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To: Clientele in Animal Agriculture

Re: Animal Science Research Report

This report, or it's predecessor the Feeders Day Report, has been published annually for over 50 years.

Why do we publish this annual report? The purpose of this publication is to provide you with our latest research findings, primarily those of the past year.

Our research results are ultimately published in scientific journals, but because experiments must often be repeated several times, and then the manuscripts subjected to review by other scientists to ensure scientific merit, several years often elapse.

We want you, those engaged in the industry and agricultural professionals, to be aware of our current research and latest findings, even though the results may be preliminary.

We often ask for your suggestions and ideas, to ensure that the central focus of our research program is aimed at solving industry problems, in addition to identifying new leading-edge opportunities. We continue to need, and welcome, your suggestions and ideas.

We also need, and will welcome, any suggestions you have regarding the format of this annual publication. We want to make this Animal Science Research Report as useful as we possibly can in meeting your needs. Let us hear from you.

Yours truly,

Robert Totusek

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

RT/csw

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Celebrating the Past . . . Preparing for the Future

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Purpose for Publication

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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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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 significant there is strong evidence that the relationship found was not due to chance. Correlation does not mean cause and effect but rather gives us insight into potential relationships between traits.

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

EVALUATION OF SALERS IN A COMMERCIAL COW HERD

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

Story in Brief

A study was initiated for the purpose of evaluating the Salers breed as a component of a commercial cow herd. Fifty females each of Hereford, Hereford x Angus and Salers x Hereford were identified for this study and were managed together. Hereford females calved later in the calving season and, as two-year olds, required more assistance at calving than did Hereford-Angus or Salers-Hereford cows. There were no significant differences in birth weight among calves out of the three cow groups. Salers-Hereford cows weaned the heaviest calves both as two- and three-year olds and Hereford-Angus two-year cows weaned heavier calves than Hereford two-year old cows. At the time the calves were weaned, Salers-Hereford cows had lower condition scores than Hereford-Angus cows as two-year olds. There were no significant differences in condition score among the cow groups for three year old cows.

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

Introduction

The Salers (pronounced Sah-lairs) is a breed of beef cattle with a relatively short history in the United States. Its place of origin in a mountainous region of France suggests that it should be a hardy breed with good performance, even in rigorous conditions. As with many other breeds previously, Salers need careful evaluation in this country before general recommendations can be made about their utility. This research was initiated with the intent of evaluating the breed, as a component of a crossbred cow herd, under range conditions. This report is an update from a preliminary report presented last year (Buchanan et al., 1989).

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[1]Professor [2]Undergraduate Assistant [3]Director of Research and Performance, American Salers Association

Materials and Methods

Pregnant females, representing three breed groups, were set aside from the herd at the Pitchfork Ranch near Meteetse in northwest Wyoming. Fifty females each of Hereford, Hereford x Angus and Salers x Hereford were identified for this study and were managed together. All Salers x Hereford females were two years of age at the initiation of the study while some of the females in the other groups were three or four years old and had calved previously. Results presented here are from two calf birth years. Only calves out of two- or three-year old cows were included in these comparisons.

Calves were born in January, February and March. Each calf was weighed within 24 h of birth and a calving ease score was assigned (1 = no difficulty, 2 = minor difficulty, 3 = major difficulty). Calves were weaned at approximately eight months of age. A weaning weight was obtained and 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, year, sire breed, sex, age of the dam and appropriate two-way interactions in the model.

Results and Discussion

Calving and weaning percentages were over 90% for all groups and no apparent differences were observed between the three breed groups. Average date of birth was calculated as days after January 1 (Table 1). For both two- and three-year old cows, the Herefords calved later in the calving season. Salers-Hereford cows calved slightly earlier as two-year olds and slightly later as three-year olds than did Hereford-Angus cows. Salers-Hereford and Hereford-Angus two-year old cows had easier births than Hereford cows (Table 2). As three-year old cows, there were no differences observed between the groups.

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

Age of Cow	Hereford	Hereford-Angus	Salers-Hereford
Two	56.3[a]	43.3[b]	41.6[b]
Three	66.1[a]	53.3[b]	59.6[b]

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

Table 2. Average calving score[a] (1=no difficulty, 2=minor assistance).

Age of Cow	Hereford	Hereford-Angus	Salers-Hereford
Two	1.73[a]	1.43[b]	1.49[b]
Three	1.15[a]	1.13[a]	1.15[a]

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

Birth weights were not substantially different between the cow groups (Table 3). Salers-Hereford cows did have heavier calves as two-year olds, but this extra weight did not cause a difference in calving difficulty. Salers-Hereford cows had significantly heavier calves at weaning (Table 4). There was a large advantage over both Hereford and Hereford-Angus cows for both two-year old and three-year old females.

Salers-Hereford cows had slightly lower average condition scores than Hereford or Hereford-Angus (Table 5). However, the average was certainly sufficient for cows of these ages under these conditions.

An additional year of data will be obtained. To date, the Salers-Hereford females have been superior in weight of calf at weaning and have been at least as good or better than the Hereford and Hereford-Angus cows for reproductive performance. These results suggest that Salers crossbred cows may have a place in the U.S. cow-calf industry.

Table 3. Average birth weight (lb).

Age of Cow	Hereford	Hereford-Angus	Salers-Hereford
Two	63.0[a]	62.3[a]	65.3[a]
Three	69.7[a]	69.7[a]	68.7[a]

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

Table 4. Average 205 day weight (lb).

Age of Cow	Hereford	Hereford-Angus	Salers-Hereford
Two	366.2[a]	401.4[b]	421.8[c]
Three	412.6[a]	435.3[b]	447.0[b]

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

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

Age of Cow	Hereford	Hereford-Angus	Salers-Hereford
Two	4.67[a]	4.89[b]	4.63[a]
Three	5.27[a]	5.06[a]	5.05[a]

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

Literature Cited

Buchanan, D.S. et al. 1989. A preliminary evaluation of the Salers breed in a commercial beef herd. Okla. Agr. Exp. Sta. Res. Rep. MP-127:1.

COMPARISONS OF ANGUS-HEREFORD RECIPROCAL CROSS COWS

D.S. Buchanan[1] and S.R. McPeake[2]

Story in Brief

Reproductive, birth and weaning records of 98 Hereford-Angus (sired by Hereford bulls) and 80 Angus-Hereford (sired by Angus bulls) cows (523 and 423 calves, respectively) were used to compare these reciprocal cow types for cow productivity. Hereford-Angus cows had a large advantage in average weaning percent (83.4 vs 72.1%). There were only minor differences in birth weight and calving difficulty, but calves from Angus-Hereford cows were slightly heavier at weaning (488.0 vs 483.1 lb) and had a slightly higher average conformation score (13.1 vs 13.0). The advantage in weaning percent provides reason to recommend the use of Hereford bulls and Angus cows as the parents of replacement heifers.

(Key Words: Beef Cattle, Crossbreeding, Reproduction, Calf Weight.)

Introduction

The "Black-baldy" (Hereford-Angus or Angus-Hereford) cow is commonly used in commercial cattle production and is generally the standard by which other crossbred cow types are evaluated. Both the Angus and Hereford breeds have several characteristics which serve well in a commercial cow-calf setting. Both breeds are moderate in size and are reasonably fertile. The Angus breed is recognized for its maternal ability and marbling while many producers like Hereford cattle because of their adaptability to harsh conditions. The maternal ability of the Angus suggests the use of Hereford bulls on Angus cows if the objective is to produce two breed cross calves. The mating of choice is not as obvious if the two breeds are to be used to produce replacement heifers. The objective of this study was to compare Angus-Hereford (sired by Angus bulls) with Hereford-Angus (sired by Hereford bulls) cows for reproduction and calf performance to weaning.

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[1]Professor [2]Graduate Assistant

Materials and Methods

This study used data from two projects at the Oklahoma Agriculture Experiment Station. Cow reproduction and calf performance to weaning for all Angus-Hereford and Hereford-Angus cows were analyzed. Both projects include numerous cows from other crossbred cow types which were not included in these analyses.

The first project was designed to compare the productivity of cows out of Hereford or Angus dams and sired by Hereford, Angus, Simmental, Brown Swiss and Jersey bulls. Data from this project were obtained from 1975 through 1986. Cows ranged in age from 2 to 13 years old. Calves were sired by Brahman, Charolais, Gelbvieh, Limousin, Red Poll, Salers and Shorthorn sires.

The second project compared the performance of 0, 1/4 and 1/2 Brahman cows in spring vs fall calving systems. The 0 Brahman cows were either Hereford-Angus or Angus-Hereford. Data were obtained from 1983 through 1987 with cows that were from two to six years old. Calves were sired by Limousin or Salers bulls.

There were 98 Hereford-Angus cows and 80 Angus-Hereford cows included in the study. Over the several years of the study these cows were exposed to bulls 642 and 548 times (Hereford-Angus and Angus-Hereford, respectively). The breeding season lasted approximately 75 days, starting in early May for spring calving cows and in early December for fall calving cows. Bulls were randomly assigned to cows within each crossbred cow group. Breeding was primarily by artificial insemination. Calvings were scored for difficulty assigned on the basis of: 1 = no difficulty, 2 = minor assistance, 3 = moderate difficulty, 4 = hard pull, 5 = Caesarian and 6 = abnormal presentation.

Birth weights were obtained and male calves were castrated within 24 h of birth. Calves remained with their dams until weaning (205 days for spring calving cows, 240 days for fall calving cows). At weaning each calf was weighed and assigned subjective weaning condition (1 = emaciated, 9 = obese) and conformation (12 = low choice) scores.

Data were analyzed with least squares procedures. The model included dam breed (Angus-Hereford vs Hereford-Angus), project, year, age of dam, sex of calf, season, sire breed and sire nested within sire breed. Two way interactions were evaluated but were excluded if not approaching significance ($P>.4$).

Results and Discussion

Reproductive performance of the two cow groups is shown in Table 1. Hereford-Angus cows were superior ($P<.01$) for lifetime percent weaned (83.4

Table 1. Reproductive performance of Hereford-Angus vs Angus-Hereford cows.

Crossbred cow group	Number of exposures	Lifetime % weaned	Calving interval, days
Hereford-Angus	642	83.4	417
Angus-Hereford	548	72.1	419
Probability level	<.01	.75	

vs 72.1). There was little difference in average calving interval between the groups. This large 11.3% advantage in weaning percent cannot be explained easily. Hereford-Angus cows were also heavier (928.4 vs 895.4 lb). The increased weight may have resulted from a higher average body condition. Such an advantage in average condition score would be consistent with the expected higher milking ability of the Angus dams of the Hereford-Angus cows. This higher average condition score would be expected to result in an advantage in reproductive performance. However, the observed difference may have been larger than could be explained by average fatness differences of the cows.

Only small differences were observed in birth weight and calving difficulty (Table 2). Performance at weaning showed a small advantage for calves out of Angus-Hereford cows (Table 3). They were 4.9 lb heavier (non-significant) at weaning and had a slightly higher average conformation score (P<.05).

These results showed a small advantage in performance at weaning for calves out of Angus-Hereford cows. However, there was a large advantage in percent weaned for Hereford-Angus cows. Despite the lack of a clear explanation for the large observed advantage, this should be useful information. It has been shown that a Hereford x Angus cross takes advantage of the superior maternal ability of the Angus female. These results indicate that the same cross can be recommended for production of replacement heifers.

Table 2. Birth weight and calving difficulty of calves out of Hereford-Angus or Angus-Hereford dams.

Crossbred cow group	Number of calves	Birth weight, lb	Calving difficulty
Hereford-Angus	523	75.5	1.37
Angus-Hereford	423	74.1	1.44
Probability level	.26	.38	

Table 3. Weaning weight, conformation and condition scores of calves out of Hereford-Angus or Angus-Hereford dams.

Crossbred cow group	Number of calves	Weaning weight, lb	Conformation score	Condition score
Hereford-Angus	498	483.1	13.0	5.1
Angus-Hereford	403	488.0	13.1	5.0
Probability level	.15	.04	.29	

GESTATION LENGTH AND BIRTH WEIGHT DIFFERENCES OF CALVES BORN TO 0, 1/4, AND 1/2 BLOOD BRAHMAN FALL- AND SPRING-CALVING COWS BRED TO SALERS AND LIMOUSIN SIRES

G. E. Selk[1] and D. S. Buchanan[2]

Story in Brief

Records of 414 gestations and live births (242 spring and 172 fall) from cows of five crossbred cow groups were analyzed for differences in gestation length and birth weight. The cows were all multiparous and ranged in age from four to seven years. Cow breed groups were: 1) 1/2 Hereford x 1/2 Angus; 2) 1/4 Brahman x 1/2 Hereford x 1/4 Angus; 3) 1/4 Brahman x 1/2 Angus x 1/4 Hereford; 4) 1/2 Brahman x 1/2 Angus; and 5) 1/2 Brahman x 1/2 Hereford, respectively. Cows were bred artificially to either Salers or Limousin bulls. The last breeding date was used to calculate gestation length. Sex of the calf, calving season, sire breed and dam breed and all two-way interactions were evaluated. Bull calves were heavier at birth than heifers (82.2 lb vs 77.9 lb) and longer in gestation length (286.0 days vs 284.8 days). Group 5 (1/2 Hereford x 1/2 Brahman) cows had greater gestation lengths than any other breed group (284.9 days, 284.1 days, 285.2 days, 284.9 days, and 287.9 days, for Groups 1, 2, 3, 4, and 5, respectively). Fall-calving cows delivered smaller birth weight calves (77.7 lb) than spring-calving cows (82.2 lb) but gestation length was not affected by season. Limousin-sired calves were heavier than Salers-sired calves (81.0 lb vs 79.1 lb) and required a slightly longer gestation (285.9 days vs 284.8 days). The partial correlation of gestation length and birth weight was r = .34. Brahman x Hereford crossbred cows had greater gestation length than other crosses evaluated and consequently fewer available days to become rebred to maintain a twelve month calving interval.

(Key Words: Gestation Length, Birth Weight, Crossbred Cow, Calving Season.)

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[1]Assistant Professor [2]Professor

Introduction

Gestation length and birth weight are traits that influence the reproductive performance of beef cattle. Lengthy gestations decrease the days available for postpartum recovery and rebreeding in those herds that strive for a 365-day calving interval. Heavy birth weights have been noted as the primary cause of dystocia in cattle (Morrison et al., 1985). Together, these two traits could have adverse effects on the reproductive performance of beef herds. Long gestation lengths and heavy birth weight calves that result in dystocia will cause extended postpartum anestrus or recovery and relatively fewer days to accomplish the necessary uterine involution. The result could be a slower return to estrus and longer calving interval or a lower calf crop the following year.

Scientific estimates of gestation lengths and birth weights of different beef and dairy breeds of cattle were reviewed in 1965 (Anderson and Plum). In that review, the reported estimates of these traits in Angus and Hereford cattle were made prior to 1962. Angus gestations were reported to require a mean of 279 days and mean birth weight was 60.9 lb. Hereford gestations lasted 285 days and mean birth weights for straightbred Hereford calves was reported at 76 lb. By contrast, the 1982 USDA Meat Animal Research Center (MARC) Report (Gregory et al., 1982) listed the gestation length of 3,129 Angus calves born to Angus parents at 285.4 days and the corresponding birth weight of 80.9 lb. In the same report 2,440 Hereford calves were gestated for 288.6 days and weighed 86.2 lb at birth. Changes in cattle type over the last 50 years may have influenced birth weight and gestation length. In that period of time, many different breeds have been introduced into the United States beef system. Brahman crossbred cattle are popular in many of the Gulf Coast and Southwestern States. Brahman-sired calves had gestation lengths estimated at 291 days in the MARC report. The effect of lengthy gestations on year-to-year calving intervals was emphasized by Bourdon and Brinks (1983) when they reported an increase in calving interval of 1.17 days for each day increase in gestation length. Little, however, is known of the gestation lengths and birth weights to be expected from Brahman crossbred cows bred to terminal sires. In addition, very little information about the differences in birth weight and gestation length in fall-calving cattle vs spring-calving cattle is available. Therefore, data from fall- and spring-calving cows of five different crosses in two years were analyzed to help answer some of these questions.

Materials and Methods

Records of 414 gestations from multiparous four to seven year old cows were analyzed. The cows were in five different breed groups:

Group 1--1/2 Angus x 1/2 Hereford
Group 2--1/4 Brahman x 1/4 Angus x 1/2 Hereford
Group 3--1/4 Brahman x 1/4 Hereford x 1/2 Angus
Group 4--1/2 Brahman x 1/2 Angus
Group 5--1/2 Brahman x 1/2 Hereford

Half of each breed group were randomly mated artificially to one of five Salers sires, and half of each breed group were mated to one of five Limousin sires. Birth weights, birth dates, and sex of calf were recorded as soon as the calf was found, and within 24 h of birth. Gestation length was defined as the number of days from the last recorded date of artificial insemination to the date of birth. The very few gestations in excess of 300 days were considered as mis-recorded breeding dates and were adjusted back into a normal range by subtracting either 21 or 42 days (the estimated length of one or two estrous cycles).

Statistical analysis was performed by analysis of variance with breed group of dam, breed of sire, sex of calf, and season of birth as the main sources of variation tested for both gestation length and birth weight. All possible two-way interactions were also examined. Nonsignificant interactions were removed and included in the error term. Partial correlation of birth weight and gestation length were calculated with the above sources of variation removed. Least squares means are reported and were considered different only if there was a significant main effect in the analysis of variance.

Results and Discussion

The least squares means for gestation length and birth weight across all five cow breed groups are presented in Table 1. Fall born calves were lighter in birth weight but gestation length was identical for both fall and spring born calves. Fall born calves have gestated during hotter months, perhaps resulting in reduced nutrients reaching the conceptus. Blood flow patterns in hot weather dictate that more of the dam's blood is shunted to extremities to dissipate heat. Salers-sired calves were slightly smaller at birth and had a shorter gestation length than Limousin-sired calves. As expected, heifer calves had a lighter mean birth weight and shorter gestation length than bull calves. However, in this data set there was an unexpected and unexplained interaction for cow breed group by sex of calf for birth weight. The bull calves born to the Brahman x Angus cows were not different in birth weight than the heifer calves born to the same breed type. Table 2 is a presentation of the mean birth weights for the five cow groups by sex of calf.

Gestation lengths for the different cow breed groups are presented in Table 3. All breed groups were similar in gestation length except for 1/2 Brahman x 1/2 Hereford cows which had a significantly longer gestation length. Any

Table 1. Least squares means for gestation length and birth weights across all cow breed groups for fall vs spring born calves, Limousin vs Salers sired calves, and heifer vs bull calves.[a]

Group	Gestation length (days)	Birth weight (lb)
Fall-born	285.4	77.7[b]
Spring-born	285.4	82.2[c]
Heifers	284.8	77.9[b]
Bulls	286.0	82.2[c]
Salers-sired	284.8[b]	79.1[b]
Limousin-sired	286.0[c]	81.0[c]

[a] Cow breed group x sex interaction was found.
[b,c] Means in the same row with different superscripts differ (P<.05).

Table 2. Least squares means of birth weights (lb) of calves born to cows of five breed groups by sex of calf.

Breed group[a]*	Bull calves	Heifer calves
1/2 H X 1/2 A	84.2[b]	77.3[d]
1/4 B X 1/2 H X 1/4 A	81.9[b]	77.8[bd]
1/4 B X 1/2 A X 1/4 H	84.6[b]	80.4[bd]
1/2 B X 1/2 A	75.5[c]	77.8[cd]
1/2 B X 1/2 H	84.9[b]	76.8[d]

[a] H=Hereford, A=Angus, B=Brahman.
[b,c,d] Means in the same row with different superscripts differ (P<.05).

overall increase in gestation length will reduce the number of days available for the cow to repair her reproductive tract, return to estrus, and rebreed for the subsequent year's calf crop. The partial correlation between birth weight and gestation length in this study is r = 0.34. This means that longer gestation cows tend to have heavier birth weights. Heavy birth weights are considered the major factor causing dystocia in cattle (Morrison et al., 1985). Although there

Table 3. Least squares means of gestation length (days) of calves born to cows of five breed groups.

Breed group[a]	Gestation length (days)
1/2 H X 1/2 A	284.9[b]
1/4 B X 1/2 H X 1/4 A	284.1[b]
1/4 B X 1/2 A X 1/4 H	285.3[b]
1/2 B X 1/2 A	284.8[b]
1/2 B X 1/2 H	287.7[c]

[a] H=Hereford, A=Angus, B=Brahman.
[b,c] Means in the same row with different superscripts differ (P<.05).

was a very low incidence of dystocia in this study, (presumably because only four to seven year old cows were included) this relationship may become important in some herds. Increased gestation length causing increased birth weight could, in turn, increase dystocia. An increase in dystocia has been linked to longer anestrus in beef cows (Brinks et al., 1973). This longer anestrus compounded by the long gestation could result in poor reproductive performance due to slow return to estrus or lowered rebreeding rates. By using the factor reported by Bourdon and Brinks (1983), the 2.9 day increase in gestation length causes a 3.4 day (1.17 x 2.9 days) increase in the year-to-year calving interval. Over the lifetime of individual cows, those with longer gestation lengths would eventually have a calving date nearly a month later than counterparts with shorter average gestation lengths.

Literature Cited

Anderson, H. and M. Plum. 1965. Gestation length and birth weight in cattle and buffaloes: a review. J. Dairy Sci. 48:1224.

Bourdon, R.M. and J.S. Brinks. 1983. Calving date versus calving interval as a reproductive measure in beef cattle. J. Anim. Sci. 57:1412.

Brinks, J.S. et al. 1973. Calving difficulty and its association with subsequent productivity in Herefords. J. Anim. Sci. 36:11.

Gregory, K.E. et al. 1982. Characterization of breeds representing diverse biological types: preweaning traits. Beef Research Program Progress Report No. 1. ARM-NC-21:7.

Morrison, D.G. et al. 1985. Discriminant analysis for predicting dystocia in beef cattle. I and II. J. Anim. Sci. 60:608.

EVALUATION OF BODY CONDITION SCORING FOR ESTIMATING CARCASS FAT PERCENTAGE OF VARIOUS COW TYPES

E.D. Tinker[1], D.S. Buchanan[2], M.N. McCarter[3], H.G. Dolezal[4], R.R. Frahm[2] and L.W. Knori[5]

Story in Brief

The accuracy of a body condition scoring system for predicting carcass fat of different biological types of cows was evaluated. Four different two-breed-cross cow groups (Hereford x Angus, Brown Swiss x Angus, Jersey x Angus and Simmental x Angus), representing different biological types were utilized. Fifty-five cows were weighed, measured for hip height and assigned a body condition score before slaughter. After a 24 hour chill the kidney and pelvic fat was removed and sampled and a random side of the carcass was deboned, ground and sampled. Samples were analyzed for moisture, protein and fat content. Equations using various live animal measurements to predict carcass fat percentage were developed for each cow type. Analysis of the prediction equations showed there were no significant differences among the different cow type equations. This indicates that the body condition scoring system utilized is appropriate for cows of different biological types.

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

Introduction

Reproductive performance of beef cows is influenced greatly by the energy status of the cow. Body condition scoring is one proven method of assessing the energy status of live beef cows. A number of studies have shown strong relationships between cows' body condition score (BCS) and carcass fat content. However, these studies have been conducted with only one breed, or cow type, in each study. It is important to know if the same relationship between BCS and carcass fat content exists for a variety of cow types. If the relationship varies for cows with different biological types, refinements may need to be made in the

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

BCS system to account for cow type. Therefore this study was conducted to examine whether a similar relationship exists between BCS and carcass fat content of cows with various breed combinations and biological types.

Materials and Methods

Fifty-five cows were used in this study, representing four different two-breed combinations: Hereford x Angus, Brown Swiss x Angus, Jersey x Angus and Simmental x Angus. All cows were mature (11, 12 or 13 years old), nonpregnant and nonlactating. Before slaughter all cows were weighed, measured for hip height and assigned a BCS by each of four people familiar with the 1 - 9 scoring system (1 = emaciated, 9 = very obese). An average of the four scores was used in statistical analysis of the data. Cows were slaughtered at the Oklahoma State University meat laboratory and allowed to chill for 24 h. Kidney and pelvic fat was removed from the chilled carcass, weighed and a sample collected. A random side of the carcass was deboned and soft tissue (lean and fat) ground and sampled for analysis. Composition of samples was determined by standard laboratory procedures for moisture, protein and fat.

Total fat content of each carcass was determined by multiplying the weight of each carcass component by the fat percentage of that component, as determined by the laboratory analysis. Total fat content was divided by chilled carcass weight to acquire carcass fat percentage. Since cow types with a wide variety of mature sizes were included in the study, fat percentage of the carcass should be a more appropriate comparison among cow types than total weight of carcass fat.

Statistical analysis was performed to develop an equation consisting of live animal measures which could be used to predict carcass fat percentage. Prediction equations were developed for each cow type and the four equations were then compared for differences.

Results and Discussion

The best model for predicting the percentage carcass fat included BCS of the cow and BCS raised to various powers. These traits were used to develop separate prediction equations for each cow group. The coefficients for prediction equations developed for all cows and individual cow groups are presented in Table 1. The cow group equations have numerical differences for the coefficients of the variables used, but these equations were not different from one another. The estimated carcass fat percentage for each equation over a BCS range of 3 to 7 is shown in Figure 1. This illustration showed that prediction of carcass fat percentage was very good for BCS in the 4 through 6.5

Table 1. Coefficients for carcass fat percentage prediction equations developed for all cows and individual cow groups[a].

Cow Type	Intercept	BCS[b]	BCS^2	BCS^3	BCS^4	R^2
All cows	-49.21	60.43	-25.05	4.27	-.25	.91
Hereford x Angus	569.60	-420.34	113.40	-13.19	.57	.96
Brown Swiss x Angus	-97.91	103.13	-38.61	6.09	-.33	.97
Jersey x Angus	-75.57	88.33	-35.28	5.86	-.33	.88
Simmental x Angus	-329.81	335.44	-121.68	18.72	-1.03	.98

[a] Use prediction equation coefficients as in this example for all cows: $-49.21 + (60.43 \times BCS) + (-25.05 \times BCS^2) + (4.27 \times BCS^3) + (-.25 \times BCS^4)$.

[b] BCS = Body condition score.

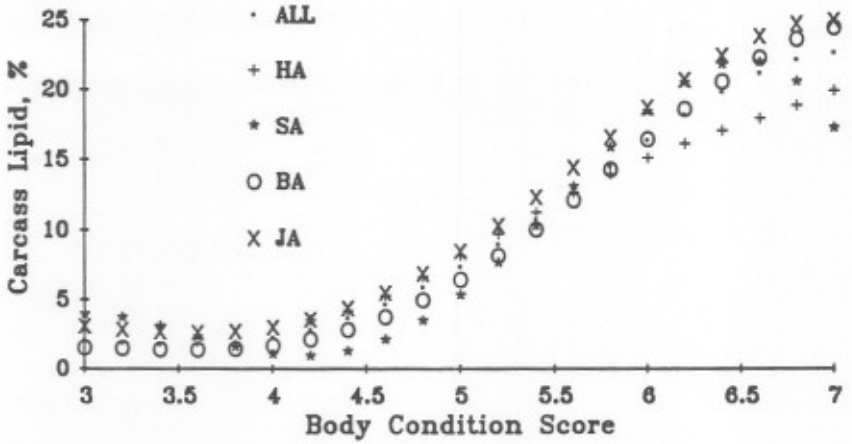

Figure 1. Estimation of carcass fat percentage with individual cow group prediction equations over a body condition score range from 3 to 7.

range, which is the range in which most of the cows in the study were scored. However, the equations do not predict very well for cows with BCS of less than 4 or greater than 6.5.

The results of this study indicate that the body condition scoring system is an accurate method of assessing body fat content of cows of different biological types.

EFFECT OF WEANING MANAGEMENT OF SPRING-BORN CALVES ON CALF SALE WEIGHT AND COW WEIGHT CHANGES

K.C. Barnes[1], J.W. Walker[2] and K.S. Lusby[3]

Story in Brief

Thirty-nine spring-born calves were randomly alloted by calf sex to three treatments consisting of: 1) calves weaned on October 4 and maintained for 22 days in drylot on a diet of bermudagrass hay and 4.1 lbs of concentrate; 2) calves weaned on October 25 and held overnight prior to simulated sale; and 3) calves separated from dams at 9 a.m. on October 26, the day of simulated sale. Calves were commingled for about 4 hours without feed or water to simulate hauling and then given access to hay and water until 3 p.m. at which time all calves were reweighed to simulate sale weight. Calves weaned on October 4 and held for 22 days before simulated marketing, tended to gain more weight than calves left with their dams on pasture. Calves weaned and held overnight lost about 16 lb more than calves weighed and returned overnight with their dams. All three groups of calves had similar weight losses when removed from feed and water for the 4-hour period from 9 a.m. to 1 p.m. to simulate hauling to an auction barn. Calves removed from their dams the previous evening lost a total of 36 lb before simulated arrival at the auction barn. Weight changes were similar when all calves were offered feed from 1 p.m. to 3 p.m. (6, 9 and 3 lb, respectively). The total weight loss from the final removal from pasture to simulated sale was -11, -27 and -15, respectively.

(Key Words: Beef Cattle, Shrink, Marketing, Weaning.)

Introduction

Cattlemen often expend much time and energy in attempts to increase weaning weights. However, they may not know how much weight is lost due to shrinkage during the marketing process. This is especially true for small producers who must sell all their cattle at local auction barns. Larger

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[3]Professor

operations must sometimes have calves stand overnight when gathering and sorting several pastures. In order to design management alternatives to minimize shrinkage, cattlemen must be aware of the magnitude of weight loss due to stress of handling during marketing. The objective of this study was to evaluate the effects on simulated sale weight of weaning calves 21 days prior to sale, holding calves overnight prior to sale or moving calves directly from the cow to sale.

Materials and Methods

The study was conducted at the Eastern Research Station near Muskogee, Oklahoma. Thirty-nine calves and their dams were randomly alloted by calf sex to three treatments. All calves were from crossbred cows of Hereford, Angus and Simmental breeding and mated to a single Brangus bull. Calves were born between February 15 and April 1, 1989 and grazed bermudagrass pastures with their dams during the summer. On October 4, all cows and calves were weighed directly off pasture and alloted to treatment groups. Treatments were: 1) calves weaned on October 4 and maintained for 22 days in drylot on a diet of bermudagrass hay (10.9% CP, DM basis) and 4.1 lb of concentrate consisting of alfalfa hay, 4.7%, corn, 54.0%, cottonseed meal, 11.7%, and wheat, 19.6%; 2) calves weaned from cows at 3:30 p.m. on October 25 and held overnight prior to simulated sale with bermudagrass hay and water available; and 3) calves separated from their dams at 9 a.m. on October 26, the day of simulated sale. At 9 a.m. all calves were commingled and held in light-confinement without feed or water to simulate hauling and reweighed at 1:15 p.m. Calves were given access to hay and water until 3:15 p.m. at which time all calves were reweighed to simulate sale weight. Treatment 1 calves were fed their concentrate before commingling with other calves at 9 a.m. on simulated sale day. Cows were weighed full on October 4 and again on October 26. Calves from all three groups were vaccinated for IBR-PI3 (modified live virus) and 7-way blackleg. Data were analyzed with initial cow weight and calf weight as covariables.

Results and Discussion

No health problems were noted with calves during the study. Calves that were weaned on October 4 and fed bermudagrass hay and concentrate for 22 days before simulated marketing tended to gain more ($P<.15$) weight than calves left on their dams (Table 1). Calves removed from their dams and held overnight lost 16 lb compared to 1 or 2 lb loss for calves weighed and returned to their pen or their dams (Treatments 1 and 3, respectively).

Table 1. Weights and weight changes of calves and their dams during three weaning and sale scenarios (least squares means).

	Treatments		
	1	2	3
	Weaned 22 days before sale	Weaned day before sale	Weaned day of sale
No. of calves	14	13	12
Calf weight Oct 4, lb	514	530	498
Weight changes, lb			
Oct 4 - Oct 25	43	37	33
Oct 25 - Oct 26 (9:15 a.m.)	-1[a]	-16[b]	-2[a]
Oct 26 (9:15 - 1:15)	-17	-19	-18
Oct 26 (1:15 - 3:15)	6	9	3
Total (Oct 4 - sale)	31[b]	11[a]	16[a]
Cow weight Oct 4, lb	1145	1211	1270
Weight changes to Oct 26, lb	-7	-25	-7

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

These losses demonstrate that while first separation from the dam presents a very stressful situation to the calf, removal for the short period required for weighing may have little negative impact on calf weight.

It is interesting that all three groups of calves had similar weight changes (-17, -19 and -18 lb) when removed from feed and water for the 4-hour period from 9:15 a.m. to 1:15 p.m. to simulate hauling to an auction barn. These losses probably represent gut fill rather than tissue losses. This means that calves removed from their dams the previous evening lost a total of 36 lb before simulated arrival at the auction barn. Weight changes were similar when all calves were offered hay and water from 1:15 to 3:15 p.m. (6, 9 and 3 lb, respectively). The total weight loss from final removal from presale treatments 9:15 a.m. on October 26 for Treatments 1 and 3, and 4 p.m. on October 25 for Treatment 2 to simulated sale was -11, -27 and -15, respectively.

Cow weight losses tended to be greater for cows with calves weaned overnight before simulated shipping. This would be expected because grazing activity would be interrupted with these cows. For cows to be sold as

culls, this weight loss could be economically important. It was surprising that dams of calves weaned 22 days before shipment did not gain more weight than cows nursing calves. An explanation is not apparent.

This study shows that weight losses from weaning to sale weight can be minimized by weaning calves about three weeks prior to sale. This period in the present study was apparently sufficient to overcome the stress of weaning and permitted the calves to gain weight and become accustomed to eating mixed feed. If preconditioning is not possible, this study suggests that the time from weaning to sale weight must be minimized. At a cost of $150/ton for the concentrate and $45/ton for hay, total feed cost for calves on Treatment 1 was $11.46/head for 22 days. Treatment 1 calves gained 17.5 lb more than the average of Treatments 2 and 3 from October 4 to sale weight. Therefore, the values of added weight of the preconditioned calves would have to be at least $.65/lb to cover cost of feed.

EFFECTS OF BODY CONDITION SCORE AT CALVING AND POSTPARTUM NUTRITION ON PERFORMANCE OF TWO-YEAR-OLD HEIFERS

D. Bell[1], R.P. Wettemann[2], K.S. Lusby[3] and D.K. Bishop[4]

Story in Brief

Eighty-one Hereford and Angus x Hereford heifers were used to study the effects of body condition score at calving and postpartum nutrition on rebreeding rates by 90 and 120 days postpartum and weaning weights of calves. Pregnancy rates of thin heifers were significantly less than for heifers with good body condition (body condition score $\geq$ 5). Greater postpartum energy intake increased pregnancy rates of thin heifers by 120 days postpartum. However, postpartum nutrition did not affect pregnancy rates of heifers that calved in good condition. Calf weaning weights were influenced by BCS at calving for the Hereford heifers but did not for the Angus x Hereford heifers.

(Key Words: Body Condition Score, Heifer, Nutrition, Reproduction.)

Introduction

The period from parturition to conception is a very demanding time in a heifer's life. She is still growing, has just calved for the first time, is nursing a calf, and is expected to rebreed. Heifers must become pregnant and wean a heavy calf to be profitable. The purpose of this study was to evaluate the effects of body condition score (BCS) at calving and postpartum nutrition on rebreeding and growth of the calf.

Materials and Methods

Eighty-one Hereford and Angus x Hereford heifers that calved as two-year-olds during February and March of 1985 and 1986 were used in this study. In November, before calving, heifers were blocked based on breed and BCS (1 = emaciated, 9 = obese) and were divided into two groups to either lose or gain weight until calving. At calving, each heifer was randomly assigned to one of

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

two nutrition groups; either to gain or maintain weight for 69 days postpartum. Body weight, BCS, and calf weight were measured at 2-week intervals. For the purpose of this study, heifers were divided into two groups; those with a BCS < 5 at calving and those with a BCS ≥ 5.

Results and Discussion

Body weights and BCS of the heifers during the first 12 weeks postpartum are depicted in Figures 1 and 2, respectively. The greatest increase in weight was for heifers calving with a BCS < 5 and assigned to the diet to gain weight. Heifers on the gain treatment gained about 100 lb after calving. The percentages of heifers that become pregnant by 90 days postpartum are depicted in Figure 3. The difference in pregnancy rates at 90 days between heifers on maintain or gain diets that calved on BCS ≥ 5.0 (35% vs 53%) was not significant (P≥.20). Nor was there a difference in pregnancy rate between maintain and gain groups that calved with a BCS < 5.0 (7% vs 18%). There was, however, a significant difference (P<.02) between pregnancy rates of heifers fed to gain weight which calved in BCS ≥ 5.0 and heifers on the gain diet that calved with a BCS < 5.0. Similarly, heifers on the maintain diet which calved with a BCS ≥ 5 had a greater pregnancy rate than those that calved with a BCS < 5 (P<.07).

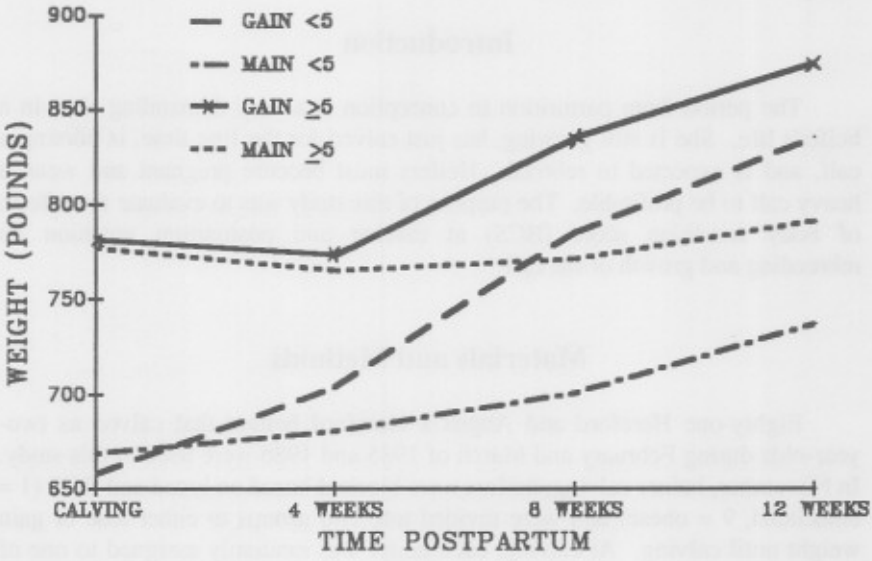

Figure 1. Postpartum weight of heifers with a body condition ≥ 5 or < 5 at calving and fed to gain or maintain weight.

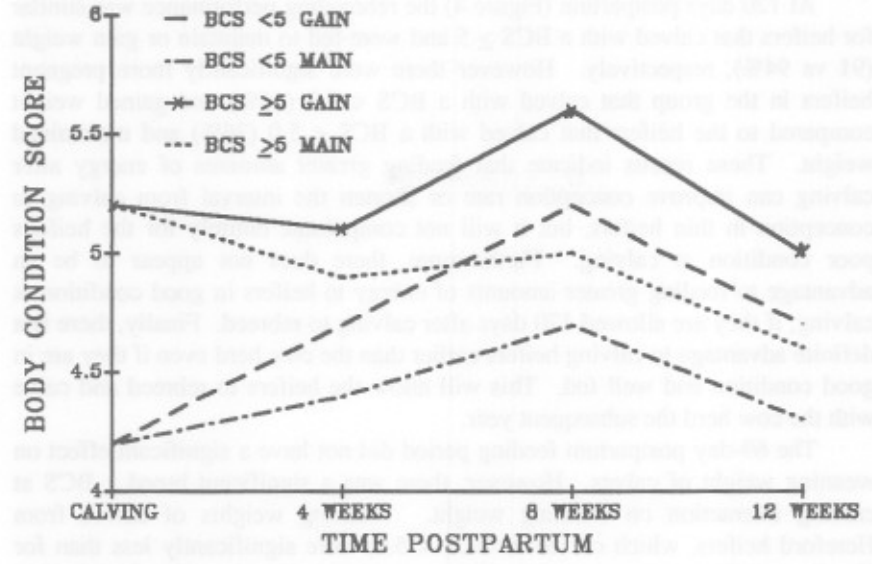

Figure 2. Postpartum body condition scores of heifers with a body condition ≥ 5 or < 5 at calving and fed to gain or maintain weight.

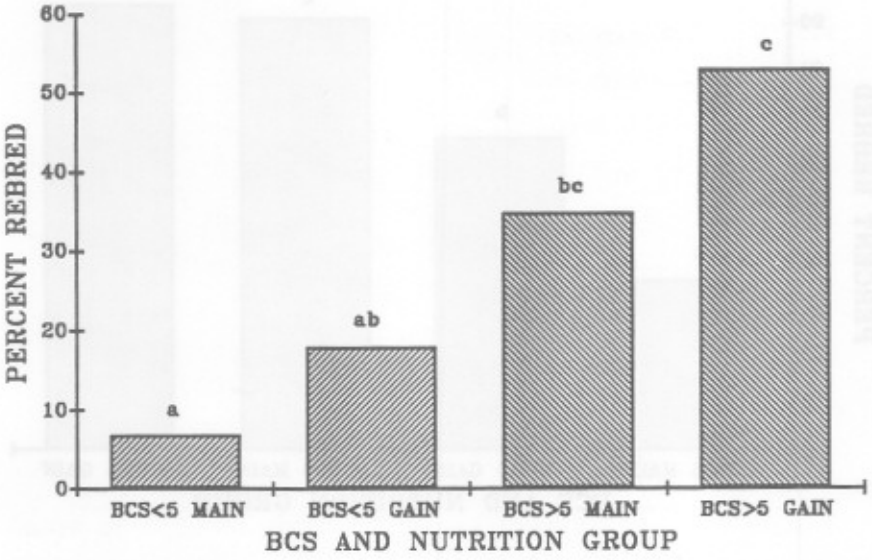

Figure 3. Percentage of heifers pregnant by 90 days after calving, when heifers calved with a BCS ≥ 5 or < 5 and were fed to gain or maintain weight. Bars with different letters (a,b,c) differ (P<.05).

At 120 days postpartum (Figure 4) the rebreeding performance was similar for heifers that calved with a BCS ≥ 5 and were fed to maintain or gain weight (91 vs 94%), respectively. However there were significantly more pregnant heifers in the group that calved with a BCS < 5.0 (66%) and gained weight compared to the heifers that calved with a BCS < 5.0 (36%) and maintained weight. These results indicate that feeding greater amounts of energy after calving can improve conception rate or shorten the interval from calving to conception in thin heifers, but it will not compensate entirely for the heifer's poor condition at calving. Furthermore, there does not appear to be an advantage to feeding greater amounts of energy to heifers in good condition at calving, if they are allowed 120 days after calving to rebreed. Finally, there is a definite advantage to calving heifers earlier than the cow herd even if they are in good condition and well fed. This will allow the heifers to rebreed and calve with the cow herd the subsequent year.

The 69-day postpartum feeding period did not have a significant effect on weaning weight of calves. However, there was a significant breed x BCS at calving interaction on weaning weight. Weaning weights of calves from Hereford heifers, which calved in BCS < 5.0, were significantly less than for Hereford heifers calving with a BCS ≥ 5, or for Angus x Hereford heifers

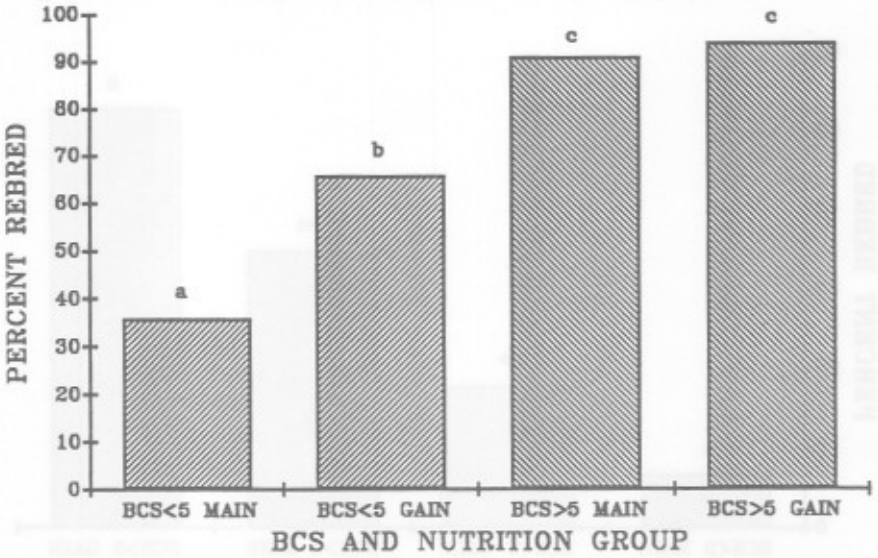

Figure 4. Percentage of heifers pregnant by 120 days after calving, when heifers calved with a BCS ≥ 5 or < 5 and were fed to gain or maintain weight. Bars with different letters (a,b,c) differ (P<.05).

calving with a BCS < 5 or ≥ 5. The weaning weights of calves from Angus x Hereford heifers were not affected by BCS at calving.

These results suggest that heifers should calve with a BCS ≥ 5 to have a majority of heifers pregnant by 120 days postpartum. A greater BCS at calving, and gaining weight after calving, is associated with more pregnant heifers by 90 days postpartum. Previous research reports on these heifers have demonstrated that a BCS of 6 at calving does not increase calving difficulty.

SUBSTITUTION OF CORN GLUTEN MEAL FOR SOYBEAN MEAL IN RANGE SUPPLEMENTS ON INTAKE AND UTILIZATION OF LOW QUALITY NATIVE GRASS HAY BY BEEF STEERS

C.A. Hibberd[1] and S.K. Martin[2]

Story in Brief

Five supplements containing blends of soybean meal and corn gluten meal were fed to cannulated (rumen, duodenum, ileum) beef steers to determine the effect of substituting ruminal escape protein for ruminal degradable protein on intake and utilization of low quality native grass hay (5.1% CP, 74.6% NDF). Supplements were formulated to supply 1.0 lb of supplemental crude protein in proportions of 100:0, 75:25, 50:50, 25:75 and 0:100 soybean meal:corn gluten meal on a protein basis. Hay organic matter intake decreased linearly from 25.3 lb/day for steers receiving 100% soybean meal to 21.7 lb/day for steers receiving 100% corn gluten meal. Corn gluten meal supplementation decreased organic matter flow to the duodenum, ileum and feces although organic matter digestibility at these sites was not altered. Digestible organic matter intake decreased linearly with increased proportions of corn gluten meal in the supplement. Duodenal nonammonia nitrogen flow peaked with 25% corn gluten meal but declined with further substitutions. Mean ruminal ammonia concentrations decreased from 1.08 to .26 mg/dl and hay disappearance from nylon bags decreased from 42.9 to 34.6% as supplemental corn gluten meal increased. This study suggests that the substitution of corn gluten meal for soybean meal in range supplements supplying 1.0 lb of supplemental protein decreases intake and utilization of hay and the flow of nitrogen to the small intestine. Consequently, ruminal escape protein should be added to range supplements only after ruminal degradable protein requirements have been met.

(Key Words: Beef Steers, Grass Hay, Soybean Meal, Corn Gluten Meal, Intake, Site of Digestion.)

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[1]Associate Professor [2]Graduate Student

Introduction

Beef cattle placed on dormant native grass pastures during the winter must receive supplemental protein to maintain performance. Traditionally, protein supplements are composed of soybean meal or cottonseed meal. These feeds are classified as ruminal degradable protein sources because most of their protein is degraded by microbial fermentation in the rumen. The major role of these protein sources is to supply ruminal ammonia to stimulate microbial activity to improve forage utilization and supply microbial protein for the cattle.

When beef cows are lactating, ruminal bacteria may not be capable of synthesizing enough protein to satisfy the protein requirement of the cow (NRC, 1985). Under these circumstances, protein sources that escape ruminal degradation can be used to supply additional protein to the small intestine. Recent evidence suggests that the use of escape protein in range supplements for lactating beef cows may improve cattle performance (Hibberd et al., 1988).

Because adequate ruminal ammonia concentrations are essential for forage utilization, feeding excess ruminal escape protein could limit ruminal ammonia concentrations and subsequent microbial activity. The level of supplemental ruminal escape protein that elicits this response is unknown. Consequently, the objective of this study was to evaluate the effect of substituting a ruminal escape protein source (corn gluten meal) for a ruminal degradable protein source (soybean meal) on intake and utilization of low quality native grass hay by mature beef steers.

Materials and Methods

Five mature Hereford steers (avg. weight 1,334 lb) were individually penned and fed coarsely chopped (2-inch) native grass hay (5.1% CP, 74.6% NDF). Steers were fitted with a ruminal cannulae and T-type cannulae in the proximal duodenum and terminal ileum. Five supplements were formulated to supply differing ratios of ruminal degradable to ruminal escape protein (Table 1). Corn gluten meal was substituted for soybean meal on a protein basis so that the proportion of supplemental protein from corn gluten meal increased linearly (0, 25, 50, 75 or 100% corn gluten meal protein). Minerals were added to supply adequate levels of calcium, phosphorus and salt. Sulfur was added to maintain a 12:1 supplemental nitrogen:sulfur ratio. Supplements were fed once daily (8:00 a.m.) and fresh hay was offered immediately after supplement consumption.

Treatments (supplements) were applied in a 5 x 5 Latin square design. Five 14-day periods consisted of eight days of adaptation and six days of sampling. Hay intake was measured on days 9 through 12. Duodenal, ileal and

Table 1. Composition and nutrient supply of supplements fed to beef steers consuming low quality native grass hay.

	Supplemental protein blend[a]				
Soybean meal, %	100	75	50	25	0
Corn gluten meal, %	0	25	50	75	100
Supplement composition, % (DM basis)					
Soybean meal	91.44	72.73	51.78	27.72	
Corn gluten meal		18.18	38.58	61.96	88.89
Mineral mix[a]	8.56	9.09	9.64	10.33	11.11
Nutrient supply, lb/day					
Feeding rate[b]	2.22	2.09	1.97	1.84	1.71
Crude protein[b]	1.01	.97	.96	.92	.82
Bypass protein[c]	.28	.34	.40	.44	.47
TDN[c]	.84	.85	.86	.88	.89

[a] Mineral mix contained 61.34% dicalcium phosphate, 29.21% trace mineralized salt, 8.28% sodium sulfate and 1.17% vitamin A premix (30,000 IU/g).
[b] Actual intake.
[c] Estimated intake.

fecal samples were collected six times during days 10 through 12 to represent every 4 h of a 24-h day. Digesta samples were composited by animal and freeze-dried. Digesta, hay and hay refusals were ground through a 1-mm screen prior to laboratory analysis. All samples were analyzed for dry matter, ash and acid insoluble ash. Acid insoluble ash was used as a digesta marker to calculate digesta flow and disappearance through the digestive tract.

Nylon bags containing ground hay were placed in the rumen of each steer on day 11 and incubated for 24 h to measure rate of hay disappearance. Ruminal samples were collected at 0, 1, 2, 3, 4, 5, 6, 9, 12 and 24 h postsupplementation on day 13. Ruminal samples were strained, acidified and frozen. Ruminal ammonia concentrations were determined at a later date.

Data were subjected to least squares analysis with the effects of period, animal and treatment included in the model. Orthogonal polynomials were used to evaluate linear, quadratic and cubic responses to the treatments (supplements).

Results and Discussion

Although supplements were formulated to supply equal quantities of crude protein/day, actual crude protein intake decreased with added corn gluten meal (Table 1). The substitution of corn gluten meal for soybean meal in the supplement decreased hay organic matter (OM) intake linearly (P<.002, Table 2). Although total tract OM digestibility appeared to decrease, the response was not significant (P=.60). Corn gluten meal supplementation decreased OM flow to the duodenum (P<.04) and ileum (P<.10). Because total OM intake decreased in a similar fashion, OM digestibilities at the duodenum and ileum were not affected. Digestible OM intake, however, decreased (linear, P<.001)

Table 2. Effect of supplemental protein source on organic matter (OM) intake and digestion by beef steers fed low quality native grass hay.

	Supplemental protein blend					
Soybean meal, %	100	75	50	25	0	
Corn gluten meal, %	0	25	50	75	100	SE
Intake, lb/day						
Hay OM[a]	25.3	24.8	23.1	23.3	21.7	.72
Total OM[a]	27.3	26.6	24.8	24.9	23.2	.72
Digestible OM[a]	14.2	13.7	12.8	12.8	11.9	.40
Duodenal						
OM flow, lb/day[a]	14.7	15.2	14.2	13.7	13.1	.67
OM digestibility, %	46.1	42.8	42.2	44.8	43.4	1.59
Ileal						
OM flow, lb/day[b]	13.3	12.9	13.1	12.2	11.8	.68
OM digestibility, %	51.4	51.4	46.4	50.7	49.2	2.05
Total tract						
OM flow, lb/day[a]	13.1	12.9	12.0	12.1	11.3	.62
OM digestibility, %	52.1	51.4	51.4	51.3	50.8	1.58
Small intestine digestibility						
OM, % of entering	10.0	15.1	7.3	10.2	9.9	3.65
Large intestine digestibility						
OM, % of entering	1.1	-.2	7.3	1.1	3.4	3.71

[a] Significant linear effect (P<.05).
[b] Significant linear effect (P<.10).

as the proportion of supplemental corn gluten meal increased. Digestible OM intake is reflective of energy intake suggesting that the use of corn gluten meal as a supplemental protein source decreased total energy intake under the conditions of this study.

Total nitrogen intake decreased linearly (P<.05) as the proportion of supplemental corn gluten meal increased (Table 3). Duodenal nonammonia nitrogen (NAN) flow peaked (quadratic, P=.06) with 25% corn gluten meal and declined with additional corn gluten meal. Duodenal NAN flow was positively correlated with nitrogen intake (r=.80). In contrast, duodenal NAN flow was negatively correlated with bypass protein intake (r=-.68). Because duodenal nitrogen flow was not partitioned, the effect of bypass protein intake on nonmicrobial nitrogen flow to the duodenum is unknown. If microbial growth was limited by inadequate ruminal degradable protein, microbial protein flow to the duodenum could have been decreased. Total tract NAN digestibility decreased (linear, P<.05) with added corn gluten meal. A portion of this response may be due to decreased corn gluten meal protein digestibility. Decreased protein intake with added corn gluten meal would also be expected to decrease apparent protein digestibility because of the contribution of metabolic fecal nitrogen.

Mean ruminal ammonia concentrations decreased linearly (P<.003) as corn gluten meal was substituted for soybean meal (Table 3). Ruminal ammonia concentrations peaked at 2 h postsupplementation when 100% soybean meal was fed (Figure 1). Maximum ruminal ammonia concentrations occurred later

Table 3. Effect of supplemental protein source on nitrogen utilization, ruminal ammonia concentrations and nylon bag disappearance in beef steers fed low quality native grass hay.

	Supplemental protein blend					
Soybean meal, %	100	75	50	25	0	
Corn gluten meal, %	0	25	50	75	100	SE
Total N intake, lb/d[b]	.34	.33	.32	.31	.29	.005
Duod NAN[a] flow, lb/d[c]	.39	.42	.40	.37	.35	.016
Fecal NAN flow, lb/d	.20	.20	.20	.20	.19	.010
Total NAN dig, %[b]	42.6	38.1	35.9	35.4	34.6	2.16
Ruminal ammonia, mg/dl[b]	1.08	.69	.63	.41	.26	.162
Nylon bag DM disappearance, %[b]	42.9	37.2	36.1	36.5	34.6	1.88

[a] NAN = Non-ammonia nitrogen.
[b] Significant linear effect (P<.05).
[c] Significant quadratic effect (P=.06).

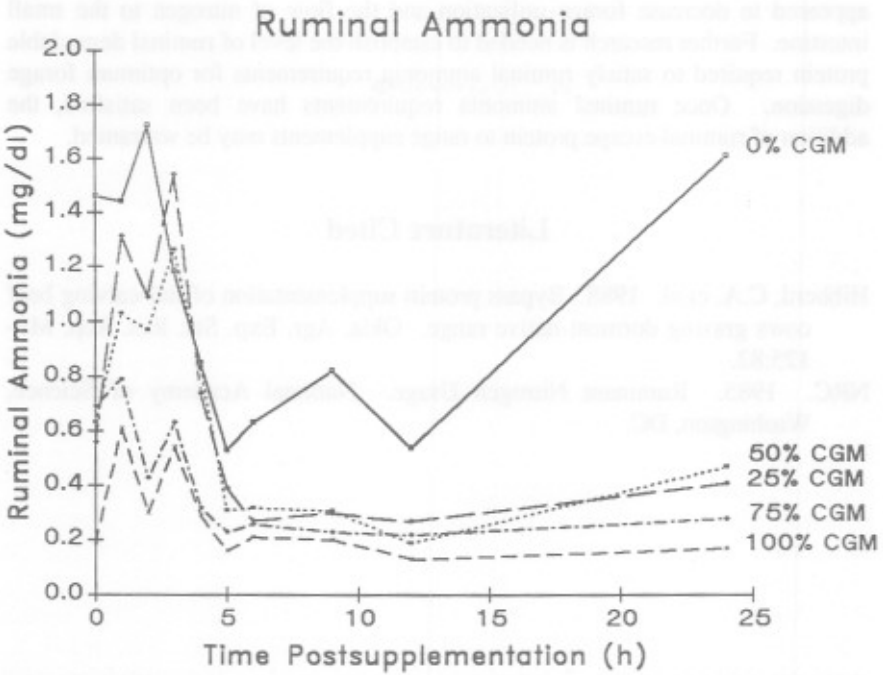

Figure 1. Effect of supplemental protein source on diurnal variation in ruminal ammonia concentrations in beef steers fed low quality native grass hay. Soybean meal was replaced by a proportion of corn gluten meal (CGM) to supply 1.0 lb supplemental crude protein.

(3 h postsupplementation) when the supplement contained 25 or 50% corn gluten meal. Ruminal ammonia concentrations remained below .4 mg/dl for 19 h of the 24-h sampling period when corn gluten meal comprised 25% or more of the supplement. The ruminal protein degradability of corn gluten meal is 35% compared to 72% for soybean meal (NRC, 1985). Inadequate ruminal ammonia concentrations may have limited ruminal microbial activity resulting in reduced digestibility. Decreased disappearance of dry matter (linear, $P<.01$) from nylon bags suspended in the rumen with increased corn gluten meal supports this theory.

Based on the results of previous research (Hibberd et al., 1988), there may be some benefit from adding ruminal escape protein feeds such as corn gluten meal or blood meal to range supplements for lactating beef cows. This study suggests that ruminal escape protein should not be substituted for ruminal degradable protein sources such as soybean meal without considering the supply of ruminal ammonia. In this study, inadequate ruminal degradable protein

appeared to decrease forage utilization and the flow of nitrogen to the small intestine. Further research is needed to establish the level of ruminal degradable protein required to satisfy ruminal ammonia requirements for optimum forage digestion. Once ruminal ammonia requirements have been satisfied, the addition of ruminal escape protein to range supplements may be warranted.

Literature Cited

Hibberd, C.A. et al. 1988. Bypass protein supplementation of fall-calving beef cows grazing dormant native range. Okla. Agr. Exp. Sta. Res. Rep. MP-125:82.

NRC. 1985. Ruminant Nitrogen Usage. National Academy of Science, Washington, DC.

REPRODUCTIVE PERFORMANCE OF FIRST CALF HEIFERS SUPPLEMENTED WITH AMINO ACID CHELATE MINERALS

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Story in Brief

Forty 2- and 3-year-old heifers nursing their first calves were utilized to determine the response to a mineral supplementation program of amino acid chelates of copper, zinc, magnesium, manganese and potassium relative to inorganic sources. Measurements included estrus activity as determined by standing heat, first service artificial insemination conception rate, conception rate at the end of the breeding season, days from calving to conception of second calf and weaning weight of first calves. At the start of the trial (approximately 45 days post-calving), the cow-calf pairs were randomly assigned to a mineral supplementation program by breed, calving date and body condition score to minimize differences among treatments. Estrus was synchronized to facilitate artificial insemination 70 days post-calving. Three females were removed from the trial due to matters unrelated to the study. Fourteen of the 18 females receiving amino acid-mineral chelates were observed in standing heat within 72 hours of removal of the synchronizing agent implant and 10 of 14 settled on first artificial insemination. Only 8 of 19 females receiving inorganic minerals were observed in standing heat after implant removal and two settled on first service. Sixteen of 18 chelate-supplemented females and 17 of 19 inorganic supplemented females conceived during the 60-day breeding season; however, the inorganic-supplemented females conceived an average of 19 days later than the chelate-supplemented females.

(Key Words: Cattle, Reproduction, Estrus, Minerals.)

Introduction

The Oklahoma State University Beef Cattle Center herd currently consists of over 250 head of producing females of six different breeds - Angus, Polled Hereford, Horned Hereford, Brangus, Limousin and Simmental. Prior to 1986, despite feeding protein and energy levels in excess of 1984 NRC requirements,

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fertility as measured by percentage of females pregnant 90 days after breeding season was relatively low (less than 75%).

An intense investigation was initiated in 1986 to identify the reason for the fertility problems. Soil samples (Table 1), forage samples (Table 2) and feed grains were analyzed for nutrient composition, especially mineral analyses. Initial blood serum analyses are shown in Table 3. Low levels of calcium, phosphorus, magnesium, selenium, copper and zinc were noted. Liver copper levels of a Hereford cow slaughtered was 8.4 ppm (normal > 40 ppm). An Angus calf which died shortly after birth had a liver copper level of 62 ppm (normal > 300 ppm). One of the first clinical symptoms in a copper deficient cow herd is achromotrichia (loss of hair color). Angus cattle typically will exhibit brown pigmentation rather than a black color particularly around the eyes, tips of the ears and over the top, especially behind the shoulders. This condition was prevalent in the Angus herd. In addition, feet and leg problems, reduced weaning weights and general growth and respiratory edema were noted. A mineral mix of 66% dicalcium phosphate, 29% trace mineralized salt and 5% cottonseed meal appeared to improve visually indicated traits. This trace mineral salt contained salt, manganous oxide, iron oxide, ferrous carbonate, copper oxide, ethylenediamine dihydroiodide, zinc oxide, cobalt carbonate and technical white mineral oil. The guaranteed analysis of the trace mineral salt is shown in Table 4.

As a direct result of preliminary findings and a desire to increase the levels of trace minerals, all animals in the herd were placed on a free choice mineral supplementation program consisting of Bluebonnet Tech-Master mineral in a 50:50 mixture with salt. This Tech-Master mineral contains major minerals,

Table 1. Soil mineral composition.

Item	ppm
Phosphorus	3.1
Potassium	141.7
Magnesium	347.1
Calcium	923.0
Sulfur	9.5
Zinc	1.6
Manganese	14.3
Iron	60.9
Copper	1.8
Boron	.5

Table 2. Forage mineral composition.

Item	Analysis
Phosphorus, %	.08
Potassium, %	1.06
Magnesium, %	.10
Calcium, %	.38
Sodium, %	.02
Iron, ppm	122
Aluminum, ppm	103
Manganese, ppm	52
Boron, ppm	14
Copper, ppm	5
Zinc, ppm	21

Table 3. Initial blood serum analyses.

Mineral	Level	Normal range
Calcium, mg/dl	6.6	9 - 12
Phosphorus, mg/dl	3.4	4.5 - 7
Magnesium, mg/dl	1.4	2 - 3
Potassium, mg/dl	19.4	15 - 23
Selenium, ppm	.047	.07 - .3
Copper, ppm	.217	.7 - 1.0
Zinc, ppm	.913	1.5 - 1.8
Iron, ppm	1.317	.9 - 2.5
Manganese, ppm	.039	.01 - .03

inorganic trace minerals, Albion's patented protein chelated trace minerals plus vitamins A, D_3 and E (Table 5). A 3-oz intake of this mineral salt supplement should supply 63 mg of copper.

Subsequent blood serum analysis suggested that the trace mineral supplementation program had increased blood serum copper levels. All tested animals had an average blood serum copper level of .8 ppm copper, well within the normal range and a 4-fold increase from the first analysis (Table 3).

The objective of this study was to investigate the effectiveness of free choice supplementation of a combination of chelated and inorganic trace

Table 4. Inorganic trace mineral salt composition.

Item	Content
Salt	92-97%
Manganese	>.25%
Iron	>.20%
Copper	>.033%
Iodine	>.007%
Zinc	>.005%
Cobalt	>.0025%

Table 5. Mineral and vitamin composition of Bluebonnet Tech-master mineral.

Component	Content
Calcium	8-9%
Phosphorus	>8.0%
Potassium	>3.0%
Magnesium	>4.75%
Zinc	> .7%
Manganese	> .3%
Copper	> .2%
Cobalt	> .0025%
Iodine	> .001%
Selenium	.002%
Vitamin A	>280,000IU/lb
Vitamin D_3	>59,000IU/lb
Vitamin E	>400IU/lb

minerals in enhancing bovine reproductive performance and calf weaning weights.

Material and Methods

Forty 2- and 3-year-old first calf heifers located at the OSU Purebred Beef Center Range were utilized in the study. Five different breeds were represented:

Angus (15), Horned Herefords (12), Polled Herefords (5), Brangus (5) and Simmental (3). All females calved between January 31, 1988 and March 5, 1988. In addition, all females utilized in the study had free access to a 50% salt:50% Tech-Master mineral supplement consisting of Albion amino acid chelates, inorganic trace minerals, major minerals plus Vitamin A, D_3 and E (Table 5) for one year prior to the start of the study.

Prior to the trial, all females were maintained on dormant Old World Bluestem pasture and supplemented with 20 lb of mature native range grass hay (6% CP, 45% TDN) and 5 lb of 20% CP range protein supplement per head daily plus free access to the 50% salt:50% Tech-Master mineral supplement. The base diet contained 31 ppm zinc, 81 ppm manganese, 5.6 ppm copper and 2.3 ppm molybdenum. The copper:molybdenum and zinc:copper ratios were 2.4 and 5.6, respectively.

A schematic diagram of the trial is presented in Figure 1. On April 4 (start of the trial), the cow-calf pairs were assigned randomly to one of two mineral supplementation programs by breed, calving date and body condition score to minimize the differences among treatments. In addition, the free choice 50% salt:50% Tech-Master mineral supplement consisting of Albion amino acid chelates, inorganic trace minerals, major minerals plus Vitamins A, D_3 and E was removed from the pasture and replaced with a mineral supplement containing 66% dicalcium phosphate, 29% salt and 5% cottonseed meal.

A 90 acre Old World Bluestem pasture was split into two 45 acre pastures by electric fence. All females remained on the base nutritional program (Old World Bluestem pasture, 20 lb of native grass hay, 5 lb of a 20% CP range supplement). The mineral treatments consisted of amino acid chelates (copper, zinc, manganese, magnesium and potassium) vs inorganic trace minerals

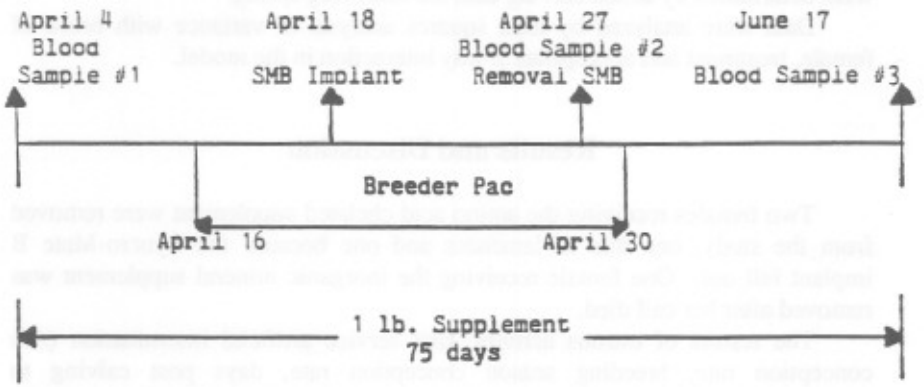

Figure 1. Schematic design of trial, SMB is Synchro-Mate B.

(copper sulfate, zinc sulfate, manganese oxide, magnesium oxide and potassium chloride) to supply identical levels of copper, zinc, magnesium, manganese and potassium. The mineral mixes were incorporated into a 20% CP range pelleted supplement fortified with 14,687 IU Vitamin A/lb, 3,125 IU Vitamin D_3/lb, 150 IU Vitamin E/lb and 2.5 mg Selenium/lb. The total mineral analyses of both treatment diets are presented in Table 6. Both treatment supplements were fed at the rate of 1 lb per day to supply 178 mg copper, 275 mg manganese, 563 mg zinc, 1,352 mg magnesium and 823 mg potassium. Including the basal nutritional program, the diets were formulated to supply a total of 18 ppm copper, 71 ppm zinc and 89 ppm manganese. The supplemental native grass hay and 5 lb of 20% CP range supplement were discontinued on April 30 (Figure 1). The 1 lb per head daily treatment supplements were fed until June 15, 1988.

An Albion Breeder Pac was utilized 14 days prior to breeding at the level of 2 oz per head per day in 1 lb ground corn. The amino acid chelated group received the standard Albion Breeder Pac formula which contains 5.5% Mg, 3.8% K, 400,00 IU Vitamin A/lb, 85,000 IU Vitamin D/lb, 570 IU Vitamin E/lb as well as 21 mg copper, 44 mg manganese and 110 mg zinc per oz in an amino acid chelate form. The inorganic trace mineral group received a similar Breeder Pac except the copper, manganese, zinc, magnesium and potassium amino acid chelates were replaced by inorganic sources (Table 6).

The Breeder Pac was supplied to treatment groups from April 17 to April 30. On April 17, all females were injected with 2 ml of Synchro-Mate B Injectable (Norgestomet plus estradiol valerate) and implanted with the Synchro-mate B implant (Norgestomet). The implant was removed on April 27 (Day 10). Females were observed four times daily for signs of estrus starting on April 28. Females exhibiting estrus were artificially inseminated approximately 12 h after observed heat. Actual conception and days post calving to conception were determined by actual calving date the following spring.

Data were analyzed by least squares analysis of variance with breed of female, treatment and appropriate 2-way interaction in the model.

Results and Discussion

Two females receiving the amino acid chelated supplement were removed from the study, one due to lameness and one because the Syncro-Mate B implant fell out. One female receiving the inorganic mineral supplement was removed after her calf died.

The results of estrous activity, first service artificial insemination (AI) conception rate, breeding season conception rate, days post calving to conception and 205-day weaning weight of first calves are presented in Table 7. The amino acid chelate supplemented cows exhibited more standing heats and

Table 6. Treatment group levels (mg) of copper, manganese, zinc, magnesium and potassium.

	1 lb. 20% Supplement		2 oz Breeder Pac		Total supplement	
	Chelated	Inorganic	Chelated	Inorganic	Chelated	Inorganic
Cu S04	——	178 mg	——	48 mg	——	226 mg
Cu Chelate	154 mg	24 mg	45 mg	3 mg	199 mg	27 mg
MnO	——	275 mg	——	80 mg	——	355 mg
Mn Chelate	231 mg	44 mg	65 mg	15 mg	296 mg	59 mg
ZnSO4	——	563 mg	——	258 mg	——	821 mg
Zn Chelate	466 mg	97 mg	233 mg	25 mg	699 mg	122 mg
MgO	——	1352 mg	——	3660 mg	——	5012 mg
Mg Chelate	142 mg	1210 mg	368 mg	3292 mg	510 mg	4502 mg
KCl	——	823 mg	——	2452 mg	——	3275 mg
K Chelate	142 mg	681 mg	368 mg	2084 mg	510 mg	2765 mg

Table 7. Estrous activity, first service conception rate, breeding season conception rate, days post calving to conception and 205-day adjusted weaning weights.

Item	Mineral supplements	
	Chelates	Inorganic
Females, total	18	19
Females, exhibiting estrus	14	8
Females exhibiting estrus, %	77.8[a]	42.1[b]
Females, first service conception	10	2
Females exhibiting estrus that conceived on first services, %	71.4[a]	25.0[b]
Total females conceiving on first service, %	55.6[a]	10.5[b]
Females conceiving during breeding season	16	17
Days post calving to conception	86	105
Body condition score	5.0	5.3
Weaning weight (205 day), lb	575[c]	527[d]

[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<.01).

had a greater percentage of females conceiving on first service than the inorganic mineral supplemented cows. Fourteen of the 18 amino acid chelate supplemented cows exhibited a standing heat after removal of the Syncro-Mate B implant. Of the 14 females that cycled, 10 conceived on first AI service. The reproductive performance of the females receiving the inorganic trace mineral supplement was poorer (P<.05). Only 8 of the 19 females receiving inorganic trace minerals cycled after removal of the Synchro-Mate B implant. In addition, only two of those eight conceived. Therefore, 55.6% of the amino acid chelate supplemented cows conceived compared with 10.5% of the inorganic trace mineral supplemented females on first service (P<.05).

Addition of increased trace mineral supplementation to all females improved reproductive performance during the breeding season. Only two females in each treatment group failed to conceive during the 60-day breeding season. The supplementation trial started approximately 45 days post calving, the first AI service was 70 days post calving and the last possible AI breeding date was 130 days post calving. The average days post calving to actual conception was 86 days for the chelate supplemented females as compared to 105 days for the inorganic mineral supplemented females.

The females first calf weaning weights were adjusted for age in days to a 205-day equivalent. No age of dam corrections were made since all females were nursing their first calf. The amino acid chelate supplemented females weaned 47 lb more calf than the inorganic supplemented females ($P<.01$). The reason for the magnitude of this difference is not apparent. A large breed effect ($P<.01$) was noted for weaning weight.

The results of this trial indicate early breeding season estrus activity and conception rate may be improved by the addition of amino acid chelated minerals to a mineral program; however, total breeding season conception rate was not improved over addition of inorganic traced minerals at higher levels than commonly found in commercial mineral mixes. Though the number of females were limited, the differences in early reproductive performance were large. Previous indications of trace mineral deficiencies were noted and may account for the reduced reproductive performance early in the breeding season.

Literature Cited

NRC. 1984. Nutrient Requirements of Beef Cattle (6th Ed.). National Academy Press, Washington, DC.

EFFECTS OF LACTATIONAL STATUS ON FORAGE INTAKE, DIGESTIBILITY AND PARTICULATE PASSAGE RATE OF BEEF COWS SUPPLEMENTED WITH SOYBEAN MEAL, WHEAT MIDDLINGS AND CORN/SOYBEAN MEAL

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Story in Brief

Sixteen mature lactating and 16 early pregnant Hereford and Angus x Hereford beef cows were used to determine effects of different supplements and lactational status on forage intake, digestibility and particulate passage rate. Supplement treatments were: control or equal daily amounts of protein from soybean meal, wheat middlings or a blend of corn/soybean meal. Cows fed soybean meal consumed more hay dry matter and had greater hay digestibility than cows on all other treatments. Mean hay intake (pounds hay/pound body weight) was 1.93, 2.16, 1.91 and 1.88% while hay dry matter digestibility was 52.2, 60.7, 55.2 and 52.7% for control, soybean meal, wheat middlings and corn/soybean meal supplements, respectively. Passage rate was 3.18, 3.58, 3.68 and 3.72% per hour for the same treatments. Lactating cows consumed more hay dry matter (2.11 versus 1.86 pounds hay/pound body weight) than nonlactating cows but hay dry matter digestibility (54.9 versus 55.5%) and particulate passage rate (3.46 versus 3.62% per hour) were not affected by lactational status. No interaction was observed between lactational status and supplement type for hay dry matter intake, digestibility or particulate passage rate. There appears to be no effect of physiological status on utilization of protein or energy supplements when nonlactating cows are nonpregnant or in early gestation.

(Key Words: Cows, Lactation, Wheat Middlings, Supplementation, Forage Intake.)

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Introduction

Wheat middlings (WM) are a by-product of the flour milling industry made up of fine particles of wheat bran, wheat shorts, wheat germ, wheat flour and some of the offal from the tail of the mill. Wheat middlings contain approximately 16% crude protein (CP) and a maximum of 9.5% fiber (AAFCO, 1987). In studies with pregnant, nonlactating spring calving cows, Lusby and Wettemann (1988b) and Cox et al. (1989) found significant increases in weight gains from November to calving when WM were fed at isonitrogenous levels to soybean meal (SBM). After calving however, cow weight changes were similar for SBM and WM. When the same supplements were fed throughout the winter to lactating, fall calving cows (Lusby and Wettemann, 1988a; Ovenell et al., 1989) weight changes were similar for SBM- and WM-supplemented cows, in agreement with results from spring calving cows following parturition. These studies suggest that weight change responses for protein and energy supplements may differ with lactational status. Results from numerous studies indicate that moderate protein, high fiber energy sources have more favorable effects on forage intake and digestibility than energy supplements. The objective of this study was to compare effects of SBM, WM and corn/SBM supplements on forage intake, digestibility and particulate passage rate in lactating and nonlactating cows.

Materials and Methods

Sixteen lactating and 16 nonlactating early pregnant Hereford and Hereford x Angus cows were individually fed prairie hay plus supplement for three 10-day periods for a total of 24 observations on each of four treatments. In period one, cows were randomly allotted within breed, age, body weight and condition and pregnancy status to four treatment groups. In periods two and three, cows were realloted by the above criteria plus previous treatment, so that each cow was on three of the four treatments. Treatments were control (no supplement), SBM, WM and corn/SBM. Supplement composition, amount fed and chemical composition of supplements are presented in Tables 1 and 2. Supplements were fed once daily and provided equal daily amounts of supplemental CP. A 50:50 mixture of salt and dicalcium phosphate was provided free choice to all cows. Cows were housed individually with ad libitum access to prairie hay for 6 h/day.

Voluntary intake of hay was measured directly for 10 days following a 7-day adaptation to supplements. Fecal output was estimated using chromic oxide (Cr at .02 lb/day) as an indigestible marker. Chromic oxide was mixed with ground corn at a concentration of .02 lb per .25 lb of corn and fed with the supplements (.5 lb WM to control cows) once daily from day 1 through

Table 1. Supplement composition and amounts fed (DM basis).

	Control (no supp.)	Soybean meal	Wheat middlings	Corn/ soybean meal
Ingredients, %:				
Soybean meal		90.8		21.9
Wheat middlings			98.2	
Corn, ground				76.3
Dicalcium phosphate		7.7		1.8
Limestone			1.7	
Potassium chloride		1.5		
Amount fed, lb/day[a]		3.0	7.5	7.5
Nutrients supplied per day[b]				
CP from supp., lb	0	1.2	1.2	1.2
ME, Mcal/day[c]	17.0	26.0	27.3	26.2
ME, Mcal/lb BW[d]	1.6	2.5	2.6	2.5
TDN, lb (expected)[e]	10.3	13.7	14.8	15.9
TDN, lb (observed)[f]	10.3	15.8	16.6	15.9

[a] As-fed basis.
[b] Hay included in all calculations.
[c] ME = .82(DDMI · 2 Mcal/lb). ME = metabolizable energy; DDMI = daily dry matter intake.
[d] Total ME/constant BW (1034 lb).
[e] Total Digestible Nutrients (TDN). NRC, 1984.
[f] Total ME/1.645. NRC, 1984.

Table 2. Chemical composition (% of DM) of supplements and prairie hay.

Item[a]	Hay	Soybean meal	Wheat middlings	Corn/ soybean meal
Dry matter	93.5	92.2	90.1	90.8
Ash	-	15.5	7.2	4.8
Crude protein	4.9	43.3	17.3	17.3
Neutral detergent fiber	77.6	10.2	38.7	43.6
Acid detergent fiber	46.6	8.1	8.0	4.7
Starch	-	0	13.1	29.6
Crude fiber	-	5.2	7.7	3.2

[a] Actual chemical analyses.

day 13 of each period. Fecal grab samples were obtained at 8 a.m. and 4 p.m. from day 10 to day 14, composited and used to estimate digestibility. Samples were obtained at 24, 36, 48, 60, 72 and 96 h after terminating Cr dosing to determine particulate passage rate based on the decline in Cr concentration of fecal DM. Total feces were collected from Hereford and Angus x Hereford steers fed prairie hay (ad libitum) and 3 lb WM (five steers in periods one and two and four in period three) to determine marker recovery. Feces were obtained during the same time cows were being sampled.

Hay and supplement samples were analyzed for CP, neutral detergent fiber and acid detergent fiber. Fecal Cr concentrations were determined by atomic absorption spectrophotometry. Fecal output was calculated from Cr concentration and was corrected for Cr recovery which averaged 90.0, 95.3 and 92.3% for periods one, two and three, respectively. Particulate passage rate was estimated by regressing the natural logarithm of fecal Cr concentration against time following withdrawal of Cr from the diet.

Data were analyzed by least squares analysis of variance with a model that included treatment, cow (within lactational status), period, lactational status and a lactational status by treatment interaction. Since there was no interaction, the model was modified to analyze differences between treatments and included cow, period and treatment. Data were pooled across periods for analysis as there was no interaction between period and treatment or lactational status. The least significant difference technique was used to determine differences in means ($P<.05$).

Results and Discussion

Intake, digestibility, particulate passage rate and fecal output measurements are shown in Table 3. Soybean meal supplementation increased ($P<.001$) both hay DM intake and digestibility ($P<.01$) compared with other supplements. Supplementation increased ($P<.001$) total diet DM digestibility (supplement + hay) but no differences between supplements were noted. Fleck et al. (1988) reported that hay DM intake and digestibility were higher for SBM than corn gluten feed supplements. When low-quality forages are supplemented with a high-protein, oilseed meal-based supplement, forage intake and utilization usually increases.

Hay DM intake and DM digestibility tended to be greater for WM than corn/SBM, possibly because of the lower starch content of WM. The supplements used in this study contained 29.6, 13.1 and 0% starch for corn/SBM, WM and SBM, respectively. High levels of starch generally decrease forage intake and digestibility (Fleck et al., 1988). Increased starch in the diet decreases ruminal pH, thus having a detrimental effect on

Table 3. Least squares means for voluntary forage intake, forage digestibility and particulate passage rate.

	Treatment			
	Control (no supp.)	Soybean meal	Wheat middlings	Corn/ soybean meal
Cow weight, lb	1038	1030	1036	1032
Hay DM intake				
Amount, lb/d	20.0[a]	22.2[b]	19.8[a]	19.4[a]
% of body weight/d	1.93[a]	2.16[b]	1.91[a]	1.88[a]
DM digestibility, %				
Hay	52.2[a]	60.7[b]	55.2[a]	52.7[a]
Total	52.2[a]	63.3[b]	62.4[b]	60.7[b]
Particulate flow rate, %/h	3.18[a]	3.58[b]	3.68[b]	3.72[b]
Fecal DM output, lb/day				
Hay	9.7	8.8	8.8	9.2
Total	9.7	9.2	9.9	10.3

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

cellulolytic bacteria. Also, it has been suggested that starch alters fiber digestion by increasing digestion lag time. Particulate passage rate was lowest ($P<.01$) for cows on the control diet but not different among cows being fed other supplements. Cows fed supplements with greater amounts of starch had ($P<.09$) faster passage rates. Increased lag time for WM and corn/SBM supplements as compared to SBM may partially explain the lower hay DM intake and digestibility noted.

Studies by Cox et al. (1989) and Lusby and Wettemann (1988b) indicate that cow performance is similar for cows fed WM or SBM supplements following parturition but beneficial effects of additional energy from WM on cow weight and condition changes occur before calving. Lusby and Wettemann (1988b) reported similar performance for cows fed WM and corn/SBM supplements indicating that the greater fiber content and lower energy content of WM compared to corn/SBM can be apparently offset by more favorable effects on forage intake and/or digestibility.

Results of forage intake, digestibility, particulate passage rate and fecal output measurements of lactating vs nonlactating cows are shown in Table 4. Hay DM intake and fecal output were greater ($P<.05$) for lactating than nonlactating cows. Many dairy researchers have reported greater DM intake

Table 4. Voluntary forage intake, forage digestibility and particulate passage rates of lactating and nonlactating cows.

	Lactating	Nonlactating
Hay DM intake		
Amount, lb/day	20.9[a]	20.0[b]
% of body weight/day	2.11[a]	1.86[b]
DM digestibility, %		
Hay	54.9	55.5
Total	59.4	59.9
Particulate flow rate, %/h	3.46	3.62
Fecal DM output, lb/day		
Hay	9.5[c]	8.8[d]
Total	10.1[c]	9.5[d]

[a,b] Means in the same row with different superscripts differ (P<.01).
[c,d] Means in the same row with different superscripts differ (P<.05).

by lactating vs nonlactating cows. Increased intake during lactation may be a function of metabolic changes and/or hypertrophy of the digestive tract.

Hay DM digestibility and particulate passage rate were similar for both lactating and nonlactating cows. There was no supplement by lactational status interaction (P>.50). Results of this study do not explain why cow weight changes were different for nonlactating and lactating cows fed SBM or WM supplements on winter range. In pasture trials by Lusby and Wettemann (1988b) and Cox et al. (1989) cows were in the last trimester of gestation while nonlactating cows used for the intake and digestion study were in early pregnancy. Digestive kinetics of the cow would not be expected to be affected by the fetus during early gestation.

In conclusion, WM appear to be utilized by cows with an efficiency at least equal to that found for an isonitrogenous supplement of corn and SBM. While lactating cows consume more forage than nonlactating cows, there appears to be no effect of physiological status on utilization of protein or energy supplements when nonlactating cows are nonpregnant or in early gestation.

Literature Cited

Association of American Feed Control Officials, Inc. (AAFCO). 1987. Official publication. p. 189. Charlston, W. Va.

Cox, D.A. et al. 1989. Wheat middlings versus soybean meal and two wheat middlings/soybean meal supplements for wintering spring calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-127:41.

Fleck, A.T. et al. 1988. Effects of corn gluten feed on forage intake, digestibility and ruminal parameters of cattle fed native grass hay. J. Anim. Sci. 66:750.

Lusby, K.S. and R.P. Wettemann. 1988a. Value of wheat middlings as a winter supplement for fall calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-125:69.

Lusby, K.S. and R.P. Wettemann. 1988b. Wheat middlings vs soybean meal and corn/soybean meal supplements of two protein levels for wintering spring calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-125:72.

NRC. 1984. pp 2-3. Nutrient Requirements of Beef Cattle (6th Ed.). National Academy Press, Washington, DC.

Ovenell, K.H. et al. 1989. Wheat middlings versus soybean meal and two wheat middlings/soybean meal supplements for wintering fall calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-127:46.

THE VALUE OF WHEAT MIDDLINGS AS A SUPPLEMENT FOR WINTERING SPRING CALVING BEEF COWS GRAZING NATIVE RANGE

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

Story in Brief

Ninety-six spring calving, two-to-four year old Hereford and Hereford x Angus cows were used to determine the amount of wheat middlings needed to replace 3 pounds of soybean meal as a supplement for cows wintered on dormant native tallgrass range. Supplements were soybean meal (3 pounds/day) and wheat middlings fed at 5.0, 6.25 and 7.5 pounds per day. Soybean meal and the 7.5 pound level of wheat middlings provided 1.2 pounds of daily crude protein. Cow weight changes from November 1, 1988 to calving were 76, 45, 62 and 102 pounds for soybean meal, 5.0, 6.25 and 7.5 pounds of wheat middlings, respectively. Cow weight changes from just prior to calving to the end of supplementation (April 18) were -179, -186, -168 and -194 lb for the same treatments. From November 1, 1988 to October 11, 1989 cow weight changes were 90, 74, 110 and 103 pounds. Weaning weights and rebreeding rates were not significantly affected by treatment although weaning weights tended to be highest for calves of cows fed 7.5 pounds of wheat middlings and rebreeding rates were lowest for soybean meal-supplemented cows. A linear increase in precalving cow weight change indicated that the protein and/or energy in wheat middlings is well utilized. However, after parturition, cow weight change was not affected by increasing amounts of wheat middlings. Wheat middlings may be fed at less than isonitrogenous levels to soybean meal to produce equal performance from spring calving beef cows when forage supplies are adequate.

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

Introduction

Wheat middlings (WM), a by-product of the flour milling industry, comprise the layer of the wheat kernel just inside the outer bran covering.

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They contain granular particles containing different proportions of endosperm, bran, ground weed seeds and other nonwheat materials. Wheat middlings have approximately 16% CP and a maximum of 9.5% crude fiber (AAFCO, 1987). Fiber from bran type feeds has been shown to be highly digestible and to be an excellent source of supplemental energy for beef cattle. Lusby and Wettemann (1988b) and Cox et al. (1989) found that spring calving cows fed WM at isonitrogenous levels to cows fed 3 lb of soybean meal had improved precalving weight changes, increased weaning weight of calves and improved rebreeding rates. The objective of this study was to determine the daily amount of WM needed to produce equivalent winter weight change and reproductive performance to SBM, fed to provide 1.2 lb of daily CP in spring calving beef cows.

Materials and Methods

Ninety-six, two-to-four year old, spring calving Hereford and Hereford x Angus cows wintered on dormant native tallgrass range (3.4% CP) were fed supplements to provide increasing amounts of daily CP and equal daily amounts of calcium, phosphorus, potassium and vitamin A. Treatments were SBM (3.0 lb/day) or WM fed at 5.0, 6.25 or 7.5 lb/day. SBM at 3.0 lb/day and WM at 7.5 lb/day each provided 1.2 lb of CP. Composition of supplements and daily amounts fed are summarized in Table 1. Supplementation began on November 1, 1988. Feeding rates were increased on November 29, 1988. All cows grazed in a single pasture and were gathered 6 days per week and individually fed supplements in covered stalls. Supplements were prorated for a 6-day-per-week feeding schedule. Grass hay (6% CP) was fed during March and early April when snow or ice covered the ground, extreme cold was encountered or when available forage was inadequate to maintain the cow herd.

Cow weights and body condition scores (score of 1 = very thin to 9 = very fat) were taken after overnight withdrawal from feed and water at 28-day intervals until calving, at which time measurements were taken every 14 days. The 14-day weight nearest to calving was used as the final pregnant weight. Supplement feeding was terminated on April 18, 1989. From April to weaning in October, cow weights and body condition scores were taken at 28-day intervals.

Calf birth date and weight, sex, monthly weight changes and weaning weight were recorded. Calves were weaned on October 11, 1989. Calf birth and weaning weights were adjusted for age of dam and calf sex.

Cows were bred by natural service to Hereford x Angus bulls from May 8, 1989 to July 17, 1989 (70 days). Pregnancy was determined by rectal palpation at weaning.

Table 1. Composition of supplements and daily feeding rates (DM basis).

	Soybean Meal, lb/d	Wheat middlings, lb/d		
	3.0	5.0	6.25	7.5
Ingredients, %				
Soybean meal	90.8			
Wheat middlings		95.2	97.2	98.24
Dicalcium phosphate	7.7	2.7	.98	
Potassium chloride	1.45	1.09	.38	
Limestone		.98	1.41	1.74
Vitamin A[a]	.05	.03	.03	.02
Crude protein, %	44.45	16.80	17.16	17.34
Feeding rates per day, lb[b]				
11/01/88 to 11/28/88	2.0	3.3	4.2	5.0
11/29/88 to 4/18/89	3.0	5.0	6.25	7.5
Daily CP supplied, lb	1.21	.75	.96	1.16

[a] 30,000 IU/g
[b] Expressed as-is.

Data were analyzed by the least squares analysis of variance procedure and the protected least significant difference technique was used to separate means for characteristics in which differences were significant ($P<.05$).

Results and Discussion

Cow weight and condition changes are summarized in Table 2. Cows fed 7.5 lb WM gained more ($P<.01$) weight from November 1 to calving than cows on all other treatments, although differences were smaller than in previous studies with these levels of SBM and WM at this location. Unusually mild weather during the December-January period probably explains the small differences. Lower weight gain was noted ($P<.01$) for cows fed 5.0 lb WM than cows fed 3 lb SBM. Precalving cow weight gains increased linearly ($P<.001$) with increasing amounts of WM in the diet. Condition change for this period was not significant but reflected weight change.

Table 2. Weight and body condition changes and pregnancy rates of cows fed soybean meal and wheat middling supplements (least squares means).

	Soybean meal, lb/d	Wheat middlings, lb/d		
	3.0	5.0	6.25	7.5
No. of cows	24	22	26	24
Initial weight 11/01/88	1001	1001	1008	999
Initial condition score[a]	6.1	6.0	6.0	6.0
Precalving				
Weight change, lb 11/01/88 to calving	76[c]	45[b]	61[bc]	103[d]
Condition change 11/01/88 to calving	-.07	-.15	-.14	.03
Postcalving				
Weight change, lb				
Calving - 4/18/89	-179	-186	-168	-194
4/18/89 - 10/11/89	193	218	216	194
Condition changes				
Calving - 4/18/89	-.80[b]	-.93[c]	-.61[b]	-.57[b]
4/18/89 - 10/11/89	.34[b]	.63[c]	.43[bc]	.19[b]
Total trial period				
Weight change, lb 11/01/88 - 10/11/89	90	74	110	103
Condition changes 11/01/88 - 10/11/89	-.57	-.42	-.31	-.38
Pregnancy rates, %[e]	86	98	97	100

[a] Body condition scale: 1 = very thin, 9 = very fat.
[b,c,d] Means in a row with different superscripts differ (P<.05).
[e] Includes data only from cows weaning a calf.

Cow weight changes were similar for all treatments from calving to the end of supplementation in April. During this period, cows fed 5.0 lb WM lost more ($P<.05$) body condition than cows from other groups. From April to weaning cows previously fed either 5.0 or 6.25 lb of WM tended ($P<.10$) to gain more weight than cows fed 3 lb SBM or 7.5 lb WM. Cows fed 5.0 lb WM regained more condition ($P<.05$) during the summer than cows on other diets. Previous studies have reported that cows fed low levels of nutrition during the winter tend to compensate for winter weight losses during the summer. Neither weight nor condition changes were different among supplements for the total trial period (November 1, 1988 to October 11, 1989) but cows fed the two highest levels of WM tended ($P<.12$) to gain more weight than cows fed 5 lb WM or 3 lb SBM per day.

While feeding increased amounts of WM significantly increased cow weight before calving, weight changes from calving to the end of the supplementation period and from the end of supplementation to weaning were similar for all treatments. This is supported by results of previous studies by Lusby and Wettemann (1988b) and Cox et al. (1989). In both studies, precalving cow weight changes were greater for cows fed 7.5 lb WM compared to 3 lb SBM, but after calving no differences were noted between treatments. In companion studies by Lusby and Wettemann (1988a) and Ovenell et al. (1989) lactating, fall calving cows fed the same diets as the spring calving cows had similar performance when fed 3 lb SBM or 7.5 lb WM. This suggests that weight and condition change responses of cows to supplements may depend on lactational status.

Calf birth weights (Table 3) increased linearly ($P<.001$) with increasing amounts of WM in the diet. Calves of cows fed 7.5 lb WM tended to gain faster from birth to the end of supplementation (April), as well as from April to weaning. This advantage was also observed for weaning weights (572 vs 544, 555 and 545 for 7.5 lb WM vs SBM, 5.0 lb WM and 6.25 lb WM, respectively). This suggests that milk production was greater for cows fed higher levels of energy.

Pregnancy rates (Table 2) were high and similar among treatments, indicating that cows in all supplemental groups had adequate body condition and overall nutrition for good rebreeding performance.

In conclusion, it does not appear necessary to feed WM at isonitrogenous levels to 3 lb of SBM in order to achieve equal pregnancy rates, cow weight changes and calf weaning weights. When adequate forage is supplied over the winter, 5.0 lb WM may be fed to spring calving beef cows to achieve similar postcalving weight change, calf weight and pregnancy rate. However, if there are adverse weather conditions and/or forage shortages 5.0 lb WM may not be adequate to maintain cow and calf performance due to negative cumulative effects. When SBM costs \$240/ton and WM is \$120/ton, cost/day for 3.0 lb SBM is \$.36 compared to \$.30 for 5 lb of WM, \$.38 for 6.25 lb WM and \$.45 for 7.5 lb WM.

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

	Soybean meal, lb/d	Wheat middlings, lb/d		
	3.0	5.0	6.25	7.5
Calf birth weights, lb	80[a]	78[a]	83[ab]	89[b]
Calf gain, lb				
Birth - 4/18/89	87	88	86	93
4/19/89 - 10/11/89	377	384	377	390
Weaning weight, lb	544	555	545	572

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

Literature Cited

Association of American Feed Control Officials, Inc. (AAFCO). 1987. Official publication. p 189. Charlston, WV.

Cox, D.A. et al. 1989. Wheat middlings versus soybean meal and two wheat middlings/soybean meal supplements for wintering spring calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-127:41.

Lusby, K.S. and R.P. Wettemann. 1988a. Value of wheat middlings as a winter supplement for fall calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-125:69.

Lusby, K.S. and R.P. Wettemann. 1988b. Wheat middlings vs soybean meal and corn/soybean meal supplements of two protein levels for wintering spring calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-125:72.

Ovenell, K.H. et al. 1989. Wheat middlings versus soybean meal and two wheat middlings/soybean meal supplements for wintering fall calving beef cows. Okla. Agr. Exp. Sta. Res. Rep. MP-127:46.

INCREMENTAL LEVELS OF SUPPLEMENTAL RUMINAL DEGRADABLE PROTEIN FOR BEEF COWS FED LOW QUALITY NATIVE GRASS HAY

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Story in Brief

Five mature beef cows fitted with ruminal, duodenal and ileal cannulae were utilized in a 5 x 5 Latin square design to determine the effect of increasing levels of supplemental ruminal degradable protein on hay intake, site of digestion and duodenal nitrogen flow. Cows were fed native grass hay (4% crude protein) ad libitum and blends of soybean hulls and soybean meal to supply graded levels of ruminal degradable protein (.39, .65, .94 and 1.20 lb/day). Ruminal ammonia concentrations increased with added supplemental ruminal degradable protein. Hay organic matter intake peaked with .94 lb/day. In addition, ruminal and total tract organic matter disappearance both peaked with .94 lb/day. Supplement stimulated a linear increase in rate of hay organic matter digestion. Duodenal nitrogen flow increased linearly with supplement and was three-fold higher with 1.20 lb/day compared to the control. This study suggests that ruminal degradable protein exerts a powerful influence on forage utilization and that approximately .94 lb/day supplemental ruminal degradable protein is required to maximize intake and digestion of low quality native grass hay.

(Key Words: Beef Cattle, Grass Hay, Ruminal Degradable Protein, Soybean Meal, Feed Intake, Site of Digestion.)

Introduction

Fall calving beef cows grazing dormant native grass satisfy a large proportion of their energy and protein requirements from fermentation of consumed forage. Microbial fermentation of low quality forage in the rumen is limited by the quantity of ruminal degradable protein supplied in the supplement (Guthrie and Wagner, 1988). In addition to energy, microbial fermentation also

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produces microbial protein which can be used to meet the protein requirement of the cow.

Previous studies have illustrated increased forage digestion with ruminal degradable protein (RDP) supplementation but have not determined the quantity of RDP required to maximize forage utilization. In addition, the effect of RDP supplementation on duodenal nitrogen flow has not been quantified. The objective of this experiment was to determine the effect of increasing levels of supplemental RDP on forage intake, site of organic matter digestion and nitrogen flow to the small intestine.

Materials and Methods

Five mature beef cows (1,186 lb, average weight) fitted with ruminal, duodenal and ileal cannulae were fed native grass hay and graded levels of supplemental RDP. Treatments and cows were arranged in a 5 x 5 Latin square with pen randomized in each period. The native grass hay used in this study was coarsely chopped (2-inch) and contained 4.0% CP, 79.9% NDF and 7.3% lignin. Supplements were composed of blends of soybean meal and soybean hulls (Table 1). Soybean meal (50% CP) and soybean hulls (12% CP) differ markedly in protein concentration but appear to be similar in RDP (72%). Supplemental energy supply was equalized with soybean hulls to prevent confounding effects between supplemental protein and energy levels. Soybean hulls were used to minimize negative associative effects. A control (.24 lb

Table 1. Feed composition of supplements supplying increased quantities of ruminal degradable protein.

		RDP, lb/day[a]			
Feed, % (DM basis)	Control	.39	.65	.94	1.20
Soybean hulls		91.00	62.71	32.49	
Soybean meal			28.04	57.95	90.11
Molasses	35.14	3.00	3.00	3.00	3.00
Dicalcium phosphate	37.27	3.24	3.34	3.46	3.58
TM salt[b]	27.05	2.35	2.43	2.51	2.60
Sodium sulfate		.36	.43	.55	.66
Vitamin A (30,000 IU/g)	.54	.05	.05	.05	.05

[a] RDP=Ruminal degradable protein.

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

mineral plus .13 lb dried molasses) was used to assess the digestibility of unsupplemented hay. The highest treatment supplied 1.65 lb supplemental protein (Table 2) which provided 140% of the protein requirement of a gestating beef cow and 120% of the protein requirement of a lactating beef cow (NRC, 1984).

Cows were adapted to supplements for two weeks followed by one week of intensive sampling. Supplements were fed once daily at 7:00 a.m. Hay intake was measured on days 16 through 19 as hay offered minus hay refused. Hay refusals were discarded and fresh hay was fed daily. Nutrient intake was calculated by subtracting total nutrients refused from total nutrients offered. Duodenal, ileal and fecal samples were obtained eight times over days 16 through 19 to represent every 3 h of a 24-h day. Acid insoluble ash was determined on hay, hay refusal and digesta samples to calculate nutrient flow and digestibility. Nylon bags containing hay were incubated ruminally to measure rate of organic matter digestion. Ytterbium-labeled hay was fed on day 16 and subsequent timed fecal samples were collected to measure particulate passage rate. Intensive ruminal sampling was performed on day 20 to measure ruminal ammonia concentrations.

Table 2. Nutrient composition and daily nutrient supply of supplements providing increased quantities of ruminal degradable protein.

		RDP, lb/day[a]			
	Control	.39	.65	.94	1.20
Nutrient, % DM					
Crude protein[b]	3.0	12.9	22.1	33.1	43.4
TDN[c]	22.2	71.0	73.4	75.8	78.4
Calcium[c]	12.64	1.19	1.17	1.15	1.13
Phosphorus[c]	11.09	.82	.98	1.14	1.32
Feeding rate, lb DM/day	.34	4.17	4.07	3.95	3.84
Nutrient supply, lb DM/day					
Crude protein					
Total[b]	.01	.54	.90	1.31	1.66
RDP[ac]	.01	.39	.65	.94	1.20
TDN[c]	.08	2.99	3.00	3.00	3.00

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

All data were subjected to least squares analysis with a model that included period, animal and treatment. Orthogonal contrasts were used to compare the control vs all supplements plus the linear, quadratic, and cubic response to level of supplemental ruminal degradable protein.

Results and Discussion

Ruminal ammonia concentrations showed a time x treatment interaction (P<.0001) which suggests that treatment differences were dependent on sampling time (Figure 1). Ruminal ammonia concentrations peaked at 2 h after supplementation and increased linearly (P<.0001) with added RDP supplementation. Ruminal ammonia concentrations remained below 1 mg/dl for the control and .39 lb RDP treatments for most of the day. When .94 or 1.20 lb RDP were fed, ruminal ammonia concentrations were sustained above 2 mg/dl for most of the day. Ammonia is a primary end product of ruminal protein degradation and should be elevated when ruminal degradable protein sources such as soybean meal are fed.

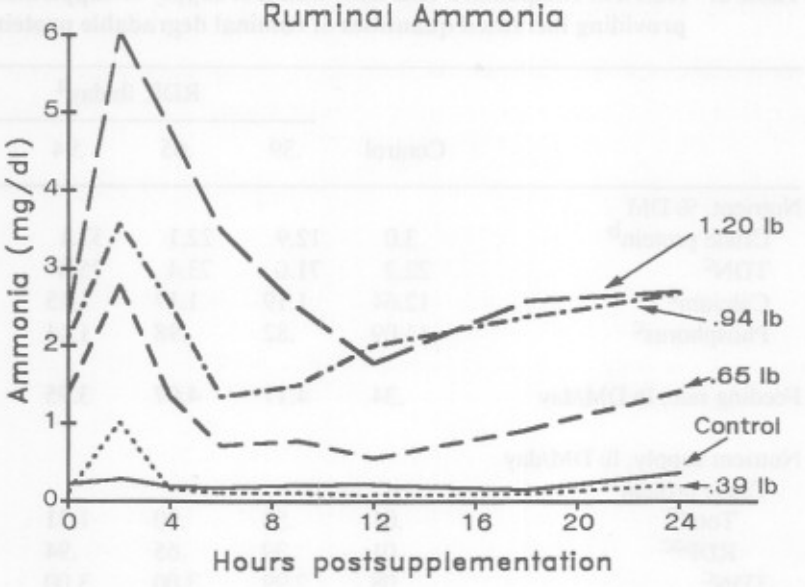

Figure 1. Diurnal changes in ruminal ammonia concentrations in beef cows fed low quality native grass hay supplemented with graded levels of ruminal degradable protein.

Supplementation increased (P<.001) hay and total organic matter (OM) intake (Table 3). Hay OM intake increased from 11.6 lb/day with .39 lb RDP to 15.8 lb/day with 1.20 lb RDP. Hay OM intake peaked (quadratic, P=.08), however, with .94 lb RDP (16.6 lb hay OM/day). Total OM intake followed a similar trend. Unlike previous studies (Guthrie and Wagner, 1988), supplemental RDP in this study was increased to the point that hay OM intake was maximized.

Total tract OM digestibility was 46.6% for unsupplemented hay and was increased (P<.001) with RDP supplementation (Table 3). Total tract OM digestibility increased linearly (P<.05) with added supplemental RDP. Total tract OM disappearance peaked (quadratic, P<.10) with .94 lb supplemental RDP. Increased hay OM intake (quadratic, P<.10) coupled with increased total tract OM digestibility (linear, P<.05) to improve total tract OM disappearance. Because total tract OM disappearance is indicative of energy intake, cows supplemented with .94 lb RDP should have maximized daily energy consumption.

Supplemental RDP increased (P<.001) OM disappearance in the rumen compared to the control (Table 3). Ruminal OM disappearance peaked (quadratic, P<.10) with .94 lb supplemental RDP. Maximal ruminal OM disappearance matched the peak in hay OM intake. In addition, the largest proportion of OM disappearance (84 to 92% of total OM disappearance) occurred in the rumen. Supplemental RDP did not affect uncorrected ruminal OM digestibility. Rate of hay OM digestion, measured with nylon bags, was increased (P<.001) with supplementation. Supplemental RDP increased rate of hay OM digestion linearly (P<.0001). Supplemental RDP supplies ammonia (Figure 1) which would be expected to stimulate ruminal microbial activity and increase forage fermentation. Supplemental RDP also increased particulate passage rates (linear, P<.01) which may have increased particulate flow to the extent that OM digestibility was not altered.

Organic matter disappearance in the small and large intestines was small compared to ruminal OM disappearance (Table 3). Because the native grass hay utilized in this study was composed primarily of cell wall (79.9% NDF), ruminal fermentation of fiber was essential to diet utilization. Consequently, most of the residual forage flowing to the lower tract may have been largely undigestible fiber components. Thus, most of the OM disappearing in the small intestine was probably microbial cells produced in the rumen.

Duodenal N flow was increased (linear, P<.001) with added supplemental RDP (Table 4). Duodenal N flow, however, tended to peak with .94 lb RDP (quadratic, P<.12). Duodenal N flow was three-fold higher with 1.20 lb supplemental RDP compared to the control. Supplemental RDP should increase ruminal microbial growth and subsequent protein flow to the duodenum. A portion of the nitrogen reaching the duodenum could be undegraded hay and soybean meal/hull nitrogen. Even with 1.20 lb supplemental RDP, however,

Table 3. Effect of ruminal degradable protein supplementation on intake and digestion of organic matter by beef cows fed low-quality native grass hay.

	RDP, lb/day[a]				
	Control	.39	.65	.94	1.20	SE
Organic matter intake, lb/day						
Hay[cd]	8.4	11.6	14.0	16.6	15.8	.84
Total[cd]	8.5	15.3	17.6	20.0	19.1	.84
Organic matter disappearance[b]						
Rumen						
lb/day[cd]	3.7	7.5	8.6	10.0	9.3	.43
Mouth to duodenum, %[c]	43.3	49.4	49.0	50.5	48.8	1.30
Small intestine						
lb/day[ce]	.2	.3	1.0	.9	1.6	.19
Duodenum to ileum, %[e]	8.7	4.0	17.2	12.6	25.5	3.38
Mouth to ileum, %[ce]	46.2	50.8	54.8	55.0	57.1	2.04
Large intestine						
lb/day[c]	.1	.6	.3	.6	.3	.16
Ileum to anus, %[c]	.4	7.8	3.4	6.6	3.6	2.16
Total tract						
lb/day[cd]	4.0	8.4	9.9	11.6	11.1	.46
Mouth to anus, %[ce]	46.6	54.9	56.5	58.1	58.6	1.33
OM digestion rate, %/h[ce]	2.75	2.92	3.38	3.73	4.73	.188
Particulate passage, %/h[ce]	.80	1.64	2.36	2.19	2.54	.213

[a] RDP=Ruminal degradable protein.
[b] Uncorrected for microbial organic matter.
[c] Control vs all RDP supplements (P<.005).
[d] Quadratic response to increased supplemental RDP (P<.10).
[e] Linear response to increased supplemental RDP (P<.05).

dietary N flow to the duodenum would not be expected to exceed .12 lb/day. Consequently, most of the nitrogen flowing to the duodenum is probably in the form of microbial N.

This study illustrates that supplemental RDP exerts a powerful influence on intake and utilization of low quality native grass hay. As much as .94 lb of supplemental RDP was required to maximize forage intake and digestion. This

Table 4. Effect of ruminal degradable protein supplementation on nitrogen intake and flow to the duodenum.

	RDP, lb/day[a]				
	Control	.39	.65	.94	1.20	SE
Nitrogen intake, lb/day						
Total[bc]	.06	.16	.24	.32	.37	.006
Hay[bcd]	.05	.08	.09	.11	.11	.006
Supplement[bc]	.00	.08	.14	.21	.27	.003
Duodenal N flow, lb/day[bcd]	.12	.23	.30	.36	.37	.015

[a] RDP=Ruminal degradable protein.
[b] Control vs all RDP supplements (P<.001).
[c] Linear response to increased supplemental RDP (P<.005).
[d] Quadratic response to increased supplemental RDP (P<.12).

level of RDP corresponds to 1.28 lb supplemental protein or 2.56 lb soybean meal. When combined with hay protein intake, total daily protein intake was 2.31 lb/day. This level is 36% higher than the protein requirement for a 1,200 lb gestating beef cow and 10% above the protein requirement for a 1,200 lb lactating beef cow (NRC, 1984). Consequently, protein supplementation based on NRC requirements may not maximize intake and utilization of low quality native grass.

Literature Cited

Guthrie, M.J. and D.G. Wagner. 1988. Influence of protein or grain supplementation and increasing levels of soybean meal on intake, utilization and passage rate of prairie hay in beef steers and heifers. J. Anim. Sci. 66:1529.

NRC. 1984. Nutrient Requirements of Beef Cattle (6th Ed.). National Academy Press, Washington, DC.

THE EFFECT OF CLORSULON ON WEIGHT GAIN ON LACTATING COWS AND THEIR CALVES

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Story in Brief

The effect of clorsulon (tradename, Curatrem) for control of liver flukes on subsequent weight changes in 118 lactating beef cows and their calves was evaluated in a trial conducted in Choctaw County in southeastern Oklahoma. There were no significant differences in cow or calf weight changes between treatment groups or pairings. This study suggests that, dependent upon the incidence and rate of infestation, subclinical field liver fluke infestations in a cow/calf operation may not constitute a production or economic burden.

(Key Words: Beef Cattle, Liver Flukes, Parasites.)

Introduction

Fascioliasis, liver fluke disease, caused by *Fasciola hepatica*, is endemic primarily along the Gulf Coast, West Coast, and Rocky Mountain Region of the United States. Observations indicate that liver fluke infestation is spreading to significant portions of Oklahoma. In an Oklahoma study feedlot steers with liver flukes gained 8.8% slower than steers without flukes over a 119-day feeding period (Hicks et al., 1987). Another Oklahoma experiment analyzed economic effects; liver flukes found to infect 101 of 317 feedlot steers at slaughter (Hicks et al., 1989). This trial demonstrated that for each 10% increase in the incidence of flukes in a pen of cattle, daily gain decreased by .028 lb/day and dry matter intake decreased by .151 lb/day; the economic impact was a difference in profitability of $14/head between pens of feedlot cattle either free of flukes or 100% infected. Australian workers reported that gains were reduced by 14.4% in grazing steers artificially infected with flukes. Other work has shown fluke infestations reduced reproduction rates in cows by 15% and calf weaning weights by 22 lb.

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Materials and Methods

One-hundred-eighteen lactating crossbred beef cows and their Charolais sired spring-born calves were used to evaluate the effect of clorsulon on cow and calf weight change during 68 days from mid-July to mid-September. The initiation and termination of the trial were timed to coincide with the end of weather conducive to fluke infestation and the scheduled weaning of the nursing calves, respectively. The trial was conducted in southeastern Oklahoma. The site and herd used were selected on the basis of three veterinary testimonials regarding the fluke infestation of the herd, presence and prevalence of lymnaeid snails, and other facets of herd history.

Cows and their previously vaccinated and castrated calves were individually identified and weighed, injected with ivermectin (Ivomec), and randomly sorted into two treatment groups, one of which was treated with clorsulon (Curatrem). Cows and calves were observed to determine and confirm cow/calf pairings.

Shortly following the initial weighing, the cattle were moved to an upland pasture not infected with snails and returned to the original pasture three weeks prior to trial termination. Control and treated cattle were pastured together.

Results and Discussion

Mean body weight changes were -16.2, -17.6, 117.3, and 120.1 lb (Table 1) for control cows, clorsulon treated cows, control calves, and clorsulon treated calves, respectively. Mean cow weight changes within cow/calf treatment pairs were -13.4, -19.8, -18.9, and -15.4 lb (Table 2) for control/control, control/clorsulon, clorsulon/control, and clorsulon/clorsulon pairings, respectively. Mean calf weight gains within cow/calf treatment pairs were 115.7, 118.8, 119.2, and 121.1 lb for control/control, control/clorsulon, clorsulon/control, and clorsulon/clorsulon pairings, respectively. These values were not significantly different.

Given feedyard data demonstrating a .2 lb/day reduction in ADG due to subclinical fluke infestations, one may expect a lesser difference in weight gain performance in grazing cattle generally performing at a lower level. Economic justification for treatment of subclinically fluke infested grazing cattle would rely on sufficient days to accumulate added weight. Time from treatment at the end of the period of infestation to weaning may not be long enough for the accumulation of increased calf weaning weights to justify treatment. Cow weight changes in this trial would indicate that there is no

Table 1. Effect of clorsulon on weight changes of lactating beef cows and calves.[a]

	Treatment	
	Control	Clorsulon
Cows		
No.	56	62
Beginning weight, lb	898	921
Weight gain, lb	-16.2	-17.6
Calves		
No.	57	61
Beginning weight, lb	338	325
Weight gain, lb	117.3	120.1
Average daily gain, lb	1.73	1.76

[a] Least squares means. Means are not different (P>.05).

Table 2. Effect of clorsulon on weight changes of beef cow/calf pairs.[a]

Cow/Calf treatment[b]	Cow beg. weight, lb	Cow weight change, lb/hd	Calf beg. weight, lb	Calf weight gain, lb	Calf ADG lb/day
Cnt/Cnt	883	-13.4	327	115.7	1.70
Clor/Cnt	910	-19.8	336	118.8	1.75
Cnt/Clor	918	-18.9	346	119.2	1.75
Clor/Clor	923	-15.4	315	121.1	1.78

[a] Least squares means. Means in the same row with different supercripts (P>.05).

[b] Cnt is control; Clor is clorsulon treatment.

effect upon reproductive performance of the cowherd by treatment with clorsulon as body weight relates to body condition score. If the results of this trial reflect this reasoning then subclinical incidences of fluke infestations commonly found in cow/calf operations in southeast Oklahoma are of little production or economic consequence as they relate to calf weaning weights. If, however, significant numbers of cows are clinically exhibiting signs of liver fluke disease, then fluke incidence and infestation levels may warrant treatment of the entire cowherd resulting in increased cow reproductive performance and calf weaning weights.

Literature Cited

Hicks, R.B. et. al. 1987. The effect of liver flukes on the performance of feedlot steers. Okla. Agr. Exp. Sta. Res. Rep. MP-119:337.

Hicks, R.B. et. al. 1989. Impact of liver flukes on the performance of feedlot steers. Okla. Agr. Exp. Sta. Res. Rep. MP-127:123.

COMPARISON OF HIGH 20 AND LOW 20 HOLSTEIN HERDS ON DAIRY HERD IMPROVMENT ASSOCIATION TEST DURING 1989

J. D. Stout[1] and R. B. Stout[2]

Story in Brief

Rolling herd averages for Holstein herds on Oklahoma's Dairy Herd Improvement records program range from 9,481 to 22,565 lb of milk. A study of the differences in various management factors between the High 20 and Low 20 herds provides information for dairy workshops, Animal Science courses, and producer discussions. Forty production data factors were taken from the monthly Dairy Herd Improvement Herd Summary of each herd or calculated for the comparisons. Those factors with a wide variation between groups which seemed to contribute most to the difference in production levels were: 1) quality of forage and quantity of grain fed; 2) management of dry periods and reproduction; and 3) genetic levels of the herd as controlled by use of artificial insemination. When Holstein herds were ranked on lb of milk, Rolling Herd Average, the Low 20 herds averaged 12,188 lb of milk valued at $1,554 compared to 20,741 lbs of milk valued at $2,553 for the High 20 Holstein herds. Average cost of feed was $356 more for the High 20 herds, however there was $606 more return above feed costs per cow. The High 20 farms had approximately $55,000 per farm additional income above feed costs as compensation for extra labor, management expertise, and genetic potential needed to reach their production levels.

(Key Words: Dairy Herd Improvement, Genetics, Dairy Management, Production Testing.)

Introduction

The January 1990 Dairy Herd Improvement Association Herd Summaries (DHIA-202) show that 20 Oklahoma dairy producers had Rolling Herd Average (RHA) production surpassing 20,000 lb of milk. This number represents approximately 7.5% of the total herds on DHI in Oklahoma and is more than triple the number of 1988. The production leader had 22,565 lb. Because the

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dramatic increase in high producing herds was accompanied by a 380 lb increase in the state average production, we evaluated management factors across all levels of production. Dividing the Oklahoma herds on DHI into four production levels at 2,000 lb increments, from less than 14,000 lb to over 18,000 lb indicate that the good herds improve and the low herds seemed to decrease during 1989.

Why were Oklahoma herds polarizing toward the extremes? The objectives of this study were to analyze the DHIA-202 Herd Summaries of the High 20 and Low 20 herds to determine management differences of the two groups.

Materials and Methods

Holstein herds on official DHIA programs were sorted in descending order of RHA milk production. The High 20 and the Low 20 were selected to study the criteria that contribute to the production difference of the two groups. All data on the Herd Summary (DHIA-202) of each herd were used in the analysis. The data was averaged or percentages calculated where appropriate with standard deviation calculated for each management factor. Production data was also compared to a similar study conducted 10 years ago.

Results and Discussion

There was 8,620 lb of milk difference between the High 20 Holstein herds averaging 20,741 lb and the Low 20 Holstein herds averaging 12,121 lb of milk on a RHA basis in 1989. Seven herds of the High 20 and five herds of the Low 20 were in the same group in 1980. Over the last 10 years, the top 20 herds increased an average of 1,423 lb or 7.4%. During the same 10 years, herds now ranking as the Low 20 have production 21.5% higher than the 10,028 lb for the Low 20 in 1980.

Table 1 lists the production, income, and feed cost data for the two groups. The value of milk produced was $1,545 for the Low 20 herds compared to $2,540 for the High 20 herds, a $995 difference. The income over feed cost of the High 20 herds was $585 per cow more even after paying for the $409 higher feed costs required to produce at those levels.

Table 2 lists the feeding program of the two groups. Not all herds of either group fed hay, silage, and pasture. Two of the High 20 herds were feeding a total mixed ration with cows in confinement. Some herds of each group were fed a combination of hay and pasture as the roughage, others used silage as the primary forage with hay and pasture as a supplement. The quality codes on the DHIA-202 are only listed for the current month with pounds fed and cost listed

Table 1. Production and income of High and Low 20 Holstein herds.

Factor, per cow	Low 20 average	SE	High 20 average	SE	Difference
Herd milk	12,121	1,025	20,741	645	8,620 lb
Herd fat	431	35	703	56	272 lb
Herd protein	395	31	655	30	260 lb
Milk value	$1545	$126	$2540	$208	$995
Feed cost	$770	$119	$1179	$153	$409
Income/over feed cost	$776	$169	$1361	$221	$585

Table 2. Feed data for High and Low 20 Holstein herds.

Factor, per cow	Low 20 average	SE	High 20 average	SE	Difference
Body weight	1133	101	1300	92	167 lb
Forage dm, cwt./ body weight, lb	1.90	.60	1.86	.69	.04 lb
Lb milk/lb grain	2.02	.32	2.43	.29	.41 lb
Hay fed	6011	2332	5825	3346	-187 lb
Silage, lb	10330	4695	10932	3137	601 lb
Pasture days	277	90	272	124	-5 days
Grain, lb	6107	1006	8647	1308	2540 lb

for the current month and the year. These codes indicate that the forage program of the High 20 herds contain a higher percentage of alfalfa and would have a higher protein and energy content than that of the Low 20 herds.

Also, average body weight was 167 lb heavier for the High 20 compared to the Low 20 herds. These weights indicate that the managers of the High 20 Holstein herds possibly make genetic selections for larger animals, and feed for heavier growth rates than the managers of the Low 20 herds. These improved management conditions of the High 20 herds result in larger cows at first freshening and they continue to feed for growth and milk production during later lactations.

Pounds of forage dry matter per cwt body weight was nearly equal for the two groups. More grain by 2,540 lb was fed to the High 20 herds. However, the High 20 herds produced 2.43 lb of milk produced per lb of grain compared to 2.02 lb for the Low 20 herds.

Table 3 refers to the days in milk and the dry period analysis for the two groups. Days in Milk is a very important figure to RHA as 1% of a year equates to 7 milkings on 2X milking or 11 extra on a 3X milking schedule. The High 20 cow group averaged 3.7% more days in milk or 26 milkings more per cow going into the bulk tank compared to the Low 20 herds.

Average Days Dry was 70 days for the Low 20 herds compared to 64 days for the High 20 herds. The extra 6 days dry is not as significant as the percent of cows in the 40 to 70 day range. Cows dry 10 days and 110 days would average 60 days dry. However, milk yield of each would be negatively affected in the subsequent lactation. The cow dry for only 10 days would not have enough rest to achieve maximum milk yield in the subsequent lactation, while the cow dry for 110 days would be susceptible to fatty udder, fat cow syndrome, etc. The High 20 group had 18% more cows in the desired 40 to 70 day range for dry periods than the Low 20 herds.

All factors of Table 4, reproductive data, favor the High 20 group of herds. Calving interval was 21 days shorter for the High 20 herds, at 418 compared to

Table 3. Dry period analysis for High and Low 20 Holstein herds.

Factor	Low 20 average	SE	High 20 average	SE	Difference
Days in milk, %	84.6	6.36	88.3	2.21	3.7%
Dry periods <40 days, %	17.6	13.40	13.0	16.30	-4.6%
Dry periods 40-70 days, %	45.5	18.30	63.5	8.95	18.0%
Dry periods >70 days, %	31.7	16.40	23.9	13.50	-7.8%
Dry days	70.0	27.90	64.0	8.95	6.0 days

Table 4. Reproductive data of High and Low 20 Holstein herds.

Factor	Low 20 average	SE	High 20 average	SE	Difference
Calving interval	439	40.2	418	21.6	-21 days
Days to 1st bred	99	23.1	88	15.0	-11 days
Open, days	159	40.6	140	23.0	-19 days
Services/conception	2.1	.55	2.0	.42	-.1 ser

439 for the Low 20 herds. Days open was 19 days less for High 20 herds compared to that of the Low 20. Services/conception was at or near the state average of 2.0 for each group. It should be noted however, that all of the High 20 were reporting breeding dates, whereas only 13 of the Low 20 herds reported breeding dates.

There are wide differences in genetic levels between the low and high groups (Table 5). Only 25.9% of the producing cows of the Low 20 herds are out of proven sires compared to 84.9% for the High 20. Also the level of proof favors the High 20 by $48.50. The High 20 herds are going to perpetuate their advantage as 73.1% of the current heifer inventory are out of proven bulls and 89.3% of the cows are bred back to sires with known genetic levels. The Low 20 herds have only 35.7% of the heifers out of proven sires and 35.3% of the cows bred to sires with known genetic levels. The genetic level of sires used is also significant. Low herds average $112.70 plus Predicted Difference Dollars (PD$) bulls to $160.00 PD$ sires of the High group. When natural service or young sires without PD are calculated into the average as zero PD$, the High 20 average $142 PD$ compared to $70 for the Low 20 herds.

Other factors (Table 5) that indicate a difference in management level between the High and Low 20 herds are heifer to cow ratio, age of herd, and percent first lactation. Culling rate is only calculated on the Herd Genetic Evaluation once per year in March. However, the calculation of percent cows in first lactation will usually be almost equal to the culling percentage. When

Table 5. Genetic evaluation of High and Low 20 Holstein herds.

Factor	Low 20 average	SE	High 20 average	SE	Difference
Herd size	82	43.4	99	79.0	17 cows
Cow:heifer ratio	1:.54	45.3	1:1.11	31.1	.57 hfrs
Heifers with PD, %	35.7	35.1	73.1	27.2	37.4 %
Cows with PD, %	25.9	22.6	84.9	17.2	59.0 %
PD$ of cows with PD	26.60	52.40	75.10	19.20	48.50 $
PD$ of service sires with PD	112.70	64.10	160.00	16.20	47.30 $
PD$ of all service sires	70.10	60.80	142.00	18.70	71.90 $
Cow bred to sires with PD, %	34.30	38.30	89.30	10.40	55.00 %
Age at first freshening	29.21	4.78	27.21	2.21	2.00 mo
Age of herd	54.40	9.87	46.30	2.93	8.10 mo
Herd as first lactation, %	25.0	7.40	36.0	2.30	11.0 %

making this calculation, the High 20 herds had 36% first Lactation animals compared to 25% for the Low 20. The High 20 also had a younger herd and a higher replacement heifer to cow ratio. The lower replacement heifer ratio can usually be attributed to use of beef bulls, higher heifer death loss, and longer calving interval of the low production herds.

Somatic Cell Counts (SCC) measure the amount of white blood cells and epithial cells discharged from milk secreting tissue of the udder. The higher the count the more stress or infection to that tissue. Healthy cows are considered to have counts below 100,000/ml. The age of cow will have some effect on somatic cell counts and healthy cows will increase with successive lactations. Milk quality standards suggest that bulk tank somatic cell counts should be below 300,000. Research with SCC indicate that as the linear score changes one score, up or down, the change in milk production due to change in udder stress is 1.5 lb per day in the same direction. The linear scale is devised as 1 to 9 with the raw SC count doubling for each score above 25,000. (1 = 25,000, 2 = 50,000, 3 = 100,000, etc.) The High 20 herds had 241,000 SC count compared to 481,000 for the Low 20 producing herds for the end of 1989 (Table 6). A factor that is probably more significant is that the High 20 herds had 10.9% of individual cows with counts above 400,000 compared to 32.8% for the Low 20 group.

Dairymen of both groups should analyze their DHIA and financial records to determine the areas of needed improvement. Applying the management resources in the areas of most impact on the immediate and future profits will be rewarding.

Table 6. Somatic cell counts of High and Low 20 Holstein herds.

Factor	Low 20 average	SE	High 20 average	SE	Difference
Raw somatic cell count	481,000	164,000	241,000	104,000	240,000
Linear score	4.65	.51	3.65	.35	1.0
Cows over 400,000, %	32.8	13.7	10.9	7.5	25.3

COMPARISON OF PRODUCTION RECORDS OF COWS USING ONE AND TWO MILKING PLANS OF DAIRY HERD IMPROVEMENT TESTING

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Story in Brief

Oklahoma Dairy Herd Improvement Association supervisors are testing as many herds each month as their time or family responsibilities will allow. A greater acceptance of a one-milking testing program by producers would allow supervisors to test current herds in a shorter work month or to add additional herds and only work the same time frame. The one-milking program has not been universally accepted by Oklahoma dairymen due to their lack of confidence in the adjustment factors. This study was undertaken to determine the correlation of production records made on one-milking or two-milking testing plans under Oklahoma conditions. Test day and lactation-to-date pounds of milk, protein, and somatic cell data each met the tolerance levels set by the National Cooperative Dairy Herd Improvement Policy Board having correlations of .96, .98 and .96, respectively. Butterfat content had sufficient variation to indicate additional research is needed to improve alternate one-milking adjustment factors for fat. Oklahoma dairy producers should avail themselves of the alternate one milking testing plans to reduce their personal costs of DHIA testing, improve supervisor scheduling, reduce energy costs and travel time, and reduce on-farm labor connected with the production records program.

(Key Words: Dairy Herd Improvement, Alternate Testing Plans, One Milking Test.)

Introduction

Oklahoma has approximately 1,050 dairies scattered in 74 counties with 300 of these enrolled in the Dairy Herd Improvement Association (DHIA) program. The majority of these herds are using the standard testing plans requiring the weighing and sampling of each consecutive milking in a 24-h period for one day each month. Twenty-five supervisors test the herds with 21

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having other part time employment. Travel distance and time, plus the milking schedules, make it difficult for supervisors to test enough herds to make sufficient income to be fully employed.

A testing plan, labeled AM-PM, using one milking per month alternating the sampling between night and morning milkings was developed by the National Cooperative Dairy Herd Improvement Program. With this plan, one milking is sampled in the PM one month and in the AM the following month. Appropriate factors according to length of time between milkings are used to convert data collected at one milking to a 24-h period. Although many states have a large portion of dairies converted to the AM-PM plan, Oklahoma has only 6% of DHIA herds on this plan. Dairymen cite lack of confidence in the accuracy of conversion factors as their main objection to use of AM-PM plans.

The purpose of this study was to test the same cows, under controlled conditions, on both two-milking-two-sampling (DHI) and one-milking-one-sampling (AM-PM) testing plans to determine the correlations among production records made on each plan under controlled Oklahoma conditions.

Materials and Methods

Fifty-one cows in the Oklahoma State University Holstein herd that freshened between September 1 and October 20, 1988 were selected as the test herd. Cows were selected only on date of freshening, therefore a general cross section of age, lactation number, and production levels were represented. Each cow was concurrently tested on DHI and AM-PM so each served as its own control. The Control group was assigned to DHI using the standard two consecutive milkings. Test 1 group was the same cows assigned to AM-PM starting with the first PM milking. Test 2 group was the same cows assigned to AM-PM starting with the first AM milking. All rules of the National Cooperative Dairy Herd Improvement Policy (NCDHIP) appropriate to the testing plans were followed. Management of the test herds was identical to that of the total Holstein herd. Cows were fed a total mixed ration containing alfalfa hay, sorghum silage, grain, and protein supplement in varying amounts to meet their nutritional needs.

Results and Discussion

The Policy Board governing NCDHIP, when adopting the AM-PM testing plan, set the criteria that AM-PM records must be within 5% of DHI record values. The individual records of the 51 cows or the group analysis of milk pounds, protein, and somatic cell fell within the 95 to 105% range. Butterfat on a test-day basis or lactation-to-date basis had variations outside the 5% range.

Listed in Table 1 are the means and correlations for test-day milk weights for each test period as well as the percent Test 1 and Test 2 varied from Control. The correlations of test-day milk weights range from .93 to .99 indicating that there was a significant relationship between test-day milk weights of cows tested on each of the DHIA plans. The high correlation values indicated that as DHI milk weights change up or down, the AM-PM will vary in the same direction.

Prior research indicates that cows in early lactation are most susceptible to stress and management changes and may have more fluctuation in daily milk yield. Correlations in this study were also lower for the test intervals when a higher percentage of the cows were in early lactation. As days in lactation progressed the correlation of DHI to AM-PM approached 1.0. The correlation comparing Test 1 and Test 2 to Control for interval 8 was .99.

The 51 cows listed in Table 2 are divided into High, Medium, and Low groups based on actual milk production. The table is printed in rank order of the Control group. Only three cows of Test 2 and two cows of Test 1 group ranked in different High, Medium and Low thirds when AM-PM was compared to DHI groups. The cows were divided into three groups according to production as this is a typical grouping pattern used by Oklahoma producers when grouping cows for feeding purposes. Individual test day groupings showed similar results having no more than five cows in different groups. The five cows were clustered close to the break line and would have made little difference in feed offered on group basis.

Table 1. Test day milk weights and correlations.

Test interval	DHI[a] mean weight, lb	Test 1 mean weight, lb	Test 2 mean weight, lb	r[b] Test 1	r[b] Test 2	Test 1 as % of DHI	Test 2 as % of DHI
Int. 1	79.8	82.3	76.5	.96	.94	103	96
Int. 2	75.4	78.1	73.0	.94	.94	103	97
Int. 3	72.8	79.2	69.1	.98	.96	109	95
Int. 4	63.5	60.3	66.7	.97	.97	095	105
Int. 5	58.6	61.8	56.5	.94	.93	106	97
Int. 6	55.5	56.3	53.6	.97	.97	101	97
Int. 7	44.7	42.9	46.4	.98	.98	96	104
Int. 8	39.2	38.4	39.5	.99	.99	98	101
Int. 9	37.1	33.3	37.8	.98	.98	90	102

[a] DHI is two-milking-two-sampling/month test.
[b] All correlations are significant ($p<.01$).

Table 2. Rank order of cows based on complete lactation milk pounds.

Cow number	DHI[a] milk, lb	Rank on DHI	Test 2 milk, lb	Rank on AM	Test 1 milk, lb	Rank on PM
			High DHI Milk Cows[b]			
617	31590	H1	29660	AH1	33520	PH1
746	24870	H2	24790	AH3	24820	PH4
861	24550	H3	22500	AH9	26420	PH2
704	24540	H4	22900	AH8	26110	PH3
382	24250	H5	24560	AH4	23960	PH7
869	23670	H6	23220	AH5	21880	PH10
410	23660	H7	25100	AH2	21530	PH14
770	23610	H8	23160	AH6	23970	PH5
885	23490	H9	22950	AH7	23970	PH6
298	22740	H10	22470	AH10	23030	PH8
303	22260	H11	21640	AH11	22770	PH9
687	21530	H12	20990	AH13	21800	PH13
819	21420	H13	20850	AH15	21850	PH11
698	21400	H14	21380	AH12	20440	PM2
848	21240	H15	20740	AH16	20810	PH16
738	21140	H16	20320	AH17	21850	PH12
817	20790	H17	20130	AM1	21440	PH15
			Medium DHI Milk Cows[c]			
934	20670	M1	20870	AH14	20130	PM4
951	20070	M2	19610	AM3	18710	PM12
546	19820	M3	19080	AM4	20480	PM1
360	19700	M4	19840	AM2	19490	PM8
955	19270	M5	18990	AM6	17800	PM16
556	19250	M6	18340	AM11	20180	PM3
736	19150	M7	18730	AM9	18780	PM11
737	19070	M8	18410	AM10	19810	PM6
520	19050	M9	17180	AM16	20510	PH17
884	19000	M10	18870	AM7	19100	PM9
638	18880	M11	17870	AM12	19830	PM5
727	18690	M12	17690	AM14	19620	PM7
802	18380	M13	18860	AM8	18120	PM14
966	18340	M14	19040	AM5	18200	PM13
900	18320	M15	17730	AM13	18870	PM10

Table 2. (Continued).

Cow number	DHI[a] milk, lb	Rank on DHI	Test 2 milk, lb	Rank on AM	Test 1 milk, lb	Rank on PM
503	17570	M16	17470	AM15	17680	PM17
766	17300	M17	16550	AL1	17910	PM15
			Low DHI Milk Cows[d]			
340	17180	L1	16800	AM17	17420	PL1
928	16220	L2	15060	AL5	16580	PL3
867	16190	L3	16080	AL2	16200	PL4
571	15780	L4	15150	AL4	16610	PL2
788	14820	L5	14680	AL6	15000	PL6
868	14640	L6	15280	AL3	15630	PL5
971	14140	L7	14400	AL7	13850	PL11
376	14070	L8	14190	AL8	13920	PL10
686	13960	L9	13660	AL9	14160	PL8
840	13800	L10	13170	AL12	14210	PL7
942	13700	L11	13470	AL11	13960	PL9
845	13690	L12	13610	AL10	13720	PL12
941	13160	L13	13000	AL13	13300	PL13
946	11360	L14	10920	AL15	11790	PL15
498	11350	L15	11000	AL14	11810	PL14
958	10520	L16	10390	AL16	10690	PL16
839	8190	L17	8370	AL17	7940	PL17

[a] See text for explanation of symbols.
[b] High DHI milk cows: PH = PM high milk cows AH = AM high milk cows.
[c] Medium DHI milk cows: PM = PM medium milk cows AM = AM medium milk cows.
[d] Low DHI Milk Cows: PL = PM low milk cows AL = AM low milk cows.

Total butterfat pounds is dependent on two factors, lb of milk produced and butterfat percent of that milk. Lactation-to-date fat pounds (Table 3) followed a similar pattern of milk as Table 1. There was more variation during early lactation, 104 to 96 for Interval 1 and more closely related in late lactation, 100 to 99 in Interval 8.

Test day fat percentages were evaluated in the same manner as milk weights. The average fat percentages for test day and correlations are presented in Table 4. The weighted means of test interval fat percentages of the 51 cows on Test 1 and Test 2 matched the Control in only four intervals. Test 1 was equal to Control on interval 6, varied .1 on two intervals, .2 on three intervals and had one interval each at .3 and .6 difference.

Test 2 cows had three intervals with the fat percentage equal to Control. Test 2 also had the most single variation with interval 3 averaging 4.5% fat, .8 more than the 3.7% of the Control. Test 2 also had three intervals with .2 difference and one with .3. The average fat percentage for the eight test intervals was 3.76, 3.65 and 3.79 for the Control, Test 1 and Test 2, respectively.

Examination of individual fat tests of the same cow between groups indicate a wide range of variation. Correlation values listed in Table 5 range from .43 to .95. Test 1 and Test 2 as a percent of DHI values range from 85 to 122 which is also more than the acceptable variation by NCDHIP standards.

Somatic cell data collected in this study indicates that somatic cell counts (SCC) do vary on a milking to milking basis. Somatic cell counts for each cow

Table 3. Lactation to date fat pound means and correlations for DHI[a] and DHI-AM-PM.

Test interval	DHI mean lb	Test 1 mean lb	Test 2 mean lb	r[b] Test 1	r[b] Test 2	Test 2 as % of DHI	Test 2 as % of DHI
Int. 1	98	102	94	.92	.95	104	96
Int. 2	241	244	233	.90	.91	101	97
Int. 3	333	337	329	.91	.92	101	99
Int. 4	434	421	426	.91	.92	97	98
Int. 5	478	481	475	.91	.91	101	99
Int. 6	570	583	559	.92	.92	102	98
Int. 7	633	650	617	.93	.93	102	97
Int. 8	701	704	693	.93	.95	100	99

[a] See text for explanation of symbols.

b All correlations are significant ($p<.01$).

Table 4. Test day fat percentage means and correlation for DHI[a] and DHI-AM-PM herds.

Test interval	DHI mean fat, %	Test 1 mean fat, %	Test 2 mean fat, %	r Test 1	r Test 2	Test 1 as % of DHI	Test 2 as % of DHI
Int. 1	3.9	3.8	3.9	.68	.95	97	100
Int. 2	4.1	3.5	3.8	.77	.70	85	93
Int. 3	3.7	3.6	4.5	.65	.88	97	122
Int. 4	3.8	4.0	3.8	.87	.43	105	100
Int. 5	3.6	3.8	3.4	.76	.77	106	94
Int. 6	3.5	3.5	3.5	.75	.62	100	100
Int. 7	3.7	3.9	3.5	.78	.72	105	95
Int. 8	3.8	3.5	3.9	.94	.90	92	103

[a] See text for explanation of symbols.

Table 5. Somatic cell raw score and linear score of herds on DHI[a] and DHI-AM-PM test plans.

	Raw score[b]			Linear scores		
Test interval	DHI	Test 1	Test 2	DHI	Test 1	Test 2
Int. 1	183	167	144	3.4	3.3	3.2
Int. 2	175	189	184	3.4	3.4	3.5
Int. 3	149	155	141	3.2	3.2	3.3
Int. 4	158	163	136	3.3	3.3	3.0
Int. 5	241	381	213	3.3	3.1	3.6
Int. 6	269	272	286	4.0	4.1	4.1
Int. 7	189	209	202	3.9	3.9	3.9

[a] See text for explanation of symbols.
[b] Raw score is expressed in 1000 cell units. For example: 50, is 50,000 somatic cells.

provides an evaluation as to the udder condition of the cow and response she was giving at the time of test. The data in Table 5 are the raw scores and linear score averages for each test period. The data received from any of the three testing plans would allow a dairyman to evaluate his cows and herd to make any management decisions needed. No correlation values were calculated as a condition causing an increase in SCC can be sudden and a low SCC on one milking would have no relationship to the SCC of the same cow the following milking if problems occured.

Protein is one of the least variable components analyzed by DHIA. Most cows, regardless of the type of testing program, have very little change in protein tests from night to morning or day to day. This allows for correlation values to be near 1.0 for the complete research project. Each month the r values were at least .97 comparing Test 2 or Test 1 to DHI. The lactation-to-date means and correlations are listed in Table 6.

Table 6. Lactation to date protein pounds, means and correlations for DHI[a] and DHI-AM-PM herds.

Test interval	DHI mean lb	Test 1 mean lb	Test 2 mean lb	r[b] Test 1	r[b] Test 2	Test 1 as % of DHI	Test 2 as % of DHI
Int. 1	86	88	82	.98	.97	102	95
Int. 2	206	208	195	.97	.97	101	95
Int. 3	284	290	274	.97	.97	102	96
Int. 4	362	371	350	.97	.91	103	97
Int. 5	409	415	398	.98	.98	102	97
Int. 6	501	513	484	.98	.98	102	97
Int. 7	548	560	532	.98	.98	102	97
Int. 8	607	614	593	.98	.97	101	98
Int. 9	765	625	658	.98	.97	82	86

[a] See text for explanation of symbols.
[b] All r values indicate significant relationship ($p < .01$)

SIMILAR DIETARY CATION-ANION BALANCES ACHIEVED VIA THE ADDITION OF SODIUM CHLORIDE OR POTASSIUM CHLORIDE: INFLUENCE ON SYSTEMIC ACID-BASE STATUS, MILK YIELD AND MINERAL METABOLISM IN LACTATING DAIRY COWS

W.B. Tucker[1] and J.F. Hogue[2]

Story in Brief

Dietary cation-anion balance can be defined as meq((Na+K)-Cl)/100 g diet dry matter. The objective of this study was to evaluate the response of lactating dairy cows to altering concentrations of dietary Na, K and Cl while holding dietary cation-anion balance constant. Fifteen lactating Holstein cows were fed three diets containing sorghum silage and concentrate in a 40:60 ratio (dry matter basis), formulated to provide +32 meq ((Na+K)-Cl)/100 g diet dry matter via: 1) basal concentrations of dietary Na, K and Cl; 2) basal diet with addition of 20 meq Na and 20 meq Cl/100 g diet dry matter in the form of NaCl (1.17% of diet dry matter); and 3) basal diet with the addition of 20 meq K and 20 meq Cl/100 g diet dry matter in the form of KCl (1.56% of diet dry matter). Blood pH was reduced by addition of NaCl and KCl, although no other measures of acid-base status were significantly affected. Plasma K was higher, and plasma Mg lower, for the diets with supplemental NaCl or KCl than for basal diet. Urine mineral excretion reflected dietary mineral concentration, with the exception that Ca and Mg excretion rates were reduced on the KCl diet. Milk yield reflected dry matter intake, which was lowest with NaCl. The results from this study indicate that at a dietary cation-anion balance of +32 meq/100 g diet dry matter, actual dietary concentration of Na, K and Cl may be a more important determinant of dietary impact on systemic acid-base status than the ratio of Na and K to Cl in the diet.

(Key Words: Dietary Cation-Anion Balance, Dairy Cows, Acid-Base Status, Minerals, Sodium, Potassium, Chloride.)

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Introduction

Dietary cation-anion balance (DCAB) can be defined quantitatively as meq((Na+K)-Cl)/100 g diet dry matter (DM), and more generally as the balance of positively and negatively charged fixed ions in the diet. This balance has been shown to affect systemic acid-base status and performance in lactating dairy cows (Tucker et al., 1988), Ca metabolism in peripartum dairy cows (Block, 1984) and lactating goats (Fredeen et al., 1988), and P metabolism in young calves (Beighle et al., 1988).

Before DCAB can be utilized to manipulate acid-base status and mineral metabolism in dairy cows on a widespread basis, it will be necessary to evaluate responses to diets that have the same DCAB, but different concentrations of dietary fixed ions. Therefore, the objective of this trial was to examine the response of lactating dairy cows to diets containing similar DCAB (+32 meq), but vastly different dietary fixed ion concentrations effected by the addition of either NaCl or KCl.

Materials and Methods

Fifteen lactating Holstein cows, averaging 165 days postpartum and producing 55 lb milk daily were blocked according to age and previous milk yield. Blocks were randomly assigned to five squares in a replicated, 3 x 3 Latin square design with experimental periods 3 weeks in length. Treatments were diets containing sorghum silage and concentrate in a 40:60 ratio (DM basis) and were formulated to provide DCAB of +32 via: 1) basal concentrations of dietary Na, K and Cl (Ctrl); 2) basal diet with addition of 20 meq Na and 20 meq Cl/100 g diet DM in the form of NaCl (NaCl+20); and 3) basal diet with addition of 20 meq K and 20 meq Cl/100 g diet DM in the form of KCl (KCl+20). Since NaCl and KCl contain equimolar and equivalent proportions of cation and anion, dietary addition of these compounds allows manipulation of total mineral concentrations without altering DCAB. Total mixed diets (Tables 1 and 2) were formulated to meet established nutrient requirements of lactating dairy cows and were offered ad libitum twice daily. Samples of the total mixed diets were collected weekly, frozen, and composited at the end of the trial for subsequent nutrient analysis via commercial laboratory. Dry matter composition of the sorghum silage was determined weekly and utilized to maintain a consistent ratio of ingredients in the diet DM.

Blood and urine samples were collected at 4 h postfeeding on the morning of the last day of each experimental period. Fifteen milliliters of blood was collected via jugular venipuncture and dispensed into two evacuated, glass tubes, one containing Li heparin for subsequent plasma collection and the other, Na heparin for blood pH, pCO_2 and pO_2 analysis. Urine was collected in

Table 1. Ingredient composition of experimental diets[a].

Ingredient:	Diet		
	Ctrl	NaCl+20	KCl+20
Sorghum silage	40.26	40.26	40.26
Dried sorghum distillers grain	30.56	30.56	30.56
Ground corn	13.46	13.46	13.46
Soybean meal	11.91	11.91	11.91
Dynamate[b]	.22	.22	.19
Potassium chloride	.....	.....	1.56
Trace mineralized salt[c]	.38	1.55	.38
Limestone	.70	.70	.71
Dicalcium phosphate	.37	.37	.37
Potassium bicarbonate	.30	.30	.31
Magnesium oxide	.10	.10	.10
Calcium chloride (95%)	.19	.19	.18
Silicon dioxide	1.55	.38	.01

[a] Listed as percentage on DM basis.
[b] Double sulfate of K and Mg.
[c] Contains NaCl 92%, Mn .250%, Fe .200%, Cu .033%, I .007%, Zn .005%, Co .0025%.

polyethylene vials via manual stimulation of the vulva and analyzed for pH. One, 4 ml aliquot of urine was collected for analysis of creatinine, Cl and P, while an additional 10 ml aliquot was acidified with .3 ml concentrated HCl. Blood plasma and acidified urine were then frozen for subsequent mineral analysis. Blood plasma and urine Na, K, Ca and Mg were analyzed via atomic absorption spectrophotometry, Cl via potentiometric titration, and inorganic P via spectrophotometry. Statistical analysis was via a general linear model which included variation due to square, cow within square, period within square, treatment, treatment x square, and residual.

Results and Discussion

Blood pH (Table 3) was reduced ($P<.03$) by the NaCl and KCl diets, although no other measures of acid-base status were affected. Gastrointestinal absorption of monovalent mineral ions from the diet influences systemic acid-base status. Absorption of cation occurs in exchange for the secretion of free

Table 2. Nutrient composition of experimental diets[a].

Nutrient[b]	Diet		
	Ctrl	NaCl+20	KCl+20
DM	46.40	47.00	46.70
CP	19.10	18.40	18.40
NE_l, Mcal/kg	1.63	1.65	1.65
ADF	25.40	24.30	23.40
NDF	42.50	36.60	36.50
Ca	.67	.69	.69
P	.48	.47	.46
Mg	.42	.41	.42
Na	.20	.67	.22
K	1.32	1.29	2.17
Cl	.35	1.05	1.07
S	.48	.49	.47
Fe, ppm	310	329	297
Zn, ppm	37	32	35
Cu, ppm	9	11	8
Mn, ppm	70	107	74
Mo, ppm	2	2	2
(Na+K)-Cl, meq/100 g diet DM	32.6	32.5	34.9

[a] Listed as percentage on DM basis.
[b] Nutrient composition from laboratory analyses.

proton (H^+) into the gastrointestinal tract (GT) lumen, while anion absorption is accompanied by the secretion of bicarbonate ion (HCO_3^-). The net result is that cation absorption increases systemic base generation and anion absorption increases systemic acid generation. Therefore, the ratio of monovalent cation to anion in the diet (DCAB) could reasonably be expected to influence blood acid-base status, an idea which has been confirmed previously (Tucker et al., 1988). In the present study, vastly different dietary mineral concentrations were utilized in the three diets to achieve a similar DCAB of +32 meq/100 g diet DM. Although each diet contained the same DCAB, blood pH differed among treatments, indicating that at the dietary mineral concentrations utilized, the ratio of Na and K to Cl was not a reliable indicator of dietary impact on acid-base status.

Plasma Na (Table 4) was unaffected by diet, plasma K was highest for KCl+20, and plasma Cl tended to reflect dietary Cl concentration, although this

Table 3. Least squares means and orthogonal contrasts for blood acid-base status response to experimental diets.

	Diet				P	
Blood	1 Ctrl	2 NaCl+20	3 KCl+20	SE	1 vs 2 and 3	2 vs 3
pH	7.395	7.387	7.383	.0033	.0245	NS[a]
pCO_2, mm Hg	44.9	45.2	46.8	.65	NS	NS
pO_2, mm Hg	32.7	34.3	33.1	.96	NS	NS
HCO_3^-, meq/L	27.8	27.4	28.1	.32	NS	NS
Standard HCO_3-, meq/L	26.2	25.8	26.1	.20	NS	NS
Total CO_2, mmol/L	29.2	28.8	29.5	.33	NS	NS
Base excess, blood, mmol/L	2.96	2.39	2.91	.275	NS	NS
Base excess, extracellular fluid, mmol/L	2.79	2.35	2.85	.318	NS	NS

[a] P >.10.

Table 4. Least squares means and orthogonal contrasts for mineral response to experimental diets.

	Diet				P	
Plasma, meq/L	1 Ctrl	2 NaCl+20	3 KCl+20	SE	1 vs 2 and 3	2 vs 3
Na	143.1	144.3	143.8	.77	NS[a]	NS
K	4.50	4.63	4.95	.090	.0246	.0315
Cl	101.2	102.0	103.6	.86	NS	NS
Ca	5.25	5.27	5.35	.031	NS	.0831
Mg	2.17	2.04	2.04	.023	.0001	NS
P, mg/L	70.3	73.4	72.6	3.10	NS	NS
Cation-anion balance[b]	4.64	4.69	4.51	.128	NS	NS
Urine mineral excretion, mg urine mineral/mg urine creatinine						
Na	2.10	7.91	3.18	.646	.0004	.0001
K	8.27	7.94	18.04	.695	.0001	.0001
Cl	3.29	10.12	11.26	.721	.0001	NS
Ca	.297	.379	.193	.0390	NS	.0035
Mg	.647	.648	.591	.0201	NS	.0584
P	.427	.628	.503	.0936	NS	NS

1 P >.10.

2 Expressed as meq((Na+K)-Cl)/100 ml plasma.

response was most evident for KCl+20. Plasma Ca tended to be higher (P<.09) for KCl+20 than NaCl+20. Supplemental KCl stimulates parathyroid hormone release, which could account for the elevation in plasma Ca. The reduction (P<.001) in plasma Mg on KCl+20 can likely be attributed to the high K concentration of that diet, since high dietary K inhibits Mg absorption from the reticulorumen. The plasma Mg response to NaCl+20 is more difficult to explain, and is in disagreement with O'Connor et al. (1988), who reported that the addition of 1% NaCl to the diet DM had no influence on plasma Mg.

Renal excretion of Na, K and Cl closely corresponded to dietary concentrations of these elements. Urinary Ca excretion tended to be higher for NaCl+20 and lower for KCl+20 than for Ctrl. The increased urinary Ca excretion is likely attributable to competition between Na and Ca for reabsorption from glomerular filtrate, while the reduction in Ca excretion observed with KCl+20 in the present study is in agreement with Deetz et al. (1982). They reported that ruminal infusion of KCl increased plasma parathyroid hormone which would subsequently increase renal conservation of Ca. The reduction in Mg excretion effected by KCl+20 is likely a result of reduced gastrointestinal absorption of Mg effected by high dietary K.

Milk yield and composition (Table 5) were generally unaffected by diet, although milk fat percentage, fat yield and protein yield tended to be higher (P<.10) for Ctrl than NaCl+20 and KCl+20. These responses can likely be attributed to lower DM intake (P<.001) for NaCl+20 and KCl+20.

In conclusion, dietary addition of 20 meq of Na and Cl, or K and Cl while holding DCAB constant at +32 meq/100 g diet DM resulted in a reduction in blood pH, but it had no significant effects on other measures of systemic acid-base status. Certain metabolic disorders (e.g., acidosis, parturient paresis) should, by nature of the disorder, respond to dietary manipulation of systemic acid-base status. This relationship has already been well documented for parturient paresis, which has been virtually eliminated by feeding a low DCAB during the dry period (Block, 1984). However, before DCAB can be utilized with confidence to control acid-base status, confirmation of the response of acid-base status to various points on the DCAB scale encountered in practical dairy feeding situations is essential. In addition, the variable response of acid-base status to a specific DCAB achieved via vastly different mineral concentrations in the present study indicates that the close association of DCAB and acid-base status demonstrated previously by Tucker et al. (1988) may only be operational within specific ranges of dietary Na, K, and Cl concentrations. This would make the practical application of DCAB more complicated, but would not preclude its use as a tool for controlling metabolic disorders associated with alterations in systemic acid-base status.

Table 5. Least squares means and orthogonal contrasts for milk yield, composition and dry matter intake response to experimental diets.

	Diet				P	
Milk	1 Ctrl	2 NaCl+20	3 KCl+20	SE	1 vs 2 and 3	2 vs 3
Yield, kg	22.7	21.4	22.1	.47	NS[a]	NS
Fat, %	3.55	3.68	3.46	.076	NS	.0574
Fat yield, kg	.80	.78	.76	.015	.0784	NS
Protein, %	3.23	3.21	3.23	.016	NS	NS
Protein yield, kg	.73	.69	.71	.015	.0984	NS
Lactose, %	5.08	5.07	5.10	.024	NS	NS
Solids-not-fat, %	8.94	8.91	8.96	.023	NS	NS
Dry matter intake, kg	18.5	16.5	17.4	.30	.0007	.0424

[a] P >.10.

Literature Cited

Beighle, D.E. et al. 1988. Interactions of dietary cation-anion balance and phosphorus: Effects on growth and serum inorganic phosphorus in dairy calves. J. Dairy Sci. 71:3362.

Block, E. 1984. Manipulating dietary anions and cations for prepartum dairy cows to reduce incidence of milk fever. J. Dairy Sci. 67:2939.

Deetz, L.E. et al. 1982. Renal function and magnesium clearance in young and old cows given potassium chloride and sodium citrate. J. Anim. Sci. 55:680.

Fredeen, A.H. et al. 1988. Characterization of acid-base disturbances and effects on calcium and phosphorus balances of dietary fixed ions in pregnant or lactating does. J. Anim. Sci. 66:159.

O'Connor, A.M. et al. 1988. Lactational responses to dietary magnesium, potassium, and sodium during winter in Florida. J. Dairy Sci. 71:971.

Tucker, W.B., et al. 1988. Influence of dietary cation-anion balance on milk, blood, urine and rumen fluid in lactating dairy cattle. J. Dairy Sci. 71:346.

TRACE MINERAL SUPPLEMENTATION OF CATTLE FED FINISHING RATIONS

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Story in Brief

Sixty one Angus x Hereford crossbred steers and heifers and 36 Holstein steers were used to evaluate trace mineral supplementation during the late finishing period. Trace mineral supplementation during the last 73 days on feed had no effect on the performance or carcass traits of the Angus x Hereford cattle fed from 960 pounds to slaughter. However, marbling score and percentage of cattle grading choice were improved for Holstein steers fed added trace minerals during the last 132 days on feed. Trace mineral supplementation did not affect hematocrit, plasma zinc or plasma copper levels.

(Key Words: Trace Minerals, Feedlot Cattle, Holstein, Marbling.)

Introduction

Feedlot rations usually are supplemented with protein, macrominerals, vitamins and feed additives to optimize animal performance; trace mineral supplementation often is overlooked. Compared to estimated trace mineral needs, typical corn, milo and wheat-based feedlot rations frequently are deficient in cobalt, iodine, copper, iron, manganese, zinc and selenium. Most feedlots rely on either a trace mineral supplement package or trace mineralized salt as their source of supplemental trace minerals. Sometimes an additional but separate selenium premix is added. A survey of trace mineral supplement packages and trace mineral salts commercially available revealed that most supplements do not provide appropriate levels of trace minerals to balance feedlot rations (Hicks and Owens, 1988). In some cases, inadequate levels of trace minerals were being supplemented, and in others excessive amounts were being provided. None of the trace mineral salts provided adequate amounts of all of the trace minerals. Few premixes or salts provided supplemental selenium.

This experiment was designed to test the response of both Holstein and beef cattle during the finishing period to supplemental trace minerals. The trace

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minerals were added to meet the NRC (1984) requirements for growing cattle. Feed intake, gain, carcass characteristics and blood measurements were recorded.

Materials and Methods

Thirty-six Holstein steers from the Oklahoma State University dairy unit, and 61 Angus x Hereford (AxH) cattle from a previous study were started on feed in June or July, 1988. The cattle were adapted to a corn finishing diet by gradually decreasing the roughage level. On July 22, cattle were weighed individually and divided into blocks according to body weight. The Holstein steers were allocated into three blocks of two pens each (six cattle per pen). The 52 AxH steers and 9 AxH heifers were divided into five blocks, four blocks of steers allocated by weight and one block of heifers. Animals within each block were allocated randomly to two pens, one pen receiving the control treatment and one pen receiving the same diet with supplemental trace minerals. All cattle had ad libitum access to feed in self feeders.

The diet composition is shown in Table 1. The supplemental trace mineral package added 20.8 ppm manganese from manganous oxide, 31.2 ppm zinc from zinc oxide, 5.2 ppm iron from ferrous sulfate, 3.12 ppm copper from copper sulfate, .21 ppm iodine from EDDI, .65 ppm cobalt from cobalt sulfate, and .104 ppm selenium from sodium selenite to the diet dry matter.

The AxH cattle were shipped to slaughter in two groups. Forty head of these cattle from six pens of steers of the heaviest weight blocks, and several steers from each of the other two pens, were shipped 75 miles to Booker, TX on September 29. The remaining AxH steers and heifers were shipped to the same plant on November 1. All Holsteins were shipped to Wellington, KS and slaughtered on December 5.

Table 1. Composition of diets on an as-fed basis.

Ingredient	Ration composition, %
Rolled corn	80.87
Alfalfa pellets	3.91
Cottonseed hulls	4.88
Supplement[a]	6.24
Molasses	4.10

[a] Supplement composition: soybean meal 44.88%, cottonseed meal 31.26%, calcium carbonate 11.73%, salt 4.36%, urea 5.76%, Vitamin A, Vitamin E, Rumensin and Tylan.

On October 20, blood samples were obtained from three cattle in each of the ten pens remaining (six pens of Holsteins, four pens of AxH cattle).

The data were analyzed within breed by analysis of variance. Means were compared using the Duncan's multiple range test.

Results and Discussion

Beef Cattle

Average daily gain, feed intake, and feed efficiency were not significantly affected by trace mineral treatment (Table 2). Trace mineral requirements probably are higher for younger, rapidly growing animals than for cattle like ours, which started receiving the supplement at 960 lb near the end of the finishing period. A significant response to trace mineral treatment would not be expected to occur during the last two months on feed unless cattle are deficient.

Carcass characteristics were not significantly altered by trace mineral treatment (Table 3). There was a trend toward an increased marbling score, fat thickness, and yield grade with trace mineral supplementation.

Limited blood data from the AxH cattle indicated that these animals had adequate levels of plasma copper and zinc (Table 4). Treatment did not affect blood measurements. The mean plasma copper level was 1.08 ppm in both groups, with values ranging from .94 to 1.38 ppm for controls, and .94 to 1.30 ppm for trace mineral treated cattle. Plasma or serum copper levels between .80 and 1.50 ppm are considered to reflect adequate copper status (Puls, 1981). Plasma zinc levels ranged from .90 to 1.25 ppm with a mean of 1.15 ppm for controls, and .95 to 1.30 ppm with a mean of 1.09 ppm for trace mineral treated cattle. Normal levels are .7 to 1.4 ppm for plasma zinc. Hematocrit was 38.8% for controls and 41.0% for the trace mineral treatment, indicating iron status was adequate.

Holstein Cattle

Growth, intake and feed efficiency also were not significantly affected by trace mineral treatment (Table 2). However, trace mineral treatment tended to increase feed intake and weight gains, and reduce feed required per lb of gain. As with the AxH cattle, there was a tendency toward increased fat thickness and ribeye area with trace mineral supplementation (Table 3). Marbling score was increased from 11.47 to 12.90 ($P<.05$), and the percentage of cattle grading choice was increased from 41.2 to 68.4%.

Blood measurements were not affected by treatment (Table 4). Hematocrit levels of Holsteins were lower ($P<.05$) than for AxH cattle (32.8 vs 40.0%,

Table 2. Effects of trace mineral supplementation on steer performance.

Breed	Angus x Hereford		Holstein	
Item Treatment[a]	0	+	0	+
No. of pens	5	5	3	3
No. of animals	30	30	17	19
Avg. days fed	73	73	132	132
Weight, lb				
Initial	953	968	764	759
33 days	1052	1073	857	856
64 days	1165	1175	955	967
92 days	1187	1202	1054	1076
110 days			1136	1162
132 days			1188	1213
Gain, lb/day	3.27	3.20	3.20	3.44
Intake, lb/day[b]	20.20	20.59	21.96	23.20
Feed/Gain[b]	6.37	6.73	7.31	6.84

[a] 0 is control diet; + is trace mineral supplemented diet.
[b] As-fed basis.

Table 3. Effects of trace mineral supplementation on carcass characteristics.

Item	Breed	Angus x Hereford		Holstein	
	Treatment[a]	0	+	0	+
Carcass weight, lb		746	758	693	707
Dressing percentage		62.8	63.0	58.3	58.3
Fat thickness, in					
measured		.44	.47	.20	.23
adjusted		.49	.51	.25	.28
KPH[b], %		1.95	1.96	2.13	2.08
Ribeye area, in^2		12.67	12.81	10.89	11.23
Marbling score[c]		14.77	15.48	11.47[d]	12.90[e]
USDA yield grade		2.89	2.94	2.70	2.70
Choice, %				41.2	68.4

[a] 0 is control diet; + is trace mineral supplemented diet.
[b] KPH-Kidney, heart and pelvic fat.
[c] Slight minus=10; small minus=13; modest minus=16.
[d,e] Means in the same row for the same breed with different superscripts differ (P<.05).

Table 4. Effect of trace mineral treatment on plasma copper and zinc and on hematocrit.

Item	Breed	Angus x Hereford		Holstein	
	Treatment[a]	0	+	0	+
No. of animals		6	6	9	9
Plasma copper, ppm					
Mean		1.08	1.08	1.06	.94
Range		.94-1.38	.94-1.30	.76-1.30	.80-1.18
Plasma zinc, ppm					
Mean		1.15	1.09	1.11	1.04
Range		.90-1.25	.95-1.30	.80-1.39	.80-1.35
Hematocrit, %					
Mean		38.8	41.0	31.9	33.7
Range		35.0-47.0	38.0-44.0	27.0-36.0	28.0-38.0

[a] 0 is control diet; + is trace mineral supplemented diet.

respectively). Plasma levels of copper and zinc tended to be lower in Holsteins than in the AxH cattle. Some of the Holsteins in the unsupplemented group had marginal plasma copper levels (.76 to .80 ppm) compared to copper considered indicative of adequate copper status (.8 to 1.5 ppm).

Some of the cattle finished in feedlots are Holstein cattle. Usually marketed with less external fat than other breeds, this often reduces their marbling score and quality grade. Studies with zinc methionine, a chelated zinc source, have shown a marbling response in cattle. This study indicates that supplementation of trace minerals to NRC levels with common trace mineral sources also may improve marbling and fat deposition in cattle. Effects of trace mineral supplementation on performance were not conclusive, but considering the small costs involved and the risks involved with deficiencies, routine supplementation at NRC levels is recommended.

Literature Cited

Hicks, R.B. and Owens, F.N. 1988. In: Mineral Supplements for Feedlot Cattle. Proc. Symp. Trace Minerals in Beef Cattle Nutrition, September 15, 1988, Texas A & M University, Amarillo, p 1A-14A.

NRC. 1984. Nutrient Requirements of Beef Cattle. National Academy Press, Washington, DC.

Puls, R. 1981. Veterinary Trace Mineral Deficiency and Toxicity Information. Pub. 5139, Agriculture Canada, Ottawa, Ontario.

SYNOVEX-S, FINAPLIX-S, OR REVALOR IMPLANTS FOR FEEDLOT STEERS

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Story in Brief

One hundred forty steers (778 lb) were implanted at the start of a feeding trial with: No implant (Control); Synovex-S; Revalor; Synovex-S + Finaplix-S (140 mg trenbolone acetate-TBA); Synovex-S + Finaplix-S with a reimplant of Finaplix-S at 58 days and fed a feedlot diet for 119 to 126 days. Daily gains were increased by treatments having trenbolone acetate (from Revalor or Finaplix-S) with the highest response from steers reimplanted with Finaplix-S at 58 days on feed. Carcass adjusted gains for the five respective treatments were 3.24, 3.07, 3.38, 3.45, and 3.50 pounds per day. Feed efficiency improved with implants (6.15, 6.07, 5.88, 5.63, and 5.66 lb feed/lb gain); the largest improvement (8.5%) occurring with Synovex-S + Finaplix-S administered at processing time. Steers receiving both estrogen and trenbolone acetate produced carcasses with larger ribeyes and slightly more masculine carcass characteristics than control or Synovex-S steers. The percentage of choice carcasses was similar for Contol, Synovex-S and early Finaplix-S treatments (82.1, 82.1 and 85.7% respectively) while percentage choice for Revalor was substantially lower at 51.8% and double Finaplix-S was slightly lower at 71.4%. Skeletal maturity was more advanced for all steers receiving implants while subcutaneous fat thickness, percentage kidney, pelvic and heart fat, marbling score, lean color and ribeye chemical composition were not affected. Implanted steers produced ribeye steaks with slightly higher shear force measurements than non-implanted steers.

(Key Words: Implants, Steers, Trenbolone Acetate, Carcass Traits.)

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Introduction

Anabolic implants have been used to increase rate of gain and improve feed efficiency in feedlot cattle in the United States for many years; the vast majority of cattle today are implanted once or more during growth and finishing. Until recently, only estrogenic implants were approved for use in the United States; however, trenbolone acetate (TBA), an androgenic compound, now is approved for use as an implant. Besides improving efficiency of beef production, both estrogenic and androgenic implants increase muscle tissue growth and thus provide beef consumers with a leaner product. The biological method by which estrogens and androgens improve productivity differs; hence additive effects are observed when the two are used in combination.

Effects of implants on growth rate and efficiency have been studied extensively, but effects of implants on carcass traits and meat palatability have been largely ignored. Administration of implants increases muscling in feedlot cattle, but quality grade, which still has a large impact on beef prices, may be altered adversely (Cross and Belk, 1989; Foutz et al., 1989). Consequently, effects of implants on beef quality characteristics need further attention.

The dosage levels of the active compounds (estradiol benzoate and trenbolone acetate), sex classes (steers, heifers, or bulls) and times of administration employed in implant studies have varied; thus, results are difficult to compare. Currently, Synovex-S and Finaplix-S usage is widespread in the U.S. for finishing feedlot steers and, although **Revalor is not currently FDA approved for use in the United States**, the level of active compounds (140 mg of trenbolone acetate and 20 mg of estradiol benzoate) is equivalent to that of combined implants of Finaplix-S and Synovex-S except for the progesterone in Synovex-S. Therefore, the objectives of this study were to examine the effects of various implant programs involving estradiol and trenbolone acetate (at dosage levels employed by industry) on rate and efficiency of growth, carcass traits, and meat tenderness of feedlot steers.

Materials and Methods

One hundred forty crossbred yearling steers averaging 778 lb, which previously had been implanted with Compudose (late August), were obtained from wheat pasture in late March. These steers were shipped approximately 100 miles to Oklahoma State University, individually weighed, tagged and processed. Because these cattle were initially weighed on arrival after being subjected to the stress of movement, trucking and fasting, initial weights were considered to be shrunk weights. Processing of animals consisted of IBR-PI3, 4-way clostridia vaccination and deworming with Ivermectin. The cattle were blocked into one of four different replications based upon initial weight. Steers

in each weight replication (n = 35) were assigned randomly to one of five different implant treatments: C = no implant (Control); S = Synovex-S (20 mg estradiol benzoate + 200 mg progesterone) on day 1; R = Revalor (20 mg estradiol benzoate + 140 mg trenbolone acetate) on day 1; ST = Synovex-S + Finaplix-S (140 mg trenbolone acetate) on day 1; and STT = Synovex-S + Finaplix-S on day 1 with a reimplant of Finaplix-S alone on day 58. Following implantation, steers in the same weight replication with common implant treatments (n = 7) were assigned to one of 20 different pens for feeding.

All pens were equipped with self feeders. All steers were started on an initial 50% concentrate diet which was increased stepwise (60, 70, 80, 90%) over a period of 15 days, to a final concentrate level of 95% in the finishing diet (Table 1). Individual live animal weights were obtained on day 30 of the trial and every 28 days thereafter. Feed consumption records for individual pens were recorded each weigh period. To compensate for fill, live weights taken throughout the feeding trial were shrunk by 4% (live weight x .96). Steers from the two heavier weight replications were fed for 119 days; the two lighter replications were fed 126 days prior to slaughter.

On the day designated for slaughter, steers were transported approximately 250 miles and slaughtered within 2 h of arrival at a commercial packing plant. Approximately 24 h postmortem, complete yield and quality grade data (USDA, 1989) were recorded. Additionally, all carcasses were scored subjectively for lean color and masculinity characteristics (bullock score) using the following systems: lean color score of 8 = pink, 7 = very light cherry red, 6 = cherry red, 5 = slightly dark red, 4 = moderately dark red, 3 = dark red, 2 = very dark red, 1 = black; bullock score of 5 = no evidence, 4 = slight, 3 = moderate, 2 = severe, 1 = extremely severe. The bullock score reflects the extent of pizzle eye (crus of the penis), bald spot (bulbo-cavervosus muscle) and crest (chuck splenius muscle) development.

Following collection of carcass data, a boneless portion of the wholesale rib (9th through 12th ribs) was fabricated from the left side of each carcass and vacuum packaged. These samples were cooler aged for 7 days (33°F), crust frozen (outer 1 inch) and faced (removal of .25 inch dehydrated and uneven 12th rib end portion) before a .25 inch steak (for pH and proximate analysis) and a 1 inch steak (for cooking property and tenderness determinations) were removed. For proximate analysis, samples were completely denuded of exterior fat and epimysial connective tissue, placed in Whirlpack bags and stored at -22°F until analysis. Shear force steaks were vacuum packaged and stored at -22°F. Proximate analysis followed procedures outlined by AOAC (1984). Shear force steaks were thawed (35°F) for 24h and broiled on Farberware Open-hearth broilers to an internal temperature of 158°F (AMSA, 1978). Cooking time (minutes to a medium degree of doneness) and cooking shrinkage (percent weight loss) were recorded for each steak. After steaks cooled to 77°F, 6 cores (.5 inch diameter) were removed and individually sheared one time to determine

Table 1. Composition of finishing diet, dry matter basis.

	Percent concentrate					
Feed	50	60	70	80	90	Final
Corn, whole, %	41.6	51.6	61.6	71.6	80.6	86.6
Cotton seed hulls, %	25.0	20.0	15.0	10.0	8.5	5.0
Alfalfa pellets, %	25.0	20.0	15.0	10.0	2.5	-----
Supplement[a], %	8.4	8.4	8.4	8.4	8.4	8.4

	Calculated analysis	
Nutrients	Diet composition	Supplement composition
NE_m, mcal/cwt	95	59
NE_g, mcal/cwt	61	38
Crude protein, %	12.3	48.4
NPN, % of diet	1.12	13.36
Crude fiber, %	5.37	9.37
Potassium, %	.55	2.06
Calcium, %	.45	5.06
Phosphorus, %	.33	.87

[a] Supplement composition: calcium carbonate 12.95%, cotton meal, solvent process 65.55%, potassium chloride 1.91%, Rumensin 60 units .26%, salt 3.57%, soymeal 44 10.47%, trace mineral .01%, Tylan 40 units .13%, urea 4.75%, vitamin A-30 units .26%, vitamin E 226,800 units .01%.

the average pounds of force required for each steak.

During the course of the trial, one steer from each of treatments S, R and ST suffered a broken leg. These steers were excluded from the data set and feed consumption records for their respective pens were adjusted according to net energy requirements for these steers. Feed efficiency and calculated net energy determinations were computed using pen means for feed consumption because animals were not fed individually. All carcass data were analyzed on a per animal basis. Statistical analysis was conducted with implant treatment and weight replication included in the model as main effects. No apparent interactions existed between implant treatment and weight replication. Least squares means were utilized to account for the unequal number of steers among treatments. Contrasts were conducted for the following effects: CI, ci = control versus all implants; CS, cs = control versus Synovex-S; CT, ct = control versus

treatments with TBA (R, ST, STT); ST, st = Synovex-S versus treatments including TBA; and EL, el = early versus late TBA administration. Significance was reported at the .05 and .10 probability levels.

Results and Discussion

Effects of implant treatment on cattle performance are presented in Table 2. Final weights were adjusted (hot carcass weight/.64, an assumed dressing

Table 2. Live cattle performance as stratified by implant treatment.

	Treatment[a]						
	C	S	R	ST	STT	SE	Effect[b]
Number of steers	28	27	27	27	28		
Weights, lb							
Initial	776	779	778	777	777	1.15	
Day 114	1203	1188	1230	1222	1240	11.31	ct ST
Final[b]	1172	1156	1192	1199	1206	8.43	CT ST
Gain, lb/d							
0-114 days	3.33	3.16	3.53	3.47	3.63	.10	ct ST
0-slaughter	3.24	3.07	3.38	3.45	3.50	.07	CT ST
Feed intake, lb/d							
0-114 days	20.21	19.45	18.37	18.93	20.05	.53	CS st
0-slaughter	19.94	18.64	19.87	19.39	19.79	.31	CS ST
Feed / Gain							
0-114 days	6.08	5.84	5.50	5.47	5.54	.24	ci ct
0-slaughter	6.15	6.07	5.88	5.63	5.66	.12	CI CT ST
Calculated net energy							
NE_g,mcal/cwt	63.7	65.0	66.2	68.7	68.3	1.09	CI CT ST

[a] Implant treatments: C = control (non-implanted); S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.

[b] Contrast effects:
CS (P<.05), cs (P<.10) = control versus Synovex-S;
CI (P<.05), ci (P<.10) = control versus all implants;
CT (P<.05), ct (P<.10) = control versus treatments with TBA;
ST (P<.05), st (P<.10) = Synovex-S versus treatments with TBA.

[c] Final weight = hot carcass weight/.64.

percentage) for more accurate estimation of average daily gain, feed efficiency and estimation of net energy content of the diet. Steers receiving TBA either from Revalor or combined implants of Synovex-S and Finaplix-S were heavier ($P<.05$) at slaughter than Synovex-S implanted or non-implanted steers ($P<.05$). In contrast to previous studies, slaughter weights for steers receiving a single implant of Synovex-S tended to be slightly lower than for non-implanted steers. A combination of estradiol and TBA (Treatments R, ST, and STT) increased average daily gains by an average of 6.2 and 11.6% respectively above controls and Synovex-S alone ($P<.05$). Feed efficiency was improved 1.3, 4.4, 8.5, and 8.0% for treatments S, R, ST, and STT respectively, over controls. The most apparent improvements ($P<.05$) in feed efficiency occurred for steers receiving TBA. Daily feed intake was similar across treatments except for steers treated with Synovex-S on day 0; they consumed less ($P<.05$) feed than controls or steers receiving TBA. This may account for their lower gains and final weights. Calculated NE_g values were highest ($P<.05$) for steers implanted with TBA (R, ST and STT) suggesting these steers used dietary energy most efficiently for live weight gain.

Values for the various carcass traits analyzed are represented in Table 3. Adjusted fat thickness, percentage kidney, pelvic and heart fat, and marbling score were unaffected ($P>.05$) regardless of implant treatment. However, steers with TBA had larger ($P<.05$) ribeyes than C or S steers. This increase was also observed when expressed as ribeye area/100 lb of carcass weight. A slight improvement in yield grade was also noted for TBA steers over controls ($P<.10$). The percentage of carcasses attaining choice was lowest ($P<.05$) for steers implanted with Revalor (51.8%) and a slight, but not significant reduction in percentage choice was noted for steers reimplanted with Finaplix-S on day 58 (71.4%). Percentage choice for C, S and ST treatments were 82.1, 82.1 and 85.7%, respectively. Exogenous sources of estrogen hasten physiological maturity. Skeletal maturity scores for all steers receiving implants were slightly more advanced ($P<.05$) than maturity scores for control steers. However, maturity scores for all treatments were well within "A" and this slight increase likely has no practical implication. No differences were noted across treatments for lean maturity or lean color scores ($P>.05$). Likewise, no problems with "dark-cutting" beef were detected. Steers receiving TBA either from Finaplix-S or Revalor produced carcasses with more masculine characteristics (lower numerical bullock scores) than non-implanted or Synovex-S implanted steers and additionally, bullock traits were most apparent with late administration (day 58) of TBA. Again, the practical implications are minor for these slightly elevated bullock scores since the means for all treatments were between 4 (slight bullock tendencies) and 5 (no evidence).

Values for post rigor longissimus (ribeye) muscle pH , proximate analysis, cooking properties and resistance to shear are presented in Tables 4 and 5. Implant treatment had no effect ($P>.05$) on post rigor pH or chemical

Table 3. Carcass traits as stratified by implant treatment.

	Treatment[a]						
	C	S	R	ST	STT	SE	Effect[b]
No. of carcasses	28	27	27	27	28		
Carcass weight, lb	751	740	763	767	771	5.39	CT ST
Fat thickness, in	.59	.61	.53	.55	.57	.04	
Ribeye area, in^2	12.8	13.0	13.7	13.8	13.8	.26	CI CT ST
KPH fat, %	2.1	2.0	2.1	2.1	2.0	.06	
Yield grade	3.2	3.1	2.8	2.8	2.8	.15	ct
Percent YG 4	7.1	14.2	0	7.7	10.7	6.66	
Skeletal maturity[c]	145	158	169	160	157	3.76	CI CT
Lean maturity[c]	139	139	138	140	139	1.92	
Marbling score[d]	463	435	418	447	438	14.7	
Percentage Choice	82.1	82.1	51.8	85.7	71.4	7.87	
Lean color score[e]	6.25	6.33	6.33	6.26	6.39	.09	
Bullock score[f]	4.6	4.6	4.3	4.4	4.1	.10	CT ST EL

[a] Implant treatments: C = control (non-implanted); S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.

[b] Contrast effects:
CI (P<.05), ci (P<.10) = control versus all implants;
CT (P<.05), ct (P<.10) = control versus treatments with TBA;
ST (P<.05), st (P<.10) = Synovex-S versus treatments with TBA;
EL (P<.05), el (P<.10) = early versus late TBA adminstration.

[c] Maturity score: 100 to 199 = "A" maturity (approximately 9 to 30 months of age).

[d] Marbling score: 400 to 499 = "small" corresponding to choice.

[e] Lean color score: 7 = light cherry red; 6 = cherry red; 5 = slightly dark red.

[f] Bullock score: 5 = no evidence; 4 = slight bullock tendencies.

Table 4. Proximate analysis and pH values as stratified by implant treatment.

	Treatment[a]					
	C	S	R	ST	STT	SE
Number of samples	28	27	27	27	28	
Post rigor pH[b]	5.7	5.7	5.7	5.7	5.7	.02
Moisture, %[b]	72.5	72.9	73.2	72.8	72.9	.19
Protein, %[b]	22.8	22.6	23.1	22.5	22.8	.18
Lipid, %[b]	4.0	4.1	3.3	3.9	3.6	.26
Ash, %[b]	1.1	1.1	1.1	1.1	1.1	.03

[a] Implant treatments: C = control (non-implanted); S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.
[b] All means did not differ (P>.05).

Table 5. Cooking property and shear force values as stratified by implant treatment.

	Treatment[a]						
	C	S	R	ST	STT	SE	Effect[b]
Number of steaks	28	27	27	27	28		
Cooking time, min	22.6	21.6	22.3	22.4	22.4	.61	
Cooking shrink, %	29.1	30.0	28.9	30.0	29.5	.65	
Shear force, lb	8.82	9.77	9.52	9.08	9.72	.13	CS CI ct
Percent tough[c]	21.4	37.5	37.5	25.8	35.7	8.57	

[a] Implant treatments: C = control (non-implanted); S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.
[b] Contrast effects:
CS (P<.05), cs (P<.10) = control versus Synovex-S;
CI (P<.05), ci (P<.10) = control versus all implants;
CT (P<.05), ct (P<.10) = control versus treatments with TBA;
ST (P<.05), st (P<.10) = Synovex-S versus treatments with TBA.
[c] Percentage of steaks with shear force values of 10 lb or higher.

composition of the ribeye muscle. Additionally, cooking time and cooking shrinkage of boneless rib steaks from implanted steers did not differ ($P>.05$) from the controls. Implanted steers produced steaks with slightly higher ($P<.05$) shear force values than non-implanted steers. No differences among treatments were noted for percentage of tough (shear force values greater than 10 lb) steaks.

The results of this study indicate that steers implanted with a combination of TBA and estradiol, managed under similar conditions, are faster gaining, more feed efficient, and more muscular than steers receiving no implant or an estrogen only. However, Revalor or TBA administered late in the finishing phase may reduce the number of carcasses reaching the choice grade. Implants did not adversely affect the ribeye muscle chemical composition and only a slight increase in shear force was noted.

Literature Cited

AMSA. 1978. Guidelines for cookery and sensory evaluation of meat. Am. Meat Sci. Assoc. and National Live Stock and Meat Board, Chicago, IL.

AOAC. 1984. Official Methods of Analysis (14th Ed.). Association of Official Analytical Chemists, Washington, DC.

Cross, H.R. and Belk, K.E. 1989. Two edged sword: Anabolic implants improve yield, hinder quality. Beef. Vol. 26, No. 1A:11.

Foutz, C.P. et al. 1989. Effects of trenbolone acetate in yearling feedlot steers on carcass grade traits and shear force. Okla. Agr. Exp. Sta. Res. Rep. MP-127:272.

USDA. 1989. Official United States standards for grades of carcass beef. AMS-USDA, Washington, DC.

EFFECT OF MONENSIN AND LASALOCID ON WATER INTAKE, RUMEN VOLUME, LIQUID PASSAGE RATE AND RUMINAL DRY MATTER IN FEEDLOT HEIFERS

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

Story in Brief

Nine Angus x Hereford heifers (1,200 lb) were used to compare the effect of two commercial ionophores on drinking water kinetics and on the amount of dry matter found in the rumen. Heifers were fed an 80% concentrate diet with or without monensin (300 mg/day) or lasalocid (220 mg/day) twice daily at 1.6% of body weight. Ionophores were hand-mixed with the diet and offered daily in the morning feeding. Water was offered free choice. Water intake was recorded daily. Water intake was similar (6.5 gallons/day) for the three diets. Ruminal evasion of drinking water was higher (5.9 gallons/day) for the monensin-fed animals as compared to control (5.2 gallons/day). Rumen volume and rate of fluid passage were not altered by either monensin or lasalocid when compared to the control diet. Dry matter in the rumen was 22% higher for heifers fed monensin. Increased residence time of dry matter in the rumen with monensin may partially explain why it often reduces feed intake.

(Key Words: Monensin, Lasalocid, Water Intake, Ruminal Contents.)

Introduction

Numerous studies with ionophores have stressed their value in diets for ruminants. Mode of action of these compounds still is debatable; however, one primary response to ionophores is an increase in feed efficiency achieved through regulating ruminal fermentation and site of digestion. Although very little research has focused on the effect of ionophores on water intake, liquid kinetics and rumen volume, Lemenager et al. (1978) and Owens et al. (1979) indicated that monensin reduced ruminal passage rates of liquid and solid fractions. These effects are highly correlated associated with feed intake and digestibility. By reducing turnover rate, extent of ruminal digestion should be

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enhanced. The objective of this trial was to study the effect of monensin and lasalocid on ruminal liquid passage rate, daily water intake, and ruminal volume of both solid and liquid in beef heifers limit-fed a high concentrate diet.

Materials and Methods

Nine Hereford x Angus heifers (1,200 lb) with large rumen cannulas housed in individual pens were used in three 3 x 3 Latin squares. Water was available at all times and daily water consumption was recorded during the 42-day study. Periods lasted 14 days. The first 11 days were for adaptation to the test diets (Table 1). Diets were fed twice daily (8:30 a.m. and 3:30 p.m.) at 1.6% of body weight (DM basis).

Previous to the experiment, each ionophore was mixed separately with 6.6 lb of ground corn. Each day, 20 g of this mixture was hand-mixed with the diet, and included in the morning's feed. On days 12 through 14 of each period, polyethylene glycol (PEG; M.W. 3350) was included in the drinking water (11.36 g/gallon of water offered) to study ruminal evasion. To estimate ruminal liquid dilution rate, 245 ml of cobalt ethylenediaminetetracetate (Co-EDTA; 880 mg Co) were dosed intraruminally 21 h prior to total ruminal evacuation. Ruminal digesta was

Table 1. Composition of concentrate (dry matter basis[a]).

Ingredient	Percent
Corn, dry rolled	63.10
Cottonseed hulls	14.10
Soybean meal, 44% CP as fed	10.05
Alfalfa, dehydrated pellets	6.00
Cane molasses	5.00
Salt	.50
Ground limestone	.50
Dicalcium phosphate	.50
Aurofac-10	.15
Urea, 42% N	.10
Ionophore[bc]	

[a] Control diet.
[b] Control + 300 mg Monensin/hd/day.
[c] Control + 220 mg Lasalocid/hd/day.

obtained by evacuation, weighed, separated by passing through a sieve with .25 x .25 inch pores, subsampled, and promptly returned to the rumen. Immediately after ruminal sampling, 2.2 lb of solid digesta and 1 quart of liquid were weighed separately and dried at 60°C for approximately 48 h. Concentrations of PEG and Co were estimated in ruminal liquid samples. Liquid dilution rate for Co was calculated as the slope of the natural logarithm of marker concentration vs time (Teeter, 1981). Total PEG intake (g/day), PEG outflow, ruminal volume, and the calculations for water evasion were similar to those described by Garza and Owens (1989). Data generated were analyzed for a triplicated 3 x 3 Latin square design using a general linear models procedure. Classes included squares, pen within squares, period within squares and treatments. When significant treatment effects were detected, means were separated using least significant difference.

Results and Discussion

Water intake and ruminal liquid volume estimated by direct evacuation were not affected by added ionophores (Table 2). Likewise, distribution of liquid associated with the solid fraction, expressed as bound liquid per lb DM, showed no appreciable difference between these three diets. Rumen liquid outflow remained constant (4.7 %/h) in all treatments. This is in contrast to data presented by Owens et al. (1979) in which liquid dilution rate decreased when monensin was added to a high concentrate diet. Although daily dry matter intake was held constant between treatments, total dry matter in the rumen and percent DM of ruminal contents were greater ($P<.02$) when heifers were fed monensin (Table 2). Similar trends were evident for lasalocid. This indicates that residence time for dry matter in the rumen was increased.

Whether increased ruminal dry matter fill in the monensin-fed animals, without altering ruminal liquid volume, was due to an increased water adsorption to the solids and altered chewing or by enhanced evasion of fluids to the lower tract is not clear. An increased rumen solids content would be expected to decrease rate of passage of ruminal solids as suggested by Owens and Goetsch (1986) and could explain reduced intake of cattle fed monensin (Potter and Wagner, 1987).

Effects of ionophores on ruminal water evasion are presented in Table 2. Evasion of drinking water, estimated by PEG inflow and outflow, was extremely high (90%) in the heifers fed monensin but similar for the control and heifers fed lasalocid. Evasion values generally agree with observations by Garza and Owens (1989).

Table 2. Effect of monensin and lasalocid on water intake, ruminal liquid distribution, volume and passage rate (n=9).

Item	Diets		
	Control	Lasalocid	Monensin
Intake:			
Feed, lb/d	23.4	23.4	23.4
Water, gal/d	6.4	6.5	6.5
Evasion,			
gal/d	5.2[e]	5.3[ef]	5.9[f]
% of intake	84.1[c]	81.2[c]	90.2[d]
Rumen contents:			
Liquid,			
Total, gal	12.5	13.0	13.0
Free, gal	10.5	10.6	10.4
Bound to feed, gal	2.0[a]	2.4[ab]	2.6[b]
pH	6.0	6.1	6.1
Solids, lb	15.7[a]	17.2[a]	19.7[b]
Liquid, lb	101.4	103.0	107.3
Dry matter, %	13.4[c]	14.3[cd]	15.4[d]
Ratio of bound liquid:DM	1.0	1.1	1.1
Rumen liquid outflow, %/h	4.7	4.7	4.6

[a,b] Means in the same row with different superscripts differ (P<.01).
[c,d] Means in the same row with different superscripts differ (P<.05).
[e,f] Means in the same row with different superscripts differ (P<.10).

Results suggest that monensin and lasalocid may affect ruminal fill but do not alter water intake, distribution of the liquid in the rumen, or rumen liquid volume. The increased evasion of drinking water from the rumen of animals fed monensin deserves further study. Delivering specific nutrients to the hindgut via drinking water may enhance animal performance.

Literature Cited

Garza F., J. D. and F. N. Owens. 1989. Quantitative origin of ruminal liquid with various diets and feed intakes. Okla. Agr. Exp. Sta. Res. Rep. MP-127:84.

Lemenager, R. P. et al. 1978. Monensin effects on rumen turnover rate, twenty-four hour VFA pattern, nitrogen components and cellulose disappearance. J. Anim. Sci. 47:255.

Owens, F. N. et al. 1979. Ruminal turnover rate-influence of feed additives, feed intake and roughage level. Okla. Agr. Exp. Sta. Res. Rep. MP-104:27.

Owens, F. N. and A. L. Goetsch. 1986. Digesta passage and microbial protein synthesis. In: L. P. Milligan, W. L. Grovum, and A. Dobson (Eds.). Control of Digestion and Metabolism in Ruminants. Prentice Hall, New Jersey.

Potter, E. L. and J. F. Wagner. 1987. The effect of feed additives and anabolic implants upon the feed intake of beef cattle. In: F. N. Owens (Ed.) Symposium Proceedings: Feed Intake by Beef Cattle. Okla. Agr. Exp. Sta. MP-121:182.

Teeter, R. G. 1981. Ph.D. dissertation. Oklahoma State University, Stillwater.

RUMINAL WATER EVASION AND STEADY STATE

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Story in Brief

Three experiments were conducted to compare the behavior of water soluble markers in the rumen. A total of 17 cannulated mature cattle were fed an 80% concentrate diet or a prairie hay diet. Water was offered free choice and individual water intake was monitored at 2 hour intervals. Markers were dosed either in the drinking water or infused directly into the rumen. Animals tended to drink more water during the late afternoon in all experiments. Evasion of drinking water estimated by the inflow-outflow method was 79 and 44% for polyethylene glycol or 66 and 51% for chromium for the concentrate and hay-fed animals, respectively. Water evasion for the concentrate-fed animals was 41% with the marker ratio method. Markers added to the water behaved similarly in the rumen, but they never reached steady state concentrations in the rumen. Estimates of liquid passage rate were similar for chromium and cobalt, but showed diurnal patterns. Although water evasion estimated by the ratio approach was lower, values indicate that a sizable percentage of imbibed water evades the rumen. Nutritional effects of ruminal evasion of drinking water deserve study.

(Key Words: Drinking Water, Evasion, Markers.)

Introduction

Ruminal passage rate of liquids and solids can influence digestibility, feed intake and efficiency of microbial growth (Owens and Isaacson, 1977). In general, as dilution rate of liquids in the rumen increases, efficiency of bacterial growth increases. Consequently changes in rate of flow from the rumen may have a direct effect on animal performance. The rate at which water flows through the gastrointestinal tract of the ruminant is influenced partially by the amount of liquid ingested, however the quantity of ingested water that enters the rumen has not been clearly defined. Woodford et al.

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(1984) reported that a small amount of drinking water (18%) evaded the rumen of lactating cows. Our experience (Garza and Owens, 1989) with beef heifers fed high concentrate diets indicated that drinking water evasion from the rumen was as high as 80%. The objectives of this research were to compare the behavior of chromium-EDTA (Cr-EDTA) and polyethylene glycol (PEG) in the rumen to verify previous water evasion results which were all based on PEG, to evaluate an alternative approach to calculate water evasion, and to estimate the passage rate of fluids and rumen liquid volume during a 48-h period with water soluble markers.

Materials and Methods

Experiment 1

Four rumen cannulated Hereford heifers (1,300 lb) housed in individual pens were fed a prairie hay or an 80% concentrate diet (Table 1) at 1.8% of body weight twice daily (0830 and 1600) in a crossover experiment with 2-week periods. All heifers were adapted to their diets during the initial 11 days of each period. Water was offered free choice and water intake was recorded daily. On days 12 through 15 of the trial, a solution of Cr-EDTA (68 mg Cr/gallon) was added to the drinking water. Polyethylene glycol (MW 3350) in solution also was included in the drinking water at a rate of 10.0 g per gallon of water offered. Water disappearance from the trough was measured at 3-h intervals. Water samples were collected to determine

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

Ingredient	Percent
Dry rolled corn	63.10
Dehydrated alfalfa pellets	6.00
Cottonseed hulls	14.10
Soybean meal	10.05
Cane molasses	5.00
Salt	.50
Ground limestone	.50
Dicalcium phosphate	.50
Aurofac-10	.15
Urea, 42% N	.10

concentration of Cr and PEG. On day 14 of the study, one pulse dose of 250 ml of a Co-EDTA solution (1.2 g Co) were administered intraruminally after the afternoon feeding and approximately 18 h prior to the ruminal evacuation. Samples from the rumen (250 ml) were obtained at 4-h intervals during the final three days of the trial starting immediately after the water soluble marker (WSM) solutions were included in the drinking water.

Chromium and cobalt concentrations in ruminal fluid were analyzed by atomic absorption spectroscopy and PEG concentration was analyzed turbidimetrically. Values from ruminal evacuation were used to calculate percentage of water evading the rumen (Garza and Owens, 1989). Mean water intake, rumen volume, marker concentration in ruminal fluid and dilution rate data were used to simulate ruminal steady state conditions and compare this condition with the observed behavior of markers in the rumen.

Experiment 2

Five mature beef steers (990 lb) were used to investigate ruminal evasion of drinking water. Calculations were based on comparison of concentration of markers dosed by two routes, either in the rumen or in the drinking water. Experimental procedures and management were similar to those described previously for Experiment 1.

In contrast to Experiment 1, animals were dosed intraruminally a solution of Co-EDTA (60 ml containing 150 mg CO) every 8 h during an 80-h period. Meanwhile, 25 ml of Cr-EDTA (12.1 g/gallon) were mixed per gallon of offered water. Water and ruminal samples were collected immediately after dosing began for three consecutive days at 8 a.m., noon, 2 p.m., 4 p.m., 8 p.m. and midnight. Data from marker concentration in the drinking water and ruminal liquid were used to calculate water evasion from the rumen, based on the following ratio:

$$\frac{\text{[Cr-EDTA] in ruminal fluid/drinking water dosed Cr-EDTA}}{\text{[Co-EDTA] in ruminal fluid/ruminally dosed Co-EDTA}}$$

This ratio will represent directly the proportion of drinking water mixing with rumen liquid; consequently 1 minus this value equals the proportion of water that evaded the rumen. No attempt was made to correct for marker absorption from the rumen.

Experiment 3

Eight Angus x Hereford cattle (1,230 lb) fitted with rumen cannulas were used in a 48-h trial. Animals were fed as outlined for Experiments 1

and 2. All animals were dosed in the rumen at 4 a.m. and noon of day 1 or 4 a.m. of day 2 with 120 ml of Co-EDTA (8.0 g Co/gallon) and Cr-EDTA (5.1 g Cr/gallon) solutions according to the schedule presented in Table 2. Ruminal samples (250 ml) were collected at approximately 2-h intervals for 40 h after dosing. Water intake was recorded for the intervals between times of rumen sampling. Ruminal samples were used to determine Cr and Co concentrations. Liquid rate of passage was estimated for both markers within and between infusion times by regressing the natural logarithm of marker concentration against time (Grovum and Williams, 1973). Rumen volume was calculated by dividing marker dose by the antilogarithm of the intercept of the slope line (marker concentration at time zero).

Statistics

Data generated from Experiment 1 were analyzed for a crossover experimental design. Classes in the statistical model were represented by animal, period and treatment. In Experiment 2, the statistical model included animal, marker, day and hour as classes. In Experiment 3, the slopes (liquid dilution rate) were compared between markers for the same infusion time; in addition, the overall slopes also were compared between the three different infusion periods. For the three experiments, means were separated using least significant differences when significant effects were detected.

Table 2. Sequence of markers used for intraruminal dosing.

	Infusions[a]		
Animal	1	2	3
1	Cr,Co		Cr,Co
2	Co	Cr	Co
3	Cr,Co		Cr,Co
4	Cr	Co	Cr
5	Cr	Co	Cr
6	Co	Cr	Co
7	Cr	Co	Cr
8	Co	Cr	Co

[a] Infusion 1 markers were dosed at 4 a.m. on day 1.
Infusion 2 markers were dosed at noon on day 1.
Infusion 3 markers were dosed at 4 a.m. on day 2.

Results and Discussion

Consumption of drinking water and frequency (number of animals drinking) across the three experiments were higher during the evening following the late afternoon meal (Figure 1). Compared to the hay diet, estimates of drinking water evasion from the rumen were higher for the concentrate diet (79 vs 49% for PEG; $P<.02$ and 66 vs 51% for Cr; $P<.08$). Marker comparison within diets showed a higher estimate of drinking water evasion for PEG as compared to Cr (79 vs 66%; $P<.02$) for the concentrate diet (Table 3, Experiment 1). The marker ratio method gave a lower evasion estimate (41%, Experiment 2; Table 3). Ruminal concentration of two markers, PEG and Cr-EDTA, placed in the drinking water, expressed as a ratio yielded similar marker behavior in the rumen (Figure 2), indicating that either PEG or Cr-EDTA could be used for water evasion estimates; however, marker concentrations even after three days of continuous ingestion, never reached steady state conditions (Figure 2). This suggests that rumen liquid volume or outflow were not constant; changes might occur from day to day as feed or water intakes change. Diurnal and nycterohemeral shifts also may cause erroneous interpretations when steady

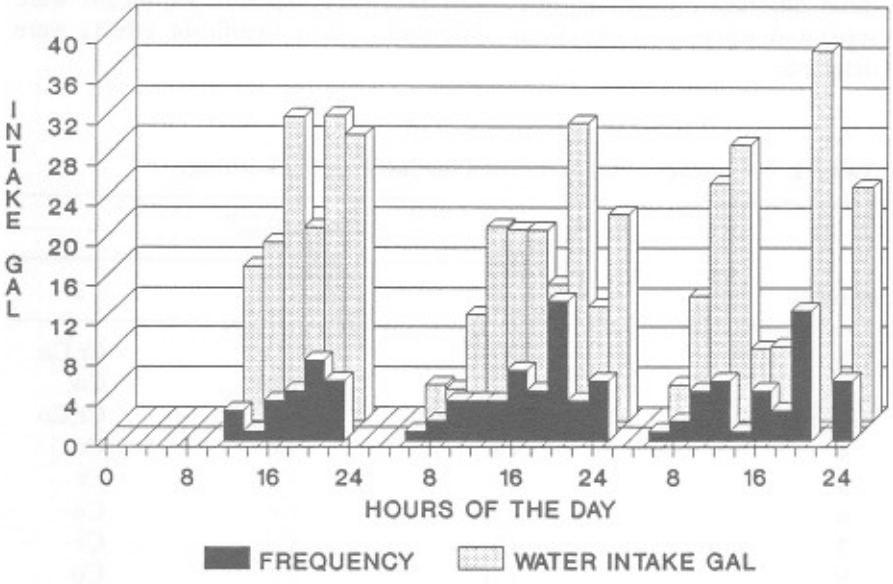

Figure 1. Water intake across the three experiments and number of animals (frequency) drinking water during three consecutive days.

Table 3. Water evasion estimates using two different methods.

Method	Evasion, % water intake		
	Concentrate	Hay	SE[a]
Experiment 1			
Inflow/outflow, PEG	79[bf]	44[c]	3.6
Inflow/outflow, Cr-EDTA	66[dg]	51[e]	3.2
Experiment 2			
Marker ratio[h]	41		9.9

[a] Standard error.
[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<.10).
[f,g] Means in the same column with different superscripts differ (P<.02).
[h] $\frac{\text{Cr-EDTA in rumen/drinking water dosed Cr}}{\text{Co-EDTA in rumen/intraruminally dosed Co}}$

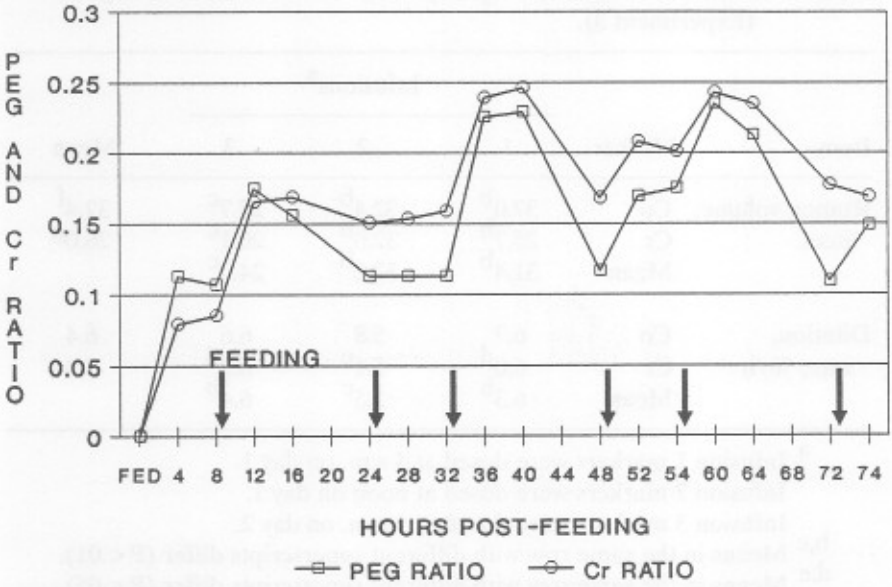

Figure 2. Marker (PEG and Cr) concentration ratios in ruminal fluid of beef heifers fed hay or concentrate diets (Experiment 1).

state is assumed. Consequently, in Experiment 3, short term ruminal liquid dilution rate and ruminal volumes were estimated on two consecutive days at different hours of the feeding cycle (Table 4). Mean liquid dilution rate were similar between Co-EDTA (6.4 %/h) and Cr-EDTA (5.8 %/h). Changes in dilution rate also were observed ($P<.01$) at various times of the day (Table 4) being lower at noon than at 4 a.m. In addition, ruminal volume was smaller ($P<.01$) when estimated form the 4 a.m. infusion on the second day of the trial, suggesting that volumes may change from day to day. Calculated volumes also were different ($P<.01$) between markers (32.4 liters for Co vs 26.0 liters for Cr). Results from these trials indicate that the rumen is a very dynamic pool. Estimates of drinking water evasion using different diets and different approaches remain high (41 to 80%). Even though PEG and Cr-EDTA behaved similarly in the rumen when included in the drinking water (Experiment 1) liquid dilution rate differences among times (Experiment 3) suggest nycterohemeral flow patterns in liquid digesta.

Table 4. Ruminal volume and liquid passage rate estimates during 48 h (Experiment 3).

Item	Marker	Infusions[a] 1	2	3	Mean
Rumen volume, liters	Co	37.0[b]	32.4[b]	27.7[c]	32.4[f]
	Cr	25.7[b]	32.0[b]	20.1[c]	26.0[g]
	Mean	31.4[b]	32.2[b]	24.0[c]	
Dilution, rate, %/h	Co	6.7	5.8	6.6	6.4
	Cr	6.0[d]	5.1[e]	6.2[d]	5.8
	Mean	6.3[b]	5.5[c]	6.4[b]	

[a] Infusion 1 markers were dosed at 4 a.m. on day 1.
Infusion 2 markers were dosed at noon on day 1.
Infusion 3 markers were dosed at 4 a.m. on day 2.
[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 column with different superscripts differ ($P<.01$).

Literature Cited

Garza F., J. D. and F. N. Owens. 1989. Quantitative origin of ruminal liquid with various diets and feed intakes. Okla. Agr. Exp. Sta. Res. Rep. MP-127:84.

Grovum, W. L. and V. J. Williams. 1973. Rate of passage of digesta in sheep. 4. Passage of marker through the alimentary tract and the biological relevance of rate-constants derived from the changes in concentration of marker in feces. Br. J. Nutr. 30:313.

Owens, F. N. and H. R. Isaacson. 1977. Ruminal microbial yields: factors influencing synthesis and bypass. Fed. Proc. 36:198.

Woodford, S. T. et al. 1984. Ruminal bypass of drinking water in lactating cows. J. Dairy Sci. 67:2471.

VIRGINIAMYCIN VERSUS MONENSIN FOR FEEDLOT STEERS

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Story in Brief

Two hundred twenty-four yearling feedlot steers were used to compare Virginiamycin (an antibiotic under preliminary evaluation) at 10 grams or 17.5 grams per ton to diets containing either no feed additives or monensin at 25 grams per ton. Feed efficiency was improved 4.0% by virginiamycin when fed at the 17.5 grams per ton and 1.8% at the 10 gram level. For comparison, monensin at 25 grams per ton improved feed efficiency 3.4%. No difference in carcass traits were detected, although incidence of liver abscess was less for the 17.5 gram virginiamycin level than for monensin or the 10 gram level of virginiamycin, but were about the same as for the control cattle. Feeding virginiamycin or monensin improved the energy (NEg) values of the test rations with the higher level of virginiamycin improving NEg by 4.3%.

(Key Words: Virginiamycin, Monensin, Antibiotics, 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 examine virginiamycin for proper feeding level, effect on gain, feed efficiency, and the incidence of liver abscesses, as well as 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 previous studies at Oklahoma State University (Gill et al., 1989; Smith et al., 1989) virginiamycin has improved feed efficiency 5.7 and 2.6%. In vitro studies (Nagaraja et al., 1987) have shown that virginiamycin inhibits lactic acid

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production. Volatile fatty acid production within the rumen varies with concentration of virginiamycin. This and other test data suggest that virginiamycin is beneficial in improving feedlot performance. **However, virginiamycin is not cleared for feeding to cattle.**

Materials and Methods

Two hundred twenty-four yearling steers were selected for uniform size and weight from a larger group of cattle. Steers were Hereford x Angus crossbred cattle from western Nebraska and South Dakota. The cattle were processed and individually tagged on March 20, 1989 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 Compudose-200 at the start of the study. The cattle were fed a receiving ration for one week, then trucked approximately 10 miles to the trial site at Goodwell, Oklahoma on March 28. Upon arrival, steers were individually weighed and subdivided into seven weight replicates of 32 head each (4 pens of 8 steers). Within each weight replicate, one pen was designated as control, one as virginiamycin (10 g per ton), one as virginiamycin (17.5 g per ton) and one as monensin (25 g 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 60% concentrate (Ration 1 of Table 1) in order to facilitate starting the cattle on feed. Roughage level was decreased sequentially in three steps until cattle were receiving the final ration by 15 days of the trial.

Initial weights were obtained off-truck, whereas period weights were taken full on all cattle. Gain and feed efficiency were calculated based on shrunk weights (96% of each weight except the initial weight) to account for fill. The cattle were fed for 117 days and weighed off test. Two days later they were trucked to Booker, Texas (75 miles) for slaughter. At slaughter, livers were examined for presence of liver abscesses or flukes. Carcass data were obtained 24 h postmortem. Three steers were removed from the analysis of the data, two for causes related to injury and one due to death (bloat on the control treatment). The removals were not related to the experimental treatments. Least squares means were separated using the least significant difference procedure protected by an initial F test ($P<.05$).

Results and Discussion

Effects of feeding monensin or virginiamycin on cattle performance are presented in Table 2. In contrast to a previously reported trial at the same

Table 1. Composition of diets on a dry matter basis.

Ingredient	Ration sequence 1	2	3	Final
	(%)			
Corn, steam flaked	49.53	59.53	69.53	81.53
Alfalfa hay	20.00	15.00	10.00	5.00
Cottonseed hulls	20.00	15.00	10.00	3.00
Cane molasses	3.75	3.75	3.75	3.75
Supplement[a]	6.72	6.72	6.72	6.72

Calculated composition of the final ration:

Nutrients	Ration composition DM %	As Fed %	Supplement composition DM %	As Fed %
NEm, Mcal/cwt	95.04	80.39	67.55	62.39
NEg, Mcal/cwt	61.56	52.07	44.85	41.42
Crude protein, %	12.25	10.36	51.33	47.41
Crude fiber, %	5.46	4.62	9.55	8.82
K, %	.69	.58	1.03	.95
Ca, %	.45	.38	4.73	4.37
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.

location, cattle receiving virginiamycin or monensin tended to consume slightly less feed. These results are similar to those reported by (Bartle et al., 1989) at Texas Tech where they reported about a 3% improvement in feed efficiency with 17.5 grams of virginiamycin in a similar trial. The differences for the 17.5 g virginiamycin level differed from the controls ($P<.05$). There were no differences in daily gain on either a live or on a carcass adjusted basis. In this trial improvements in feed efficiency were the result of reduced feed intake for both virginiamycin and monensin. This is in contrast to a previous test (Gill et al., 1989) where the virginiamycin cattle gained .71 lb

Table 2. Effects of virginiamycin or monensin on steer performance.

	Control	VM 10 g	VM 17.5 g	Monensin 25 g
No. of pens	7	7	7	7
No. of head	55	56	55	55
Weight, lb				
Initial	745	743	745	745
56 days	997	988	990	996
117 days	1198	1195	1200	1198
Daily gains, lb				
0-56	3.79	3.66	3.67	3.77
57-117	3.16	3.27	3.31	3.18
0-117	3.46	3.45	3.48	3.46
Carcadg[a]	3.58	3.53	3.62	3.55
Daily feed, lb DM				
0-56	21.37[b]	20.66[bc]	20.59[c]	20.71[bc]
57-117	21.57	21.32	20.88	20.80
0-117	21.47[b]	21.01[bc]	20.73[c]	20.75[c]
0-Slaughter	21.38[b]	20.91[bc]	20.62[c]	20.65[c]
Feed/gain				
0-56	5.66	5.68	5.62	5.52
57-117	6.84[b]	6.57[bc]	6.31[c]	6.54[bc]
0-117	6.21[b]	6.10[bc]	5.96[c]	6.00[bc]
0-Slaughter	5.99[b]	5.93[bc]	5.71[c]	5.83[bc]
Metabolizable energy, Mcal/kg	3.18[b]	3.20[bc]	3.29[c]	3.24[bc]
Net energy, Mcal/cwt				
Maintenance	97.43[b]	98.64[bc]	103.24[c]	100.85[bc]
Gain	64.13[b]	64.63[b]	66.90[c]	65.76[b]

[a] Carcass average daily gain (carcass weight/.64).
[b,c] Means in the same row with different subscripts differ ($P<.05$).

more weight per day ($P<.01$) than the control cattle (4.25 vs 3.54) in the first 28 days on feed. As in the previous studies these cattle received high levels of concentrate early. However, these test cattle were younger in age and may have been less prone to digestive upsets while receiving higher concentrate levels. One animal on the control treatment was foundered but its performance was considered normal and is included in the analysis. Feed efficiency over the total trial was improved 4.0% with virginiamycin 17.5 g, 1.8% with virginiamycin 10 g, and 3.4% with monensin (live basis). On a carcass adjusted weight basis, these differences were 4.7, 1.0 and 2.7%,

respectively. Only the response to the higher virginiamycin level (17.5 g) differed significantly ($P<.05$) from the controls.

Carcass traits (Table 3) were not altered by treatment; however, the data suggest that the cattle receiving the higher level of virginiamycin or monensin tended to be fatter. This would indicate that the energetic efficiency may be even higher than the values calculated for NEm and NEg. These values were calculated from an equation (Owens et al., 1984) that assumes an equal energy density in the carcass for all treatments at time of slaughter. With these calculations, only the virginiamycin 17.5 g treatment exhibited a higher NEm or NEg value than the controls ($P<.05$). Liver abscesses were detected in 49 of the 221 cattle. The highest level, 32.9%, occurred in the cattle receiving monensin and with the 10 g level of virginiamycin 23.2%. Steers fed higher level of virginiamycin (17.5 g/ton) had fewer abscesses than did the monensin fed cattle. Marbling scores in this trial are more indicative of the youthfulness of the cattle rather than lack of finish as indicated by an average of .48 inch subcutaneous fat thickness across all treatments. When cleared for use virginiamycin shows promise as being a useful additive to improve the efficiency of feedlot cattle.

Table 3. Effect of virginiamycin or monensin on carcass characteristics.

Item	Control	Virginiamycin 10 g	Virginiamycin 17.5 g	Monensin 25 g/ton
Carcass wt, lb	749.1	744.6	752.2	746.8
Dressing %[a]	62.6	62.3	62.7	62.4
Rib eye area, sq in	13.33	13.37	13.27	13.23
KPH, %	2.11	2.13	2.12	2.24
Fat thickness, in	.46	.46	.50	.49
Marbling score[b]	398	399	381	384
Percent choice	47.5	50.0	45.7	38.0
Percent YG 4	.00	1.8	1.8	7.1
USDA yield grade	2.59	2.55	2.69	2.70
Liver abscess:				
Incidence, %	17.9[ab]	23.2[ab]	14.5[a]	32.9[b]
Severity[c]	2.3[a]	2.1[a]	1.7[ab]	1.5[b]

[a] Calculated by dividing hot carcass weight by the gross 117 day weight.
[b] 300-399 = slight; 400-499 = small (USDA, 1987).
[c] 0=no abscesses; 1=one or two small, well organized inactive abscesses; 2=two to four well organized abscess without inflammation; 3=one or more active abscesses with inflammation, only among cattle with abscesses.

Literature Cited

Bartle, S.J. et. al. 1989. The effects of Virginiamycin on performance and carcass characteristics of feedlot cattle. Texas Tech University, Agricultural Sciences Technical Report No. T-5-263:50.

Gill, D.R. et al. 1989. Virginiamycin versus monensin for feedlot steers. Okla. Agr. Exp. Sta. Res. Rep. MP-127:89.

Smith, M.T. et al. 1989. The effect of virginiamycin on performance of feedlot cattle. Okla. Agr. Exp. Sta. Res. Rep. MP-127:137.

Nagaraja, T.G. et al. 1987. In vitro lactic acid inhibition and alterations in volatile fatty acid production by antimicrobial feed additives. J. Anim. Sci. 65:1064.

Owens, F.N. et al. 1984. Net energy calculations from feedlot performance data. Okla. Agr. Exp. Sta. Res. Rep. MP-117:290.

LIMIT FEEDING VS FULL FEEDING HIGH CONCENTRATE DIETS TO EARLY WEANED CALVES - EFFECTS ON PERFORMANCE TO SLAUGHTER

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Story in Brief

Fifty-eight fall-born calves were allotted on January 18 to four treatment groups consisting of: 1) early weaning and limit-feeding a 90% concentrate ration to gain 1.0 lb/day; 2) same as Treatment 1 except fed to gain 1.5 lb/day; 3) same as 1 except full-fed the 90% concentrate diet; or 4) calves remained with their dams until normal weaning on May 1, 1989. On May 1, all calves were placed on full feed until slaughter at .5 inch backfat estimated by ultrasound scan. Limit-fed calves gained at or slightly above projected gains, while full-fed calves gained 3.86 lb/day during the same period. On an as fed basis, lb feed/lb gain during the limit feeding period were 5.7 and 4.4 for limit-fed groups and 3.7 for the full-fed group. During finishing calves previously limit-fed at 1.0 lb/day tended to gain faster than calves limit-fed at 1.5 lb (3.23 vs 3.06 lb/day). Full-fed calves made the lowest gains during finishing (2.45 lb/day) and also had the lowest feed intake throughout the finishing phase. Finishing gain and feed intake were similar for normally weaned calves and calves previously limit-fed. Full-fed calves tended to be the youngest at slaughter although slaughter weights were similar for all treatments. Marbling score was not improved by feeding concentrate at an early age.

(Key Words: Beef Cattle, Early Weaning, Limit Feeding, Marbling.)

Introduction

Early weaning can be a useful tool during conditions when forage for the cow herd is inadequate, cows are too thin to breed, or other conditions in which the amount of purchased feed required to maintain both cow and calf can be more efficiently fed directly to the calf. The most commonly used

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early weaning rations contain relatively high levels of roughage to limit daily gains during the growing period to normal weaning age. Recent research has shown that a more efficient approach to growing young cattle at moderate rates of gain may be to feed high concentrate rations at daily amounts necessary to achieve target gains. A computer program can generate daily feeding rates based on calf sex, weight and desired rate of gain. Preliminary research at other universities has also suggested that feeding high concentrate diets to young calves may improve marbling at slaughter. The severe drought of 1988 created the need to early wean a group of fall-born calves at the Range Cow Research Center. The objectives of this study were to evaluate performance of early weaned calves limit-fed or full-fed high concentrate diets to normal weaning age and to evaluate subsequent finishing performance and carcass characteristics.

Materials and Methods

Fifty-eight calves born between September 1 and November 7, 1988 were weighed on January 18, 1989 after 4 h withdrawal from their dams. Calves were then allotted to four treatment groups based on breed, sex and weight. Treatments were: 1) early weaned and limit-fed a 90% concentrate ration to gain 1.0 lb/day; 2) same as Treatment 1 except fed to gain 1.5 lb/day; 3) same as 1 except full-fed the 90% concentrate diet; or 4) calves remained with their dams until normal weaning on May 1, 1989. Treatment 4 calves received 2 lb/day of salt-limited creep (67% rolled corn - 33% soybean meal) while on pasture.

All calves were vaccinated with 7-way blackleg (Ultra-bac 7), intranasal IBR-PI3 (Nasamune-IP), a live culture Pasteurella vaccine (Respirvac - Beecham Labs), and implanted with Synovex C. Early weaned calves were maintained in one pen for a 26-day weaning period and fed a complete mixed ration (Table 1). On February 13, calves were sorted to treatments and fed the 90% concentrate ration (Table 1) at designated levels. Feeding rates for limit-fed treatments were changed at 14-day intervals as weight increased. Steers were fed separately from heifers during the limit-feeding period. Average feeding levels for limit- and full-fed calves are shown in Table 2.

On May 1, calves from Treatment 4 were weaned and fed the weaning ration (Table 1) for 12 days after which they were switched to the final finishing ration which was fed to all treatments until slaughter (Table 3). Calves from Treatments 2 and 3 were adjusted to full feed by increasing daily feed by 1 lb/day until some feed was left. At this point, all calves were fed from self-feeders. On May 12, all calves were revaccinated with 7-way blackleg and IBR-PI3 (Norden Resbo 3). Heifers and steers were fed together during the finishing phase. Fat over the 12th rib was estimated every 14 days during the finishing phase using ultrasound. Calves were

Table 1. Weaning ration used for early and normally weaned calves (as fed basis).

Ingredient[a]	Ration		
	Weaning	Limit feeding	Finishing
Rolled corn	47.5	66.5	71.9
Cottonseed hulls	25.0	6.0	5.9
Cane molasses	3.5	3.5	4.1
Alfalfa, suncured	5.0	5.0	4.9
Soybean meal	14.8	14.8	9.71
Calcium carbonate	1.71	1.71	1.26
Cottonseed meal	2.02	2.02	1.94
Dicalcium phosphate	.15	.15	---
Rumensin 60	.02	.02	.02
Salt	.30	.30	.30
Trace mineral premix	.01	.01	.01
Vit E (222800)	.01	.01	.01
Vit A (30,000)	.01	.01	.01
Tylan 40	.01	.01	.01
Calculated analysis, %			
Crude protein	13.9	14.6	12.7
Calcium	.78	.61	.61
Phosphorus	.29	.29	.29

[a] Soybean meal, cottonseed meal, minerals, vitamins and additives were pelleted (3/16 in) before mixing with other ingredients.

slaughtered at a local commercial facility when estimated backfat reached .5 in. Except for initial weight on January 18, all calf weights were taken without withdrawal from feed or water and were adjusted for 4% shrink. Carcass measurements were taken 24 h following slaughter.

Data were analyzed using general linear models procedure. The model included treatment, breed and sex of calf, age of dam, calf birthweight and birthdate.

Results and Discussion

No sickness was observed during the weaning period from January 18 to February 13. Early weaned calves' gains averaged 1.77 lb/day (Table 2)

Table 2. Gains and feed intakes of early and normally weaned calves through slaughter (least squares means).

	Treatments			
	Early weaned			
	1.0 lb/day	1.5 lb/day	Full feed	Normal weaned
No. of calves	12	14	15	14
Calf weight, lb				
Jan 18	222	229	211	231
Feb 13	269	268	263	245
May 1	352[a]	415[b]	560[c]	402[b]
slaughter	838	852	854	843
Daily gain, lb				
Jan 18 to Feb 13	1.81[ab]	1.49[a]	2.00[b]	.57[c]
Feb 13 to May 1	1.08[a]	1.91[b]	3.86[c]	2.04[b]
May 1 to slaughter	3.23[bc]	3.06[b]	2.45[a]	3.12[b]
Jan 18 to slaughter	2.43[b]	2.53[b]	2.90[a]	2.50[b]
Feed:gain, as fed				
Feb 13 to May 1	5.7	4.4	3.7	-----
May 1 to slaughter	5.3	5.80	5.7	5.9
Feed intake, lb/day				
Feb 13 to May 1	6.2	8.25	14.5	-----
May 1 to slaughter	16.9	18.0	14.9	18.3
Days from May 1 to slaughter	153	144	118	142
Age at slaughter/days	379	370	343	367

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

Table 3. Carcass characteristics of early and normally weaned calves (least squares means).

	Treatments			
	Early weaned			
	1.0 lb/day	1.5 lb/day	Full feed	Normal weaned
Hot carcass weight	551	552	567	542
Dressing, %	65.9	64.7	66.3	64.2
Quality grade[a]	340	326	342	352
Ribeye area, in	11.3	11.4	11.6	10.7
Marbling score[b]	339	326	338	358
Fat thickness, in	.50	.45	.50	.47
KHP, %	1.89	1.73	1.72	1.95
Yield grade	2.62	2.42	2.54	2.71
Maturity[c]				
lean	152[a]	144[ab]	133[b]	141[b]
skeletal	138	135	129	131
overall	145	139	131	136

[a] 200 = standard, 300 = select, 400 = choice.
[b] 200 = traces, 300 = slight, 400 = small.
[c] 100 = A maturity.

during the 26-day weaning period. Calves that remained on pasture with their dams gained only .57 lb/day ($P < .01$) during the same period. This is consistent with our previous Oklahoma State University studies with early weaned calves and demonstrates that early weaned calves can adapt quickly to mixed rations.

During the limit-feeding period, it was necessary to remove one calf from Treatment 1 on April 28 because of chronic bloating. An additional calf from Treatment 1 was removed during the finishing phase of the study because of poor performance. It was not believed that the poor performance of this calf was related to the study. Only one calf was treated for respiratory infection throughout the study. A number of calves were treated for footrot in May and June, probably because of heavy rainfall and muddy lot conditions.

The small amount of the high concentrate diet used for 1.0 lb/day gain during limit feeding (Table 2) was insufficient to maintain comfort among the calves. Calves from this group consumed their feed (avg of 6.2 lb) within 5

min and were continuously hungry. Calves consumed dirt and attempted to paw out hay residues in the pen. Although 1.0 lb/day is not a low rate of gain for cattle on a full feed of roughage, there may be a minimum daily amount of feed to provide satiety. The amount of feed for a projected 1.5 lb/day gain was consumed within 1 to 2 h. Calves from this group appeared comfortable.

Calves in Treatment 1 were very close to their projected 1.0 lb/day gain (1.08 lb/day, Table 2) while Treatment 2 calves gained about .4 lb/day faster than projected. Full-fed calves gain 3.86 lb/day during the same period. This rate of gain demonstrates that even light-weight, young calves are capable of rapid gains when fed high concentrate diets. Calves that remained on their dams, gained 2.04 lb/day, very similar to limit-fed calves from Treatment 2. Although it was not possible to analyze individual feed intake because calves from each treatment were fed together, feed intake and feed efficiency data are shown in Table 2. Young, light weight calves fed high concentrate diets are very efficient. On an as fed basis (diet dry matter approximately 89%), lb feed/lb gain during the limit feeding period were 5.7 and 4.4 for Treatments 1 and 2 and 3.7 for the full-fed group.

Because one objective of this study was to evaluate the effects of early concentrate feeding on ability to deposit marbling at early ages, all calves were switched to full feeding at approximately 7 months of age on May 1. Light weights at 7 months of age and a sex distribution of 2 heifers for each steer, resulted in slaughter weights that were lighter than desirable for the beef trade. For commercial purposes, calves should have remained on growing diets until they reached heavier weights.

Gains of calves during the finishing phase were generally inverse to gains during growing or nursing. Calves from Treatment 1 tended to gain faster than calves from Treatment 2 (3.23 vs 3.06 lb/day). Full-fed calves from Treatment 3 made the lowest gains during finishing and also had the lowest feed intake throughout the finishing phase. Calves from Treatment 4 gained at a similar rate during finishing as calves from Treatment 2. Similar gain and feed intake for Treatments 2 and 4 before and during finishing suggests that limit feeding does not affect finishing gains when calves are limit-fed at the same rate they would have achieved on pasture. Feed efficiency during finishing was best for Treatment 1 calves, suggesting that calves limit-fed at low rates of gain can show compensatory gain.

Age at slaughter tended ($P<.06$) to be youngest for Treatment 3 calves that were full-fed from weaning to slaughter. Treatment 1 calves tended to be the oldest at slaughter. Days from initiation of the finishing phase to slaughter also tended to be lowest for Treatment 3. Contrary to popular belief, Treatment 3 calves full-fed high concentrate from an early age did not reach an equivalent level of fatness at lighter weight than calves grown more slowly.

Carcass traits are shown in Table 3. All groups were killed at similar

backfat thickness. Quality grade and marbling score were not increased by feeding high concentrate diets from an early age. Ribeye area, yield grade, KHP% and dressing percent were similar for all treatments. Lean maturity scores were greatest ($P < .01$) for Treatment 1. Skeletal and overall maturity scores also tended to be highest for Treatment 1. Differences in maturity scores probably reflect the greater age at slaughter of Treatment 1 calves.

In conclusion, fall-born calves can be successfully early weaned during the winter and grown efficiently to normal weaning age on limit-fed, high concentrate diets. Limit feeding apparently does not affect subsequent finishing performance when preweaning rate of gain is similar to that achieved on forage and milk. Feeding high concentrate diets from an early age may not, however, increase marbling when calves are slaughtered at about one year of age.

AN EVALUATION OF AN INACTIVATED, LEUKOTOXIN-RICH, CELL-FREE *PASTEURELLA HEMOLYTICA* VACCINE FOR PREVENTION OF UNDIFFERENTIATED BOVINE RESPIRATORY DISEASE

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Story in Brief

Four hundred and fifty-nine mixed breed 414 pound calves were randomized into three treatments and transported 750 miles from Mississippi to Pawhuska, Oklahoma to observe the effect of a commercially prepared experimental *Pasteurella hemolytica* vaccine on morbidity, mortality, and average daily gain during a 28-day receiving period. The calves were received in four loads (trials) sequentially over a 106-day period. After arrival, all calves received daily prairie hay free choice plus 2 pounds of a 38% protein pellet. Treatment A was vaccinated pre-transit (Mississippi), Treatment B was vaccinated post-transit (Oklahoma), and Treatment C was not vaccinated. Treatments A and B were revaccinated seven days following arrival. Average daily gains of calves vaccinated post-transit were higher than for calves vaccinated pre-transit. Post-transit vaccinated calves tended to gain faster than non-vaccinated calves. Gains of sick calves in post-transit and non-vaccinated groups were higher than for sick calves vaccinated pre-transit. Morbidity was lower in pre-transit vaccinated calves than in post-transit vaccinated calves and, although not statistically significant, morbidity tended to be lower for pre-transit vaccinated than non-vaccinated calves. Mortality differences were not altered by treatment. The morbidity rates obtained were typical for stressed calves received at this research station. However, mortality rates were higher than usually observed.

(Key Words: *Pasteurella Hemolytica*, Morbidity, Stressed Calves.)

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Introduction

Undifferentiated bovine respiratory disease, "shipping fever", causes the loss of millions of dollars annually to the cattle industry. An effective and predictable vaccine for the prevention of this disease is desired.

The effect of undifferentiated bovine respiratory disease on individual animals varies. In general, it will elevate rectal temperature to beyond 104°F (Gill and Richey, 1982) when normal body temperatures are at a diurnal low point. Excessive nasal discharge will be present and labored breathing and coughing, lethargy, and a reluctance to eat will be observed. If left untreated, the disease often will result in death.

Pasteurella hemolytica has been the primary pathogen associated with undifferentiated bovine respiratory disease for many years (Carter, 1954; Gale and King, 1961). Martin et al. (1980) isolated the organism from the pneumonic lungs of feedlot cattle. It has been the most commonly isolated bacterial pathogen from the acutely affected bovine lung (Frank and Smith, 1983).

Research with *Pasteurella hemolytica* vaccine has met with mixed results. Smith (1983) reported an 89%, 77%, and 44% reduction in morbidity when a *Pasteurella hemolytica* vaccine was administered to commercial cattle, preconditioned cattle, and feedlot cattle, respectively. Smith et al. (1986), using 504 newly received steer and bull calves, reported an 18% decrease in the incidence of sickness when a live *Pasteurella hemolytica* vaccine was administered at processing. Daily gains were not affected.

The objective of this study was to determine the effectiveness of an inactivated, leukotoxin-rich, cell-free *Pasteurella hemolytica* vaccine in preventing undifferentiated bovine respiratory disease in calves under stress conditions.

Materials and Methods

Four truck loads (trials) of mixed breed calves were purchased by order buyers from auction markets in the southeastern United States over a 106-day period. The calves were assembled in Mississippi where they were weighed, ear tagged and assigned randomly to three treatments and two pen replications within each load. Treatment A received an inactivated, leukotoxin-rich, cell-free *Pasteurella hemolytica* vaccine pre-transit; Treatment B received the vaccine post-transit; and Treatment C received no *Pasteurella hemolytica* vaccine. All calves received a modified-live IBR-PI3-BRSV vaccination pre-transit in Mississippi. The calves were transported 750 miles to Pawhuska, OK. The arrival date and weight, number of head, in-transit shrink, and hours in-transit for each load are summarized in Table 1.

Table 1. Arrival date, number of head, in-transit shrink, and hours in-transit for each load.

Load	Arrival date	Number of head	Arrival wt, lb	Shrink, %	Transit, h
1	10-28-88	102	467	3.9	13
2	11-18-88	139	340	5.3	14
3	12-07-88	117	404	5.0	16
4	01-11-89	101	476	3.1	12.5

Upon arrival at Pawhuska, Oklahoma the calves were individually weighed off truck and allowed access to prairie hay and water. The morning following arrival, the calves were processed as follows:

1. Weighed individually.
2. Vaccinated with 7-way clostridial.
3. Injected with ivermectin.
4. Calves allocated to Treatment B received a *Pasteurella hemolytica* vaccination.
5. Calves were started on antibiotic treatment if clinical signs of illness were detected.
6. A hospital card was initiated for calves diagnosed as being sick, and each sick calf was placed in the hospital pen away from the healthy calves.
7. Calves were assigned randomly to one of two pens per treatment immediately following processing.
8. Seven days following arrival, all calves were revaccinated with modified live IBR-PI3.
9. Seven days following arrival in Oklahoma calves in Treatments A and B were revaccinated with the *Pasteurella hemolytica* vaccine.

Upon entering their home pen, the calves had ad libitum access to prairie hay and water. Once daily the calves were offered 2 lb of a 38% protein pellet (Table 2).

Calves were checked twice daily for signs of bovine respiratory disease throughout the 28-day period. Signs used to diagnose the disease were excessive nasal discharge, coughing, labored breathing, lethargy, reluctance to eat, and a rectal temperature exceeding 104°F. Calves diagnosed as being sick were treated with antibiotics and put in the hospital pen. Postmortem

Table 2. Composition of 38% protein supplement.

Ingredient	As fed, %
Cottonseed meal	5.00
Soybean meal	88.99
Salt	3.00
Vitamin A-30	.11
Bovatec	.15
Dicalcium phosphate	2.75

inspections were performed by the Oklahoma Animal Disease Diagnostic Laboratory on all animals that died.

At the end of the 28-day period, the cattle were held overnight without feed or water, weighed individually the following morning, castrated and horns were tipped as necessary.

Least squares analysis of variance was performed on data for all response criteria using the General Linear Model of the Statistical Analysis System (SAS). The initial models across all cattle for weight gains, sick days, and mortality included load, pen, treatment, initial weight, and all two way interactions. In all models sources of variation with observed significance levels greater than .25 were removed. Treatment remained in all models.

Results and Discussion

Calves receiving vaccination pre-transit had a lower (P<.10) morbidity rate (60.32%) than those vaccinated post-transit (72.29%). Compared to those not vaccinated, calves vaccinated pre-transit tended to have lower morbidity. Morbidity rates of non- and post-transit vaccinates were similar (Table 3).

No statistical differences in mortality (Table 3) were detected although pre-transit vaccination tended to reduce mortality rate. Typically, differences in mortality or proportions are difficult to detect with such small numbers of observations.

Average daily gain of healthy calves in this trial was not altered by vaccination. However, gains of all calves (healthy plus sick) were higher (P<.10) in the post-transit than in the pre-transit vaccinates. Among sick calves, those in the post-transit vaccinated group had average daily gains higher than those vaccinated pre-transit (P<.01) but similar to those not vaccinated (Table 3).

Table 3. Effect of *Pasteurella hemolytica* vaccine on morbidity, mortality, and average daily gains in stressed calves.

	Time of vaccination		
	Pre-transit	Post-transit	None
Calves	147	160	152
Pens	8	8	8
Daily gain, lb[a]			
All calves	1.25[b]	1.52[c]	1.36[bc]
Healthy calves	1.98	2.09	2.11
Sick calves	.732[d]	1.34[e]	1.07[de]
Morbidity, %[a]	60.32[b]	72.19[c]	71.77[bc]
Mortality, %[a]	4.54	8.84	7.00

[a] Expressed as least squares means based on pen data.
[b,c] Means in the same row with different superscripts differ (P<.10).
[d,e] Means in the same row with different superscripts differ (P<.01).

The highly stressed calves in this study experienced most of their respiratory disease early in the receiving period. The vaccine manufacturer recommends that the inactivatied *Pasteurella hemolytica* vaccine be administered 2 to 3 weeks prior to shipment and that two doses be given. Although not studied in this trial, perhaps the time interval between administration of the vaccine and the onset of illness was insufficient to allow those calves to develop full immunity.

Literature Cited

Carter, G.R. 1954. Observations on the pathology and bacteriology of shipping fever in Canada. Can. J. Comp. Med. 18:359.

Frank, G.H. and P.C. Smith. 1983. Prevalence of *Pasteurella hemolytica* in transported calves. Am. J. Vet. Res. 44:981.

Gale, C. and N.B. King. 1961. Isolation of a virus from clinical shipping fever in cattle. J. Am. Vet. Med. Assoc. 138:235.

Gill, D.R. and E.J. Richey. 1982. Health nutrition and management of new cattle. Okla. Cattle Feeders Seminar, p BB-1.

Martin, S.W. et al. 1982. Factors associated with mortality and treatment costs in feedlot calves: The Bruce County beef project, years 1978, 1979, 1980. Can. J. Comp. Med. 46:341.

Smith, C.K. 1983. The use of live *Pasteurella hemolytica* vaccine to prevent bovine respiratory disease. In: R.W. Loan (Ed.). Bovine Respiratory Disease, A Symposium. Texas A&M Univ. Press, p 470 (Abstr.).

Smith, R.A. et al. 1986. The effect of live *Pasteurella hemolytica* vaccine on health and performance of newly received stocker cattle. Okla. Agr. Exp. Sta. Res. Rep. MP-118:244.

PROVIDING SUPPLEMENTAL NUTRIENTS IN DRINKING WATER TO GROWING CATTLE

I.W.M. Schutte[1], J. Zorrilla-Rios[2], J. McCann[3] and F.N. Owens[4]

Story in Brief

The potential of different routes of supplementation (drinking water vs feed) and the timing of supplementation in the feed (morning vs evening) to deliver dietary ingredients of high nutritive value postruminally was investigated using growing steers. Over two-thirds of the water was consumed within 4 hours after feeding; hence, nutrients may be flushed through the rumen naturally. Casein offered in water, as compared to in feed, tended to increase N retention as proportion of intake and to decrease plasma urea levels. Nitrogen utilization was greater for casein than urea, but morning vs evening feeding of casein proved comparable. B-vitamin supplementation in the drinking water vs the feed, increased N output in urine (31.4 vs 23.4 g/day) but decreased total protein in plasma. Dietary supplementation with B-vitamins increased free fatty acids in plasma and decreased insulin concentration, suggesting that altering B-vitamin supply can alter lipid metabolism. Results indicate that drinking water may be useful as a means to strategically supplement cattle postruminally with specific nutrients.

(Key Words: Cattle, Water Kinetics, Supplementation, Ruminal Evasion.)

Introduction

From 40 to 80% of water consumed by adult cattle evades the rumen (Garza and Owens, 1989). Increasing ruminal evasion of ingredients of high nutritive value improves their overall utilization. Casein is fermented rapidly in the rumen and some B-vitamins are degraded in the rumen as well. Hence, water may provide one means to supplement nutrients postruminally, enhancing cattle performance and efficiency.

Based on the above concept, this trial was conducted to measure nutrient utilization in growing steers given casein or a B-vitamin supplement

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in the feed or the drinking water. Morning vs evening feeding of casein in feed also was investigated.

Materials and Methods

Five yearling steer calves (690 lb) in metabolism crates were fed 1.8% BW/day at 8 a.m. and 8 p.m. a diet composed of 2.2 lb of prairie hay and 9.2 to 12.8 lb of a 9.5% crude protein concentrate (Table 1). All calves had free access to water, with consumption being recorded at various intervals during the day. Two sets of treatment supplements (casein and a swine based B-vitamin mixture) were superimposed on a 4 x 5 Youden Square (Table 2). The B-vitamin mixture composition is shown in Table 3. Each of the four 10-day periods consisted of five days for adaptation to treatment followed by five days for collection of feces and urine. Daily casein treatments were: A) basal diet plus urea (80 g/head); B) basal diet plus casein in 0800 feeding (246 g/head); C) basal diet plus casein in 2000 feeding (246 g/head); D) basal diet plus casein dissolved in drinking water (from 27 to 45 g/gallon). Daily B-vitamin treatments were: a) no B-vitamin supplementation; b) B-vitamins in feed (2 g/head); c) B-vitamins in drinking water (from 1.6 to 1.8 g/head). Digestibility was estimated using chromic oxide as a marker. Jugular blood samples were collected one hour before and two hours after morning and evening feedings via a catheter on the last day of each experimental period.

Table 1. Ingredient and nutrient composition of concentrate (dry matter basis).

Ingredient	Percent
Corn dent, cracked	70.8
Cottonseed hulls	14.5
Alfalfa hay	5.9
Molasses, dried	5.4
Salt	.6
Limestone	.6
Dicalcium phosphate	.6
Urea, 42.5% N	.1
Aureomycin 50	.15
Crude protein	9.5
Organic matter	96.7

Table 2. Experimental design.

Period	Animal 1	2	3	4	5
I	Ac	Da	Ba	Cc	Bb
II	Ca	Bc	Ab	Db	Da
III	Db	Cb	Db	Aa	Cc
IV	Bb	Ac	Cc	Ba	Ab

A = Basal diet + urea.
B = Basal diet + casein morning feeding.
C = Basal diet + casein evening feeding.
D = Basal diet + casein in water.
a = No B-vitamin supplementation.
b = B-vitamin in feed.
c = B-vitamin in water.

Table 3. B-vitamin supplement composition[a].

Ingredient	Amount, g/lb
Niacin	49.277
d-pantothenic acid	49.277
Riboflavin	14.045
Thiamin	7.090
Pyridoxine	7.090
Folic acid	2.100
Biotin	.360
Vitamin B12	.035
Ascorbic acid	135.954
Dextrose	112.377

[a] As provided by manufacturer. Values do not total 454 g because individual sources of vitamins are not fully active.

Results and Discussion

Organic matter, crude protein and water intakes were similar among casein treatments (Table 4). Twice as much water was consumed within 4 h after feeding as compared to between meals (1.8 vs .9 gal). N digestibility tended to be lower ($P<.10$) when casein was offered in the drinking water, but decreased urinary N output caused efficiency of retention of dietary N to

Table 4. Least squares means for casein treatments.

Item	Treatments[a] Urea	Casein AM	Casein PM	Casein in water	SE
Intake/day:					
OM, lb	10.6	10.8	10.8	10.6	.4
N, g	103.9^{c}	101.2^{bc}	100.7^{bc}	92.8^{b}	3.6
Water, gal	4.2	5	4.6	5.2	.5
Digestibility, %					
OM	64.9	66.3	66.2	64.3	1.6
N	56.4^{bc}	55.6^{bc}	59.2^{c}	53.4^{b}	1.8
N-balance, g/day:					
Feces	45.5^{c}	45.1^{c}	40.7^{b}	43.0^{bc}	1.8
Urine	31.8^{c}	27.0^{bc}	28.6^{c}	20.7^{b}	2.7
Retained	26.6	29.1	31.4	29.2	2.6
Retained, % of intake	25.7^{b}	28.8^{bc}	30.8^{bc}	31.3^{c}	2.2
Plasma parameters:					
Total protein, g/dl	4.77^{c}	4.84^{c}	4.52^{b}	4.83^{c}	.11
Urea, mg/dl	14.8^{d}	12.4^{c}	12.7^{c}	9.2^{b}	.87
Albumin, g/dl	1.45^{b}	1.45^{b}	1.71^{c}	1.57^{bc}	.10
Glucose, mg/dl	70.2^{b}	69.8^{b}	72.2^{c}	71.5^{bc}	.70
Free fatty acids nMol/ml	144.2^{c}	95.2^{b}	114.8^{b}	114.8^{b}	8.6
Insulin, uIU/ml	13.7	14.6	14.7	13.4	.73

[a] Urea, casein AM (morning) and PM (evening) were offered with the feed.

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

be unchanged (Table 4). The higher protein concentration in plasma together with lower values for plasma urea may reflect better utilization of absorbed N in animals consuming casein in their water as compared to those given casein in their feed. Morning vs evening feeding had no effect on dietary N utilization. Previous studies (Garza et al., 1990) indicated that water intake and potential flushing through the rumen might be greater in the evening.

Addition of B-vitamins to the drinking water vs the feed increased N output in urine ($P<.10$) and decreased plasma total protein even though albumin concentration was increased (Table 5). Supplementation with this

Table 5. Least squares means for B-vitamin treatments.

Item	Treatments			SE
	No B-vitamins	B-vitamins in feed	B-vitamins in water	
Intake/day:				
OM, lb	10.5	10.7	11.0	.4
N, g	98.4	97.8	103.4	3.5
Water, gal	4.8	4.8	4.6	.5
Digestibility, %				
OM	66.4	64.1	66.2	1.3
N	55.9	54.6	58.5	1.7
N-balance, g/day:				
Feces	43.3	44.3	42.9	1.8
Urine	27.4^{ab}	23.4^{a}	31.4^{b}	2.6
Retained	27.7	30.0	29.1	2.4
Retained, % of intake	28.0	30.8	28.1	2.1
Plasma parameters:				
Total protein, g/dl	4.81^{ab}	4.84^{b}	4.58^{a}	.09
Urea, mg/dl	11.8	12.1	13.0	.91
Albumin, g/dl	1.40^{a}	1.50^{a}	1.74^{b}	.09
Glucose, mg/dl	70.6	71.5	70.5	.65
Free fatty acids nMol/ml	98.9^{a}	127.5^{b}	122.1^{b}	7.9
Insulin, uIU/ml	15.1^{b}	13.8^{ab}	13.5^{a}	.69

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

B-vitamin mixture, either with the feed or in the water, increased ($P<.10$) free fatty acids concentration in plasma and insulin tended to decrease.

These results suggest that providing supplemental nutrients in water may shift the site of nutrient absorption and thereby could prove useful as an alternative to feeding to increase supply of nutrients postruminally.

Literature Cited

Garza, J. and F.N. Owens. 1989. Quantitative origin of ruminal liquid with various diets and feed intakes. Okla. Agr. Exp. Sta. Res. Rep. MP-127:84.

Garza, J. et al. 1990. Ruminal water evasion and steady state. Okla. Agr. Exp. Sta. Res. Rep. MP-129:114.

USE OF CHEMICAL COMPOSITION OR NEAR INFRARED REFLECTANCE SPECTROSCOPY TO PREDICT THE GROSS ENERGY CONTENT OF CANE MOLASSES

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Story in Brief

Twenty-three samples of cane molasses were analyzed to evaluate the relationship between chemical composition and gross energy (GE; kcal/g) content. Ash content (%) was the best single predictor (R^2=.74) of gross energy. The best multiple regression equation included both dry matter (%) and ash (%): GE = 505,792 - 19,332.16*DM + 247.842*DM^2 - 1.0581*DM^3 - .092*ASH^3 (R^2=.86). Analysis of cane molasses samples with near infrared reflectance spectroscopy showed that gross energy could be predicted fairly accurately (R^2=.86). This study suggests that the gross energy content of cane molasses can be predicted with either a simple laboratory analysis (ash) or near infrared reflectance spectroscopy. Due to the small data base, however, further sample analyses and development of near infrared reflectance spectroscopy calibration equations should be completed prior to implementation of the technique.

(Key Words: Cane Molasses, Gross Energy, Near Infrared Reflectance Spectroscopy.)

Introduction

Cane molasses, a byproduct of the sugar refining industry, is one of the most common feedstuffs used in livestock diets. Its primary function is to reduce dust thereby enhancing palatability. The nutrient composition of molasses is affected by the variety and maturity of the cane as well as climatic and soil conditions during growth. In addition, plant refinement conditions and procedures can alter composition. Because of these inherent sources of variation, the energy content of molasses is not consistent. Therefore, the

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objective of this research was to evaluate laboratory procedures which could be used to predict the gross energy content of molasses.

Materials and Methods

Cane molasses samples (n=23) were obtained from various sources by Cargill's Molasses Division. Molasses samples were frozen, freeze dried, and ashed (500°C, 8 h) to determine their dry matter and ash content. Freeze drying was preferred over conventional oven drying (100°C, 24 h) to reduce volatilization of organic compounds by high temperature. Gross energy content was determined on non-dried samples with a Parr Oxygen-Bomb Calorimeter. Subsequent gross energy (GE) values (kcal/gram) were converted to a dry matter basis. Total sugars as invert (TSI), solids (S) and brix values were determined by a Cargill Laboratory and are expressed on a non-dried basis. Invert sugars are a measure of fructose content and solids are equivalent to dry matter content. Brix is the specific gravity of the molasses relative to solutions of known sucrose content. All independent variables were submitted to stepwise regression analysis to derive relationships between chemical constituents and GE. Multiple linear regression was used to determine the best multiple variable equation.

In addition, molasses samples were evaluated with near infrared reflectance spectroscopy (NIR) at the Southwest Livestock and Forage Research Laboratory located at El Reno, OK. Samples were scanned with near-infrared light (1100-2500 nm) and the reflected energy recorded at 2 nm intervals. Samples were placed in forage sample cups encased in polyethylene film. Although the film has a spectra, all samples were treated the same so the polyethylene peaks would be ignored in the regression for gross energy. Calibration equations were developed using a modified stepwise regression of gross energy on each of the 700 absorbance values across the spectrum.

Results and Discussion

Gross energy content of cane molasses averaged 3,447 kcal/g DM and was the least variable (CV=2.17) chemical component (Table 1). Ash content was the most variable chemical component (CV=11.53) followed by invert sugars (CV=7.82). Observed values for all chemical analyses were similar to reported values (Baker, undated).

The gross energy content (DM basis) of cane molasses was most highly correlated (r=-.85) with ash content expressed on a DM basis (Table 2). Ash dilutes energy density and should reduce gross energy content. A simpler analytical procedure would be to measure the ash content of wet molasses. The

Table 1. Variation in chemical composition of cane molasses samples.

Component	N	Range		Mean	SD[a]	CV[b]
		Minimum	Maximum			
Gross energy, kcal/g DM	23	3294.3	3588.2	3447.2	74.82	2.17
Dry matter, %	23	72.5	82.3	78.6	3.54	4.50
Ash, % of DM	23	9.5	15.6	13.1	1.51	11.53
Invert sugars, % of as-is	23	44.8	57.5	50.9	3.98	7.82
Solids, % of as-is	23	69.9	83.5	76.5	3.32	4.34
Brix, degrees, as-is basis	23	79.8	87.7	84.5	2.73	3.23

[a] Standard deviation.
[b] Coefficient of variation (SD/mean x 100).

Table 2. Simple correlations between gross energy content and chemical components[a] of cane molasses.

	DM	ASH(DM)	ASH(AS-IS)	SOLIDS	TSI	BRIX
GE	.17 (.44)[b]	-.85 (.01)	-.77 (.01)	.17 (.43)	.35 (.10)	.05 (.82)
DM		-.30 (.16)	-.61 (.01)	.88 (.01)	.60 (.01)	.95 (.01)
ASH(DM)			.94 (.01)	-.27 (.21)	-.62 (.01)	-.10 (.64)
ASH(AS-IS)				-.54 (.01)	-.73 (.01)	-.42 (.04)
SOLIDS					.58 (.01)	.87 (.01)
TSI						.56 (.01)

[a] GE=gross energy (DM basis); DM=dry matter; ASH(DM)=ash (DM basis); ASH(AS-IS)=ash (as-is basis); SOLIDS=solids (as-is basis); TSI=total sugars as invert (as-is basis); BRIX=degrees brix (as-is basis).

[b] Simple correlation coefficient (probability value).

correlation between gross energy and as-is ash content was lower (r=-.77) than for ash content corrected for moisture. Common molasses analyses were poorly correlated (r=.17 for SOLIDS, r=.35 for TSI, r=.05 for BRIX) with gross energy. The brix scale relates the specific gravity of a sucrose solution to its sucrose content. Degrees brix, however, does not indicate the sugar content of molasses (Baker, undated). Consequently, the low correlation between brix and gross energy (r=.05) was expected. Brix (r=.95) and solids (r=.88) were highly correlated with molasses dry matter content.

Single component linear regression analysis showed that ash content (% of DM) was the single best predictor (GE=3,999-42.21*ASH; R^2=.72) of the gross energy content (kcal/g DM) of cane molasses (Figure 1). Simple linear regression using ash cubed (GE=3,657-.091*ASH^3) improved the relationship slightly (R^2=.74; Table 3).

Multiple regression was utilized to evaluate the predictive value of multiple chemical analyses for gross energy content (Table 3). Adding variables deemed significant (P<.10) increased the R^2 and decreased the mean square error (MSE). The equation with the highest correlation coefficient and lowest MSE utilized DM, DM^2, DM^3, and ASH^3.

The predictive value of NIR analysis for gross energy (R^2=.86) and brix values (R^2=.86) of cane molasses was high (Table 4). NIR predicted the dry matter, invert sugars and solids values with intermediate accuracy. The poorest

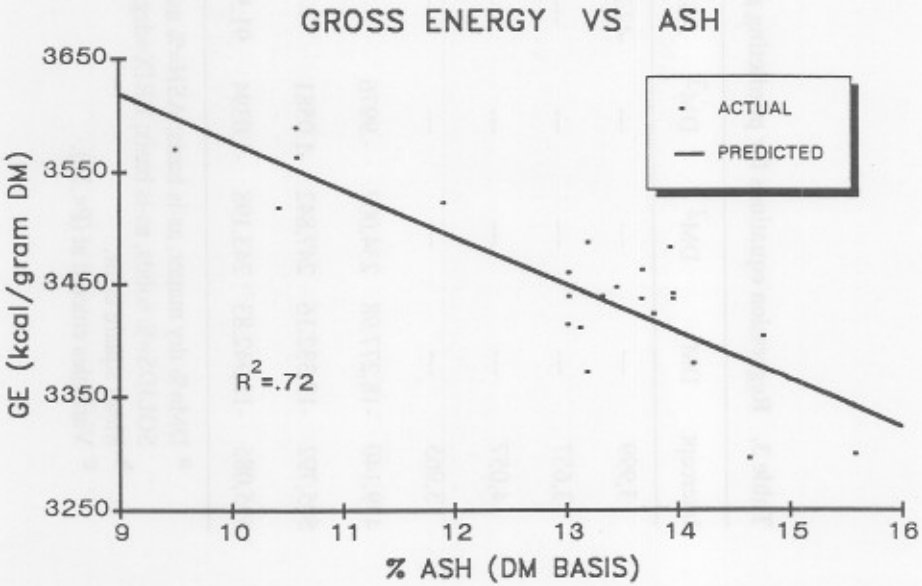

Figure 1. Relationship between the ash content of cane molasses and gross energy (GE).

Table 3. Regression equations for predicting gross energy from molasses chemical composition[a].

Intercept	DM	DM^2	DM^3	ASH	ASH^2	ASH^3	TSI	SOLIDS	BRIX	R^2	MSE[b]
3,999	---	---	---	-42.21	---	---	---	---	---	.72	1,616.3
3,657	---	---	---	---	---	-0.091	---	---	---	.74	1,495.0
4,057	---	---	---	---	-2.04	---	-5.05	---	---	.78	1,329.9
3,965	---	---	---	---	-2.06	---	-6.13	1.96[c]	---	.79	1,367.5
479,140	-18,277.98	234.007	-.9976	---	-1.74	---	---	---	---	.85	1,023.9
505,792	-19,332.16	247.842	-1.0581	---	---	-0.092	---	---	---	.86	956.2
495,085	-18,942.83	243.198	-1.0394	91.50[c]	-5.28	---	---	---	-9.36[c]	.87	981.9

[a] DM=% dry matter, as-is basis; ASH=% ash, DM basis; TSI=% total sugars as invert, as-is basis; SOLIDS=% solids, as-is basis; BRIX=degrees brix, as-is basis.
[b] Mean square error.
[c] Variables entered at (P<.35).

Table 4. Near infrared reflectance spectroscopy analysis of cane molasses samples.

Item	R^2	SEC[a]
Gross energy	.86	34.20
Dry matter	.76	1.68
Ash	.60	.97
Solids	.70	1.82
Invert sugars	.72	2.11
Brix	.86	1.05

[a] Standard error of calibration.

relationship was for ash (R^2=.60). Because the same 23 molasses samples were used to generate and to test the NIR calibration, the usefulness of these data are limited. The high coefficients of determination (R^2) suggest that NIR may be useful for cane molasses analysis.

These data indicate that the ash content of cane molasses is the best single predictor (R^2=.72) of gross energy content. A multiple regression equation using dry matter content combined with ash accounted for 86% of the variation in gross energy. But because the number of samples was small, the data from this study should be considered as preliminary. A larger data set should be evaluated to determine these relationships more precisely and to detect outliers.

Literature Cited

Baker, B.P. Undated. Composition, properties and uses of molasses and related products. Pacific Molasses Co.

RUMINAL AND INTESTINAL DISAPPEARANCE OF SEVERAL SOURCES OF VITAMIN E

I.S. Shin[1] and F.N. Owens[2]

Story in Brief

Four different sources of vitamin E were fed to five adult steers with duodenal cannulas and five young calves without cannulas to investigate ruminal destruction as well as intestinal supply and disappearance of this vitamin. Among the sources of vitamin E tested, disappearance in the small intestine was highest for the absorbate form (44% of fed) and least for liquid form (16% of fed).

(Key Words: Vitamin E, Steer, Intestine, Cannula.)

Introduction

Vitamin E is present as eight different isomers of tocopherol in most common feedstuffs. Free tocopherol is unstable to oxidation. Each form differs in its biological activity. Hence, the vitamin E activity of foods and feedstuffs depends upon both the chemical form and storage conditions for the product. In practice, the vitamin E content of feedstuffs is variable and not readily predictable. Therefore, animal feeds commonly are supplemented with vitamin E at the rate of 5 to 15 IU/lb. The form generally used for this purpose is the fully racemic form of alpha-tocopheryl acetate which is stable to oxidation. Most species hydrolyze dietary tocophery esters (the forms of vitamin E used as feed supplements) effectively at the mucosal surface of the small intestine. Vitamin E is absorbed as the free alcohol form, tocopherol. Hidiroglou and Jenkins (1974) observed that the administration of labelled tocopherol resulted in higher radioactivity in the blood and tissues when it was dosed into the duodenum than into the rumen. They found that the jejunum was the main site of vitamin E absorption. However, information on the mechanisms of absorption, transport, and metabolism of vitamin E in ruminants is limited. This study was conducted to examine the influence of the form of vitamin E on ruminal digestion and on intestinal supply and disappearance.

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Materials and Methods

A total of 10 steers, one group of five adult steers with "T" cannulas in the proximal duodenum (15 cm from pyloric sphincter) and five young steers without cannulas, were used in a 5x5 Latin square design. The basal diet, a finishing ration, consisted of rolled corn and cottonseed hulls. The basal diet with 9.1 IU vitamin E per lb was fed twice a day at 1.5% of body weight to the adult steers and at 2.0% of body weight to the young steers. The digesta marker for this trial was chromium sesquioxide. The steers were allowed two weeks for adaptation to the basal diet. Thereafter, experimental periods each lasted 14 days with digesta sampling during the last three days of each experimental period. During each experimental period, the steers received one of the five following supplements: Control (no supplemental vitamin E); dl-alpha-tocopherol (free form), 2000 IU/day; dl-alpha-tocopheryl acetate (absorbate form), 2000 IU/day; dl-alpha-tocopheryl acetate (liquid form), 2000 IU/day; dl-alpha-tocopheryl acetate (spray dried form), 2000 IU/day[1]. During the digesta sampling period, samples were collected simultaneously from the duodenum and rectum with a 12-h feeding interval between each of the six collections. Samples consisted of 500 ml of duodenal and about of 200 g fecal material. Digesta samples were lyophilized, extracted and analyzed for dl-alpha tocopherol and for dl-alpha tocopheryl acetate as described by Karimi and Owens (1988). Based on feed and digesta tocopherol concentrations and digesta flow rates calculated from chromium enrichment of digesta, ruminal and intestinal disappearance of each source of vitamin E was calculated. Means were compared statistically by Duncan's multiple range test.

Results and Discussion

Vitamin E flow to duodenal and fecal samples from the steers fed four different sources of vitamin E is presented in Table 1. For adult steers, the vitamin E concentration of duodenal samples was from highest to lowest for spray, absorbate, liquid, and free form. Fecal excretion by both young and adult steers ranked these sources, from highest to lowest, as liquid, spray, absorbate, and free.

For total tract disappearance of vitamin E (Figure 1), the availability of free form was high compared to the other three forms. This supports the suggestion that the free alcohol form may be more biologically active for animal cells (Parrish, 1980). However, disappearance in the tract also includes ruminal destruction.

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[1]Vitamin products provided by Hoffman LaRoche, Nutley, NJ.

Table 1. Vitamin E concentrations of duodenal and fecal samples from steers.

Animal and sample	Sources of vitamin E			
	Absorbate	Free	Liquid	Spray
Adult steers	IU/day/head			
Supplement	2000	2000	2000	2000
Duodenal	1202^{ab}	957^{c}	994^{bc}	1287^{a}
Fecal	316^{c}	209^{d}	682^{a}	597^{b}
Young steers				
Supplement	2000	2000	2000	2000
Fecal	386^{a}	120^{b}	407^{a}	394^{a}

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

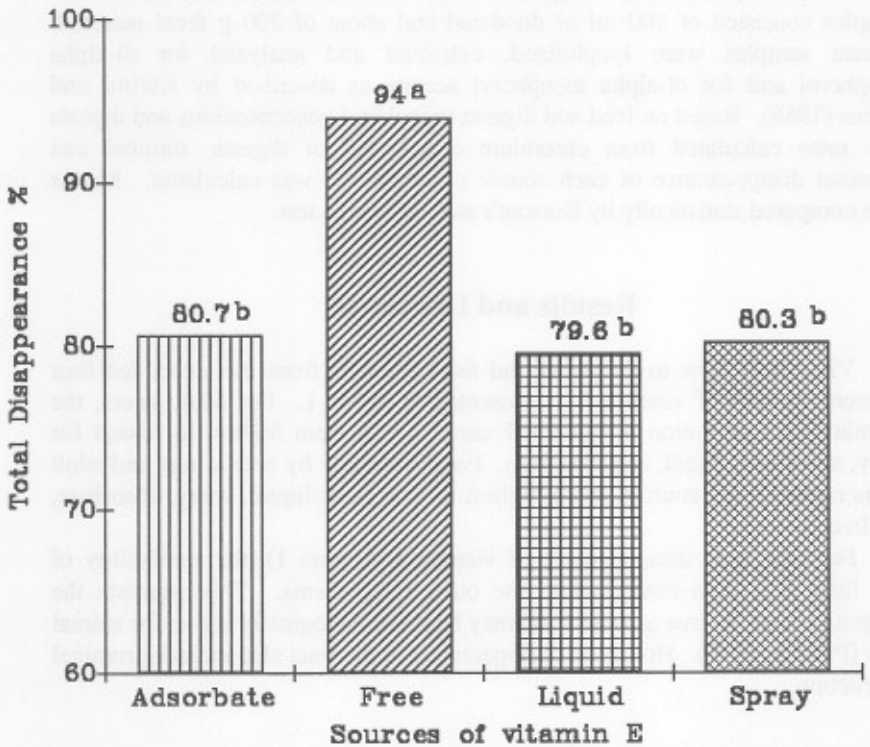

Figure 1. Total disappearance of vitamin E in young steers. Values with different superscripts differ (P<.05).

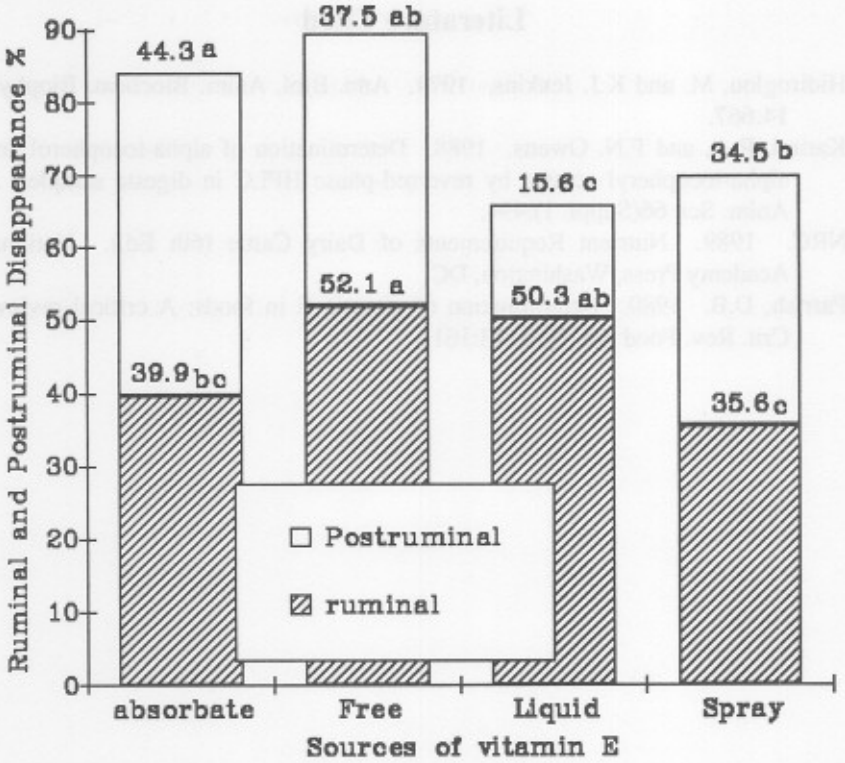

Figure 2. Ruminal and postruminal disappearance of vitamin E in adult steers. Values within location with different superscripts differ (P<.05).

The ruminal and postruminal disappearance of vitamin E from these four different sources are shown in Figure 2. Ruminal destruction of vitamin E from highest to lowest was free, liquid, absorbate, and spray form. This means that the postruminal supply of vitamin E from highest to lowest was spray, absorbate, liquid and free. Postruminal digestion, however, was lower for the liquid and spray forms making postruminal disappearance, an index of availability, equal to 44, 38, 34 and 16% for the absorbate, free, spray and liquid forms, respectively. The free form was readily available for destruction in rumen and absorption from the intestine whereas the absorbate form resisted ruminal attack but was available in the small intestine. The liquid form had the least availability in the small intestine. The spray form showed moderate destruction in the ruminal and absorption from the postruminal tract. Average availability of these four synthetic vitamin E in the small intestine of steers used in this study was 33%, in close agreement with the 30% value reported by NRC (1989).

Literature Cited

Hidiroglou, M. and K.J. Jenkins. 1974. Ann. Biol. Anim. Biochem. Biophys. 14:667.

Karimi, R.A. and F.N. Owens. 1988. Determination of alpha-tocopherol and alpha-tocopheryl acetate by reversed-phase HPLC in digesta samples. J. Anim. Sci. 66(Suppl. 1):494.

NRC. 1989. Nutrient Requirements of Dairy Cattle (6th Ed.). National Academy Press, Washington, DC.

Parrish, D.B. 1980. Determination of vitamin E in foods: A critical review. Crit. Rev. Food Sci. Nutr. 13:161.

EFFECT OF SORGHUM HYBRID ON SITE AND EXTENT OF NITROGEN DIGESTION IN BEEF STEERS

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Story in Brief

To compare the effect of two yellow, two cream and two hetero-yellow sorghum grain hybrids on site and extent of nitrogen digestion, sorghum grain was dry rolled and fed in 81% sorghum grain diets to Angus-Hereford steers (752 lb) equipped with ruminal, duodenal and ileal cannulae. Diets were fed at 1.85% of body weight (dry matter basis) in a 6 x 6 Latin square. Total tract non-ammonia nitrogen digestibility (%) was greater for hetero-yellow 2 (58.2) and creme 2 (58.1) than for hetero-yellow 1 (48.2), yellow 2 (51.8) and creme 1 (53.5), with yellow 1 (56.2) being intermediate. Ruminal feed nitrogen (excluding urea) digestibility ranged from 31.7 (hetero-yellow 1) to 53.7 (hetero-yellow 2), with other sorghums intermediate. Conversely, escape of feed nitrogen from ruminal degradation varied from 46.2 (hetero-yellow 2) to 68.3% (hetero-yellow 1). Microbial N flow to the duodenum was strongly correlated while feed N flow to the duodenum was weakly correlated to fractional non-ammonia nitrogen digestion in the small intestine. Moreover, ruminal starch digestion was negatively related to feed nitrogen flow to the duodenum. Hybrids differed considerably in site and extent of nitrogen digestion.

(Key Words: Sorghum Grain, 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. Improvements in sorghum grain hybrids should improve the feeding value of sorghum. Endosperm characteristics and digestion may differ among sorghum hybrids, altering efficiency of utilization. The objective of this study was to assess the

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differences which may exist in site and extent of nitrogen (N) digestion among several homozygous and heterozygous yellow endosperm sorghum hybrids.

Materials and Methods

Six sorghum hybrids (Table 1) representing two yellow (Y1 and Y2), two cream (C1 and C2) and two hetero-yellow (HY1 and HY2) grains were grown under dryland conditions. Hybrids within an endosperm type and color were of different genetic background. Rainfall was evenly distributed throughout the growing season and totalled 15 inches.

All grains were dry rolled and fed in 81% sorghum diets (Table 2). Diets were fed at 1.85% (DM basis) of body weight to ensure uniform consumption. Molasses was included in the diet to reduce dust. Urea was used as the source of supplemental nitrogen (N) to enhance the estimation of sorghum feed N digestion in the rumen. Chromic oxide was used as an indigestible marker. Diets were fed three times daily to Angus-Hereford steers surgically fitted with permanent ruminal, duodenal and ileal cannulae in a 6 x 6 Latin square. Experimental periods lasted 10 days, with days 1 through 7 used for diet adaptation and 8 through 10 for feed, digesta and fecal sampling. Digesta samples were collected every 3 h in a 24-h period.

Digesta and fecal samples were composited across time and day within steer for each period, lyophilized and ground through a 1-mm screen. Ruminal fluid for ammonia N (NH_3-N) determination was collected at 3:00 p.m. and 9:00 p.m. on day 9 and at 3:00 a.m. and 9:00 a.m. on day 10. Ruminal fluid also was collected at 2:00 p.m. on day 10 for determination of microbial N characteristics. Grain, feed, duodenal, ileal, fecal and microbial samples were analyzed for DM, ash, crude protein (CP), NH_3-N, purine N (RNA basis) and chromic oxide. Nitrogen digestibility was determined by chromic oxide ratio, while purine-N was utilized to distinguish feed protein from microbial protein escaping the rumen. Data were subjected to least squares analysis with period, animal and treatment included in the model. Least squares means were separated by a protected least significant difference.

Results and Discussion

Sorghum grain hybrids varied in CP content from 9.5 to 10.5% CP ($P<.05$) (Table 3). The proportion of NaCl-N tended to be greater for Y1 (26.7% of N) and lower for HY1 (19.6%). Ruminal NH_3-N levels were not altered by hybrid and averaged 4.39 mg/dl (Table 4). If CP content is multiplied by the percentage of NaCl-N, the corresponding values are 2.5 (Y1), 2.4 (Y2), 2.3 (C1), 2.1 (C2), 1.9 (HY1) and 2.3 (HY2) with the ruminal NH_3-N values being

Table 1. Characteristics of sorghum grain hybrids.

Sorghum hybrid[a]	Seed coat color	Endosperm color	Endosperm cross
Y1 and Y2	yellow	homozygous yellow	yellow x yellow
C1 and C2	white	heterozygous yellow	white x yellow
HY1 and HY2	red	heterozygous yellow	white x yellow

[a] Y = yellow; C = cream; HY = hetero-yellow.

Table 2. Ingredient composition of experimental diets (DM basis).

Ingredient	DM, %
Grain	81.2
Cottonseed hulls	12.0
Molasses	3.0
Supplement:	
Urea	1.0
Calcium carbonate	.93
Dicalcium phosphate	.44
Potassium chloride	.57
Sodium sulfate	.36
Trace mineralized salt	.25
Chromic oxide	.20
Vitamin A premix[a]	.05

[a] Vitamin A was included at 1,000 IU/lb DM.

4.9, 6.0, 4.3, 3.9, 3.8 and 3.4 for the same grains, respectively, suggesting that sorghum with more soluble protein results in higher ruminal NH_3-N values.

Total tract non-NH_3-N (NAN) digestibility (%) was greater (P<.05) for HY2 (58.2) and C2 (58.1) than for C1 (53.5), Y2 (51.8) and HY1 (48.2), with HY1 (56.2) intermediate (Table 4). Differences in total tract NAN digestibility may affect total tract organic matter and starch digestibility. With all diets, there was a net gain in the amount of N reaching the duodenum above that consumed. A gain in N through the rumen reflects N recycling to the rumen. Non-urea feed N digestibility in the rumen was highest (P<.10) for HY2 (53.7%) and lowest for HY1 (31.7%), with values for other sorghum ranging from 40.4% (Y2) to 49.9% (C2). Conversely, ruminal escape of feed N ranged from 46.2 to 68.3% (P<.10). Feed N digestibility within the rumen and escape of N from ruminal degradation reflected differences in feed N flow to the duodenum. Although differences in feed N flow to the small intestine tended to reflect NAN flow, NAN flow was correlated more strongly to microbial N flow (r=.79; P<.001) than to feed N flow (r=.45; P<.01). Although starch data are not reported herein, ruminal starch digestion was negatively correlated (r=.46; P<.08) to feed N flow to the duodenum.

Flow (g/day) of NAN to the cecum ranged from 48.8 (C2) to 58.2 (C1), averaging 54.0. Pre-cecal digestibility of NAN was greater (P<.10) for C2 (57.8%) than for HY1 (50.2%) and C1 (49.8%) with others intermediate. Feed N flow to the duodenum was positively correlated (r=.72, P<.01) to NAN flow to the cecum and negatively correlated (r=-.66; P<.01) to pre-cecal NAN

Table 3. Chemical composition of sorghum grain hybrids and diets (DM basis).

Item	Sorghum hybrid[a]						SE
	Y1	Y2	C1	C2	HY1	HY2	
Grain							
CP,%	9.5	10.5	9.7	9.7	9.6	10.3	.15
Starch, %	79.9	76.1	78.4	77.4	74.4	76.8	.69
NaCl soluble N, % of total N	26.7	23.2	23.6	22.0	19.6	22.3	1.57
Pepsin insoluble N, % of total N	11.1	12.5	12.5	10.8	12.2	11.5	.57
Feed							
CP, %	11.3	11.5	11.5	11.4	11.4	11.6	.15
Starch, %	59.5	59.8	60.2	59.4	59.8	55.2	.98

[a] Y=yellow; C=Cream; HY=Hetero-yellow.

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

Item	Sorghum hybrid[a]						SE
	Y1	Y2	C1	C2	HY1	HY2	
Ruminal NH_3-N, mg/dl	4.9	6.0	4.3	3.9	3.8	3.4	.88
Nitrogen intake, g/day							
Total feed N	115.0	115.6	115.6	115.9	115.7	115.7	.21
Feed N (excluding urea N)	85.8	86.8	86.8	86.7	86.6	87.2	.16
Entering the duodenum, g/day							
Non-NH_3-N	120.0^{xy}	124.8^{xy}	125.4^{xy}	116.2^{y}	132.3^{x}	100.4^{z}	6.79
Microbial N	71.3	73.0	75.8	72.9	77.3	68.3	6.05
Feed N	48.7^{y}	51.8^{xy}	49.6^{xy}	43.3^{yz}	58.3^{x}	39.0^{z}	4.14
Pre-cecal non-NH_3, g/day	52.8	54.6	58.2	48.8	58.0	51.9	2.70
Fecal non-NH_3-N, g/day	50.3^{de}	55.9^{bc}	53.8^{cd}	48.5^{de}	60.4^{b}	48.2^{e}	1.98
Nitrogen digestibility, % of intake:							
Ruminal feed N (excluding urea)	42.1^{xy}	40.4^{yz}	42.0^{xy}	49.9^{wx}	31.7^{z}	53.7^{w}	4.32
Ruminal escape of feed N	57.9^{xy}	59.6^{yz}	58.0^{xy}	50.1^{wx}	68.3^{z}	46.2^{w}	4.32

Table 4. (Continued).

Item	Sorghum hybrid[a]						SE
	Y1	Y2	C1	C2	HY1	HY2	
Pre-cecal non-NH_3-N	54.2^{xyz}	53.0^{xyz}	49.8^{z}	57.8^{x}	50.2^{yz}	55.2^{xy}	2.13
Total tract non-NH_3-N	56.2^{bc}	51.8^{de}	53.5^{cd}	58.1^{b}	48.2^{e}	58.2^{b}	1.54
Non-NH_3-N digestibility in the small intestine:							
disappearance, g/day	67.2	70.2	67.2	67.4	76.0	52.2	5.89
% of entry	54.9	55.8	53.5	57.6	57.2	52.0	2.49
% of intake	59.5	60.3	58.0	58.4	66.6	45.8	5.33

a Y = yellow; C = cream; HY = hetero-yellow

^{b,c,d,e} 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).

digestibility, indicating perhaps that feed N originating primarily from sorghum is less digestible in the small intestine than microbial N. Moreover, microbial N flow to the duodenum was strongly correlated (r=.88; P<.001) and feed N flow to the duodenum was poorly correlated (r=.17; P=.52) to NAN disappearance from the small intestine.

In summary, sorghum grain hybrids differed considerably in site and extent of N digestion. Moreover, there appeared to be considerable variation both within and among hybrids. Additionally, although not reported herein, starch digestibility was generally positively correlated to N digestibility. Since starch granules may be embedded in less soluble or more poorly digestible protein, even larger diferences in N and starch digestibility among hybrids may be observed with greater dry matter feed intakes than used in this study.

FATE OF DRINKING WATER IN RUMINANTS: SIMULTANEOUS COMPARISON OF TWO METHODS TO ESTIMATE RUMINAL EVASION

J. Zorrilla-Rios[1], J.D. Garza[2] and F.N. Owens[3]

Story in Brief

Two methods to estimate ruminal evasion of drinking water in cattle were tested simultaneously. Estimates of evasion were 30.5 18 and 45.3 9% of intake for the inflow/outflow method and the marker ratio method, respectively. Estimates were comparable to previous estimates from other experiments. Based on relative precision and the need to base input/output data on a single estimate of ruminal volume and outflow, the marker ratio method seems preferable to estimate evasion.

(Key Words: Drinking Water, Ruminants.)

Introduction

In our studies of the fate of drinking water in cattle, we have used several approaches to measure ruminal evasion. Xylose, a sugar presumably excreted following absorption, and water soluble markers (WSM) have been employed. Failure to quantitatively recover intravenously injected xylose in urine forced us to focus our attention on WSM.

In previous experiments, two approaches were used to study behavior of WSM within the rumen. These were the measurement of ruminal outflow of the WSM offered in the drinking water as a proportion of its inflow (intake), and the ruminal concentration ratio of two WSM, one being offered in the drinking water and the other being infused directly into the rumen. These were compared and differences were observed (Garza et al., 1990). Nevertheless, simultaneous use of both approaches had not been conducted. Direct comparison avoids confounding of method with experiments, diets and animals. This report describes results from a simultaneous comparison of these two approaches.

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

Materials and Methods

A completely randomized design with three replicate measurement periods was used with three mature cattle (990 lb BW) fitted with large ruminal cannulas, housed individually and given ad lib access to a high roughage diet (2.3% BW as-fed basis) with fresh feed added twice each day. Water was continuously available from open troughs and individual voluntary consumption was recorded at 2 to 4-h intervals from 8 a.m. till midnight. The two mathematical models applied were:

Marker ratio method:

$$\text{Ruminal evasion} = \frac{\text{[WSM 1] in rumen/daily oral dose of WSM 1}}{\text{[WSM 2] in rumen/daily ruminal dose of WSM 2}}$$

Ruminal input-output method:

$$\text{Ruminal evasion} = \text{Daily consumption of water} \times \text{[WSM 1 in water]} - (\text{Ruminal fluid outflow} \times \text{[WSM 2 in rumen fluid]})$$

where

WSM 1 is CrEDTA offered in the drinking water and WSM 2 is CoEDTA infused into the rumen.

During the last 5 days of each 15-day period, CrEDTA was added to the drinking water (daily dose range 650-970 mg/head). CoEDTA was infused into the rumen (daily dose range 350-420 mg/head) at 8-h intervals on the first four days of the 5-day period. During the third, fourth and fifth day, ruminal fluid samples were obtained at approximately 4-h intervals. Terminating CoEDTA dosing into the rumen allowed us to estimate ruminal fluid dilution rate. At the end of each period, total ruminal contents were evacuated and volumes of total digesta were separated into free liquid and total solids by filtration through a screen with .25 x .25 inch pores.

Least squares means for ruminal evasion estimates were compared with a model including method, animal, period, period x animal, and animal x method interaction as sources of variation. The animal x method interaction was used as the error term to test differences between methods. In addition, coefficients of variation and determination were obtained for each evasion estimate approach.

Results and Discussion

Mean estimates for drinking water evasion for each method together with coefficients of variation (CV) and determination for each model are shown in Table 1. Although no difference was observed between methods of estimation of ruminal evasion, numerical values differed by 15 percentage units. Because we have no absolute measurement of evasion, relative validity of the two methods cannot be determined. Based on the relative repeatability of these methods, the marker ratio model had a lower CV and accounted for a greater proportion of the total variation.

The ruminal inflow-outflow balance method relies on the assumption that ruminal volume and fractional outflow rate are constant and outflow is based on a single estimate of dilution rate and ruminal volume. With infrequent feeding and water intake, these assumptions may be invalid. Hence, the marker ratio approach seems more suitable for dynamic systems and more appropriate for estimating ruminal evasion of drinking water in cattle. However, dosing times relative to water intake and site of ruminal dosing and sampling may add to the error and complicates physiological interpretation of evasion, if evasion is simply a phenomenon of incomplete ruminal mixing.

Table 1. Comparison of two methods to estimate ruminal evasion.

	Method	
Item	Marker ratio	Input - Output
Water evasion, % of drinking	45.3 ± 9.1[a]	30.5 ± 18.0
Coefficient of:		
Determination	.874	.841
Variation	10.6	47.2

[a] Least squares mean ± standard deviation.

Literature Cited

Garza, J. et al. 1990. Ruminal water evasion and steady state. Okla. Agr. Exp. Sta. Res. Rep. MP-129:114.

IMPACT OF OSMOTICALLY ACTIVE COMPOUNDS ON RUMEN DIGESTA KINETICS

J. Zorrilla-Rios[1], J.D. Garza[2] and F.N. Owens[3]

Story in Brief

With concentrate diets, high intakes of NaCl increased intake of water by 55% (5.81 ± .69 vs 8.98 ± .45 gallons/day), while reducing rumen volume 35% (12.68 ± 1.69 vs 8.19 ± 2.35 gallons). Consequently, a shifting of digesta downstream could be expected, flushing small dietary particles, like protein meals, to the small intestine and improving its utilization. Cattle consuming high roughage diets may be less susceptible to ruminal manipulation by means of osmotically active compounds.

(Key Words: Ruminants, Digesta Kinetics, Osmolality, Drinking Water.)

Introduction

Osmotically active compounds within the rumen have been used to alter ruminal fermentation through modification in the kinetics of the fluid fraction of the digesta. Traditionally, the rumen is viewed to thoroughly mix consumed feed and water with ruminal contents, assuming all drinking water arrives into the rumen. Our recent research supports the concept that a substantial proportion of drinking water evades or does not fully mix with rumen fluids (Garza et al., 1990). Therefore it seems possible to manipulate the extent of ruminal evasion and(or) residence time of drinking water within the rumen.

To test the possibility for altering the ruminal function and fate of drinking water, two experiments were conducted under contrasting dietary regimes, high concentrate or hay-based diets.

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Materials and Methods

Experiment 1.

Four adult ruminally cannulated steers (990 lb BW) housed in individual stalls were fed twice daily on 80% concentrate diet (2% of body weight; as fed basis). Three steers received 5% NaCl in their diets, while one animal remained on a .5% NaCl. Water was always available from an open trough.

Ruminal water evasion was estimated by comparing the intake of polyethylene glycol (PEG) in drinking water and its outflow from the rumen. Outflow was calculated from dilution rate of ruminally dosed CoEDTA, ruminal volume (evacuation) and PEG concentration in the rumen fluid. Osmolality of rumen fluid was measured also.

Two previous measurements of drinking water and rumen volumes obtained under similar management and feeding regimes as those adopted in the present trial for the only animal kept on the low NaCl diet were also included to compare treatment means difference against the high NaCl diet.

Experiment 2.

A 3 x 3 Latin square design was used with three mature steers (990 lb) with rumen cannulas. Steers were individually penned and fed a hay-based diet ad libitum, plus a protein supplement (2 lb/head/day). Treatments were: 1) Control (C, no extra supplement); 2) Salt (NaCl, 140 to 160 g/head/day); or 3) Dried molasses (Molasses, 2 lb/head/day). Water was always available from open troughs, provided with a scale indicator to facilitate recording of water intake. In each of the three 21-day periods employed, voluntary hay intake and ruminal evasion of drinking water was estimated in the last 4 days, in addition to a manual rumen evacuation on day 21. Jugular blood samples were obtained simultaneously with the evacuation.

Results and Discussion

Results for Experiments 1 and 2 are presented in Tables 1 and 2, respectively. In Experiment 1, the supply of NaCl (approximately 450 g/head/day) was intentionally kept at a level which would not depress intake. The net amount of drinking water estimated not to enter into the rumen (water evasion) was enhanced (59%) by a high level of NaCl in the diet. This effect was partially mediated by an increase in water consumption. Ruminal volume was cut by nearly one half (12.42 ± 1.69 vs 6.87 ± 2.01 gallons), largely

Table 1. Effect of NaCl on rumen function and liquid kinetics in steers consuming high concentrate diets in Experiment 1. (Mean ± SD).

	NaCl, % DM	
Measurement	0.5	5.0
Observations/treatment	3	3
Water intake, gallons/day	5.81 ± .69	8.98 ± .45
Water evasion[a], % intake	77 ± 9.2	79 ± 3.1
Ruminal volume:		
Total, gallons	12.68 ± 1.69	8.19 ± 2.35
Fluids, gallons	12.42 ± 1.29	6.87 ± 2.01
Solids, lb	13 ± 3.1	11 ± 3.1
Fluids/solids ratio	7 ± 1.5	5 ± 0.7
Total DM, %	12 ± 2.0	17 ± 2.0
Ruminal fluid dilution rate, %/h	3.9 ± 1.1	4.3 ± 1.2
Ruminal DM disappearance rate, %/h[b]	5.3 ± 1.3	8.3 ± 2.1
Rumen osmolality, mOsm/kg	300 ± 8.1	344 ± 8.5

[a] Water evasion = percentage of drinking water not mixing with rumen fluid.

[b] Ruminal DM disappearance rate = DM intake/DM in rumen.

due to a reduction in fluids. Total DM concentration in the rumen was increased. Ruminal osmolality failed to reach the values that would be expected if all of the added NaCl had reached the rumen (344 ± 8.5 observed vs 406 mOsm expected/kg).

With hay-based diets (Experiment 2), NaCl and molasses supplements increased water consumption over control ($P<.10$), though to a lesser extent than with concentrate diets. Neither rumen volume or fluid dilution rates, nor hay intake were influenced by treatment. Ruminal evasion of drinking water was similar among treatments, with the lowest numerical value noted for the molasses treatment (43.5% of intake) and highest for the control (48.2%). The NaCl treatment was intermediate (44.2%). Rumen fluid and plasma osmolality were similar and not influenced by treatment.

Table 2. Effect of osmotically active supplements on rumen function and liquid kinetics in steers consuming high roughage diets in Experiment 2 (Means).

	Supplements			
Measurement	Control	NaC1	Molasses	SE
Observations/treatment	3	3	3	
Daily intake:				
Hay, lb	23.1	23.5	21.1	.11
Water, gallons	8.88[a]	9.85[b]	9.72[b]	.47
Rumen content lb:				
Free liquid	104.7	111.1	104.9	2.7
Fresh solids	110.2	115.3	101.6	7.7
Total fluid	185.0	194.7	178.0	3.5
Total DM	29.9	31.7	28.8	1.5
Ruminal fluid dilution rate, %/h	5.7	5	5	.38
Water evasion, % of intake	48.2	44.2	43.5	1.95
Feces DM, %	20.2	19	18.8	1.06

a,b Means in the same row with different superscripts differ ($P<.10$).

Kinetics of ruminal fluid seems to be more susceptible to osmotically active substances in concentrate diets as compared to roughage diet. In both cases, the net ruminal evasion of drinking water appeared to be enhanced, increasing the potential for utilization of nutrients of feed origin that can be digested postruminally.

Literature Cited

Garza, J. et al. 1990. Ruminal water evasion and steady state. Okla. Agr. Exp. Sta. Res. Rep. MP-129:114.

RUMINAL FLUID, A MULTI-POOL SYSTEM?

J. Zorrilla-Rios[1], J.D. Garza[2] and F.N. Owens[3]

Story in Brief

Liquid mixing within the rumen of three mature steers consuming a hay-based diet was investigated by administering two water soluble markers (cobalt and chromium complexes of ethylenediamine-tetraacetic acid) simultaneously by direct ruminal infusion or by mixing into the drinking water, respectively. Sampling sites differed in marker concentrations, being lower in the reticulum than at other sites in the rumen. This suggests that drinking water does not fully mix with total rumen fluid and that several pools of ruminal fluid exist. The reticular liquid pool has a faster dilution rate than total ruminal fluid. Incomplete mixing and presence of subpools may explain why drinking water partly evades the rumen and suggests that small dense particles flushed with liquids from the rumen also may evade ruminal digestion as well.

(Key Words: Rumen, Kinetics, Fluid Digesta.)

Introduction

Greater understanding of the drinking behavior of cattle and the fate of consumed fluid within the rumen may lead to new strategies for delivering specific nutrients to the post-ruminal tract of cattle. An increased nutrient supply may improve performance or efficiency.

For many years, ruminal fluid volume and passage in cattle has been studied using water soluble markers (WSM) under the assumption that these WSM mix with and behave similarly to total rumen fluid. Estimates that 40 to 90% of drinking water evades the rumen questions this assumption and suggest that several liquid subpools may exist in the rumen which differ in size and turnover rate. The objective of this study was to investigate this theory.

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Materials and Methods

A completely randomized design with three replicate measurement periods was used with three mature steers (990 lb) limit-fed a hay-based diet (2.3% BW/day; as-fed basis). During four consecutive days of a 20-day period, all animals were dosed three times a day via ruminal cannula with the cobalt salt of ethylenediamine-tetraacetic acid cobalt (CoEDTA) every 8 h; chromium (CrEDTA) was present in the drinking water. Ruminal fluid samples were obtained at 10:00 a.m. of day 5 (26 h after the last ruminal CoEDTA dose) from the reticulum, the ventral anterior and posterior sacs and as a total mixed sample of fluid obtained by total evacuation of ruminal contents.

Least squares means for marker concentrations were compared with a general linear model including marker type, rumen sampling site, animal, period and respective interactions. The error term for period x marker x animal interaction was used to analyze marker differences. Site differences among markers were tested using the residual error term.

Results and Discussion

Least squares mean relative concentrations for each marker (marker concentration expressed as a fraction of the daily dose) and relative difference comparisons across markers (the difference between Co and Cr relative concentration within each sampling site) are shown in Table 1. For CrEDTA, which was given in drinking water, relative marker concentrations differed ($P<.01$) between the reticulum and the total mixed fluid pool sample. With CoEDTA, the marker dosed into the rumen, relative marker concentrations differed ($P<.05$) between the reticulum and the ventral posterior ruminal sac. Relative differences between fractional concentrations of both markers were similar among all rumen sites suggesting that both markers were equilibrating with the same total fluid pools.

The lower concentration of Cr, the marker given in drinking water, and Co, the marker dosed intraruminal, in the reticulum as compared to the total pool samples and the ventral posterior sac, respectively, indicates that the liquid pool of the reticulum has a greater dilution rate (indicated by its lower concentration). Dissimilarity of these two markers when administered by different routes (infused directly vs in the drinking water) is further evidence for the presence of a reticular subpool which has a faster turnover rate than the total ruminal liquid pool.

Table 1. Rumen fluid concentrations of two water soluble markers obtained from different sites of the rumen of cattle consuming a hay-based diet (least squares means; n=3).

Sampling site[b]	Water soluble marker, relative concentration[a]		
	CoEDTA dosed in rumen	CrEDTA in drinking water	Relative difference[c]
Total content	.0076[de]	.0051[f]	.0025
Reticulum	.0075[d]	.0045[g]	.0030
Ventral ruminal:			
Anterior	.0077[de]	.0048[fg]	.0029
Posterior	.0078[e]	.0048[fg]	.0030
SE	.00011	.00011	.00074

[a] Marker concentration as a fraction of daily dose.
[b] Total content is whole rumen fluid content obtained after evacuation. All others are samples obtained manually through a large rumen cannula, before evacuation.
[c] Relative difference is the difference between concentrations of the two markers for each rumen site sampled.
[d,e] Means in the same column with different superscripts differ ($P<.05$).
[f,g] Means in the same column with different superscripts differ ($P<.01$).

INTAKE RESPONSE OF HORSES CONSUMING A CONCENTRATE VARYING IN PELLET SIZE

D.W. Freeman[1], D.L. Wall[2] and D.R. Topliff[1]

Story in Brief

Four yearling and four mature horses were fed a concentrate processed in four different sized pellets in order to measure intake response. The four yearling horses and two of the mature horses were fed four pounds of concentrate and four pounds of hay twice daily. The remaining two mature horses were fed six pounds of concentrate and six pounds of hay twice daily. The yearling horses consumed slightly less concentrate by 20 minutes post feeding when offered the 3/16 inch pellet as compared to the 5/8 inch pellet. Mature horse response was similar to yearlings although differences were not significant. Pellet density appeared to affect intake response as less dense pellets were consumed at a faster rate during the first 20 minutes post feeding. The mature horses offered more ration consumed a lower amount during the first 20 minutes post feeding. No significant differences in chewing rates were detected between pellet sizes. No digestive disorders were observed with any of the horses on any of the pellets. Results of this trial suggest that pellet sizes ranging from 5/32 inch to 3/4 inch in diameter had little effect on consumption of the concentrate portion of the ration.

(Key Words: Horse, Feed Intake, Pellet Size.)

Introduction

Previous work indicates that horses consume total rations processed into pellets faster than rations which are not pelleted (Hintz and Loy, 1966). Similar responses have been documented in dairy cattle (Kertz et al., 1981). While previous research with horses has noted differing consumption rates of total diets fed in pelleted verses unpelleted form, there is little documentation of intake response of the concentrate portion of a ration fed in different sizes of pellets. The objective of this trial was to measure intake responses of mature and yearling horses consuming a concentrate ration fed in varying pellet sizes.

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[1]Associate Professor [2]Graduate Student

Materials and Methods

Four yearling and four mature Quarter Horses were randomly assigned treatments within two 4 x 4 Latin square experiments consisting of four 2-week periods. Treatments consisted of a single concentrate mixture (Table 1) processed into pellet sizes of 5/32, 3/16, 5/8, or 3/4 inch in diameter. Total diets consisted of 50% concentrate and 50% Bluestem hay. The horses were fed twice daily at 12-h intervals. Yearlings were fed 4 lb of concentrate and 4 lb of hay each feeding to meet estimated nutrient requirements for growth. The mature horses were fed at levels to maintain a moderately fleshy body condition (Henneke et al., 1983); two received 4 lb of concentrate and 4 lb of hay each feeding. The remaining two mature horses received 6 lb of concentrate and 6 lb of hay each feeding. One required the additional feed because of activity as a breeding stallion and the other horse was fed to increase body condition from a thin condition at the start of the trial to a moderately fleshy condition by the end of the trial. The horses were maintained in individual stalls with free access to water. The horses were immunized and dewormed prior to the initiation of the study.

The amount of concentrate remaining at 20 min post feeding was measured to determine relative consumption rate during the last three days of each experimental period. The hay portion of the diet was fed after the 20 min post feeding measurement to remove the effects of hay intake on concentrate consumption. Chews per minute were determined twice in each of the monitored feedings by observation of jaw movements.

A random sample of each pellet size was taken for density determination. Ten pellets of each size were measured for length and diameter for area determinations and weighed on an air dried basis. Density was expressed as weight per unit volume (mg/mm^3).

Table 1. Composition of concentrate, as fed basis[a].

Ingredient	percent
Corn, grain	50.0
Alfalfa hay, midbloom	25.0
Soybean meal	20.0
Molasses, sugarcane, dehydrated	3.0
Limestone, ground	1.5
Sodium chloride	.5

[a] Vitamin A topdressed at levels of 450 IU Vitamin A/lb.

All data were subjected to analysis of variance to determine differences in treatments, and Tukey's procedure was used to identify differences between treatment means ($P<.05$).

Results

Small differences ($P<.05$) were observed in the amount of concentrate consumed in different pellet sizes fed to yearlings (Table 2). Mean amounts consumed at 20 min post feeding ranged from 2.6 lb for the 3/16 inch pellet to 2.9 lb for the 5/8 inch pellet. The number of chews per minute were similar for all the pellet sizes ($P>.05$).

Consumption of pellets by mature horse followed a pattern similar to the yearlings, although differences were not significant. Amounts consumed after 20 min ranged .5 lb with smallest amounts consumed corresponding to the 3/16 inch pellet and the largest with the 5/8 inch pellet. Chews per minute were not different between treatments, and were similar to values observed in yearlings.

A contrast between the mature horses consuming 4 lb and 6 lb per feeding was constructed to determine the influence of concentrate level on consumption patterns. The two horses fed 6 lb concentrate across treatments consumed less in 20 min post feeding (2.88 lb) than those receiving 4 lb concentrate (3.78 lb).

Table 2. Mean concentrate intake of horses consuming pellets with different diameters.

	Pellet diameter, inch				
Age	5/32	3/16	5/8	3/4	SE
Yearlings					
Amount consumed, post 20 min, lb	2.8[ab]	2.6[b]	2.9[a]	2.8[ab]	.11
Chew rate, chews/min	83.8	81.8	82.0	79.8	2.4
Mature					
Amount consumed, post 20 min, lb	3.4	3.0	3.5	3.4	.16
Chew rate, chews/min	82.8	85.3	83.5	81.3	2.5

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

Slower intakes for those horses consuming more concentrate and hay per feeding would be expected if gut fill from the previous feeding had an effect on appetite.

Discussion

These results indicate that pellet size differences (5/32 to 3/4) had little effect on the acceptability and consumption patterns of both groups of horses. Results of this trial may be more influenced by pellet density than pellet size. Although it was not the intent of the trial to vary pellet density between treatments, differences in density were observed between pellets of different sizes. Pellet densities ranged 1.64 mg^3/mm^3 across treatments (Table 3). Pellet density and consumption followed a similar pattern across treatments. Lowest consumption amounts post 20 min of feeding were observed with the denser pellets.

One disadvantage of pellets, particularly very small pellets, has been suggested to be rapid intake (NRC, 1989). The rapid intake may more readily lead to digestive disorders from overconsumption and rapid fermentation in the horse's digestive tract. No digestive disorders were apparent in any of the horses on any of the treatments. Another perceived disadvantage of feeding large pellets to young horses is the increased potential for choking due to swallowing large particles. No evidence of choking or difficulty in swallowing was observed for any of the treatments. Apparently, pellet size did not influence the ability of these horses to break the pellets into a safe size for swallowing.

Additional studies need to be conducted to verify intake responses of horses consuming rations differing in physical form. Many of the traditional whole grain rations fed to horses are becoming more and more uneconomical,

Table 3. Density of pellets with different diameters and intake response of horses.

	Pellet diameter, inch				
Item	5/32	3/16	5/8	3/4	SE
Pellet density, mg^3/mm^3	12.63^{bc}	13.99^{a}	12.35^{c}	12.84^{b}	.13
Amount consumed, post 20 min, lb	3.1^{a}	2.8^{b}	3.2^{a}	3.1^{a}	.14

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

and many of the alternative grains can be fed in pelleted form. Pelleted feeds have many advantages in utilization of different feedstuffs; however, potential problems with digestive disorders of feeding pellets need further research. While Scott and Potter (1989) recently reported that varying the fiber content of pellets has little effect on intake responses of horses, level of intake and pellet density are two confounding factors observed in this trial which do appear to affect intake response. These factors need to be considered in the design of further studies on intake response of horses fed rations of differing physical form.

Literature Cited

Henneke, D.R. et al. 1983. Relationship between condition score, physical measurements and body fat percentage in mares. Equine Vet. J. 15(4):371.

Hintz, H.F. and R.G. Loy. 1966. Effects of pelleting on the nutritive value of horse rations. J. Anim. Sci. 25:1059.

Kertz, A.F. et al. 1981. Eating rate of lactating cows fed four physical forms of the same grain ration. J. Dairy Sci. 64:2388.

NRC. 1989. Nutrient Requirements of Horses (5th Ed.). National Academy Press, Washington, DC.

Scott, B.D. and G.D. Potter. 1989. Rate of feed consumption and chewing by mature horses fed diets with varying amounts of fiber. In: Proc. of the Eleventh Equine Nutr. and Physiol. Symp. p 274. Oklahoma State Univ., Stillwater.

GROWTH OF WEANLING HORSES FED YEAST, SOYBEAN MEAL OR MILK BASED PROTEIN SUPPLEMENTS

D.R. Topliff[1] and T. Monin[2]

Story In Brief

Twenty-five weanlings were blocked by sex and birthdate and randomly allotted to one of five experimental treatments to test the effects of source of dietary protein on growth and development of young horses. Treatments included a control which received a base concentrate diet of oats and molasses at 1.75% of body weight daily and free access to bermudagrass hay, and four experimental treatments which received the base concentrate and hay plus one of four commercially available protein supplements fed at the manufacturers recommended level. Two of the protein supplements contained yeast as a portion of the protein, one contained soy based protein, and the fourth was a milk based protein supplement. The protein supplemented treatments were isonitrogenous while the control treatment was lower in crude protein. Weight and height measurements were taken every two weeks while radiographs of the third metacarpal for determination of presence of osteochondrosis, ultrasonic measurements of subcutaneous fat thickness and numerical body condition scores were taken at the beginning and end of the 18-week trial. Weanlings consuming one of the yeast proteins and the milk protein gained significantly faster and had better feed efficiency than the other three treatments. Results of this experiment suggest that protein quality may be critical for efficient growth when the protein to calorie ratio falls significantly below 50 g crude protein/Mcal of digestible energy, the recommended ratio for weanlings of this age.

(Key Words: Equine, Growth, Protein Requirement, Skeletal Soundness.)

Introduction

Since today's horse industry demands near maximum growth of weanlings for show or sale, horsemen are continually in search of products that will help them achieve the genetic potential of their foals. While the National Research

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Council (NRC, 1989) has defined the nutrient requirements for growth rates to achieve mature size at about three years of age, questions still remain as to the effect of different nutrient sources on growth and soundness of young horses.

Topliff et al. (1988) has shown that weanlings can be grown at faster rates than suggested by the NRC without compromising skeletal mineralization or composition of gain so long as the protein to calorie ratio (PCR) is maintained at or above 50 g of crude protein (CP) per Mcal of digestible energy (DE). Since the commonly utilized feed grains in weanling rations have a PCR of 30 to 40, it is necessary for horsemen to supplement protein in those rations. Several commercially available protein supplements are available, each with differing protein sources as a base. It was therefore the objective of this experiment to investigate the effect of protein from yeast, soybean meal or milk on growth of weanlings over a 126-day (18-week) feeding trial.

Materials and Methods

Twenty-five foals were weaned by a partial separation method at approximately 120 days of age, blocked by birthdate and sex and randomly allotted to one of five dietary treatments for a 126-day growth trial. All foals were fed a base concentrate of oats fortified with ground limestone and trace mineralized salt. In addition, foals on four of the treatments received supplemental protein from one of four commercially available sources added to the base diet at the manufacturer's recommended level. Composition of the experimental concentrate diets is shown in Table 1. Additionally, all weanlings were fed bermudagrass hay on an ad libitum basis. Concentrate diets were offered at 1.5% of body weight divided into two equal daily feedings for the first four weeks of the experiment and 1.75% for the remainder of the trial.

At the beginning and bi-weekly throughout the remainder of the trial, weanlings were weighed individually on a conventional beam-type scale and measured for height at point of the withers using the marked stick and level technique. Additionally, ultrasonic measurements of subcutaneous fat thickness over the rump and last rib were taken at the beginning and end of the trial (Westervelt et al., 1976) using a Corometrics 210 linear array real-time unit equipped with a 5 Mhz transducer. Measurements were taken directly from the television screen of the machine using internal calipers which measured to the nearest millimeter.

Since weanlings used in this experiment were obtained from two sources and allotted to treatments without regard to origin and mixed, the first four weeks of the trial were considered an adjustment period and those data excluded from the analysis. Therefore, weight and height gains as well as feed conversion ratios were calculated over a 98-day period even though the trial was conducted for 126 days.

Table 1. Composition of experimental diets (as fed basis)[a].

Ingredient	Control	Yeast 1	Yeast 2	Soy	Milk
Oats, %	97.5	*	*	*	*
Limestone, %	1.5				
NaPO4, %	.5				
Trace mineral salt, %	.5				
Supplement, lb/day	----	2	2	1	1
DE Mcal/lb	1.27	1.32	1.32	1.32	1.32
Crude protein, %	11.0	12.5	12.5	12.5	12.5
Calcium, %	.6	.8	.8	.85	.75
Phosphorus, %	.5	.6	.6	.65	.65
CP, g/Mcal DE	40	43	43	43	43

[a] Yeast 1 and Yeast 2, Care Cubes, Provesta Corporation; Soy, Calf Manna, Carnation-Albers; Milk, Start to Finish, Milk Specialties Company.

To further document skeletal mineralization, radiographs of the front leg were taken before and after the trial (Meakim et al., 1981) and were analyzed by a Board Certified Radiologist for any signs of osteochondrosis or other bone abnormalities.

All data were analyzed by analysis of variance using a model accounting for variation due to treatment, sex, birthdate and time. When the variation due to a particular source was significant at the $P<.05$ level, least squares means were then calculated. The least significant difference procedure was then used to determine differences between means.

Results and Discussion

Least squares means for initial and final height and height gain at the withers are shown in Table 2. While significant differences in the absolute heights existed at the beginning and end of the trial, the week by treatment interaction was not significant, suggesting that weanlings gained height at the same rate regardless of treatment. Those results agree with the concept that the first priority for nutrients is for bone growth. There was also considerable variation between and within treatments in the initial heights of the weanlings.

Least squares means for initial and final weight, weight gained and feed per lb of gain are shown in Table 3. Weanlings receiving Yeast 2 and Milk gained significantly faster over the 98-day feeding trial than those on Yeast 1, Soy or Control. Mean average daily gains for Yeast 2 and Milk were 1.52 and

Table 2. Treatment least squares means for initial, final and gain of height at the withers of weanlings over a 98-day feeding trial.

Item	Treatment				
	Control	Yeast 1	Yeast 2	Soy	Milk
Initial height, inches	48.8	50.7	48.0	51.0	49.9
Final height, inches	50.6	52.1	49.7	52.1	51.2
Height gain, inches	1.8	1.4	1.7	1.1	1.3

Table 3. Treatment least squares means of initial weight, final weight, weight gained, average daily gain and feed efficiency over the 98-day feeding trial.

Item	Treatment				
	Control	Yeast 1	Yeast 2	Soy	Milk
Initial weight, lb	479	521	454	509	531
Final weight, lb	601	647	598	635	687
Weight gained, lb	122[a]	126[a]	144[b]	126[a]	156[b]
Average daily gain, lb	1.30[a]	1.22[a]	1.52[b]	1.27[a]	1.55[b]
Feed efficiency, lb/lb gain	10.5[a]	10.7[a]	9.0[b]	11.1[a]	8.7[b]

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

1.55 lb, respectively while the average daily gains for Yeast 1, Soy and Control were 1.22, 1.27 and 1.30 lb, respectively. As would be expected the feed efficiency for Yeast 2 and Milk treatments was significantly better (9.0 and 8.7) as compared to 10.5, 10.7 and 11.1 for the Controls, Yeast 1 and Soy, respectively. It should be pointed out that the means listed in Table 3 are least squares means and not arithmetic means. Therefore, average daily gains and feed efficiencies cannot be calculated from the data displayed in the table. Least squares means are adjusted to account for differences in initial weights.

Gains observed in this trial for treatments Yeast 2 and Milk are within acceptable normal range for weanlings of this age, if mature height and weight

are to be reached at 24 months of age. Gains observed in the other three treatments are somewhat low if the objective is to reach maximum growth at 24 months of age. Several researchers and veterinary pathologists have suggested that if maximum growth is to be achieved by two years of age that growth should be accomplished in a consistent manner and not in rapid bursts during the yearling year. With weanlings on treatments Yeast 1, Soy and Control, growth would have to be accelerated during the yearling year to achieve comparable size.

The explanation for the differences in average daily gain between Yeast 2 and Milk versus the controls is seemingly apparent when one considers the difference in crude protein levels (12.5 vs 11%). However, that does not explain the advantage over Yeast 1 and Soy, nor does it explain the lack of difference between Yeast 1, Soy and Control. Those results can partially be explained in two parts. First, the absolute differences in protein intake are relatively small as indicated by the protein to calorie ratios (43 vs 40 g/Mcal). Secondly and more importantly, protein quality is likely involved. The NRC recommends a protein to calorie ratio of 50 g/Mcal, so the diets fed here are protein deficient compared to their recommendations. However, the NRC recommendations are based on experiments where soybean meal was used as the protein source. Diets formulated using protein sources with a better amino acid profile may not require as high a percent of crude protein. However, the amino acid profile of Yeast 1 should have been comparable to Yeast 2 and Milk, so the inferior performance of weanlings consuming Yeast 1 is somewhat puzzling and no readily apparent explanation for those results is available. No problem with consumption, wastage, or health of the weanlings on that treatment was noted.

Treatment least squares means of condition score, backfat and rumpfat thickness at the beginning and end of the trial are shown in Table 4. No significant differences for any of the traits measured were found. This would suggest that weight gains observed during the trial were indicative of true growth and not simply subcutaneous fat accretion. The numerical condition scores tended to decrease throughout the trial across all treatments, although the magnitude of the decrease averaged about .5 condition score which translates into a body fat percentage of less than 2%. The small magnitude of that change is also borne out by the lack of measurable change in rumpfat thickness, which has the highest correlation with total body fat.

While the radiographs taken were largely unremarkable, there was some radiographic evidence of osteochondrosis (OCD) in some of the weanlings on this trial. Those occurrences appeared to be random and were not related to treatment and have no bearing on the results presented here. It has been estimated that as high as 20% to 25% of all horses have some degree of OCD, the cause of which is unknown at this time. Rapid growth, or at least the genetic ability for rapid growth, has been theorized to be the main cause, although that has not been proven at this point. Very likely there are other causes as well,

Table 4. Treatment least squares means of condition score, backfat thickness and rumpfat thickness at the beginning and end of the 98-day feeding trial.

Item	Treatment				
	Control	Yeast 1	Yeast 2	Soy	Milk
Condition score					
Initial	4.7	4.7	4.8	4.2	5.0
Final	4.1	4.0	4.4	3.8	4.3
Backfat thickness, inches					
Initial	.12	.10	.13	.13	.16
Final	.14	.16	.16	.13	.18
Rumpfat thickness, inches					
Initial	.14	.13	.14	.18	.19
Final	.14	.13	.15	.13	.18

such as nutrition. One factor that has been shown conclusively to result in skeletal unsoundness is the practice of retarding growth of weanlings and then feeding for rapid growth as yearlings.

The results of this trial indicate that acceptable growth rates in weanlings can be achieved on diets that contain less protein per Mcal of DE than is recommended by the NRC if the quality of the protein source is taken into account. This would be particularly true when feeding an oats and grass hay type of diet similar to that used in this trial, one which is very common in today's horse industry. Therefore, if diets of that type are to be fed, protein supplements that contain high quality sources such as yeast and milk could be beneficial.

Literature Cited

Topliff, D.R. et al. 1988. Growth of weanling Quarter horses fed varying levels of energy and protein. Equine Vet. Sci. 8(5):371.

Meakim, D.W. et al. 1981. Estimation of mineral content of the equine third metacarpal by radiographic photometry. J. Anim. Sci. 53:1019.

National Research Council. 1989. Nutrient Requirements of Horses. National Academy Press. Washington, DC.

Westervelt, R.G. et al. 1976. Estimating fatness in horses and ponies. J. Anim. Sci. 43:781.

MINERAL BALANCE OF HEAT DISTRESSED BROILERS

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Story in Brief

A study was conducted using eight colostomized and fourteen intact eight week posthatching Arbor Acre x Vantress broilers to investigate the impact of heat distress on mineral balance. Birds were housed in environmental chambers maintained at either a cycling 74-95°F heat distress or constant 74°F thermoneutral environment. Feed consumption was equalized between environments by force feeding at 6% of body weight daily. Feces and urine were analyzed for Ca, K, Cu, Fe, Mg, Mn, Mo, P, S, Se, Zn and Na by an Inductively Coupled Argon Plasma Emission Spectrophotometer. Urinary excretion was increased for K, Mg, P and S when birds were exposed to heat distress. Fecal excretion was increased by heat distress for Se, Cu and Mg. Mineral balance expressed as intake less excretion was reduced for Cu, K, Mg, Mo, P, S, Se, Zn, and Na in the HD birds. This study suggests that heat distress may increase the mineral requirements of broilers.

(Key Words: Heat Distress, Mineral Balance, Colostomy, Broiler.)

Introduction

Reduced broiler feed intake during heat distress is considered to be a major factor limiting productivity. Such a reduction lowers consumption of all nutrients. Husseiny and Creger (1981), reported that broilers subjected to 90°F for 42 days had reduced retention efficiency for calcium (Ca), copper (Cu), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), phosphorus (P), and zinc (Zn). Young turkeys housed at 95°F for four days exhibited reduced absorption of K, P and Ca than the birds held at 75°F (Wolfenson et al, 1987). Research conducted by Smith and Teeter (1987) indicated that broilers subjected to 95°F excreted over 600% more K than those held at 75°F. Supplementing drinking water with up to .15% K increased live weight gain, feed efficiency and survival (Smith and Teeter, 1986). The objective of the study described herein was to evaluate the route of mineral loss in broilers during heat distress.

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Materials and Methods

Arbor Acre x Vantress broiler chicks were colostomized at four weeks posthatching and subsequently individually caged. Feed and water were available for ad libitum consumption until the pretest period was initiated. Eight colostomized and 14 intact birds were allocated at eight weeks of age to environmental chambers maintained at either a cycling 74 to 95°F heat-distress (HD) or a constant 74°F thermoneutral (TN) temperature. Birds were force fed 6% of their body weight per day according to the methodology of Teeter et al. (1984). Feces and urine or total excrement for the colostomized and intact broilers respectively, were collected at 12 h intervals during the 48-h experimental period. Excrement and experimental diet (Table 1) were analyzed by an Inductively Coupled Argon Plasma Emission Spectrophotometer for Ca,

Table 1. Composition of diet.

Ingredient	Percent
Ground corn	56.8
Soybean meal	36.0
Fat	3.0
Dicalcium phosphate	2.35
Calcium carbonate	.90
Salt	.50
Vitamin mix	.25
Trace mineral	.10
DL-Methionine	.10
Total	100
Analyzed mineral composition:	
Ca, %	1.25
K, %	1.08
P, %	1.02
S, %	3.60
Na, %	.21
Mg, %	.19
Cu, ppm	11.13
Fe, ppm	481.40
Mn, ppm	360.40
Mo, ppm	4.94
Se, ppm	32.35
Zn, ppm	148.25

Table 2. The effect of heat distress on major mineral balance, urinary and fecal excretion of broilers.

Parameter	Treatment[a]	Mineral					
		Ca	P	K	Na	Mg	S
Mineral balance[1]	TN	268[b]	271[b]	299[b]	10.3[b]	43.5[b]	1976[b]
	HD	163[b]	59[c]	57[c]	-52.3[c]	19.3[c]	1751[c]
Urinary excretion[1]	TN	7.69[b]	46[c]	57[c]	20[b]	9.4[c]	73[c]
	HD	7.67[b]	93[b]	287[b]	34[b]	17.4[b]	140[b]
Fecal excretion[1]	TN	337[b]	214[b]	213[b]	78[b]	60.2[c]	53[b]
	HD	377[b]	239[b]	206[b]	75[b]	77.7[b]	68[b]

[a] TN is thermoneutral, HD is heat distress.
[b,c] Means within a column in a parameter with different superscripts differ ($P < .05$).
[1] Expressed as parts per million.

Table 3. The effect of heat distress on minor mineral balance, urinary and fecal excretion of broilers.

Parameter	Treatment[a]	Mineral					
		Mn	Se	Fe	Zn	Mo	Cu
Mineral balance[1]	TN	15.3[b]	1.4[b]	9.5[b]	3.1[b]	.04[b]	-.04[b]
	HD	12.9[c]	1.1[c]	5.4[b]	1.7[c]	-.05[c]	-.26[c]
Urinary excretion[1]	TN	.02[b]	.28[b]	.13[b]	.58[b]	.06[b]	.023[b]
	HD	.02[b]	.26[b]	.13[b]	1.1[b]	.11[b]	.023[b]
Fecal excretion[1]	TN	5[b]	.26[c]	17[b]	4.7[b]	.12[b]	.67[c]
	HD	5.3[b]	.35[b]	16.1[b]	4.8[b]	.14[b]	.87[b]

[a] TN is thermoneutral, HD is heat distress.
[a,b] Means within a column in a parameter with different superscripts differ ($P < .05$).
[1] Expressed as parts per million.

K, Cu, Fe, Mg, Mn, Mo, P, S, Se, Zn, and Na using the method of Trudeau and Freier (1967) and DeRuig (1986). Upon completion of the two consecutive switch-back experimental periods, mineral balance, urinary and fecal excretion were determined.

Results and Discussion

The heat distressed colostomized broilers had significantly reduced balance for K, P, S, Na, Zn, Se, Mo, Mn, Mg, and Cu (Tables 2 and 3). The lower mineral balance of these broilers was reflected by a higher urinary excretion for K, P, S (Table 2) and by a higher fecal excretion for Cu and Se, (Table 3). Magnesium loss was elevated for both urine and feces. However, the reduced balance for Na, Zn, Mo and Mn was not attributable to either route of excretion. The balance for Ca and Fe had a tendency to be reduced ($P<.1$). Intact HD broilers displayed a similar trend in that their balance for K, P, Na, Zn, Se, Mo, Mn, Mg and Cu was significantly lowered. Results of this study are in agreement with Husseiny and Creger (1981). Studies are underway to evaluate the potential of mineral supplementation to offset the deleterious effects of heat distress.

Literature Cited

De Ruig, W.G. 1986. Atomic absorption spectrometric determination of Ca, Cu, Fe, Mg, Mn, K, Na, and Zn in animal feeding stuffs. J. Assoc. Off. Anal. Chem. 69:1009.

Husseiny, O.El. and C.R. Creger. 1981. Effect of ambient temperature on mineral retention and balance of the broiler chicks. Poult. Sci. 60:1651.

Smith, M.O.and R.G. Teeter. 1987. Effect of ammonium chloride and potassium chloride on survival of broiler chicks during acute heat stress. Nutri. Res. 7:677.

Smith, M.O. and R.G. Teeter. 1987. Potassium balance of the 5 to 8 week-old broiler exposed to constant heat or cycling high temperature stress and the effect of supplemental potassium chloride on body weight gain and feed efficiency. Poult. Sci. 66: 487.

Teeter, R.G. and M.O. Smith. 1986. High chronic ambient temperature stress effect on broiler acid-base balance and their response to supplemental ammonium chloride, potassium chloride, and potassium carbonate. Poult. Sci. 65: 1777.

Teeter, R.G. et al. 1984. Force feeding methodology and equipment for poultry. Poult. Sci. 63:573.

Trudeau, D.L. and E.F. Freier. 1967. Determination of calcium in urine and serum by atomic absorption spectrophotometry. Clin. Chem. 13:101.

Wolfenson, D. et al. 1987. Absorption of protein, fatty acids and minerals in young turkeys under heat and cold stress. Brit. Poult. Sci. 28:739.

RIOBOFLAVIN AND PANTOTHENIC ACID REQUIREMENT OF THE BROILERS THROUGH EIGHT WEEKS POSTHATCHING

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Story in Brief

One study utilizing 2,340 (Vantress x Arbor Acre) broilers was conducted to evaluate the NRC riboflavin and pantothenic acid requirement for growth. Parameters monitored include pantothenic acid tissue concentration and blood GSH-Reductase. Birds were randomaly divided into 60 pens at hatching. Treatments evaluated were as follows: 1) basal diet lacking both pantothenic acid and riboflavin; 2) NRC recommandations for both vitamins; 3) as 2 with 2 x NRC supplemented riboflavin; 4) as 2 with 4 x NRC supplemented riboflavin; 5) as 2 with 2 x NRC supplemented pantothenic acid; 6) as 2 with 4 x NRC supplemented pantothenic acid; 7) as 4 and 6 in combination. Pectoralis major and blood samples were collected at eight weeks for pantothenic acid and GSH-Reductase analysis, respectively. Live weight gain and survival were depressed at four weeks when pantothenic acid and riboflavin were deficient. However, no sign of muscle weakness or leg paralysis was observed. Blood GSH-Reductase was not impacted by dietary riboflavin level while growth rate was increased by 6% at 56 days posthatching when dietary riboflavin was increased. However, increasing pantothenic acid elevated tissue concentration of pantothenic acid by 35% and 74% with no impact on growth rate. The data suggests that NRC recommandations of 10 ppm for pantothenic acid are satisfactory for growth while the 3.6 ppm for riboflavin requires further investigation.

(Key Words: Pantothenic Acid, Riboflavin, Growth, Tissue Concentration, GSH-Reductase.)

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Introduction

The importance of dietary pantothenic acid and riboflavin for most poultry classes is well established (Lepkovsky and Juke, 1936; Bauernfeind and Norris, 1939; Gillis et al., 1942). The National Research Council (1984) has established the requirement for pantothenic acid at 10 ppm and at 3.6 ppm of diet for riboflavin. Typical corn-soybean meal rations for starting to growing broilers contain from 5.59 to 5.06 ppm of patothenic acid and 2.69 to 2.5 ppm of riboflavin of feed and as a result must be supplemented.

Pantothenic acid deficiency in rats and chickens has been observed to reduce growth (Nelson and Evans, 1946; Cupo and Donaldson, 1986) and vitamin content of tissue (Snell et al., 1940). Bauernfeind et al. (1942) reported that Rhode Island Red chicks are less susceptible to pantothenic acid deficiency and require less amount of the vitamin than layers.

The dietary riboflavin needs of broilers varies with age, growth, genetic background, stage of production, and ration compostion criteria. Bolton (1944) reported that the minimum requirement of 3.0 ppm is optimum for the broiler until six weeks of age and the leg problem associated with the riboflavin deficiency is preventable with 3.6 ppm of the vitamin. Ogunmodede (1977) reported that 5.1 ppm dietary riboflavin is the optimum level for maximizing broiler's body weight. However, McDowell (1989) noted that chickens riboflavin requirement is positively correlated with consumption of rations containing high levels of fat and protein. Turkki and Holtzapple (1982) reported that increased riboflavin requirement is related to the growth rate rather than protein intake. The importance of riboflavin for maintaining enzyme functions such as glutathione (GSH) reductase is well established (Beutler, 1975). Bamji (1969) has shown that activity of GSH decreases in humans consuming suboptimal riboflavin levels.

The purpose of the research described herein was to evaluate the dietary pantothenic acid and riboflavin requirement established by the NRC for adequacy to promote optimal broiler growth rate, feed efficiency, survival, and carcass composition as well as observe the impact of supplemental vitamin levels on tissue pantothenic acid concentration and lysed red blood cell rate of reaction of GSH-reductase.

Materials and Methods

Two-thousand-three-hundred-forty male broilers (Vantress x Arbor Acre) were divided and randomly allotted at hatching into 60 pens such that each pen contained 39 chicks (.8 ft^2/bird). Treatments evaluated were as follows: 1) basal diet containing no supplemental riboflavin or pantothenic acid; 2) as Treatment 1 with vitamins supplemented to met the NRC recommendations of

3.6 ppm of riboflavin and 10 ppm of pantothenic acid; 3) as Treatment 2 with vitamin supplementation such that the riboflavin level was 2 x NRC recommendations; 4) as Treatment 2 with vitamin supplementation such that the riboflavin level was 4 x NRC recommendations; 5) as Treatment 2 with pantothenic acid supplemented to 2 x NRC recommendation; 6) as Treatment 2 with pantothenic acid supplemented to 4 x NRC recommendation and 7) as Treatment 2 with both riboflavin and pantothenic acid supplemented to 4 x NRC recommendations. Basal ingredients (Table 1) were analyzed for riboflavin (2.69 ppm) and pantothenic acid (5.59 ppm) content to ensure accurate fortification levels. Due to pen limitations Treatments 1, 3, and 5 had eight replications per treatment while the other treatment groups had nine.

Birds were provided drinking water and starter (weeks 1-4), and grower (weeks 4-8) rations (Table 1) for ad libitum consumption during the experiment. Body weight and feed consumption were tallied by gravimentric analysis at four and eight weeks posthatching. Two chickens per pen were selected upon completion of week 8 for carcass dressing percentage, liver weight, gizzard weight, and fat pad determination. One bird was selected from each pen, the pectoralis major (breast muscles) were removed wrapped in aluminium foil and frozen at -20°C for pantothenic acid analysis AOAC (1984).

Table 1. Basal ration formulation.

Ingredient	Starter ration, %	Grower ration, %
Corn	45.43	53
Soybean meal	42	37
Fat	6.3	6.5
DiCalcium phosphate	2.35	1.61
Calcium carbonate	1.2	1.23
Salt	.4	.4
Vitamin mix[1]	.2	.2
Trace elements[2]	.1	.1
DL-methionine	.25	.2
Fish meal	1.90	

[1] Mix supplied Vit. A, 14,109 I.U.; Vit. D_3, 5291 I.U.; Vit. E, 47.62 I.U.; Vit. B_{12}, .014mg; Riboflavin, 8.82 mg; Niacin, 26.5 mg; d-Panthothenic Acid, 28.2 mg; Choline, 705.5 mg; Menadione, 1.16 mg; Folic Acid, 1.76 mg; Pyridoxine, 3.52 mg; Thiamine, 3.52 mg; d-Biotin, .176 mg (per kg of diet).

[2] Mix supplies manganese, 120 mg; zinc, 80 mg; copper, 10 mg; iodine, 1 mg; calcium, 180 mg (per kg of diet).

Blood samples were collected from the bracial vein upon completion of week 8 for glutathione reductase analyses. The analytical technique utilized was modified from Beutler (1975).

Results and Discussion

Live weight gain and survival (P<.05) were depressed at four and eight week posthatching (Table 2) when both the riboflavin and pantothenic acid vitamin supplements were deleted from the basal ration. However, the basal corn-soy diet containing 2.69 ppm riboflavin and 5.59 pantothenic acid was sufficient to prevent deficiency symptoms such as perosis, dermatitis, and curled-toe-paralysis similar to other studies (Bird et al., 1946; Scott et al., 1982). The resultant growth rate and survival reductions cannot be attributed specifically to pantothenic acid or riboflavin since the basal ration fell below NRC recommendations for both vitamins.

The NRC dietary recommendation of 10 ppm pantothenic acid of ration appears adequate for maximal weight gain, feed efficiency and survivability throughout the 8-week growth period examined in this study.

Despite the differences in pantothenic acid supplementation, tissue concentration of the vitamin did also increase (P<.05) with an increase in dietary vitamin supplementation (Table 3). This data indicates that there is no significant difference between tissue concentration of dietary supplemented Treatment 1 (5.59 ppm) vs Treatment 2 (10 ppm).

In spite of the lack or excess vitamin supplementation there was not a significant effect on dressing percentage, liver, gizzard, and fat pad expressed as a percent body weight (Table 3).

Table 2. The effect of riboflavin and pantothenic acid supplementation on body weight and feed efficiency.

Treatment	28 Days	Feed efficiency	56 Days	Feed efficiency
1	1.88^{b}	.50	6^{c}	.44
2	2.05^{a}	.53	6.05^{a}	.42
3	2.10^{a}	.53	6.42^{b}	.44
4	2.07^{a}	.54	6.28^{bc}	.43
5	2.05^{a}	.52	6.09^{ac}	.43
6	2.04^{a}	.54	6.07^{ac}	.45
7	2.06^{a}	.54	6.20^{ac}	.43

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

Table 3. The effect of riboflavin and pantothenic acid on carcass composition.

	Treatment						
	1	2	3	4	5	6	7
Change in A_{340} / time (min)	.034	.036	.040	.040	---	---	.047
Pantothenic acid PPM	11[c]	11.3[c]	---	---	15.3[b]	19.7[a]	18.8[a]
Dressing, %	.69	.68	.68	.69	.69	.68	.69
Liver as % body weight	2.39	2.30	2.40	2.42	2.34	2.52	2.32
Gizzard as % body weight	2.30	2.35	2.46	2.30	2.26	2.42	2.41
Fat pad, %	2.28	1.77	2.13	1.98	2.10	2.20	2.37

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

Brady et al. (1979) reported that in rats, 2 ppm supplementation of riboflavin was adequate to increase weight gain to that observed in rats fed 4 and 10 ppm. While for broiler chickens Ruiz and Harms (1988) reported that 2.6 ppm of riboflavin resulted in leg paralysis and recommended 4.6 ppm riboflavin. In contrast to earlier finding, the basal diet containing 2.6 ppm of the vitamin did not show sign of leg paralysis due to riboflavin deficiency. While the suggested NRC level of 3.6 ppm of riboflavin in the diet seems to be adequate in order to prevent poor growth through four weeks posthatching, beneficial effects of additional riboflavin were noted at week eight. The riboflavin requirement should be increased after four weeks of age to maximize growth (Table 2).

Riboflavin deficiency has been reported to decrease the erythrocyte activity of GSH-reductase Bamji (1969). Bamji and Sharada (1972) reported that 28 days after initiation of a riboflavin deficient diet the erythrocyte GSH-reductase activity was lowered in rats. Brady et al. (1979) reported that the erythrocyte percent active-GSH plateaued between 2 and 4 ppm of diet. However, since all the treatments were fed levels which met the minimum dietary riboflavin requirement therefore the rate of reaction based on a change of absorbance of NADPH to NADP at 340 nm over time and overall NADPH utilization by the lysed RBC's GSH-reductase was not changed by the increase in dietary riboflavin supplementation (Table 3).

Literature Cited

Association of Official Analytical Chemists. 1984. Official Methods of Analysis (14th Ed.). Assoc. Off. Anal. Chem., Arlington, VA.

Bamji, M.S. 1969. Glutathione reductase activity in red blood cells and riboflavin nutritional status in humans. Clin. Chim. Acta 26: 263.

Bamji, M.S. and D. Sharada. 1972. Hepatic glutathione reductase and riboflavin concentration in experimental deficiency of thiamin and riboflavin in rats. J. Nutr. 102: 443.

Bauernfeind, J.C. and L.C. Norris. 1939. The role of the antidermatosis vitamin and a new water soluable growth factor in the nutrition of the mature fowl. J. Nutr. 18:579.

Bauernfeind, J.C. et al. 1942. The pantothenic acid requirement of chicks. Poult. Sci. 21:142.

Beutler, E. 1975. Red Cell Metabolism. A Manual of Biochemical Methods. Grune and Stratton, New York.

Bird, F.H. et al. 1946. The comparative requirements of chicks and turkey poults for riboflavin. Poult. Sci. 25:47.

Bolton, W. 1944. The riboflavin requirement of White Wyandotte chicks. J. Agric. Sci. 34:198.

Brady, P.S. et al. 1979. Effects of riboflavin deficiency on growth and glutathione peroxidae system enzymes in the baby pig. J. Nutr. 109:1615.

Cupo, M.A. and W.E. Donaldson. 1986. The effect of pantothenic acid deficiency on lipogenisis in the chick. Nutr. Rep. Inter. 33:147.

Gillis, M.B. et al. 1942. The need for pantothenic acid and an unidentified factor in reproduction in the domestic fowl. J. Nutr. 23: 153.

Lepkovsky, S. and T.S. Juke. 1936. The response of rats, chicks, and turkey poults to crystalline vitamin G (flavin). J. Nutr. 12: 515.

McDowell, L.R. 1989. Riboflavin. In: Vitamins in Animal Nutrition. Academic Press, Inc., California.

Nelson, M.M. and H.M. Evans. 1946. Pantothenic acid deficiency and reproduction in the rat. J. Nutr. 31:497.

NRC. 1984b. Nutrition Requirements of Domestic Animals: Nutrition Requirement of Poultry (8th Ed.). National Academy Press, Washington, DC.

Ogunmodede, B.K. 1977. Riboflavin requirement of starting chickens in a tropical environment. Poult. Sci. 56: 231.

Ruiz, N. and R.H. Harms. 1988. Riboflavin requirement of broiler chicks fed a corn-soybean diet. Poult. Sci. 67: 794.

Scott, M.L. et al. 1982. Nutrition of the Chicken. Scott and Associates, New York.

Snell, E.E. et al. 1940. The effect of diet on the pantothenic acid content of chick tissues. J. Biol. Chem. 133:559.

Turkki, P. R. and P.G. Holtzapple. 1982. Growth and riboflavin status of rats fed different levels of protein and riboflavin. J.Nutr. 112: 1940

COMPARISION OF DAY FIVE ACCLIMATION AND FASTING TECHNIQUES TO REDUCE BROILER HEAT DISTRESS MORTALITY

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Story in Brief

A study utilizing 780 male broilers was conducted to test the 24 hour day five posthatching acclimation procedure. Two-hundred-sixty broilers were exposed to 95 - 100°F for 24 hours on day five posthatching. In addition, 520 control birds were maintained at an initial brooding temperature of 85°F. Of the 520 control birds, 260 birds were fasted 6 hours prior to the heat distress period. After the acclimation period both groups were brooded together. On day 45 posthatching, a 95°F (40% relative humidity) heat distress was imposed on all birds. The control and acclimated birds had a 87.5% and 87.9% survivability while the fasted birds had a 98% survivability. In this study the 24-hour day five acclimation procedure failed to impact broiler heat tolerence.

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

Introduction

Removing feed from broilers that are susceptible to and likely to encounter heat distress has also been demonstrated to reduce heat distress induced prostration (Teeter et al., 1987). Likewise, acclimating broilers to heat distress has also been shown to reduce heat distress prostration. The heat distress acclimation process may be defined as the physiological adaptations made by the bird to maintain homeostasis during high temperature distress. Acclimation as it relates to heat distress has been studied since the early 1950's when Hutchinson and Sykes (1953) reported that birds acclimated for 24 days at 100.4°F exhibited increased heat tolerance when placed under heat distress. More recently, Reece et al. (1972) and May et al. (1986) demonstrated that prior extended exposure to elevated ambient temperatures increased bird survivability during subsequent exposure to acute heat challanges.

The precise physiological processes involved and the specific time frame required to produce a benifical acclimation effect are not understood. Arjona et

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al. (1988) suggested that as little as a 24-h acclimation period at five days posthatching would increase broiler heat distress tolerance later in life. More specifically, Arjona acclimated day five posthatching chicks at 95.0 to 100.0°F for 24 h. The birds were then brooded at normal temperatures until days 44 and 45 posthatching at which time they were exposed to acute heat distress (95.0 to 100.0°F) for 8 h daily over a 2-day period. The results of this experiment indicated that acclimated birds had increased survivablity over non-acclimated birds (99 and 88%, respectively). If these results are repeatable, then even short term broiler acclimation to heat distress can have a profound and long lasting impact on bird resistance to heat distress. The objective of the study reported herein was to evaluate and compare the day five posthatching acclimation procedure with the well established fasting technique.

Materials and Methods

Seven-hundred-eighty, day old, Cobb x Cobb commercial broiler chicks were placed in grower batteries and fed a typical corn-soybean meal starter ration. The chicks were housed in an environmental chamber with the brooding temperature initiated at 85°F and lowered 3.3°F per week to 75°F at 3 weeks posthatching. Birds were allowed to consume feed and water ad libitum. The three treatment groups consisted of: 1) non-acclimated controls; 2) birds acclimated for 24 h at five days posthatching; and 3) non-acclimated birds fasted for 6 h prior to acute heat distress initiation.

The acclimation period was initiated on day five posthatching. Initial temperature of 85°F was raised to between 95 and 100°F over a 4-h period. The 95 to 100°F temperature was maintained at 95 to 100°F for 24 h after which the birds were returned to the initial brooding temperature of 85°F (over a 2-h period).

The heat distress period was initiated on day 45 posthatching. The chamber temperature was elevated from 75°F to 95.0°F (at 40% relative humidity) over a 6-h period. Birds were maintained at 95.0°F for 1 h followed by a slow reduction to 75.0°F over the next 4 h. The temperature was reduced after 1 h at 95.0°F as the birds were exhibiting extreme heat distress symptoms. This protocol was repeated on days 46 and 47.

Results and Discussion

The treatments evaluated in this study did not impact live weight gain and body weight of the three treatment groups were similar during the acute heat distress period (Table 1). However, bird survival was significantly impacted by treatment. The acute heat distress period resulted in an average of 87.7%

Table 1. The effects of five day posthatching acclimation and fasting procedures on body weight, feed consumption and survivability.

	Treatment		
	1	2	3
Bird weight, lb	3.04	3.06	3.03
Feed consumption, lb	3.86^{ac}	4.19^{a}	3.30^{bc}
Survivability, %	87.5^{a}	87.9^{a}	98.0^{b}

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

survivability for the control and day five acclimated birds. The day five acclimation procedure failed to influence bird survivability. Which is in agreement with several unpublished studies (J.W. Deaton and M.O. Smith, personal communication). However, the 6-h fasting procedure prior to heat distress exposure was effective and dramatically increased survival to 98.0%. Therefore, we conclude that the 24-h acclimation of day five posthatching chicks is ineffective in preparing broilers to cope with heat distress later in life.

Literature Cited

Arjona, A.A. et al. 1988. Effect of heat stress early in life on mortality of broilers exposed to high environmental temperature just prior to marketing. Poult. Sci. 67:226.

Hutchinson, J.C.D. and A.H. Sykes. 1953. Physiological acclimation of fowls to hot humid environment. J. Agric. Sci. 43:294.

Reece, F.N. et al. 1972. Effects of high temperature and humidity on heat prostration of broiler chickens. Poult. Sci. 51:2021.

May, J.D. et al. 1986. Effect of acclimation and heat stress on thyroid hormone concentration. Poult. Sci. 65:1211.

Teeter, R.G. et al. 1987. Effects of feed intake and fasting duration upon body temperature and survival of thermostressed broilers. Nutrition Rep. Int. 35:531.

NITROGEN CORRECTED TRUE METABOLIZABLE ENERGY VALUE OF PROPIONIC ACID, GLYCEROL AND LUPROSIL™ FOR BROILERS

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Story in Brief

Broilers were employed to evaluate the nitrogen corrected true metabolizable energy (TMEn) value of propionic acid, propylene glycol and luprosil™, a mold inhibitor, administered at two inclusion levels. Bomb calorimetry measurement determined the gross energy content of feed grade propionic acid, propylene glycol and luprosil™ to be 2,134, 2,542 and 1,634 Kcal/lb, respectively. Nitrogen corrected TME, averaged over inclusion level, was 2,088, 2,497 and 1,680 Kcal/lb for the propionic acid, glycerol and luprosil™, respectively. Energy from these three compounds had a high bioavailability.

(Key Words: Energy, Caloric Density, True Metabolizable Energy.)

Introduction

Numerous chemical preservatives are used to prevent or inhibit mold growth on feedstuffs during storage or while residing in feeders. Propionic acid is an effective mold inhibitor for corn (Christensen, 1973; Moran et al., 1974), hay products (Lacey and Lord, 1977), liquid media (Stewart et al., 1977) and poultry feed (Paster, 1979). Propylene glycol also has mold inhibitory action and is included along with propionic acid in mold inhibitor products such as luprosil™ to reduce mycotoxin contamination.

Inclusion of mold inhibitors in poultry rations means that the inhibitor displaces other nutrients. Modern poultry rations are formulated to provide specific quantities and ratios of energy to other nutrients. Thus knowledge concerning the utilization of energy from propionic acid and propylene glycol is needed so that the ration can be adjusted to reflect the energy content of these substances. Jensen and Chang (1976) indicated that propionic acid is readily metabolized by animals; inclusion of up to .8% propionic acid in the ration did not adversely impact egg production, egg weight or body weight of hens.

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However, little quantitative information is available regarding the energy utilization of either propionic acid or propylene glycol. The purpose of our study was to determine the true metabolizable energy (TME) and nitrogen corrected true metabolizable energy (TME_n) of propionic acid, propylene glycol and luprosil™.

Materials and Methods

This experiment was conducted to estimate the TME and TME_n of propionic acid, propylene glycol and luprosil™ (a mixture of propionic acid (53.5%), propylene glycol (11.5%), ammonium hydroxide (9.5%) and water (25%)). Twelve weeks posthatching, Vantress X Arbor Acre male broilers were allotted to seven treatment groups as follows: 1) basal ration (BR); 2) BR+ 1% propionic acid; 3) BR+2.5% propionic acid; 4) BR+2.5% propylene glycol; 5) BR+5% propylene glycol; 6) BR+2.5% luprosil™ and 7) BR+5% luprosil™. Birds were force fed (Teeter et al., 1984) a constant amount of basal ration (6% of body weight) with the test ingredient added on top. Samples of feed and excreta were analyzed for gross energy content, dry matter and protein as specified by the Association of Official Analytical Chemists (1970). The TME and TME_n was determined according to the method of Sibbald (1976) with the exception that excreta samples were dried in a forced air oven at 140°F (Dale and Fuller, 1982). Treatments were arranged in a randomized complete block experimental design (Steel and Torrie, 1960). Ingredient means, inclusion level and interactions were evaluated using the general linear model of the Statistical Analysis System (Barr et al., 1976). When a significant F statistic was indicated by analysis of variance, means were separated by Duncan's multiple range test (Steel and Torrie, 1960).

Results and Discussion

Bomb calorimetry analysis yielded gross energy values of 2,138 and 2,551 Kcal/lb respectively for propionic acid and propylene glycol. Reported gross energy values in The Handbook of Chemistry and Physics (1987) were 2,238 for propionic acid and 2,570 for propylene glycol indicating that the feed grade products have an energy content nearly identical to the pure compound. Estimated from gross energy of its components, luprosil™ has a gross energy content of 1,439 Kcal/lb this contrast with its determined value of 1,634 Kcal/lb. Reasons for this discrepancy are unknown though the product may vary in composition or ingredient stratification may have caused disproportionate sampling.

Nitrogen balance and energy values of the rations and ingredients are summarized in Table 1. All birds were in negative nitrogen balance during the

Table 1. Nitrogen balance[a] and energy value[b] of rations and test ingredients.

Test ingredient	Dietary level(%)	Nitrogen balance x10^{-4}	Ration TME	Ration TME_n	Ingredient TME	Ingredient TME_n
Control	---	-9.9	1,575	1,616	---	---
Propionic	1	-6.6	1,602	1,634	1,670	2,192
Acid	2.5	-4.2	1,625	1,638	1,734	2,011
Propylene	2.5	-3.7	1,661	1,675	2,378	2,655
Glycol	15.0	-4.2	1,684	1,697	2,201	2,333
Luprosil	2.5	-6.2	1,593	1,620	971	1,652
	5.0	-13.4	1,575	1,625	1,044	1,738
Statistical Summary						
Source of variation	DF					
Ingredient	2	**	**	**	**	**
Level	1	NS	NS	NS	NS	NS
I*L	2	**	NS	NS	NS	NS
Residual MS	97	5.7	37.2	28.7	658	522

[a] Nitrogen balance expressed as lbs nitrogen lost per day.
[b] TME and TME_n energy values expressed as Kcal/lb.

TME assay. Birds consuming luprosil™ lost more ($P<.01$) nitrogen during the experiment reflecting its larger nonprotein nitrogen content. Energy availability as TME_n percentage of determined gross energy averaged 98, 98 and 104% for the propionic acid, propylene glycol and luprosil™, respectively. These data indicate that these mold inhibitors contain biologically available energy that should be utilized to calculate caloric density of rations containing these preservatives.

Literature Cited

Association of Official Analytical Chemists. 1970. Official Methods of Analysis (11th Ed.). Assoc. Offic. Anal. Chem., Washington, DC.

Barr, A.J. et al. 1976. A user's guide to SAS. Statistical Analysis Systems Inc. Cary, NC.

Christensen, C.M. 1973. Tests with propionic and acetic acids as grains preservatives. Feedstuffs 45:37.

Dale, N.M. and H.L. Fuller. 1982. True metabolizable energy of fats at low dietary inclusion. Poult. Sci. 61:2415.

Jensen, L.S. and C.H. Chang. 1976. Effect of calcium propionate on performance of laying hens. Poult. Sci. 55:816.

Lacey, J. and K.A. Lord. 1977. Methods for testing chemical additives to prevent moulding of hay. Ann. Appl. Biol. 87:327.

Moran, E.T. et al. 1974. High moisture corn for the broiler chicken and a spoilage-provoked vitamin E-selenium deficiency. Feedstuffs 46(7):27.

Paster, N. 1979. A commercial scale study of the efficiency of propionic acid and calcium propionate as fungistats in poultry feed. Poult. Sci. 58:572.

Sibbald, I.R. 1976. A bioassay for true metabolizable energy in feedingstuffs. Poult. Sci. 55:303.

Steel, R.G.D. and J.H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Co., Inc., New York, NY.

Stewart, R.G. et al. 1977. The effect of various antifungal agents on aflatoxin production and growth characteristics of *Aspergillus parasiticus* and *Aspergillus flavus* in liquid medium. Poult. Sci. 56:1630.

Teeter, R.G. et al. 1984. Force feeding methodology and equipment for poultry. Poult. Sci. 63:573.

INTAKE OF A SELF-FED MONENSIN-CONTAINING ENERGY SUPPLEMENT BY STOCKER CATTLE ON WHEAT PASTURE AND EFFECTS ON PERFORMANCE

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Story in Brief

Two trials were conducted to determine (1) intake of self-fed, energy supplements containing 75 mg monensin/lb by stocker cattle grazing wheat pasture and (2) in the second study, the effect of the supplement on cattle performance. Mean daily intake of supplement and monensin during the period of December 1 to March 14 of the first trial was 2.83 lb/head and 212 mg/head, respectively. In Trial 2, mean daily intake of supplement and monensin by steers of two pastures was (pasture 1) 2.63 lb/day and 197 mg/head and (pasture 2) 4.24 lb/day and 318 mg/head, respectively. Supplement intake in Trial 2 was much more variable than Trial 1. Weight gain of the steers was increased about .5 lb/day by the monensin-containing energy supplement. Apparent supplement conversion was 6.48 lb of supplement per lb of increased gain.

(Key Words: Monensin, Wheat Pasture, Growing Cattle.)

Introduction

Rumensin (monensin) and Bovatec (lasalocid) increased daily gains of growing cattle on wheat pasture by about .20 to .25 lb/day over that of the carrier supplement (Horn et al., 1981 and Andersen and Horn, 1987) and greatly improve the economics of supplementation programs for stocker cattle on wheat pasture. Research conducted at Clayton, New Mexico has shown that monensin decreases the incidence and severity of bloat on wheat pasture. Therefore, depending on how the ionophore is fed, monensin may be the preferred ionophore of the two for stocker cattle on wheat pasture. An alternative approach to including ionophores in mineral mixes or supplements that are designed to be hand-fed daily is to use monensin and

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salt to limit intake of free-choice supplements designed to be consumed at a level of about 2 lb/day. The objective of this study was to determine (1) intake of self-fed, monensin-containing supplements by stocker cattle grazing wheat pasture and (2) in the second trial, the effect of the supplement on cattle performance.

Materials and Methods

Trial 1

Twenty-five Hereford, Angus and Hereford x Angus fall-weaned heifers (456 lb mean initial weight) were used to determine voluntary intake of a self-fed, monensin-containing supplement by cattle grazing wheat pasture. The cattle were from one of the OSU beef cattle herds at the Lake Carl Blackwell Range just west of Stillwater. The cattle were placed on 50 acres of clean-tilled wheat pasture and had free-choice access to an energy supplement for the 125-day trial (December 1, 1988 to April 6, 1989). Composition of the energy supplement is shown in Table 1. The supplement

Table 1. Composition of energy supplement fed to heifers on wheat pasture (Trial 1).

Ingredient	% As-fed
Ground milo	63.33
Wheat middlings	20.91
Sugarcane molasses	4.78
Calcium carbonate	3.99
Dicalcium phosphate	2.26
Magnesium oxide	.60
Salt[a]	4.00
Rumensin 60 Premix	.125
Calculated Nutrient Content (as-fed basis)	
NE_{gain}, Mcal/cwt	39.6
Crude protein, %	10.8
Calcium, %	2.05
Phosphorus, %	.83
Magnesium, %	.55
Monensin content, mg/lb	75.0

[a] Fine gradation of Rock Salt (95.6 to 96.8% NaCL). Carey Salt Co.

was fed in covered feeders, with 16 feet of total bunk space, that were located near the water source. The water source consisted of a steel tank that was located in the southwest corner of the pasture. There was no other source of water, and no additional salt or mineral supplements were offered to the cattle. Supplement intake was measured twice weekly (i.e., at 4- and 3-day intervals) throughout the trial. Prairie grass hay was fed during periods of snow and ice cover of the pasture. Although this trial did not permit effects of the supplement on performance to be measured, weight gains of the heifers were measured twice during the trial. All weights were measured after 16- to 18-hour shrinks without feed and water.

Trial 2

Ninety-four British and exotic crossbred calves that weighed 488 lb were randomly allotted to four groups of 21, 23, 21 and 29 head per group according to breed and initial weight and were placed on four pastures of clean-tilled wheat pasture at a stocking density of 1.4 acres/head. These cattle had been purchased by an order buyer in Arkansas and had grazed Plains Bluestem pasture for 72 days after being received in Oklahoma prior to placement on wheat pasture. While grazing Plains Bluestem, the steers had free-choice access to a commercial mineral supplement that contained 18.0 to 21.5% salt, 13.0 to 15.5% calcium, 6.6% phosphorus, iodine and 720 mg lasalocid/lb. One-half of the cattle within each group received a subcutaneous injection of 120 mg of copper (as Ethylenedinitrilo-Tetraacetic Acid Copper Disodium Salt; BOVI-CU; Anthony Products Co., Arcadia, CA) immediately prior to being placed on wheat pasture. All cattle had free-choice access to large round bales of medium-quality bermudagrass hay throughout the trial. Treatments consisting of no energy supplement or a monensin-containing energy supplement were randomly assigned to the pastures. Supplements were fed in covered feeders with 20 feet of bunk space per group of cattle. As in Trial 1, supplement intake was measured twice weekly. Because of over-consumption of the first formula, the cattle receiving the supplement were given free-choice access to block salt on November 14 (day 19 of the trial) and the salt content of the supplement was increased from 4.00 to 6.00% (as-fed basis) on December 1 (day 36 of the trial). Composition of the supplements is shown in Table 2. Cattle that were not fed the energy supplement had free-choice access to a commercial mineral mixture throughout the trial. The mineral mixture was fed in weather vane type mineral feeders located near the waterers of each pasture. Guaranteed analysis of the mineral mixture was: calcium, 15 to 17%; phosphorus, not less than 4%; salt, 18.5 to 21.5%; magnesium, not less than 5.5% and vitamin A, not less than 150,000 I.U./lb. Intake of the commercial mineral mixture and block salt was measured weekly. All cattle weights were

Table 2. Composition (as-fed basis) of energy supplements fed to steers on wheat pasture (Trial 2).

Ingredient	First formula	Second formula
Ground milo, %	63.33	60.81
Wheat middlings, %	20.91	20.97
Sugarcane molasses, %	4.78	4.79
Calcium carbonate, %	3.99	4.00
Dicalcium phosphate, %	2.26	2.54
Magnesium oxide, %	.60	.75
Salt[a], %	4.00	6.00
Rumensin 60 Premix, %	.125	.125
Calculated nutrient content (as-fed basis)		
NE_{gain}, Mcal/cwt	39.6	38.3
Crude protein, %	10.8	8.9
Calcium, %	2.05	2.11
Phosphorus, %	.83	.88
Magnesium, %	.55	.64
Monensin content, mg/lb	75	75

[a] Fine gradation of Rock Salt (95.6 to 96.8% NaCl). Carey Salt Co.

Salt was changed to Carey Ev'r Flo Fine Mixing Salt on 1/19/90.

measured after 16 to 18 h shrinks without feed or water.

Ten .5 square meter quadrats were hand-clipped from each pasture periodically throughout the trial in order to estimate amounts of available forage. There was only about 980 lb forage DM/acre at the onset of the trial. On December 19 (day 53 of the trial) it was necessary to decrease stocking density in two of the pastures in order to maintain about equivalent amounts of available forage per steer in each of the pastures. Numbers of cattle were decreased from 21 to 10 in pasture 3 and from 21 to 17 in pasture 1 as shown in Table 5.

Results and Discussion

Trial 1

The mean and range of supplement and monensin consumption by heifers for the entire trial and from December 1 to March 14 (i.e., not including the early part of the grazeout period) is shown in Table 3. Mean supplement and monensin consumption during the entire trial was 2.75 lb/head/day and 206 mg/head/day, respectively. Supplement consumption ranged from 1.19 to 4.22 lb/head/day and monensin intake ranged from 89 to 316 mg/head/day. Mean supplement and monensin consumption during the period from December 1 to March 14 (i.e., middle portion of Table 3) was about the same as the total trial, but a smaller range of monensin consumption was observed (i.e., 137 to 316 mg/head/day. Two-thirds of the time during the December 1 to March 14 period, monensin intake ranged from 167 to 258 mg/head/day which was reasonably close to the desired intake of 150 to 200 mg. Weight gains of the cattle were excellent and averaged 2.53 lb/day for the 125-day trial as shown at the bottom of Table 3.

Table 3. Supplement and monensin consumption and weight gains of heifers grazing wheat pasture (Trial 1).

	Mean	Standard deviation	Minimum	Maximum
---------- December 1, 1988 to April 6, 1989 (36 Observations)[a] ----------				
Supplement, lb/head/day	2.75	.64	1.19	4. 22
Monensin, mg/head/day	206	48.2	89	316
---------- December 1, 1988 to March 14, 1989 (29 Observations)[a] ----------				
Supplement, lb/head/day	2.83	.61	1.83	4.22
Monensin, mg/head/day	212	45.7	137	316
Live weight gains		lb/day		
December 1 to January 27 (56 days)		2.35		
January 27 to April 6 (69 days)		2.68		
December 1 to April 6 (125 days)		2.53		

[a] Supplement consumption was measured twice weekly.

Trial 2

Consumption of the monensin-containing energy supplement, mineral mixture and plain block salt by steers is shown for each pasture in Table 4. Daily supplement consumption by steers of both pastures was greater than desired. However, mean intake of supplement and monensin by steers of pasture 1 was 2.63 lb/head and 197 mg/head, respectively, which was within the range of 150 to 200 mg monensin/head/day. Consumption of

Table 4. Supplement, mineral and monensin consumption by steers grazing wheat pasture (Trial 2).[a]

	Mean	Standard deviation	Minimum	Maximum	Plain block salt (Mean ± SD)
Pasture 1					
Supplement, lb/hd/day	2.63	1.00	1.05	5.21	.021±.017
Monensin, mg/hd/day	197	75	79	391	
Pasture 2					
Supplement, lb/hd/day	4.24	1.02	2.73	6.42	.022±.011
Monensin, mg/hd/day	318	77	205	481	
Pasture 3					
Mineral mixture, lb/hd/day	.11	.031	.04	.15	
Pasture 4					
Mineral mixture, lb/hd/day	.13	.036	.06	.20	

[a] Thirty-four (34), 17 and 15 observations for supplement, mineral mixture and block salt, respectively, during the 120-day trial (10/26/89 to 2/24/90).

Table 5. Weights and daily gains of steers (Trial 2).

	Treatment					
	Control		Energy supplement		Means	
Pasture:	3	4	1	2	Control	Energy supplement
October 26, 1989 to December 19, 1989 (53 days)						
Number steers	21	29	21	23		
Initial weight, lb	493	489	490	482		
Final weight, lb	603	608	630	624		
Daily gain, lb	2.07	2.25	2.64	2.68	2.16	2.66
December 19, 1989 to February 24, 1990 (67 days)						
Number steers	10	29	17	23		
Weight, lb						
February 24, 1990	729	684	770	754		
October 26, 1989 to February 24, 1990 (120 days)						
Number steers	10	29	17	23		
Daily gain, lb	1.89	1.63	2.31	2.27	1.76	2.29

supplement by steers of pasture 2 was much greater and averaged 4.24 lb/day and 318 mg monensin. Provision of free-choice block salt did not affect supplement consumption by the steers. Steers consumed only about .02 lb of salt daily. An explanation for the large variation in supplement consumption between the two pastures is not readily apparent. Initially the supplement feeders were located close to the water supply in each pasture. Steers of pasture 2 seemed to spend quite a bit of time loafing in the area of the waterer and feeder; whereas those of pasture 1 did not. On day 27 of the trial, the feeders were moved further away from the waterers of each pasture in an attempt to decrease supplement consumption. This seemed to help for a while but did not last for very long. The feeders were about 106 and 415 feet away from the waterers of pastures 1 and 2, respectively.

Consumption of the commercial mineral mixture by control steers (i.e., steers of pastures 3 and 4) was about .12 lb/head for both pastures (Table 4).

Weight gains of steers were not influenced by the copper injection nor was the copper by supplement interaction significant. Therefore, data were pooled across copper levels. Because of the fairly large difference in supplement consumption by steers of pastures 1 and 2, average weights of the steers at the onset of the trial, on December 19 (day 53) and on February 24 (day 120) and the daily gains during the first 53 days and the total duration of the trial are shown for steers of each pasture in Table 5. Even though steers of pasture 2 consumed more supplement than was desired, performance did not appear to be decreased by the excessive amount of monensin. Daily gains of steers fed the monensin-containing energy supplement were .50 and .53 lb greater ($P < .05$) during the first 53 days and the total trial (120 days), respectively. Apparent supplement conversion, expressed as lb of supplement per lb of increased gain over the total trial, was 6.48 (i.e., 3.435 lb of supplement divided by .53 lb of increased gain). This figure along with the expected value of weight gain of the cattle can be used in evaluating the economics of this supplementation practice for wheat pasture stocker cattle.

Literature Cited

Andersen, M.A. and G.W. Horn 1987. Effect of lasalocid on weight gains, ruminal fermentation and forage intake of stocker cattle grazing winter wheat pasture. J. Anim. Sci. 65:865.

Horn, G.W. et. al. 1981. Effect of monensin on ruminal fermentation, forage intake and weight gains of wheat pasture stocker cattle. J. Anim. Sci. 52:447-454.

NAXCEL® FOR STRESSED STOCKER CATTLE

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Story in Brief

In six 28-day receiving trials, 580 newly received steer calves, bull calves and yearlings were used to evaluate the effects of Naxcel® on the health and performance of stressed stocker cattle. As clinical signs of illness or a body temperature of 104°F or greater developed, the cattle were assigned to a randomized antimicrobial medical treatment of Naxcel® or control. Spectinomycin was used as the control treatment. Daily gains were increased from 1.67 to 1.76 pounds per day in the Naxcel® group and medical treatments required per head were similar in both groups. There was no significant difference in response of treatment after day 3 for the Naxcel® treated cattle (67.7% vs 66.0%) but the treatment group exhibited a statistical difference in response after day 5 (97.3% vs 84.0%). Furthermore a lower mortality rate (2.0% vs 3.0%) was shown among the Naxcel® cattle but the control treated animals had a lower percentage of cattle repulled as sick (11.3% vs 16.5%).

(Key Words: Naxcel®, Antimicrobial, Stressed Stocker Cattle, Medical Treatment.)

Introduction

Typical morbidity ranges from 0 to 100% with an average of 25 to 30% in newly received stocker cattle in Oklahoma. Additionally, 2 to 5% of the calves die of stress related shipping fever-bovine respiratory disease complex (BRD). Producers must be prepared with a complete health program for incoming stocker cattle. Antimicrobial drugs have been demonstrated to be effective in decreasing the effects of bovine respiratory disease. Naxcel® is a recently approved broad spectrum antibiotic of the cephalosporin group for treatment of bovine respiratory disease complex. The objective of this study was to evaluate the effect of Naxcel® compared to spectinomycin on the health and performance of newly received stocker cattle.

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Materials and Methods

Five hundred eighty head of cattle were assembled by order buyers and shipped to Pawhuska, Oklahoma in the spring of 1988. The origin, arrival dates and weight, number of head and transit shrink for each trial are summarized in Table 1. Upon arrival, cattle were weighed individually, ear tagged and assigned randomly in one of eight pens. Water and native prairie hay were provided free choice. On the morning following arrival, individual cattle in each pen were processed as follows:

1. Body temperature and time were recorded.
2. Cattle were vaccinated with IBR-PI 3 (MLV) intermuscularly, Leptospira pomona bacterin, Clostridia chavoei, septicom, novyi and sordellii bacterin and dewormed with Ivomec[a].
3. Cattle with clinical signs of illness and a body temperature of 104°F or greater received antibiotic treatment and sick animals were placed in the hospital pen and healthy animals were returned to their home pen.

As cattle were determined to be morbid, the animals were randomly assigned a medical treatment. The treatment group received a 1 ml per cwt injection of Naxcel®. The control animals received a 10 ml per cwt injection of Spectinomycin.

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

	Origin	Arrival date	Number of head	Arrival wt., lb	Shrink, %
Trial 1	OK	1-22-1988	100	526	7.2
Trial 2	AR	2-06-1988	87	515	7.7
Trial 3	AL	2-28-1988	85	528	4.8
Trial 4	AL	3-13-1988	51	543	7.3
Trial 5	AL	3-20-1988	81	537	7.8
Trial 6	MS	4-16-1988	176	262	4.8

[a]Ivomec, MSD Agvet, Rahway, NJ.

Cattle were checked twice daily for signs of illness. Sick animals were moved to the processing area where body temperature was measured and severity of illness was clinically appraised. If body temperature exceeded 104°F or the animal exhibited clinical signs of illness, the animal was considered sick. Sick animals received a medical treatment based on a specified sequence of antimicrobial drugs. This medical treatment was continued for three days and then was evaluated. If the medical treatment had alleviated clinical symptoms and restored normal rectal temperature, treatment was discontinued. If clinical symptoms and rectal temperature improved but the animal was not determined as well, the treatment was continued for two additional days. If the animal exhibited no improvement to the initial medical treatment, the next drug in the sequence was administered. This process was repeated until a health improvement was detected.

Cattle received free access to prairie hay and were fed 2 lb/day a pelleted feed supplement (Table 2) for the first 21 days. The amount of supplement was decreased to 1 lb/day during days 22 to 28 of the receiving trial.

Least squares analysis of variance was performed on data for all response criteria. Responses to the Naxcel® or control treatments were analyzed using individuals as the experimental unit. The initial models for weight gains, medical treatment, morbidity, and removal due to sickness at day 3 and at day 5 included trial (truck load), medical treatment, and trial by medical treatment interaction as class variables. In models, excluding medical treatment, sources of variation with observed significance levels greater than .20 were removed.

Table 2. Composition of feed supplement.

Ingredient	As Fed, %
Soybean meal	88.97
Cottonseed meal	5.00
Salt	3.94
Dicalcium phosphate	2.75
Vitamin A-30,000 IU/g	.11
Deccox 6%[a]	.18
Vitamin E-50%	.09

[a] Deccox, Rhone - Roulenc, Inc., Monmouth Junction, NJ.

Table 3. Effects of Naxcel® on weight gain, morbidity and mortality in newly received stocker cattle.

Treatment	Control	Naxcel®
Number of head	101	99
Arrival weight, lb	437	437
Daily gain, lb[a]	1.67	1.76
Medical treatments per head[a]	4.6	4.6
Removed as sick, %[a]	11.3	16.5
Response to treatment, day 3%[a]	66.0	67.7
Response to treatment, day 5%[a]	84.0[b]	97.3[c]
Total mortality, %	3.0	2.0

[a] Expressed as least squares means.
[b,c] Means in the same row with different superscripts differ (P<.002).

Results and Discussion

Average daily gains were increased by 5.4% in the Naxcel® group (1.76 vs 1.67 lb) and required similar medical treatments per head as shown in Table 3. Additionally, the cattle receiving the Naxcel® treatment showed little difference in response to treatment following 3 days (67.7% vs 66.0%) but exhibited a significantly higher (P<.002) response to treatment after day 5 (97.3% vs 84.0%). However, the Naxcel® group had more animals removed as sick (16.5% vs 11.3%). Total mortality among the Naxcel® group also declined (2.0% vs 3.0%).

The results of this study showed that the gains and required medical treatments of morbid newly received stocker cattle were not effected by the Naxcel® medical treatment compared to the control group. However, the 16% greater response to treatment (97.3% vs 84.0%) after day 5 in the Naxcel® treated cattle demonstrates a positive benefit. Another advantage of the Naxcel® treatment is that Naxcel® is used under an approved label whereas many of the other medical treatments are used at extra label levels. These benefits are coupled with a cost difference of $2.35 vs $3.50 between Naxcel® and Spectam and a single injection site with Naxcel® compared to multiple sites with other treatments. The above factors, suggest that Naxcel® medical treatment can be both economical and beneficial at least when compared to the other treatments used in this study.

SYNTABAC® FOR STRESSED STOCKER CATTLE

B.D. Johnson[1], D.R. Gill[2], R.A. Smith[3] and R.L. Ball[4]

Story in Brief

The effects of Syntabac® on health and performance of stressed stocker cattle were measured in four trials using 323 newly received steer and bull calves. Similar gain (2.13 vs 2.10 lb/day), feed intake and gain to feed were observed with the use of a drench of probiotic Syntabac® in the newly received cattle. The number of medical treatments required per head was decreased by 5% (2.6 vs 2.8), although morbidity was increased slightly (40.4% vs 37.0%) in the treatment group. Mortality was similiar (1.2% vs 0.0%) in both groups. Because probiotic treatment could not have had an effect on the cattle that were sick at processing, the data were analyzed with those animals detected as sick during the first three days excluded. Gains were improved (1.91 vs 1.86 lb/day) and mean medical treatments required were decreased (2.5 vs 2.6) in this analysis. Furthermore, of the sick cattle that were removed after day 3, the Syntabac® cattle had 45% higher average gains (1.8 vs 1.2 lb/day), required fewer medical treatments (3.8 vs 3.9) and fewer were again observed as sick (4.7% vs 10.7%). Although, overall performance was similar in both cattle groups, the probiotic Syntabac® decreased the number of medical treatments required per head and reduced the incidence of sickness beyond day 3 after arrival.

(Key Words: Syntabac®, Probiotic, Stressed Stocker Cattle.)

Introduction

William and Mahoney (1984) stated that stresses such as fasting, transportation, assembly, vaccination, castration and dehorning may alter the gut microflora reducing the numbers of beneficial gut bacteria. These losses may decrease performance and increase morbidity and death loss. Administration of a microbial culture probiotic to repopulate the gut may help reduce these changes in the population of gut microflora. Probiotics administered at processing and fed in the receiving diet for 28 days sometimes will increase daily gain and feed efficiency as well as reduce

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morbidity among the stressed cattle (Hutcheson et al., 1980; Davis, 1982; Hicks et al., 1986; Gill et al., 1987). This study was conducted to determine the effect of Syntabac®, a microbial culture drench (8×10^9 CFU Streptococcus faecium M74), on the health and performance of newly received stocker cattle.

Materials and Methods

Three hundred twenty-three head of cattle were assembled by order buyers and shipped to Pawhuska, Oklahoma in the spring of 1988. The origin, arrival dates and weight, number of head and transit shrink for each trial are summarized in Table 1. Upon arrival, cattle were weighed individually, ear tagged and placed at random in one of eight pens which had been assigned to one to the following treatments: control or 10 ml drench treatment of Syntabac®. The drench treatments were applied at the time of processing on the morning following arrival. Individual cattle in each pen were processed as follows:

1. Body temperature and time were recorded.
2. Cattle were vaccinated with IBR-PI3 (MLV) intermuscularly Leptospira pomona bacterin, Clostridia chavoei, septicom, novyi and sordellii bacterin and dewormed with Ivomec[a].
3. Cattle assigned to the treatment group received a drenching of Syntabac®.
4. Cattle with clinical signs of illness and a body temperature of 104°F or greater received antibiotic treatment and sick animals were placed in the hospital pen and healthy animals were returned to their home pen.

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

	Origin	Arrival date	Number of head	Arrival wt., lb	Shrink, %
Trial 1	OK	1-22-1988	100	529	7.2
Trial 2	AR	2-06-1988	87	514	7.7
Trial 3	AL	2-28-1988	85	514	4.8
Trial 4	AL	3-13-1988	51	488	7.3

[a]Ivomec, MSD Agvet, Rahway, NJ.

Cattle were checked twice daily for signs of illness. Sick animals were moved to the processing area where body temperature was measured and severity of illness was clinically appraised. If body temperature exceeded 104°F or the animal exhibited clinical signs of illness, the animal was considered sick. Sick animals received a medical treatment based on a specified sequence of antimicrobial drugs. This medical treatment was continued for three days and then was evaluated. If the medical treatment had alleviated clinical symptoms and restored normal rectal temperature, treatment was discontinued. If clinical symptoms and rectal temperature improved but the animal was not determined as well, the treatment was continued for two additional days. If the animal exhibited no improvement to the initial medical treatment, the next drug in the sequence was administered. This process was repeated until a health improvement was detected.

Cattle received free access to prairie hay and were fed 2 lb/day a pelleted feed supplement (Table 2) for the first 21 days. The amount of supplement was decreased to 1 lb/day during days 22 to 28 of the receiving trial.

Least squares analysis of variance was performaned on data for all response criteria. Responses to the Syntabac® treatments were analyzed using animal as the experimental unit except for the feed efficiency and feed intake responses which were analyzed using pen as the experimental unit. The initial models for weight gains, (Table 3) medical treatment, morbidity, feed intake and feed efficiency included trial (truck load), Syntabac® treatment and trial by Syntabac® treatment interaction as class variables. In models, excluding Syntabac® treatment, sources of variation with observed significance levels greater than .20 were removed.

Table 2. Composition of feed supplement.

Ingredient	As Fed Basis, %
Soybean meal	88.97
Cottonseed meal	5.00
Salt	3.00
Dicalcium phosphate	2.75
Vitamin A-30,000 IU/g	.11
Deccox 6%[a]	.18
Vitamin E-50%	.09

[a] Deccox, Rhone - Roulenc, Inc., Monmouth Junction, NJ.

Table 3. Effect of Syntabac® on weight gains, morbidity and mortality in stressed cattle.

Treatment	Control	Syntabac®
Number of head	162	159
Number of head never sick	102	96
Arrival weight, lb	527	525
Daily gain, lb[a]	2.10	2.13
Daily gain of head never sick, lb[a]	2.54	2.51
Medical treatment per head[a]	2.8	2.6
Morbidity, %[a]	37.0	40.4
Mortality, %	.0	1.2

[a] Expressed as least squares means.

Results and Discussion

Cattle which were in the Syntabac® treatment group had similar weight gains (2.13 vs 2.10 lb/day) but required fewer medical treatments per head (2.6 vs 2.8) compared to the control animals. The treatment group had slightly higher morbidity than the control group (40.4% vs 37.0%).

No treatment effects were apparent in feed intakes and gain to feed ratios (Table 4).

The effects of the Syntabac® drench on daily gain and medical treatments in the cattle that became sick during the trial are reported in Table 5. Although nonsignificant, daily gains of sick cattle favored the Syntabac® cattle over the control cattle (1.92 vs 1.86 lb, respectively) as well as in mean medical treatments required per head (3.9 vs 4.2). Also, fewer Syntabac® treated cattle were repulled as sick (12.7% vs 16.0%).

Table 4. Effect of Syntabac® on feed intake and gain to feed ratio.

	Control	Syntabac®
Number of pens	14	14
Feed intake, lb[a]	16.68	16.52
Gain/feed[a]	.138	.140

[a] Expressed as least squares means.

Table 5. Effect of Syntabac® on daily gains, medical treatments and repulls in all sick cattle.

	Control	Syntabac®
Number of head	60	63
Average daily gain, lb[a]	1.86	1.92
Medical treatments per head[a]	4.20	3.88
Repulls as sick, %[a]	16.0	12.78

[a] Expressed as least squares means.

Because any probiotic treatment on arrival may have a delayed effect, the data were reanalyzed excluding those animals that detected as sick within 2 days after processing. Cattle treated with Syntabac® had 2.7% faster gain (1.91 vs 1.86 lb/day) and a 3.4% decline in required medical treatments (2.5 vs 2.6) as shown in Table 6. However, the treatment group had an increase in morbidity (25.1% vs 18.4%) over the control cattle.

The effects of Syntabac® on the health and performance of the cattle that became sick during the trials excluding those pulled during the first three days are presented in Table 7. Gains tended to be improved ($p=.16$) (1.76 vs 1.21 lb/day) and mean medical treatments to decrease in treated cattle. Additionally, the sick cattle that became sick a second time tended to be lower (4.7% vs 10.7%) in the Syntabac® group.

Under the conditions of this study, average daily gains, feed intake and feed to gain averaged across all cattle were similar with vs without the use of Syntabac®. However, the number of medical treatments per head for illness

Table 6. Effect of Syntabac® on daily gains, medical treatments and morbidity in stressed cattle with sick head pulled on day 1 and day 2 excluded.

	Control	Syntabac®
Number of head	118	124
Arrival weight, lb	531	526
Average daily gain, lb[a]	1.86	1.91
Medical treatments per head[a]	2.6	2.5
Morbidity, %[a]	18.4	25.1

[a] Expressed as least squares means.

Table 7. Effect of Syntabac® on daily gains, medical treatments and repulls in sick cattle with head pulled during day 1 and day 2 excluded.

	Control	Syntabac®
Number of head	16	28
Average daily gain, lb[a]	1.21	1.76
Medical treatments per head[a]	3.9	3.8
Repulls as sick, %[a]	10.7	4.7

[a] Expressed as least squares means.

was decreased in the treatment cattle by approximately 5% and number of repulls was lower for the Syntabac® group. Further studies are needed before conclusions about efficacy of Syntabac® can be drawn.

Literature Cited

Davis, G.V. 1982. Probios for stressed calves and yearlings. Kansas State Univ. Cattle Feeders Day, Report of Progress 416:30.

Gill, D.R. et al. 1987. The effect of probiotic feeding on health and performance of newly-arrived stocker calves. Okla. Agr. Exp. Sta. Res. Rep. MP-119:202.

Hicks, R.B. et al. 1986. The effect of a microbial culture on the health and performance of newly-arrived stocker cattle. Okla. Agr. Exp. Sta. Res. Rep. MP-118:256.

Hutcheson, D.P. et al. 1980. The use of a living, nonfreeze-dried Lactobacillus acidophilus culture for receiving feedlot calves. Proc. Western Section Amer. Soc. Anim. Sci. 31:213.

Williams, D.L. and J.H. Mahoney. 1984. Pre-weaning and post-weaning nutrition. Proc. 17th Annual Conv. Amer. Assoc. Bovine Pract. p 98.

VALUE OF FEATHER MEAL FOR REPLACING SOYBEAN MEAL IN SUMMER PROTEIN SUPPLEMENTS

K S. Lusby[1] and F.T. McCollum[2]

Story in Brief

Hydrolyzed feather meal at a rate of 12% was used to replace 22% soybean meal in a supplement for heifers grazing summer native range from late June to October. Over the summer grazing period, unsupplemented heifers gained 1.33 lb/day compared to 1.55 for soybean meal and 1.57 lb/day for the feather meal-soybean meal treatment. In another trial, weaned fall-born calves grazing native range were offered the same supplements from May to mid-July. Unsupplemented calves gained 1.16 lb/day while calves fed the soybean meal and soybean meal/feather meal supplements gained 1.51 and 1.31 lb/day, respectively. With prices existing at the time of the study, including feather meal at a 12% rate in a soybean meal-based supplement would reduce supplement costs by $10.60 per ton.

(Key Words: Beef Cattle, Feather Meal, Protein.)

Introduction

It is common to feed protein supplements to stocker calves grazing native grass or bermudagrass pastures from mid to late summer. Because of volatile prices for soybean meal and cottonseed meal, interest has grown in finding alternative sources of natural protein. Large quantities of hydrolyzed feather meal are available in Oklahoma because of the close proximity of several major poultry processors. Hydrolyzed feather meal, typically priced slightly higher per ton than cottonseed meal or soybean meal but with twice the crude protein content, would be an attractive product if two questions could be resolved. The first is the relative nutritive value of hydrolyzed feather meal in supplements compared to cottonseed meal and soybean meal, and the second is palatability of feather meal in supplements. The objective of this study was to compare performance of yearling heifers and weaned fall-born calves grazing summer native range when hydrolyzed feather meal was used to replace about 22% of the soybean meal in a protein supplement.

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[1]Professor [2]Associate Professor

Materials and Methods

The first trial was conducted on native tallgrass prairie at the Range Cow Research Center 12 miles west of Stillwater. Thirty-two spring-born and fifteen fall-born Hereford and Hereford x Angus heifers were allotted by breed, age and weight to three treatment groups. Treatments were Control, no supplement; Soybean meal (1.0 lb/day) or Feather meal-Soybean meal (1.0 lb/day) in which hydrolyzed feather meal was included at a rate of 12%. Supplement compositions and feeding rates are shown in Table 1. A level of 12% feather meal was chosen because it should be palatable and still provide an economically significant substitution for soybean meal. Supplement amounts were prorated for 3 days per week feeding on Monday, Wednesday and Friday. Supplements were individually fed in covered stalls and all heifers grazed the same pasture. The trial period was June 23 to October 17 with intermediate weights taken at 28- or 35-day intervals. All weights were taken after overnight withdrawal from feed and water.

In a second trial, fall-born steers were weaned in late April and transported to the Pawhuska Research Station on May 10. The cattle were allotted to treatments (Table 1) and placed on a common pasture on May 16. The supplements and feeding rates were the same as mentioned above (Table 1). Supplement amounts were prorated for 3 days per week feeding on Monday, Wednesday, and Friday. On feeding days, the calves were

Table 1. Composition (% as-fed) of supplements and feeding rates.

	Control	Soybean meal	12% Feather meal
Ingredients			
Soybean meal	---	98	72
Feather meal		--	12
Sorghum grain		--	13.73
Dicalcium phosphate		1.86	2.09
Vit A (30,000 IU/gm)		.18	.18
Nutrient content			
Crude protein		40	40
Phosphorus		1.0	1.0
Feeding rates, lb			
Per day	0	1.0	1.0
Per feeding (3 days/week)	0	2.3	2.3

gathered and separated into respective treatment groups. Supplements were group-fed in community troughs. The trial ended on July 18. All weights were recorded after overnight withdrawal from feed and water.

Results and Discussion

Heifer gains are shown in Table 2. Heifers weighed about 780 lb at the start of the study and were in good body condition. Some difficulty was encountered during the first two weeks of the study in getting heifers to consume supplements. Excellent forage availability and introduction to the individual feeding facility were likely causes. Two heifers from the soybean meal group and one from the feather meal group were removed from the study after they consistently refused to eat supplements for two weeks. All other heifers readily consumed supplements after the first few days. Although there are numerous reports of palatability problems with feather meal, the fact that two heifers refused to eat soybean meal precluded any conclusions about effects of feather meal on supplement palatability.

Table 2. Effects of feather meal on summer gains of heifers grazing native range.

	Control	Soybean meal	12% Feather meal
No. of heifers[a]	16	13	15
Weights, lb			
Initial, 6/23	785	771	782
Daily gains, intermediate, lb/d			
6/23 - 7/25, 35 days	1.75	1.59	1.68
7/25 - 8/22, 28 days	1.04[b]	1.43[c]	1.14[b]
8/22 - 9/19, 28 days	.84[b]	1.01[b]	1.28[c]
9/19 - 10/17, 28 days	1.60[b]	2.16[c]	2.13[c]
Entire study, 119 days, lb/d	1.33[b]	1.55[c]	1.57[c]

[a] Two heifers from the soybean meal group and one from the 12% feather meal group were removed for failure to eat supplements.

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

Similar gains for all control and supplemented heifers (Table 3) during the first 35 days in June and July suggest that protein was adequate in the forage during this period. During the second and third 28-day periods from July 22 to August 22, supplemented heifers tended ($P<.1$) to gain faster than controls. The advantage for soybean meal during the second period and for feather meal-soybean meal during the third period probably reflects fill differences frequently encountered with short term weights. During the fourth period, gains from both supplemented groups were similar and both were significantly greater than for controls. For the entire 119 days of the study, both supplemented groups gained faster ($P<.01$) than control heifers (1.55 and 1.57 vs 1.33 lb/day).

Fall-born heifers held over the previous winter on dry winter grass were lighter (756 vs 792 lb) and thinner than the spring-born heifers wintered on wheat pasture. It is interesting to note that no interaction was detected between heifer age and response to supplementation. This means that supplementation increased daily gains of the older, thinner heifers to the same extent as for younger, fatter heifers.

In conclusion, results suggest that hydrolyzed feather meal can be used at a rate of 12% to replace 22% soybean meal in protein supplements with no effect on summer weight gains. Assuming ingredient costs ($/cwt) of: sorghum grain, $4.50; feather meal, $12.00; soybean meal, $10.00; dicalcium phosphate, $13.50, the supplement containing 12% feather meal cost $9.53/cwt while the soybean meal supplement cost $10.06. With these prices, including feather meal at a rate of 12% reduced supplement cost by $10.60 per ton.

Table 3. Effects of feather meal on weight gains of calves grazing native range.

	Control	Soybean meal	12% Feather meal
No. of heifers	14	14	14
Weights, lb			
Initial, 5/16	392	394	399
Total gain, lb, 63 days	76	96	86
Daily gain, lb/d			
5/16 - 7/18	1.16[a]	1.51[b]	1.31[ab]

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

In the second trial, the soybean meal supplement increased daily gain .35 lb/day ($P<.05$) compared to controls. Performance of the cattle consuming the feather meal-soybean meal supplement was intermediate to controls and soybean meal. The inferior response to feather meal-soybean meal cannot be readily explained in light of the results in Trial 1. Response to the soybean meal treatment is similar to responses noted in previous trials utilizing weaned calves grazing in May and June (Scott et al., 1987; McCollum and Lusby, 1989). Because the supplements were not individually fed, we cannot determine if gains were depressed due to reluctance of some cattle to consume the feather meal supplement. Cattle were observed during feeding but there were no apparent nonconsumers. Other possible causes for the apparent poorer response to the 12% feather meal supplement may be the short duration of the study and younger age of the cattle in Trial 2.

Literature Cited

McCollum, F.T. and K.S. Lusby. 1989. Early summer supplements for weaned fall-born calves grazing tallgrass prairie. Okla. Agr. Exp. Sta. Res. Rep. MP-127:192.

Scott, R.R. et al. 1987. Response of fall-born calves to spring pasture burning or early summer protein supplementation. Okla. Agr. Exp. Sta. Res. Rep. MP-125:283.

RELATIONSHIPS AMONG FECAL NITROGEN, DIET NITROGEN, AND DAILY GAIN OF STEERS GRAZING TALLGRASS PRAIRIE

F.T. McCollum[1]

Story in Brief

Methods of indirectly monitoring plane of nutrition and performance of grazing livestock would be useful for livestock managers. The relationship between dietary nitrogen and fecal nitrogen in beef steers grazing tallgrass prairie was monitored over a four year period. Regression analysis developed a relationship, Y=.79X-.17 with a coefficient of determination of .74, where Y is diet nitrogen and X is fecal nitrogen (both variables were adjusted to an organic matter basis). In addition, the relationship between average daily gain and fecal nitrogen in grazing steers was monitored in two of four years. Regression analysis produced a relationship, Y=1.23X-1.06 where Y is average daily gain (lb/head) and X is fecal nitrogen (percent organic matter basis) with a coefficient of determination of .78.

(Key Words: Fecal Nitrogen, Cattle, Range, Diet Composition, Gain.)

Introduction

The development of indirect methods of monitoring nutrition and performance of grazing livestock could potentially increase the efficiency of supplemental feeding programs, improve marketing decisions, and as a result, improve ranch profitability. Body condition scoring is an example of monitoring cow and ewe performance and has been widely adapted by producers. However, body condition at a given time is the result of previous plane of nutrition and therefore may not be an expedient means of determining nutritional needs. Forage testing may be utilized to monitor plane of nutrition but also has its limitations for short-term management decisions. Fecal nitrogen (N) may provide a useful means for monitoring immediate plane of nutrition as well as performance.

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[1]Associate Professor

The studies described in the following report were conducted to determine if useful relationships among diet N, steer performance and fecal N could be developed.

Materials and Methods

All of the trials in this study were conducted at the Downey Range Research area located southwest of Stillwater, OK. The vegetation on the study pastures is typical of the tallgrass prairie and is dominated by big bluestem, little bluestem and indiangrass. Stocking rates during the trials were similar to stocking rates recommended for moderate utilization.

Relationships among diet N and fecal N were studied with data collected during four summer grazing seasons. Sampling periods were spread at approximately equal time intervals from mid-May to early October. Diet samples were collected four or five times during the summer grazing season using esophageally fistulated beef steers. During each sampling period, a group of intact beef steers were grazed in conjunction with the fistulated steers. Fecal samples were collected from this group at the same time masticate samples were collected from the fistulated steers. All diet and fecal samples were analyzed for dry matter, ash, and N content. Nitrogen content was adjusted to an organic matter basis. Means from each sampling period were used in regression analysis resulting in a total of 20 diet N:fecal N couples.

Relationships among average daily gain and fecal N were studied during two summer grazing seasons. Data were obtained by weighing beef steers every 21 to 28 days through the summer grazing season (May to October) and collecting fecal samples from each steer each time they were weighed. Twenty-three steers were monitored in the first year and 30 steers were monitored in the second year. The fecal samples were analyzed for dry matter, ash, and N. Fecal N was adjusted to an organic matter basis. A mean fecal N was then determined for each weigh date. Average daily gains on the dates of fecal collection were estimated by taking the first derivative of weight accumulation curves for each steer during the grazing season. The derivative equation was then solved with respect to the date of each fecal collection. A mean average daily gain was then determined for each weigh date. A total of 34 average daily gain:fecal N couples were then analyzed using regression procedures.

Results and Discussion

Results of the diet N:fecal N analysis are illustrated in Figure 1. Diet N varied from about 1% to 2.2% during the trial, therefore application of this

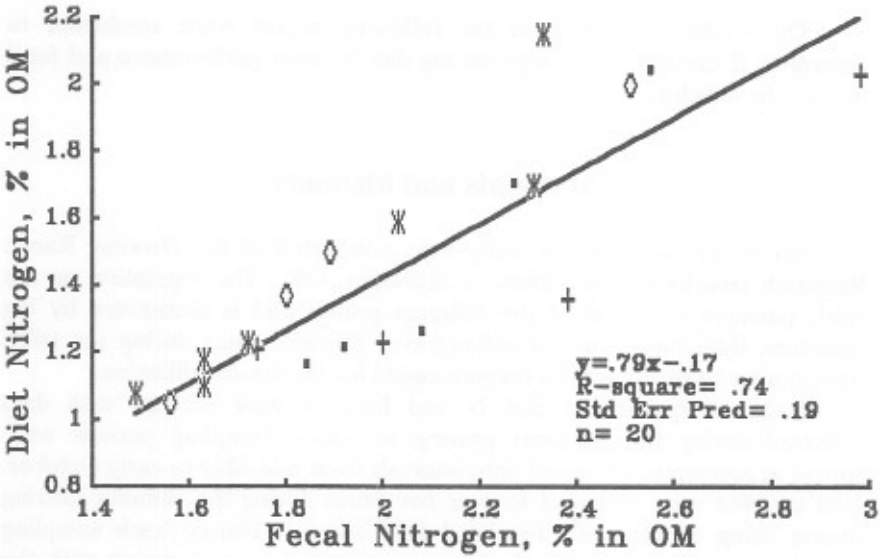

Figure 1. Association of diet nitrogen and fecal nitrogen in grazing steers.

equation should probably be restricted to this range of diet N. Overall, a very good association between the diets and feces was observed with 74% of the variation in diet N accounted for by fecal N. This coefficient is similar to other studies with similar degrees of freedom. Threshold fecal N values corresponding to 6, 8 and 10% crude protein in the diet are 1.42, 1.83, and 2.23%, respectively. Different symbols in Figure 1 represent data from different years. The relationship between feces and diet was not the same every year. If data were analyzed within years the fits are much better but the conditions under which the relationships apply are much more restricted. The variation among years indicated that these relationships are more qualitative guidelines than quantitative guidelines.

Results of the average daily gain:fecal N analysis are illustrated in Figure 2. Average daily gain varied from 1 lb/head to 2.5 lb/head during the trial. Fecal N accounted for 78% of the variation in average daily gain. Threshold fecal N values corresponding to average daily gains of 2.0, 1.5 and 1.0 lb/head are 2.5, 2.1, and 1.7%, respectively. The data points in this analysis represented various planes of nutrition that resulted from the use or nonuse of prescribed burning and protein supplementation. If these variables are removed and the data are analyzed within burning regimes or supplement regimes, the associations between gain and fecal N are much stronger (R^2=.80-.90). However, these have a restricted range of application. The composite relationship in Figure 2 would have a wider range of application.

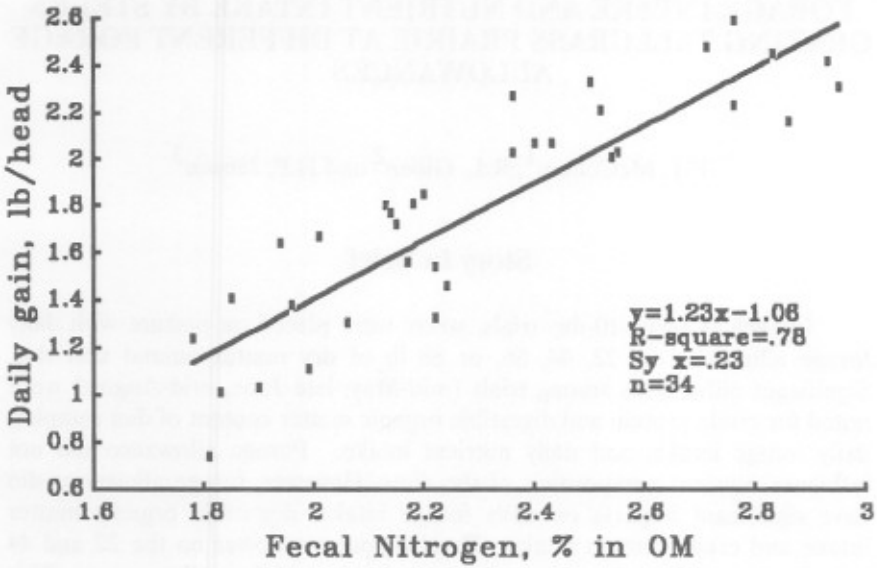

Figure 2. Associaton of average daily gain and fecal nitrogen of grazing steers.

These studies developed very acceptable mathematical relationships between diet N, average daily gain, and fecal N. Using these relationships to develop threshold fecal N values that indicate the need for supplement feeding or fecal N values that describe anticipated average daily gains can improve tactical decision making for stocker cattle producers in the tallgrass prairie regions of Oklahoma and Kansas. A missing key is a method of rapid N analysis.

FORAGE INTAKE AND NUTRIENT INTAKE BY STEERS GRAZING TALLGRASS PRAIRIE AT DIFFERENT FORAGE ALLOWANCES

F.T. McCollum[1], R.L. Gillen[2] and H.P. Jensen[3]

Story in Brief

In each of three 10-day trials, steers were placed on pasture with daily forage allowances of 22, 44, 66, or 88 lb of dry matter/animal unit day. Significant differences among trials (mid-May, late June, mid-August) were noted for crude protein and digestible organic matter content of diet samples, daily forage intake, and daily nutrient intake. Forage allowance did not influence nutrient composition of the diets. However, forage allowance did have significant impacts on daily forage intake, digestible organic matter intake and crude protein intake. Fecal output was lower on the 22 and 44 lb/animal unit day allowances than on the two higher allowances. This difference suggests that forage availability limited intake at the two lower allowances. Total daily forage intake was reduced about 6% and daily digestible energy intake was reduced about 9% at the 22 and 44 lb/animal unit day allowances.

(Key Words: Forage Intake, Forage Allowance, Grazing, Cattle, Range.)

Introduction

Interest in improving the efficiency of forage utilization and livestock production from rangelands has increased the study of intensified grazing management programs. In several areas of the United States, researchers have studied one-herd, multipasture rotational grazing systems. However, research in the tallgrass prairie has focused on intensive-early stocking (IES) systems. Although IES programs increase beef production efficiency (lb gain/acre), they are based on continuous grazing during a shortened grazing season. Development of intensive rotational grazing management programs could improve production efficiency while complementing IES by allowing for extended grazing seasons.

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Keys to successful implementation of rotational grazing are proper timing of plant defoliation to maintain plant vigor and proper forage allocation to maintain livestock performance. The study described below was designed to determine the influence of varied forage allowances on nutrient intake by cattle at three periods during the summer grazing season.

Materials and Methods

The study was conducted near Stillwater, OK, on a claypan prairie range site. During the study year, big bluestem, little bluestem and indiangrass accounted for over 75% of the forage production at this site.

Three 10-day trials were conducted during the grazing season. Trial conditions are described in Table 1. The trials were purposely spread across the growing season in order to test interactions among forage conditions and forage allowances. Within each trial, beef steers were placed in pastures of varied size in order to attain daily forage allowances of 22, 44, 66, and 88 lb/animal unit day (AUD). Each forage allowance was replicated twice. The forage allowances were characteristic of allowances in 16-32 paddock grazing systems stocked at a moderate rate or an 8 paddock system with stocking rate increased significantly.

During each trial, fecal output of three steers in each pasture replicate was estimated using chromic oxide as an external marker. The marker was administered daily at 7:00 a.m. Fecal samples were collected twice daily from each steer. Diet nutrient composition was monitored by collecting masticate samples from each pasture daily with three esophageally fistulated steers.

Table 1. Tallgrass prairie range site conditions.

	Trial		
	1	2	3
Date	May 15-25	July 2-12	August 12-22
Steer weight, lb	594	671	781
Standing crop, lb/ac	965	2608	3646
Diet, Day 1			
CP, %	11	8	7
IVOMD, %	60	55	53

Table 2. Effects of trial and forage allowance on diet composition and forage intake.

		Trial			Forage allowance			
		May	July	August	22	44	66	88
Diet, %								
	CP	9.9[a]	7.7[b]	6.8[c]	8.4	8.0	8.2	7.9
	DOM	57.5[a]	54.1[b]	48.3[c]	52.5	52.8	54.0	53.8
Fecal output, lb/day		1.22[a]	.89[b]	.82[c]	.95[a]	.96[a]	1.00[b]	1.00[b]
Daily intake, lb/100 lb BW								
	OM	2.87[a]	1.96[b]	1.59[c]	2.11[a]	2.72[a]	2.22[b]	2.25[b]
	DOM	1.65[a]	1.06[b]	.77[c]	1.11[a]	1.12[a]	1.20[b]	1.21[b]

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

Diet samples were analyzed for crude protein and in vitro digestibility. Forage intake was calculated from the ratio of fecal output and diet indigestibility. All values were adjusted to an organic matter basis.

Results and Discussion

No interactions ($P>.05$) among trial and forage allowance were detected. The lack of interaction indicates that forage allowance affected cattle nutrition in a similar manner regardless of forage conditions. Trial means and forage allowance means are presented in Table 2.

All nutritional responses declined ($P<.0001$) as the grazing season progressed. Diet crude protein (CP) and digestibile organic matter (DOM) reflect the seasonal decline noted in previous studies in the Stillwater area. Forage intake during Trial 1 is higher than noted in previous trials conducted in May. The higher intake reflects compensatory forage intake by the steers following a winter period on a low plane of nutrition. The intake values in Trials 2 and 3 are similar to intakes observed in other trials conducted at similar periods on similar rangeland.

Forage allowance did not significantly ($P>.15$) impact nutrient composition of the diets. Diet CP tended to increase as forage allowance was reduced. In contrast, DOM in the diet tended to be higher at the more liberal forage allowances.

Forage intake (lb OM/day) decreased in a linear manner ($P<.01$) as forage allowance was reduced. Further analysis revealed there were no differences between the two higher allowances or the two lower allowances. The difference between the high and low treatments represents a 6.3% reduction in daily intake. The reduction in intake is the result of both diet digestibility and reduced fecal output. Fecal output was 4.7% lower ($P<.01$) on the 22 and 44 lb/AUD allowance compared to the higher allowances. A reduction in fecal output suggests that forage availability limited daily forage intake. Intake of DOM also declined in a linear manner ($P<.01$) as forage allowance decreased. Once again, the primary difference occurred as allowance fell below 66 lb/AUD and as a result digestible energy intake was 9.1% lower at the 22 and 44 lb/AUD allowances.

The forage allowances tested in these trials are much lower than allowances that occur under continuous grazing but are similar to allowances that would be encountered in a multipasture, single herd grazing system. Under the conditions of our trials, forage allowance did not have a significant impact on diet nutritive value. But forage intake and digestible energy intake were reduced as forage allowance fell below 66 lb/AUD. Our data suggest that livestock performance will be reduced almost 10% on intensive rotation grazing systems which allocate less than 66 lb/AUD.

INFLUENCE OF WINTER BACKGROUNDING PROGRAM AND SUMMER GRAZING PROGRAM ON PERFORMANCE OF STEERS GRAZING TALLGRASS PRAIRIE

G.S. McLean[1], F.T. McCollum[2] and D.R. Gill[3]

Story in Brief

During an 84-day period, 160 beef steers (initial weight 463 lb) were backgrounded prior to summer grazing on one of four treatments: dormant native range with 2 lb/day 38% protein supplement, or a high concentrate (90% conc.) ration limit-fed, based on NEg requirements, to result in 1.0, 1.5, or 2.0 lb gain/day. On May 1, the four groups were split and allocated to either an 84-day intensive-early stocking (2X stocking density) program or a 153-day seasonlong stocking program on native range. Weights and ultrasound backfat were monitored during the background and grazing periods. Forage intake was measured once during the grazing period on six calves from each treatment. Gain on dormant native range during the backgrounding period was .95 lb/day. Gains for the limit-fed steers were spread at the desired increments but were .51 to .55 lb/day higher than projected. Ultrasound backfat depth increased with increasing gain. During summer grazing, the cattle previously on dormant range gained more weight and tended to accumulate more backfat than the limit-fed cattle. Limit-fed steers lost backfat during the grazing period. Backgrounding treatment did not affect forage intake. For intensive-early stocking, the relationship between daily gain during backgrounding (X) and grazing (Y) was: $Y = 2.27 - .49X$. For seasonlong stocking, the relationship was $Y = 1.72 - .33X$. Total gain/steer was lower on intensive-early stocking due to the shortened grazing period but adjusted gain per acre was 47% higher because of increased stocking density.

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

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Introduction

Stocker cattle production is an important segment of the beef industry in the Southern Great Plains. Generally, cattle prices favor the purchase of stocker cattle in the fall/winter months but fall/winter is the period of poorest forage quality on rangeland and warm-season pastures. Weight gains by cattle over the winter are low and unpredictable resulting in high interest costs and feed costs. Therefore producers are faced with either purchasing relatively inexpensive cattle with high variable costs of production or purchasing relatively expensive cattle in the spring with lower variable inputs.

Many of the wintering programs for stockers are intended to hold cattle at low rates of gain, therefore preparing them for compensatory gain on summer pasture. Although wintering at higher rates of gain may reduce gain on summer pasture, improved performance in the winter phase may increase total weight gain and profitability. One predictable means of improving winter performance would be backgrounding on high concentrate rations limit-fed to produce a desired rate of gain (Zinn, 1987; Gill and Lusby, 1989; Lake, 1987). The relationship between level of gain during the backgrounding phase and gain in the grazing phase must be understood in order to project economies of different management programs.

Intensive-early stocking (IES) is a grazing program which can increase weight gain per unit of land area by 20 to 40% (Smith and Owensby, 1976; Olson, 1988; McCollum et al., 1990). This is accomplished by shortening the summer grazing season by approximately one-half and increasing stocking density (head/acre) two or three times normal.

A study was conducted to determine the effects of accelerated winter gains on the performance of beef steers grazing rangeland during the late spring/summer grazing season. Subsequent feedlot performance was also monitored (McLean, 1990). This paper reports on performance during the winter and summer grazing phases.

Materials and Methods

Winter phase

One-hundred sixty head of bull and steer calves (initial wt = 463 lb) were purchased in January, 1989, and transported to the Pawhuska Research Station in north central Oklahoma. Following processing, all calves were placed in pens of 20 head. The cattle had ad libitum access to prairie grass hay and were fed 2.0 lb/head/day of 38% CP pellets. After 14 days, bull calves were castrated and all calves were implanted, weighed, and scanned by

ultrasound to estimate backfat depth. Calves were then allocated to two replications of four winter nutritional management programs. One treatment group (DW) was placed on dormant tallgrass prairie rangeland and fed 2.0 lb/head/day of 38% CP range cubes. A salt/mineral supplement was provided free choice. The remaining treatment groups were confined to drylot and limit-fed a high concentrate diet (Table 1) in sufficient quantities to promote 1.0 (LG), 1.5 (MG), or 2.0 (HG) lb gain/head/day. Daily feed allowances were based on estimated NEg content of the ration and energy requirements of the steers (NRC, 1984; Gill and Lusby, 1989). Daily feed allowances were adjusted every 14 days based on the projected gains of the cattle. The calves were fed once daily between 9 a.m. and 10 a.m.

Grazing phase

After 84 days on the four nutritional treatments, the cattle were again weighed, scanned and implanted following a 16 h overnight period without feed and water. Each winter treatment replication was then randomly divided into two groups with similar average weights and assigned to either

Table 1. Ingredient composition of growing supplement.

Ingredient	% As fed
Corn, #2 whole shelled	81.08
Supplement	18.92
Supplement composition	
Soybean meal	61.45
Cottonseed meal	20.60
Calcium carbonate	12.10
Dicalcium phosphate	2.87
Salt	1.69
Potassium chloride	.86
Vitamin A - 300,000 IU/gram	.14
Rumensin 60[a]	.13
Tylan 40[a]	.07
Trace mineral premix[b]	.06
Vitamin E - 226800	.03

[a] Elanco Products Co., A Division of Eli Lily and Co., Indianapolis, IN.
[b] Contained as percentage of trace mineral mix: Zn, 24%; Mn, 16%; Fe, 4%; Cu, 2.4%; I, .16%; Co, .05%; Se, .08%.

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

On July 15, 1989, 84 days into the summer grazing season, all cattle were again weighed, scanned and implanted following an overnight period without feed and water. The SLS groups were returned to pasture and the IES groups were transported 310 miles to Goodwell, Oklahoma to be finished. The SLS cattle remained on pasture for an additional 69 days (153 days total grazing) prior to being shipped to the same location for finishing. Protein supplement (1.0 lb/head/day, 38% CP cubes) was fed to the SLS cattle during the final 69 day grazing period. Weights and backfat estimates were recorded prior to shipment.

Forage intake

Midway through the first 84 days of grazing, six steers were selected from the mean weight class of each winter treatment group. A slow-release chromic oxide bolus was administered to each animal and the animals were returned to pasture. Fecal grab samples were collected from each steer at 7 a.m. and 7 p.m. on days 9 and 14 after bolus administration. The samples were composited within day and steer and analyzed for DM, ash, chromium, and indigestible ADF.

Three esophageally fistulated steers were used to sample forage. Masticate was collected during 30 min grazing periods on days 9 and 14. Diet samples were composited across days within steer and analyzed for DM, ash and indigestible ADF (AOAC, 1984; M.L. Galyean, pers. comm.).

Forage digestibility was estimated from ratios of fecal and masticate indigestible ADF. Fecal output was estimated from the ratio of daily chromium payout from the bolus and fecal chromium concentration. Forage intake was estimated as the ratio of fecal output to forage indigestibility.

Statistical analyses

Data were analyzed using the GLM procedure of SAS. The model for the winter phase, the forage intake trial and the final 69 days of the grazing season included winter treatment and replication. Comparisons for the first 84 days of the grazing season and the total grazing season were made using a model containing winter treatment, grazing treatment, replication and winter

treatment x grazing treatment. Least significant difference procedures were used to separate means when a significant ($P < .05$) model effect was present.

Regression equations among winter gains and gains during the grazing phase were developed for the first 84-day period of grazing and for the entire 153-day season. In both cases, one group of equations was based on means from the winter treatment groups. A second group was developed without regard to winter treatment.

Results and Discussion

Winter phase

Weight gains during the winter phase were relatively high for the DW treatment cattle. With the exception of approximately 10 days of snow, weather conditions were mild and conducive to gains that were higher than expected. Performance of the limit-fed cattle was also greater than projected from the estimated ration energy density and daily feed allowances. The desired targets for average gain were set at intervals of .50 lb/head/day beginning at 1.0 lb/head/day. Although the actual average daily gains were spread at the desired intervals, all limit-fed treatment groups gained .49 to .53 lb/day more than projected (Table 2). Bloat and acidosis were not problems during the feeding period.

Table 2. Peformance of steers during 84 day winter phase.

	Dormant range	Programmed gain, lb/d		
		1.0	1.5	2.0
		lb/hd		
Initial weight	467	459	463	465
Final weight	547[a]	587[b]	631[c]	677[d]
Gain	79.8[a]	127.7[b]	166.7[c]	211.2[d]
Daily gain	.95[a]	1.52[b]	1.99[c]	2.51[d]
Backfat depth		in		
Initial	.083	.083	.083	.087
Final	.087[a]	.118[b]	.114[bc]	.126[c]
Change	.008[a]	.035[b]	.047[bc]	.059[c]

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

At the end of the winter phase, weights of the treatment groups were spread over a 130 lb range with treatment groups separated by approximately 40 lb weight intervals from low to high (Table 2). Although the winter treatments resulted in weight differences ($P<.05$) among all groups, ultrasound backfat depth after 84 days was most different between the DW cattle and the limit-fed groups. Within the limit-fed groups, the LG cattle carried less ($P<.05$) backfat than the HG group but the differences were much smaller in comparison to the DW cattle. Change in backfat over the 84-day period reflected the difference between the DW and limit-fed treatments but there was some indication that change in backfat depth increased as level of limit-feeding increased (Table 2).

Grazing phase

No interactions between winter treatment and summer grazing treatment were observed for weight gain and backfat depth during the first 84 days of grazing (Table 3). Cattle from the DW group gained more ($P<.05$) weight than the LG, MG or HG cattle. Despite the compensatory gain, the DW steers were still 44 and 73 lb lighter ($P<.05$) than the MG and HG steers at the end of the early grazing period. In contrast to the end of the winter period, steer weights were similar ($P>.05$) for the DW and LG groups. Steers in the DW group accumulated backfat (.02 in) during the early grazing period while the limit-fed steers lost fat cover (average -.01 in).

Weight gain during the final 69 days of grazing (Table 4) tended to be greater (model $P<.08$; treatment $P<.13$) for the DW and LG steers compared to the MG and HG steers indicating that winter treatments were still promoting compensatory gain by the DW and LG groups and/or hindering gain by the MG and HG groups. At the end of 153 days of grazing, the HG cattle tended to be heavier (model $P<.12$; treatment $P<.07$) than the three other winter treatments. Changes in backfat depth were similar among all groups.

Steers from the IES grazing treatment were on average 55 lb lighter (732 lb) than SLS steers (787 lb) at the end of their respective grazing seasons. Average gain for the IES cattle was lower (121 lb/head; $P<.05$) than gains of the SLS steers (169 lb/head; Table 5) because of the shorter grazing season. Seventy-two percent of the weight gain by SLS steers occurred during the IES period. If steer gains are adjusted to reflect the heavier stocking density (2X) on IES, total gains per seasonal steer unit were 42.8% greater for the IES program (Table 5). Comparing among winter treatment groups, IES produced from 38 to 51% more gain per seasonal steer unit than SLS.

The rather uniform spread of winter gains across treatments provided an opportunity to evaluate the relationships among performance level prior

Table 3. Peformance of steers during the first 84 days of grazing.

	Grazing program	Dormant range	Programmed gain, lb/d 1.0	1.5	2.0	Mean
		lb/hd				
Weight	IES	697	714	745	772	732
	SLS	706	721	745	774	736
	Mean	701[a]	719[ab]	745[bc]	774[c]	
Gain	IES	150.4	124.6	116.0	95.7	121.7
	SLS	155.7	125.7	103.2	95.0	119.9
	Mean	153.0[a]	125.2[b]	109.6[bc]	95.3[c]	
Daily gain	IES	1.79	1.48	1.39	1.55	1.46
	SLS	1.85	1.50	1.23	1.12	1.43
	Mean	1.83[a]	1.50[b]	1.30[bc]	1.12[c]	
Backfat depth		in				
Final	IES	.114	.118	.122	.122	.122
	SLS	.110	.114	.114	.122	.114
	Mean	.110	.114	.114	.122	
Change	IES	.020	.004	-.020	-.016	-.002
	SLS	.024	-.012	-.004	-.024	-.004
	Mean	.023[a]	-.005[b]	-.011[b]	-.019[b]	

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

Table 4. Peformance of steers during the first 69 days of grazing.

	Dormant range	Programmed gain, lb/d		
		1.0	1.5	2.0
		lb/hd		
Weight	763	778	789	818
Gain	58.7	55.6	43.9	42.6
Daily gain	.86	.82	.64	.62
Backfat depth		in		
Final	.102	.106	.098	.114
Change	-.008	-.008	-..020	-.008

to grazing and performance during the grazing phase. The relationship between daily gain prior to grazing (X) and daily gain during the first 84 days of grazing (Y) was described by the equation $Y=2.27-.49X$ ($P<.0001$; $r^2=.99$). This relationship is based on treatment means. The relationship for the 153-day season was $Y=1.72-.33X$ ($P<.0001$; $r^2=.98$). Based on the relationships, each additional pound of gain prior to grazing depressed daily gain .49 lb in the early grazing season and .33 lb over the entire 153-day season. The same relationships based on individual cattle, without regard to winter treatment, were $Y=2.05-.35X$ ($P<.0001$; $r^2=.32$) for the first 84 days of grazing and $Y=1.61-.27X$ ($P<.0001$; $r^2=.38$).

Forage intake

Forage digestibility and fecal output were similar for the four treatment groups (Table 6). It appeared that forage intake was higher for the treatment groups that were heavier at the start of the grazing season but the differences were not significant ($P>.10$). Intake of DOM was calculated from daily OM intake and forage digestibility and subsequently converted to DE intake and NEm intake (NRC, 1984). These conversions suggested that daily forage intake above maintenance was lowest for the DW cattle and increased with increasing level of winter gain. This trend was not reflected in the actual performance (gain and backfat accumulation) by the cattle during the grazing season.

Accelerated growth during the winter phase resulted in slower growth during spring/summer grazing. Based on treatment means, daily gains during grazing decreased .33 to .49 lb for every 1 lb that winter gain was increased. This decline in summer performance is less severe than noted by

Table 5. Seasonal performance of steers comparison for IES and SLS grazing programs.

	Grazing program	Dormant range	Programmed gain, lb/d 1.0	1.5	2.0	Mean
		lb/hd				
Total gain,	IES	150.6	125.0	116.0	92.3	121.7a
	SLS	214.3	181.3	147.1	137.6	73.0b
	Mean	182.4[a]	153.0[b]	131.4[bc]	116.4[c]	
Total gain, lb/steer unit	IES	1.8	1.5	1.4	1.1	1.5a
	SLS	1.4	1.2	.9	.9	1.1b
	Mean	1.6[a]	1.3[b]	1.2[bc]	1.0[c]	
Daily gain	IES	301.4	250.0	231.7	190.5	243.4a
	SLS	214.4	181.3	147.1	137.6	170.2b
	Mean	257.8[a]	215.6[b]	189.4[bc]	164.1[c]	

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

Table 6. Forage intake and digestibility of steers during early summer.

	Dormant range	Programmed gain, lb/d		
		1.0	1.5	2.0
Forage digestibility, %	57.1	58.6	55.6	57.9
Forage intake,				
lb/d	12.3	13.0	14.2	15.1
lb/100 lb BW	1.90	1.94	2.01	2.07
Digestible organic matter intake,				
lb/d	7.1	7.6	7.9	8.7
Fecal output,				
lb/100 lb BW	.81	.81	.89	.87
Forage intake, lb/d				
Maintenance	10	9.9	11.3	10.7
Gain	2.3	3.1	2.9	4.4

Lewis et al. (1989) for cattle in Nebraska. Forage intake during the early season was similar for all groups and therefore could not explain the poorer gains and loss of backfat by the cattle that were wintered on higher planes of nutrition. The loss of fat cover and reduced weight gains in spite of similar forage intakes suggests that wintering programs altered maintenance requirements of the cattle.

The lack of interaction between winter treatments and summer grazing treatments indicates that pregrazing nutrition continued to affect steer performance over the entire 5-month grazing season. Weights suggest that the DW steers had compensated enough to catch the LG steers by the end of the IES period. But daily gains and final weights after 153 day grazing suggest that the DW and LG cattle were still experiencing some compensatory growth.

Averaged across all winter treatments, IES produced 42% more gain than SLS grazing. This advantage is the combined result of a doubling the stock density and adding 72% of the total SLS gain during the IES period.

Due to incomplete compensation by cattle on the lower winter nutrition programs, the combined use of HG and IES produced the most total pounds of gain per unit land area among all systems. Whether this is the economically optimum production system was not determined. The combined use of IES and accelerated winter growth may have some

advantages in terms of overall cost of gain. Influence of these programs on subsequent feedlot performance is discussed in another paper (McLean, 1990).

Literature Cited

Gill, D.R. and K.S. Lusby. 1989. Programmed feeding for calves. Okla. State Univ. Coop. Ext. Ser. CR-3025.

Lake, R.P. 1987. Limit feeding high-energy rations to growing cattle. pp. 305-313. In: F.N. Owens (Ed.) Feed Intake by Beef Cattle. Okla. Agr. Exp. Sta. MP-121.

Lewis, M. et al. 1989. Wintering gain on subsequent grazing and finishing performance. Nebraska Beef Cattle Report, Univ. Nebraska-Lincoln, MP-54:34.

McCollum, F.T. et al. 1990. Stocker cattle performance and vegetation response to intensive-early stocking of Cross Timbers rangeland. J. Range Manage. 43:99.

McLean, G.S. 1990. Effect of Programmed Feeding High Energy Diets to Growing Cattle During the Winter and Grazing Regime During the Summer on Pasture, Feedlot, and Carcass Performance. M.S. Thesis. Oklahoma State Univ., Stillwater.

NRC. 1984. Nutrient Requirements of Beef Cattle. National Academy Press, Washington, DC.

Olson, K.C. 1987. Intensive-early stocking of western Kansas shortgrass rangeland. Kansas Agr. Exp. Sta. Prog. Rep. P-846.

Smith, E.F. and C.E. Owensby. 1978. Intensive-early stocking and seasonlong stocking of Kansas Flint Hills range. J. Range Manage. 31:14.

Williams, C.H. et al. 1962. The determination of chromic oxide in feces samples by atomic absorption spectrophotometry. J. Agric. Sci. (Camb.) 59:381.

Zinn, R.A. 1987. Programming feed intake to optimize performance of feedlot cattle. pp.290-296. In: F.N. Owens (Ed.) Feed Intake by Beef Cattle. Okla. Agr. Exp. Sta. MP-121.

VOLUNTARY CONSUMPTION OF A LASALOCID-CONTAINING COMPRESSED PROTEIN BLOCK BY STOCKER CATTLE GRAZING BERMUDAGRASS

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Story in Brief

Voluntary consumption of a lasalocid-containing compressed protein block by stocker cattle grazing bermudagrass was measured weekly during a 98-day trial (June 22 to September 29, 1989). The compressed block contained 37% crude protein with 16% of the crude protein equivalent from urea. Three groups of 8 steers/group were used in the consumption trial. In addition, a cottonseed meal supplement containing lasalocid was fed at the rate of 1 lb/head/day during the latter part of the trial for comparison of effects of the two protein supplements on cattle performance. Daily consumption of the compressed protein block averaged .85 lb/head or 85 mg lasalocid/head. Performance of steers fed the compressed protein block and cottonseed meal supplements was similar and averaged 1.37 and 1.46 lb/head/day, respectively for the total trial.

(Key Words: Protein Supplementation, Lasalocid, Growing Cattle, Bermudagrass.)

Introduction

Protein supplementation of growing cattle on tallgrass native and bermudagrass pastures during the mid- to late-summer grazing period has proven to be a very effective and economical practice. Some estimate of available forage nitrogen (i.e., pepsin soluble N and(or) total N minus acid-detergent nitrogen) accounted for 52 to 73% of the variation in forage intake by steers grazing bermudagrass throughout the summer (Wilson and Horn, 1979). An initial report of protein supplementation of stocker cattle during the late-summer grazing period on tallgrass native range was reported by Lusby et al. (1982). Subsequently, this supplementation strategy was modified to include an ionophore (monensin or lasalocid), and is known as the Oklahoma Gold Program. More recently, a 7-trial summary (Gill and

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Lusby, 1989) reports that the practice increased gains of stocker cattle over the total grazing period by .49 lb/day at a supplement conversion of 2.16 lb/lb of increased gain. Cottonseed meal or soybean meal was used as the protein source in all of the trials, and the supplements have usually been fed 3 times/week at a level to provide 1 lb/head/day. Development of supplements that can be fed free-choice on pasture would further decrease costs of labor and transportation (i.e., pickup costs) associated with pasture supplementation programs. This would be particularly important for the more extensive production units. The objective of this study was to measure voluntary consumption, at weekly intervals, of a medicated protein supplement in the form of compressed blocks by stocker cattle grazing bermudagrass. In addition, effects of protein supplementation in the form of free-choice compressed blocks and the Oklahoma Gold Program on cattle performance were compared.

Materials and Methods

Forty-three (43) crossbred yearling steers were treated for internal parasites, blocked according to body weight and previous management, and randomly assigned within blocks to one of six pastures. Each pasture consisted of 6.2 acres of Midland bermudagrass which had all of the previous year's residue burned and had been fertilized with 75 lb of N/acre prior to the initiation of the experiment on June 7, 1989. The steers were allowed one week to adapt to the pastures. During the second week, three of the six groups were given free-choice access to a nonmedicated commercial protein supplement in the form of compressed blocks. After the second week these blocks were replaced with similar compressed blocks that contained 37% total crude protein with 16% of the crude protein equivalent from urea, 2.5% calcium, 1.0% phosphorus and 100 mg lasalocid/lb. The primary sources of all-natural protein in the medicated blocks were cottonseed meal, meat and bone meal and dehydrated alfalfa meal. The blocks were fed in weather-vane type mineral feeders (one/pasture) to protect them from rain. The feeders were located within 50 feet of the water supply and were secured to the ground with steel spikes. The steers were observed daily and the supply of blocks was monitored to insure a continuous supply. Beginning on July 27 (i.e., day 50 of the trial), the remaining three groups of steers were fed 3 days/week (Monday, Wednesday and Friday) 2.33 lb/head of a pelleted cottonseed meal supplement that contained (as-fed basis) cottonseed meal, 95.7%; sugarcane molasses, 4.0% and lasalocid, 200 mg/lb. This level of feeding of the cottonseed meal supplement was equivalent to feeding 1 lb/head/day. The steers were weighed at the beginning, after 35 days of feeding the medicated supplement (i.e., day 50 of the trial) and at the end of

the trial. All weights were measured after 16- to 18-hour shrinks without feed and water.

Steers within each treatment were rotated among the three pastures every 2 weeks. Stocking densities averaged 1.29 and 1.08 steers/acre, respectively, for steers fed the medicated block and the pelleted cottonseed meal supplement. Rainfall during the summer of 1989 was well above average and all the pastures contained in excess of 5,000 lb DM/acre of available forage throughout the trial.

Table 1. Consumption of compressed protein blocks by steers (lb/head/day).

Week	Start date	Group 1	Group 2	Group 3
1	6/7	---------- Adapt to pastures ----------		
---------- Non medicated block ----------				
2	6/14	.39	.62	.92
---------- Medicated block[a] ----------				
3	6/22	.41	.98	.82
4	6/29	.37	1.01	.83
5	7/6	.88	.71	.50
6	7/13	1.07	.86	.52
7	7/20	1.26	.45	.41
8	7/27	.91	.67	1.61
9	8/3	1.15	.64	1.61
10	8/10	1.23	.94	1.21
11	8/17	1.46	.91	1.14
12	8/24	.86	.53	1.36
13	8/31	1.58	.62	1.09
14	9/7	1.04	.30	.52
15	9/14	.68	.96	.21
16	9/21	.66	.31	.35
Mean[b]		.97	.71	.87
Standard deviation[b]		.36	.24	.45

[a] Contained 100 mg lasalocid/lb.
[b] Medicated block only.

Results and Discussion

The steers readily consumed both the nonmedicated and lasalocid-containing blocks. Mean consumption of the blocks for each group of steers is shown in Table 1. Daily consumption of the lasalocid-containing blocks during weeks 3 through 16 of the trial averaged .97, .71 and .87 lb/head for the three groups of steers or .85 lb/head overall. This level of intake would have supplied 85 mg lasalocid/head/day.

Initial, intermittent and final weights of the steers are shown in Table 2. Weight gains of steers of the two treatments were similar during all periods of the trial even though the cottonseed meal supplement was fed only during the last 64 days of the trial. Daily gains for the entire 114-day trial were 1.37 and 1.46 lb for steers fed the compressed protein block and cottonseed meal supplements, respectively. In general, utilization of urea by beef cattle is

Table 2. Initial, intermittent and final weights and daily gains of steers.

	Compressed protein block[a]	Cottonseed meal suppl[bc]
Number of steers	24	19
Number groups of steers	3	3
Stocking density, steers/acre	1.29	1.08
Initial weight, lb		
June 7	652	643
Intermittent weight, lb		
July 27	721	719
Final weight, lb		
September 29	807	810
Daily gain, lb[d]		
Initial-intermittent, 50 days	1.38	1.51
Intermittent-final, 64 days	1.35	1.43
Initial-final, 114 days	1.37	1.46

[a] Contained 37% crude protein with 16% of the crude protein equivalent from urea and 100 mg lasalocid/lb.
[b] Contained 38% crude protein and 200 mg lasalocid/lb.
[c] Steers were supplemented with cottonseed meal only during the last 64 days of the trial.
[d] No supplement effect (P>.15).

improved as intake of energy or fermentable organic matter is increased. The bermudagrass grazed during this trial was at least of medium-quality during most of the trial, and would have aided utilization of the urea in the compressed protein block as compared with lower quality and(or) dormant forages.

Literature Cited

Gill, D.R. and K.S. Lusby. 1989. OSU Summary of Research: The effect of high protein supplementation of summer stocker cattle. OSU Extension Pub.

Lusby, K.S. et al. 1982. Energy vs protein supplementation of steers grazing native range in late summer and early fall. Okla. Agr. Exp. Sta. Res. Rep. MP-112:36.

Wilson, R. and G. W. Horn. 1979. Indices of forage quality and forage intake and weight gains of steers grazed on bermudagrass. J. Anim. Sci. 49(Suppl. 1):39.

BYPASS PROTEIN SUPPLEMENTATION OF STOCKER CATTLE ON WHEAT PASTURE

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Story in Brief

A 92-day trial using 80 fall-weaned steer calves (502 lb average initial weight) was conducted to evaluate the effects of supplemental protein supplied as mechanically produced cottonseed meal or corn gluten meal on weight gains of growing steers grazing wheat pasture. Cattle received no supplement or were fed 2 lb/head of either a corn-based energy supplement (8.6% crude protein on a dry matter basis) or protein supplements that contained 20.2% crude protein and 31% cottonseed meal or 20.5% corn gluten meal. Weight gains were increased about .3 lb/day irregardless of type of supplement. Supplements containing additional high bypass protein did not increase gains compared with the corn-based energy supplement.

(Key Words: Wheat Pasture, Protein, Supplementation, Growing 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 non-protein nitrogen (NPN) are present in the crude protein fraction (Johnson et al., 1974; Horn et al., 1977). 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 decreased by inadequate flow of protein to the small intestine (Beever, 1984; Vogel et al., 1987). Results of previous studies to determine the effect of feeding additional supplemental protein of low ruminal degradability on weight gains of stocker cattle grazing wheat pasture were reported by Horn et al. (1989) and Vogel et al. (1989). Protein sources used in the previous studies were meat meal, meat and bone meal or cottonseed meal (produced by the mechanical process). An additional study using mechanically produced cottonseed meal and corn gluten meal as the protein sources are reported herein.

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Materials and Methods

Eighty Hereford and Hereford x Angus fall weaned calves that weighed 502 lb were randomly allotted by weight within breed groups to four treatments. A randomized complete block design with two replications was used. The trial was conducted at the Forage and Livestock Research Laboratory (USDA/ARS) in El Reno, Oklahoma. The steers were vaccinated for IBR, BVD, PI3 and 7-way Clostridium, treated for internal and external parasites and implanted with Ralgro. The steers grazed wheat pasture (TAM 101) at a stocking density of 2 acres/head from December 8, 1988 to March 10, 1989 (92 days). The wheat pasture was produced by minimum tillage and received 80 lb of N/acre. Cattle of Treatment 1 received no supplement (other than free-choice access to a commercial mineral mixture) while those of Treatments 2, 3 and 4 were fed daily 2 lb/head of a corn-based energy supplement or supplements that provided additional protein from cottonseed meal (mechanical process) or corn gluten meal. Composition of the supplements is shown in Table 1. The energy and protein supplements contained, respectively, 8.6 and 20.2% crude protein (CP) on a DM basis. The supplements were isocaloric, contained equivalent amounts of calcium, phosphorus and magnesium and provided 150 mg monensin/head/day. Because of the relatively mild winter, no hay was fed to the cattle during the trial.

The steers were weighed after an overnight shrink of about 16 h in drylot. Data were analyzed by least squares analysis of variance. In addition, orthogonal contrasts were conducted to test the following effects: 1) no supplementation vs supplementation, 2) energy vs protein supplementation and 3) cottonseed meal vs corn gluten meal supplementation.

Results and Discussion

Mean initial and final weights of the cattle, daily gains for the entire 92-day trial and supplement conversions are shown in Table 2. Consumption of the supplements was good and it was never necessary to measure any refusals. Daily gains of the cattle were increased ($P<.03$) about .3 lb by supplementation. The cottonseed meal or corn gluten meal supplements did not increase ($P>.50$) gains compared to the corn-based supplement, nor did source of supplemental protein influence gains. These results are similar to those reported by Horn et al. (1989) and Vogel et al. (1989) in which cottonseed meal, meat and bone meal and meat meal were used as the sources of high bypass protein.

Ruminal degradability of feedstuffs varies with type of diet and level of feed intake (Zinn and Owens, 1983; Goetsch and Owens, 1985). Vogel et al.

Table 1. Composition of supplements (DM basis) fed to steers.

Item	Corn %	Cottonseed meal[a] %	Corn gluten meal[b] %
Corn, ground	77.80	53.05	56.57
Cottonseed meal		31.44	
Corn gluten meal			20.53
Cottonseed hulls	5.98	.36	6.81
Dehydrated alfalfa	4.00	4.00	4.00
Sugarcane molasses	4.20	4.20	4.20
Dicalcium phosphate	3.95	2.37	3.72
Calcium carbonate	2.74	3.51	2.84
Magnesium oxide	.45	.20	.46
Salt	.45	.45	.45
Trace-mineralized salt	.30	.30	.30
Rumensin 60 Premix[c]	.13	.13	.13
---------- Nutrient composition ----------			
Crude protein, %	8.64	20.20	20.20
Calcium, %	2.00	2.00	2.00
Phosphorous, %	1.00	1.00	1.00
Magnesium, %	.40	.40	.40
NE_g, Mcal/lb	.56	.56	.56

[a] Produced by mechanical process. Traders Oil Mill, Fort Worth, TX.
[b] American Fructose, Dimmitt, TX.
[c] Supplied 75 mg monensin/lb (as-fed).

(1988) and Vogel (1988) characterized ruminal N degradation of several high protein feedstuffs in cattle grazing wheat pasture. Ruminal N degradation of cottonseed meal produced by the mechanical process was 49% and was less than 66% for cottonseed meal produced by direct solvent extraction. Ruminal degradabilities of meat and bone meal and meat meal were 44 and 52%, respectively.

Calculated supplement conversions in this trial were 7.3, 5.5 and 8.0 lb of supplement (as-fed) per lb of increased gain for cattle fed the energy, cottonseed meal and corn gluten meal supplements, respectively (Table 2). Differences among treatments were not significant ($P > .45$).

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 .2 lb/day as compared with a control, hominy feed-based

Table 2. Effect of protein supplementation on performance of growing steers on wheat pasture.

	Supplement				
	Control	Energy	Cottonseed meal[a]	Corn gluten meal	SE
Number of cattle	20	20	20	20	
Supplement consumption, lb/head/day	0	2	2	2	
Initial weight, lb	503	497	501	504	13.5
Final weight, lb	726	745	758	755	15.0
Daily gain (92 d), lb	2.42[b]	2.69	2.79	2.72	.06
Supplement conversion[c]		7.3	5.5	8.0	1.88

[a] Produced by mechanical extraction.
[b] No supplement vs supplement ($P<.03$).
[c] Lb of supplement (as-fed) per lb of increased gain. Differences among treatments are not significant ($P>.45$).

supplement. Anderson et al. (1987) reported a similar gain response by stocker cattle grazing wheat pasture and fed 1.5 lb/head/day of a supplement that contained 11.5% feather meal and 19.4% meat and bone meal. Our studies 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 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.

Literature Cited

Anderson, S.J. et al. 1987. Monensin and bypass protein for wheat pasture calves. Kansas Cattle Feeders Day Report of Progress 518. p 7.

Beever, D.E. 1984. Utilization of the energy and protein components of forages by ruminants - A United Kingdom Perspective. In: Gerald W. Horn (Ed.). National Wheat Pasture Symposium Proceedings. Okla. Agr. Exp. Sta. Pub. No. MP-115:65.

Goetsch A.L. and F.N. Owens. 1985. The effects of commercial processing method of cottonseed meal on site and extent of digestion in cattle. J. Anim. Sci. 60:803.

Horn, G.W. et al. 1977. Wheat pasture bloat of stockers. Okla. Agr. Exp. Sta. Res. Rep. MP-101:26.

Horn, G.W. et al. 1989. Effects of supplemental protein on weight gains of cattle grazing wheat pasture. J. Anim. Sci. 67(Suppl. 2):51.

Johnson, R.R. et al. 1974. Influence of harvest date and N and K fertility levels on soluble carbohydrate and nitrogen fractions in winter wheat pasture. Okla. Agr. Exp. Sta. Res. Rep. MP-92:37.

Lee, Robert W. 1985. Bypass protein supplementation for cattle grazing wheat pasture. Kansas Agric. Exp. Sta. Report of Progress 474, Garden City Branch. p 7.

Vogel, G.J. 1988. Kinetics of ruminal nitrogen digestion of wheat forage and high protein feedstuffs and the effects of supplemental protein on the performance of growing cattle on wheat pasture. Ph.D. Dissertation. Oklahoma State University, Stillwater.

Vogel, G.J. et al. 1987. Kinetics of ruminal nitrogen disappearance from wheat forage in situ. J. Anim. Sci. 65(Suppl. 1):341.

Vogel, G.J. et al. 1988. Ruminal degradability of protein supplements by stocker cattle grazing wheat pasture. J. Anim. Sci. 66(Suppl. 1):465.

Vogel, G.J. et al. 1989. Effects of supplemental protein on performance of stocker cattle grazing wheat pasture. Okla. Agr. Exp. Sta. Res. Rep. MP-127:208.

Zinn, R.A. and F.N. Owens. 1983. Influence of feed intake level on site of digestion in steers fed a high concentrate diet. J. Anim. Sci. 56:471.

EFFECT OF CORN GLUTEN FEED, SOYBEAN MEAL, AND COTTONSEED MEAL ON INTAKE AND UTILIZATION OF PRAIRIE HAY BY BEEF HEIFERS

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

Story in Brief

Twelve 704 lb crossbred beef heifers were used in three simultaneous 4 x 4 Latin squares to determine the effect of supplemental protein source on intake and digestibility of medium quality prairie hay (5.2% crude protein) fed free choice. Treatments included: 1) control, prairie hay; 2) soybean meal; 3) cottonseed meal; and 4) corn gluten feed. Daily dry matter intakes for these protein supplements were 1.67, 1.87, and 3.83 lb, respectively, to provide equal amounts of supplemental protein at the level of .80 lb per day. Daily hay intakes (dry matter basis) were 15.0, 20.9, 19.6 and 18.7 lb or 2.1, 2.9, 2.7 and 2.6% of body weight on the control, soybean meal, cottonseed meal and corn gluten feed treatments, respectively, with total daily dry matter intakes of hay plus supplement and minerals of 15.1, 22.7, 21.6 and 22.6 lb on the same treatments. Ration dry matter digestibilities were 44.3, 55.0, 54.6 and 54.1%, and total daily digestible dry matter intakes were 6.7, 12.5, 11.8 and 12.2 lb on the control, soybean meal, cottonseed meal and corn gluten feed treatments, respectively. Supplementation increased digestibility of the total diet above expected or calculated values (55.0 vs 47.7% for soybean meal; 54.6 vs 48.3% for cottonseed meal; 54.1 vs 51.1% for corn gluten feed). Forage intake was decreased slightly (7%) on the corn gluten feed treatment probably because of slightly more energy being fed in the supplement. Supplementation increased forage intake and digestibility for all supplements with little difference among supplements.

(Key Words: Prairie Hay, Protein Supplement.)

Introduction

Corn gluten feed (CGF) is a byproduct of wet-milling corn to produce corn syrup. It includes the corn bran and condensed steepwater solubles. Corn gluten feed contains about 22 to 23% CP, 2% ether extract, 9% crude fiber and

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is high in phosphorus and potassium. As the corn refining industry has grown, CGF has found wider use in the United States as a protein supplement and has become more widely available in recent years.

Some studies have been conducted with CGF, primarily in beef finishing or dairy rations, but only limited work has been done to investigate the use of CGF in range supplements for beef cattle or to compare the effects of CGF with more traditional protein supplements like soybean meal (SBM) or cottonseed meal (CSM) on the intake and digestibility of medium quality range forages similar to those grazed by cattle during summer months. Therefore, this study was conducted to investigate the effects of providing equal amounts of supplemental protein from SBM, CSM or CGF on forage intake, digestibility, ruminal pH, ruminal NH_3-N and rate of passage when fed with medium quality prairie hay to beef heifers.

Materials and Methods

Twelve crossbred beef heifers (704 lb) were used in three simultaneous 4 x 4 Latin squares. All animals were fed medium quality prairie hay ad libitum. Prairie hay was cut during the first half of July from a meadow harvested annually. The treatments included: 1) Control, consisting of hay (C); 2) SBM supplement (SBM); 3) CSM supplement (CSM), and 4) CGF supplement (CGF).

All heifers were housed individually in slatted-floor pens. The SBM, CSM, and CGF supplements were fed once daily at rates of 1.67, 1.87, and 3.82 lb, respectively (Table 1) to provide equal amounts of supplemental crude protein (.8 lb/day). A mineral and vitamin A mixture was fed to all animals at a level of .11 lb/day on all treatments (Table 1). Nutrient composition of the hay and supplements is denoted in Table 2.

Each period in the Latin square lasted 14 days, with days 1 through 8 for adaptation. Hay, fed and rejected, and supplements were weighed and sampled daily. Chromic oxide was fed as an indigestible marker to estimate digestibilities. Fecal grab samples were collected twice daily on days 10 through 13 in each collection period. Fecal samples from each animal for each period were refrigerated until the end of each period, composited, subsampled and dried at 60° C for 96 h. Hay, supplement and fecal samples were analyzed for moisture and chemical determinations.

Rate of particulate passage values for hay were determined using ytterbium (Yb). Hay was labeled with Yb and fed as a single pulse dose according to the procedure of Teeter et al. (1984). The rumen of each animal was sampled via stomach tube on the last day of each period within 2 to 4 h of feeding supplement. The pH of the ruminal fluid was measured immediately; then fluid was acidified and frozen for later NH_3-N analysis.

Table 1. Intake of the supplements (DM basis) and composition of mineral-vitamin A mixture.

Ingredient	Supplement[a]			
	C	SBM	CSM	CGF
	lb/day			
SBM	---	1.67	---	---
CSM	---	---	1.87	---
CGF	---	---	---	3.83
Mineral and vitamin mixture[b]	.11	.11	.11	.11
Total supplement	.11	1.78	1.98	3.94

[a] C is control; SBM is soybean meal; CSM is cottonseed meal; CGF is corn gluten feed.

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

The statistical analysis included square, period, animal within period and square x treatment as variables. Treatments were compared using orthogonal contrasts of supplementation (all vs C), CGF vs the SBM plus CSM and, finally, SBM vs CSM.

Results and Discussion

Supplementation increased (P<.01) the daily intake of prairie hay from 15.0 lb (C) to 20.9, 19.6 and 18.7 lb on the SBM, CSM and CGF treatments, respectively (Table 3), representing increases in hay consumption of 39, 30 and 24% above the C. Total daily dry matter intakes (hay + protein supplement + mineral-vitamin A) also were increased (P<.01) by supplementation from 15.1 (C) to 22.7 (SBM), 21.6 (CSM) and 22.6 lb. While hay intake was about 7% lower (P<.01) on the CGF treatment compared to SBM + CSM, there was no difference in total daily dry matter intake (hay + supplement). Slightly lower forage intake on the CGF treatment can likely be attributed to the larger quantity

Table 2. Chemical composition (%) of hay and supplements[a].

Item[a]	Prairie hay	SBM[b]	CSM	CGF
Dry matter	89.5	88.3	89.0	86.2
Organic matter	93.6	93.0	92.1	92.1
Crude protein	5.2	47.9	42.9	20.8
Acid detergent fiber	45.6	10.5	14.7	13.4
Neutral detergent fiber	72.5	15.3	29.0	45.4
Ash	6.4	6.9	7.9	7.9

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

of supplement fed and thus the extra energy supplied by the CGF. Slightly lower forage consumption by heifers fed CGF agrees with results by Fleck and Lusby (1986) in which mature cows grazing native winter range lost similar amounts of weight when fed SBM or CGF as a supplement.

Total ration dry matter digestibility (%) was increased from 44.3 on the C to 55.0 (SBM), 54.6 (CSM) and 54.1 (CGF) (Table 3). Supplement should improve digestibility of the diet since supplement is more digestible than hay. Predicted digestibility values also were calculated based on the value obtained for prairie hay on the C treatment and using an assumed digestibility of 80% for the supplement. Improvements in digestibility noted above predicted values with the different supplementation programs are graphically noted in Figure 1. Supplementation improved digestibility above anticipated values on all treatments, although no significant differences were noted among the protein supplement treatments. In the case of SBM, for example, the observed digestibility of 55.0% exceeded the anticipated digestibility of 47.1%, demonstrating the positive effect of supplemental protein on digestibility of prairie hay.

Digestibility of acid detergent fiber was increased ($P<.01$) from a value of 35.4% on the C to a range of 44.4 to 47.5% on the supplemental protein treatments, with no difference among protein source (Table 3). As anticipated, supplementation resulted in increased ($P<.01$) protein digestibility, being 24.8%

Table 3. Influence of supplementation on daily intake and digestibility by heifers.

Item	Supplement[a]					Orthogonal comparisons[b]		
	C	SBM	CSM	CGF	SE	S	A	B
Prairie hay DM intake,								
lb	15.0	20.9	19.6	18.7	.44	.0001	.01	.04
% of BW	2.1	2.9	2.7	2.6	.06	.0001	.01	.04
Total DM intake,								
lb	15.1	22.7	21.6	22.6	.44	.0001	.28	.08
Dry matter dig, %	44.3	55.0	54.6	54.1	2.71	.003	.82	.92
Digestible DM intake,								
lb	6.76	12.5	11.8	12.2	.64	.0001	.72	.37
Indigestible DM intake,								
lb	8.5	10.2	9.8	10.4	.55	.01	.65	.71
% of BW	1.2	1.4	1.4	1.5	.07	.01	.65	.71
Apparent crude protein dig, %								
Observed	24.8	55.8	54.3	51.5	2.60	.0001	.01	.68
Expected	31.3	53.4	54.0	51.1	.35	.0001	.0001	.22
Acid detergent								
fiber dig, %	35.4	47.5	45.4	44.4	31.5	.009	.68	.64

[a] C is control; SBM is soybean meal; CSM is cottonseed meal; CGF is corn gluten feed.

b Comparison included: S for C vs all other treatments; A for CGF vs SBM plus CSM; B for SBM vs CSM.

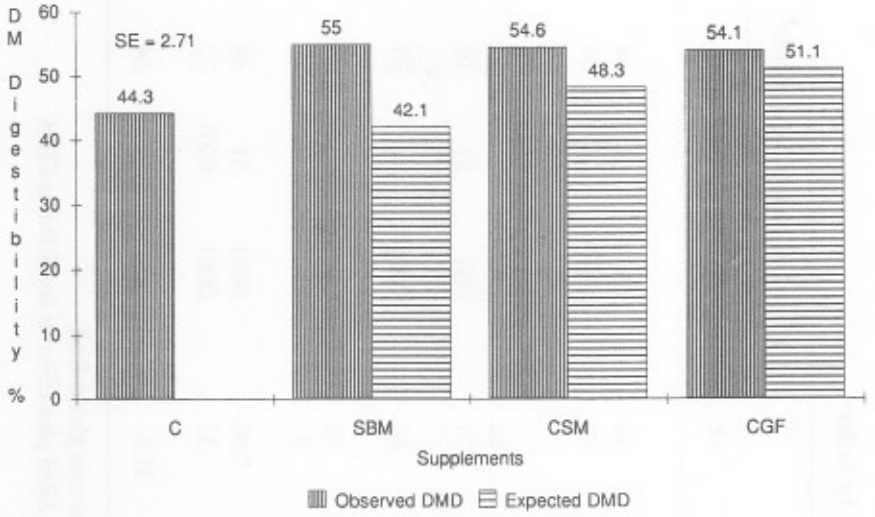

Figure 1. Comparison of observed vs expected diet dry matter digestibilities. Expected digestibilities are based upon values obtained for hay on the control treatment and an assumed 80% DM digestibility for supplements. C is control, SBM is soybean meal, CSM is cottonseed meal and CGF is corn gluten feed supplements.

on the C and from 51.5 to 55.8% on the three protein treatments. An increase in protein intake should result in an increase in apparent protein digestibility because of dilution of metabolic fecal nitrogen. Corrections for metabolic fecal nitrogen resulted in calculated (anticipated) digestibilities close to observed values. Although the differences were small, the average (55.0%) protein digestibility for SBM and CSM was higher ($P<.01$) than for CGF (51.5%).

Because of an increase in both forage intake and diet digestibility, daily digestible dry matter intake (DDMI) was increased ($P<.01$) from 6.6 lb (C) to 12.5 (SBM), 11.8 (CSM) and 12.2 (CGF), representing an average increase of about 84% on the three protein treatments (Table 3). No differences in DDMI were noted among protein sources.

Intake of indigestible dry matter was calculated to determine if improved intake could be attributed solely to increased digestibility of the diet. Ellis et al. (1983) reported indigestible daily dry matter intake tended to remain constant in cattle grazing ryegrass pastures of differing qualities and proposed that gut fill of indigestible material was responsible for restricting forage intake. In our study, however, daily intake of indigestible dry matter intake was increased

Table 4. Influence of protein supplement on ruminal measurements.

Item	Supplement[a]				SE	Orthogonal comparisons[b]		
	C	SBM	CSM	CGF		S	A	B
Ruminal fluid pH	7.0	7.0	6.4	6.8	.25	.89	.76	.15
Ruminal NH_3-N, mg/dl	.77	3.36	3.48	5.27	.213	.0001	.0001	.69
Particulate passage rate, %/hour	1.7	3.3 +94%[c]	2.9 +70%[c]	2.8 +64%[c]	.19	.001	.31	.19

[a] C is control; SBM is soybean meal; CSM is cottonseed meal; CGF is corn gluten feed.
[b] Contrasts included: S for C vs all other treatments; A, CGF vs SBM plus CSM; b, SBM vs CSM.
[c] Percentage change from control supplement.

(P<.01) by supplementation on all protein treatments by an average of 19.4% (Table 3). An increase (24 to 43%) in indigestible dry matter intake when prairie hay was supplemented with SBM also was noted by Guthrie and Wagner (1988).

Ruminal fluid pH (Table 4) was not significantly altered by supplementation, although there was a tendency for slightly lower values on the CSM and CGF treatments. Ruminal NH_3-N values were increased (P<.01) by supplementation, with values (mg/dl) ranging from .77 on the C to 3.36 (SBM), 3.48 (CSM) and 5.27 (CGF). Additionally, NH_3-N values were higher (P<.01) for the CGF treatment than for the average of the SBM and CSM. The higher NH_3-N values on CGF imply that protein in CGF was either degraded more rapidly or extensively in the rumen or that NH_3-N was less completely utilized for microbial synthesis on CGF than for SBM or CSM. Particulate passage rates ranged from 1.7 (C) to 3.3% per hour, being increased (P<.01) by supplementation by an average of 76% (Table 4), with no significant differences among the three protein sources.

Feeding of either SBM, CSM or CGF increased forage intake, digestibility of dry matter and acid detergent fiber, total digestible dry matter intake and rate of passage. Differences between protein sources were generally small, although there appeared to be a small, but consistant (usually nonsignificant) increase for SBM compared to CSM or CGF.

Literature Cited

Ellis, E.C., et al. 1983. Forage and grazing effects on intake and utilization of animal ryegrass by cattle. Proceedings National Wheat Pasture Symposium.

Fleck, A.T. and K.S. Lusby. 1986. Corn gluten feed or soybean meal as winter supplements for pregnant beef cows grazing native range. Okla. Agri. Exp. Sta. Res. Rep. MP-118:196.

Guthrie, M.J. and D.G. Wagner. 1988. Influence of protein or grain supplementation and increasing levels of soybean meal on intake, utilization and passage rate of prairie hay in beef steers and heifers. J. Anim. Sci. 66:1529.

Teeter, R.G. et al. 1984. Ytterbium chloride as a marker for particulate matter in the rumen. J. Anim. Sci. 58:465.

EFFECT OF RIBOFLAVIN SUPPLEMENTATION ON REPRODUCTIVE PERFORMANCE OF BRED SOWS

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Story in Brief

Riboflavin supplementations during a specific time interval following breeding has been reported to increase litter size. A field trial was conducted with 281 crossbred sows to study the effect of riboflavin supplementation (100 mg/day) from day 4 to day 10 after breeding. Differences between control and riboflavin treated sows were not significant for litter size born, litter size born alive, stillborn pigs per litter or mummies per litter. Significant linear and quadratic regressions of litter size born and litter size born alive on parity were observed. Significant linear regressions on the average number of stillborns or mummies per litter on parity were also observed. No significant riboflavin x parity interaction was observed for any trait measured.

(Key Words: Swine, Riboflavin, Reproduction, Parity.)

Introduction

Litter size born alive and weaned is of extreme economic importance in swine production. Thus research scientists are seeking potential methods of improving these economic traits. Bazer and Zavy (1988) reported that riboflavin concentrations increased in uterine flushings of cyclic and pregnant gilts between days 6 and 8 after onset of estrus and that additional riboflavin supplementation to gilts during this period resulted in increased litter size born and weaned. This study was conducted to determine if additional riboflavin supplementation from days 4 to 10 after breeding would result in increased litter size born in a highly productive sow herd on a commercial swine farm.

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Materials and Methods

The trial was conducted at the Hudson Foods Swine Farm near Colcord, Oklahoma with 281 crossbred sows. The sows were bred in confinement and were housed in individual confinement gestation stalls after breeding until day 111 of gestation. They were then moved to individual farrowing crates.

A gestation diet (Table 1) was fed to all sows at a level of 4 lb/day until day 84 of gestation and then increased to 5 lb. All sows were hand-fed a daily

Table 1. Composition of experimental diet.

Ingredients	%
Yellow corn, ground	57.546
Rice bran	29.829
Soybean meal, 47.5% CP	5.870
Meat and bone meal, 50%	3.160
Fat	.500
Dyna-K[a]	.750
Calcium carbonate	1.470
Salt	.400
Vitamin premix [b]	.200
Trace mineral premix [c]	.075
Choline chloride, 70%	.100
Aureo-100[d]	.100
Total	100.000
Calculated composition	
M.E. kcal/lb	1407
Crude protein, %	12.50
Lysine, %	.54
Calcium, %	.90
Phosphorus, %	.80
Riboflavin, mg/lb	3.84

[a] 50% potassium supplement - Pittman Moore Inc.

[b] Supplied 2,000,000 IU Vitamin A, 200,000 IU Vitamin D, 15,000 IU Vitamin E, 1500 mg riboflavin, 10,000 mg niacin, 7,000 mg pantothenic acid and 10 mg vitamin B-12 per lb premix.

[c] Supplies 55,000, 200,000, 100,000, 11,000, 200 and 1500 ppm per lb of premix for manganese, zinc, iron, copper, selenium and rodine, respectively.

[d] Chlorotetracycline, 100 g/lb.

supplemental wafer of wheat flour, molasses and vegetable oil from day 4 to day 10 after breeding. The level of supplemental riboflavin was 0 in the wafers fed the control sows and 100 mg in the wafers fed the riboflavin treated sows.

Results and Discussion

The results of the trial are shown in Table 2. Significant differences between the control sows and the riboflavin supplemented sows were not found for litter size born, litter size born alive, average number of stillborns or mummies per litter.

These results are not in agreement with the increased litter size of over one pig per litter of total pigs born or pigs born alive reported by Bazer and Zavy (1988) with females fed supplemental riboflavin utilizing the same method and levels as outlined in this paper. The study by Bazer and Zavy (1988) utilized gilts while the current study utilized primarily sows with two or more parities as shown in Table 3. Note that the parity 1 group in this study included only nine litters. This difference may explain the lack of agreement.

The effect of parity on litter size is shown in Table 3. The parity groupings used are based on the recommendation made by the National Swine Improvement Federation when adjusting sow productivity for parity.

Significant linear and quadratic regressions were observed for parity on both average litter size born and average litter size born alive as shown in Table 3. The largest litters of total born and born alive occurred during parities 4 through 7. Significant positive linear regressions of and average number of stillborns and number of mummies per litter on parity were also observed. No significant parity x treatment interaction was observed for any trait measured.

Table 2. Effect of riboflavin supplementation on performance of bred sows.

	Control	Riboflavin
Number litters	138	143
Mean litter size born	10.71	10.48
Mean litter size born alive	9.98	9.77
Mean stillborn/litter	.59	.48
Mean of mummies/litter	.10	.16

Table 3. Effect of parity on litter size.

	Parity				
	1	2	3	4-7	8-11
Number litters	9	35	47	145	45
Mean litter size born[a]	10.08	10.02	10.54	11.37	10.99
Mean litter size born alive[b]	9.75	9.62	9.91	10.36	9.72
Mean stillborn/litter[c]	.33	.26	.51	.77	.80
Mean of mummies/litter[d]	0	.05	.12	.22	.26

[a] Linear and quadratic effect (P<.01).
[b] Linear and quadratic effect (P<.02).
[c] Linear effect of (P<.03).
[d] Linear effect of (P<.08).

Literature Cited

Bazer, F.W. and M.T. Zavy. 1988. Supplemental riboflavin and reproductive performance of gilts. J. Anim. Sci. 66 (Suppl. 1):324.

WHEAT VS SORGHUM GRAIN FOR GESTATING GILTS

W.G. Luce[1], C.V. Maxwell[2], D.S. Buchanan[2], A.C. Clutter[3], M.D. Woltmann[4] and R. Vencl[5]

Story in Brief

A study was conducted to compare diets of hard red winter wheat vs sorghum grain for bred gilts. A total of 264 gilts were allotted from three seasons to the two dietary treatments. Average litter size was higher at birth, 21 and 42 days for gilts fed sorghum grain vs those fed wheat diets. Little difference was noted in individual birth weights between treatments, but pigs were significantly heavier at 21 and 42 days for those nursing gilts fed sorghum grain. Litter birth weight was also higher for gilts fed sorghum grain. In two of the three seasons, significant decreases in average litter weight at 21 and 42 days were observed for pigs from gilts fed wheat. Significant decreases in gestation weight gain and less weight loss during lactation was observed for gilts fed wheat in two of the three seasons. This resulted in a significant treatment x season interaction for litter weight at 21 and 42 days, weight gain during gestation and weight loss during lactation. The reasons for the reduced reproductive performance of the gilts fed wheat diets are not known.

(Key Words: Wheat, Sorghum Grain, Gestation, Swine.)

Introduction

Interest in wheat as a swine feed depends largely upon the price relationship between wheat and other cereal grains. There have been periods in recent years when wheat has been competitively priced with other cereal grains, justifying its use in swine diets. When wheat becomes competitively priced with other 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 150 to 225 million bushels annually. However, reduced performance has been reported feeding soft winter wheat to brood sows. Bryant et al. (1985) reported sows fed soft winter wheat farrowed significantly less total

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and live pigs per litter than those fed corn diets. Research investigating the effects of feeding hard red winter wheat grown in Oklahoma on reproductive performance in sows was not available. Thus, this study was initiated to compare hard red winter wheat to sorghum grain as an energy source in gilt gestation diets.

Materials and Methods

A total of 264 crossbred gilts mated to crossbred boars (1986 Fall, 1987 Spring and 1987 Fall) were randomly allotted to the two dietary treatments. A control sorghum grain-soybean meal diet and a hard red winter (TAM-101 variety) soybean meal diet was fed in all three seasons (Table 1). The diets were

Table 1. Composition of experimental diets.

Ingredients, %	Gestation diets		Lactation diet
	Sorghum	Wheat	
Sorghum grain	81.20	---	77.80
Wheat, hard red winter	---	85.30	---
Soybean meal, 44% CP	14.40	10.40	17.80
Dicalcium phosphate	1.75	1.55	1.70
Calcium carbonate	1.05	1.15	1.10
Salt	.35	.35	.35
Vitamin-trace mineral mix[a]	.25	.25	.25
Chlorotetracycline	1.00	1.00	1.00
Total	100.00	100.00	100.00
Calculated composition			
Metabolizable energy, kcal/lb	1370	1411	1371
Protein, %	13.65	14.98	14.83
Lysine,%	.62	.62	.72
Calcium, %	.85	.85	.85
Phosphorus, %	.65	.65	.65

[a] Supplied 800,000 IU Vitamin A, 80,000 IU Vitamin D, 3,400 IU Vitamin E, 4,000 mg d-pantothenic acid, 5,400 mg niacin, 800 mg riboflavin, 660 mg menadione, 4 mg Vitamin B12, 80,000 mg choline chloride, 18 mg selenium, 5 g manganese, 18 g zinc, 18 g iron, 2 g copper and 36 mg iodine per lb of premix.

[b] Supplied 200 g chlorotetracycline per ton of feed.

formulated to be equal in lysine, calcium and phosphorus. Metabolizable energy and other nutrients were similar in both diets.

In all seasons, gilts were housed outside in dirt lots during gestation and group fed 5 lb of feed per head per day. At day 110 of pregnancy, gilts were moved to individual confinement farrowing crates and litters were penned separately until weaning at 42 days. Beginning at day 110, all gilts were fed a common lactation diet (Table 1) at a rate of 4.5 lb/day until farrowing. After farrowing, the gilts were self-fed the lactation diet for the duration of the 42-day lactation. Pigs had access to creep feed from 21 to 42 days of age.

Results and Discussion

Dietary treatment effects on litter size at birth, 21 days and 42 days; individual pig weight at birth, 21 days and 42 days; and litter weight at birth is presented in Table 2. No significant season interaction with these traits was observed.

Average litter size was greater at birth (P<.06), 21 days (P<.09) and 42 days (P<.14) for gilts fed sorghum grain vs those fed wheat diets. Little difference was noted in individual birth weights between treatments, but individual pigs were heavier at 21 and 42 days (P<.08 and P<.03, respectively) for those nursing gilts fed sorghum grain vs those fed wheat diets during

Table 2. The effects of grain source on reproductive performance of gestating gilts.

Item	Sorghum grain gestation diet	Wheat gestation diet	Level of significance
No. litters	143	121	
Litter size			
Birth	9.83	9.28	.06
21 days	8.19	7.73	.09
42 days	7.92	7.52	.14
Pig weight, lb			
Birth	3.35	3.29	
21 days	11.22	10.78	.08
42 days	23.70	22.56	.03
Litter weight, lb			
Birth	32.70	30.08	.01

Table 3. The effect of grain source on performance of gestating gilts within season.

	Farrowing season					
	1 (1986 Fall)		2 (1987 Spring)		3 (1987 Fall)	
Item	Sorghum	Wheat	Sorghum	Wheat	Sorghum	Wheat
No. litters	53	36	46	40	44	42
Litter weight, lb						
21 days	84.36	85.31	95.61[a]	80.26[b]	94.31[a]	79.98[b]
42 days	188.97	189.45	199.02[a]	162.71[b]	173.75[a]	151.40[b]
Gestation gain, lb	122.86	121.74	117.04[c]	104.56[d]	119.11[a]	95.65[b]
Lactation loss, lb	7.76	13.38	18.39[c]	.90[d]	20.90[a]	-3.00[b]

[a,b] Means in a row with different superscript within season differ (P<.01).
[c,d] Means in a row with different superscript within season differ (P<.05).

gestation. Litter weights at birth were also higher (P<.01) for gilts fed sorghum grain than those fed wheat diets during gestation.

A treatment x season interaction was observed for litter weight at 21 days (P<.05), litter weight at 42 days (P<.08), weight gain during gestation (P<.05) and weight loss during lactation (P<.05). Thus, this data is presented by season in Table 3.

Significant decreases in average litter weight at 21 and 42 days (P<.01) were noted for pigs from gilts fed wheat vs those fed sorghum grain in seasons 2 and 3. Similar average litter weights at 21 and 42 days were noted for the two dietary treatments during season 1.

Significant decreases in gestation weight gain (P<.05) were observed for gilts fed wheat diets in seasons 2 and 3 as compared to those fed sorghum grain during gestation. Similar weight gains were noted during gestation for the two dietary treatments during season 1.

Lactation weight loss was (P<.05) greater for gilts fed sorghum grain during gestation than those fed wheat for seasons 2 and 3. Gilts fed wheat during gestation in season 3 actually gained an average 3.0 lb during the 42-day lactation. No significant differences were noted for average lactation weight loss between the two treatments in season 1.

The reasons for the decreased reproductive performance of the gilts fed wheat during gestation when compared to those fed sorghum grain is not understood. The wheat diet was calculated to be equivalent in lysine and other essential amino acids, calcium and phosphorus. The wheat diets had a calculated higher level of metabolizable energy and crude protein (Table 1). Bryant et al. (1985) reported similar results when comparing soft winter wheat to yellow corn in gestation diets. They had no explanation for this occurrence.

Literature Cited

Bryant, K.L. et al. 1985. Supplemental protein for swine. II. Influence of supplementation to corn and wheat based diets on reproductive performance and various biochemical criteria of sows during four parities. J. Anim. Sci. 60:145.

THE EFFECT OF FAT SOURCE AND MEDIUM-CHAIN TRIGLYCERIDE LEVEL ON PERFORMANCE OF THE EARLY-WEANED PIG

B.D. Rodas[1] and C.V. Maxwell[2]

Story in Brief

The effect of dietary fat source and medium chain triglyceride level was studied in two trials utilizing 71 early-weaned pigs. The five treatment groups were fed diets containing 10% fat. Fat sources used were butterfat, lard, and increasing levels of medium-chain triglycerides substituted at the expense of lard. Pigs were housed in an environmentally controlled room in individually elevated pens with temperature maintained at 86°F and 84°F for weeks 1 and 2, respectively. Trial length was 14 days with gain and efficiency of gain estimates obtained weekly. All pigs were fed a common starter diet for an additional 3-week period. There were no significant differences in average daily gain or efficiency of gain between pigs fed butterfat and lard, although pigs fed butterfat tended to grow faster and were more efficient. There was a linear increase in average daily gain and efficiency of gain with increasing level of medium-chain triglycerides in the ration for week 1 and during the 2-week experimental period. No differences (P>.76) were observed among dietary treatments for average daily feed intake. Average daily gain, gain-to-feed ratio, and average daily feed intake during the subsequent 3-week period were not affected by treatment. This study suggests that medium-chain triglycerides may be superior to lard or butterfat as an energy source for early weaned pigs.

(Key Words: Early Weaned Pig, Fat Source.)

Introduction

Several studies have indicated that source of fat influences its utilization by the young pig and further that fat utilization may be influenced by fatty acid composition. Studies also indicate that fat sources high in medium-chain or unsaturated fatty acids are preferentially utilized. Wolfe et al. (1977) has suggested that the young pig is capable of efficiently utilizing a high fat diet

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when butterfat, which is intermediate in both chain length and degree of saturation, is used as the fat source.

Recently, medium-chain triglycerides (MCT), which are composed primarily of a mixture of C8:0 (65 to 75%) and C10:0 (25 to 35%), have been manufactured and may offer an alternative fat source for the early-weaned pig. This study was conducted to compare lard with butterfat as a fat source and to determine the effect of replacing a portion of lard with medium-chain triglycerides (Captex 300 medium-chain triglycerides)[3] on the performance of early-weaned pigs.

Materials and Methods

Seventy-one Yorkshire pigs were used to compare lard with butterfat as a fat source and to determine the effect of different medium-chain triglycerides levels on performance of early-weaned pigs. A total of 71 pigs in two replicates were allotted by sex, litter, and weight to one of five dietary treatments after weaning at 22 to 23 days of age. During the first fourteen days (Period 1), treatment groups were fed diets containing 10% fat. Fat sources used were butterfat (T1), lard (T2), 8% lard with 2% captex 300 medium-chain triglycerides (T3), 6% lard with 4% captex 300 medium-chain triglycerides (T4), and 4% lard with 6% captex 300 medium-chain triglycerides (T5; Table 1). Pigs had ad libitum access to feed and water. All diets were formulated to contain 1.40% lysine, .90% Ca and .70% P. Sources of fat were selected to vary in fatty acid composition (Table 2).

Pigs were individually housed in metabolism crates measuring 18.5 x 30 inches in an environmentally controlled room. The temperature was maintained at 86°F during the first week and was decreased 2°F per week for the remainder the experiment.

In the subsequent 21-day period (Period 2), all pigs were fed a common 18% crude protein diet (Table 1) to test for any carry-over effects from Period 1.

During the 5-week trial, individual pig weights and feed intake by pen were measured, while feed efficiency (G:F) was calculated weekly. Waste feed was collected in pans directly under individual feeders and dried to correct feed intake for waste. Protein, moisture, ether extract of feed and the fatty acid composition of the fat sources were determined.

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[3]Capital City Products, Columbus, OH

Table 1. Composition of diets.

Ingredient	Treatments[a], Period 1					Period 2 Diet
	10% Butterfat	10% Lard	8% Lard 2% MCT	6% Lard 4% MCT	4% Lard 6% MCT	
Yellow corn	--	--	--	--	--	67.30
Soybean meal, 44% CP	--	--	--	--	--	28.50
Soybean meal, 50% CP	14.00	14.00	14.00	14.00	14.00	--
Whey, dried whole	20.00	20.00	20.00	20.00	20.00	--
Dried skim milk	10.00	10.00	10.00	10.00	10.00	--
Corn, ground	37.73	37.73	37.73	37.73	37.73	--
Butterfat[b]	10.00	.00	.00	.00	.00	--
Lard[b]	.00	10.00	8.00	6.00	4.00	--
Captex 300 MCT[bc]	.00	.00	2.00	4.00	6.00	--
Fish meal	6.00	6.00	6.00	6.00	6.00	--
Lysine, HCI	.18	.18	.18	.18	.18	.15
Calcium carbonate	.33	.33	.33	.33	.33	.90
Dicalcium phosphate	.42	.42	.42	.42	.42	1.95
Apralan	.10	.10	.10	.10	.10	--
Vit. TM premix[d]	.94	.94	.94	.94	.94	.37
Salt	.30	.30	.30	.30	.30	.40
Copper sulfate	--	--	--	--	--	.08
Banmith (pyrantel tartrate-48 g/lb)	--	--	--	--	--	.10
Mecadox - 10 (carbadox - 10 g/lb)	--	--	--	--	--	.25

Table 1. (Continued).

Ingredient	Treatments[a], Period 1					Period 2 Diet
	10% Butterfat	10% Lard	8% Lard 2% MCT	6% Lard 4% MCT	4% Lard 6% MCT	
Calculated analysis						
Crude protein	19.67	19.67	19.67	19.67	19.67	18.48
Calcium	.90	.90	.90	.90	.90	.85
Phosphorus	.70	.70	.70	.70	.70	.70
Lysine	1.40	1.40	1.40	1.40	1.40	1.10
Tryptophan	.25	.25	.25	.25	.25	.22
Threonine	.89	.89	.89	.89	.89	.75
Met + Cys	.72	.72	.72	.72	.72	.61
M.E. (Mcal/lb)	1.67	1.67	1.67	1.67	1.67	1.43
Actual analysis						
Crude protein (N X 6.25)	19.75	19.48	19.90	20.00	20.00	20.60
Ether extract	14.49	14.56	14.71	14.60	14.63	--

[a] As fed basis, percent.
[b] Each was stabilized with ethoxyquin (624 ppm).
[c] From Capital City Products Company, Columbus, OH.
[d] Period 1 diet supplied 8,800 IU Vitamin A, 880 IU Vitamin D, 37 IU Vitamin E, 44 mg Panothenic acid, 59 mg Niacin, 8.8 mg Riboflavin, 7.3 mg Menadione, .04 mg Vitamin B_{12}, 880 mg choline chloride, .2 mg selenium, .06 g manganese, .2 g zinc, .2 g iron, .2 g copper, .4 mg iodine, 3 mg biotin, 8.7 mg pyridoxine, 2 mg folic acid, 10 mg thiamine, per kg of feed, .02% magnesium and .10% potassium (Period 2 diet does not include Mg and K).

Table 2. Fatty acid composition (%) of fats.

Fatty acid, %	Fat		
	Butterfat[a]	Captex 300[b]	Lard[a]
C 6[c]:0[d]		1.7	
C 8:0	1.4	68.6	
C 10:0	4.1	29.1	
C 12:0	4.7	0.6	
C 14:0	14.2		2.3
C 16:0	32.4		28.6
C 16:1	3.2		2.8
C 18:0	10.6		14.0
C 18:1	24.8		43.8
C 18:2	2.2		8.5
C 18.3	0.5		
	1.9		

[a] Fatty acid mehyl esters were separated on a crosslinked 50% phenylmethyl silicone 25m x .2mm x .17mm film thickness column in a Perkin-Elmer 5890 gas-liquid chromatographic equipped with a flame ionization detector operated at 285°C. Temperature program 125 - 225°C at 10°C/min.

[b] Analysis from Capital City Products Company, Columbus, OH.

[c] Number of carbon atoms in fatty acid.

[d] Number of double bonds in fatty acid.

Results and Discussions

The effect of dietary fat source and medium-chain triglyceride level on average daily gain is shown in Table 3. During the first week, pigs fed 10% butterfat grew 19% faster than those fed 10% lard although differences between the means were not significant.

Average daily gain during the first week increased with increasing dietary level of medium-chain triglycerides (Diet 2 to Diet 5, linear effect, $P<.01$). These results suggest that the level of medium-chain triglycerides improve gain and have the greatest effect on gain when added at the highest level (6%) evaluated. Pigs fed 6% medium chain triglycerides and 4% lard outperformed those fed 10% lard and 8% lard with 2% MCT by 49 and 20%, respectively. In addition, pigs fed 6% lard with 4% MCT grew 25% faster than those fed 10% lard. Average daily gain over the entire 14-day experimental period continue to

Table 3. The effect of fat source and medium-chain triglyceride (MCT) level on average daily gain, feed efficiency and average daily feed intake[a].

Item	Diet					SE
	10% Butterfat	10% Lard	8% Lard 2% MCT	6% Lard 4% MCT	4% Lard 6% MCT	
No. of pigs	14	12	14	13	13	
Average daily gain, lb						
day 0-7[b]	.56	.47	.58	.61	.70	.04
day 0-14[b]	.75	.72	.76	.79	.84	.02
day 14-35	1.14	1.14	1.17	1.17	1.18	.04
Feed efficiency, gain/feed						
day 0-7[b]	.92	.80	.92	.98	1.07	.05
day 0-14[b]	.89	.84	.89	.91	.96	.02
day 14-35	.70	.69	.68	.67	.69	.01
Average daily feed intake, lb						
day 0-7	.60	.57	.62	.62	.64	.04
day 0-14	.83	.82	.84	.86	.86	.03
day 14-35	1.63	1.64	1.72	1.75	1.70	.05

[a] Least squares means.
[b] Linear response ($P<.01$) to increasing level of medium-chain triglyceride (Treatment 2 to Treatment 5).

be greater for pigs fed 10% butterfat than for those fed 10% lard; however the magnitude of difference was lower than that observed during the first week. As was observed in week 1, average daily gain increased linearly (P<.01) with increasing level of medium-chain triglyceride in the diet during the entire 14-day experimental period. Pigs fed the highest level of MCT grew 17% faster than those fed 10% lard and 11% faster than those fed 2% MCT. Average daily gain was similar among all treatments during the subsequent three weeks (days 14 to 35), although pigs fed 10% lard continued to show reduced gains.

Initial pig weights averaged 14.01, 15.11, 14.39, 14.39,and 14.89 lb for Treatments 1 through 5, respectively (Table 4). After week l, pigs fed 10% butterfat were heavier than those fed 10% lard. Pig weight increased linearly with increasing level of medium-chain triglycerides in the diet during the first 2 weeks on trial (P<.01). Differences in pig weight continued throughout the 3-week carryover period when pigs were fed a common diet. A linear increase in pigs' weight at the end of week 3 (P<.01), week 4, and week 5 (P<.05) was observed with increasing levels of medium-chain triglyceride in the previous diet. Pigs fed 10% lard weighed less at the completion of the trial when compared to the other dietary treatments; however, differences were not significant. Differences in weight during the final 3 weeks were primarily the results of differences observed in weight gain during the initial 2-week experimental period.

Feed required per unit of gain followed a pattern similar to that observed for gain (Table 3). Pigs fed 10% butterfat gained 15% more per unit of feed during the first week on trial than those fed 10% lard, although this difference was not significant. Gain-to-feed ratio increased linearly as medium-chain triglycerides increased in the diet (P<.01). Pigs fed 6% MCT had a 34% and 16% higher gain-to-feed ratio (G:F) than those fed 10% lard and 8 with lard with 2% MCT, respectively. Also pigs fed Diet 4 had a 22% higher gain-to-feed-ratio than those fed 10% lard. Over the entire 14-day experimental period, efficiency of feed utilization increased linearly (P<.01), with increasing medium-chain triglyceride level in the diet. Gain-to-feed ratio was similar among all treatments during the subsequent 3-week period .

The effect of the dietary fat source and the medium-chain triglyceride level on average daily feed intake (ADFI) is presented in Table 3. Average daily feed intake during the first week was similar among all treatments, although pigs fed the diet supplemented with 10% butterfat consumed 5% more feed per day than those fed 10% lard. Pigs fed the medium-chain triglyceride-supplemented diet at the level of 6% had 12% greater intake when compared to pigs fed the 10% lard-supplemented diet. Average daily feed intake during the overall 14-day experimental period was similar among treatments, even though pigs fed medium-chain triglyceride supplemented diets had greater intakes when compared to pigs fed the 10% lard-supplemented diet. The effect of medium-chain triglyceride level on ADFI during the subsequent 21-day period was

Table 4. The effect of fat source and medium-chain triglyceride (MCT) level on pig weight, lb[a].

Item	Diet					SE
	10% Butterfat	10% Lard	8% Lard 2% MCT	6% Lard 4% MCT	4% Lard 6% MCT	
No. of pigs	14	12	14	13	13	--
Initial weight	14.01	15.11	14.39	14.39	14.89	--
Week 1[b]	18.44	17.82	18.59	18.81	19.40	.29
Week 2[b]	24.99	24.57	25.12	25.63	26.29	.40
Week 3[b]	31.29	30.82	31.17	32.36	32.99	.59
Week 4[c]	39.84	38.85	40.61	40.46	41.91	.92
Week 5[c]	49.01	48.42	49.65	50.29	51.00	.88

[a] Least squares means.
[b] Linear response ($P<.01$) to increasing level of medium-chain triglyceride (Treatment 2 to Treatment 5).
[c] Linear response ($P<.05$) to increasing level of medium-chain triglyceride (Treatment 2 to Treatment 5).

similar to that observed in Period 1, with a trend toward increased feed intake in pigs fed the medium-chain triglycerides supplemented diets when compared to pigs fed the 10% lard supplemented diet.

In general, diet supplementation with butterfat, which is intermediate in both chain length and degree of saturation, did not significantly affect average daily gain and gain-to-feed ratio relative to the lard supplement diet; however, pigs fed butterfat grew more rapidly and had a better G:F ratio than pigs fed lard. Lawrence and Maxwell (1983) and Frobish et al. (1970) also reported that pigs fed butterfat had better performance than those fed lard, but these differences were not significant.

Diet supplementation of early-weaned pigs with 6% medium-chain triglycerides significantly increased average daily gain and feed efficiency (G:F) during the first week postweaning relative to diets supplemented with 10% lard or butterfat. A linear response in average daily gain and G:F, with increasing levels of medium-chain triglycerides was also observed during the overall 14-day experimental period. Although the mechanism by which medium-chain triglycerides improved the average daily gain and the gain-to-feed ratio cannot be determined from the present study, a number of possibilities exist. Fatty acids of medium-chain triglycerides are readily hydrolyzed and absorbed from the digestive tract and transported to the liver via the portal vein, thereby enhancing the opportunity for hepatic uptake. In addition, medium-chain fatty acids do not require the carnitine acyltransferase system for transport into the mitochondria for oxidation (Breemer, 1983). As such, medium chain fatty acids could result in greater potential for hepatic uptake and oxidation when compared with the long-chain fatty acids (Frost and Wells, 1981).

Lloyd and Crampton (1957) reported a highly inverse relationship between mean molecular weight (chain length) and apparent digestibility, with short-chain fatty acids being more efficiently utilized than long-chain fatty acids. Frobish et al. (1970) and Lawrence and Maxwell (1983) reported that young pigs showed greater and more efficient gains when fed lower molecular weight fat sources (butterfat and coconut oil) than those fed higher molecular weight fats (lard, corn oil, and soybean oil). The authors suggested that the differential performance of pigs may be partially due to the fatty acid composition of the fat.

Several studies indicated that short-chain fatty acids are oxidized more rapidly than long chain fatty acids. Duee et al. (1985) and Lepine et al. (1989) using hepatocytes of neonatal pigs, reported a greater oxidation rate of octanoate relative to long-chain fatty acids. Miller et al. (1971) reported that lauric acid was oxidized more rapidly than palmitic, oleic, and linoleic acid, suggesting that short chain fatty acids are oxidized more rapidly than long chain fatty acids, an observation which generally supports the finding of this study.

In general, the results of this study indicate that faster growth and a higher gain-to-feed ratio can be achieved during the first week postweaning when pigs weaned at 3 weeks of age are fed a diet supplemented with 6% medium-chain

triglycerides and 4% lard in place of a diet supplemented with 10% lard or 10% butterfat. Similar gain and efficiency of gain can be achieved after the first week postweaning. Feeding butterfat to the young pig during the first week postweaning appears to provide some advantage over lard; however, differences were relatively small.

Literature Cited

Breemer, J. 1983. Carnitine metabolism and functions. Physiol. Rev. 63:1420.

Duee, P.H. et al. 1985. Separate effects of fatty acid oxidation and glucagon on gluconeogenesis in isolated hepatocytes from newborn pigs. Biol. Neonate 47:77.

Frobish, L.T. et al. 1970. Effect of diets form and emulsifying agents on fat utilization by young pigs. J. Anim. Sci. 29:320.

Frost, S. and M.A. Wells. 1981. A comparison of the utilization of medium and long chain fatty acids for oxidation and Ketogenesis in the suckling rat: in vivo and in vitro study. Arch. Biochem. Biophys. 211:537.

Lawrence, N.J. and C.V. Maxwell. 1983. Effect of dietary fat source and level on the performance of neonatal and early weaned pigs. J. Anim. Sci. 57:936.

Lepine, A.J. et al. 1989. Effect of colostrum or medium-chain triglyceride supplementation on the pattern of plasma glucose, non-esterified fatty acids and survival of neonatal pigs. J. Anim. Sci. 67:983.

Lloyd, L.E. and E.W. Crampton. 1957. The relationship between certain characteristics of fat and oils and their apparent digestibility by young pigs, young guinea pigs and pups. J. Anim. Sci. 40:1081.

Miller, G.M. et al. 1971. Fatty acid oxidation in young pigs. J. Nutr. 101:1343.

Wolfe, B.G. et al. 1977. Effect of dietary fat level on growth and lipogenesis in the colostrum deprived neonatal pig. J. Nutr. 107:2100.

EFFECT OF SOURCE OF DIETARY PROTEIN ON PERFORMANCE OF EARLY WEANED PIGS

K. S. Sohn[1] and C. V. Maxwell[2]

Story in Brief

Seventy-two Yorkshire pigs weaned at 21 days of age were allotted to one of seven treatments with different protein sources serving as the primary lysine source at the expense of dried skim milk. All diets were formulated to contain 18% crude protein, 1.5% lysine and 40% whey. Trial length was 14 days with gain and efficiency of gain estimates obtained weekly. Average daily gain and efficiency of gain was higher in pigs fed the dried skim milk diet, the two isolated soy protein diets or the three soy protein concentrate diets when compared to pigs fed the soybean meal diet during week 1, week 2 or for the 2-week period. Average daily feed intake during the first week was lowest in pigs fed the soybean meal diet. During the second week on trial and for the 2-week period, average daily feed intake among the dietary treatments was similar. Performance of pigs fed either isolated soy protein or soy protein concentrate as the supplemental protein source was equal to the performance of those fed the dried skim milk diet. During the subsequent 3-week period there was no treatment effect. Either isolated soy protein or soy protein concentrate 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, Soy Protein Concentrate.)

Introduction

Weaning of pigs as early as three weeks is commonly followed by a decrease in growth rate and feed intake. In addition, diarrhea is a frequent problem. Weaning as early as 18 days is considered essential in order to shorten the breeding cycle and maximize reproductive efficiency.

It has been very well documented that growth rate and efficiency of feed utilization of early weaned pigs are much better with milk protein than with soy

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protein. Milk proteins have been used in the prestarter diet to minimize the effect of the 5- to 10-day postweaning lag period.

Due to the high cost of milk proteins, soybean flakes have been supplemented with essential amino acids and/or digestive enzymes as well as treated with alkali or acid to improve performance and efficiency of utilization. Recently two studies (Dietz et al., 1988; Geurin et al., 1988) indicate that some sources of refined soy protein will support performance similar to that observed in pigs fed milk proteins. The ability to utilize the soy protein from soy protein concentrate or isolated soy protein could be a means of reducing the inclusion rate of more expensive milk proteins in the diet of early weaned pigs. This study was conducted to determine the effect of source of protein and method of processing of soy protein upon gain, efficiency of gain and feed intake for pigs weaned at 21 days of age.

Materials and Methods

Seventy-two Yorkshire pigs were used to study the effect of dietary protein source on performance of early weaned pigs. Thirty-six pigs in each of two replicates were allotted by sex, litter and weight to one of seven dietary treatments providing a total of 10 pigs per treatment with a mean initial weight of 11 lb. Pigs began the trial after being weaned at approximately 21 days of age. During the first 14 days (Period 1), one milk and six soy protein sources were used to formulate experimental diets (Table 1) which met NRC (1988) requirements for the 11- to 22-lb pig. Protein sources were dried skim milk (DSM), two isolated soy proteins, three soy protein concentrates (SPC) and 50% crude protein solvent extracted soybean meal. The two isolated soy proteins were selected to include a soluble (ISP I) and an insoluble (ISP II) isolated soy protein. The three soy protein concentrates represent three different methods for insolubilizing the major proteins while the low molecular weight components were removed. Pigs were individually housed in metabolism crates measuring 1.54 x 2.49 feet in an environmentally controlled feeding room. Temperature was maintained at 88°F during the first week and was decreased 3.6°F per week for the remainder of the experiment. Pigs had ad libitum access to feed and water throughout the trial and remained on trial for a 35-day period with pig weight and feed intake recorded weekly. In the subsequent 21-day period, all pigs were fed a common 18% crude protein starter diet (Table 2) to determine the effect of previous diet on subsequent performance. The data for each response criteria were analyzed by least squares analysis of variance.

Table 1. Composition (%) of experimental diets fed during Period 1 (2 weeks).

Ingredient	Diets[a,b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Soybean meal, 50% CP							24.12
Soy protein concentrate I[c]				25.09			
Soy Protein concentrate II[d]					25.09		
Soy protein concentrate III[e]						25.09	
Isolated soy protein I[f]		20.29					
Isolated soy protein II[g]			20.29				
Dried skim milk	40.00						
Whey, dried whole	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Lactose		20.62	20.62	20.62	20.62	20.62	20.62
Cerelose	7.31	4.77	4.77				.27
Soybean oil	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Lysine, HCl	.19.			.04	.04	.04	.44
DL-Methionine	.16	.30	.30	.24	.24	.24	.35
Tryptophan							.03
Threonine							.09
Lecithin	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Apralan[h]	.10	.10	.10	.10	.10	.10	.10
Calcium carbonate		.53	.53	.50	.50	.50	.39
Dicalcium phosphate		1.15	1.15	1.17	1.17	1.17	1.35
Vit. TM premix[i]	.94	.94	.94	.94	.94	.94.	.94

Table 1. (Continued).

Salt	.30	.30	.30	.30	.30	.30	.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] As fed basis.
[b] DSM: dried skim milk diet; ISP I: isolated soy protein (soluble) diet, ISP II: isolated soy protein (insoluble) diet; SPC I, II AND III: Soy protein concentrate diet; SBM: soybean meal diet.
[c] Promocon-plus, Central Soya, Fort Wayne, IN.
[d] Promine, Central Soya, Fort Wayne, IN.
[e] Promocaf, Central Soya, Fort Wayne, IN.
[f] PP-620, Protein Technologies International, St Louis, MO.
[g] PP-HD-90, Protein Technologies International, St Louis, MO.
[h] Contained 75 g Apramycine per lb.
[i] Supplied 8,800 IU vitamin A, 880 IU vitamin D, 37 IU vitamin E, 44mg pantothenic acid, 59 mg niacin, 8.8 mg riboflavin, 7.3 mg menadione sodium bisulfate, .04 mg vitamin B_{12}, 3 mg biotin, 6 mg pyridoxine, 2 mg folic acid, 10 mg thiamin, 880 mg choline chloride, .2 mg selenium, .06 g manganese, .2 g zinc, .2 g iron, .2 g copper, .2 g magnesium, 1.0 g potassium and .4 mg iodine, per kg of feed.

Table 2. Composition of experimental diets fed during Period 2 (3 weeks).

Ingredients	% of diet[a]
Yellow corn	67.30
Soybean meal (44% CP)	28.50
Dicalcium phosphate	1.95
Calcium carbonate	.90
Vitamin TM premix[b]	.37
Lysine, HCl	.15
Salt	.40
Copper sulfate	.07
Banmith (pyrantel tartrate - 48 g/lb)	.10
Mecadox - 10 (Carbadox - 10 g/lb)	.25
	100.00
Calculated composition of diet	
ME (Kcal/lb)	1429
Lysine, %	1.1
Crude protein, %	18.5
Threonine, %	.75
Tryptophan, %	.22
Met + Cys, %	.61
Calcium, %	.85
Phosphorus,%	.70
Actual analysis	
Crude protein (N X 6.25)	20.6

[a] As fed basis.

[b] Supplied 8,800 IU vitamin A, 880 IU vitamin D, 37 IU vitamin E, 44 mg pantothenic acid, 50 mg niacin, 8.8 mg riboflavin, 7.3 mg menadione sodium bisulfate, .04 mg vitamin B12, 880 mg choline chloride, .2 mg selenium, .06 g manganese, .2 g zinc, .2 g iron, .2 g copper, .4 mg iodine.

Results and Discussion

During the first week postweaning, pigs fed the dried skim milk, isolated soy protein and soy protein concentrate diets grew faster (P<.01) than those fed soybean meal (Table 3). The magnitude of response ranged from a 110% increase in average daily gain in pigs fed the ISP I diet to a 70% increase in average daily gain in pigs fed the SPC III diet when compared to gain of pigs fed the soybean meal diet. Average daily gain was similar between pigs fed the two isolated soy protein diets or among pigs fed the three soy protein concentrate diets. During the second week, pigs fed the soybean meal diet continued to grow more slowly (P<.01) than those fed either of the two isolated soy protein diets or the three soy protein concentrate diets, however, average daily gain in pigs fed the dried skim milk or soybean meal diet was similar. During the entire 14-day period, average daily gain of pigs fed the soybean meal diet was lower (P<.05) than that of pigs fed any other dietary treatments.

Average daily feed intake during the first week was lowest (P<.01) in pigs fed the soybean meal diet when compared to pigs fed the dried skim milk, the two isolated soy protein or the three soy protein concentrate diets. Average daily feed intake was similar among pigs fed the dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets. The largest difference in feed intake was observed during week 1 where pigs fed the dried skim milk diet, the two isolated soy proteins and the three soy protein concentrate diets during the first week consumed 40, 38 and 32% more feed per day, respectively, than those fed the soybean meal diet. During the second week on trial and for the entire 2-week period, average daily feed intake among the dietary treatments was similar.

The effect of dietary protein source on efficiency of feed utilization was similar to that observed for average daily gain. Pigs fed the dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets had a higher (P<.05) gain to feed ratio during the first and the second weeks and for the entire 14-day experimental period than those fed the soybean meal diet. No significant differences were observed, however, among the dried skim milk, the two isolated soy protein and the three soy protein concentrate diets. Average daily gain, average daily feed intake and feed efficiency were similar (P>.74) among pigs fed the seven dietary treatments (Table 4) during the subsequent three weeks.

Initial pig weight (Table 5) averaged 11.0, 11.0, 10.9, 11.0, 10,9, 10.9 and 10.9 lb for pigs fed the DSM, ISP I, ISP II, SPC I, SPC II, SPC III and SBM diets, respectively. After week 1, due to inferior gains by pigs fed soybean meal diet, dietary protein source affected pig weight (P<.05) and by the end of week 2, pigs fed the SBM diet weighed 13, 15 and 12% less than pigs fed the DSM diet, the two ISP diets and the three SPC diets, respectively. Differences in pig weight continued throughout the 3-week carryover period when pigs were given

Table 3. The effect of protein source on performance of weaned pigs in Period 1[a].

Days	Diet[b]							
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM	SE
				Average daily gain, lb				
0 - 7	.44[c]	.46[c]	.44[c]	.42[c]	.40[c]	.37[c]	.22[d]	.08
7 - 14	.68[cd]	.77[c]	.86[c]	.81[c]	.79[c]	.79[c]	.64[d]	.11
0 - 14	.27[e]	.62[e]	.64[e]	.62[e]	.60[e]	.57[e]	.42[f]	.08
				Average daily intake, lb				
0 - 7	.55[e]	.53[e]	.53[e]	.48[e]	.51[e]	.48[e]	.33[f]	.08
7 - 14	1.01	.99	1.06	1.06	1.01	1.01	.95	.13
0 - 14	.79	.77	.79	.77	.77	.75	.64	.18
				Feed efficiency, lb gain/lb feed				
0 - 7	1.87[e]	1.89[e]	1.89[e]	1.83[e]	1.74[e]	1.74[e]	1.45[f]	.18
7 - 14	1.65[e]	1.74[e]	1.83[e]	1.74[e]	1.74[e]	1.72[e]	1.45[f]	.11
0 - 14	1.76[e]	1.83[e]	1.87[e]	1.78[e]	1.74[e]	1.74[e]	1.45[f]	.18

[a] Least squares means.
[b] See Table 1 for explanation of diet code names.
[c,d] Means in the same row with different superscripts differ (P<.01).
[e,f] Means in the same row with different superscripts differ (P<.05).

Table 4. The effect of protein source on performance of weaned pigs in Period 2[a].

	Diet[b]							
Days	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM	SE
				Average daily gain, lb				
14 - 35	.99	1.02	1.05	1.02	1.05	1.06	1.07	.09
				Average daily intake, lb				
14 -35	1.63	1.71	1.72	1.68	1.75	1.78	1.69	.26
				Feed efficiency, lb gain/lb feed				
14 -35	1.34	1.37	1.38	1.37	1.39	1.38[c]	1.40	.24

[a] Least squares means.
[b] See Table 1 for explanation of diet code names.

Table 5. The effect of protein source on pig weight (lb)[a].

	Diet[b]							
Item	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM	SE
No. of pigs	10	10	10	10	10	10	11	
Initial weight	11	11	10.9	11.0	10.9	10.9	10.9	
Week 1	14.1[c]	14.2[c]	14.1[c]	13.9[c]	13.7[c]	13.5[c]	12.4[d]	.70
Week 2	19.4[c]	19.7[c]	20.1[c]	19.7[c]	19.3[c]	19.2[c]	16.9[d]	.99
Week 3	25.1	25.2	26.4	25.7	25.5	25.5	23.6	1.37
Week 4	33.8	35.1	35.4	34.9	34.7	34.8	34.8	2.62
Week 5	43.7	45.2	45.2	45.1	44.7	44.8	42.3	2.60

[a] Least squares means.
[b] See Table 1 for explanation of diet code names.
[c,d] Means in the same row with different superscripts differ (P<.05)

a common diet. Pigs fed the SBM diet weighed 4 to 7% less at the completion of the trial when compared to the other dietary treatments although these differences were not significant.

Due to diminishing dairy surpluses, changing milk processing technology and demand in the human food sector, the cost of milk proteins continues to accelerate. It has become necessary to seek alternative protein sources for early weaned pigs. The present results suggest that selected isolated soy protein or soy protein concentrate can be used to replace dried skim milk in a complex starter diet without affecting performance. These sources of protein should be considered when economic circumstances allow.

Literature Cited

Dietz, G.N. et al. 1988. Effect of protein source on performance of early weaned pigs. J. Anim. Sci. 66(Suppl. 1):314.

Geurin, H.B. et al. 1988. Effect of isolated soy protein and whey on replacing dried skim milk in a prestarter for weaned baby pigs. J. Anim. Sci. 66(Suppl. 1):320.

NRC. 1988. Nutrient Requirements of Domestic Animals. Nutrient Requirements of Swine (9th Ed.). National Academy Press, Washington, DC.

EFFECT OF DIETARY PROTEIN SOURCE ON NUTRIENT DIGESTIBILITY IN EARLY WEANED PIGS

K.S. Sohn[1] and C.V. Maxwell[2]

Story in Brief

Experimental diets with supplemental protein from either dried skim milk, two isolated soy proteins, three soy protein concentrates or soybean meal were fed to 36 Yorkshire pigs weaned at 21 days to determine dry matter, ash, nitrogen and amino acid digestibility. All diets were formulated to contain 1.5% lysine and 40% whey. Trials were 14 days in length. Digestibilities were determined from fresh fecal samples collected during the last three days of the first and second week on trial. The apparent digestibilities of dry matter, nitrogen and amino acids were lower in pigs fed the soybean meal diet when compared to those fed any other dietary treatments. The apparent fecal availability was higher for lysine and valine in pigs fed the dried skim milk diet than for pigs fed any of the soybean protein diets. There were no significant differences among dried skim milk, the two isolated soy proteins and the three soy protein concentrates for apparent digestibility of overall essential amino acids and nonessential amino acids.

(Key Words: Early Weaned Pig, Protein Source, Amino Acid Digestibility.)

Introduction

Numerous studies have indicated that a reduction in both performance and nutrient digestibility is associated with the replacement of dietary milk proteins with various soybean protein sources in the early weaned pigs. Possible explanations include: 1) antinutritional factors present in soybean protein; 2) lower amino acid availability in soybean protein than in milk protein; 3) a reduction in proteolytic activity which probably contributes to the poor digestibility of soybean proteins; 4) morphological changes of the small intestine due to soybean protein.

Much economic incentive exists to determine if soybean proteins could be improved by processing for young pigs. Alkali or acid treatment has met only limited success. Recently, isolated soy protein and soy protein concentrate,

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which are treated by alkali and acid, respectively, have been manufactured and may offer an alternative protein source for early weaned pigs. This study was conducted to determine the effect of protein source and soybean protein processing method upon dry matter, ash, nitrogen and amino acid digestibility in pigs weaned at 21 days of age.

Materials and Methods

Thirty-six Yorkshire pigs were alloted by sex, litter and weight to one of seven dietary treatments with a mean initial weight of 11 lb. Pigs began the trial after being weaned at approximately 21 days of age. One milk and six soybean protein sources were used to formulate experimental diets (Tables 1 and 2) which met NRC (1988) requirements for the 11- to 22-lb pig. Protein sources were dried skim milk, two isolated soy proteins (one soluble and one insoluble), three soy protein concentrates and soybean meal. Pigs were housed in individual 2.0 x 3.3 feet metal pens within an environmentally controlled feeding room maintained between 92°F and 90°F. Pigs had ad libitum access to feed and water throughout trial. Chromic oxide (.25%) was added to each diet as an indigestible marker. A fresh fecal sample was collected from each pig on the last three days of the first and second weeks, respectively. Samples were stored at -20°C composited by treatment prior to lypolyzation and grinding. Dry matter, ash and nitrogen content of both feed and feces were determined according to the AOAC (1980) methods. Chromic oxide was determined by an automic absorption spectrophotometer method. Amino acid analyses were performed following acid hydrolysis under nitrogen reflex in 6 N HCL using an automatic amino acid analyzer.

Results and Discussion

Performance data including feed intake, rate and efficiency of gain has been reported (Sohn and Maxwell, 1990). Apparent fecal availability of dry matter in pigs fed the soybean meal diet was lower than that observed in pigs fed the other protein sources which had similar values (Table 3). The apparent dry matter digestibility for pigs fed isolated soy protein diets was similar to that observed for pigs fed soy protein concentrate diets but higher ($P<.01$) than that observed for pigs fed soybean meal diet. Pigs fed the soybean meal diet during Period 2 had higher dry matter availability than during Period 1. Greater dry matter digestibility for the two isolated soy proteins and the three soy protein concentrates than the soybean meal may be due to the removal of complex indigestible carbohydrates during the isolation and extraction procedures. No differences in the fecal availability among dietary treatments for ash were observed.

Table 1. Composition of experimental diets fed during Period 1 (2 weeks).

Ingredient	Diets[ab]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Soybean meal, 50% CP							24.12
Soy protein concentrate I[c]				25.09			
Soy protein concentrate II[d]					25.09		
Soy protein concentrate III[e]						25.09	
Isolated soy protein I[f]			20.29				
Isolated soy protein II[g]				20.29			
Dried skim milk	40.00						
Whey, dried whole	40.00	40.00	40.00	40.00	40.00	40.00	40.00
Lactose		20.62	20.62	20.62	20.62	20.62	20.62
Cerelose	7.31	4.77	4.77				.27
Soybean oil	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Lysine, HCl	.19			.04	.04	.04	.44
DL-Methionine	.16	.30	.30	.24	.24	.24	.35
Tryptophan							.03
Threonine							.09
Lecithin	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Apralan[h]	.10	.10	.10	.10	.10	.10	.10
Calcium carbonate		.53	.53	.50	.50	.50	.39
Dicalcium phosphate		1.15	1.15	1.17	1.17	1.17	1.35

Table 1. (Continued).

Ingredient	Diets[ab]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Vit. TM premix[i]	.94	.94	.94	.94	.94	.94	.94
Salt	.30	.30	.30	.30	.30	.30	.30
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

[a] As fed basis.
[b] DSM: dried skim milk protein diet; ISPI: isolated soy protein (soluble) diet; ISP II: isolated soy protein (insoluble) diet; SPC I, II, and III: Soy protein concentrate diet; SBM: soybean meal diet.
[c] Promocon-plus, Central Soya, Fort Wayne, IN.
[d] Promine, Central Soya, Fort Wayne, IN.
[e] Promocalf, Central Soya, Fort Wayne, IN.
[f] pp-620, Protein Technologies International. St. Louis. MO.
[g] pp-HD-90, Protein Technologies International. St. Louis. Mo.
[h] Contained 75 g Apramycine per lb.
[i] Supplied 8,800 IU vitamin A, 880 IU vitamin D, 37 IU vitamin E, 44 mg pantothenic acid, 59 mg niacin, 8.8 mg riboflavin, 7.3 mg menadione sodium bisulfate, .04 mg vitamin B12, 3 mg biotin, 6 mg pyridoxine, 2 mg folic acid, 10 mg thiamine, 880 mg choline chloride, .2 mg selenium, .06 g manganese, .2 g zinc, .2 g iron, .2 g copper, .2 g magnesium, 1.0 g potassium and .4 mg iodine, per kg of feed.

Table 2. Protein and amino acid composition of experimental diets[a].

Item	Diet[a]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Crude protein, %	19.36	22.76	22.84	22.77	21.53	21.32	17.73
Amino acids, %							
Essential							
Arginine	.96	1.28	1.27	1.17	1.22	1.21	1.07
Histidine	.51	.59	.59	.56	.59	.57	.49
Isoleucine	.82	.99	.95	.94	.98	.95	.80
Leucine	1.59	1.79	1.75	1.64	1.68	1.63	1.58
Lysine	1.48	1.53	1.52	1.48	1.57	1.56	1.54
Methionine	.51	.51	.48	.44	.47	.45	.46
Phenylalanine	.78	1.00	.99	.91	.90	.91	.76
Threonine	.93	1.04	1.03	1.00	1.04	1.02	.94
Valine	.94	1.00	.96	.96	.99	.96	.86

Table 2. (Continued).

Item	Diet[a]						
	DSM	ISPI	ISPII	SPCI	SPCII	SPCIII	SBM
Nonessential							
Alanine	.71	1.01	1.01	.94	.84	.95	.79
Aspartic acid	1.38	2.38	2.36	2.23	2.31	2.25	1.73
Cystine	.20	.28	.29	.26	.27	.32	.31
Glutamic acid	3.19	3.92	3.89	3.52	3.66	3.55	2.84
Glycine	.44	.76	.76	.72	.74	.73	.69
Proline	1.34	1.18	1.12	1.05	1.06	1.03	.92
Serine	.90	1.11	1.10	1.01	1.05	1.02	.91
Tyrosine	.67	.73	.72	.68	.70	.68	.62

[a] Dry matter basis.
[b] See Table 1 for explanation of diet code names.

Table 3. Apparent availability of dry matter and ash measured over the total digestive tract for early weaned pigs at first and second week postweaning.

Item	Diet[a]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Dry matter, %							
Day 28	92.37[b]	91.08[b]	91.00[b]	90.43[b]	90.48[b]	90.22[b]	80.39[c]
Day 35	92.64[b]	92.43[b]	92.15[b]	91.98[b]	91.48[b]	91.24[b]	82.95[c]
Difference[d]	.27	1.35	1.15	1.55	1.00	1.02	2.56
Ash, %							
Day 28	87.55	86.10	85.70	85.70	85.31	85.47	84.90
Day 35	87.93	85.76	86.84	85.70	85.42	86.70	84.70
Difference[d]	.38	-.34	1.14	.00	.11	1.23	-.20

[a] See Table 1 for explanation of diet code names.
[b,c] Means in the same row with different superscripts differ (P<.05).
[d] Differences obtained by subtraction of availability estimate of day 28 from availability of day 35.

The apparent fecal availability of nitrogen differed among dietary treatments (P<.05) and was lowest in pigs fed the soybean meal diet. No significant differences among dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets were observed (Tables 4 and 5).

The digestibilities of lysine and thereonine are of particular interest because these are often present in limited amounts in diets for young pigs. The apparent fecal availability was higher for lysine and valine (P<.05) in pigs fed the dried skim milk diet than for pigs fed any of the soybean protein diets (Tables 4 and 5). The apparent availability of lysine and valine in pigs fed the dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets was higher (P<.01) than for pigs fed the soybean meal diet with the availability of these two amino acids in pigs fed the two isolated soy protein diets and the three soy protein concentrate diets being intermediate. Phenylalanine availability in pigs fed the dried skim milk diet during the first week postweaning was higher (P<.05) than that of pigs fed any of the soybean protein source diets; however, during the second week there were no significant differences among dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets. The actual digestibility of arginine and histidine was higher in pigs fed the two isolated soy protein diets and the three soy protein concentrate diets than in those fed the dried skim milk diet, but the differences were not significant.

The small increase (1 to 2%) in the apparent availability of nitrogen with increasing age of the pigs from 28 to 35 days was observed when diets containing soybean proteins were fed, but the apparent availability of nitrogen did not improve with increasing age of pigs fed the milk diet (Table 6). Pigs fed the soybean meal diet had a small improved essential amino acid availability (2.1%) with increasing age from 28 to 35 days, but pigs fed the dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets did not show any improved availability with increasing age.

Difference in the fecal availability among dietary treatments for the nonessential amino acids were observed for proline (P<.01) and glutamic acid (P<.01). Availability of the these two amino acids was the highest in pigs fed the dried skim milk diet and the lowest in pigs fed the soybean meal diet with the availability estimates intermediate for the two isolated soy protein and the three soy protein concentrate diets. The apparent fecal availability of the remaining nonessential amino acids was similar among the dried skim milk diet, the two isolated soy protein diets and the three soy protein concentrate diets. Pigs fed the soybean meal diet had the lowest (P<.05) nonessential amino acid availability. Availability values of amino acids for pigs fed the dried skim milk diet and the isolated soy protein diets reported in this study were fairly similar to values reported by Wilson and Leibholz (1981) which are 86.8 and 84.0% for pigs fed milk and isolated soybean protein diets, respectively. The two isolated soy protein diets and the three soy protein concentrate diets appeared to improve

Table 4. Apparent availability of nitrogen and amino acids measured over the total digestive tract for 28-day-old pigs[a].

Item	Diet[b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Pigs per Treatment	10	10	10	10	10	10	11
Initial age, days	20.9	21.0	21.0	20.9	20.9	21.0	21.0
Initial weight, lb	11.00	11.0	11.00	10.9	11.00	10.7	10.9
Nitrogen, %	92.61[d]	91.19[d]	90.71[d]	91.05[d]	90.65[d]	90.37[d]	80.06[e]
Amino acids, %							
Essential							
Arginine[c]	86.3	90.1	90.3	89.1	88.4	88.7	78.3
Histidine[c]	84.2	86.3	86.7	86.0	85.9	85.7	79.4
Isoleucine[c]	87.8	85.7	85.9	85.0	86.2	85.2	78.7
Leucine[c]	88.4	86.8	86.9	87.0	86.2	86.3	79.2
Lysine[c]	91.7[d]	87.0[e]	86.9[e]	87.2[e]	86.9[e]	86.7[e]	79.1
Phenylalanine[c]	89.4[d]	84.2[e]	84.1[e]	83.9[e]	84.4[e]	84.0[e]	79.2
Threonine[c]	81.9	80.4	80.7	80.4	81.0	80.2	73.4
Valine[c]	87.2	85.0	85.1	84.9	84.8	84.5	78.1
Mean	87.1	85.7	85.8	84.9	85.5	84.6	78.2

Table 4. (Continued).

Item	Diet[b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Nonessential							
Alanine[c]	83.2	81.7	80.9	81.4	80.3	79.9	69.9
Aspartic acid[c]	82.6	84.1	83.7	84.3	82.7	81.8	70.4
Glutamic acid[c]	85.9[d]	82.4[e]	83.0[e]	81.9[e]	82.2[e]	82.0[e]	71.3
Glycine[c]	81.3	80.9	80.4	79.7	79.2	78.3	70.2
Proline[c]	90.5[d]	86.7[e]	85.9[e]	87.0[e]	85.8[e]	86.2[e]	74.2
Serine[c]	80.6	79.7	78.9	78.4	79.1	77.9	69.2
Tyrosine[c]	90.7	89.2	88.7	89.0	87.7	87.9	80.0
Mean	85.0[f]	83.5[f]	83.1[f]	83.1[f]	82.4[f]	82.0[f]	72.2[g]

[a] One pig on the DSM diet was removed because of feed refusal.
[b] See Table 1 for explanation of diet code names.
[c] Soybean meal diet differs from other diets (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<.01).

Table 5. (Continued).

Item	Diet[b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Nonessential							
Alanine[c]	82.9	82.0	81.4	81.7	81.0	80.2	71.0
Aspartic acid[c]	82.5	84.2	83.1	84.2	82.6	82.0	72.2
Glutamic acid[c]	87.2[d]	83.1[e]	83.5[e]	82.1[e]	82.7[e]	83.2[e]	79.9
Glycine[c]	81.7	81.2	81.5	80.2	81.0	79.7	72.2
Proline[c]	90.9[d]	87.9[e]	86.2[e]	87.3[e]	87.1[e]	87.4[e]	75.6
Serine[c]	85.2	84.1	83.4	83.2	83.7	83.5	76.3
Tyrosine[c]	91.0	89.9	89.2	89.4	88.2	88.7	83.0
Mean	85.9[g]	84.6[g]	84.0[g]	84.0[g]	83.8[g]	83.5[g]	75.7[h]

[a] One pig on the DSM diet was removed because of feed refusal.
[b] See Table 1 for explanation of diet code names.
[c] Soybean meal diet differs from other diets (P<.01).
[d,e,f] Means in the same row with different superscripts differ (P<.05).
[g,f] Means in the same row with different superscripts differ (P<.01).

Table 6. Difference of apparent fecal amino acid availability estimates between two periods (first vs second week postweaning) in early weaned pigs[a].

	Diet[b]						
Item	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Nitrogen, %	-.01	1.08	1.27	1.16	1.10	1.71	2.02
Amino acids, %							
Essential							
Arginine	1.4	1.1	.4	1.1	.7	.2	2.1
Histidine	.5	.6	.3	.2	.4	.5	3.8
Isoleucine	-.1	.5	1.1	.4	.7	1.7	2.0
Leucine	-.2	.2	1.3	.7	.9	2.6	3.0
Lysine	.2	1.7	.7	1.2	.9	.3	3.5
Phenylanine	-.7	1.0	1.8	1.4	.8	1.0	2.9
Threonine	.1	3.0	2.2	2.7	1.7	2.8	2.1
Valine	-1.0	1.5	1.5	1.5	1.9	1.3	2.0
Mean	.03	1.20	1.16	1.03	1.00	1.30	2.10

Table 6. (Continued).

Item	Diet[b]						
	DSM	ISP I	ISP II	SPC I	SPC II	SPC III	SBM
Nonessential							
Alanine	-.3	.3	.5	.3	.7	.3	1.1
Aspartic acid	-.1	.1	-.6	-.1	-.1	.2	1.8
Glutamic acid	1.3	.7	.5	.3	.5	1.2	3.6
Glycine	.4	.3	1.1	.5	1.8	1.4	2.0
Proline	.4	1.2	.3	.3	1.3	1.2	1.4
Serine	4.6	4.4	4.5	4.8	4.6	5.6	7.1
Tyrosine	.3	.7	.5	.4	.5	.8	3.0
Mean	.90	1.10	.90	.90	1.40	1.50	3.50

[a] One pig on the DSM diet was removed because of feed refusal.
[b] See Table 1 for explanation of diet code names. Differences were obtained by subtraction of the apparent fecal availability estimate of second week after weaning from the fecal availability estimate of 1st week after weaning.

amino acid availability when compared to the soybean meal diet, while no significant difference was observed either between the two isolated soy protein diets or among the three soy protein concentrate diets.

These nutrient availability data are consistent with the observed differences in performance data (Sohn and Maxwell, 1990), suggesting that lower nutrient availability may explain the poor performance observed in pigs fed the soybean meal diet. From these results it can be concluded that in the 28- to 35-day-old pigs, soybean protein isolates or concentrates but not soybean meal are digested as well as milk protein.

Literature Cited

AOAC. 1980. Official Methods of Analysis (13th Ed.). Association of Official Analytical Chemists, Washigton, DC.

NRC. 1988. Nutrient Requirements of Domestic Animals. Nutrient Requirements of Swine (9th Rev. Ed.). National Academy Press, Washington, DC.

Sohn, K.S and C.V. Maxwell. 1990. Effect of source of dietary protein on performance of early weaned pigs. Okla. Agr. Exp. Sta. Res. Rep. MP-129: 288.

Wilson, R.H and J. Leibholz. 1981. Digestion in the pig between 7 and 35 d of age. IV. The digestion of amino acids in pigs given milk and soya-bean proteins. Br. J. Nutr. 45:347.

EFFECT OF SOURCE OF DIETARY PROTEIN ON ILEAL AMINO ACID AVAILABILITY IN EARLY WEANED PIGS

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Story in Brief

A 4 x 4 Latin square trial was conducted using four early weaned gilts fitted with simple ileal T-cannula to determine the effect of protein source on protein and amino acid availability. The availability of dry matter, ash, nitrogen and amino acid in 25-day-old pigs fed either dried skim milk, isolated soy protein, soy protein concentrate or soybean meal diets were determined at the ileum. The pigs were fed semi-purified diets formulated to contain 22% crude protein. The availability of dry matter, nitrogen and overall essential amino acids and nonessential amino acids at the terminal ileum of early weaned pigs was higher in pigs fed dried skim milk, isolated soy protein and soy protein concentrate diets than in those fed a soybean meal diet. The availability of nitrogen and all amino acids except glutamic acid increased with increasing piglet age. Ileal availabilities for lysine and valine were higher for pigs fed the dried skim milk diet than for those fed any of the soybean protein diets. Availabilities of all other amino acids were similar among dried skim milk, isolated soy protein and soy protein concentrate diets. This study suggests that low availability of lysine may limit performance of pigs fed soybean proteins.

(Key Words: Swine, Early Weaned Pig, Amino Acid Availability.)

Introduction

Weaning as early as 18 days often is desirable for swine producers to maximize efficiency. However, early weaning commonly results in low feed intake, poor feed conversion, intestinal malabsorption and weight losses in the early weeks post-weaning. Weaning causes changes in the morphology of the small intestine of pigs.

Protein is utilized more efficiently from casein than from soybean meal until the pig is about 5 weeks of age. This can be explained partially by lower digestibility of the nitrogen in the soybean proteins and incomplete hydrolysis of soybean protein in the small intestine.

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Soybean proteins can be improved by processing for early weaned pigs. Alkali or acid treatment of soybean protein has been shown to improve pig performance. Isolated soy protein and soy protein concentrate now available may be improved over those used previously. Knowledge of differences in amino acid availability, particularly for lysine, should allow formulation of early weaned pig diets on an available amino acid basis.

Several studies have shown that protein sources vary not only in amino acid content but also in amino acid availability as measured either at ileum or in fecal samples. However, studies in early weaned pigs, where the effects of protein source may be more critical, have not been tested adequately. This study was conducted to determine the biological availability of dry matter, ash, nitrogen and individual amino acids in milk and soybean proteins fed to ileally cannulated early weaned pigs.

Materials and Methods

Four Yorkshire gilts were surgically fitted with simple T-cannula located in the distal ileum approximately 2 inches from the ileocecal junction. Pigs were removed from their sows at 18 days of age at which time the cannulas were surgically installed. Immediately following surgery pigs were returned to the sow where they remained with the rest of the litter for a 5-day recovery period. Creep feed and water were available at all times during the convalescent period. After recovery, the pigs were removed to an environmentally controlled feeding room where they were housed in individual elevated metal pens measuring two by 3 feet. Temperature in the feeding room was maintained between 80 and 90°F for the duration of the trial. After a 2-day adjustment period, the pigs at 25 days of age were started on a 4 x 4 Latin square trial.

Dietary treatments consisted of one milk and three soybean protein sources in semi-purified cornstarch-cerelose based diets (Table 1). Protein sources included dried skim milk (DSM), isolated soy protein (ISP), soy protein concentrate (SPC) and soybean meal (SBM). Twenty-two percent crude protein diets were formulated to exceed the NRC (1988) requirement for crude protein for the 11- to 22-lb pig by 10% such that no single amino acid would be limiting. Diets were supplemented with vitamins and minerals to provide completely balanced diets for this age and weight of pigs. Chromic oxide was added as an indigestible marker to allow for availability determinations. Each pig was fed a measured quantity of feed twice daily at 8:00 a.m. and 8:00 p.m. and allowed continuous access to the feed for a 1-h period after which all uneaten feed was removed. Water was available all the time.

Each of the four 7-day experimental periods consisted of a 4-day adjustment period followed by a 3-day collection period. Ileal samples were collected continuously on each collection day, beginning 1 h after the morning

Table 1. Composition of experimental diets.

Ingredients	Diet[a]			
	DSM	ISP	SPC	SBM
Corn starch	13.60	14.47	9.33	4.13
Cerelose	13.60	14.47	9.33	4.13
Solka floc	5.00	5.00	5.00	5.00
Lactose		32.01	32.01	32.01
Soybean oil	5.00	5.00	5.00	5.00
Dried skim milk	60.88			
Isolated soy protein[b]		24.35		
Soy protein concentrate[c]			33.49	
Soybean meal, 50%				45.30
Calcium carbonate	.08	.65	.67	.73
Dicalcium phosphate	.24	2.45	2.36	2.10
Vitamin, TM premix[e]	.95	.95	.95	.95
Salt	.30	.30	.30	.30
Apralan[d]	.10	.10	.10	.10
Chromic oxide	.25	.25	.25	.25
Total	100.00	100.00	100.00	100.00

[a] DSM: dried skim milk protein; ISP: isolated soy protein; SPC: soy protein concentrate; SBM: soybean meal.

[b] Isolated soy protein, soluble, PP-620, Protein Technologies International.

[c] Soy protein concentrate, promocalf, Central Soya, Fort Wayne, IN.

[d] Contained 75 g Apramycin per lb.

[e] Supplied 8,800 IU vitamin A, 880 IU vitamin D, 37 IU vitamin E, 44 mg pantothenic acid, 59 mg niacin, 8.8 mg riboflavin, 7.3 menadione sodium bisulfate, .04 mg vitamin. B_{12}, 3 mg biotin, 6 mg pyridoxine, 2 mg folic acid, 10 mg thiamin, 880 mg choline chloride, .2 mg selenium, .06 g manganese, .2 g zinc, .2 g iron, .2 g copper, .2 g magnesium, 1.0 g potassium, and .4 mg iodine, per kg of feed.

feeding and continuing until either 50 g of wet samples was collected for each pig or until feeding time of the evening meal. Samples were collected in vinyl bags suspended from the cannula. Bags containing samples were changed at a maximum of 1-h intervals. After removal from the pig all digesta samples were immediately frozen and stored at -20°C. Ileal and fecal samples collected over the three collection days of each period were composited by treatment prior to lyophilyzation and grinding for laboratory analysis.

Dry matter (DM), ash, nitrogen (N) and amino acid content of feed, ileal and fecal samples were determined by AOAC (1980) methods. Amino acid concentration was determined by ion exchange chromatography using a Beckman model 6300 automatic AA analyzer. Acid hydrolysis was conducted under nitrogen reflex in 6 N HCl for 22 h.

Results and Discussion

Protein and amino acid composition of the complete diets are shown in Table 2. The three soybean protein diets were similar in essential amino acid content but higher in all essential amino acids except methionine, valine and isoleucine than the dried skim milk diet.

The availability of dry matter and ash from various protein sources at both the terminal ileum and over the total digestive tract is shown in Table 3. The apparent availability of DM and ash in protein sources at both sites was lower ($P<.01$) in pigs fed soybean meal diet than in pigs fed all other protein sources; DM availability among pigs fed the dried skim milk, isolated soy protein and soy protein concentrate diets was similar. Dry matter disappearance from the hind gut ranged from 10.5% for soybean meal diet to 5.5% for dried skim milk diet which may reflect the higher fiber content of soybean meal and the high digestibility of nutrients in dried skim milk. The ash availability at both sites was similar for all dietary treatments.

The ileal availability of nitrogen, essential amino acid and nonessential amino acid was lower ($P<.01$) in pigs fed soybean meal diet than in those fed all other protein sources (Table 4). The average ileal availability of essential amino acids by pigs fed the SBM was 79.2% compared to 89.3, 88.5 and 88.4% for those fed the DSM, ISP and SPC diets, respectively. The ileal availability of lysine and valine was higher ($P<.05$) in pigs fed the DSM than in those fed any of the soybean protein sources; availability of these essential amino acids was higher from ISP and SPC than from the SBM diet. For the other essential amino acid, there were no significant differences among DSM, ISP and SPC diets.

The availability of N and amino acid in pigs fed the SBM diet was lower than for those fed other dietary protein sources. This may reflect the presence of proteolytic enzyme inhibitors, indigestible carbohydrate complexes and antigenic constituents in soybean endosperm; these may account for the inferior

Table 2. Protein and amino acid composition of diets[a].

Ingredients	Diet[a]			
	DSM	ISP	SPC	SBM
Crude protein, %	23.30	23.75	23.87	24.04
Amino acids, %				
Essential				
Arginine	.71	1.56	1.64	1.68
Histidine	.51	.58	.61	.64
Isoleucine	1.32	1.06	1.10	1.13
Leucine	1.99	2.01	2.02	2.12
Lysine	1.33	1.49	1.56	1.60
Methionine	.54	.35	.37	.38
Phenylalanine	.97	1.19	1.23	1.22
Threonine	.97	1.03	1.09	1.15
Valine	1.39	1.18	1.14	1.17
Nonessential				
Alanine	.90	1.15	1.19	1.13
Aspartic acid	1.73	2.77	2.89	3.02
Cystine	.23	.29	.37	.33
Glutamic acid	5.01	4.55	4.52	4.76
Glycine	.69	.92	.97	1.02
Proline	2.76	1.27	1.27	1.32
Serine	1.21	1.26	1.29	1.36
Tyrosine	.84	.75	.76	.83

[a] Dry matter basis.
[b] See Table 1 for explanation of diet code name.

Table 3. Availability of dry matter and ash at the end of the small intestine and in the total digestive tract of early weaned pigs[a].

Ingredients	Diet[a]				
	DSM	ISP	SPC	SBM	SE
Dry matter, %					
Terminal ileum	84.72[c]	83.57[c]	82.74[c]	71.80[d]	2.2
Total tract	90.24[c]	89.29[c]	88.72[c]	82.27[d]	1.5
Difference[e]	5.52[f]	5.72[f]	5.98[f]	10.47[f]	.5
Ash, %					
Terminal ileum	60.92	59.17	58.40	59.00	2.6
Total tract	63.99	62.83	61.73	63.12	2.3
Difference[e]	3.07[f]	3.66[f]	3.33[f]	4.12[f]	1.1

[a] Values are least squares means of four observations.
[b] See Table 1 for explanation of diet code names.
[c,d] Means in the same row with different superscripts differ (P<.01).
[e] Differences were obtained by subtracting ileal availabilities from total tract availabilities. In DM availability SBM differs from others (P<.01).
[f] Availability of DM and ash between feces and ileum differs (P<.05).

growth and feed efficiency observed for early weaned pigs fed the SBM diet compared to those fed milk protein diets. Similar availabilities of amino acids among the DSM, ISP and SPC diets may reflect removal of antinutritional factor(S) and antigenic material(s) present in the soybean during production of isolated soy protein or soy protein concentrate.

A linear increase over time (P<.05) was observed in ileal availability of N, of essential amino acids and of nonessential amino acids with the exception of glutamic acid (Table 5). These changes in availability due to protein sources and time should be considered when formulating diets for young pigs, especially when SBM is used as a supplemental protein source to meet minimum requirements for lysine.

The apparent availability of amino acids to the ileum of pigs fed soybean protein source diets increased with increasing age. Pigs fed the SBM diet showed 10.7% increase in apparent essential amino acid availability from first to fourth week. However, the utilization of milk protein diet has been shown not to change with age of pigs (Table 6). More precise diet formulation may be achieved when availability of the amino acids in a feedstuff are considered. Formulation of diets based upon available amino acids should result in a more valid comparision of soybean protein vs milk based protein.

Table 4. Apparent ileal availability of nitrogen and amino acids in milk and soybean protein sources in early weaned pigs[a].

	Diet[b]				
Item	DSM	ISP	SPC	SBM	SE
Nitrogen[c], %	89.22	88.32	87.65	77.29	1.8
Amino acids, %					
Essential					
Arginine[c]	88.4	90.7	90.4	82.2	2.2
Histidine[c]	86.5	88.4	88.2	80.5	2.0
Isoleucine[c]	92.2	90.2	90.1	81.9	2.2
Leucine[c]	92.5	91.8	91.6	82.2	.9
Lysine[c]	91.7[d]	88.2[e]	88.3[e]	79.3	1.7
Phenylalanine[c]	88.6	87.8	87.9	77.4	1.2
Threonine[c]	85.3	84.9	85.3	74.9	1.7
Valine[c]	89.5[d]	85.7[e]	85.6[e]	75.3	1.6
Mean	89.3[f]	88.5[f]	88.4[f]	79.2[g]	1.6
Nonessential					
Alanine[c]	89.7	88.9	89.1	79.9	1.7
Aspartic acid[c]	88.6	90.2	89.3	81.2	1.6
Glutamic acid[c]	93.4	92.2	92.4	82.2	2.0
Glycine[c]	84.9[d]	81.7[e]	81.9[e]	73.5	1.9
Proline[c]	85.8	85.4	84.9	77.8	1.6
Serine[c]	94.4	93.7	93.2	84.5	1.4
Tyrosine[c]	89.9	87.5	86.9	77.8	3.1
Mean	89.5[f]	88.7[f]	88.2[f]	79.5[g]	1.7

[a] Values are means of four observations.
[b] See Table 1 for explanation of diet code name.
[c] The SBM diet differs from other diets(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<.01).

Table 5. Effect of age on apparent ileal amino acid availability in early weaned pigs[a].

Item	Week				
	1	2	3	4	SE
Dry matter, %	78.9	78.2	83.3	82.6	1.3
Nitrogen, %	82.8	83.2	87.7	88.4	.8
Amino cids, %					
Essential					
Arginine[c]	84.2	84.7	90.4	88.7	1.4
Histidine[c]	83.7	83.5	89.2	88.4	1.7
Isoleucine[c]	87.2	81.9	89.7	91.3	1.6
Leucine[b]	87.4	89.4	90.9	92.0	2.1
Lysine[c]	83.1	84.2	88.3	90.7	2.0
Phenylalanine[c]	84.2	85.1	86.9	88.4	1.6
Threonine[c]	78.5	78.7	84.7	85.7	1.9
Valine[c]	83.6	83.4	85.8	88.4	1.9
Nonessential					
Alanine[b]	85.3	85.9	88.3	91.3	1.8
Aspartic acid[c]	84.2	84.7	89.5	90.2	2.0
Glutamic acid	89.7	88.6	90.8	89.3	2.0
Glycine[b]	76.9	77.7	82.1	83.4	2.1
Proline[c]	80.2	80.4	83.3	84.9	1.8
Serine[c]	86.4	85.2	91.3	92.2	1.7
Tyrosine[c]	83.2	83.7	89.0	89.7	1.9

[a] Values are means of four observations.
[b] Linear effect P<.01.
[c] Linear effect P<.05.

Table 6. Effect of age on apparent ileal amino acid availability of milk and soybean protein sources in early weaned pigs[a].

Diet[b]	Week 1	2	3	4
	%	%	%	%
DSM				
EAA	88.1	87.6	89.5	90.7
NEAA	89.5	89.7	89.3	89.0
ISP				
EAA	86.0	86.1	90.1	91.2
NEAA	86.9	87.2	90.9	91.4
SPC				
EAA	87.1	86.9	90.1	91.5
NEAA	86.8	87.1	89.8	90.9
SBM				
EAA	74.9	75.3	83.5	85.6
NEAA	75.2	77.1	83.2	85.4

[a] Values are obtained by means of eight essential amino acids and seven nonessential amino acids, respectively.

[b] See Table 1 for explanation of diet code names.

Literature Cited

AOAC. 1980. Official Methods of Analysis (13th Ed.). Association of Official Analytical Chemists, Washington, DC.

NRC. 1988. Nutrient Requirements of Domestic Animals. Nutrient Requirements of Swine. (9th Rev. Ed.). National Academy Press, Washington, DC.

THE EFFECTS OF LIMIT FEEDING ON TESTICULAR VOLUME IN GROWING BOARS

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

Story in Brief

Boars were allowed either ad libitum or restricted feed intake levels to initiate a project comparing selection for postweaning growth under two nutritional environments. All boars used were from a line of pigs previously selected for postweaning growth. Ad libitum fed boars were pen fed, while restricted boars were fed individually. Separate spring and fall farrowing replicates were utilized, with 36 boars tested from each line within each of the two replicates. Measurements of testicular width and length were taken at 150 days of age and again after reaching 230 lb. Total volume was estimated using the measurements of testicle length and width. Testicular volume was higher in the ad libitum fed boars at 150 days of age, while the difference at 230 lb varied between farrowing replicates. Limit fed boars were leaner and gained more slowly. These data suggest that testing boars under limited intakes may decrease testicle volume.

(Key Words: Boars, Testicle, Restricted Intake, Selection, Gain.)

Introduction

Alternative methods of selection for lean growth rate and efficiency in swine are of interest. One suggested method is selection for rapid growth on a fixed level of intake. This would eliminate variation in intake, meaning those individuals selected would be the most efficient in depositing lean tissue. A possible concern of limit feeding of boars is their rate of sexual development. A relatively easily attained indicator of sexual development is testicular volume. The purpose of this study was to determine if restricting feed intake of boars decreased testicular volume at a common age and/or weight.

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

Materials and Methods

Boars used in this study were housed at the Southwest Forage and Livestock Research Station near El Reno. All boars were from a composite line of pigs that had been closed to outside genetics and selected for rapid postweaning gain. Boars from spring and fall farrowing replicates were tested for rapid daily gain under two levels of intake. Within each replicate 36 males were tested on ad libitum intake and 36 on limited intake, for a total of 144. The limited level of intake was 83% of predicted ad libitum based on each boar's metabolic body weight. The diet which the limit fed boars received was higher in protein to meet their requirements. Ad libitum fed pigs were penned with 12 males per pen, while limit fed pigs were individually penned.

All males were tested from 80 lb until the first weekly weighing over 230 lb. Limit fed boars were weighed weekly and intake was adjusted based on this weight. In situ measurements of testicular length and width were taken at 150 days of age and upon removal from test at 230 lb by use of a caliper. In addition, ultrasonic backfat probes were taken at the shoulder, last rib and last lumbar vertebrae upon completion of test. Testicular volume was estimated by $(\text{width}/2)^2 \times \text{length}$.

Results and Discussion

Daily gain and adjusted backfat are presented in Table 1. Ad libitum fed boars gained faster and deposited more backfat. However, a farrowing replicate by level of intake interaction was observed for average daily gain (Table 2). In the spring replicate, there was a much larger difference in gain between the full and limit fed boars. This is due to full fed males gaining faster in the spring

Table 1. Performance traits across farrowing replicates.

Trait	Level of intake	
	Ad libitum	Limited
Age, days	155.8	156.1
Off-test weight, lb	237.0	237.1
Average daily gain[a], lb/day	2.16	1.86[b]
Adjusted backfat, inches	1.14	1.05[b]

[a] Significant replicate x level of intake interaction ($P < .05$) (see Table 2).
[b] Level of intake significant at $P < .05$.

Table 2. Farrowing replicate by level of intake interaction[a] for average daily gain and testicular volume at 230 days.

Replicate-level of intake combination	Trait	
	Average daily gain, lb/day	Testicular volume at 230 days, cubic inches
Fall-ad libitum	2.06	35.0
Fall-limited	1.87	31.5
Spring-ad libitum	2.27	22.5
Spring-limited	1.85	24.5

[a] Interaction significant at $P < .05$.

than in the fall. However, there was no replicate difference in gain when intake was limited. Due to the range of dates on which ad libitum fed males were placed on test within a pen, accurate comparisons of feed efficiency could not be made.

Measurements of testicular volume are presented in Table 3. At 150 days of age testicular volume was higher in boars on full feed, while at 230 lb there was no difference. However, a replicate by level of intake interaction was significant for testicular volume at 230 lb and is presented in Table 2. This interaction suggests possible replicate or seasonal differences in the effect of feed intake on volume at a common weight.

The boars that were used in this study represent the base generation of a selection project comparing the efficiency of lean gain in progeny of boars

Table 3. Testicular volume across farrowing replicates.

Trait	Level of intake	
	Ad libitum	Limited
Volume at 150 days, cubic inches[a]	23.7	18.5[b]
Volume at 230 lb, cubic inches[b]	28.7	28.0

[a] Level of intake significant at $P < .05$.
[b] Significant replicate x level of intake interaction ($P < .05$) (see Table 2).

selected for rapid gain under the two nutritional environments. The fourth generation of selection is currently being evaluated. These data suggest that testicular volume at a common age is decreased by this level of limited feeding, but that the effect at a constant weight may be dependent upon seasonal factors. Correlated response in testicular volume to selection under reduced intake has not been evaluated.

BODY ENERGY RESERVES INFLUENCE THE ONSET OF LUTEAL ACTIVITY AFTER EARLY WEANING OF BEEF COWS

D.K. Bishop[1] and R.P. Wettemann[2]

Story in Brief

The influence of body energy reserves, at early weaning, on the onset of luteal activity in postpartum anestrous beef cows was evaluated. Multiparous Hereford and Hereford x Angus cows were fed on range pastures during gestation to establish body condition scores (1=emaciated; 9=obese) between 3 and 6 at parturition. Concentrations of progesterone in blood plasma were determined weekly, and body weights and body condition scores were recorded biweekly for 12 weeks postpartum. Calves were weaned from anovulatory cows on day 45 $\pm$ 3 postpartum. Within 25 days after weaning, 100% of the cows with a body condition score $\geq$ 5 (n=7) had initiated luteal activity, whereas only 43% of the cows with body condition score < 5 (n=12) had luteal activity. The interval to the onset of ovarian activity following weaning was influenced by the body condition score of cows at early weaning.

(Key Words: Beef Cows, Body Condition, Early Weaning, Postpartum.)

Introduction

A period of ovarian inactivity occurs following parturition in beef cows. Two factors associated with the duration of postpartum anestrus are body energy reserves and suckling. The body condition of beef cows influences reproductive performance and may be associated with the varied results observed when calf separation or early weaning are used in an attempt to induce cyclicity in anestrus cows. The objective of this study was to evaluate the influence of body condition score, at early weaning, on the onset of luteal activity in postpartum anestrous beef cows.

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[1]Graduate Student [2]Regents Professor

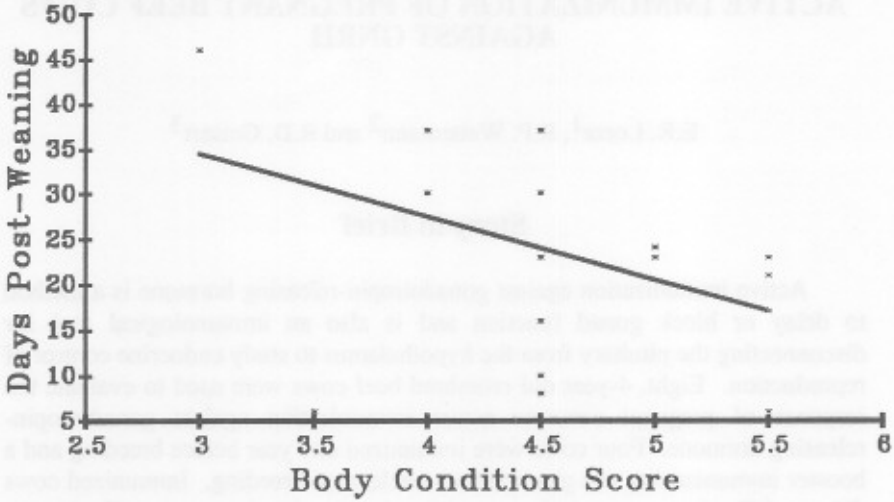

Figure 2. Relationship between body condition score (X) of beef cows at early weaning and days to luteal activity (Y). Regression equation; Y = 55.5 + (-6.98) X (n = 19, r = -.426, P<.06).

BCS $\geq$ 5 (n=7) had LA, whereas only 43% (P<.01) of the thin cows (BCS < 5, n=12) had LA. In addition, fewer (P<.05) of the thin cows, compared to the cows with BCS $\geq$ 5, had LA at 30 and 35 days after weaning.

The relationship between BCS and days from weaning until LA is summarized in Figure 2. For each one unit increase in BCS, LA occured an average of seven days earlier following weaning.

We conclude that the interval to the onset of ovarian activity after early weaning is influenced by the BCS of beef cows. Therefore, BCS of cows must be considered when evaluating the use of calf separation or early weaning to enhance rebreeding of beef cows.

ACTIVE IMMUNIZATION OF PREGNANT BEEF COWS AGAINST GNRH

E.R. Loetz[1], R.P. Wettemann[2] and R.D. Geisert[3]

Story in Brief

Active immunization against gonadotropin-releasing hormone is a method to delay or block gonad function and is also an immunological tool for disconnecting the pituitary from the hypothalamus to study endocrine control of reproduction. Eight, 4-year old crossbred beef cows were used to evaluate the response of pregnant cows to active immunization against gonadotropin-releasing hormone. Four cows were immunized one year before breeding and a booster immunization was given at five weeks post-breeding. Immunized cows did not differ from controls for gonadotropin-releasing hormone antibody titer prior to the booster administration, but titers were greater after one week in cows given the booster immunization. Immunization against gonadotropin-releasing hormone did not influence concentration of progesterone during early pregnancy. Pregnancy proceeded normally in cows immunized against gonadotropin releasing hormone and resulted in the birth of live calves.

(Key Words: Immunization, GnRH, Progesterone, Cow.)

Introduction

Active immunization against gonadotropin-releasing hormone GnRH, a hypothalamic decapeptide, is a non-traumatic and non-surgical method of altering gonadotropin secretions. Production of antibodies against (GnRH) neutralized hypothalamic GnRH which results in a depressed synthesis and secretion of pituitary gonadotropins. Active immunization of heifers against GnRH results in a variety of reproductive dysfunctions, including delayed puberty (Wettemann and Castree, 1988), and cessation of estrous cycles and anovulation (O'Connell and Wettemann, 1989).

In the cow, presence of the corpus luteum (CL) as the source of progesterone is required for maintance of pregnancy during the first 200 days of gestation. Basal secretion of luteinizing hormone (LH) from the anterior pituitary, is essential for maintenance of the CL of pregnancy. Because active

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

immunization against GnRH reduces secretion of LH and follicle stimulating hormone it is possible that pregnancy may be compromised by a reduced luteotrophic effect of LH.

The objectives of this experiment were to evaluate the GnRH antibody response of pregnant cows, and to determine if immunization of pregnant cows against GnRH influences concentrations of progesterone in plasma and maintenance of pregnancy.

Materials and Methods

GnRH was conjugated to human serum albumin by the carbodiimide reaction. Both primary and booster immunization utilized conjugate (100 mg) emulsified in Freund's complete adjuvant which was injected intradermally and subcutaneously in the mammary gland.

Four pregnant cows that were actively immunized against GnRH about one year previously, were given a booster immunization. Four pregnant control cows were not treated. Pregnancy was confirmed prior to treatment by ultrasound to verify the presence of an embryo (day 28 to 38).

Collection of blood was initiated at 5 weeks post-breeding. Blood for serum titers of GnRH was obtained once a week for a period of 5 weeks. Plasma to quantify progesterone was obtained twice a week for 7 weeks. Blood samples for plasma and serum were collected by venipuncture.

Plasma concentrations of progesterone and LH were quantified by radioimmunoassays and analyzed by split plot analyses of variance. Antibody titers were expressed as total percent binding of the radioactive (^{125}I) GnRH by the diluted antiserum.

Results and Discussion

Titers against GnRH (Figure 1) were present in cows within one week after the booster immunization (week 6 of gestation). Prior to the booster immunization, titers were similar in control and treated cows. Immunization against GnRH did not influence ($P > .10$) concentration of progesterone in plasma. Concentrations of progesterone during weeks 5 through 12 of gestation averaged 9.8 ± 1.2 ng/ml in cows immunized against GnRH and 11.5 ± 2.4 ng/ml in control cows (Figure 2). Concentrations of LH in plasma were not influenced ($P > .10$) by treatment and averaged $1.19 \pm .10$ ng/ml in control cows and $1.04 \pm .19$ ng/ml in cows immunized against GnRH, during weeks 6 to 12 of gestation. Normal gestations were verified by the birth of live calves at term.

We conclude that a booster immunization against GnRH in pregnant cows will result in production of antiserum titers against GnRH. Production of

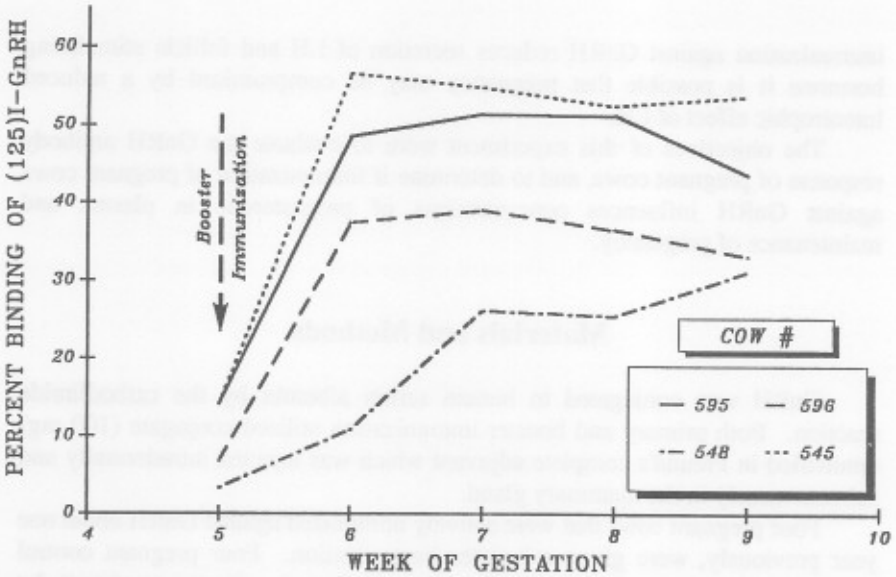

Figure 1. Antibody titers to GnRH in pregnant cows.

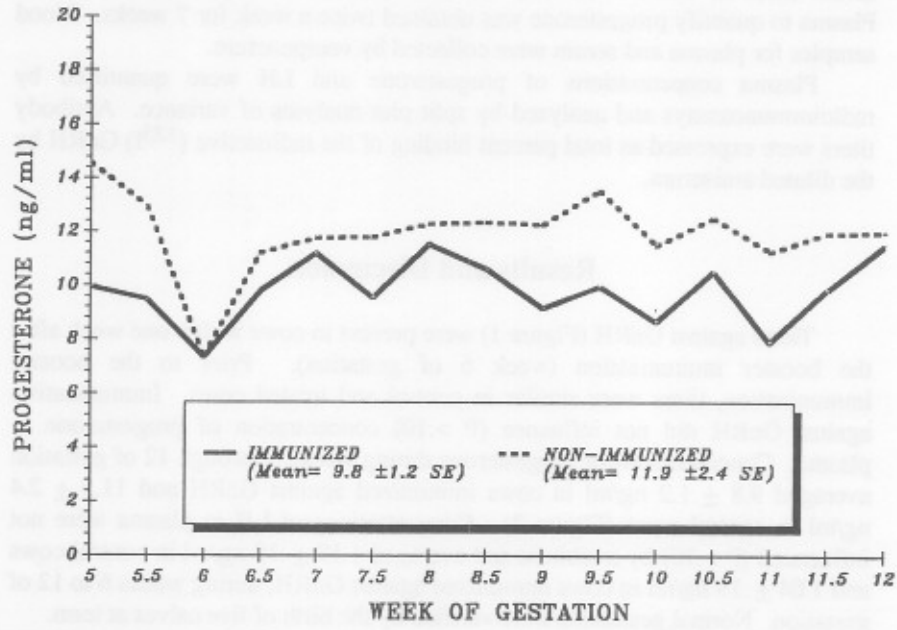

Figure 2. Concentrations of progesterone during early gestation in cows immunized against GnRH and in non-immunized cows.

antibodies against GnRH did not influence concentrations of progesterone in plasma or the maintenance of pregnancy.

Literature Cited

O'Connell, C. and R.P. Wettemann. 1989. Effects of active immunization agaist LHRH in beef heifers on the onset of ovarian activity. Okla. Agr. Exp. Sta. Res. Rep. MP-127:242.

Wettemann, R.P. and J.W. Castree. 1988. Immunization of heifers against luteinizing hormone releasing hormone delays puberty and causes anestrus. Okla. Agr. Exp. Sta. Res. Rep. MP-125:17.

IMMUNIZATION OF POSTPARTUM COWS AGAINST GONADOTROPIN RELEASING HORMONE INFLUENCES THE ONSET OF LUTEAL ACTIVITY AND ESTABLISHMENT OF PREGNANCY

C.M. O'Connell[1] and R.P. Wettemann[2]

Story in Brief

Ten Angus x Hereford postpartum cows were used to evaluate the long term effects of active immunization against gonadotropin releasing hormone. Five cows immunized before gestation were reimmunized approximately 30 days after parturition. Nonimmunized control cows were maintained in the same herd. The onset of luteal activity was delayed, and the interval from calving to conception was greater in immunized cows when compared to control cows. All control cows and three of five immunized cows became pregnant. We conclude that a booster immunization of cows previously immunized against gonadotropin releasing hormone results in a rapid increase in anti-gonadotropin releasing hormone titers. Resumption of luteal activity after parturition is delayed, affecting the establishment of pregnancy during the breeding season.

(Key Words: GnRH, Immunization, Luteal Activity.)

Introduction

Episodic release of gonadotropin releasing hormone (GnRH) from the hypothalamus has a primary role in the hormonal events necessary for normal reproductive function. The production of antibodies against GnRH creates an immunological barrier which prevents GnRH from reaching the anterior pituitary and stimulating the synthesis and secretion of luteinizing hormone (LH). The secretion of LH is essential for ovarian activity to occur. Neutralization of endogenous GnRH in heifers resulted in a reduction in pregnancy rate associated with an increase in antibody production (Johnson et al., 1988). In addition, the onset of pubertal cycles was delayed in heifers immunized against GnRH (Wettemann and Castree, 1988; O'Connell and

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[1]Graduate Student [2]Regents Professor

Wettemann, 1989). The objective of this study was to evaluate the long term effects of GnRH immunization in postpartum cows.

Materials and Methods

Five Angus x Hereford postpartum cows which had been immunized against GnRH 6, 12 and 14 months prior to gestation were used to determine the long term effects of GnRH neutralization on reproduction. To enhance the immune response, GnRH was conjugated to human serum albumin (HSA) by the carbodiimide reaction. The GnRH-HSA complex was emulsified in Freund's Complete adjuvant and injected subcutaneously and intradermally into six sites in the mammary gland. Cows were given a booster immunization at 30 days postpartum. Nonimmunized control cows (n=5) were maintained in the same herd. Blood samples were obtained by venipuncture for 17 weeks to monitor antibody titers against GnRH and to quantify concentrations of progesterone in plasma. Antibody titers against GnRH were confirmed by the ability of serum dilutions to bind radiolabeled GnRH. Progesterone was quantified by radioimmunoassay. All cows were exposed to fertile bulls for a minimum of 90 days. Pregnancy was determined by rectal palpation 60 days after the end of the breeding season.

Results and Discussion

Antisera titers against GnRH increased in four of five cows within one week following reimmunization (Figure 1). Maximum antibody production was acheived one to three weeks after treatment and titers gradually declined.

Luteal activity (LA) after parturition was delayed in three of five immunized cows when compared to controls (Table 1). In one of the two remaining cows, LA was detected five days prior to immunization. After normal regression of the corpus luteum (CL), and the simultaneous increase in titer, the cow became anestrous for six weeks. The other cow was immunized seven days prior to detection of LA and titers against GnRH were probably not established rapidly enough to prevent ovulation. Progesterone concentrations over the nine weeks following treatment were elevated, and unlike those in a normal cyclic cow, indicating that pregnancy may have been established following exposure to bulls. After seven weeks, progesterone rapidly declined, suggesting that the CL had regressed.

Rectal palpation confirmed pregnancy in three of five immunized cows. All controls were pregnant. The calving to conception intervals in pregnant control and immunized cows were 74 ± 6 and 98 ± 8 days, respectively.

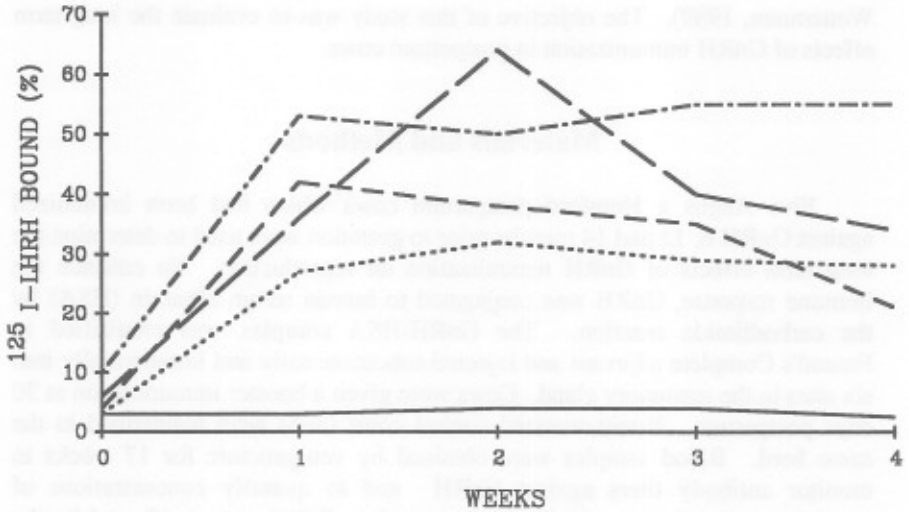

Figure 1. Antibody titers against GnRH in postpartum cows after booster immunization at week 0.

Table 1. Reproductive characteristics of immunized and control cows.

Cow	Treatment[a]	Days to LA[b]	Days exposed to bulls	Pregnant (P) or open (O)	Calving to conception, days
595	I	28[c]	102	O	---
547	I	34[d]	108	P	101
596	I	74	125	P	109
548	I	79	153	P	83
545	I	84	90	O	---
Controls (n=5)		63 ± 5	142 ± 5	All P	74 ± 6

[a] I is immunized against GNRH.
[b] Luteal activity.
[c] Immunized 5 days after LA was detected - anestrus for 6 weeks.
[d] Immunized 7 days before LA was detected.

We conclude that reimmunization of postpartum cows after parturition delayed the resumption of LA and caused a reduction in pregnancy rate and an increased interval from calving to conception. Immunization against GnRH is a technique to study the role of GnRH in controlling gonadotropin secretion and reproductive function in postpartum anestrous cows. This procedure also has potential to induce temporary sterility in cattle.

Literature Cited

Johnson, H.E. et al. 1988. Active immunization of heifers against luteinizing hormone releasing hormone, human chorionic gonadotropin and bovine luteinizing hormone. J. Anim. Sci. 66:719.

O'Connell, C.M. and R.P. Wettemann. 1989. Effects of active immunization against LHRH in beef heifers on the onset of ovarian activity. Okla. Agr. Exp. Sta. Res. Rep. MP-127:242.

Wettemann, R.P. and J.W. Castree. 1988. Immunization of heifers against luteinizing hormone releasing hormone delays puberty and causes anestrus. Okla. Agr. Exp. Sta. Res. Rep. MP-125:17.

RELATIONSHIPS BETWEEN ENERGY BALANCE, INSULIN-LIKE GROWTH FACTOR-I AND ESTROUS BEHAVIOR DURING EARLY LACTATION IN DAIRY COWS

L.J. Spicer[1], W.B. Tucker[1] and G.D. Adams[2]

Story in Brief

Relationships between energy balance, concentrations of insulin-like growth factor-I in serum and estrous behavior were investigated in dairy cattle. From 0 to 12 weeks of lactation, 11 Holstein cows were individually fed a total mixed diet, and to estimate energy balance, individual feed intake and milk production were recorded daily while milk composition and body weight were measured weekly. Cows with positive energy balance during the first 12 weeks postpartum had greater concentrations of insulin-like growth factor-I in serum and greater luteal-phase progesterone secretion than in cows with negative energy balance. Interval to first ovulation or first estrus did not differ between cows with positive versus negative energy balance. However, 60% of the first postpartum ovulations in cows with positive energy balance exhibited estrus compared to only 16.7% for those in negative energy balance. We conclude that reduced estrous and luteal activity that accompanies negative energy balance may be associated with reduced serum concentrations of insulin-like growth factor-I.

(Key Words: Insulin-like Growth Factor-I, Energy Balance, Estrous Behavior.)

Introduction

Increased milk production is associated with decreased reproductive performance in lactating dairy cows (Butler and Smith, 1989). Recent studies have concentrated on evaluating the association between energy balance and reproduction (Butler and Smith, 1989). Energy balance (EB) is quantified using measures of milk production (quantity and composition), dietary intake (quantity and composition) and body weight. Since many high producing cows are unable to consume enough feed to meet energy demands during early

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[1]Assistant Professor [2]Instructor

lactation, they must rely on their ability to mobilize body energy reserves to meet energy requirements.

Although studies have implicated EB as a regulator of ovarian function, the hormone(s) or metabolite(s) mediating the effects of EB on ovarian function is unknown. Since in vitro studies have suggested insulin-like growth factor-I (IGF-I) is a stimulator of ovarian cell steroidogenesis (Hammond et al., 1988), it holds potential as a hormonal mediator of ovarian function. In addition, IGF-I in blood of cattle, predominantly of liver origin, is modified by variations in protein and(or) energy intake (Houseknecht et al., 1988). The objective of this study was to determine the relationships among EB, ovarian function, and IGF-I in lactating dairy cows.

Materials and Methods

From parturition to 85 days postpartum, 11 pluriparous Holstein cows were milked twice daily (3:00 a.m. and 3:00 p.m.) and individually fed a total mixed diet of sorghum silage, alfalfa hay, whole cottonseed and concentrate (30, 15, 8.5 and 53.5% on DM basis). Net energy for lactation fluctuated between .76 and .71 Mcal/lb DM throughout the trial and was adequate to support an average of approximately 79.4 lb milk per day. Milk samples were collected weekly during consecutive afternoon and morning milkings for analysis of fat and solids-not-fat composition. Body weights (BW) and body condition scores (1 to 9; 9 = fat) for each cow (Aalseth et al., 1983) were recorded weekly.

Daily energy balance was calculated each week as (NE_l intake - net energy required for maintenance - energy secreted in milk). Net energy intake was calculated as the average daily DM intake for the week, multiplied by the NE_l concentration of the diet. Net energy (Mcal) required for daily maintenance of the animals was calculated as $(44.218(\text{lb BW}^{.75}))/1{,}000$ (NRC, 1988). Energy balance was expressed as megacalories of NE per day for each week and could be positive (PEB) or negative (NEB). Cows were divided into two groups depending on their average EB during the 12-week experiment: PEB cows (n = 5) had a 12-week EB greater than .2 Mcal/day, whereas NEB cows (n = 6) had a 12-week EB less than .2 Mcal/day. Data were analyzed as a completely randomized split-plot design with EB group as a main plot and week postpartum as a subplot.

Cows were observed twice daily for estrous behavior. Estrus was defined as the day a cow stood to be mounted by another cow. Days to first and second ovulation were defined as the days to first and second rise in serum progesterone >1.5 ng/ml. For this, blood was collected twice weekly from 1 to 12 weeks postpartum. To be defined as an ovulation, each serum progesterone rise had to be maintained for two consecutive sampling days. Serum concentrations of IGF-I were also quantified.

Luteal function was evaluated using area under progesterone curve. Multiple regression was utilized to best fit a curve through progesterone concentrations from the initial to terminal low values of each estrous cycle, and progesterone area was calculated as the definite integral of the equation used to generate the curve. Proportions of ovulations associated with estrus were compared between groups using Chi-square analysis.

Results

The various components that were used to calculate EB and their average values for PEB and NEB cows are presented in Table 1. Average daily EB during the 12-week study was 3.43 ± .71 Mcal/day (range .74 to 6.42) and -1.69 ± .66 Mcal/day (range -2.60 to .16) for PEB (n = 5) and NEB (n = 6) cows (P<.001). In both groups of cows, EB became progressively more positive (P<.01) with week of lactation (Figure 1A). Cows in PEB group were in negative EB only during weeks 1 and 2 postpartum whereas NEB cows were in negative EB from week 1 through week 7.

Table 1. Mean components (± SE) of energy balance calculations for negative energy balance (NEB) and positive energy balance (PEB) cows.

	NEB	PEB
Body weight, lb	1578 ± 61	1460 ± 65
Net energy for maintenance, Mcal/day	11.08 ± .35	10.44 ± .37
DM intake, lb/day	50.9 ± 1.8	51.1 ± 2.0
Net energy intake, Mcal/day	36.85 ± 1.35	37.09 ± 1.45
Milk yield, lb/day	85.1 ± 6.6	72.9 ± 7.3
Milk fat, %	3.58 ± .18	3.68 ± .18
Milk SNF, %	8.94 ± .17	8.80 ± .19
Milk energy, Mcal/day[a]	27.46 ± 1.55	23.23 ± 1.66
Energy balance, Mcal/day[b]	-1.69 ± .66	3.43 ± .71

[a] Means are different (P<.10).
[b] Means are different (P<.001).

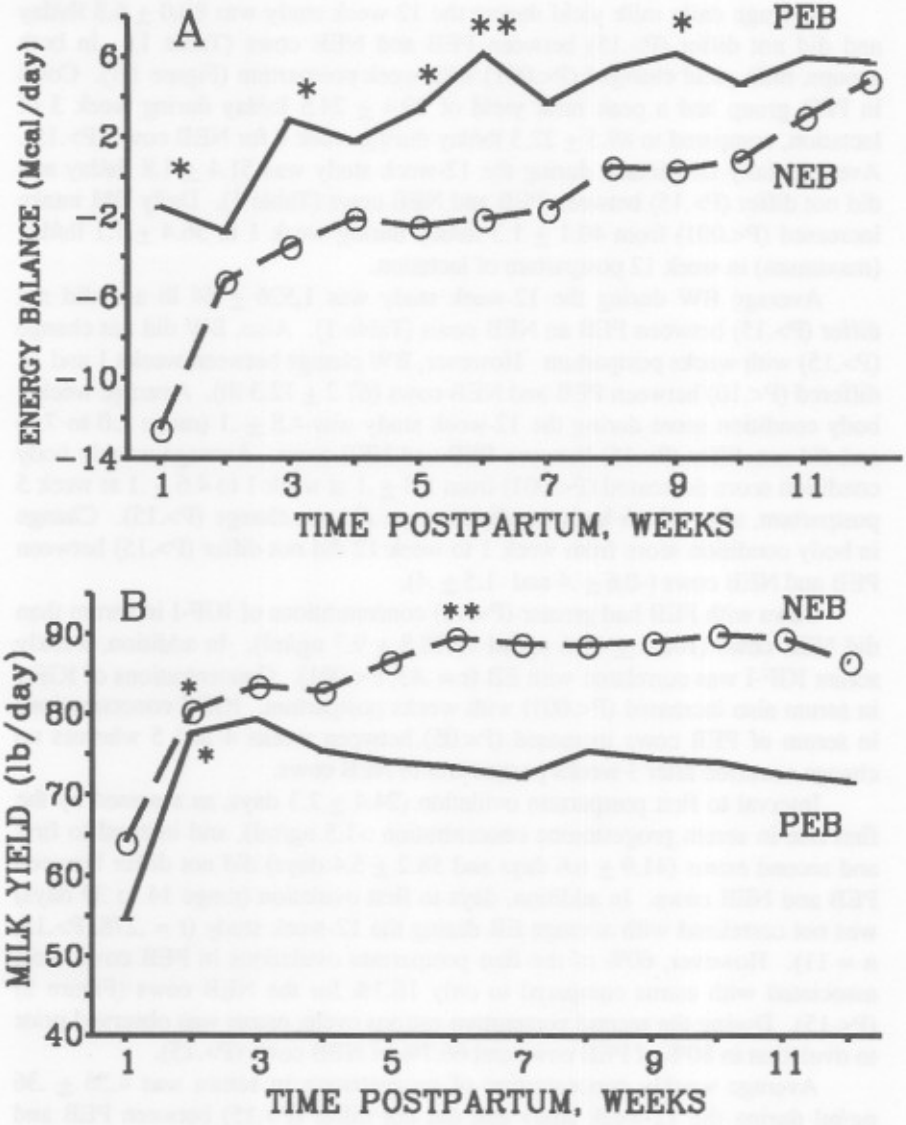

Figure 1. Changes in energy balance (Panel A) and milk yield (Panel B) during the first 12 weeks postpartum in positive energy balance (PEB) and negative energy balance (NEB) cows. Panel A: Asterisks indicate mean for that week differs (*P<.10, **P<.05) from NEB cows. Panel B: (*) indicates first mean within group that differs from week 1 (P<.05); (**) indicates first mean within group that differs from week 2 (P<.05).

Average daily milk yield during the 12-week study was 80.0 ± 6.8 lb/day and did not differ (P>.15) between PEB and NEB cows (Table 1). In both groups, milk yield changed (P<.001) with week postpartum (Figure 1B). Cows in PEB group had a peak milk yield of 79.4 ± 24.5 lb/day during week 3 of lactation, compared to 89.5 ± 22.5 lb/day during week 6 for NEB cows (P>.15). Average daily DM intake during the 12-week study was 51.4 ± 1.8 lb/day and did not differ (P>.15) between PEB and NEB cows (Table 1). Daily DM intake increased (P<.001) from 40.1 ± 1.3 lb/day during week 1 to 56.4 ± 1.1 lb/day (maximum) in week 12 postpartum of lactation.

Average BW during the 12-week study was 1,526 ± 64 lb and did not differ (P>.15) between PEB an NEB cows (Table 1). Also, BW did not change (P>.15) with weeks postpartum. However, BW change between weeks 1 and 12 differed (P<.10) between PEB and NEB cows (67.2 ± 12.3 lb). Average weekly body condition score during the 12-week study was 4.8 ± .1 (range 2.0 to 7.0) and did not differ (P>.15) between PEB and NEB cows. Average weekly body condition score decreased (P<.001) from 5.8 ± .1 at week 1 to 4.6 ± .1 at week 5 postpartum, after which body condition score did not change (P>.15). Change in body condition score from week 1 to week 12 did not differ (P>.15) between PEB and NEB cows (-0.6 ± .4 and -1.5 ± .4).

Cows with PEB had greater (P<.15) concentrations of IGF-I in serum than did NEB cows (102.5 ± 10.6 ng/ml vs 78.8 ± 9.7 ng/ml). In addition, weekly serum IGF-I was correlated with EB (r = .43, P<.001). Concentrations of IGF-I in serum also increased (P<.001) with weeks postpartum. IGF-I concentrations in serum of PEB cows increased (P<.05) between weeks 4 and 5 whereas no change occurred after 3 weeks postpartum in NEB cows.

Interval to first postpartum ovulation (24.4 ± 2.3 days, as assessed by the first rise in serum progesterone concentration >1.5 ng/ml), and interval to first and second estrus (41.9 ± 6.6 days and 58.2 ± 5.4 days) did not differ between PEB and NEB cows. In addition, days to first ovulation (range 14 to 39 days) was not correlated with average EB during the 12-week study (r = .278, P>.15, n = 11). However, 60% of the first postpartum ovulations in PEB cows were associated with estrus compared to only 16.7% for the NEB cows (Figure 2) (P<.15). During the second postpartum estrous cycle, estrus was observed prior to ovulation in 80% of PEB cows and 66.7% of NEB cows (P>.15).

Average weekly concentration of progesterone in serum was 4.56 ± .36 ng/ml during the 12-week study and did not differ (P>.15) between PEB and NEB cows. Average progesterone in serum increased (P<.05) from .55 ng/ml on week 1 to 7.86 ng/ml on week 12. Progesterone area was 1.8-fold greater (P<.10) in PEB than NEB cows during the first and second estrous cycles (data not shown).

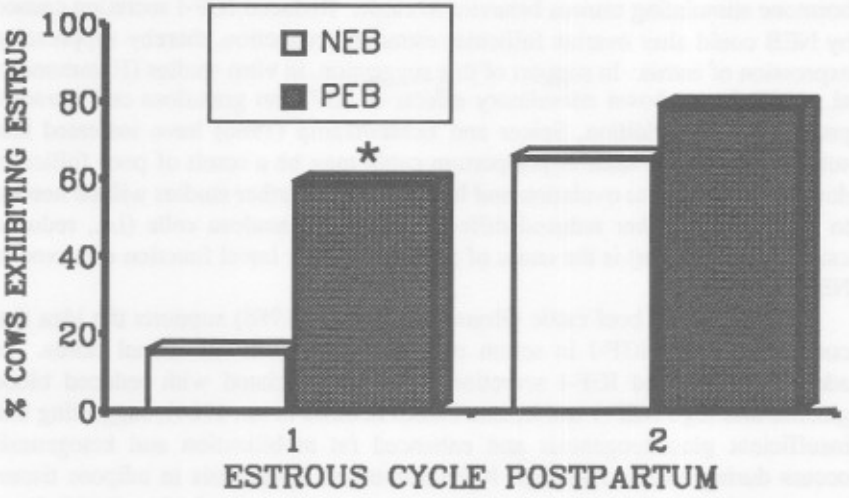

Figure 2. The percentage of negative energy balance (NEB) and positive energy balance (PEB) cows exhibiting estrus during their first and second estrous cycle postpartum. Asterisk (*) indicates mean differs from NEB (P<.15).

Discussion

Previous studies have linked negative EB with reduced ovarian activity during early lactation (Butler and Smith, 1989). Similarly, we observed that progesterone concentrations in serum during diestrus of the first and second estrous cycles, as measured by area under the curve, were significantly greater in PEB than NEB cows.

The hormonal and(or) metabolic signals that mediate adverse effects of NEB on luteal function have not been elucidated. In the present study, we found that EB was positively associated with concentrations of IGF-I in serum. Because IGF-I is a potent stimulator of progesterone production by bovine luteal cells (McArdle and Holtorf, 1989) and IGF-I secretion is decreased during NEB (present study), IGF-I holds potential as a hormonal mediator of the effects of EB on luteal function.

Cows in NEB exhibited a lower frequency of estrus expression before the first postpartum ovulation (but not the second postpartum ovulation) than did cows in PEB. Similarly, lactating dairy cows exhibiting estrus at their first postpartum ovulation had a less severe NEB than did cows not exhibiting estrus (Berghorn et al., 1988). Estradiol, produced by ovarian follicles, is the primary

hormone stimulating estrous behavior in cattle. Reduced IGF-I secretion caused by NEB could alter ovarian follicular estradiol production, thereby suppressing expression of estrus. In support of this suggestion, in vitro studies (Hammond et al., 1988) have shown stimulatory effects of IGF-I on granulosa cell estradiol production. In addition, Spicer and Echternkamp (1986) have indicated that subnormal corpora lutea in postpartum cattle may be a result of poor follicular development prior to ovulation and luteinization. Further studies will be needed to determine whether reduced differentiation of granulosa cells (i.e., reduced estradiol production) is the cause of subsequent poor luteal function observed in NEB cows.

A study with beef cattle (Houseknecht et al., 1988) supports the idea that concentrations of IGF-I in serum may be an index of nutritional status. In addition to reduced IGF-I secretion, NEB is associated with reduced blood glucose and high NEFA and ketone bodies (Collier et al., 1984), suggesting that insufficient gluconeogenesis and enhanced fat mobilization and ketogenesis occurs during NEB. Although IGF-I stimulates lipogenesis in adipose tissue, the role of IGF-I, if any, in mobilizing energy stores awaits further elucidation.

In summary, results of the present study demonstrate that: 1) an increase in EB is associated with an increase in concentrations of IGF-I in serum during early lactation; 2) an increase in concentration of IGF-I is associated with increased progesterone secretion during diestrus of the first and second postpartum estrous cycles; and 3) fewer NEB than PEB cows exhibit estrus during their first estrous cycle. Thus, reduced ovarian activity that accompanies negative EB may be due, in part, to a decrease in concentration of IGF-I in serum. The potential exists to develop IGF-I-related techniques for enhancing estrus expression and, ultimately, improving reproductive efficiency in lactating dairy cattle.

Literature Cited

Aalseth, E.P. et al. 1983. A system for evaluating the body condition of dairy cows. Okla. Agr. Exp. Sta. Res. Rep. MP-114:261.

Berghorn, K.A. et al. 1988. Influence of energy balance on postpartum reproduction. In: Purdue Dairy Day Report. pp 65-74. Purdue Univ., W. Lafayette, IN.

Butler, W.R. and R.D. Smith. 1989. Interrelationships between energy balance and postpartum reproductive function in dairy cattle. J. Dairy Sci. 72:767.

Collier, R.J. et al. 1984. A review of endocrine regulation of metabolism during lactation. J. Anim. Sci. 49:498.

Hammond, J.M. et al. 1988. Paracrine and autocrine functions of growth factors in the ovarian follicle. J. Anim. Sci. 66 (Suppl. 2):21.

Houseknecht, K.L. et al. 1988. Effect of dietary energy source and level on serum growth hormone, insulin-like growth factor-I, growth and body composition in beef heifers. J. Anim. Sci. 66:2916.

McArdle, C.A. and A. P. Holtorf. 1989. Oxytocin and progesterone release from bovine corpus luteal cells in culture: Effects of insulin-like growth factor-I, insulin, and prostaglandins. Endocrinology 124:1278.

NRC. 1988. Nutrient Requirements of Dairy Cattle (6th Ed.). National Academy Press, Washington, DC.

Spicer, L.J. and S.E. Echternkamp. 1986. Ovarian follicular growth, function and turnover in cattle: A review. J. Anim. Sci. 62:428.

HAIR GROWTH OF CATTLE IS STIMULATED BY MELATONIN

R.P. Wettemann[1], S.C. Smith[2], K.S. Lusby[3], and H.A. Tucker[4]

Story in Brief

Yearling Hereford and Hereford x Angus steers were used to determine the effect of daily melatonin consumption on growth of hair. Treatment commenced on June 29 and steers were exposed to natural photoperiod. Melatonin was added to the daily diet of treated steers and was fed at 1:30 p.m.. At four weeks, steers treated with melatonin had longer hair on the hip than controls. At 12 weeks, steers treated with melatonin had 38% more hair on the shoulders than control steers. We conclude that oral consumption of melatonin commencing at the summer solstice increases hair growth in cattle.

(Key Words: Hair, Growth, Melatonin, Steer.)

Introduction

Duration of daily photoperiod controls hair growth in many species. Yeates (1955) demonstrated that if day lengths that cattle were exposed to were artificially reversed, hair growth pattern was also reversed. Photoperiod is the most important factor controlling hair growth in cattle; however temperature and nutrition can also influence hair growth. Cattle at the same latitude and time of year had a heavier hair coat at cooler temperatures (Berman and Volcani, 1961). Nutrition influences the shedding of hair in cattle (Yeates, 1958).

In most species, concentrations of melatonin, secreted by the pineal gland, are greater during periods of darkness than during light periods. Melatonin is orally active in the bovine. The objective of this study was to determine the effect of melatonin on hair growth of steers.

Materials and Methods

Twelve yearling Hereford and Hereford x Angus steers were used to determine the effect of daily feeding of melatonin on hair growth. Steers (744 ±

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55 lb) were randomly allotted to treatments and fed a diet to maintain weight for 12 weeks. Treatment started on June 29 and steers were exposed to natural photoperiod. Melatonin (1.8 mg/100 lb body weight) was added to the daily diet of treated steers (n=6) and was fed at 1:30 p.m. Hair growth and body weight were evaluated after 8 and 12 weeks of treatment. Hair was clipped at the shoulder and hip to evaluate hair weight per area (about 100 cm^2).

Results and Discussion

Daily gain of the steers was not influenced by treatment. Steers gained .71 lb/day. After eight weeks of melatonin treatment, treated steers had 23% more hair on the hip when compared with control steers (Table 1). Hair weight on the shoulder was also 38% greater in treated than control steers.

After 12 weeks of treatment, the amount of hair per unit area was 38% greater on the shoulders of treated steers when compared with control steers. The increased amount of hair at week 12 (September 21) in control steers, compared to amount at week 8 (August 24) is most likely caused by the natural stimulation of decreasing day length. During shorter days, greater amounts of melatonin are secreted by the pineal gland of many animals. We conclude that increased hair coat in cattle during decreased day length is probably regulated by increased secretion of melatonin by the pineal.

Table 1. Influence of melantonin on gain and hair weight of steers.

Criteria	Week of treatment	Treatment		
		Control	Melatonin	SE
Daily gain, lb		.16	.13	.02
Hair weight (mg/cm^2)				
Hip[a]	8	10.99	13.49	.89
Shoulder[b]	8	6.97	9.60	1.11
Hip	12	15.57	17.70	1.78
Shoulder[c]	12	10.36	14.27	.72

[a] Treatments differ (P<.15).
[b] Treatments differ (P<.06).
[c] Treatments differ (P<.005).

Literature Cited

Berman, A. and R. Volcani. 1961. Seasonal and regional variation in coat characteristics of dairy cattle. Aust. J. Agric. Res. 12:528.

Yeates, N.T.M. 1955. Photoperiodicity in cattle. I. Seasonal changes in coat character and their importance in heat regulation. Aust. J. Agric. Res. 6:891.

Yeates, N.T.M. 1958. Observations on the role of nutrition in coat shedding in cattle. J. Agric. Sci. Camb. 50:110.

IMPLANT EFFECTS ON BONELESS SUBPRIMAL YIELDS AND BOXED BEEF VALUE

C.P. Foutz[1], H.G. Dolezal[2], D.R. Gill[3], T.L. Gardner[1] and J.L. Hensley[1]

Story in Brief

Crossbred yearling steers (n=140) weighing 778 lb were allocated to one of five implant treatments: Nonimplanted = Control; Synovex-S on day 1; Revalor on day 1; Synovex-S + Trenbolone acetate (TBA) on day 1; Synovex-S + TBA on day 1 with a reimplant of TBA on day 58. Steers were fed for 119 to 126 days on a high concentrate finishing diet and slaughtered. A subsample of 40 carcasses equally distributed across implant treatment and weight block were selected for fabrication into boneless, trimmed subprimals to determine boxed beef cutout yields and values. Fat thickness, percentage kidney, pelvic and heart fat and marbling score were unaffected by implants. Larger ribeyes and more desirable yield grades were observed for TBA implanted steers than for controls. The percentage of choice carcasses was lowest for steers receiving Revalor. Compared to controls, absolute weight and percentage yields of subprimal and total side lean were higher for implanted steers; the most notable increases occurred in TBA treatments. Likewise percentage of fat trim to .25 inch was lowest for implanted steers. By increasing weight, TBA increased absolute carcass value, however due to a reduced percentage of choice, carcass value/cwt was lower for Revalor and double TBA implanted steers than for controls. Boxed beef cutout values ranged from $0.76 to $1.96/cwt higher for implanted steers compared to controls. Based on these values, increased subprimal yields associated with implants (particularly TBA) apparently offset discounts in carcass prices resulting from lower percentages of choice.

(Key Words: Steers, Implants, Carcass, Cutability, Subprimals.)

Introduction

Exogenous sources of anabolic steroids in the form of subcutaneous implants are used extensively in the cattle feeding industry. In the United

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States, estrogenic implants have been used commercially for over 30 years and recently the androgenic compound trenbolone acetate (TBA), a synthetic analogue of testosterone, was approved. Extensive research has shown that estrogenic implants and TBA increase average daily gain, improve feed efficiency and often increase muscle mass. The exact mode of action for these anabolic compounds is not known although it is postulated that estrogen increases the rate of protein synthesis while TBA decreases the rate of protein catabolism. It is thought that the modes of action are independent and therefore improvements in performance above that of a single implant of estrogen or TBA can be realized when the two are combined.

Traditionally, slaughter cattle are marketed on a live or carcass (grade and yield) basis. Regardless of marketing scheme used, absolute weight is extremely important since producers receive payment on a per pound basis. Until the advent of USDA yield grades in the 1960's, there was no systematic method to assess carcass merit based on cutability; dressing percentage and quality grade were the two traits with the greatest impact on carcass value. Because dressing percentage and quality grade are positively correlated with carcass fatness, cattle which are over fattened by today's standards, often receive the highest prices when marketed on a grade and yield basis. Quality grade still remains important in carcass pricing, but with the shift in consumer preference towards leaner beef, yield grade or cutability also influences carcass value.

The extent to which USDA yield grades are used to reflect cutability-based value differences is limited. Presently, the only large discrepancy in price is a discount for Yield Grade 4 and 5 carcasses and retail trim levels are much lower (0 - .25 inch) than the .5 inch trim level that yield grades were initially designed to reflect. Furthermore, boxed beef has virtually eliminated historical carcass beef as the method of trade between packer and retailer. Although, the USDA National Carlot Meat Report provides carcass beef prices, these values are becoming more unreliable based on limited volume of trade. Conversely, "boxed beef cut-out value", a reflection of the composite price of major subprimals, is based on a much higher volume of trade and is becoming a more reliable method for determining value. Currently, the National Association of Meat Purveyors (NAMP) Institutional Meat Purchase Specifications (IMPS) for boxed beef require only that external fat not exceed 1 inch in thickness. Perhaps if a standard fat trim level more indicative of retail trim levels was established for boxed beef subprimals, cutout value would become an even more accurate method to assess value differences based on cutability.

At the feedlot level, implants improve profitability by increasing live gains and improving feed efficiency. At the packer and retail levels, composition and quality as well as weight are important economically. Increased growth in the form of muscle is beneficial to both producer and packer; unfortunately, the use of implants has also been associated with decreased numbers of cattle grading choice (Cross and Belk, 1989; Foutz et al., 1989). The objectives of this study

were twofold: 1) to examine the effect of implant protocol on carcass grade traits as well as boxed beef subprimal yields at two fat trim levels (1.0 inch and .25 inch) and 2) to examine possible value differences in the cattle relative to different implant programs.

Materials and Methods

One hundred forty crossbred yearling steers were obtained from wheat pasture in late March and shipped to Oklahoma State University where they were individually weighed, tagged and processed. The steers were blocked by initial weight into four different weight replications and assigned to one of five implant treatments: nonimplanted = Control (C); Synovex-S (20 mg estradiol benzoate + 120 mg progesterone) on day 1 (S); Revalor[4] (20 mg estradiol benzoate + 140 mg TBA) on day 1 (R); Synovex-S + Finaplix-S (140 mg TBA) on day 1 (ST); Synovex-S + Finaplix-S on day 1 with reimplants of Finaplix-S on day 58 (STT). Steers in the same weight replication and treatment (n=7) were assigned to one of 20 pens and were fed a typical high concentrate finishing diet. The two heavier replications of steers were commercially slaughtered after 119 days and the two lighter replications slaughtered after 126 days on feed.

Quality and yield grade data were collected approximately 24 h after slaughter (USDA, 1989). Two carcasses with carcass weights closest to the mean of their respective pen were selected for a boxed beef cutout subsample. Carcasses in the subsample were equally distributed across weight replication and implant treatment, but were selected independent of quality and yield grade. The left side of each carcass in the subsample was shipped to the Oklahoma State University Meat Laboratory for fabrication into boneless subprimals. Sides were initially fabricated into the four major wholesale cuts (round, loin, rib and chuck) and further fabricated into the subprimals as listed in the USDA National Carlot Meat Report to determine boxed beef cutout value (Table 1). Weights were recorded for the untrimmed subprimals and at two subcutaneous fat trim levels (1.0 inch and .25 inch). The quantity of seam fat in chucks is relatively large because of the large number of muscles comprising this cut. Therefore, seam fat was trimmed to approximately .25 inch along with external fat. The minor wholesale cuts (foreshank, plate and flank) were fabricated into the various items reported in the Blue Sheet to determine carcass credit value. Weights for 1.0 inch fat trim, .25 inch fat trim, total retail product (trimmed to .25 inch) and total bone were recorded for each side. Component percentages were calculated using aggregate side weight.

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[4]Currently, **Revalor is not FDA approved** for commercial use.

Boxed beef cutout value was calculated using Blue Sheet prices current at the time of slaughter (Table 1). The price listed for choice carcasses was $104/cwt with discounts of $12/cwt and $6/cwt for Yield Grade 4 and select carcasses, respectively. A standard kill cost of $23.00/head and a fabrication-boxing cost of $40.00/carcass were assumed. Blue Sheet prices of $8.30/cwt live weight and $25.67/cwt carcass weight were used for drop credit (hide, blood, offal etc.) and carcass credit (minor subprimals, fat trim etc.) values, respectively. Total dollar value and value/cwt were calculated for each carcass and estimated live values were derived from these calculations. Whole carcass and corresponding live values for the subsample (n=40) and entire data (n=137) set were determined using the respective grade data for each group. Boxed beef prices were calculated for the subsample, but due to a disparity in the percentage of choice carcasses between the subsample and overall data set, boxed beef prices were also determined by adjusting values to reflect that of the entire data set.

Previous studies have indicated that TBA tends to magnify masculinity characteristics in steers, particularly in the development of the neck and

Table 1. Boxed-Beef pricing schedule.[a]

IMPS	Cut name	Price/cwt	
		Choice	Select
112A	Ribeye Roll (lip-on)	$340.00	$315.00
115	Chuck, 2 piece, boneless	114.50	114.00
120	Brisket (boneless)	102.00	100.00
167	Knuckle	147.00	144.00
168	Top Inside Round	163.00	162.00
170	Bottom Gooseneck Round	125.00	123.00
180	Strip Loin, boneless	293.00	258.00
184	Top Sirloin Butt	207.00	201.00
185A	Bottom Sirloin Flap	225.00	225.00
185B	Bottom Sirloin Ball-tip	198.00	156.00
185C	Bottom Sirloin Tri-tip	175.00	175.00
189A	Tenderloin, defatted	525.00	465.00
	Credits Value	25.67	25.67
	Blue Sheet Value	112.87	108.89

[a] Prices based on the USDA National Carlot Meat Report (Blue Sheet) July 24, 1989.

shoulders (Foutz et al., 1989). Development of the crest muscle, pizzle eye (crus of penis) and bald spot (bulbo-cavernosus muscle) was subjectively scored for each carcass using a 5 point bullock score (5 = no bullock tendencies, 1 = extremely severe bullock tendencies). Individual weight of the splenius (crest) muscle was recorded after fabrication of the chuck. Additionally, semitendinosus muscle (eye of round) weights were recorded to determine if implants affect muscle development differently at a posterior anatomical location.

Statistical analysis of grade traits and carcass components was conducted using least squares means with treatment and weight replication included in the model as main effects. No apparent interactions were observed between weight replication and implant treatment. Contrasts were conducted for effects of all implants compared to controls (CI); TBA+estradiol (treatments R, ST and STT) compared to controls (CT) and Synovex-S only (ST); TBA on day 1 and day 58 compared to TBA on day 1 only (EL). Significance was reported at the .05 and .10 probability levels. The various boxed beef cutout, carcass and live values shown in Figures 1-6, were not statistically partitioned since they are highly dependent on current market prices.

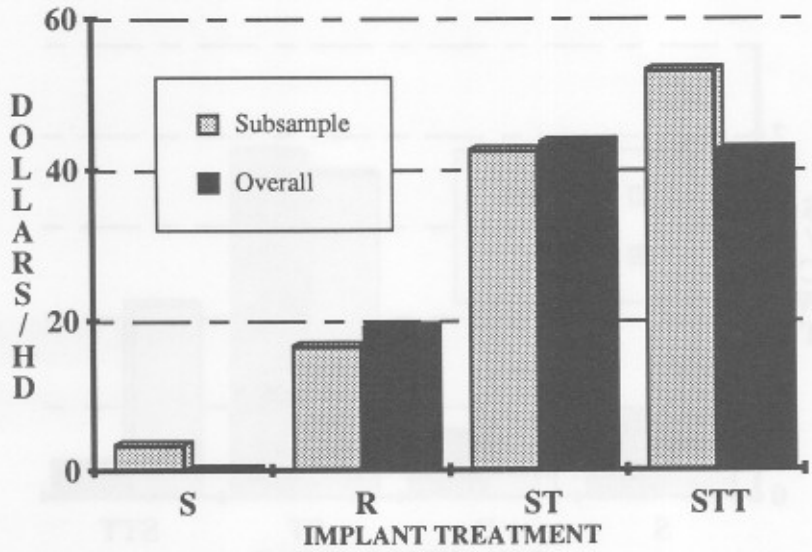

Figure 1. Absolute boxed beef value differences of implanted steers compared to controls (See text for explanation of implant treatment).

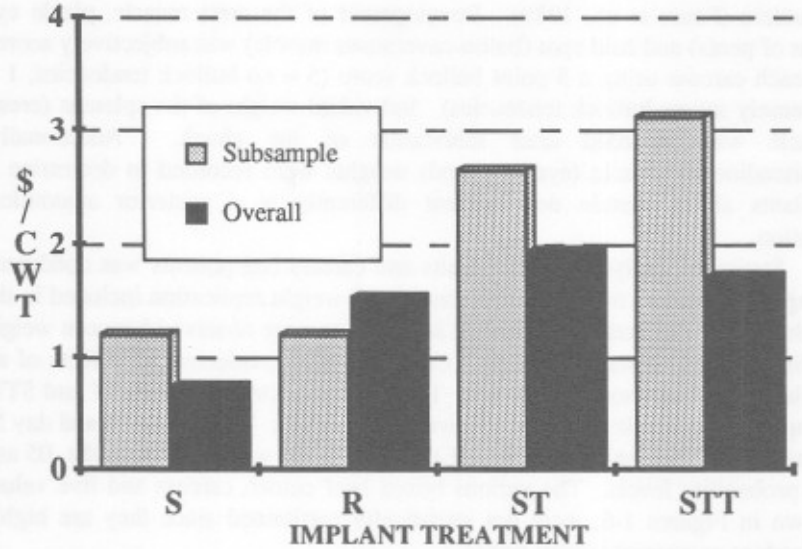

Figure 2. Boxed beef cutout value differences of implanted steers compared to controls (See text for explanation of implant treatment).

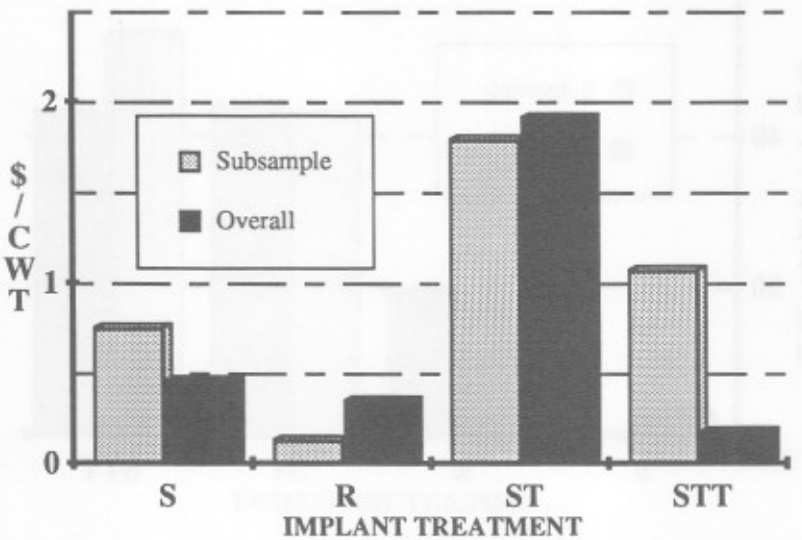

Figure 3. Boxed beef adjusted live value differences of implanted steers compared to controls (See text for explanation of implant treatment).

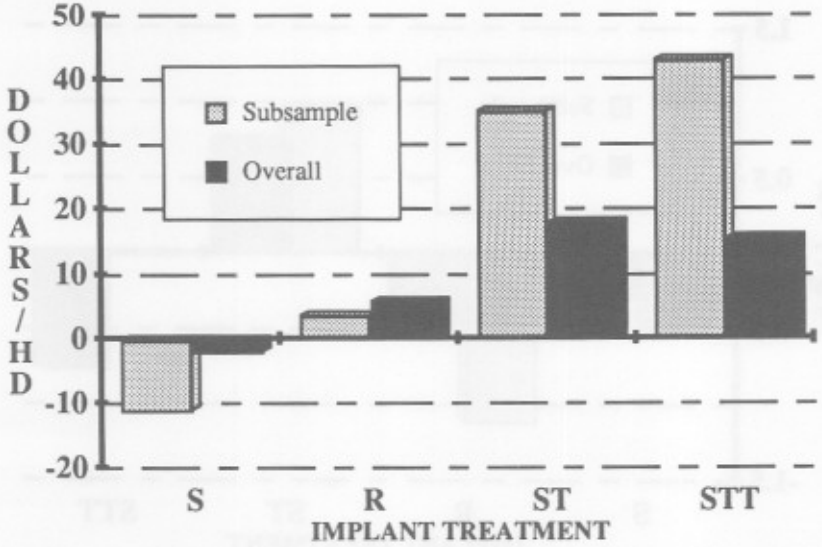

Figure 4. Absolute carcass beef value differences of implanted steers compared to controls (See text for explanation of implant treatment).

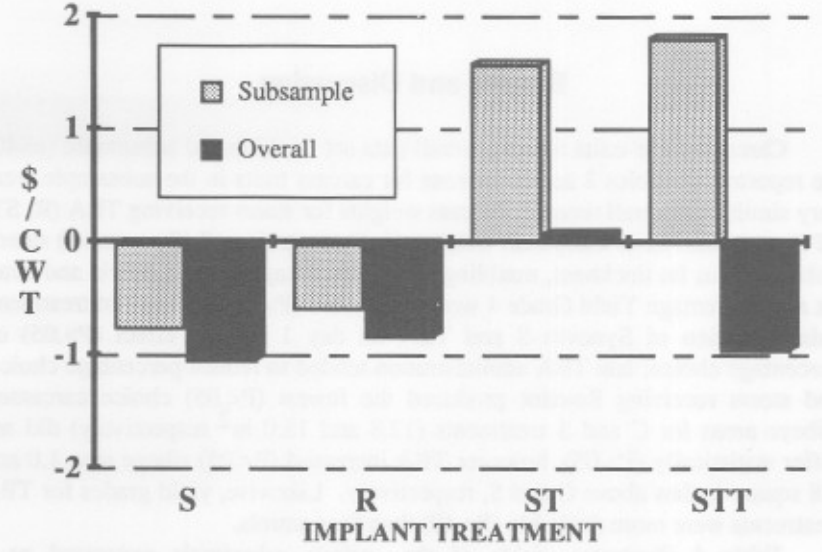

Figure 5. Carcass value differences of implanted steers compared to controls (See text for explanation of implant treatment).

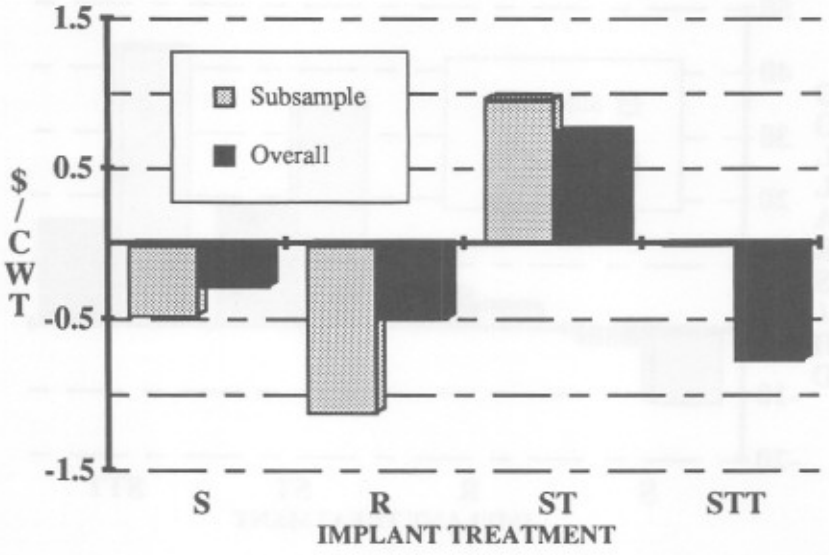

Figure 6. Carcass adjusted live value differences of implanted steers compared to controls (See text for explanation of implant treatment).

Results and Discussion

Carcass grade traits for the overall data set (n=137) and subsample (n=40) are reported in Tables 2 and 3. Means for carcass traits in the subsample were very similar to overall means. Carcass weights for steers receiving TBA (R, ST, STT) were heavier (P<.05) than weights for C (control) or S (Synovex-S) steers. Subcutaneous fat thickness, marbling score, percentage kidney, pelvic and heart fat and percentage Yield Grade 4 were unaffected (P>.05) by implant treatment. Administration of Synovex-S and TBA on day 1 had no effect (P>.05) on percentage choice; late TBA administration tended to reduce percentage choice, and steers receiving Revalor produced the fewest (P<.05) choice carcasses. Ribeye areas for C and S treatments (12.8 and 13.0 in^2 respectively) did not differ statistically (P>.05), however TBA increased (P<.05) ribeye area 1.0 and 0.8 square inches above C and S, respectively. Likewise, yield grades for TBA treatments were more desirable (P<.10) than for controls.

Table 4 illustrates yields of the various subprimals expressed as a percentage of side weight. Yields exhibited a positive numerical response to implants in 34 of the 40 observations, but most differences were too slight for

Table 2. Overall carcass traits as stratified by implant treatment.

	Treatment[a]						
	C	S	R	ST	STT	SE	Effect[b]
No. of carcasses	28	27	27	27	28		
Carcass weight, lb	751	740	763	767	771	5.39	CT ST
Fat thickness, in	.59	.61	.53	.55	.57	.04	
Ribeye area, in^2	12.8	13.0	13.7	13.8	13.8	.26	CI CT ST
KPH fat, %	2.1	2.0	2.1	2.1	2.0	.06	
Yield Grade	3.2	3.1	2.8	2.8	2.8	.15	ct
Percent YG 4	7.1	14.2	0	7.7	10.7	6.66	
Marbling score[c]	463	435	418	447	438	14.7	
Percentage Choice	82.1	82.1	51.8	85.7	71.4	7.87	
Bullock score[d]	4.6	4.6	4.3	4.4	4.1	.10	CT ST EL

[a] Implant treatments: C = control (non-implanted); S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.

[b] Contrast effects:
CI (P<.05), ci (P<.10) = control versus all implants;
CT (P<.05), ct (P<.10) = control versus treatments with TBA;
ST (P<.05), st (P<.10) = Synovex-S versus treatments with TBA;
EL (P<.05), el (P<.10) = early versus late TBA administration.

[c] Marbling score: 400 to 499 = "small" corresponding to choice.

[d] Bullock score: 5 = no evidence; 4 = slight bullock tendencies.

significance. Boneless chuck (IMPS 115) yields were higher for implanted compared to control steers and TBA increased yield above Synovex-S alone (P<.05). Striploin (IMPS 180) yields were also significantly higher for implanted compared to nonimplanted steers. Overall, implants increased (P<.05) cumulative subprimal yields by 0.8, 2.4, 2.7 and 1.7% for S, R, ST and STT, respectively, over controls.

Values for subprimal lean, total side lean, fat trim and side bone are presented in Table 5. An increase in muscling due to TBA was observed. Steers receiving TBA produced more total pounds of subprimal and total lean (trimmed to .25 inch fat) than C or S steers (P<.05). TBA increased total lean yields by 2.8 and 2.4% above C and S, respectively. Apparently, reimplants of TBA on day 58 did not increase muscling beyond TBA on day 1 only. Fat trim

Table 3. Subsample carcass traits as stratified by implant treatment.

	Treatment[a]						
	C	S	R	ST	STT	SE	Effect[b]
No. of carcasses	8	8	8	8	8		
Live weight, lb	1142	1135	1165	1173	1202	15.1	CT ST
Hot carcass wt, lb	746	741	754	766	772	7.59	CT ST
Fat thickness, in	.63	.64	.54	.52	.63	.07	
KPH fat, %	2.3	2.1	1.9	2.2	2.0	.16	CI
Ribeye area, in^2	12.4	12.6	13.3	13.9	14.1	.40	CT ST
Yield grade	3.4	3.3	2.8	2.7	2.9	.25	ci CT st
Percent YG 4, %	12.5	25.0	0.0	0.0	12.5	10.9	
Marbling score[c]	436	411	385	460	459	23.1	
Percent Choice, %	75.0	87.5	37.5	75.0	100	14.3	

[a] Implant treatments: C = control (non-implanted); S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.

[b] Contrast effects:
CI (P<.05), ci (P<.10) = control versus all implants; CT (P<.05), ct (P<.10) = control versus treatments with TBA; ST (P<.05), st (P<.10) = Synovex-S versus treatments with TBA.

[c] Marbling score: 300 = "slight" = select; 400 = "small" = lower 1/3 of choice.

was inversely related to lean yields with larger differences occurring at the .25 rather than 1.0 inch level. Although no differences were noted in fat thickness or internal fat at the carcass level for the subsample, TBA carcasses produced fewer total pounds of fat at the .25 inch trim level than controls (P<.05). Percentage of fat trim at the 1.0 and .25 inch levels was likewise lowest for TBA treatments. The increase in total bone weight due to implants can be attributed to heavier carcass weights as no significant differences (P>.05) were noted in the proportion of bone.

Development of the splenius (crest) muscle is illustrated in Table 6. Absolute weights for splenius muscle and chuck lean were heaviest (P<.05) for steers receiving TBA. Absolute weight alone is not a strong indicator of splenius development since it could reflect an increase in overall weight,

Table 4. Boneless trimmed (.25 inch) subprimal yields expressed as a percentage of cumulative side weight.

	Treatment[a]						
	C	S	R	ST	STT	SE	Effect[b]
No. of cuts	8	8	8	8	8		
112A Ribeye roll	2.91	2.83	2.94	3.05	3.02	.08	st
115 Bnls chuck	17.91	18.16	19.29	18.92	18.99	.36	CI CT ST
120 Brisket	2.61	2.66	2.40	2.86	2.56	.10	EL
167 Knuckle	2.51	2.72	2.48	2.71	2.64	.08	
168 Top round	4.96	5.11	5.22	5.16	5.08	.11	
170 Btm round	6.88	6.92	7.10	7.15	6.93	.13	
180 Striploin	3.00	3.12	3.37	3.22	3.18	.09	CI CT
184 Top sirloin	2.76	2.89	2.89	2.93	2.89	.10	
185 Btm sirloin[c]	1.87	1.79	2.07	1.98	1.78	.10	
189A Tenderloin	1.43	1.45	1.49	1.56	1.50	.04	ct
Total primal lean increase, %	----	.81	2.41	2.70	1.73	.71	CI CT st

[a] Implant treatments: C = control (non-implanted) S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.

[b] Contrast effects:
CI (P<.05), ci (P<.10) = control versus all implants;
CT (P<.05), ct (P<.10) = control versus treatments with TBA;
ST (P<.05), st (P<.10) = Synovex-S versus treatments with TBA;
EL (P<.05), el (P<.10) = early versus late TBA administration.

[c] 185 Bottom sirloin represents the combination of 185A-flap, 185B-ball tip and 185C-triangle.

Table 5. Side boxed beef lean, fat trim and bone weights and percentages.

	Treatment[a]						
	C	S	R	ST	STT	SE	Effect[b]
No. of sides	8	8	8	8	8		
Primal lean, lb[c]	168.5	170.8	178.8	182.5	180.9	2.83	CI CT ST
Side lean, lb	226.3	226.8	239.1	244.4	242.2	3.78	CI CT ST
Fat trim 1", lb	56.4	53.4	49.2	49.8	53.9	2.78	
Fat trim .25", lb	87.4	82.5	75.7	75.1	81.9	4.19	ci CT
Side bone, lb	45.6	49.0	48.4	48.8	48.1	1.24	CI ct
Primal lean, %	46.8	47.6	49.3	49.6	48.6	.71	CI CT st
Side lean, %	62.9	63.3	65.8	66.3	65.0	.89	CI CT ST
Fat trim 1", %	15.8	14.9	13.6	13.5	14.5	.75	ci CT
Fat trim .25", %	24.4	23.0	20.9	20.4	22.1	1.12	CI CT
Side bone, %	12.7	13.7	13.3	13.3	12.9	.34	

[a] Implant treatments: C = control (non-implanted); S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.

[b] Contrast effects:
CI (P<.05), ci (P<.10) = Control versus all implants;
CT (P<.05), ct (P<.10) = Control versus treatments with TBA;
ST (P<.05), st (P<.10) = Synovex-S versus treatments with TBA.

[c] Primal lean consists of the 12 major boneless subprimals used to calculate boxed beef cutout value.

however a slight increase in splenius development was detected when expressed as a percentage of chuck lean. Bullock scores were also slightly elevated (P<.05) for the same treatments. Although statistically significant, differences noted in bullock score and splenius development in this study were considered too slight for practical implication.

Figures 1 through 6 summarize boxed beef cutout values, whole carcass (grade and yield) values and corresponding calculated live values. Percentage choice for the various treatments differed between the subsample and overall data sets. Because of a larger number of observations, means for carcass traits in the overall data set were presumed to be more accurate than subsample means. Values for the subsample are presented, but only the overall means are addressed in our discussion.

Table 6. Splenius muscle development.

	Treatment[a]						
	C	S	R	ST	STT	SE	Effect[b]
No. of samples	8	8	8	8	8		
Splenius, lb[c]	1.40	1.60	1.94	1.79	1.69	.11	CI CT
Chuck lean, lb	69.01	69.93	74.70	74.73	75.50	1.41	CI CT ST
Splenius/chuck lean, %	2.03	2.28	2.60	2.39	2.22	.14	CI CT
Splenius ratio[d]	.35	.38	.42	.37	.37	.02	

[a] Implant treatments: C = control (non-implanted); S = Synovex-S on day 1; R = Revalor on day 1; ST = Synovex-S + TBA on day 1; STT = Synovex-S + TBA on day 1 and TBA reimplanted on day 58.

[b] Contrast effects:
CI (P<.05), ci (P<.10) = Control versus all implants;
CT (P<.05), ct (P<.10) = Control versus treatments with TBA;
ST (P<.05), st (P<.10) = Synovex-S versus treatments with TBA.

[c] Splenius weight is the dissected weight of the crest muscle.

[d] Splenius muscle weight divided by semitendinosus muscle (eye of round) weight.

Boxed beef value determinations

Administration of implants enhanced total boxed beef value per/head with the largest increases of $43.86 and $42.85 for ST and STT treatments, respectively. A portion of this increase is attributed to an increase in absolute weight although ST and STT treatments did maintain respective advantages of $1.96/cwt and $1.74/cwt over controls. Advantages of $0.76/cwt and $1.55/cwt were also observed in S and R treatments, respectively, over controls. Percentage choice for S and ST were very comparable to controls, but R and STT exhibited substantially fewer choice carcasses, suggesting the advantage in boxed beef cutout value for all implant treatments was largely due to increased cutability or subprimal yields. Corresponding adjusted live cattle values were $0.47, $0.36, $1.92 and $0.19/cwt higher for S, R, ST, and STT, respectively, over controls. Synovex-S steers surpassed Revalor steers in live value/cwt; the disparity between boxed and live value differences for these two treatments can be partially explained by the slightly higher dressing percentage of steers in the S treatment.

Traditional carcass value determinations

Interestingly, carcass (grade and yield) prices did not follow the same pattern as boxed beef cutout prices. Compared to controls, total carcass value/head was higher for TBA (R, ST and STT) steers while lower for S steers. Carcass price/cwt surpassed controls in the ST group only, and was lower than controls in other treatments (-$1.05, -$0.84 and -$0.96/cwt for S, R, and STT, respectively). All carcasses ranged between 600 and 850 lb and, accordingly, quality and yield grade were the primary determinants of price/cwt. Lower carcass prices in the S treatment can be attributed to the higher number of yield grade 4 carcasses whereas R and STT steers were discounted because of a lower number of choice carcasses. Adjusted live value/cwt differences followed the same relative trend.

Summary

The increase in muscling for steers in this study receiving a combination of TBA and an estrogen was apparent both in ribeye area and lean yields. Additionally, the tendency for fewer choice carcasses associated with late administration of TBA is consistent with prior studies (Foutz et al., 1989). Since TBA was not evaluated as a single implant, it is difficult to determine the proportion of differences in traits specifically due to TBA. Reimplants of TBA on day 58 did not yield additional improvements in muscling beyond TBA implants on day 1 only, but a slight reduction in percentage choice occurred. Although the dosage levels of TBA (140 mg) and estradiol (20 mg) are identical for Revalor and combined implants of Synovex-S and Finaplix-S, steers in R and ST treatments did not exhibit the same response across all traits.

Boxed beef pricing is a step closer to consumer demands than historical carcass pricing. The disparity in relative value differences using boxed beef cutout and whole carcass pricing schemes indicates that boxed beef cutout value may send a stronger message from consumers to cattlemen concerning the net worth of their end product. This could be strengthened if boxed beef fat trim levels are standardized to coincide with ultimate retail trim levels (*.25 inch or less*). The use of implants increased boxed beef value in this study despite reduced percentages of choice in two treatments. This value increase may be attributed primarily to increased subprimal yields. Attempts to relate the use of implants to end product value are limited and additional research is need in this area to strengthen predictions.

Literature Cited

Cross, H.R. and Belk, K.E. 1989. Two edged sword: Anabolic implants improve yield, hinder quality. Beef. Vol. 26, No. 1A:11.

Foutz, C.P. et al. 1989. Effects of trenbolone acetate in yearling feedlot steers on carcass grade traits and shear force. Okla. Agr. Exp. Sta. Res. Rep. MP -127:272.

USDA. 1989. Official United States standards for grades of carcass beef. AMS-USDA, Washington, DC.

EFECT OF PORCINE SOMATOTROPIN AND SEX-CLASS ON PORK CARCASS CHEMICAL COMPOSITION

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Story in Brief

Thirty hogs (15 gilts and 15 barrows) were allocated to one of five treatments receiving 0 (control), .71, 1.43, 2.86, or 4.29 mg/day of porcine somatotropin (pST). Hogs were slaughtered upon attaining an individual live weight of 230 lb. Left sides were physically separated into lean, inseparable lean, fat and bone components. Additionally, the femur and tenth rib bones were collected from each side. Proximate analysis was performed in triplicate on a subsample from each tissue aggregate and bone group. Hogs treated with 2.86 mg/day or more of somatotropin had lower levels of lipid and higher protein, moisture and ash levels than control hogs. No additional improvement in carcass chemical composition was attained by increasing pST level to 4.29 mg/day. Gilt carcasses had lower percentages of total lipid and higher percentages of protein and moisture than barrow carcasses.

(Key Words: Porcine Somatotropin, Sex Class, Carcass Composition.)

Introduction

Because of consumer concerns emphasizing a reduction in caloric intake from dietary fat, retailers and meat processors have become increasingly concerned with product fat levels. Therefore, methods of producing trimmer carcasses should be expanded to meet demand. 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 ultimately decrease lipid accumulation and increase protein synthesis in market weight hogs.

The dosage level of somatotropin for optimum efficiency has not been determined. Previously, analysis of carcass grade traits and cooking properties revealed that somatotropin treatments of 1.43 mg/day produced trimmer carcasses with no adverse effects on cooking properties when compared to non-treated controls (Gardner et al., 1989). Additional information is needed to

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further examine the impact of growth hormone on carcass chemical composition. Physical dissection accompanied by chemical analysis is considered an ideal endpoint for measurement of carcass composition (Cross, 1982). Therefore, the objective of this study was to examine the effects of porcine somatotropin, administered daily, on barrow and gilt carcass chemical composition.

Materials and Methods

Complete background information (slaughter, carcass grade and cookery data) was previously reported by Gardner et al. (1989). Briefly, 15 gilts and 15 barrows were allocated across five treatment groups and administered porcine somatotropin (pST) as follows: none (control), .71, 1.43, 2.86, and 4.29/mg/day.

Approximately 48 h postmortem, the left side of each carcass was physically separated into lean, inseparable lean (a combination of fat and lean tissues trimmed from bone), fat, bone and skin components. Soft tissue aggregates were weighed and then ground (Biro Model 5424852) individually through a .375 inch plate. Samples were ground a second time through a .125 inch plate. One-pound samples were collected randomly from the second grind and frozen at -22°F. The frozen samples from each tissue group were cubed using a band saw (Biro Model 44), immersed in liquid nitrogen and subsequently powdered in a Waring Commercial Blendor (Model 34BL22). Powdered samples were stored in whirl-pack bags at -22°F until proximate analysis was performed.

All aggregate samples were analyzed in triplicate. Samples were dried at 216°F for 24 h to determine moisture content. Lipid content was determined by ether extraction. Protein analysis was performed with a KJELTEC Auto 1030 Analyzer. Ash was measured after samples were held 8 h at 1250°F in an oven.

The femur and 10th rib bone were obtained from each side for proximate analysis. Bone samples were trimmed of any remaining external tissue, vacuum packaged and stored at -22°F. These samples were placed in liquid nitrogen and pulverized (Micro Mill 372520000) until powdered. Previously described procedures were used for triplicate proximate analysis of rib and femur bones.

Data were analyzed using the model of treatment, sex-class and the treatment x sex-class interaction. Least squares means were partitioned following dosage-based contrasts (control versus pooled and individual treatment groups).

Results and Discussion

Least squares means for protein, lipid, moisture and ash content stratified by tissue group and somatotropin treatment level are reported in Table 1.

Table 1. Pounds of soft tissue protein, lipid, moisture, and ash stratified by porcine somatotropin (pST) dosage.

	pST dose, mg/d						
Item	0	.71	1.43	2.86	4.29	SE	P[a]
Lean:							
protein	5.6	5.9	6.3	6.5*	6.3	.25	.10
lipid	1.4	1.6	1.6	1.7	1.4	.15	.55
moisture	19.3	20.8	22.0*	23.4**	22.6*	.81	.018
ash	.28	.31	.32*	.35**	.33*	.013	.018
IS Lean[b]:							
protein	2.6	2.6	2.6	2.9	2.8	.12	.24
lipid	3.0	3.0	2.7	2.6	2.5	.25	.51
moisture	9.1	9.4	9.4	10.4	10.6	.56	.26
ash	.13	.14	.14	.15	.15	.008	.30
Fat:							
protein	.93	.95	.95	.94	.88	.07	.96
lipid	24.1	21.9	19.2	15.0**	15.7**	1.64	.003
moisture	2.8	2.9	2.9	2.5	2.8	0.12	.17
ash	.05	.05	.05	.04	.04	.002	.18
Total:							
protein	9.1	9.4	9.9	10.4*	10.0	.32	.08
lipid	28.5	26.4	23.5	19.3**	19.6**	1.75	.004
moisture	31.2	33.1	34.4*	36.3**	36.0**	1.00	.016
ash	.46	.49	.51*	.54**	.52*	.016	.02
Protein/Water ratio	.29	.28	.28	.28	.27*	.003	.22
Protein/Lipid ratio	.35	.36	.43	.55**	.52**	.03	.002

[a] Probability of treatment effect. Mean differs from that of negative control * P<.05; ** P<.01.

[b] IS Lean = Inseparable lean and fat.

Consistent improvement in side chemical composition was attained once pST dosage level reached 2.86 mg/day. The latter treatment group had higher ($P<.05$) weights of protein, moisture and ash as well as less ($P<.05$) total lipid than the control group. This resulted from higher protein, moisture and ash levels in the lean component and lower lipid levels in the fatty tissue. Protein-to-lipid ratios were also highest for the 2.86 mg/day level. Little additional enhancement was achieved in chemical composition by increasing the pST dosage level to 4.29 mg/day.

Similar trends were evident for chemical composition data expressed as a percentage of side weight (Table 2). Hogs treated with 2.86 mg pST/day produced carcasses with higher ($P<.05$) percentages of protein, moisture and ash; lower ($P<.05$) percentages of ether-extractible lipid.

The effects of pST level on femur and rib bone chemical composition are presented in Table 3. A dosage level of 2.86 mg/day resulted in an increased femur weight, a higher percentage of moisture (femur and rib) and a decreased percentage of ash (femur and rib). Percentages of protein and lipid remained unchanged regardless of pST dosage level.

Chemical composition data stratified by sex-class are presented in Tables 4, 5 and 6. Gilts had a greater amount of protein from inseparable lean and total soft tissue coupled with an increased amount of moisture from fat tissue than barrows (Table 4). Also, gilts had decreased amounts of lipid from fat and total soft tissue, and increased amounts of moisture and ash from total soft tissue. The protein/lipid ratio was higher ($P<.05$) for gilts. Gilts had higher percentages of moisture and protein in fat and total soft tissue, increased ash percentage in fat tissue, and a greater percentage of moisture in lean tissue ($P<.05$). Furthermore, gilts possessed a lower ($P<.05$) percentage of lipid in lean, fat and total soft tissue. Proximate analysis indicated that gilts had increased lipid and decreased moisture percentages in femurs. Sex class effects were not significant for rib chemical composition.

The proximate analysis of the soft tissue components indicate that a dosage level of 2.86 mg/day or more decreases lipid and increases protein and moisture. Additionally, gilt carcasses have higher protein and moisture levels as well as lower lipid contents than barrow carcasses.

Table 2. Proximate analyses of soft tissue components stratified by porcine somatotropin (pST) dosage.

	pST dose, mg/d						
Item	0	.71	1.43	2.86	4.29	SE	P[a]
Lean:							
protein %	20.84	20.48	20.82	20.34	20.4	30.21	.37
lipid %	5.23	5.54	5.34	5.32	4.5	10.55	.73
moisture %	72.04	72.20	72.78	73.01*	73.49**	.26	.005
ash %	1.04	1.06	1.07	1.08*	1.07	.01	.24
IS Lean[b]:							
protein %	16.66	16.53	17.11	17.51	16.97	.35	.34
lipid %	20.01	19.02	17.73	15.62	15.37	1.67	.24
moisture %	59.24	60.38	61.01	62.72	62.94	1.41	.32
ash %	.85	.87	.88	.91	.90	.02	.53
Fat:							
protein %	3.45	3.61	4.02	5.09*	4.53	.49	.16
lipid %	83.49	82.92	81.06	75.78*	78.26	1.95	.056
moisture %	10.37	10.96	12.43	13.29*	14.58**	0.82	.011
ash %	.17	.18	.20	.21*	.21*	.01	.10
Total:							
protein %	10.82	11.15	11.90	12.62**	12.18*	0.40	.03
lipid %	33.83	31.29	28.25	23.42**	23.86**	2.00	.005
moisture %	37.19	39.14	41.34*	44.23**	43.87**	1.34	.005
ash %	.54	.58	.61*	.66**	.64**	.02	.009

[a] Probability of treatment effect. Mean differs from that of negative control * P<.05; ** P<.01.

[b] IS Lean = Inseparable lean and fat.

Table 3. Effect of porcine somatotropin (pST) dose on weight and proximate analyses of femur and rib bones.

Item	pST dose, mg					SE	P[a]
	0	.71	1.43	2.86	4.29		
Femur:							
weight, oz.	8.9	9.3	9.5	9.9*	9.6	.26	.15
protein, oz.	1.4	1.5	1.6*	1.6*	1.5	.04	.12
moisture, oz.	2.6	2.7	2.8*	3.1**	3.0**	.07	<.001
lipid, oz.	1.8	1.7	1.7	2.0	1.9	.15	.77
ash, oz.	2.8	3.0	2.9	2.8	2.8	.08	.60
protein, %	16.2	16.4	16.8	16.1	16.1	.46	.78
moisture, %	29.1	28.8	30.0	31.5*	31.2*	.62	.016
lipid, %	19.9	18.6	18.3	19.8	19.8	1.24	.81
ash, %	31.5	31.9	30.9	28.6*	29.4	.79	.03
Rib:							
weight, oz.	1.0	.94	.98	.94	1.0	.04	.78
protein, oz.	.21	.20	.21	.20	.21	.009	.78
moisture, oz.	.35	.33	.34	.35	.38	.019	.56
lipid, oz.	.07	.06	.05	.06	.08	.007	.27
ash, oz.	.34	.31	.34	.30	.30	.016	.24
protein, %	20.9	21.7	21.7	21.4	21.1	.35	.41
moisture, %	34.8	35.7	35.0	37.4*	38.1**	.74	.016
lipid, %	6.6	6.5	5.5	6.5	7.9	.64	.18
ash, %	34.0	33.5	34.4	31.5*	29.9**	.84	<.01

[a] Probability of treatment effect. Mean differs from that of negative control * P<.05; ** P<.01.

Table 4. Pounds of soft tissue protein, lipid, moisture, and ash stratified by sex-class.

Item	Sex-class		SE	P[a]
	Gilt	Barrow		
Lean:				
protein	6.3	5.9	.35	.11
lipid	1.4	1.6	.22	.11
moisture	22.4	20.9	1.15	.052
ash	.33	.31	.018	.08
IS Lean[b]:				
protein	2.9	2.6	.18	.017
lipid	2.7	2.8	.35	.87
moisture	10.3	9.3	.79	.06
ash	.15	.14	.011	.14
Fat:				
protein	.99	.87	.10	.08
lipid	17.4	21.0	2.32	.02
moisture	2.9	2.7	.17	.02
ash	.05	.05	.003	.94
Total:				
protein	10.1	9.4	.45	.013
lipid	21.6	25.4	2.48	.02
moisture	35.6	32.8	1.52	.009
ash	.52	.49	.023	.03
Protein/Water ratio	.28	.28	.005	.91
Protein/Lipid ratio	.50	.39	.05	.004

[a] Probability of treatment effect. Mean differs from that of negative control * P<.05; ** P<.01.

[b] IS Lean = Inseparable lean and fat.

Table 5. Proximate analyses of soft tissue components stratified by sex-class.

Item	Sex-class		SE	P[a]
	Gilt	Barrow		
Lean:				
protein %	20.6	20.6	.31	.80
lipid %	4.6	5.8	.79	.02
moisture %	73.2	72.3	.36	.001
ash %	1.07	1.06	.01	.43
IS Lean[b]:				
protein %	17.2	16.7	.49	.08
lipid %	16.6	18.5	2.36	.22
moisture %	62.0	60.5	1.99	.24
ash %	.89	.88	.03	.75
Fat:				
protein %	4.7	3.6	.70	.017
lipid %	77.4	83.3	2.76	.003
moisture %	13.8	10.9	1.16	<.001
ash %	.21	.18	.02	.02
Total:				
protein %	12.1	11.3	.57	.03
lipid %	25.7	30.6	2.83	.012
moisture %	42.6	39.7	1.90	.02
ash %	.62	.59	.02	.09

[a] Probability of treatment effect. Mean differs from that of negative control * P<.05; ** P<.01.

[b] IS Lean = Inseparable lean and fat.

Table 6. Effect of sex-class on weight and proximate analyses of femur and rib bones.

Item	Sex-class		SE	P[a]
	Gilt	Barrow		
Femur:				
weight, oz.	9.6	9.3	.37	.15
protein, oz.	1.5	1.5	.05	.77
moisture, oz.	2.8	2.9	.10	.25
lipid, oz.	2.0	1.7	.21	.03
ash, oz.	2.9	2.8	.11	.33
protein, %	16.1	16.6	.65	.29
moisture, %	29.2	31.1	.87	<.01
lipid, %	20.5	18.1	1.76	.04
ash, %	30.3	30.6	1.11	.70
Rib:				
weight, oz.	.99	.96	.06	.47
protein, oz.	.21	.20	.01	.26
moisture, oz.	.36	.34	.02	.40
lipid, oz.	.06	.07	.01	.36
ash, oz.	.32	.32	.02	.98
protein, %	21.5	21.2	.50	.44
moisture, %	36.3	36.0	1.04	.70
lipid, %	6.2	7.0	.91	.16
ash, %	32.1	33.2	1.19	.18

[a] Probability of treatment effect. Mean differs from that of negative control * P<.05; ** P<.01

Literature Cited

Cross, H.R. 1982. In Vivo and In Vitro Measurement of Composition, AMSA Composition Committee. Proc. Reciprocal Meat Conf. 35:1.

Gardner, T.L. et al. 1989. Effect of porcine somatotropin and sex-class on pork carcass grade traits and cooking characteristics. Okla. Agr. Exp. Sta. Res. Rep. MP-127:266.

Ivy, R.E. et al. 1986. Effects of various levels of recombinant porcine growth hormone (rpGH) injected intramuscularly in barrows. J. Anim. Sci. 63(Suppl. 1):218.

EVALUATION OF REAL-TIME ULTRASOUND FOR PREDICTING CARCASS TRAITS OF FEEDLOT STEERS

M.T. Smith[1], J.W. Oltjen[2], H.G. Dolezal[2], D.R. Gill[3], and B.D. Behrens[4]

Story in Brief

One hundred thirty-seven yearling crossbred steers were ultrasonically measured for fat thickness and ribeye area. Additionally, a trained livestock evaluator visually estimated these same parameters prior to slaughter. Live animal ultrasound measurements and visual estimates were then compared to actual carcass values to determine the accuracy of each method. Overall, ultrasound measurements were more accurate than visual estimates for predicting carcass fat thickness (within .1 inch 62% of the time) and ribeye area (within 1 inch^2 58% of the time), versus 56 and 42% for subjective estimates, respectively. Both visual and ultrasonic estimates were more accurate in predicting fat thickness on thinner cattle. Subjective estimates of ribeye area were more accurate than ultrasound measurements on heavier muscled steers. These results suggest that ultrasonic measurements of fat thickness are accurate in determining carcass fat thickness, but ribeye area estimates are inconsistent and warrant further investigation.

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

Introduction

Live animal estimation of carcass parameters and the ultimate determination of composition of livestock remains an important research goal in animal agriculture. Methodology for obtaining carcass estimates are as varied in scope and complexity as the results which they produce. They range from relatively inexpensive and readily obtainable linear measurements to complex, and often costly, imaging technologies currently employed in the field of human medicine. Ultrasound is an imaging technology which holds great promise for elucidating compositional differences in animals. Presently, both the Australian

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and U.S. beef industries have assigned high priority to the development of an objective instrument grading system utilizing ultrasound. The ability to accurately identify individuals with superior carcass traits will enable the beef industry to abandon the current practice of trading cattle "on the average" and adopt a new value-based marketing system.

Ultrasound involves the transmission of high frequency sound waves through the hide of the animal. The interaction of these soundwaves with varying tissue structures of different densities enables a cross-sectional image to be produced. From these images, the dimensions and nature of the structural makeup of deep tissue can be quantified. The reported accuracy with which ultrasound predicts carcass parameters in live animals has varied. Initial studies at Oklahoma State University (Smith et al., 1989) indicated that ultrasound could accurately determine carcass fat thickness in live animals; however, estimates of carcass ribeye area were imprecise. Research has shown that accuracy is highly technician dependent and improves with experience (Henderson-Perry et al., 1989). Therefore, the objective of this study was to reevaluate live animal ultrasonic measurements for predicting actual carcass values and to compare these results with subjective visual estimates of the same carcass traits. An additional component of the study involved comparing ribeye area estimates of two technicians' interpretation of the same ultrasound image.

Materials and Methods

The one-hundred-thirty-seven yearling crossbred steers used in this study were part of a trial conducted to determine the effect of anabolic implants, both estrogenic and androgenic, on performance and carcass characteristics of feedlot steers (Foutz et al., 1990). Steers were slaughtered in two groups (one week apart) to facilitate ease of data collection. Steers in the first group (Kill 1) were fed a total of 119 days and those in the second group (Kill 2) were fed 126 days. Five days prior to slaughter, steers were scanned using a real-time, diagnostic ultrasound unit (Aloka 210DX)[5] equipped with a linear array, 3 megahertz transducer. Scanning site, as determined by physical palpation, was located between the twelfth and thirteenth ribs on the left side of each animal. The ultrasound images produced were recorded on video tape and later viewed on a large display monitor[6] to determine carcass ribeye area estimates. Fat thickness (USFT) was determined at the time of scanning by internal electronic calipers. Recorded ultrasound images were interpreted independently by two technicians for the determination of ribeye area values. Using the same images, tracings

[5]Distributed by Corometrics Medical System Inc, Wallingford, CT
[6]Sony 12 inch PVM 122

were made of each technicians' interpretation of muscle configuration. Area was determined from these tracings using an electronic digitizing board. Technician A (USREA1) was responsible for the generation and recording of ultrasonic images and had more ultrasound experience than Technician B (USREA2). In addition to ultrasonic measurements, ribeye area was also predicted as a function of shrunk final live weight (BWREA).

One day prior to shipping steers to the slaughter facility, a trained evaluator visually estimated carcass fat thickness (SFT) and ribeye area (SREA) for each animal. Off-test weights for each steer were made available to the evaluator. Carcass fat thickness (FT), adjusted fat thickness (AFT) and ribeye area (REA) were measured at the 12th and 13th rib interface 24 h postmortem. Adjusted fat thickness is a subjective adjustment made by the grader in response to irregular fat distribution in other carcass locales. Means and standard deviations for parameters of interest in this study are presented in Table 1.

Results and Discussion

Simple correlations (r) between predicted (USFT, SFT) and observed fat thickness (FT, AFT) are presented in Table 2. Ultrasonic fat thickness measurements were highly correlated with actual values (r=.82, FT; r=.81, AFT). Similar results were observed in a previous study (Smith et al., 1989), thus indicating that ultrasound can accurately predict carcass fat thickness.

Table 1. Description of data used for analysis[a].

Parameter	Mean	Standard deviation
Final weight, lb	1185.0	98.63
Carcass weight, lb	758.2	56.78
FT, in	.54	.19
AFT, in	.57	.18
REA, in^2	13.40	1.49
USFT, in	.51	.15
SFT, in	.52	.14
USREA1, in^2	12.96	1.30
USREA2, in^2	12.90	1.29
SREA, in^2	14.40	1.50
BWREA, in^{2b}	12.78	.96

[a] See text for explanation of symbols.
[b] BWREA=((final weight*.96)/100)*1.1.

Table 2. Correlations of predicted and observed fat thickness[a].

	AFT	SFT	USFT
FT	.96	.56	.82
AFT		.60	.81
SFT			.52

[a] See text for explanation of symbols.

Subjective estimates were less closely associated with actual (r=.56) and adjusted (r=.60) carcass fat thickness (r=.56). When visually estimating fat thickness the evaluator uses indicators of overall fat cover, therefore, one would expect higher correlation coefficients between subjective and adjusted fat thickness due to the adjustments made by the grader.

Table 3 contains simple correlations (r) between predicted (USREA1, USREA2, SREA, BWREA) and observed ribeye area (REA). Ultrasonic ribeye area measurements were moderately correlated with actual values and did not differ between technicians (r=.63). It is apparent that there were interpretational differences of ultrasonic images, as the relationship between technician estimates was not perfect (r=.71). Subjective estimates of ribeye area were also moderately correlated with actual values (r=.61), thus indicating that the evaluator was able to identify differences in muscularity between animals. Ribeye area predicted from final shrunk live weight showed the weakest relationship (r=.48) between predicted and observed values in this study.

Perhaps a more useful measure of the predictive capacity of a given technique is an evaluation of the residual, the difference between the predicted and actual parameter values. In this study, the relative frequency with which estimates are within a given range of actual carcass values was determined.

Table 3. Correlations of predicted and observed ribeye area[a].

	SREA	USREA1	USREA2	BWREA
REA	.61	.63	.63	.48
SREA		.37	.33	.63
USREA1			.71	.22
USREA2				.32

[a] See text for explanation of symbols.

Ultrasonic estimates of carcass fat thickness were within .1 inch 62% of the time and within .2 inch 95% of the time (Table 4). Steers which produced carcasses with less than .5 inch fat thickness were estimated within .1 inch 76% of the time compared to 51% for those with actual carcass fat thickness greater than .5 inch. The same general trend was noted for subjective estimates of carcass adjusted fat thickness, with 56 and 83% of all steers estimated within .1 and .2 inch of actual values, respectively. The evaluator was more accurate in assessing adjusted carcass fat thickness with thinner steers (<.5 inch actual fat thickness) as evident by a greater proportion of those cattle being estimated within .1 inch of actual values (63% vs 49%).

Of the methods used to predict carcass ribeye area (Table 5), ultrasonic estimates of Technician A (USREA1) correctly identified the greatest proportion of steers within 1 in^2 of actual carcass values (58%). Predicting ribeye area as a function of live weight (BWREA) was almost as accurate (57% within 1 in^2) as ultrasound estimates of Technician A and better than those of Technician B (52%). Subjective visual estimates (SREA) correctly identified the lowest proportion of steers within 1 in^2 of actual values (42%) even though the correlation coefficient was similar to that of ultrasonic measurements (.61 vs .63). This points to the fallacy of utilizing correlation coefficients (measures of precision) as indicators of accuracy.

Ultrasonic estimates were least accurate in determining ribeye area for steers having carcass ribeyes greater than 14 in^2, with 38 and 36% of those

Table 4. Cumulative frequency distribution (%) of carcass fat thickness measurement error[a].

Range of absolute residual, inches	All data	Actual fat thickness, inches <.5	>.5
USFT			
+/- .10	62	76	51
+/- .20	95	95	87
+/- .30	99	100	99
SAFT			
+/- .10	56	63	49
+/- .20	83	92	75
+/- .30	94	98	89

[a] See text for explanation of symbols.

Table 5. Cumulative frequency distribution (%) of carcass ribeye area measurement error[a].

Absolute residual	All data	Actual ribeye area, in^2		
		<13	13-14	>14
USREA1				
+/- 1.0	58	67	63	38
+/- 2.0	86	91	85	74
+/- 3.0	99	100	100	95
USREA2				
+/- 1.0	52	60	53	36
+/- 2.0	88	93	98	69
+/- 3.0	99	100	100	95
SREA				
+/- 1.0	42	29	50	51
+/- 2.0	80	79	85	79
+/- 3.0	96	93	100	95
BWREA				
+/- 1.0	57	84	60	26
+/- 2.0	88	95	95	59
+/- 3.0	96	100	100	79

[a] See text for explanation of symbols.

estimates within 1 in^2 for Technicians A and B, respectively. In contrast, the live evaluator was most accurate within this range, correctly estimating carcass ribeye area for 51% of the steers within 1 in^2. Predicting ribeye area as a function of live weight was most accurate for steers with carcass ribeye areas of less than 13 in^2 and least accurate for those in excess of 14 in^2.

To illustrate the accuracy of subjective and ultrasonic estimates, residuals (predicted minus observed values) were plotted against measurements of carcass fat thickness and ribeye area. As shown in Figure 1, ultrasound estimates tended to overpredict fat thickness on steers with less than .4 in actual carcass fat thickness and underpredict fat thickness for steers with greater than .6 in carcass measured fat thickness. A similar trend is noted with subjective visual estimates (Figure 2) as all carcass with greater than .8 in adjusted fat thickness were underestimated. Ultrasonic estimates of ribeye area generally underpredicted heavier muscled steers (Figures 3 and 4), with both technicians

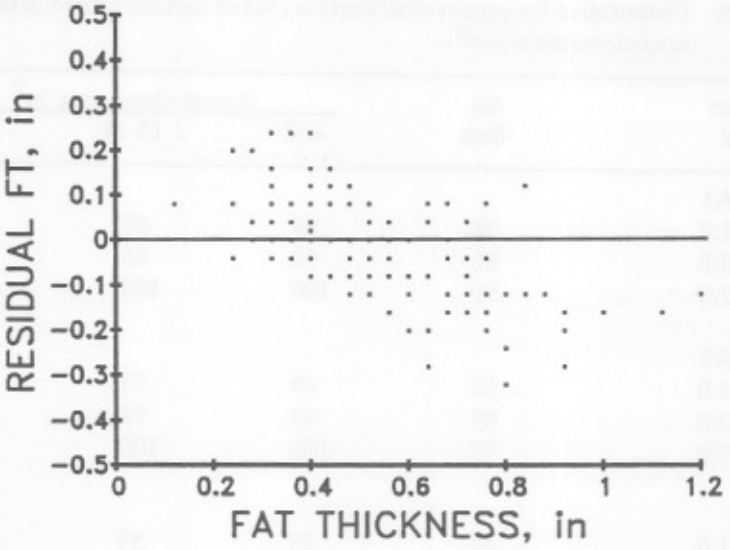

Figure 1. The relationship of residual (ultrasonically predicted minus observed) fat thickness and carcass measured fat thickness (FT) of feedlot steers.

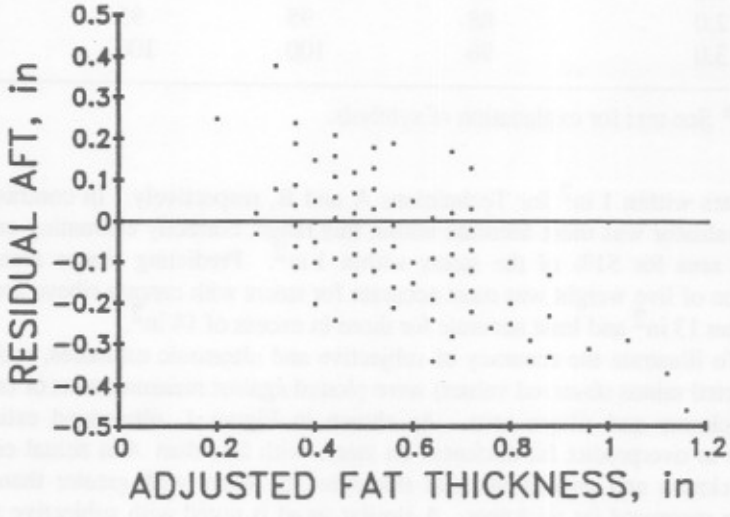

Figure 2. The relationship of residual (subjectively estimated minus observed) fat thickness and adjusted carcass fat thickness (AFT) of feedlot steers.

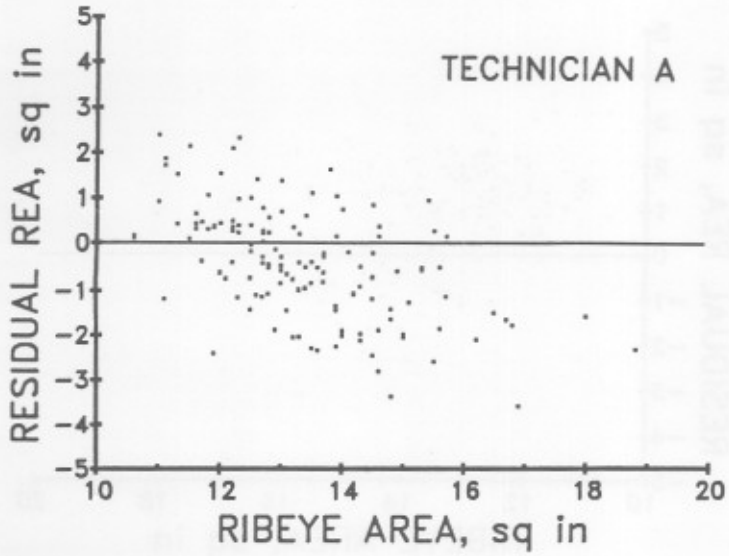

Figure 3. The relationship of residual (ultrasonically predicted minus observed) ribeye area and carcass measured ribeye area (REA) of feedlot steers for Technician A.

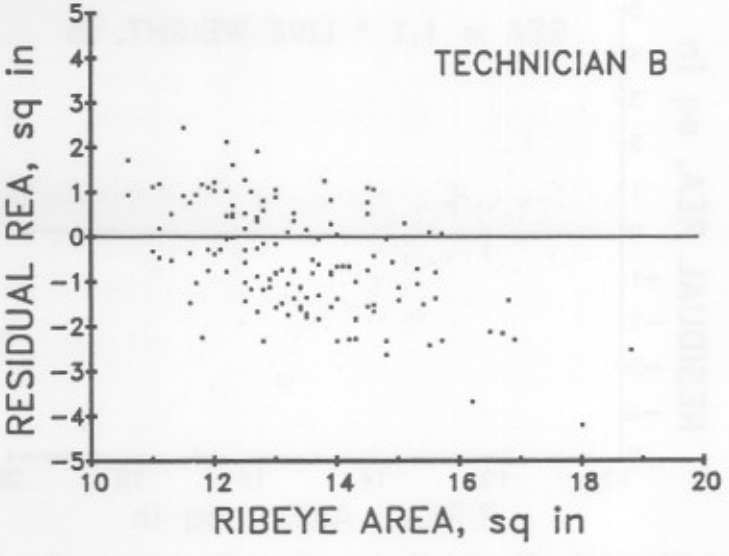

Figure 4. The relationship of residual (ultrasonically predicted minus observed) ribeye area and carcass measured ribeye area (REA) of feedlot steers for Technician B.

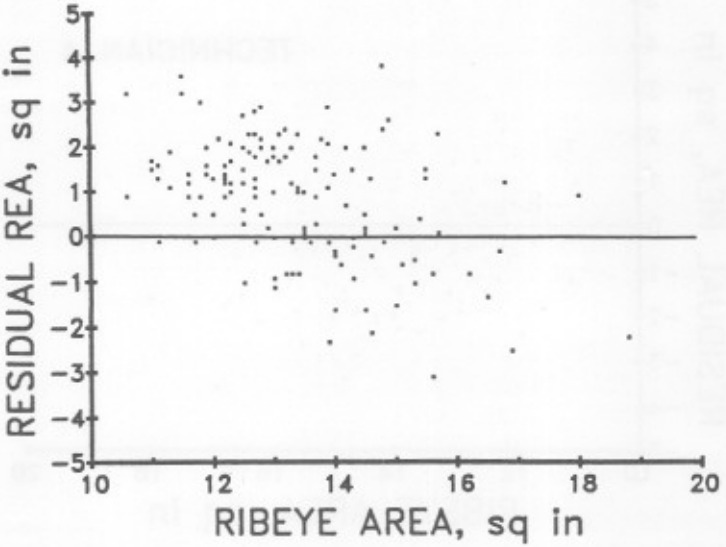

Figure 5. The relationship of residual (subjectively estimated minus observed) ribeye area and carcass measured ribeye (REA) of feedlot steers.

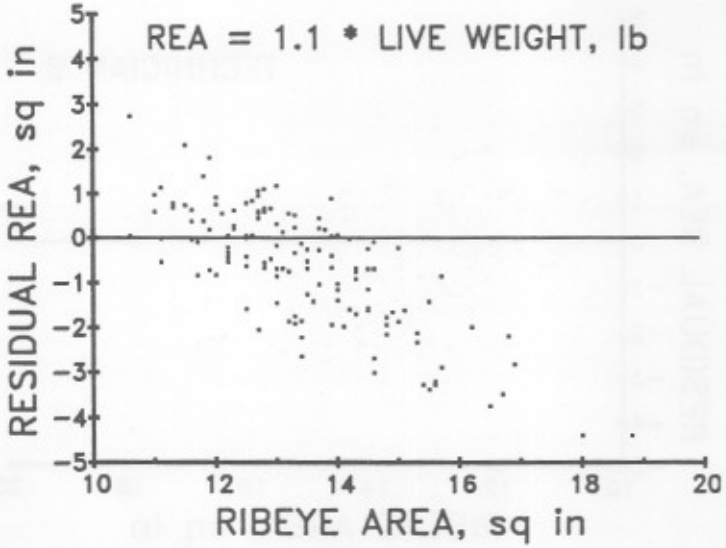

Figure 6. The relationship of residual (predicted ribeye area as a function of weight minus observed) ribeye area and carcass measured ribeye (REA) of feedlot steers.

underpredicting all animals with carcass measured ribeyes greater than 16 in^2. The residuals associated with subjective estimates of ribeye area (Figure 5) tended to be more variable; however, ribeye area was generally overpredicted for steers producing carcass ribeye areas of 13 in^2 or less. When using weight to predict carcass ribeye area, a systematic error is evident (Figure 6). As actual ribeye area increases, there is a corresponding increase in the error of prediction. These results suggest that the steers used in this study were heavier muscled than the general cattle population if one assumes that an average muscled steer will produce 1.1 in^2 of ribeye per hundred pounds of shrunk live weight.

Literature Cited

Foutz, C.P. et al. 1990. Synovex-S, Finalplix-S, or Revalor implants for feedlot steers. Okla. Agr. Exp. Sta. Res. Rep. MP-129:100.

Henderson-Perry, S.C. et al. 1989. The use of ultrasound in cattle to estimate subcutaneous fat thickness and ribeye area. J. Anim. Sci. 67 (Suppl.1):433.

Smith, M.T. et al. 1989. Evaluation of ultrasound for prediction of carcass fat thickness and ribeye area in feedlot steers. Okla. Agr. Exp. Sta. Res. Rep. MP-127:291.

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TABLE OF EQUIVALENTS

U.S. Metric

Length:

1 inch	=	2.54 centimeters	1 millimeter	=	0.03937 inch
1 foot	=	30.48 centimeters	1 centimeter	=	0.3937 inch
	=	0.3048 meters	1 meter	=	39.37 inches
1 yard	=	0.9144 meters		=	3.281 feet
1 mile	=	1609.34 meters		=	1.094 yards
	=	1.609 kilometers	1 kilometer	=	0.6214 mile

Area:

1 square inch	=	6.452 sq. centimeters	1 sq. centimeter	=	0.155 sq. inch
			1 sq. meter	=	1.196 sq. yards
1 sq. foot	=	0.0929 sq. meter		=	10.764 sq. feet
1 sq. yard	=	0.8361 sq meter	1 hectare	=	2.471 acres
1 acre	=	0.4047 hectare	1 sq. kilometer	=	0.386 sq. mile
1 sq. mile	=	259.0 hectares		=	247.1 acres

Volume:

1 cubic inch	=	16.387 cu. centimeters	1 cu. centimeter	=	0.061 cu. inch
			1 cu. meter	=	35.135 cu. feet
1 cu. foot	=	0.0283 cu. meter		=	1.308 cu. yards
1 cu. yard	=	0.7646 cu. meter	1 milliliter	=	0.0338 ounce
1 fluid ounce	=	29.573 milliliters	1 liter	=	33.81 ounces
1 pint	=	0.4732 liter		=	2.1134 pints
1 quart	=	0.9463 liter		=	1.057 quarts
1 gallon	=	3.7853 liters		=	0.2642 gallon
			1 kiloliter	=	264.18 gallons

Weight:

1 ounce	=	28.50 grams	1 gram	=	0.03527 ounce
1 pound	=	453.592 grams	1 kilogram	=	35.274 ounces
	=	0.4536 kilogram		=	2.205 pounds
1 ton	=	907.2 kilograms	1 metric ton (1,000 kg)	=	2204.6 pounds