number of boars per treatment each season to complete the evaluation of the effects of exogenous testosterone and season on sexual behavior of boars. On the basis of the boars studied, we conclude that the weekly treatment of prepuberal boars with sufficient testosterone propionate to influence testes weight does not alter sexual behavior.

INTEGRATED EXPERT SYSTEM FOR CULLING MANAGEMENT OF BEEF COWS

J. W. Oltjen[1] and G. E. Selk[2]

Story in Brief

An expert system shell, written in the C computer language, served as the inference engine for a knowledge base developed to recommend whether to keep or cull commercial beef cows. Cows are classified into three categories, cull, keep or rank. The net present value of those classified as rank is estimated based on expected future performance and salvage value by calling a cow herd simulation model, also written in C, from within the expert system. The cow with the lowest net present value is culled first when cows in addition to those classified cull must be culled. The system can be either integrated with a computer database or interactive, querying a cow data file or the user for information about each cow, making a decision, and responding with its recommendation. Evaluation revealed rankings were most sensitive to pregnancy status, age and future market conditions.

(Key Words: Expert Systems, Net Present Value, Beef Cows.)

Introduction

Commercial beef cow herds are subjected to a wide variety of culling strategies. Cows are most often removed from the herd because of illness and failure to become pregnant. Some herd owners also remove cows from the herd based upon the low dollar return of the calves they produce. For herd size to remain constant, those cows culled and/or lost from the herd must be replaced. The growing or buying of replacement heifers is costly. First calf heifers are difficult to manage through their first calving and rebreeding season. Therefore, commercial beef producers become reluctant to cull mature cows until they are convinced that those cows can no longer provide an economical return. Each year at weaning time in herds with a single, short calving season pregnancy checking and cow re-evaluation occurs. Culling or keeping of healthy, mature but nonpregnant cows, at the

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[1]Associate Professor [2]Assistant Professor

productive peak of their lives, is a rather difficult and often very subjective decision that ranchers face. Some producers choose to automatically cull any cow that has not become pregnant during the previous breeding season. Others will cull only those that are non-pregnant and advanced in age or have a physical weakness. Yet other ranchers will place more emphasis on the previous production performance of the cow in question and tend to keep nonpregnant cows that have been previously very productive. Most of these culling strategies are adhered to with only occasional regard for current market conditions or future market projections. A previously reported expert system attempted to make culling decisions based on previous calfing performance and current cow status (Oltjen et al., 1987). However, many cows could not be classified clearly. For these questionable cows, culling strategy would be improved by the incorporation of economic evaluations of the future potential return. Combining biological potential (cow production capabilities) with sophisticated economic analyses is a challenge at best and requires the utilization of every available tool. Therefore, the objective of this research was to develop a knowledge-based system integrated with an economic simulation model to assist commercial cow-calf producers make culling decisions at normal pregnancy checking time.

Materials and Methods

In order to develop an expert system to recommend whether to keep or cull commercial beef cows, a reproduction specialist, G. E. Selk, was interviewed by a knowledge engineer, L. G. Burditt. The expert's heuristic knowledge was inserted in an expert system shell programmed in C and developed by Plant (1988). The knowledge base was arranged as rules reflecting the expert's knowledge (Oltjen et al., 1987), and classified each cow to be culled, kept or ranked on future production value.

For cows that are to be ranked, a call to a subroutine written in C is made, and net present value (NPV) is estimated. Basically, NPV is the discounted income from calf sales and cow salvage minus the discounted expenses to maintain the cow. It is based on the modification by Trapp (1986) of Perin's (1972) discrete form:

$$\text{NPV} = \left\{ \sum_{t=a}^{c-1} P(t)\cdot(\text{Calf Return} + \text{Cull Cow Return} - \text{Maintenance Cost}) \right\}$$

$$+ \text{ Salvage Value}$$

where a is initial cow age (at time of pregnancy check, calendar year y), c is maximum cow age (the time at which cows are culled due to old age, rule 1) and P is expected cow population. Calf and cow prices and maintenance costs are adjusted for future years; other parameter values are adjusted for cow age. All costs and returns are discounted. Calf return is

$$(1+r)^{-(t-a+1)} \cdot WR(t) \cdot \text{Calf Price}(y+t-a+1) \cdot \text{Calf Weight}(t)$$

where r is the discount or interest rate and WR(t) is subsequent weaning rate for cows pregnancy checked at age t. The first year WR(a) is zero for nonpregnant cows, but for pregnant cows it is WRP(a), the weaning rate of structurally correct pregnant cows at pregnancy check time. Hence:

$$WR(t) = (1-SC(t)) \cdot PR(t) \cdot WRP(t)$$

where SC(t) is structural culling rate and PR(t) is pregnancy rate of cows pregnancy checked at age t, except at age a, when PR(t) is one if the cow checks pregnant, zero if nonpregnant, or .5 if unknown. Nonpregnant cows at subsequent pregnancy checks are assumed to be culled. Also, SC(a) is zero, since the expert system would have already culled the cow if she was unsound. Cull cow return is

$$(1+r)^{-(t-a)} \cdot (1-PR(t) \cdot [1-SC(t)]) \cdot \text{Cow Price}(y+t-a,t) \cdot \text{Cow Weight}(t)$$

except for the first year, t=a, when the cow must be kept for any future income to accrue and cull cow returns are zero. Annual maintenance costs are

$$(1+r)^{-(t-a+.5)} \cdot PR(t) \cdot (1-SC(t)) \cdot (1-.5 \cdot DR(t)) \cdot MC(y+t-a,t)$$

where DR(t) is annual death rate post pregnancy check of cows age t, and MC(y+t-a,t) is annual maintenance costs of cows pregnancy checked in year y+t-a at age t. The term PR(t) in the maintenance calculation is set to 1 when t=a. Salvage Value is

$$(1+r)^{-(c-a)} \cdot P(c) \cdot \text{Cow Price}(y+c-a,c) \cdot \text{Cow Weight}(c)$$

Since NPV is calculated for individual cows, expected cow population, P, declines with time:

$$P(a) = 1.0$$

$$P(a+1) = P(a) \cdot PR(a) \cdot (1-DR(a)) \cdot (1-SC(a))$$

Again PR(a) is set to 1, more generally:

$$P(t) = \prod_{i=a}^{t-1} PR(i)\cdot(1-DR(i))\cdot(1-SC(i))$$

Parameter values are either input by the user, or a default set similar to that of Trapp (1986) is used.

The program is interactive, querying the user to input information about each cow in question. The expert system uses backward chaining to arrive at a conclusion. When enough information is available for a decision to be made the program reports its recommendation.

Results and Discussion

A number of relationships are required in the NPV simulation. For example, Figure 1 shows the effect of cow age on pregnancy rate (PR), weaning rate (WRP), death rate (DR), structural culling rate (SC), and cow

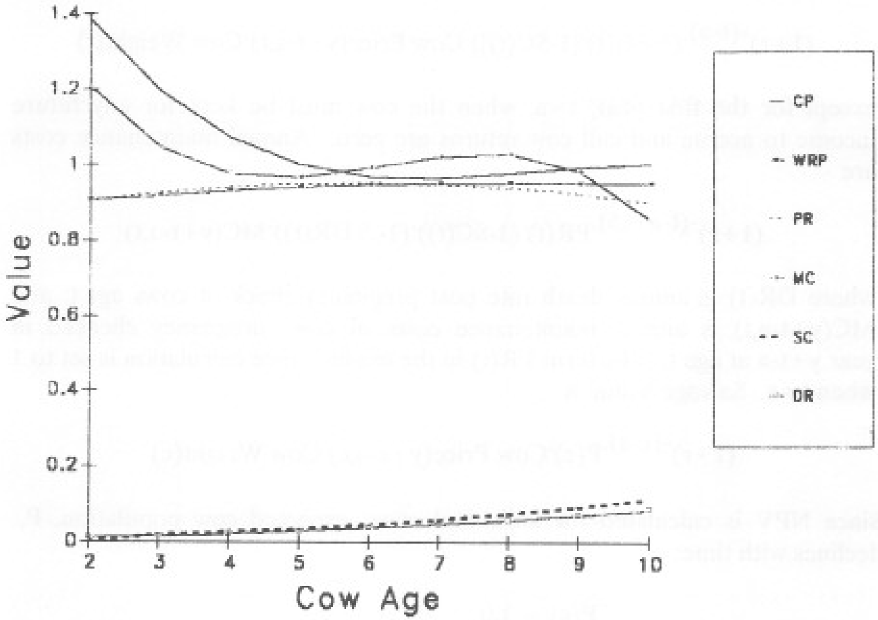

Figure 1. The effect of cow age on cow price adjustment (CP), weaning rate (WRP), pregnancy rate (PR), maintenance cost adjustment (MC), structural culling rate (SC) death rate (DR).

price and maintenance cost (MC) adjustments. These relationships can be changed to fit existing conditions to improve the reliability of projected NPV. However, the rankings of cows is relatively insensitive to changes in these in typical cow herds.

Examples of interactive sessions with the expert system are shown in Tables 1, 2 and 3. The five year-old cow in the first example (Table 1) has the necessary traits to be kept in the commercial cow herd. In contrast, the seven year-old in Table 2, which is not pregnant, is suggested to be culled. The expert system recommended culling for this cow because of her poor condition (rule 5). However, the cow in Table 3, which is not pregnant, would be culled only after all other cows with NPV less than $650 had been culled (Ben-Ari et al., 1983). Had the cow in Table 2 been in a better body condition score of 5, the expert system would not have culled her, but rather she would have been ranked with a net present value of $383. Her estimated current salvage value is $519, suggesting her sale. However the younger cow in Table 3 was ranked with a net present value of $650, considerably greater than her estimated salvage value of $552. Consequently she is a better economic risk to remain in the herd. It can be seen that the order in which

Table 1. Example interactive session using the culling expert system.

Expert system	User
This knowledge base is designed to assist you in deciding whether to cull a cow from the herd	
How old is this cow?	5
What is the condition score of this cow?	5
How many functional quarters does this cow's udder have?	4
What is the average calving difficulty of this cow using the 1-5 scale?	1.4
Has this cow ever had a cesarean section birth?	NO
Does this cow have serious structural problems?	NO
How much damage does this cow have to her eyes? NONE SLIGHT EXTREME	SLIGHT
Is this cow pregnant?	YES
Are performance records available for this cow?	YES
Enter the average weaning weight of this cows calves.	515
What is the average calf weaning weight for your herd?	500
Has the cow missed any previous calves?	NO
This cow should be kept in the herd. This cow should not be culled.	

Table 2. Example interactive session using the culling expert system.

Expert System	User
This knowledge base is designed to assist you in deciding whether to cull a cow from the herd	
How old is this cow?	7
What is the condition score of this cow?	2
How many functional quarters does this cow's udder have?	4
What is the average calving difficulty of this cow using the 1-5 scale?	1.3
Has this cow ever had a cesarean section birth?	NO
Does this cow have serious structural problems?	NO
Is this cow pregnant?	NO
This cow's poor body condition is most likely why she is open. The cost of bringing her to a higher condition so that she will cycle would be prohibitively high so she should be culled.	

Table 3. Example interactive session using the culling expert system.

Expert System	User
This knowledge base is designed to assist you in deciding whether to cull a cow from the herd	
How old is this cow?	4
What is the condition score of this cow?	6
How many functional quarters does this cow's udder have?	4
What is the average calving difficulty of this cow using the 1-5 scale?	1.1
Has this cow ever had a cesarean section birth?	NO
Does this cow have serious structural problems?	NO
How much damage does this cow have to her eyes? NONE SLIGHT EXTREME	NONE
Is this cow pregnant?	NO
Has the cow missed any previous calves?	NO
Enter the average weaning weight of this cows calves.	520
What is the average calf weaning weight for your herd?	515
This cow is in good condition and is still open this year. She should be suspect and a candidate for culling next year if she is kept in the herd. Her estimated net present value is $650.	

the consultation occurs is influenced by the backward-chaining reasoning process which the expert system employs. Thus, in the second example (Table 2), a recommendation is made as soon as enough information is collected to apply rule 5, and this session is shorter than the other two. This also shows the advantage of using an expert system to determine cow classification, if possible, before calling a computationally intense model to estimate NPV.

Rankings are relatively sensitive to expected changes in market conditions. For example, using current Oklahoma production parameters and May 1988 market conditions, a pregnant eight year old cow and a non-pregnant two year old cow weaning her first calf have similar NPV under the assumption of steady markets, $682 and $713, respectively. However, with declining markets (5% decline/year), the older, pregnant cow becomes relatively more valuable ($605 versus $419), and with rising markets (5% increase/year), the younger cow has greater relative NPV ($1074 versus $760). Thus, culling the open, young animal is the optimal strategy in the first case, while culling the older animal might be desirable with rising markets in the second case (particularly if she is a poor producer in any category). On the other hand, rank order of cow NPV was insensitive to general management changes which affected all ages of cows. For maximum profit, cows would normally be culled when estimated NPV was less than current salvage value. However, optimal culling policy must also include judgements regarding future herd size and availability, cost and value of replacement animals. Further, NPV sensitivity to the maximum cow age in rule 1 may change some rankings based on the cattle cycle (Trapp, 1986).

To make this a more useful tool, information for each cow may be stored in a database file, and the program modified to interact with the file to output a list of cows to keep and to cull. Also, additional rules reflecting optimal strategies which depend on economic considerations, such as replacement heifer cost, are needed. The rules included can and should be modified to better reflect environmental and economic situations of the potential user.

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INFLUENCE OF BILE SALTS ON β-GALACTOSIDASE ACTIVITY AND CELLULAR INTEGRITY OF *LACTOBACILLUS ACIDOPHILUS*

S.E. Gilliland[1] and D.O. Noh[2]

Milk supplemented with *Lactobacillus acidophilus* has been shown beneficial for persons who can not adequately digest lactose (clinically classified as "lactose malabsorbers"). The benefit is due to the presence of β–galactosidase in the cells of *L. acidophilus* when they have been grown and prepared properly. The enzyme is intracellular thus it is permitted to pass through the stomach unaltered. Once the organism reaches the intestinal tract the cells interact with bile which apparently alters the permeability and allows lactose to enter the cells to be hydrolyzed or permits the enzyme to exit from the cell to exert its activity. In addition the organism, being bile resistant, is able to grow in the intestinal tract producing additional cells and more enzyme to further assist lactose hydrolysis.

One theory concerning the beneficial use of *L. acidophilus* in improving lactose utilization in humans, is that bile sensitive strains should be selected so that they will lyse in the presence of bile in the intestines to release more enzyme to aid in the hydrolysis of lactose. In preliminary experiments we have compared two cultures of *L. acidophilus* in this regard. One of the cultures grew significantly better in the presence of bile than did the other. There was little difference in the β-galactosidase activity between the two cultures. Nongrowing, whole cells of the organism exhibited little if any β-galactosidase activity. However, activity was increased by both in the presence of added bile. When suspended in a solution containing up to 1 percent oxgall (dried bile) no evidence of cell lysis for either culture was observed. This indicates that bile sensitive cells do not necessarily lyse in the presence of bile. It further suggests that bile sensitive strains should not be selected for use as dietary adjuncts to benefit lactose utilization in humans. If the organism is not able to grow well in the presence of bile it is not likely that any added benefit could be obtained from growth of the organism in the intestinal tract.

Additional cultures are being evaluated to confirm these observations and to make more critical measurements on cellular integrity following exposure to bile.

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CHOLESTEROL UPTAKE BY CULTURE OF *LACTOBACILLUS ACIDOPHILUS* USED FOR NONFERMENTED ACIDOPHILUS MILK

S.E. Gilliland[1] and D.K. Walker[2]

Story in Brief

Twelve cultures of *Lactobacillus acidophilus* of human origin were compared for several characteristics considered desirable with regard to their use as a dietary adjunct for the possible production of a hypocholesterolemic effect in humans. There were significant variations among the cultures with regard to the ability to grow in the presence of bile and to assimilate cholesterol during growth. The most bile resistant cultures did not necessarily assimilate the greatest amount of cholesterol, suggesting that bile resistance is not directly related to the ability to assimilate cholesterol. However, there were significant differences in bile resistance among the cultures most active in assimilating cholesterol. Thus it is important to consider both characteristics when selecting cultures of the organism for use as dietary adjunct for these purposes. Another important characteristic of cultures of lactobacilli to be used as dietary adjunct is the ability to compete well with other cultures of lactobacilli or lactic acid bacteria. The cultures most active in assimilating cholesterol varied in this regard. Our results indicate that a strain of *L. acidophilus* can be selected which has all three of these desirable characteristics. However, the most desirable one among the twelve cultures of human origin tested in this study may not be sufficiently active with regard to cholesterol assimilation to produce a hypocholesterolemic effect.

(Key Words: *Lactobacillus acidophilus*, Cholesterol, Bile-tolerance, Bacteriocin.)

Introduction

Several studies have indicated a hypercholesterolemic activity produced by *Lactobacillus acidophilus*. We have found that variations exist among

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strains of *L. acidophilus* isolated from the intestinal tract of pigs with regard to the ability to assimilate cholesterol. Furthermore a strain which actively assimilated cholesterol was beneficial in helping exert beneficial influence on serum cholesterol levels in the pigs (Gilliland et al., 1985). The purpose of the present study was to compare strains of *L. acidophilus* of human origin, including some which are commercially available and used in preparing commercial acidophilus milk, for several characteristics desired for an organism to be used to exert a hypocholesterolemic effect.

Since it is necessary that the organism be able to grow in the intestinal tract it is important that it be bile resistance. While the degree of bile resistance required for maximum growth of the organism in the intestinal tract is not known, it is important to select the most bile resistant strain having the other desired characteristics for use as a dietary adjunct. It is also desirable to select a strain which has optimum ability for assimilating cholesterol during growth. Our earlier study indicated there is not a direct relationship between the ability to grow well in the presence of bile and the ability to assimilate cholesterol, thus both of these characteristics should be considered.

Some strains of *L. acidophilus* produce bacteriocins (antibiotic like materials which are only active against closely related strains or species of bacteria) which provides them with an advantage in being able to compete and grow in the presence of other lactic acid bacteria. This would be especially important in enabling a culture used as a dietary adjunct to be able to compete with other lactobacilli or lactic acid bacteria occurring naturally in the small intestines.

Materials and Methods

Thirteen strains of *L. acidophilus* were included in the study. Twelve of the cultures were originally of human origin. The thirteenth culture was *L. acidophilus* ATCC 43121 which was isolated from the intestines of a pig in our previous studies (Gilliland et al., 1985) and has been deposited with the American Type Culture Collection (ATCC). Because of host specificity exhibited among strains of *L. acidophilus* it is not one, however, being considered for use as a human dietary adjunct.

To determine if the cultures produced materials (bacteriocins) which inhibited other lactobacilli, each culture was grown in MRS broth at 37°C for 24 hours. The resulting cultures were centrifuged to remove the cells, the spent broth was adjusted to pH 6 and passed through a sterile .45 μm filter to remove any residual bacterial cells. The spent broth (10 μl volume) was spotted onto the surface of MRS agar seeded with the desired culture of lactobacilli. Plates were incubated at 37°C for 24 h. Clear zones where the spent broth had been placed on the surface of the agar indicated inhibition of growth of the test culture.

To compare the ability of the cultures to assimilate cholesterol during growth they were inoculated into MRS broth supplemented with .2% sodium thioglycollate, .3% oxgall (dried bile) and 10% plueropnuemonia-like organism (PPLO) serum. The inoculated media were incubated the desired time (14 or 16 h) at 37°C. Following incubation the cultures were chilled and centrifuged to remove the bacterial cells. The spent broth along with uninoculated control broth was assayed for cholesterol using a colorimetric method (Rudel and Morris, 1973). Differences in the amount of cholesterol in the control broth and the spent broth for each culture were taken as the amounts of cholesterol assimilated by the cultures during the growth period.

Results and Discussion

All of the cultures being compared in this study were confirmed to be *L. acidophilus*.

There was significant variation in the rapidity of growth of the cultures in MRS broth containing .3% oxgall (Table 1). The most rapid growing

Table 1. Comparison of cultures of *L. acidophilus* for ability to grow in presence of bile and to assimilate cholesterol.

Culture	Growth in broth + 0.3% oxgall[1]	Cholesterol assimilated[2]
L. acidophilus ATCC 43121	2.93[a]	95.7[ab]
L. acidophilus 107	3.72[b]	67.1[c]
L. acidophilus NCFM	4.48[c]	103.9[b]
L. acidophilus 606	4.65[cd]	64.6[c]
L. acidophilus TKNC3	4.80[cde]	92.4[ab]
L. acidophilus 1	4.90[cdef]	61.3[c]
L. acidophilus ATCC 4962	5.27[efg]	102.9[a]
L. acidophilus TKNC2	5.32[efgh]	27.5[d]
L. acidophilus NCFM-L	5.35[fghi]	90.7[ab]
L. acidophilus TKNC1	5.73[ghi]	97.5[ab]
L. acidophilus 223	>6.70[j]	102.1[a]
L. acidophilus NCFM-F	>7.20[k]	77.5[bc]
L. acidophilus ATCC 4356	>7.40[k]	96.3[ab]

[1]Expressed as hours for growth to increase turbidity by .3 units; each value is an average from 3 trials.
[2]Amount assimilated (µ/ml) during 16 h of growth; each value is an average from 4 trials.
a,b,c,d,e,f,g,h,i,j,kValues in same column followed by different superscript letters differ significantly (P<.05).

culture was *L. acidophilus* ATCC 43121 which was originally isolated from pig intestines. The range in times required for the growth of the other to cause an increase in absorbance of .3 units was from 3.7 hrs for *L. acidophilus* 107 to greater than 7.4 hrs for *L. acidophilus* ATCC 4356. In Table 1 the cultures are arranged in order of decreasing ability to grow in the presence of bile with the most active culture being listed first.

The μg of cholesterol assimilated by the cultures during 16 h of growth also varied significantly among the cultures (Table 1). It is obvious from these data that the cultures exhibiting the greatest ability to grow in the presence of bile did not necessarily assimilate the greatest amount of cholesterol. Cultures ATCC 43121, NCFM, TKNC3, ATCC 4962, NCFM-L, TKNC1, 223, and ATCC 4356 assimilated significantly more cholesterol than did cultures 107, 606, 1, and TKNC2. *L. acidophilus* 107, which was the fastest growing of the cultures of human origin in the presence of bile assimilated significantly less cholesterol than many other cultures. In fact, it assimilated significantly less cholesterol than did the one which grew slowest in the presence of bile (*L. acidophilus* ATCC 4356). It is possible that the group of cultures assimilating the highest levels of cholesterol in these experiments had reached maximum levels of growth and cholesterol assimilation. Thus it may have been possible to detect differences among them if a shorter incubation time had been used.

In order to determine if there were differences among the eight cultures which assimilated the highest amount of cholesterol during the 16 h incubation period, additional experiments were conducted in which the cultures were incubated only 14 h (Table 2). Results from these experiments

Table 2. Comparison of selected cultures of *L. acidophilus* for ability to assimilate cholesterol during a shortened growth period and to produce inhibitory action toward other lactobacilli.

Culture	Cholesterol assimilated[1]	Inhibition of other lactobacilli
L. acidophilus ATCC 43121	55.4[a]	-[2]
L. acidophilus NCFM-L	35.1[b]	Yes
L. acidophilus ATCC 4962	31.0[b]	No
L. acidophilus NCFM	30.6[b]	Yes
L. acidophilus 223	18.6[c]	Yes
L. acidophilus ATCC 4356	12.9[c]	Yes
L. acidophilus TKNC1	10.9[c]	Yes
L. acidophilus TKNC3	10.9[c]	No

[1]Amount (μg/ml) assimilated during 14 hours of growth; each value is an average from 3 trials.
[2]Not listed.
[a,b,c]Values with different superscript letters differ significantly ($P<.05$).

revealed significant differences among the eight cultures. *L. acidophilus* ATCC 43121 assimilated significantly more cholesterol than did the other seven cultures. This is most likely due to the fact that it grew more rapidly than did the others. Of the seven cultures of human origin, *L. acidophilus* NCFM-L, ATCC 4962 and NCFM assimilated significantly more cholesterol than did the remaining 4 cultures.

The seven cultures of *L. acidophilus* of human origin which assimilated the greatest amount of cholesterol during the 16 h incubation period were also compared for the ability to produce substances that inhibited other lactobacilli (Table 2). Of the seven cultures NCFM-L, NCFM, 223, ATCC 4356, and TKNC1 produced inhibitory materials whereas ATCC 4962 and TKNC3 did not.

Because of host specificity among cultures of *L. acidophilus*, the most active culture included in this comparison (ATCC 43121) would not be considered for use as a dietary adjunct for humans. Of the cultures of human origin included in the studies, cultures NCFM-L, ATCC 4962, and NCFM were significantly more active in assimilating cholesterol than were the others. While these three were not the most bile resistant culture included, culture NCFM did exhibit a fair degree of bile resistance. The most bile resistant culture of human origin (107) was rather ineffective in assimilating cholesterol. Thus if the purpose of the dietary adjunct is to provide benefits in helping control serum cholesterol levels it would not be a culture of choice. Of the three which most actively assimilated cholesterol NCFM-L and ATCC 4962 grew significantly slower in the presence of bile than did NCFM. Additionally ATCC 4962 did not produce bacteriocin activity. Thus of these three cultures *L. acidophilus* NCFM would appear to be the culture of choice. However, the fact that *L. acidophilus* ATCC 43121 (of swine origin) was much more active with regard to both bile tolerance and cholesterol assimilation suggests the possibility that better cultures of human origin might occur. Thus, it seems reasonable that additional cultures of human origin should be screened in order to select one having even better characteristics for use as a dietary adjunct produce hypocholesterolemic activity in humans.

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BILE SALT DECONJUGATION ACTIVITY OF CULTURES OF *LACTOBACILLUS ACIDOPHILUS* ISOLATED FROM THE INTESTINES

D.K. Walker[1] and S.E. Gilliland[2]

Story in Brief

Nineteen strains of *Lactobacillus acidophilus* were evaluated for their ability to deconjugate sodium taurocholate and sodium taurodeoxycholate. Cells from 18 to 20 hour broth cultures of *L. acidophilus* were inoculated (1%) into broth containing .001 M sodium taurocholate; also 10 ml of the broth culture was inoculated on the surface of agar containing .5% sodium taurodeoxycholate. All strains of *L. acidophilus* tested deconjugated both sodium taurocholate and sodium taurodeoxycholate.

(Key Words: Deconjugation, Bile-acids, *Lactobacillus acidophilus*.)

Introduction

Bile acids are produced in the liver and conjugated with glycine or taurine, concentrated in the gall bladder, and released into the small intestine where their major function is to solubilize dietary lipids (Stryer, 1975). This action increases the digestion and absorption of fat. These bile acids are then reabsorbed from the small intestine and transported back to the liver for reuse. This process is known as the enterohepatic circulation of bile acids. Bacterial modification of bile acids can influence their enterohepatic circulation (Garbutt et al., 1970). The major action of bacteria on the bile acids is deconjugation of the conjugated bile acids. Gilliland and Speck (1977) showed that *L. acidophilus* could deconjugate bile acids.

The purposes of this study were to compare the bile salt deconjugation activity of different cultures of *L. acidophilus* and to evaluate the use of an agar medium to detect the deconjugation activity.

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Materials and Methods

Cultures of *L. acidophilus* were grown at 37°C for 18 to 20 h in MRS broth (Difco Laboratories) prior to experimental use. One percent inocula of a freshly prepared 18 to 20 h broth cultures of *L. acidophilus* were added to 20 ml volumes of MRS broth containing .018 M sodium thioglycolate and .001 M sodium taurocholate (NaTC). The cultures were then incubated for 10 hr at 37°C and analyzed for the liberation of free cholic acid via the method of Irvin et al. (1944).

For detection of deconjugation activity on the agar medium, 10 ml of each broth culture were inoculated on the surface of MRS agar containing .5% sodium taurodeoxycholate (NaTDC). The plates were incubated (upright) anaerobically for 18 h at 37°C. After incubation, the plates were removed and observed for precipitated white zones of white precipitate surrounding the colonies of lactobacilli (Dashkevicz and Feighner, 1989).

Results and Discussion

All strains of *L. acidophilus* deconjugated NaTC in the broth medium. Strains ATCC 23121, RP34, RP43, RP42, GP1B, GP4A, DKW-9, 251, and ATCC 4356 deconjugated significantly (P<.005) more NaTC than the other strains (Table 1). The differences in deconjugation among cultures was not

Table 1. Deconjugation activity of *Lactobacillus acidophilus*.

Strain	Cholic Acid[a] (μM/ml)	Plate[a] Assay
ATCC 43121	4.30[b]	+
RP34	3.38[b]	+
251	4.15[b]	+
ATCC 4356	3.59[b]	+
DKW-9	4.30[b]	+
HM2	2.97[c]	+
2	1.78[c]	+
14F1	0.17[d]	+
NCFM-F	2.85[c]	+
NCFM-L	3.69[b]	+
15	2.17[c]	+
14	2.18[c]	+
12	1.60[c]	+
5	1.40[c]	+
P16	3.89[b]	+
GP4A	3.93[b]	+
RP43	3.77[b]	+
RP42	4.06[b]	+
GP1B	3.86[b]	+

[a]Each method was performed three times.
[b,c,d]Means with different superscripts differ significanlty (P<.005).

due to differences in growth because strains that tended to grow slower than others in the broth deconjugated similar amounts of NaTC as the faster growing strains (growth data not shown).

All strains of *L. acidophilus* exhibited deconjugation of NaTDC in MRS agar. The basis for this reaction is due to the pKa of free cholic acid (pH 5.0) which at a slightly acidic pH will be protonated and precipitate out of solution; however the taurocholic acid (pKa 1.9) will remain ionized and thus in solution in the agar medium. The formation of zones of white precipitate surrounding bacterial growth on the agar medium was considered a positive reaction.

These results reveal that there is considerable variation among strains of *L. acidophilus* with regard to deconjugation of bile salts. Also a simple procedure for detecting deconjugation can be achieved using MRS agar containing NaTDC. This latter procedure may prove useful as a simple means of screening cultures and/or determining if plasmids control deconjugation activity in *L. acidophilus*.

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EFFECT OF PORCINE SOMATOTROPIN AND SEX-CLASS ON PORK CARCASS GRADE TRAITS AND COOKING CHARACTERISTICS

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Story in Brief

Thirty hogs (15 gilts and 15 barrows) were allocated to one of five treatments with Treatment 1 serving as a control and Treatments 2 through 5 receiving .71, 1.43, 2.86, or 4.29 mg/day of porcine somatotropin, respectively. Hogs were finished on a commercial diet and slaughtered upon attaining an individual live weight of 230 lb. No significant differences were observed among treatment groups or sex classes for slaughter traits. Carcasses from hogs treated with 1.43 mg or more of somatotropin per day had less fat at the tenth rib and lower loin eye marbling scores than carcasses from control hogs. Gilt carcasses were longer, trimmer, more desirable in USDA cutability grade and higher in estimated percentage muscle than barrow carcasses. Sex classes responded similarly to somatotropin (no significant treatment x sex class interactions) for all traits examined. Cooking properties and shear force values were similar for all treatment groups and sex classes. Somatotropin treatments of 1.43 mg/day produced trimmer carcasses with less marbling, and no adverse effects on cooking properties and tenderness. Increasing the level of somatotropin beyond 1.43 mg/day provided little additional enhancement for the traits examined.

(Key Words: Porcine Somatotropin, Sex Class, Carcass Traits, Shear Force.)

Introduction

Today's health oriented consumers are concerned with the amount of fat in their diets. Accordingly, methods of producing carcasses with less fat and more muscle should be investigated. Porcine somatotropin has been shown to reduce fat deposits when injected in finishing swine (Ivy et al., 1986). Apparently, porcine growth hormone dramatically alters nutrient partitioning to decrease lipid and increase protein synthesis.

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Somatotropin treatment has been shown to have minimal effect on the quality of pork. Kanis et al. (1988) reported that cooking loss, drip loss, and tenderness were similar for somatotropin treated and control hogs.

To date, the dosage required for optimal efficiency has not been determined. Experiments thus far have focused primarily on somatotropin administered as mass per unit of body weight. This approach is not very feasible for future commercial application. Therefore, the objective of this study was to examine the effects of daily somatotropin dosage (mg/day) in barrows and gilts on subsequent slaughter, carcass, and cooking traits.

Materials and Methods

Fifteen gilts and 15 barrows were allocated across 5 treatment groups and administered porcine somatotropin (mg/day) as follows: group 1 = none (control), group 2 = .71, group 3 = 1.43, group 4 = 2.86, and group 5 = 4.29. Hogs were finished on a commercial diet and slaughtered upon attaining an individual live weight of 230 lb.

Upon delivery to the Oklahoma State University Meat Laboratory, the hogs were individually weighed, slaughtered to collect liver weight, intestinal weight (gastro-intestinal tract and contents) and hot carcass weight and chilled at 32°F. Upon 24 hours postmortem, two trained University personnel weighed each side for chilled weight and obtained all measurements and scores necessary for USDA quality and cutability grade determinations. The left side of each carcass was ribbed between the 10th and 11th ribs to obtain loin eye area, fat depth, marbling score (5=abundant, 4=moderate, 3=small, 2=slight, 1=traces), muscle color (5=dark red, 4=red-pink, 3=light pink, 2=gray, 1=white/pale) and muscle firmness (3=firm, 2=intermediate, 1=soft and watery) according to NPPC (1985) guidelines.

USDA cutability grade was calculated as follows: Grade = (4 x last rib backfat, in) - (muscling score) with muscling score coded as 3 (thick), 2 (intermediate) or 1 (thin). Percent muscle was estimated as: (10.5 + (.505 x hot carcass weight, lb) + (2.0 x loin eye area, sq in) - (14.9 x tenth rib fat depth, in) / hot carcass weight, lb) x 100 (NPPC, 1985).

At 72 hours postmortem, two loin chops (1 inch thick) were removed from the tenth rib region of each carcass, vacuum packaged and stored at -22°F. Chops were thawed (35°F) for 24 hours and broiled on Farberware Open-Hearth broilers to an internal temperature of 167°F. Data were collected to assess cooking time (minutes to a medium degree of doneness) and cooking shrinkage (% weight loss). All chops were cooled to 77°F and cored (.5 inch in diameter) to determine the average (6 cores) pounds of force required for Instron shearing (tenderness).

Data were analyzed using the model of treatment, sex class and the treatment x sex interaction. Duncan's multiple range test was used for mean separation when F-tests were significant ($P<.05$).

Results and Discussion

Means for slaughter traits stratified by somatotropin treatment level and sex class are reported in Tables 1 and 2, respectively. No significant differences were noted between treatment groups or sex for slaughter weight, hot carcass weight, dressing percentage, intestinal weight and liver weight.

Although carcass fat thickness tended to decrease with increased dosage of somatotropin, the only significant difference apparent in this study involved tenth rib fat depth (Table 3). Carcasses from hogs treated with 1.43

Table 1. Slaughter traits for hogs treated with porcine somatotropin.

Item	Porcine somatotropin treatment[a]				
	1	2	3	4	5
Slaughter weight, lb.	231.8	234.7	232.3	228.2	231.0
Hot carcass weight, lb.	175.3	177.8	174.8	172.8	173.1
Dressing percentage	75.6	75.7	75.2	75.7	74.9
Intestinal weight, lb.[b]	16.3	16.7	18.1	16.9	17.6
Liver weight, lb.	3.40	3.45	3.85	3.72	4.05

[a]Porcine somatotropin administered (mg/day/hog) to 6 hogs per treatment: 1 = none (control), 2 = 0.71, 3 = 1.43, 4 = 2.86, 5 = 4.29.
[b]Intestinal weight includes the weight of the gastro-intestinal tract and contents.

Table 2. Slaughter traits by sex-class for hogs treated with porcine somatotropin.

Item	Sex-class	
	Gilt	Barrow
Slaughter weight, lb.	232.4	230.8
Hot carcass weight, lb.	175.7	173.8
Dressing percentage	75.6	75.3
Intestinal weight, lb.[a]	17.7	16.5
Liver weight, lb.	3.79	3.60

[a]Intestinal weight includes the weight of the gastro-intestinal tract and contents.

Table 3. Carcass grade traits for hogs treated with porcine somatotropin.

Item	Porcine somatotropin treatment[a]				
	1	2	3	4	5
Carcass length, in	31.9	31.6	32.0	32.4	32.4
Backfat thickness, in					
First rib	1.99	1.85	1.66	1.66	1.69
Last rib	1.22	1.05	1.03	0.91	0.96
Last lumbar vertebra	1.46	1.26	1.22	1.02	1.17
Average	1.56	1.39	1.31	1.20	1.27
Tenth rib fat depth, in	1.50[g]	1.28[fg]	1.13[f]	0.96[f]	1.01[f]
Muscling score[b]	1.67	2.33	1.83	2.17	2.00
Loin eye area, sq.in.	5.07	4.96	4.99	5.32	5.11
USDA cutability grade[c]	3.21	1.87	2.27	1.49	1.83
Estimated percent muscle[d]	49.49	51.23	52.60	54.45	53.80
Loin eye scores[e]					
Color	2.67	2.67	2.83	2.83	2.50
Marbling	2.67[f]	2.00[fg]	1.67[g]	1.50[g]	1.83[g]
Firmness	2.50	2.33	2.00	2.17	2.00

[a]Porcine somatotropin administered (mg/day/hog) to 6 hogs per treatment: 1 = none (control), 2 = 0.71, 3 = 1.43, 4 = 2.86, 5 = 4.29.
[b]Muscle score: 1 = thin; 2 = intermediate.
[c]USDA, 1985.
[d]NPPC, 1985.
[e]Loin eye scores: Color: 2 = gray; Marbling: 1 = traces, 2 = slight; Firmness: 2 = intermediate.
[fg]Values in the same row with a common superscript letter are not statistically (P>.05) different.

mg or more of somatotropin per day (Treatments 3, 4 and 5) were significantly trimmer than carcasses from control hogs. This finding is in agreement with previous work where somatotropin treatments produced trimmer carcasses than controls. Among somatotropin-treated hogs, increasing the dosage level from .71 to 4.29 mg/day did not (P>.05) substantially decrease the depth of fat at the tenth rib. No differences (P>.05) were observed in this study for measures of carcass muscularity regardless of treatment group. Despite large ranges in USDA cutability grade (over 2 full grades) and estimated percentage muscle (5%) between treatment groups, differences were not consistent enough for statistical significance. Furthermore, the small sample size (n=3 per treatment x sex class group) used in this study posed additional difficulties in proving significance. Treatment groups were similar (P>.05) for loin eye color and firmness scores; however, loin eyes from control hogs were scored higher (P<.05) for marbling amount than those produced with 1.43 mg or more of somatotropin per day (Treatments 3, 4 and 5).

Gilt carcasses were significantly longer, trimmer at the last and tenth ribs, more desirable in USDA cutability grade and higher in estimated percent muscle than barrow carcasses (Table 4). Although muscularity differences were numerically consistent with the latter, no (P>.05) differences were observed. Loin eye quality scores were similar between sexes.

Means for cooking properties and shear force by treatment group and sex class are presented in Tables 5 and 6, respectively. No (P>.05) differences were noted between treatment groups or sex classes for cooking time to 167°F, cooking shrinkage or shear force (an objective measurement for tenderness).

Table 4. Carcass grade traits by sex-class for hogs treated with porcine somatotropin.

Item	Sex-class	
	Gilt	Barrow
Carcass length, in	32.6[e]	31.5[f]
Backfat thickness, in		
First rib	1.72	1.82
Last rib	0.95[e]	1.12[f]
Last lumbar vertebra	1.14	1.31
Average	1.27	1.42
Tenth rib fat depth, in	1.04[e]	1.32[f]
Muscling score[a]	2.13	1.87
Loin eye area, sq.in.	5.24	4.94
USDA cutability grade[b]	1.65[e]	2.62[f]
Estimated percent muscle[c]	53.65[e]	50.98[f]
Loin eye scores[d]		
Color	2.53	2.87
Marbling	1.73	2.13
Firmness	2.07	2.33

[a]Muscle score: 1 = thin; 2 = intermediate.
[b]USDA, 1985.
[c]NPPC, 1985.
[d]Loin eye scores: Color: 2 = gray; Marbling: 1 = traces, 2 = slight; Firmness: 2 = intermediate.
[e,f]Values in the same row with a common superscript letter are not statistically (P>.05) different.

Table 5. Cooking properties and shear force values for loin chops from hogs treated with porcine somatotropin

Item	Porcine somatotropin treatment[a]				
	1	2	3	4	5
Cooking time, min.[b]	27.9	28.1	29.0	30.6	33.7
Cooking shrinkage, %	31.2	31.2	33.6	31.1	35.8
Instron shear force, lb	10.6	9.9	11.9	10.6	11.3

[a]Porcine somatotropin administered (mg/day/hog) to 6 hogs per treatment: 1 = none (control), 2 = 0.71, 3 = 1.43, 4 = 2.86, 5 = 4.29.
[b]Time in minutes required to reach a broiled internal temperature of 167°F.

Table 6. Cooking properties and shear force values by sex-class for loin chops from hogs treated with porcine somatotropin.

Item	Sex-class	
	Gilt	Barrow
Cooking time, min.[a]	31.0	28.7
Cooking shrinkage, %	33.2	32.8
Instron shear force, lb	10.6	11.1

[a]Time in minutes required to reach a broiled internal temperature of 167°F.

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EFFECTS OF TRENBOLONE ACETATE IN YEARLING FEEDLOT STEERS ON CARCASS GRADE TRAITS AND SHEAR FORCE

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Story in Brief

Two trials with yearling steers were used to evaluate the effects of an androgenic implant, trenbolone acetate, in combination with an estrogenic implant (Synovex-S, Trial 1; Compudose-200, Trial 2) on carcass traits. Steers were assigned to one of four implant treatment groups (no TBA; TBA on day 0; TBA on day 70; TBA on days 0 and 70). All steers were fed a high concentrate diet and slaughtered. No significant differences were noted among treatment groups for carcass weight, fat thickness, percent internal fat, or marbling score. Carcasses from steers in Trial 1 which were doubly implanted with TBA had larger ribeyes, more desirable yield grades, more advanced lean maturity scores and darker lean color scores than carcasses from control steers. In both trials, the incidence of bullock characteristics in carcasses was increased for late and doubly TBA implanted steers. In Trial 1, the percentage of choice carcasses from doubly TBA implanted steers was slightly lower than those receiving no TBA (24.4 versus 33.4%). In Trial 2, the percentage of choice carcasses for late and doubly TBA implanted steers was significantly lower than the control group (30.5, 31.0 versus 51.4%). The results of this study indicate that the use of TBA early in the feeding period has a minimal effect on carcass traits. Late administration of TBA tended to reduce percentage of Choice and to increase muscling.

(Key Words: Feedlot Steers, Trenbolone, Implants, Carcass Traits.)

Introduction

Feedlots have used estrogenic anabolic implants to increase rate of gain and improve feed efficiency for many years. Recently, an androgenic steroid,

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trenbolone acetate (TBA), has been introduced to enhance growth beyond that produced by estrogenic compounds. In a feedlot study using yearling steers, Hicks et al. (1985) reported that Compudose plus a single TBA implant increased carcass gain and feed efficiency by 8.6 and 4.6%, respectively, compared to Compudose alone. The authors noted that dressing percentage and marbling score tended to be the lowest for steers receiving TBA implants.

There is very little information available concerning the impact of TBA implants on specific carcass traits and cooking properties. Because TBA is an androgenic compound, one would expect that several TBA production and carcass parameters could mirror those changes characteristically associated with the production of young intact males (bullocks). An extensive review of beef from intact males (Seideman et al., 1982) noted substantially greater average daily gain, feed efficiency and carcass leanness for young bulls than steers. Unfortunately, bullock carcasses commonly had lower quality grades, darker muscle color, and more variable tenderness than steer carcasses.

Variation in cooked beef tenderness usually is attributed to variation in carcass fatness (external and marbling) and subsequent rate of chill or to the amount of connective tissue in muscle. Lower sensory tenderness scores and higher collagen content are often reported for steaks from bulls than from steers.

Because TBA increases growth rate, it is being adopted rapidly by feedlot operators. Research is needed immediately to document any effects (positive or negative) of TBA on beef carcass characteristics and palatability attributes that may affect consumer acceptance. Therefore, the objective of this study was to examine the effects of androgenic implants (Finaplix-S)[5] when administered in combination with an estrogen (Synovex-S[6] or Compudose-200)[7] on USDA quality and yield grade traits, cooking properties, and shear force requirements of carcasses from feedlot steers. **At the time of this publication TBA has not been approved by the FDA for use in combination with either Synovex-S or Compudose-200.**

Materials and Methods

Yearling steers were utilized in two implant trials (one and two) at a commercial feedlot in the High Plains region. Steers in Trial 1 (n=291) were randomized by breed and assigned to one of four equally-sized implant treatment groups (Table 1). Group 1 steers received an initial estrogenic

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Table 1. Implant schedule for trial 1.

Implant period[a]	Treatment group 1	2	3	4
On-test	Synovex (SYN)	SYN + TBA	SYN only	SYN + TBA
Reimplant	SYN	SYN	SYN + TBA	SYN + TBA

[a]Implant periods: on-test = day 0 during processing; reimplant = day 70.

anabolic implant (Synovex-S) at processing (day 0) and were reimplanted with Synovex-S (SYN) on day 70 to serve as a control. The second group was implanted with SYN plus an androgenic steroid, trenbolone acetate (TBA), at processing and was reimplanted with SYN on day 70. Group 3 steers received SYN at processing and were reimplanted with SYN and TBA on day 70. The remaining steers (group 4) were implanted with SYN plus TBA at processing and were reimplanted with SYN and TBA at day 70.

Steers in Trial 2 (n=303) were randomized in a similar fashion and implanted with Compudose instead of Synovex as the estrogenic anabolic implant at the onset of the experiment (day 0). TBA was implanted with Compudose in treatment groups 2, 3 and 4 as outlined in Table 2.

Individual live weights (unshrunk) were obtained on day 1 for all steers. Steers in Trials 1 and 2 were fed a high concentrate diet for 139 and 134 days, respectively. All steers were commercially slaughtered and approximately 24 hours postmortem, complete USDA quality and yield grade data (USDA, 1987) were collected by an official USDA grader plus two experienced University personnel. In addition, all carcasses were assigned scores for lean color (8=pink, 7=light cherry-red, 6=cherry-red, 5=slightly dark red, 4=moderately dark red, 3=dark red, 2=very dark red, 1= black) and masculinity characteristics (bullock score: 5=no evidence, 4=slight, 3=moderate, 2=severe, 1=extremely severe). This bullock score reflects the extent of pizzle eye, bald spot and crest development.

Table 2. Implant schedule for trial 2.

Implant period[a]	Treatment group 1	2	3	4
On-test	Compudose (COMP)	COMP + TBA	COMP only	COMP + TBA
Reimplant	None	None	TBA	TBA

[a]Implant periods: on-test = day 0 during processing; reimplant = day 70.

A subsample of 240 carcasses in Trial 1 were randomly selected prior to grading for subsequent cooking property and shear force determinations. Approximately 48 hours postmortem, the ribeye roll (IMPS 112A) was fabricated from the left side of each carcass, vacuum packaged and transported to the Oklahoma State University Meat Laboratory. The cooler aging period was standardized at 6 days for all ribeye samples.

Ribeye rolls were crust frozen and faced before removing a steak (1.0 in. thick) for Warner-Bratzler shear force. All steaks were vacuum packaged and stored at -22°F. Steaks were thawed (35°F) for 24 hours and broiled on Farberware Open-Hearth broilers to an internal temperature of 158°F. Data were collected to assess cooking time (minutes to a medium degree of doneness) and cooking shrinkage (% weight loss). All steaks were cooled to 77°F and cored (.5 in. diameter) to determine the average (6 cores) pounds of force required for shearing.

Data were analyzed separately for each trial and the latter subset of cookery and shear steaks. All treatment groups were adjusted to a constant initial weight since many carcass traits are highly weight dependent. Least squares means were used to account for unequal treatment group sizes.

Results and Discussion

Least squares means for carcass grade traits from Trial 1 steers are presented in Table 3. Carcasses from steers implanted with TBA late in the feeding period (Treatments 3 and 4) were more advanced ($P<.05$) in lean maturity score and darker ($P<.05$) in muscle color than carcasses from control steers (Treatment 1) implanted with SYN alone. However, no significant differences were noted between Treatment (T) 2 (TBA early) and the controls. Carcasses from steers doubly implanted with TBA (T4) had significantly larger ribeyes and more desirable USDA yield grades than those from control (T1) and early TBA steers (T2). The incidence of bullock characteristics increased with the use of TBA; however, differences were only statistically significant between T1 versus T3 and T4, and T2 versus T4. No significant differences were noted between treatment groups for carcass weight, skeletal maturity, marbling score, fat thickness, percent internal fat (KPH) and percent yield grade 4 carcasses. The mean percentage Choice carcasses was quite low for this trial (30.6%). The lowest numerical percentage (24.4%) was obtained for Treatment 4 carcasses, however differences were not consistent enough for statistical significance.

The primary difference noted between Trials 1 and 2 pertained to the higher percentage (39.6%) of choice carcasses (Table 4) in the latter trial. This difference can be attributed primarily to the more advanced marbling scores that were apparent in the Trial 2 carcasses. Control (T1) carcasses

Table 3. Least squares means for carcass grade traits of steers implanted with synovex or synovex and trenbolone acetate.

Item	Implant treatment[a]			
	1	2	3	4
Number of steers	72	75	73	71
Carcass weight, lb.	689	699	692	693
Skeletal maturity[b]	A55	A58	A59	A56
Lean maturity[b]	A40[f]	A41[fg]	A47[gh]	A51[h]
Color score[c]	6.1[f]	6.0[fg]	5.8[h]	5.9[gh]
Marbling score[d]	S175	S183	S174	S161
Fat thickness, in.	.48	.46	.49	.40
Ribeye area, sq.in.	13.1[g]	13.3[g]	13.4[fg]	13.9[f]
Kidney, pelvic & heart fat, %	1.5	1.4	1.4	1.4
Yield grade	2.6[g]	2.5[g]	2.4[g]	2.1[f]
Percent choice	33.4	31.9	32.5	24.4
Percent yield grade 4's	3.2	5.5	1.6	1.6
Bullock score[e]	4.7[f]	4.6[fg]	4.4[gh]	4.3[h]

[a]Implant treatments: 1 = Synovex on days 0 and 70; 2 = Synovex + TBA on day 0, Synovex only on day 70; 3 = Synovex only on day 0, Synovex + TBA on day 70; 4 = Synovex + TBA on days 0 and 70.
[b]All carcass maturity score means were within "A" (9 to 30 months of age).
[c]Color score: 6 = cherry-red; 5 = slightly dark red.
[d]Marbling score: S1 = a "slight" amount corresponding to U.S. Select.
[e]Bullock score: 5 = no evidence; 4 = slight "bullock" characteristics.
[fgh]Values in the same row with a common superscript are not (P>.05) different.

attained a higher (P<.05) percentage of Choice than the late TBA treatment groups (T3 and T4). In fact, this difference exceeded 20% between the control and late TBA groups. The price spread between choice and select carcasses was reported as $7.00 per hundred pounds on the day these carcasses were sold (September 21, 1988 USDA National Carlot Meat Report). Using the average carcass weight (683 lb) and the 20% fewer choice carcasses for the 150 head in Treatments 3 and 4 combined, this monetary loss would be $47.81 per carcass or $1,434 for the 30 fewer Choice carcasses realized for the late TBA groups (T3 and T4).

The incidence of bullock characteristics followed a similar trend as noted in Trial 1. No significant differences were noted for scores related to lean color and ribeye area in Trial 2.

Cooking properties and shear force values for the ribeye steaks subsampled from Trial 1 are reported in Table 5. No differences (P>.05) were observed for resistance to shear, cooking time, and cooking shrinkage between treatment groups.

Table 4. **Least squares means for carcass grade traits of steers implanted with compudose or compudose and trenbolone acetate.**

Item	Implant treatment[a]			
	1	2	3	4
Number of steers	75	78	73	77
Carcass weight, lb.	680	672	685	682
Skeletal maturity[b]	A42[f]	A53[g]	A42[f]	A45[f]
Lean maturity[b]	A38	A41	A41	A40
Color score[c]	6.1	6.1	6.0	6.0
Marbling score[d]	Sm04	Sm03	Sl87	Sl85
Fat thickness, in.	.46	.47	.45	.49
Ribeye area, sq.in.	12.7	12.7	13.1	12.8
Kidney, pelvic & heart fat, %	1.5	1.6	1.5	1.5
Yield grade	2.6	2.6	2.4	2.6
Percent choice	51.4[f]	45.4[fg]	30.5[g]	31.0[g]
Percent yield grade 4's	2.3	1.9	0.9	1.7
Bullock score[e]	4.6[fg]	4.6[f]	4.4[gh]	4.3[h]

[a]Implant treatments: 1 = Compudose only on day 0; 2 = Compudose + TBA on day 0; 3 = Compudose on day 0, TBA on day 70; 4 = Compudose + TBA on day 0 and TBA on day 70.
[b]All carcass maturity score means were within "A" (9 to 30 months of age).
[c]Color score: 6 = cherry-red; 5 = slightly dark red.
[d]Marbling score: Sm = a "small" amount corresponding to U.S. Choice; Sl = a "slight" amount corresponding to U.S. Select.
[e]Bullock score: 5 = no evidence; 4 = slight "bullock" characteristics.
[fgh]Values in the same row with a common superscript letter are not statistically (P>.05) different.

Table 5. **Least squares means for shear force values and cooking properties of ribeye steaks from steers implanted with synovex or synovex and trenbolone acetate.**

Item	Implant treatment[a]			
	1	2	3	4
Number of steaks	59	60	58	59
Shear force, lb.	10.3[c]	10.0	10.4	10.6
Tough steaks, %[b]	34.7	21.8	30.1	43.9
Cooking time, min.	28.7	28.0	27.8	28.7
Cooking shrinkage, %	32.8	31.5	31.7	31.9

[a]Implant treatments: 1 = Synovex on days 0 and 70; 2 = Synovex + TBA on day 0, Synovex only on day 70; 3 = Synovex only on day 0, Synovex + TBA on day 70; 4 = Synovex + TBA on days 0 and 70.
[b]Percentage of steaks with shear force values of 11.0 pounds or higher.
[c]All comparisons were nonsignificant (P>.05).

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EFFECTS OF TIME-ON-FEED ON CARCASS GRADE TRAITS, POSTMORTEM MUSCLE CHARACTERISTICS AND BEEF PALATABILITY

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Story in Brief

Forty-eight Angus x Hereford steers with similar frame size and muscle thickness were fed a high concentrate diet and serially slaughtered at 28-day intervals over a 196-day finishing period, except for the 0-day group which served as a grass-fed control. Upon slaughter, a randomly selected side of each carcass was trimmed of subcutaneous fat in the wholesale rib region. Postmortem ribeye temperature was monitored for each side over a 24 hour chilling period. Following quality and yield grade data collection, rib steaks were removed, aged for seven days and sensory traits were evaluated. Most carcass grade traits increased linearly while most sensory panel variables and marbling increased curvilinearly with increased days-fed. As time-on-feed increased from 0 to 84 days, tenderness improved ; however, once steers were fed a minimum of 84 days there was little improvement in tenderness. Postmortem muscle temperature at 2.5 hours was the variable most highly correlated with tenderness. Simple correlation coefficients for shear force with 2.5-hour ribeye temperature, marbling score, days-fed, fat thickness and carcass weight were -.63, -.61 -.56, -.55 and -.53, respectively. Sides trimmed of subcutaneous fat chilled more rapidly, had lower 2.5-hour ribeye temperatures, shorter sarcomeres and lower sensory tenderness ratings than untrimmed sides. Path coefficient analysis revealed that ribeye temperature at 2.5 hours accounts for the most variation in shear force values.

(Key Words: Carcass Traits, Postmortem Temperature, Time-on-feed, Palatability.)

Introduction

Due to an expanding health conscious society, current consumer trends have shifted toward the consumption of leaner beef products. However, at

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the same time, a certain segment of the population does not desire to sacrifice eating quality (Savell et al., 1987). Therefore, the ability to accurately predict beef palatability is of utmost concern and crucial for the assurance of consumer satisfaction.

Several carcass, production and postmortem muscle characteristics have been associated with the enhancement and possible prediction of beef palatability. Time-on-feed, subcutaneous fat thickness, early postmortem muscle temperature and pH are traits which have been closely associated with beef palatability, particularly tenderness.

While these selected traits have been examined singularly, few attempts have been made to examine the interrelationships between these traits. Accordingly, this study was conducted to examine the interrelationships between time-on-feed, carcass weight, subcutaneous fat thickness, marbling score and beef palatability, as well as the effects of postmortem temperature and pH on ribeye muscle tenderness.

Materials and Methods

Forty-eight Angus x Hereford steers, approximately 16 months of age with similar frame size (medium) and muscle thickness (No.1) were obtained from a native range stocker operation in northwestern Oklahoma. In order to more specifically address the objectives of this study, care was taken to control age, breed and environmental background. After an initial 24-hour shrink, individual live weights were obtained and the steers were blocked by weight into eight groups to be serially slaughtered at 28-day intervals (0 through 196 days). All steers were dewormed, implanted with Compudose and fed a high concentrate finishing diet (87.5% dry matter, 83.8 Mcal/kg NEm, 54.1 Mcal/kg NEg) except for the 0-day slaughter period which served as a grass-fed control. At the end of each feeding period, a live weight was obtained for each steer and a 4% shrink was deducted to determine shrunk live weight.

All steers were conventionally slaughtered at the Oklahoma State University Meat Laboratory. Within 30 minutes postmortem, one randomly assigned side of each carcass was trimmed of subcutaneous fat over the wholesale rib region (5th to 13th ribs) with an equal number of left and right sides trimmed per slaughter period. During chilling (33°F), ribeye muscle temperature was monitored intermittently for 24 hours with probes inserted into the medial portion immediately anterior to the ninth rib. Approximately 24-hours postmortem, ribeye muscle pH was obtained and three experienced evaluators scored or measured the traits utilized in determining USDA quality and yield grades (USDA, 1980). However, only the control sides were utilized to calculate the quality and yield grades.

The wholesale rib was fabricated and the ribeye roll (IMPS 112) was removed for organoleptic and histological analysis. After a 7 day aging period, two 1.0 inch thick steaks corresponding to the eighth and ninth ribs were fabricated, vacuum packaged, and frozen at -22°F for subsequent taste panel and Instron shear force determinations. Upon completion of the slaughter phase of the study, the steaks were thawed for 24 hours in a 40°F cooler and broiled to 158°F (medium degree of doneness) on Farberware Open-Hearth broilers. An eight-member sensory panel, trained according to American Meat Science Association guidelines for cooking and sensory evaluation of meat (AMSA, 1978), evaluated the ninth rib steak samples for juiciness, tenderness, ease of fragmentation, flavor intensity, and connective tissue amount utilizing eight-point descriptive scales. Instron shear force determination for each eighth rib steak was performed on six .5 inch cores, which were removed after the cooked steaks had cooled to room temperature. A 1.0 inch steak corresponding to the seventh rib was utilized for sarcomere length determination.

Data were analyzed by a split plot analysis of variance. Orthogonal polynomials were used for each treatment (n=48), as well as for the pooled, right and left side data (n=96). Means were separated by Tukey's procedure (Steel and Torrie, 1980). Path coefficients (standard partial regression coefficients) were computed to allow direct comparisons of traits that interrelate (Wright, 1934) to influence tenderness.

Results and Discussion

Performance traits

Slaughter weight and dressing percentage generally increased ($P<.05$) across days-fed (Table 1). Growth rate did not ($P>.05$) differ between the

Table 1. Mean values for performance traits across days-fed.

Days-fed	n	Slaughter weight, lb.	Dressing percentage,%	Cumulative average daily gain,lb.
0	6	762.6[g]	56.8[c]	
28	6	949.3[f]	57.3[c]	5.14[a]
56	6	991.6[ef]	61.1[b]	3.35[b]
84	6	1104.9[de]	61.6[b]	3.51[b]
112	6	1163.4[cd]	64.6[a]	3.22[b]
140	6	1250.0[bc]	64.8[a]	3.09[b]
168	6	1295.0[b]	64.6[a]	2.80[b]
196	6	1429.9[a]	67.0[a]	3.11[b]

[a,b,c,d,e,f,g]Means in the same column that do not have a common superscript letter differ ($P<.05$).

slaughter groups, except for 28 day slaughter group. The steers in the 28-day group may have experienced a compensatory response as a result of being placed on the grain-based diet.

Carcass characteristics

Extending the time cattle receive a high concentrate diet increases subcutaneous fat thickness, yield grade and marbling score. Carcass weight, as well as most weight related traits (fat thickness, longissimus muscle area, and yield grade), increased linearly ($P<.01$) with increased days-fed (Table 2); however, all maturity scores for the individual slaughter periods remained well within "A" maturity. Marbling score and kidney, pelvic, and heart fat percentage showed quadratic trends ($P<.05$), across days-fed and means for these traits did not increase ($P>.05$) after intensive feeding for 112 days. The carcasses from steers fed 112 days were the first to attain the mean marbling score (Small) required for choice quality.

Palatability Attributes

Juiciness and flavor intensity were not significantly influenced by extending the feeding of high concentrates (Table 3). However, feeding the high concentrate diet for 0 through 84-days improved taste panel tenderness scores. Shear force and ease of fragmentation showed little ($P>.05$) improvement after 56 days. Tatum et al. (1980) and Dolezal et al. (1982a) concluded that extending the feeding period beyond 100 days will not substantially improve sensory tenderness. However, it is important to note that both studies utilized a variety of breeds which may partially explain the extended feeding time.

Dolezal et al. (1982b) and Riley et al. (1983) found a close association between subcutaneous fat thickness and palatability. The researchers noted little improvement in palatability once cattle had reached at least .3 inches of subcutaneous fat at the 12th rib. Similar results were obtained in the present study where the steers attained .3 inches between the 56 and 84 day slaughter periods.

Marbling was moderately related to taste panel tenderness ($r=.51$) and shear force ($r=.61$) in Angus x Hereford steers. In addition, marbling was the carcass grade trait most highly correlated with the palatability attributes. In fact, juiciness and flavor intensity were only associated ($P<.05$) with carcass traits related to fatness.

Taste panel tenderness, amount of perceived connective tissue, and shear force values were less desirable ($P<.05$) for the 196 day slaughter period than the 112 day slaughter period. This decrease in sensory values

Table 2. **Mean values for carcass characteristics across days-fed.**

Days-fed	Maturity score^{a}	Marbling score^{b}	Fat thickness,in.	Ribeye, sq.in.	Carcass weight,lb.	Kidney,heart & pelvic fat,%	Yield grade
0	137.2^{d}	254.2^{g}	0.12^{f}	9.81^{f}	433.4^{h}	1.0^{f}	1.4^{g}
28	133.0^{d}	299.0^{fg}	0.16^{f}	10.82^{ef}	521.8^{gh}	1.3^{ef}	1.7^{fg}
56	139.0^{d}	336.0^{efg}	0.27^{ef}	12.19^{de}	581.4^{fg}	1.5^{e}	1.7^{fg}
84	147.0^{cd}	372.8^{def}	0.39^{e}	11.83^{de}	652.1^{gef}	1.8^{de}	2.4^{ef}
112	156.7^{c}	472.2^{c}	0.57^{d}	12.84^{cd}	721.3^{de}	2.1^{cd}	2.9^{e}
140	158.0^{c}	428.3^{cde}	0.59^{d}	13.29^{cd}	778.2^{d}	2.4^{c}	3.2^{de}
168	156.5^{c}	471.7^{c}	0.72^{cd}	13.10^{cd}	804.0^{d}	2.3^{c}	3.7^{cd}
196	161.8^{c}	464.2^{cd}	0.83^{c}	14.45^{c}	920.2^{c}	2.2^{cd}	4.0^{c}

^{a}Maturity score: A=100-199.

^{b}Marbling score: small=400-499; slight=300-399; traces=200-299.

^{c,d,e,f,g,h}Means in the same column that do not have a common superscript letter differ (P<.05).

Table 3. Mean values for palatability traits.[a]

Item	Juiciness	Ease of fragmentation	Connective tissue	Flavor intensity	Tenderness	Shear force, lb.
Days-fed						
0	4.74	3.66^{f}	5.02^{e}	4.61	3.52^{d}	18.14^{e}
28	4.95	4.46^{ef}	5.51^{de}	4.93	4.20^{d}	14.73^{d}
56	4.96	5.59^{bcd}	6.12^{bcd}	4.83	5.34^{c}	11.16^{bc}
84	5.13	6.11^{bcd}	6.43^{bc}	4.81	5.88^{bc}	9.63^{bc}
112	5.49	6.41^{b}	6.66^{b}	5.04	6.36^{b}	8.40^{b}
140	4.86	5.48^{cd}	6.02^{bcd}	5.03	6.36^{b}	9.39^{bc}
168	5.46	6.39^{bc}	6.34^{bc}	5.03	6.36^{b}	9.39^{bc}
196	4.81	5.27^{de}	5.84^{cd}	4.98	5.33^{c}	11.86^{cd}
Treatment						
Control	5.09	5.65^{b}	6.14^{b}	4.94	5.59^{b}	11.38
Trimmed	5.02	5.19^{c}	5.84^{c}	4.85	5.04^{c}	11.99

[a]Juiciness: 1=extremely dry to 8=extremely juicy; ease of fragmentation; 1=extremely difficult to fragment 8=extremely easy; flavor intensity; 1=extremely bland to 8=extremely intense; amount of connective tissue: 1=abundant to 8=none; tenderness 1=extremely tough to 8=extremely tender.

[bcdef]Means in the same column and within the same item that do not have a common superscript letter differ ($P<.05$).

may be related to carcass maturity. Zinn et al. (1970), utilizing Hereford cattle, indicated that maturity may influence tenderness in cattle fed longer than 180 days. Conversely, others have shown no apparent detrimental effects in extending the feeding period beyond 200 days (Bidner et al., 1981; Dolezal et al., 1982a). However, important cattle age/weight differences at the onset of feeding must be considered when comparing studies.

Postmortem Muscle Characteristics

The 24 hour pH tended to be higher for the steers within the early slaughter groups (Table 4). Carcasses from the 0-day steers had higher ($P<.05$) 24 hour pH values than carcasses from steers fed a high-energy diet for a minimum of 84 days. Bowling et al. (1977) indicated that grass-fed steers had higher ultimate pH values than grain-fed steers and suggested that grass-fed cattle tend to be more susceptible to pre-slaughter stress, which could result in higher pH values.

The rate of temperature decline among time-based slaughter groups for days-fed are illustrated in Figure 1. The mean longissimus muscle temperature at .5 hour postmortem (the initial measurement) did not differ ($P>.05$) among days-fed groups. Steers in the early slaughter periods (0-56 days) chilled at similar rates ($P>.05$). The overall trend reflected that carcasses from steers fed for longer periods of time tended to chill more slowly than carcasses from steers in the earlier slaughter periods. These results imply that carcass fatness and mass altered the chilling rate between slaughter groups.

Simple correlation coefficients indicated a high positive correlation between 2.5 hour postmortem longissimus muscle temperature and carcass

Table 4. Mean values for postmortem muscle characteristics.

Item	Temperature at 2.5 hours, °F	24 hour pH	Sarcomere length, μm
Days-fed			
0	78.4^{f}	5.78^{a}	1.73^{c}
28	82.8^{e}	5.71^{ab}	1.89^{a}
56	86.4^{cd}	5.75^{ab}	1.87^{ab}
84	89.4^{cd}	5.69^{bc}	1.91^{a}
112	93.7^{b}	5.61^{c}	1.80^{bc}
140	92.7^{bc}	5.52^{d}	1.84^{ab}
168	92.8^{bc}	5.53^{d}	1.85^{ab}
196	98.2^{a}	5.53^{d}	1.91^{a}
Treatment			
Control	91.4^{a}	5.61^{b}	1.87^{a}
Trimmed	87.1^{b}	5.67^{a}	1.83^{b}

a,b,c,d,e,f Means in the same column that do not have a common superscript letter differ ($P<.05$).

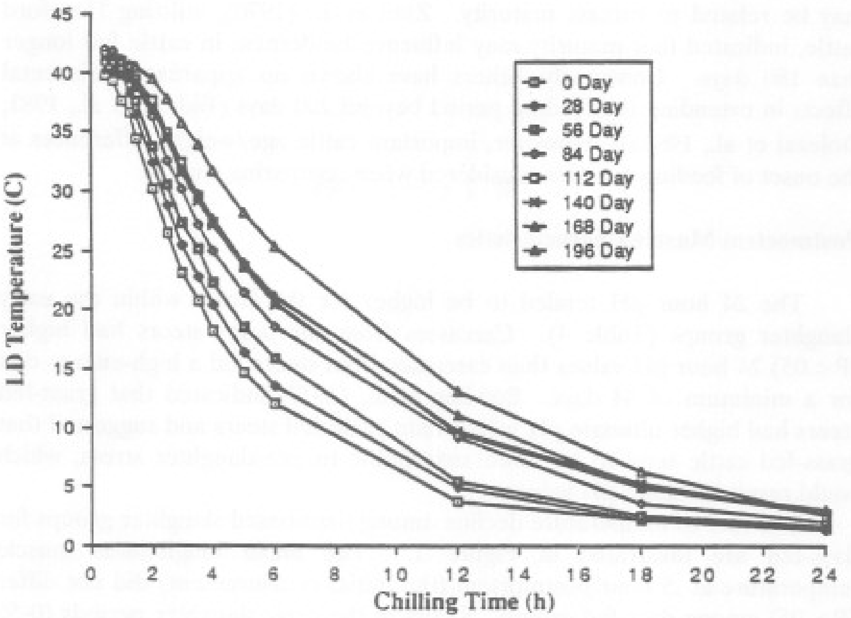

Figure 1. Longissimus muscle temperature for pooled treatment groups versus chilling time across days-fed.

weight, fat thickness and days-fed (.86, .80, .86, respectively). The 2.5 hour temperature was the trait most highly correlated with tenderness and days-fed (.54 and .86, respectively). This is in agreement with Lochner et al. (1980) in which the authors concluded that muscle temperature was most highly correlated with tenderness very early postmortem (2-4 hours). Taste panel tenderness and 2.5 hour longissimus muscle temperature follow similar trends through the 168 day slaughter period.

Few differences existed between slaughter periods for sarcomere length. However, sarcomeres measured for carcasses from the 0-day steers were shorter ($P < .05$) than all other slaughter groups, except for the 112-day group (Table 4). The lack of finish and light carcass weight may have contributed to the shortening of the sarcomeres in the 0-day cattle. Lee and Ashmore (1985) suggested that cold induced toughening is primarily a factor only in rapid chilled, light weight carcasses and has little effect in well finished beef carcasses. Sarcomere length was not significantly related to taste panel tenderness and possessed a low correlation coefficient with shear force.

Treatment Effects

Trimming of subcutaneous fat over the wholesale rib section was conducted to examine the effect of fat thickness, independent of production and carcass characteristics, on postmortem muscle traits and palatability attributes. Marbling score was not significantly different between control (Slight 87) and trimmed (Slight 94) sides. However, the control sides did have larger ($P<.05$) ribeye areas than trimmed sides (12.3 versus 11.9 sq in, respectively). Possibly, natural physical restraints on the ribeye muscle may have been severed due to the removal of the subcutaneous fat on the trimmed sides or the changes may have resulted from dehydration. Trimmed sides chilled at a faster rate ($P<.05$) than control sides (Figure 2), exemplifying the insulatory effect of subcutaneous fat. Also, temperature at 2.5 h for control sides was higher ($P<.05$) than for trimmed sides.

Sensory evaluation revealed that juiciness and flavor intensity were not ($P<.05$) affected by the trimming of subcutaneous fat (Table 3). However, steaks from the trimmed sides were less tender ($P<.05$) and more difficult to fragment ($P<.05$) than the steaks from the control sides. The latter indicates muscle temperature was playing a role in tenderness determination.

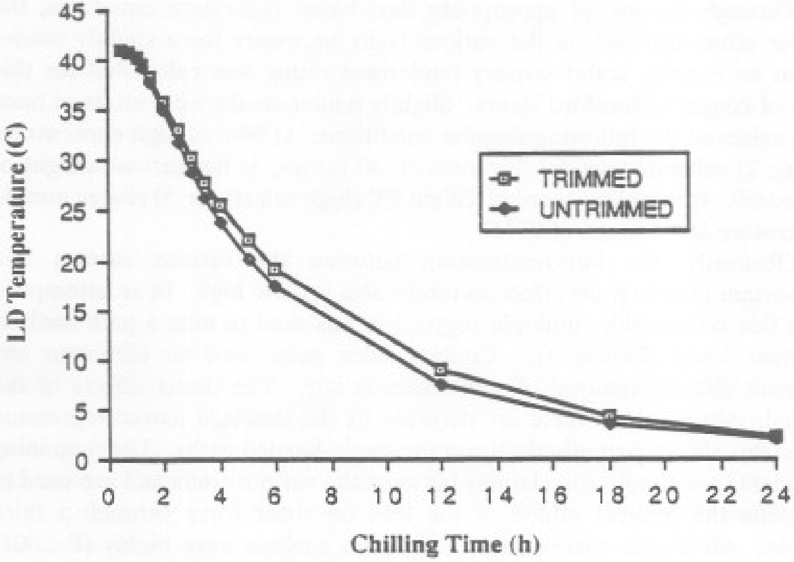

Figure 2. Longissimus muscle temperature for the treatment groups.

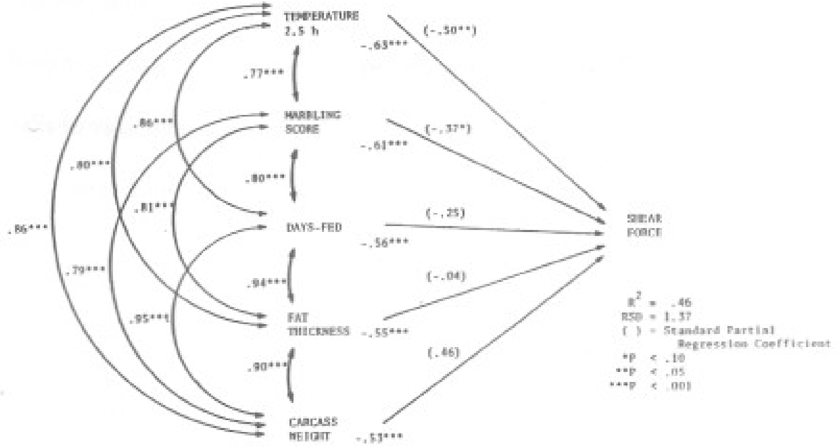

Figure 3. Path coefficient diagram for selected constituents of shear force.

The selected traits in the path analysis accounted for 46% of the variation in shear force. Temperature at 2.5 h had the greatest ($P<.05$) direct effect on shear force. Consequently, indirect paths for other variables had the greatest impact on shear force when routed through 2.5 hour temperature. Magnitudinal order of secondary paths (indirect) involved carcass weight (2nd), marbling score (3rd), and fat thickness (4th).

The results of the study indicated that with increased days on a high concentrate diet, steaks from Angus x Hereford steers markedly improved in tenderness (through 84 days). In addition, early postmortem temperature, fat thickness, carcass weight, and marbling score were associated with improved tenderness values. Among the carcass grade traits, marbling was most highly related to tenderness. The relationship between marbling score and tenderness is undoubtedly represented well in this study through the use of Angus x Hereford steers, a crossbreed known for their ability to marble.

Time-on-feed and the carcass grade traits appear to affect tenderness by delaying carcass chilling rate and enhancing early postmortem muscle temperature. Ribeye muscle temperature at 2.5 hours postmortem had the greatest direct and indirect impact on tenderness.

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EVALUATION OF ULTRASOUND FOR PREDICTION OF CARCASS FAT THICKNESS AND RIBEYE AREA IN FEEDLOT STEERS

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Story in Brief

Three hundred fifteen yearling beef steers were ultrasonically measured for backfat thickness and ribeye area. Live animal ultrasound measurements were then compared to actual carcass measurements to determine the accuracy of these values. Estimates of backfat thickness were within one-tenth of an inch of actual 75% of the time and ribeye area was predicted within one square inch 37% of the time. Fat thickness was underestimated on fatter cattle and ribeye area was underpredicted on heavier muscled steers. These results suggest that ultrasonic measurements of backfat are quite accurate in determining carcass fat thickness, but ribeye area estimates are imprecise.

(Key Words: Ultrasound, Carcass Measurements, Feedlot Steers.)

Introduction

Before the beef industry moves to a value-based marketing system, a means of accurately identifying individuals with superior performance and carcass traits is required. Recent research suggests that ultrasound technology may be beneficial in quantifying these traits of interest. Ultrasound involves transmitting high frequency sound waves through the hide of the live animal. These sound waves are reflected at varying rates due to differences in density among the primary tissue types (bone, muscle, fat). Estimates of backfat and ribeye area of the live animal are then determined from the cross-sectional image that is produced. The ability of ultrasound to accurately estimate carcass parameters in live animals is important because it would facilitate the development of genetic values for carcass traits for the seedstock producer and aid in sorting for optimal endpoints for the feedlot

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operator. Accuracy appears to be technician dependent and varies considerably. Correlations of live and carcass ultrasonic measurements for back fat and ribeye area have been reported from .42 to .92 and .47 to .86, respectively (Houghton, 1988). Therefore, the objective of this study was to evaluate ultrasonic measurements of backfat and ribeye area taken prior to slaughter for prediction of actual carcass values.

Materials and Methods

The 315 yearling steers used in this experiment were part of a feeding trial conducted to determine the effect of virginiamycin, a feed-grade antibiotic, on performance and carcass characteristics of feedlot steers (Smith et al., 1989). Steers were slaughtered in two groups. The first group (Kill 1) were fed a total of 135 days, while the second group (Kill 2) were fed 149 days. Five days prior to slaughter, steers were scanned using an Aloka 210DX ultrasound unit equipped with a 3 megahertz transducer. The images produced were recorded on video tape and later viewed to determine carcass backfat (USBF) and ribeye area (USREA) estimates. Carcass backfat (BF) and ribeye area were measured at the 12th and 13th rib interface 24 hours post mortem. Carcass ribeye area was determined using a standard dot grid (GREA) for both kill groups. In addition, acetate tracings (TREA) of the longissimus dorsi muscle were obtained from carcasses of Kill 1 steers. An electronic digitizing board was used to determine the area of these tracings. Means and standard deviations for parameters of interest in this study are presented in Table 1.

For purpose of analysis, ultrasonic ribeye area estimates were multiplied by two correction factors so that the mean ribeye area predictions were equal to observed means as determined by either grid (GREA) or tracing (TREA). Ribeye area was also predicted as a function of shrunk final weight (BWREA) using linear regression.

Table 1. Description of steer data used for analysis.

Parameter	n	Mean	Standard deviation
Initial weight, lb	315	690.3	54.6
Final weight, lb	315	1063.0	79.8
Carcass weight, lb	315	729.8	55.5
Backfat, in	315	.54	.18
GREA[a], in^2	315	12.15	1.25
TREA[b], in^2	200	12.62	1.28

[a]Ribeye area using a standard dot grid.
[b]Ribeye area digitized from acetate tracings.

Results and Discussion

Simple correlations (r) between predicted (USBF, USREA, BWREA) and observed values (BF, GREA, TREA) are presented in Table 2. Ultrasonic estimates of backfat were highly correlated with actual values (r=.81) and appear to be accurate predictors of carcass backfat thickness. The relationship between predicted and observed ribeye area, however, was moderate to low depending upon method of determining actual values (r=.43, GREA; r=.20, TREA). Improper placement of the transducer by the technician, poor image resolution or inaccurate interpretation of the image produced may explain these low values. Changes in muscle configuration during processing and onset of rigor mortis may also affect ribeye area and thus accuracy of ultrasonic estimates. Interestingly, ribeye area predicted from final weight showed a stronger relationship to actual values than did ultrasonic estimates (r=.54, GREA; r=.47, TREA).

Due to differences in backfat thickness and ribeye area configuration that exist between the standing animal and the hanging carcass, many argue that precision of ultrasound estimates should be determined by assessing the relative frequency in which estimates are within a given range of actual carcass parameters. In this study, ultrasonic backfat thickness was estimated within one-tenth of an inch 75 percent of the time and within two-tenths of an inch 92 percent of the time (Table 3). Steers with actual fat thickness less

Table 2. Correlations of predicted and observed BF and REA[a].

	BF	USBF	GREA	TREA	USREA	BWREA
BF	1.00	.81	-.17	-.14	.09	.21
USBF		1.00	-.07	-.05	.13	.23
GREA			1.00	.89	.43	.54
TREA				1.00	.20	.47
USREA					1.00	.42
BWREA						1.00

[a]See text for explanation of symbols.

Table 3. Cumulative frequency distribution (%) of ultrasound carcass backfat measurement error.

Range of absolute residual, in	All data	Actual backfat, in <.5	Actual backfat, in >.5
<.05	48	56	42
<.10	75	82	68
<.20	92	98	88
<.30	99	100	99
<.40	100	100	100

than .5 inches were estimated within one-tenth of an inch 82 percent of the time compared to 68 percent for those with actual fat thickness greater than .5 inches. Ultrasonic ribeye area estimates (GREA) were within one square inch 37 percent of the time compared to 59 percent for estimates of ribeye area as determined by weight of the animal (Table 4).

To illustrate the relative accuracy of ultrasonic measurements, residuals (predicted minus observed values) were plotted against actual measurements of carcass backfat and ribeye area. As shown in Figure 1, there is a tendency to underpredict backfat thickness on fatter cattle. This is most likely due to misinterpretation of fat layers that normally develop as an animal increases in fatness. Ribeye area is generally overpredicted for carcasses with actual longissimus muscle areas of less than 11 square inches and is underpredicted for carcasses with actual ribeye areas over 13 square inches (Figure 2).

Results of this study demonstrate that ultrasonic measurements made prior to slaughter are accurate for estimating carcass backfat thickness, yet imprecise in predicting ribeye area. In fact, predicting ribeye area as a function of live weight proved more accurate than ultrasound estimates. While ultrasonic measurements of backfat appear useful in estimating composition of growth and possibly preliminary yield grade of feedlot steers prior to slaughter, they are of little use in determining quality grade. This is due to the relatively low correlation between backfat and marbling (r=.16) observed in this study. These results question the use of ultrasound in determining differences in longissimus muscle area in feedlot steers and suggest caution in making breeding or management decisions from ribeye area estimates generated from this technology.

Table 4. Cumulative frequency distribution (%) of carcass ribeye area measurement error[a].

Range of absolute residual, square in	Comparison		
	USREA and TREA	USREA and GREA	BWREA and GREA
< .25	8	8	15
< .50	17	18	31
< .75	27	28	44
<1.00	36	37	59
<1.50	50	48	79
<2.00	62	60	90
<3.00	83	84	100
<5.00	95	98	100

[a]See text for explanation of symbols.

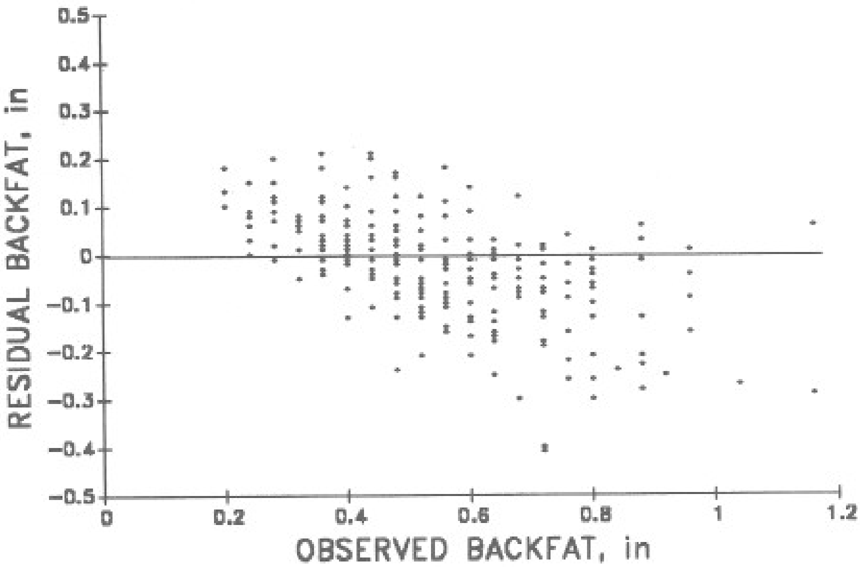

Figure 1. The relationship of residual (ultrasonically predicted minus observed) backfat and observed backfat of feedlot steers.

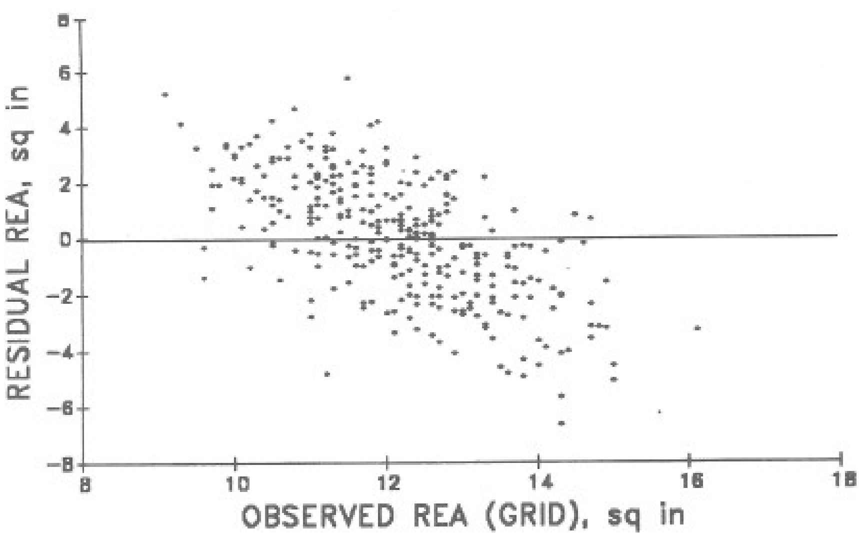

Figure 2. The relationship of residual (ultrasonically predicted minus observed) ribeye area and observed ribeye area of feedlot steers.

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GROWTH, CARCASS, CHEMICAL AND PALATABILITY TRAITS OF CROSSBRED STEERS MANAGED FOR ACCELERATED BEEF PRODUCTION

Tom Sturgeon[1], J.R. Kropp[2], D.S. Buchanan[2], H.G. Dolezal[3] and F.K. Ray[3]

Story in Brief

Forty-one steers representing seven different breed types (purebred Angus, Brahman crossbreds, Charolais-sired crossbreds, purebred Herefords, Limousin-sired crossbreds, Simmental-sired crossbreds and Angus x Hereford) were weaned, transported to a commercial feedlot and finished under normal feedlot conditions. Steers were slaughtered when 60% of a particular breed type was estimated to grade low choice; however, the maximum feeding period was deemed to be 180 days regardless of grading potential. Carcass data were collected as well as 9-10-11th rib composition, taste panel evaluation, shear force and cholesterol content. The Charolais-sired and Simmental-sired crossbreds were frame 6 while all other breed types were frame 4 upon entrance to the feedlot. Charolais-sired, Limousin-sired and Simmental-sired calves were leaner, heavier muscled and higher cutability cattle. Angus, Angus x Hereford and Hereford steers had higher USDA quality grades, but were appreciably fatter with lower cutability. The Brahman crossbreds had low quality grades and low cutability scores as well. Rib composition was related to USDA quality and yield grade with respect to lean and fat. Taste panel evaluations indicated no practical difference among breed groups with all ratings well within the acceptable range. Shear force values did not correspond with expected tenderness projections based upon quality grades.

(Key Words: Feedlot Calves, Accelerated Production, Carcass Traits, Beef Palatability.)

Introduction

Through the years, beef production management systems have changed due to advanced technology, economics, consumer demands, as well as

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changes in cattle type and the influence of new breeds. Our traditional beef production system has been geared to produce choice beef from almost any size, shape and description of steer or heifer. The typical beef management system has been to wean 7- to 8-month old calves weighing 350 to 450 lb, pasture the cattle on largely a forage diet until they reach 600 to 700 lb, then finish the cattle in a feedlot on high grain rations until they reach an apparent choice quality grade, usually at approximately 1000 to 1200 lb live weight. Total production efficiency can be greatly enhanced by increasing the efficiency of the post-weaning growth phase. Placing steers directly into the feedlot after weaning, thereby eliminating the stocker phase, may increase the total production efficiency of the beef system. However, cattle in an accelerated beef production system are much younger at slaughter and consequently do not typically deposit sufficient intramuscular fat to meet the minimum specifications for the choice quality grade under current grading standards. Marbling, currently the principal criterion used in the quality grading standards among feedlot cattle, is positively related to flavor, juiciness and tenderness. However, marbling has been shown to be of less value in segmenting lean, youthful carcasses for palatability. Previous research has indicated that days on feed and/or subcutaneous fat thickness could be used as alternatives to the present quality grading system for predicting beef palatability. Feeding younger cattle in accelerated production systems may require alternative methods of marketing and subsequent value determinations to offset the pricing discounts of select (slight marbling) beef.

The objectives of this study were to compare the growth, carcass, chemical and palatability traits of differing crossbred steer groups of known history managed for accelerated beef production.

Materials and Methods

Forty-one steers representing seven different breed types were selected from the Oklahoma State University Cooperative Extension Steer Feedout Program. Breed types represented were Angus, Brahman crossbreds, Charolais-sired crossbreds, Hereford, Limousin-sired crossbreds, Simmental-sired crossbreds and Angus x Hereford. Six steers from each breed type were evaluated except for the Brahman crossbred group which contained only five steers.

At approximately three weeks post-weaning, the steers were placed in a commercial feedlot (November 12, 1986). The average age of the steers at this time was 252 days with a range of 226 to 294 days. All steers were dewormed, treated for lice and brubs, vaccinated for IBR, EVD, PI_3, 4 way Blackleg and leptocpirosis and implanted with 36 mg of zeranol. A second implant was administered at mid test (approximately 75 days).

Four rations, ranging from approximately 50% to 90% concentrate, were used during the feeding period (Table 1). The goal of the feeding strategy was to adjust the steers to the high concentrate ration as quickly as possible while minimizing digestive problems. Steers were fed ad libitum in bunk line feeders and managed under normal feedlot conditions.

All steers were individually weighed and measured for hip height at the beginning of the feeding period. A second weight was obtained at 14 days to equalize pre-delivery management effects. Check weights were obtained on all steers on day 78 of the feeding period. Final weights were obtained on Angus, Brahman crossbred, Hereford and Angus x Hereford steers on day 162 while Charolais-sired, Limousin-sired and Simmental-sired crossbred steers were weighed off test on day 176 of the feeding period. All weights reported are actual weights with no shrink.

The intent was to slaughter the steer groups when it was estimated that 60% of the cattle should grade low choice (.5 inches fat at the 12th rib); however, the maximum feeding period was deemed 180 days regardless of grading potential.

All steers were transported to a commercial packing plant and slaughtered under normal procedures. Hot carcass weights were obtained at the time of slaughter. Additional carcass data were obtained 48 hours postmortem. Adjusted fat thickness, ribeye area and kidney, heart and pelvic fat percentage were obtained and used to calculate yield grade. Forty-eight hour marbling scores, quality grade, skeletal maturity, lean maturity and overall maturity scores were also assigned to individual carcasses. Distribution and texture scores were given for marbling; color, firmness and texture scores were appraised for the longissmus muscle. The left side of each carcass was used for compositional and sensory data.

Sixth through the twelfth wholesale ribs (IMPS 103) were removed from each carcass, vacuum packaged and transported to Oklahoma State University Meats Laboratory for further analysis. In addition, a .25 inch slice of each ribeye was removed, frozen, packed in dry ice and shipped to the Texas A & M University Meat and Muscle Biology Laboratory for cholesterol analysis.

Table 1. Feedlot rations nutrient composition

Ration numbers	1	2	3	4
Days fed	1-7	8-15	16-23	24-finish
% Concentrate	50	65	80	90
Mcal/cwt	74	80	85	90
NEm, NEg, Mcal/cwt	45	50	55	60
% Crude protein	12.0	11.0	10.0	9.50
% Calcium	.73	.63	.57	.53
% Phosphorus	.36	.29	.28	.24

At the Oklahoma State University Meats Laboratory, 9-10-11th rib sections were removed from the IMPS 103 rib. Physical separation of the 9-10-11th rib involved subcutaneous fat, seam fat, muscle, other soft tissue, and bone plus ligamentum nuchea removal. Chemical analysis of the soft tissue as well as .25 inch slice of the longissimus muscle was conducted. Ether extractable lipid and moisture determinations for each sample were obtained and used in conjunction with the physically separated components to determine the percentages of subcutaneous, intermuscular and intramuscular fat, as well as percentage of fat-free muscle, and bone for the 9-10-11th rib cuts.

Two 1.0 inch thick steaks were obtained from the longissimus muscle starting at the 12th rib end, vacuum packaged and frozen (-22°F) for subsequent taste panel evaluation and Instron shear tests. Each pair of steaks was removed from the freezer, thawed (36°F) and broiled on Farberware Open-Hearth broilers to an internal temperature of 158°F. Samples of one cooked steak were evaluated by a six member, trained sensory panel. Panelists individually scored samples from each steak for juiciness, ease of fragmentation, amount of connective tissue, overall tenderness, flavor intensity and off-flavor using eight-point, descriptive rating scales (8= extremely juicy, etc.). The second steak from each rib cut was cooled to 77°F and six .5 inch cores were removed parallel to the longitudinal orientation of the muscle fibers, for Instron shear force measurements. An average shear force value based on a minimum of six cores was recorded for each steak.

Results and Discussion

Growth Traits

Charolais-sired and Simmental-sired crossbred calves were larger framed than the other breed types upon entrance to the feedlot (Table 2). All other breed types had an average frame score of 4, suggesting that they should weigh 1050 - 1150 lb when they reach approximately .5 in of fat thickness over the rib.

During the 14 day warm-up period, the Brahman crossbred steers gained 5.5 lbs per day. The Charolais-sired and Simmental-sired crossbred calves were freshly weaned and transported to the feedlot; therefore, they lost weight.

Average daily gain performance among all breed types exceeded 3.0 lb per day during the 148-day test.

Angus, Brahman crossbred, Hereford and Angus x Hereford steers were perceived to have reached adequate fat deposition to slaughter after 148

Table 2. Least squares means for growth traits.

Trait	Breed group						
	A[a]	B	C	H	L	S	AXH
Hip ht(in)	44.4[bc]	45.2[cd]	47.8[e]	44.2[b]	45.5[d]	46.1[d]	44.0[b]
Frame score	4.1[b]	4.2[b]	6.0[d]	4.0[b]	4.8[c]	5.7[d]	3.9[b]
In wt (lb)	637[d]	571[b]	700[e]	576[b]	593[bc]	573[b]	621[cd]
14d wt (lb)	654[d]	648[d]	668[cd]	614[c]	634[cd]	560[b]	693[e]
ADG1 (lb/d)	1.2[c]	5.5[d]	-2.3[b]	2.7[c]	2.9[c]	-0.9[b]	5.1[d]
162d Wt (lb)	1137[b]	1102[b]	1194[cd]	1147[bc]	1113[b]	1113[b]	1217[d]
ADG for 148 day	3.2[b]	3.1[b]	3.5[c]	3.6[c]	3.2[b]	3.7[c]	3.5[c]
176d Wt (lb)			1220[c]		1136[b]	1155[bc]	
ADG for 162 day			3.4[bc]		3.1[b]	3.7[c]	

[a]A = Angus, B = Brahman crossbreds, C = Charolais-sired crossbreds, H = Hereford, L = Limousin-sired crossbreds, S = Simmental-sired crossbreds and AXH = Angus x Hereford.
[b,c,d,e]Means on the same row bearing a common superscript are not different (P>.05).

days on test. The Continental crossbred steers were somewhat leaner and were fed an additional 14 days prior to slaughter to increase their external fat deposition and possibly enhance their probability of attaining the choice quality grade.

All cattle attained acceptable live weights prior to slaughter. A potential problem might exist if the smaller framed cattle finished too quickly, especially since they were placed into the feedlot upon weaning. However, all cattle produced carcasses in the 600 to 800 lb desirable weight range requested by the packing and retailing industry (Table 3).

Carcass Traits

Charolais-sired, Limousin-sired and Simmental-sired crossbred calves were leaner, heavier muscled and higher cutability cattle as compared to

Table. 3 Least squares means for carcass traits

Trait	Breed group						
	A[a]	B	C	H	L	S	AXH
Dressing %	61.5[d]	61.0[cd]	63.7[e]	60.2[cd]	64.5[e]	61.2[d]	59.3[c]
Hot carcass wt (lb)	698[cde]	671[c]	777[f]	689[cd]	732[e]	707[de]	720[de]
Fat thickness (in)	.57[ef]	.46[de]	.22[c]	.55[ef]	.38[d]	.33[cd]	.61[f]
Ribeye area (sq in)	11.6[cd]	10.9[c]	15.5[f]	11.5[cd]	13.6[e]	12.0[d]	11.3[cd]
REA/100 lb carcass wt	1.66[cd]	1.62[c]	1.99[f]	1.67[cd]	1.85[e]	1.70[d]	1.57[c]
Quality grade	Ch[-e]	Sel[0cd]	Sel[0cd]	Sel[+e]	Sel[0de]	Sel[-c]	Ch[-e]
Yield grade	3.1[e]	3.2[e]	1.4[c]	3.2[e]	2.3[d]	2.4[d]	3.6[e]

[a]A = Angus, B = Brahman crossbred, C = Charolais-sired crossbreds, H = Hereford, L = Limousin-sired crossbreds, S = Simmental-sired crossbreds and AXH = Angus x Hereford.
[b]Sel[-] = Low select, Sel[0] = Average select, Sel[+] = High select Ch[-] = Low choice.
[c,d,e,f]Means on the same row bearing a common superscript are not statistically significant (P>.05).

other breed groups (P<.05, Table 3). Angus, Angus x Hereford and Hereford calves had higher quality grade scores, but at the same time were appreciably fatter and had lower ratios of lean to fat.

During the past 30 months, the beef industry has benefitted greatly by the trimming of excessive fat from the product prior to going into the retail meat case. The consumer does not want waste fat. Retailers nation-wide have accepted consumer signals and today most fresh beef sold at retail is trimmed to .25 inch or less of external fat. The Angus, Brahman crossbred, Hereford and Angus x Hereford had external fat levels that compare to current industry averages. However, a reduction in external fat while maintaining marbling would be desirable. Possibly if the cattle were of a larger frame score upon entrance to the feedlot, they would have been leaner at slaughter.

The packing and retailing industries currently recognize the acceptable range for ribeye area to be from 12 to 15 sq in. This range translates into approximately 1.8 to 2.0 sq in of ribeye area per hundred lb of carcass weight. EXCEL Corporation has developed a system to classify and score cattle according to their potential retail yields. Table 4 shows the EXCEL scoring

Table 4. EXCEL muscle scoring system.

Muscle score	External fat thickness	Area of ribeye muscle/cwt carcass
A-1	.35 inch or less	2.0 inches/cwt or more
A-2	.36 to .45 inch	1.8 to 1.99 inches/cwt
B-3	.46 to .60 inches	1.70 to 1.79 inches/cwt
C-4	.61 to .80 inches	1.40 to 1.69 inches/cwt
C-5	.80 inches or more	Less than 1.4 inches/cwt

system as it relates to external fat thickness and ribeye area per hundred lb of carcass weight. A-1's and A-2's are the most desirable cattle, B-3's are average cattle and C-4's and C-5's are inferior from a retail yield standpoint. The Charolais-sired and Limousin-sired crossbred calves were A-2's, Simmental-sired crossbred B-3's and other breed types C-4's according to the EXCEL system. This scoring system indicates that the Angus, Hereford, Angus x Hereford and Brahman crossbred calves were excessively fat and too low in cutability. Short supplies of feeder and slaughter cattle have prevented substantial price/value differentiation among live cattle. However, as supply situations are corrected, it is important for the producers to realize packer intentions to severely discount wasty, light muscled cattle.

As long as the current pricing system continues to discount select carcasses, the quality grade target for retail beef will continue to be choice. Marbling at higher levels tends to reduce variation in palatability of today's beef and keep the retail product in an acceptable category from a consumer standpoint. Angus and Angus x Hereford steers were the only breed groups to reach the choice quality grade. Marbling is a genetically inherited trait. We need to identify cattle that will transmit desirable levels of marbling to their offspring while at the same time reducing the level of external waste.

Table 5 presents the physical and chemical composition of the 9-10-11th rib section of all breed types. Percentage of muscle from the 9-10-11th rib

Table 5. Least squares means for 9-10-11th rib composition.

				Breed group			
Trait	A[a]	B	C	H	L	S	AXH
Muscle %	46.6[b]	46.6[b]	58.5[d]	46.8[b]	50.2[c]	50.2[c]	43.9[b]
Fat %	37.4[cd]	37.4[cd]	25.5[b]	37.9[cd]	34.8[c]	32.5[c]	40.5[d]
Bone %	14.9[bc]	14.9[bc]	15.6[cd]	15.0[bc]	14.2[b]	16.6[d]	15.6[cd]

[a]A = Angus, B = Brahman crossbred, C = Charolais-sired crossbreds, H = Hereford, L = Limousin-sired crossbreds, S = Simmental-sired crossbreds and AXH = Angus x Hereford.
[b,c,d]Means on the same row bearing a common superscript are not statistically significant (P>.05).

cuts was inversely related to the percentage of total fat in the rib section; whereby, Charolais-sired crossbred calves had leaner, heavier muscled rib sections and Angus x Hereford steers had fatter, lighter muscled rib sections. Intramuscular fat percentage (marbling) was greatest for Angus steers which indicates that the Angus breed has a distinct advantage in marbling ability.

Taste Panel Evaluation and Instron Shear Force

Sensory panel evaluation of cooked steaks indicated few differences between breed types (Table 6). Most traits had mean sensory ratings well within the acceptable range of 4.5 or greater (off-flavor greater than 3.5). Instron shear values for the respective breed types did not correspond

Table 6. Least squares means for sensory panel evaluation and shear force.

	Breed group						
Trait	A[a]	B	C	H	L	S	AXH
Juciness[a]	5.06[e]	4.43[cd]	4.18[c]	4.66[cde]	4.95[cde]	4.55[cde]	4.88[d]
Ease of fragmentation[a]	5.66[c]	5.99[c]	5.33[c]	5.69[c]	5.62[c]	5.58[c]	5.80[c]
Connective tissue[a]	6.22[de]	6.18[de]	5.54[c]	6.24[de]	5.87[cd]	5.65[c]	6.37[e]
Flavor intensity[a]	5.19[f]	4.64[c]	4.87[cde]	5.07[ef]	4.82[cd]	5.00[def]	4.81[cd]
Overall tenderness[a]	5.75[de]	6.15[e]	5.18[c]	5.89[de]	5.80[de]	5.38[cd]	5.83[de]
Off flavor[b]	3.75[c]	3.93[c]	3.78[c]	3.93[c]	3.92[c]	3.67[c]	3.90[c]
Shear force, lb.	11.62[e]	8.94[c]	9.33[c]	9.77[cd]	9.96[cd]	9.77[cd]	11.37[de]
Cooking time (minute)	16.67[c]	18.00[cd]	19.50[de]	19.83[de]	20.00[de]	20.33[e]	18.50[cde]
Cooking loss %	22.93[c]	26.81[d]	25.27[cd]	26.01[cd]	25.22[cd]	27.36[d]	26.01[cd]

[a]means based on 8-point rating scales (8 = extremely juicy, easy to fragment, low in connective tissue, intense flavor, tender; 1=extremely dry, difficult to fragment, abundant connective tissue, bland flavor, tough).
[b]means based on 4-point rating scale (4 = none; 3 = slight; 2 = moderate; 1 = intense).
[c,d,e,f]means on the same row bearing a common superscript are not statistically significant (P>.05).

directly with expected tenderness projections based on quality grades (i.e. Angus = 8.94/Ch^-, percentage Brahman-x = 9.33/Sel^0, Simmental-x = 11.37/Sel^-, Angus x Hereford = 11.62/Ch^-). The latter finding is supportive of numerous research publications regarding select and choice tenderness comparisons among cattle with more than .3 in of fat thickness and 100 days or more of high concentrate feeding.

Cholesterol Analysis

The cholesterol content of raw beef longissimus muscles revealed few differences attributable to breed type. The mean cholesterol content was 59.14 mg/100 grams of raw steak while the standard deviation was 6.14 mg/100 grams of raw steak. It appears, based on current industry practices and the information obtained in this study, that the variation in cholesterol is not large enough to allow for the selection of low cholesterol beef due to breed type.

The cholesterol [illegible] beef longissimus [illegible] revealed few differences attributable [illegible] types. The lowest cholesterol content was 55.14 mg/100 grams [illegible] while the highest cholesterol [illegible] was [illegible] mg/100 grams of [illegible]. It appears, based on the cholesterol quantities and the information [illegible] in this study, that the [illegible] cholesterol is not large enough to [illegible] the [illegible] breed type.

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TABLE OF EQUIVALENTS

U.S. Metric

Length:

1 inch = 2.54 centimeters
1 foot = 30.48 centimeters
= 0.3048 meters
1 yard = 0.9144 meters
1 mile = 1609.34 meters
= 1.609 kilometers

Area:

1 square inch = 6.452 sq. centimeters
1 sq. foot = 0.0929 sq. meter
1 sq. yard = 0.8361 sq. meter
1 acre = 0.4047 hectare
1 sq. mile = 259.0 hectares

Volume:

1 cubic inch = 16.387 cu. centimeter
1 cu. foot = 0.0283 cu. meter
1 cu. yard = 0.7646 cu. meter
1 fluid ounce = 29.573 milliliters
1 pint = 0.4732 liter
1 quart = 0.9463 liter
1 gallon = 3.7853 liters

Weight:

1 ounce = 28.50 grams
1 pound = 453.592 grams
= 0.4536 kilogram
1 ton = 907.2 kilograms

Metric U.S.

Length:

1 millimeter = 0.03937 inch
1 centimeter = 0.3937 inch
1 meter = 39.37 inches
= 3.281 feet
= 1.094 yards
1 kilometer = 0.6214 mile

Area:

1 sq. centimeter = 0.155 sq. inch
1 sq. meter = 1.196 sq. yards
= 10.764 sq. feet
1 hectare = 2.471 acres
1 sq. kilometer = 0.386 sq. mile
= 247.1 acres

Volume:

1 cu. centimeter = 0.061 cu. inch
1 cu. meter = 35.315 cu. feet
= 1.308 cu. yards
1 milliliter = 0.0338 ounce
1 liter = 33.81 ounces
= 2.1134 pints
= 1.057 quarts
= 0.2642 gallon
1 kiloliter = 264.18 gallons

Weight:

1 gram = 0.03527 ounce
1 kilogram = 35.274 ounces
= 2.205 pounds
1 metric ton (1,000 kg) = 2204.6 pounds

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