# Oklahoma State University

ANIMAL SCIENCE DEPARTMENT

STILLWATER, OKLAHOMA 74078
ANIMAL SCIENCE BUILDING
(405) 624-6065


March 7, 1983

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

RE: 1983 Animal Science Research Report

We are proud to bring you our 1983 Report. It is the result of our total research program in the department, and we trust it provides important, needed, profit-enhancing technology during these difficult times.

What kind of research is represented in this report? Is it basic research? Is it applied research? Actually, we strive to do problem solving research, utilizing all available resources to provide solutions to problems.

To accomplish this goal we use both the "old" and the "new", combining the same "old" resources and commitment to Animal Agriculture with the "new" Animal Science Building (with its new laboratories and equipment) and "new" faculty members (who bring new techniques) we are privileged to have.

As always, we welcome your suggestions.

Yours truly,

Bob Totusek

Robert Totusek, Head
Animal Science Department

RT/csw

# CONTENTS

## FOOD AND CARCASS EVALUATION



## PHYSIOLOGY



## NUTRITION—SHEEP

## NUTRITION—SWINE



## GENETICS—ANIMAL BREEDING

## NUTRITION—COW-CALF AND STOCKER



## NUTRITION—POULTRY

## NUTRITION—DAIRY



## RESEARCH IN PROGRESS



## PURPOSE FOR PUBLICATION

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

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

# Confidence in Research Results

The inherent variability among animals used in an experiment can lead to problems in interpreting the results. When the 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 due to the fact 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 notation "$P < .05$" is used. This means that the probability that the differences referred to in the article resulted from chance is less than 5 in 100. In other words it is highly unlikely that the results that were obtained were due to chance. Sometimes the writers state that two averages are "significantly different." This means the same thing, that is, that the probability that the difference was due to chance is less than .05. In such cases, it is very likely that the treatment caused the differences that were observed and that they did not result from random factors such as allotment of the animals to the treatment groups.

In some articles there are tables of values given in such a way that by each value in the table there is a $\pm$ and then 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 accuracy of the estimation procedure. If the standard error is quite small in relation to the size of the average with which it is associated, this suggests that the estimation procedure was accurate. The interpretation is that the probability is .68 that the value being estimated by the sample mean is within one standard error of the estimate. Example: If we took a random sample of calves from a very large herd and calculated the mean weight of those calves to be 425 pounds and calculated the standard error to be 10 pounds then we would say that the probability is .68 that the mean weight of the total group of calves is between 415 and 435 pounds. Example 2: Assume that we compared the average daily gain of calves on two different rations and found that the difference in gain between the two groups was .15 pounds per day and that the standard error of the difference was .10 pounds per day. Since the .10 is nearly as large as the .15 we do not have great confidence that the .15 is a highly accurate estimate of the true difference between the two treatments involved.

Some papers contain "correlation" coefficients. These are measures of the relationship between traits or variables. These relationships may be positive or negative. Positive relationships mean that when one variable is higher than average more often than not the other variable is also higher than average. These positive values may be anywhere between zero and 1.0. Values near 1 indicate a strong tendency for larger values for one trait to be associated with larger values for the other. Negative correlations merely mean that larger than average values in one trait are more often than not associated with smaller than average values of the other trait and the nearer the values are to $-1$ the stronger this negative relationship. When it is stated that a correlation efficient is statistically significant it means that there is very strong evidence that there is in fact a correlation in the direction indicated and that the relationship found probably was not due to chance.

Statistical analysis procedures are of great benefit to scientists to help them develop 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.

**Research Report Committee**

**L.J. Bush**
**R.L. Henrickson**
**F.N. Owens**

# Influence of Roughage Level on Soybean Meal Degradation and Microbial Protein Synthesis in the Rumen

D. C. Weakley,[1] F. N. Owens,[2]
K. B. Poling[3] and C. E. Kautz[4]

## Story in Brief

Four dairy steers (500 lb) fitted with ruminal and duodenal cannulas were fed a concentrate or roughage based diet with or without added soybean meal (SBM) to determine the influence of roughage level on escape of SBM protein from ruminal degradation. Efficiency of microbial protein synthesis was 19 percent greater with the high roughage diet. However, since organic matter digestion in the rumen was 18 percent lower with the high roughage diet, the amount of microbial nitrogen synthesized in the rumen was not greatly affected by diet. Ruminal and total tract digestion of starch was not affected by diet. Escape of SBM protein from ruminal degradation was 48 percent greater on the high concentrate diet. In cases where concentrate and roughage are fed at different times, as commonly practiced when feeding dairy cattle, feeding a SBM supplement with the concentrate portion of the diet may enhance bypass to the small intestine.

## Introduction

Previous efforts to increase the supply of supplemental protein to the small intestine of ruminants have focused on alteration of the protein source to decrease its ruminal degradability. Chemical and heat treatment have received the most attention. The influence of diet on ruminal protein degradation has received less attention. Disappearance of SBM protein from dacron bags has been shown to be greater with roughage than concentrate fed steers. Measurement of SBM protein bypass obtained with cannulated steers fed concentrate or roughage diets in different studies, suggested that bypass was lower when fed with roughage rations (Zinn and Owens, 1982). The objective of this study was to assess the effect of roughage level on ruminal degradability of supplemental SBM protein and efficiency of microbial protein synthesis, both of which can influence the supply of amino acids reaching the small intestine.

## Materials and Methods

Digestion of protein from dacron bags was studied using three Hereford steers (1400 lb) equipped with ruminal cannulas. Each animal received a diet of roughage (83 percent chopped prairie hay, 15.5 percent SBM and 1.5 per-

[1]Graduate Assistant, [2]Professor of Animal Science, [3]Animal Care Supervisor, [4]Laboratory Technician

cent minerals), concentrate (62 percent corn, 14 percent cottonseed hulls, 10 percent SBM, six percent ground alfalfa hay, six percent molasses and two percent minerals and vitamins) or a mixture of the two. All diets contained 12.5 percent crude protein. Dacron bags containing either SBM or meat meal (MM) were suspended in the rumen of each animal for 12 and 24 hr, removed, washed, dried and analyzed for loss of nitrogen (N).

To examine effects in animals, four dairy steers (500 lb) equipped with ruminal and duodenal cannulas were fed a concentrate (C) or roughage (R) based diet with or without SBM (Table 1) in a 4 x 4 latin square. Urea was added to the diets not supplemented with SBM to avoid deficiency of ruminal ammonia. Chromic oxide was included as an indigestible marker. Animals were fed every 12 hr at a daily level equal to 1.6 percent of body weight.

After five days of feeding, fecal and duodenal samples were collected twice daily (am and pm) for three days. Feed was sampled prior to each sampling day. Samples from each animal were composited for each period, dried in a 60 C oven for 48 hr and ground for analysis of organic matter, nitrogen, starch and total purines, an index of microbial protein.

On the fourth day of sampling, rumen fluid was collected (am and pm) for ammonia and pH measurements and determination of purine to nitrogen ratio in isolated bacteria.

## Results and Discussion

Disapperance of SBM N from dacron bags placed in the rumen for 12 or 24 hr was observed much greater with steers fed roughage, least with con-

**Table 1. Ration composition**

| Item | Diets | | | |
|---|---|---|---|---|
| | C | CSBM | H | HSBM |
| | % of diet DM | | | |
| Rolled corn | 82.1 | 61.6 | 41.5 | 22.3 |
| Chopped prairie hay | 8.1 | 7.9 | 48.3 | 48.0 |
| Soybean meal | 0 | 21.2 | 0 | 20.9 |
| Supplement | 9.8 | 9.3 | 10.2 | 8.8 |
| Urea | .60 | 0 | .51 | 0 |
| Cottonseed hulls | 5.16 | 5.21 | 5.68 | 4.93 |
| Chromic oxide | .25 | .25 | .25 | .24 |
| Dicalcium phosphate | 1.23 | 1.24 | 1.22 | 1.17 |
| Limestone | .47 | .48 | .47 | .45 |
| Vitamin A | .01 | .01 | .01 | .01 |
| Vitamin D | .002 | .002 | .002 | .002 |
| TM salt | .50 | .50 | .49 | .48 |
| $NaSO_4$ | .50 | .50 | .49 | .48 |
| KCl | .58 | .58 | .57 | .55 |
| Molasses | .50 | .51 | .50 | .48 |
| Crude protein, % of DM | 10.3 | 17.3 | 8.4 | 15.2 |

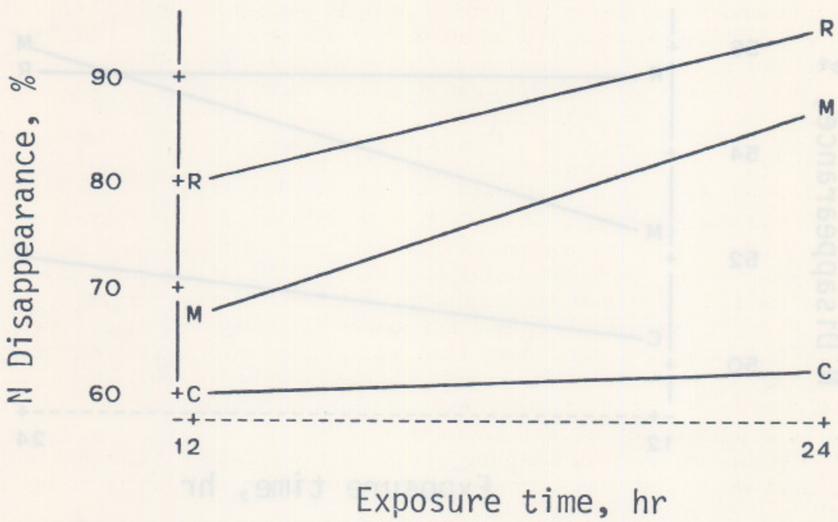



**Figure 1. Disappearance of SBM from bags**

R = Roughage diet
M = Mixed diet
C = Concentrate diet

centrate fed steers and intermediate with steers receiving a mixed diet (Figure 1). Though disappearance ranked similarly with the three diets for meat meal (Figure 2), differences were very small. Ruminal pH's on the R, M and C diets were 6.7, 6.5 and 6.4, respectively. Since SBM, a vegetable protein source, contains cellulose, microbial degradation of soybean protein may be limited by fiber barriers. Since ruminal fiber digestion is more extensive when higher roughage levels are fed, this may account for the greater SBM disappearance with the steers fed roughage. Since meat meal contains no fiber, no effect of roughage level on protein digestion would be expected.

Based on this information, the effect of roughage level on ruminal degradability of SBM was measured in steers. A concentrate diet with (CSBM) or without (C) supplemental SBM and a hay based diet with (HSBM) or without (H) supplemental SBM were used (Table 1). Hay feeding resulted in a higher ruminal pH, while microbial proteolysis and deamination of supplemental SBM produced higher ruminal ammonia-N levels (Table 2).

Organic matter (OM) digestion, both in the rumen and total tract (Table 3) was less on the higher roughage diets. However, the portion of the total tract OM digestion occurring in the rumen was similar for all diets, with the exception of the unsupplemented hay diet (H). The depression observed in the rumen on this diet may be due to an ammonia deficiency in the rumen as ammonia concentration was only 2.4 mg/dl. Total liquid flow at the duodenum was greater with steers fed the higher roughage diets, paralleling greater salivation.

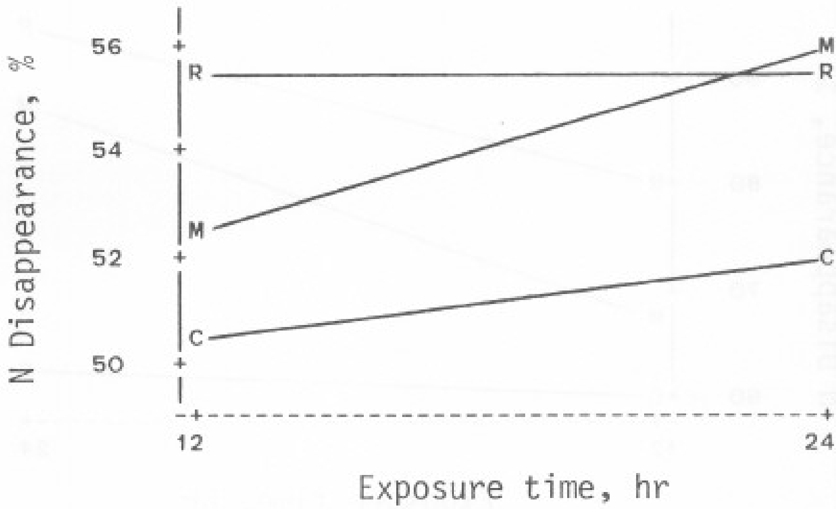



**Figure 2. Disapperance of meat meal from bags**
R = Roughage diet
M = Mixed diet
C = Concentrate diet

**Table 2. Ruminal parameters**

| Item | Diets | | | |
|---|---|---|---|---|
| | C | CSBM | H | HSBM |
| Ammonia-N, mg/dl | 5.6[c] | 18.9[a] | 2.4[c] | 12.8[b] |
| pH | 6.55[c] | 6.44[c] | 6.93[a] | 6.77[b] |

[abc]Means in a row with different superscripts differ statistically ($P < .05$).

The lower digestibility of N in the rumen and total tract with the unsupplemented diets (C and H) (Table 4) is predominantly the result of lower N intakes on these diets. Unaccounted endogenous N losses comprise a larger portion of the undigested N flow on diets low in protein, resulting in lower estimated digestibility of feed nitrogen. The negative ruminal N digestibility on diet H was a result of greater N leaving than being consumed. This commonly is observed with low N diets, due to the recycling of N to the rumen. However, microbial N synthesis on diet H was not as great as observed on the other diets, likely due to a combination of lower ruminal N availability and decreased ruminal OM digestion. Efficiency of microbial N synthesized per unit of OM digested in the rumen was greater with the higher roughage diets. Longer retention of OM in the rumen as well as decreased total ruminal OM digestion, coupled with a greater ruminal liquid dilution rate would support an increased efficiency of microbial protein synthesis.

## Table 3. Organic matter

| Item | Diets | | | |
| --- | --- | --- | --- | --- |
| | C | CSBM | H | HSBM |
| Intake | 3410 | 3403 | 3397 | 3410 |
| Leaving abomasum, g/day | | | | |
| Total | 1307[b] | 1231[b] | 1861[a] | 1435[b] |
| Non-microbial | 1017[bc] | 882[c] | 1621[a] | 1191[b] |
| Chyme, liter/day | 25.7[c] | 26.7[c] | 39.9[a] | 34.8[b] |
| Ruminal digestion | | | | |
| % unadjusted | 61.7[a] | 63.7[a] | 45.3[b] | 58.1[a] |
| % adjusted[e] | 70.2[ab] | 73.9[a] | 52.4[c] | 65.3[b] |
| Ruminal digestion, % of total | 78.0[ab] | 75.1[ab] | 65.8[b] | 79.0[a] |
| Feces, g/day | 705[c] | 516[d] | 1068[a] | 909[b] |
| Post ruminal digestion, % of entering | 45.2[b] | 58.0[a] | 41.1[b] | 36.4[b] |
| Total tract digestion, % | 79.3[b] | 84.9[a] | 68.6[d] | 73.4[c] |

[abcd]Means in a row with different superscripts differ statistically ($P < .05$).
[e]Adjusted for microbial organic matter.

## Table 4. Nitrogen

| Item | Diets | | | |
| --- | --- | --- | --- | --- |
| | C | CSBM | H | HSBM |
| Intake, g/day | 59[c] | 100[a] | 49[d] | 90[b] |
| Leaving abomasum, g/day | | | | |
| Total N | 53[b] | 61[ab] | 57[ab] | 62[a] |
| Microbial N | 23[ab] | 25[a] | 21[b] | 23[ab] |
| Non-ammonia, non-microbial | 27[b] | 32[ab] | 33[ab] | 35[a] |
| Ruminal digestion, % | | | | |
| % unadjusted | 10.2[b] | 38.9[a] | -15.6[c] | 30.7[a] |
| % adjusted[e] | 53.7[b] | 67.3[a] | 33.0[c] | 61.6[a] |
| Microbial efficiency | | | | |
| g microbial N/kg OM truly digested in rumen | 9.6[b] | 9.9[ab] | 12.8[a] | 10.5[ab] |
| Ruminal digestion, % of total | 15.2[b] | 48.2[a] | -29.3[c] | 41.1[a] |
| Feces, g/day | 20[bc] | 19[c] | 22[ab] | 23[a] |
| Postruminal digestion, % of entering | 61.9[b] | 68.4[a] | 61.4[b] | 63.1[b] |
| Total tract digestion, % | 66.0[c] | 80.8[a] | 55.3[d] | 74.7[b] |

[abcd]Means in a row with different superscripts differ statistically ($P < .05$).
[e]Adjusted for microbial and ammonia nitrogen.

**Table 5. Starch**

| Item | Diets | | | |
|---|---|---|---|---|
| | C | CSBM | H | HSBM |
| Intake, g/day | 2148$^{a}$ | 1679$^{b}$ | 1136$^{c}$ | 679$^{d}$ |
| Leaving abomasum, g/day | 374$^{a}$ | 319$^{a}$ | 279$^{a}$ | 131$^{b}$ |
| Apparent ruminal digestion, % | 82.7 | 80.9 | 75.5 | 80.7 |
| Ruminal digestion, % of total | 88.6 | 83.5 | 83.0 | 85.4 |
| Feces, g/day | 140$^{a}$ | 54$^{b}$ | 98$^{ab}$ | 37$^{b}$ |
| Postruminal digestion, % of entering | 58.8 | 84.0 | 60.4 | 70.4 |
| Total tract digestion, % | 93.5$^{ab}$ | 96.9$^{a}$ | 91.3$^{b}$ | 94.5$^{ab}$ |

[abcd]Means in a row with different superscripts differ statistically ($P < .05$).

Diet had little effect on ruminal or total tract digestion of starch (Table 5). Diet effects on fiber digestibility in the rumen remain to be determined.

Escape of SBM protein from ruminal degradation was 20.4 percent with the high concentrate diet and 13.8 percent with the high roughage diet. This calculation assumes a ruminal degradability of 40 percent for the corn that replaced the SBM in the unsupplemented diets. As the earlier dacron bag results suggested, greater cellulolytic activity in the rumen of roughage fed animals may degrade more of the SBM cellulose matrix, exposing more protein for microbial attack. All bypass values seem low, possibly due to the low intake level and high ruminal pH.

Including roughage in the diet decreased OM digestion in the rumen but had little influence on microbial N reaching the small intestine due to increased efficiency of microbial N synthesis. Since more SBM protein escaped ruminal degradation with the high concentrate diet, feeding of supplemental protein with the concentrate portion of the feeding scheme may result in more bypass of SBM protein.

## Literature Cited

Zinn, R. A. and F. N. Owens. 1982. Okla. Agr. Exp. Sta. Res. Rep. MP-112:216.

# Feeding Methods: Time Limited and Alternating Protein and Fiber Levels for Lambs

S. C. Arp[1] and F. N. Owens[2]

## Story in Brief

Sixty crossbred lambs averaging 93 lb were individually penned and fed the same ingredients (cracked corn, soybean meal, cottonseed hulls) in five different manners. One group had access to the diet, 12.5 percent crude protein (CP) and 20 percent cottonseed hulls (CSH), ad libitum. A second group was fed the same diet but had access to feed for only one hour each day. A third group received (on alternate days) diets containing 15 percent CP and 10 percent CP, and a fourth group received (on alternate days) diets containing 10 percent CSH and 30 percent CSH. Lambs fed free choice consumed 16 percent more feed ($P<.01$) than those fed for a limited time and gained 10 percent more rapidly. This gave the limit fed lambs a six percent advantage in feed efficiency. Alternating high and low roughage diets reduced feed intake by 10 percent and rate of gain by 9 percent while alternating protein levels decreased feed intake by five percent and rate of gain by 10 percent. Results indicate that an alternating protein level may reduce efficiency. Limiting the time of access to feed may stabilize digestion and improve efficiency, though severe restriction will reduce rate of gain as well. Results may not apply to group fed animals. Reduced feed efficiency with diets of varying chemical composition suggests that feed should be thoroughly mixed prior to delivery to feed bunks.

## Introduction

Growing and finishing lambs usually are provided ad libitum access to a constant diet. Alternating high and low roughage diets each day may avoid some of the adverse effects of concentrate on roughage digestion in the rumen. The purpose of this experiment was to determine the effect of alternating the protein and fiber content of diets each day and limiting the time of access to feed, on feed intake, daily gain and feed conversion efficiency.

## Materials and Methods

Sixty crossbred lambs averaging 93 lb were allotted by weight into three groups. Within each group, five wethers were randomly allotted to one of four treatments. Lambs were housed in individual pens and fed a diet of cracked corn, soybean meal, and cottonseed hulls (CSH). One treatment had ad libitum access to the diet (Table 1) which contained 12.5 percent crude protein (CP) and 20 percent CSH. The second treatment group had ad libitum access to

[1]Graduate Assistant, [2]Professor of Animal Science

**Table 1. Diet composition[a]**

| Ingredients % | Treatments | | | | |
|---|---|---|---|---|---|
| | Low protein | High protein | Low fiber | High fiber | Normal |
| Corn | 73.5 | 60.0 | 78.1 | 55.5 | 66.8 |
| Soybean meal | 5.7 | 19.3 | 11.1 | 13.8 | 12.5 |
| Cottonseed hulls | 20.0 | 20.0 | 10.0 | 30.0 | 20.0 |
| Calcium carbonate | .8 | .7 | .8 | .7 | .7 |

[a]455 IU vitamin A and 120 IU vitamin D added per pound of feed.

feed for only one hour each day. The third treatment group received (on alternative days) diets containing 15 percent CP and 10 percent CP (Table 1) while the fourth treatment group received (on alternative days) diets containing 10 percent CSH and 30 percent CSH. Daily weighbacks were taken for treatments of high/low protein, high/low roughage and the limit fed lambs. Weighbacks for the control group were taken once each week. Weights were taken at the beginning and end of the 49-day feeding period following 24 hours without feed and water. Weights were adjusted for wool weights as lambs were sheared the third week of the trial. Feed intake, average daily gain and feed conversion efficiency were monitored.

## Results and Discussion

The discussion that follows will be presented in two parts, first comparing ad libitum versus limited time access to feed and, second, alternating levels of protein and roughage.

Lambs with ad libitum access to feed consumed 16 percent more ($P < .01$) feed than limit fed animals and gained 10 percent more weight (Table 2). This calculates to an improvement in feed efficiency for limit fed animals of six percent. Increased efficiency with limit feeding could be due to increased digestibility caused by a slower rate of passage with lower feed intake. Another possibility is an increased gut size, absorptive capacity or metabolic efficiency as shown with meal fed rats, pigs and chickens (Brownlee and Moss, 1959; Fabry, 1967; Leveille, 1970). A third possibility is a reduced incidence of digestive upsets due to the regularity of feedings though no disorders were externally apparent

**Table 2. Performance data comparisons**

| Item | Treatments | |
|---|---|---|
| | Ad libitum | Limit fed |
| Average daily gain, lb | .486 | .444 |
| Daily feed intake, lb | 2.88[a] | 2.49[b] |
| Feed/gain | 6.04 | 5.69 |

[ab]Means in a row with different superscripts differ statistically ($P < .01$).

**Table 3. Performance data comparisons**

| Item | Treatments | | |
|---|---|---|---|
| | Ad libitum | Alternating fiber | Alternating protein |
| Average daily gain, lb | .486 | .442 | .440 |
| Daily feed intake, lb | 2.88[a] | 2.60[b] | 2.75[ab] |
| Feed/gain | 6.04 | 6.03 | 6.33 |

[ab]Means in a row with different superscripts differ statistically ($P < .05$).

during the trial. Data suggest that limiting the time of access to feed may slightly improve feed efficiency of individually fed lambs. Further testing with group fed animals is needed.

Lambs with ad libitum access to the totally mixed diet ate 11 percent more ($P < .05$) feed than the lambs fed diets with alternating levels of roughage and five percent more than lambs fed diets with alternating levels of protein (Table 3), while gains were reduced about 10 percent with both treatments. Superior efficiency of the lambs receiving the alternating levels of roughage can be attributed to the fact that these lambs consumed 35 percent more feed on the days the low CSH diet was offered than on days the higher CSH diet was provided. Animals fed alternating levels of protein consumed nearly identical amounts of the low and high protein diets. Variations in diet composition (protein and fiber level) tended to reduce efficiency suggesting that thorough mixing of a diet prior to feeding is beneficial.

## Literature Cited

Brownlee, A. and W. Moss. 1959. Brit. Vet. J. 115:225.

Fabry, P. 1967. In: Handbook of Physiology. Alimentry Canal. Washington, DC: Am. Physiol. Soc., 1967, sect. 6, Vol 1, Chapt. 3, p. 31.

Leveille, G. A. 1970. Fed. Proc. 29:1294.

# Effect of Ruminal pH Alteration on Digestion in Steers Fed a High Concentrate Diet

A. L. Goetsch[1], F. N. Owens[2],
C. E. Kautz[3] and K. W. Milliner[4]

## Story in Brief

Mature Angus steers were intraruminally infused with base to increase ruminal pH. Base infusions, increasing rumen pH from 5.8 to 6.2, did not change duodenal pH but tended to reduce fecal pH. Increased ruminal pH tended to increase digestion of fiber (9 percent) but reduced ruminal digestion of starch by 18 percent ($P > .05$). Ruminal pH and ruminal starch digestion were negatively correlated ($P < .05$). Rate of passage of fluid and particulates tended to be faster with base infusion. Results suggest that rumen pH alters digestion of dietary constituents and digesta kinetics.

## Introduction

Grain addition to high roughage diets increases lag time and reduces extent of fiber digestion. Explanations include decreased activity of the enzyme cellulase, shifts in microbial strains or metabolism and preferential attack of more readily degradable substrates. Decreased rumen pH with added grain may be the cause of some of these changes. Ruminal buffers, elevating pH, have sometimes alleviated depressed fiber digestibility.

Increasing rumen pH with buffer infusions have altered volatile fatty acid molar proportions and increased feed intake (Esdale and Satter, 1972; Fulton et al., 1979). However, control animals often have not received infusions of similar minerals. Activity of starch-digesting enzymes decreases with pH in the intestine, but little information is available on enzyme levels or activity for starch digestion in the rumen. Rate of protein degradation, like fiber digestion, is faster with high roughage diets. Such diets produce faster fluid passage rates and lower ruminal acidity than high concentrate feeds. Whether diet composition, pH or passage rate differences are responsible for these effects has not been determined. This study examined the influence of ruminal pH on ruminal and total tract digestion with a high concentrate diet.

## Experimental Procedure

Four mature Angus steers (1,094 lb), fitted with permanent ruminal and duodenal cannulas, were used in a switchback design. Steers in metabolism stalls were fed a 90 percent concentrate diet (Table 1) four times each day (0500, 1100, 1700 and 2300 hr) at 1.2 percent of body weight (dry matter). Steers

[1]Research Associate, [2]Professor, Animal Science, [3]Laboratory Technician, [4]Animal Care Supervisor

**Table 1. Diet composition**

| Ingredient | %[a] |
|---|---|
| Dry rolled corn | 73.0 |
| Ground alfalfa hay[b] | 10.0 |
| Soybean meal | 10.0 |
| Molasses | 5.0 |
| Trace mineral salt | .5 |
| Vitamin supplement | .2 |
| $CaCO_3$ | .8 |
| $CaHPO_4$ | .2 |
| Urea | .1 |
| $Cr_2O_3$ | .2 |
| **Composition** | **%** |
| Dry matter | 87.4 |
| Ash | 6.7 |
| Crude protein | 16.6 |
| Starch | 41.4 |
| Acid detergent fiber | 7.2 |

[a]Dry matter basis.
[b]Ground through a 3/8 inch screen.

were continuously infused intraruminally with approximately 1 quart of base or salt solution per day. Ruminal fluid samples taken before trial initiation were analyzed for Na and K concentrations to infuse base without disturbing the Na to K ratio. The base solution consisted of 1.58 M NaOH plus .19 M KOH while the salt solution contained isomolar amounts of Na and K as chloride salts.

Steers were infused with the highest concentration of buffers and salts a minimum of 5 days before collections and sampling periods lasted four days. On the first day of collection, steers were fed corn labelled with a metal (Yb) and dosed with another marker which follows fluids (Co-EDTA). Ruminal fluid volume and dilution rate and particulate passage rate were calculated from these markers. Samples from the rumen, the start of the small intestine (duodenum) and the rectum were taken and pH, ammonia, fiber, starch and markers were measured in appropriate samples.

## Results and Discussion

Mean rumen pH (Table 2) was higher with base infusion as expected. The difference was greater at 1 hr (6.13 and 5.58) than 3 (6.23 and 5.89) and 5 hr (6.27 and 5.90) after feeding. This may be due to more rapid fermentation rate shortly after feeding. It is interesting that the large amount of base infused increased pH by only .4 units. Duodenal pH tended to be higher at 1 hr postfeeding for base infused animals, but not at 3 or 5 so that overall, base infusion did not alter duodenal pH. More rapid starch digestion and volatile fatty acid production in salt receiving steers might be reflected in

**Table 2. Ammonia and pH measurements.**

| Site | Item | Treatment | | |
|---|---|---|---|---|
| | | Base | Salt | Significance |
| Rumen | pH | 6.21 | 5.81 | .07 |
| Rumen | $NH_3$, mg/dl | 22.9 | 17.5 | NS |
| Duodenum | pH | 2.26 | 2.27 | NS |
| Rectum | pH | 6.20 | 6.40 | .21 |

duodenal pH in the early hours following meal consumption. Bicarbonate feeding does not alter duodenal pH but added limestone has been reported to cause an increase. Time postfeeding may have influenced present results.

Rumen $NH_3$ concentrations (Table 2) were greater with base infusion, although, these differences declined with time after feeding. Results could imply a faster rate of degradation of protein or faster ammonia uptake by ruminal microbes. Absorption should remove more ammonia from the rumen at a higher pH. However, rumen fluid flow rates were 1.5 vs 1.6 liters per hour for the base and salt treatments, respectively. Increased ruminal protein breakdown with roughage diets and higher ruminal pH has been observed previously, but other factors, such as passage rate and various dietary characteristics may be important as well. Ruminal nitrogen digestion will be estimated when microbial contributions are estimated.

Organic matter digestibilities (Table 3) in the rumen and the total tract were not altered by base infusion, although rumen digestion of acid detergent fiber tended to increase with base infusion. This difference was smaller in the total tract fiber digestibility, implying that the large intestine and cecum were compensating for reduced digestion in the rumen. Increased fiber digestion with dietary sodium bicarbonate is often observed and these bases are soluble in rumen fluid like bicarbonate. Since roughage level was low (10 percent) and particle size small (<3/8 inches), one would not except large numbers of celluloytic organisms in the rumen with either treatment.

**Table 3. Digestibility, %**

| Item | Site | Treatment | |
|---|---|---|---|
| | | Base | Salt |
| Organic matter | Total tract | 75.6 | 77.1 |
| | Ruminal[a] | 31.6 | 32.3 |
| | Postruminal | 44.0 | 44.8 |
| Starch[b] | Total tract | 88.6 | 91.8 |
| | Ruminal | 49.8 | 60.5 |
| | Postruminal | 38.8 | 31.5 |
| Acid detergent fiber[b] | Total tract | 51.5 | 47.2 |
| | Ruminal | 43.0 | 35.2 |
| | Postruminal | 8.5 | 12.0 |
| Crude protein[b] | Total tract | 66.7 | 70.0 |

[a]Not corrected for passage of microbial organic matter.
[b]Dry matter basis.

Total tract starch digestion (Table 3) was similar for base and salt infused steers. However, ruminal digestion tended to be lower for the base treatment. No similar ruminal starch digestion estimates have been found, but trends for lower total tract starch digestion with $NaHCO_3$ have been reported (Erdman et al., 1982; Rogers and Davis, 1982). Both investigations employed ad libitum intakes and 50 to 60 percent concentrate diets. Unlimited feed consumption confounded their digestibility measurements but have more direct application than our intake level of 1.2 percent of body weight. Reduced compensatory intestinal digestion of starch with high intakes could cause reduced ruminal starch digestion to be reflected through the total tract. In addition, higher roughage levels should cause 1) greater numbers of fiber digesting microbes to be present in the rumen and 2) an increased flow rate through the small intestine. More cellulose digesting microbes may have been responsible for the increase in fiber digestion with bases and buffers and shifts from ruminal starch to fiber digestion. Fast passage would reduce capacity of the intestine to digest starch in the other experiments. With limited intake of our study, greater quantities of starch reaching the hindgut in base infused steers may have stimulated microbial fermentation in the large intestine which increased acid production to lower ($P<.21$) fecal pH. A closer relationship was noted between rumen pH and ruminal starch digestion ($r = -.82$; $P<.05$) than with ruminal fiber digestion ($r = .55$; NS). As pH increased, trends for decreased ruminal starch digestion and increased ruminal fiber digestion were noted; hence, ruminal starch digestion was inversely related to ruminal fiber digestion ($r = .70$; $P<.13$).

Fluid passage rate (Table 4) was faster ($P<.08$) in steers infused with base while rumen fluid volume tended to be reduced. Infusions of base and salt should have affected ruminal osmotic pressure to the same degree and changed fluid passage similarly. Since ruminal digestibilities differed, this would alter digesta composition which could influence ruminal mixing and stratification in the rumen. Greater particulates present may have reduced ruminal fluid space, although, at this low intake level, gut capacity is not likely to be a limiting factor.

Particulate dilution rate tended to be faster for steers infused with hydroxides. Diet particle size was small so that sufficiently hydrated particles in the proper position could flow from the rumen. The trend for decreased starch digestion (18 percent) with added base could be an indirect result of reduced time for ruminal digestion. Rumen particulate turnover time was decreased from 41 to 30 hours with base infusion. But, extent of ruminal fiber digestion tended to be greater for the base treatment despite a shorter time for ruminal digestion. Possible explanations for the increased solids flow in the base treatment may include 1) an increased rate of fiber digestion positively affecting corn particle hydratability and thereby enhancing positioning for rumen exit,

**Table 4. Digesta kinetics**

| Item | Treatment | |
|---|---|---|
| | Base | Salt |
| Particulate passage rate, %/hr | 3.37 | 2.44 |
| Fluid passage rate, %/hr | 5.92 | 4.80 |
| Fluid volume, liters | 25.2 | 34.1 |

2) infusion interactions with the particulate marker and 3) adjustment of salivation in response to gastrointestinal pH receptors. Since trends for decreased ruminal starch digestion in steers receiving base could result either from altered passage rates or pH or a combination, further work is necessary to investigate pH effects on rate of digestion and passage and their interrelationships using different diet types and intake levels.

## Literature Cited

Erdman, R. A. et al. 1982. J. Dairy Sci. 65:710.
Esdale, W. J. and L. D. Satter. 1972. J. Dairy Sci. 55:964.
Fulton, W. R. et al. 1979. J. Anim. Sci. 49:785.
Rogers, J. A. and C. L. Davis. 1982. J. Dairy Sci. 65:944.

# Effects of Reimplanting Feedlot Cattle

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

## Story in Brief

Feedlot and carcass performance was evaluated on 499 three-breed cross cattle fed a high concentrate ration from weaning to slaughter. All calves received an implant (Synovex-H and Synovex-S for heifers and steers, respectively) when entering the feedlot at an average age of 207 days. One-half of the animals received a second Synovex implant at approximately 129 days on feed.

Over the entire feeding period, reimplanted steers gained .26 lb/day (9.6 percent) more rapidly than non-reimplanted steers. Although not statistically significant overall daily gain was .06 lb/day (2.6 percent) more rapid for reimplanted than non-reimplanted heifers. Despite being on feed 11 fewer days, reimplanted steers were 27 lb heavier at slaughter and had carcasses that were 21 lb heavier than non-reimplanted steers. Reimplanted steers and heifers tended to produce trimmer carcasses with more muscle than non-reimplanted animals.

Reimplantation resulted in considerable improvement in feedlot daily gain of steers and lesser improvement in heifers. Based on actual feedlot performance and exclusive of reimplanting costs, the value of reimplantation was estimated to be $13.88 and $5.67 per head for steers and heifers, respectively.

## Introduction

Growth-stimulating implants have been shown in many studies to increase gains of feedlot cattle, as well as increase muscling and decrease fat of carcasses. However, the effects of frequency and number of implants has not been thoroughly determined. The objective of this study was to determine the effects of reimplantation with Synovex on the feedlot performance and carcass merit of steers and heifers.

## Experimental Procedure

Cattle used in the study were produced in the spring of 1979 and 1980 from eight two-breed cross cow groups (Hereford X Angus, Angus X Hereford, Simmental X Angus, Simmental X Hereford, Brown Swiss X Angus, Brown Swiss X Hereford, Jersey X Angus and Jersey X Hereford) mated to Charolais and Limousin bulls. The three-breed cross calves remained with their dams until weaning on native and bermuda grass pastures at the Lake Carl Blackwell Research Range with the exception that 35 of the calves born in 1980 were reared by their dams in a drylot.

---

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

Calves were weaned in October at an average age of 207 days and immediately transported to the Southwestern Livestock and Forage Research Station near El Reno and placed in the feedlot. Calves of a specific three-breed cross and of the same sex were fed together in a pen assigned at random. Ad libitum consumption of the finishing ration shown in Table 1 was allowed. All calves received a Synovex implant prior to entering the feedlot. A random half of the animals in each pen were reimplanted at 132 and 125 days on feed for the first and second year of the study, respectively. Cattle were individually removed from the feedlot for slaughter when attaining an estimated low choice carcass grade. A total of 259 heifers and 240 steers were involved in the study over the two years. Consideration of reimplantation effects on feed intake or feed efficiency were not possible since half the animals in each pen were reimplanted.

**Table 1. Finishing ration**

| Ingredient | | Percent of ration |
|---|---|---|
| Corn | | 78 |
| Alfalfa | | 8 |
| Cottonseed hulls | | 4 |
| Molasses | | 5 |
| Supplemental pellets[1] | | 5 |
| | Total | 100 |

[1]Supplemental pellets consisted of 67.6% soybean oil meal (44%), 12% urea, 10% calcium carbonate, 8% salt plus Aurofac, vitamin A and trace minerals.

## Results and Discussion

Preliminary analyses indicated that treatment X crossbred group and treatment X year interaction effects were not important, meaning that treatment differences were similar from one crossbred group to another and from one year to the next. Thus, treatment means and differences between treatments have been averaged over crossbred groups and years. On the other hand, the treatment X sex interaction was significant for several traits and so treatment means are presented separately for each sex.

Feedlot performance of heifers and steers is presented in Table 2. Within each sex, weights were similar for treatment groups when entering the feedlot and at the time of reimplantation. The effect of reimplantation on daily gain was positive for both sexes but considerably more pronounced for steers than for heifers. From reimplantation to slaughter, reimplanted steers gained .5 lb (21.4 percent) more weight per day than non-reimplanted steers and .26 lb (9.6 percent) more per day for the entire feedlot period. Reimplanted heifers gained .12 lb (6.0 percent) more weight per day following reimplantation and .06 lb (2.6 percent) more weight per day overall (non-significant) than non-reimplanted heifers.

Reimplanted heifers were in the feedlot eight fewer days and were 10 lb lighter (non-significant) at slaughter than non-reimplanted heifers. However, reimplanted heifers had a lower carcass grade (Table 3) which means they

**Table 2. Feedlot traits of reimplanted and non-reimplanted steers and heifers averaged over crossbred groups and years**

| | Heifers | | | Steers | | |
|---|---|---|---|---|---|---|
| | Reimplanted (A) | Non-reimplanted (B) | Difference (A - B) | Reimplanted (A) | Non-reimplanted (B) | Difference (A - B) |
| Weights (lb) | | | | | | |
| Initial | 510 | 514 | –4 | 540 | 545 | –5 |
| Time of reimplant | 848 | 854 | –6 | 939 | 936 | 3 |
| Slaughter | 1079 | 1089 | –10 | 1248 | 1221 | 27* |
| Daily gain (lb/day) | | | | | | |
| Pre-implant | 2.63 | 2.65 | –.2 | 3.10 | 3.04 | .06 |
| Post-reimplant | 2.13 | 2.01 | .12+ | 2.84 | 2.34 | .50** |
| Total feedlot period | 2.40 | 2.34 | .06 | 2.96 | 2.70 | .26** |
| Other | | | | | | |
| Age at initial wt (days) | 206 | 209 | –3 | 205 | 206 | –1 |
| Days on feed | 240 | 248 | –8* | 242 | 253 | –11** |

**Means differ significantly (P<.01).
*Means differ significantly (P<.05).
+Means differ significantly (P<.10).

should have remained in the feedlot longer. Had this been done, slaughter weight may have ended up heavier for the reimplanted heifers. In contrast, although reimplanted steers were in the feedlot 11 fewer days, they were 27 lb heavier at slaughter and had the same carcass grade as non-reimplanted steers. For both steers and heifers, it appears that reimplanted animals may need to be fed to a heavier slaughter weight to attain a given carcass grade.

Treatment means of carcass traits are presented in Table 3. Carcass weight and carcass weight per day of age was similar for the reimplanted and non-reimplanted heifer groups. However, reimplanted steers gained carcass weight .09 lb per day more rapidly and were 21 lb heavier in carcass weight than non-reimplanted steers. Dressing percentage was similar for both treatment groups.

Treatment differences in fat thickness appear to be influenced by differences in maturity (carcass grade). Carcasses of non-reimplanted animals were fatter than those of reimplant animals for both sexes. However, the difference is more pronounced in the heifer groups, in which reimplanted heifers were slaughtered at an earlier maturity than non-reimplanted heifers. For steers, both treatment groups had the same average carcass grade and so treatment differences for fat thickness should not be influenced by stage of maturity at slaughter. Fat thickness was .03 in less (non-significant) taken as an average of three measurements and .04 in less ($P<.10$) taken as a single measurement for reimplanted than non-reimplanted steers. Kidney, heart and pelvic fat was also less for reimplanted animals (.21 and .10 percent for steers and heifers, respectively).

Carcass conformation, an indicator of muscling, was similar for heifer treatment groups, but somewhat higher for reimplanted than non-reimplanted steers. A similar pattern was observed for ribeye area. Reimplanted steers and heifers had .5 ($P<.05$) and .2 (non-significant) sq in larger ribeyes, respectively, than non-reimplanted animals. However, ribeye area per hundred weight of carcass is very similar for reimplanted and non-reimplanted steers (1.66 vs 1.68 $in.^2$). Cutability was .6 percent and .5 percent higher for reimplanted than non-reimplanted heifers and steers, respectively. The heifer difference may be somewhat inflated since differences in fat thickness, a primary component of cutability, appears to be inflated by differences in maturity at slaughter.

A summary of Oklahoma reimplant studies is presented in Table 4. Daily gain response of steers to reimplantation in the present study (9.6 percent for the total feedlot period) was similar to that reported in Trial 2 of Wagner et al., 1976 (11.3 percent), but higher than in Trial 1 of Wagner et al, 1976 (4.3 percent) and a trial reported by Owens et al., 1980 (4.1 percent). Several differences in the conduct of the various studies should be noted, as these may contribute to differences in response to reimplantation. Calves used in the present study were sired by large terminal sire breeds. Earlier studies involved Hereford, Angus, Hereford-Angus crossbred and Hereford X Angus-Holstein crossbred cattle. Steers used by Wagner et al. had initial weights of 487 and 638 lb for the first and second trial, respectively, compared to 754 and 543 lb for steers used by Owens et al. and the present study, respectively. Days from initial implant to reimplantation, as well as days from reimplantation to the end of the trial were longer in the present study than in earlier studies. Therefore (and perhaps this is the most important difference) total days on feed was greater in the present study. In addition, calves in the present study were individually removed from the feedlot for slaughter while in previous trials calves were taken off test as a group.

Table 3. Carcass traits of reimplanted and non-reimplanted steers and heifers averaged over crossbred groups and years

| | Heifers | | | Steers | | |
|---|---|---|---|---|---|---|
| | Reimplanted (A) | Non-reimplanted (B) | Difference (A - B) | Reimplanted (A) | Non-reimplanted (B) | Difference (A - B) |
| Carcass weight (lb) | 696 | 701 | –5 | 800 | 779 | 21* |
| Carcass wt/day of age (lb/day) | 1.56 | 1.53 | .03 | 1.79 | 1.70 | .09** |
| Dressing percentage (%) | 64.4 | 64.3 | .1 | 64.1 | 64.0 | .1 |
| Average fat thickness (in) | .60 | .69 | –.09** | .67 | .70 | –.03 |
| Single fat thickness (in) | .44 | .49 | –.05* | .48 | .52 | –.04⁺ |
| KHP (%) | 2.89 | 2.99 | –.10 | 2.67 | 2.88 | –.21** |
| Carcass grade[a] | 9.3 | 9.7 | –.4** | 9.9 | 9.9 | 0 |
| Conformation[b] | 10.7 | 10.6 | .1 | 11.3 | 10.9 | .4** |
| Ribeye area ($in^2$) | 13.2 | 13.0 | .2 | 13.4 | 12.9 | .5* |
| Cutability | 50.8 | 50.2 | .6** | 49.8 | 49.3 | .5* |

[ab]9 = good +, 10 = choice –.
**Means differ significantly ($P<.01$).
*Means differ significantly ($P<.05$).
⁺Means differ significantly ($P<.10$).

Table 4. Summary of Oklahoma reimplant studies

| Study | No. Animals | Implant type: Initial | Implant type: Reimplant | Days between initial and mid-trait implants | Days from reimplant to end of trial | Weight at reimplant | Improvement in total feedlot daily gain |
|---|---|---|---|---|---|---|---|
| *Steers* | | | | | | | |
| Wagner et al., 1976 | 36 | Synovex-S | Synovex-S | 113 | 58 | 864 | 4.3% |
| Wagner et al., 1976 | 18 | Synovex-S | Synovex-S | 77 | 65 | 892 | 11.3% |
| Owens et al., 1980 | 240 | DES, 30 mg | Synovex-S | 56 | 62 | 986 | 4.1% |
| Present Study | 240 | Synovex-S | Synovex-S | 129 | 112 | 938 | 9.6% |
| *Heifers* | | | | | | | |
| Present study | 259 | Synovex-H | Synovex-H | 129 | 119 | 851 | 2.6% |

An economic analysis of reimplanted and non-reimplanted steers and heifers was conducted on the feedlot data. Feed costs, overhead costs and live animal value were based on prevailing prices for January 1983, and an annual interest rate of 14 percent was assumed. Differences in carcass merit due to reimplantation were not considered. Not including the cost of the implant itself, reimplantation resulted in $13.88 and $5.67 greater returns per head above feedlot expenses for steers and heifers, respectively. Any costs associated with the disturbance of animals caused by the implanting process were not considered in the economic analysis.

## Literature Cited

Owens, F.N. 1980. Okla. State Animal Science Research Report MP-107:118.
Wagner, D.G. 1976. Okla. State Animal Science Research Report MP-96:65.

# Effect of Stage of Maturity the Chemical Composition and In Vitro Digestibility of Sorghum Grain — Year 2

C.A. Hibberd[1], D.G. Wagner[2], R.L. Hintz[3] and D.E. Weibel[4]

## Story in Brief

Waxy (Dwarf Redlan), waxy bird resistant (1133), normal (Redlan) and normal bird resistant (Darset) varieties of sorghum grain were harvested at weekly intervals starting eight weeks preharvest (35 percent dry matter — DM) to determine the effect of maturity on chemical composition and IVDMD. Physiological maturity, measured by dry matter deposition (g/berry), was essentially complete by the time the grain reached 70 percent DM. At 70 percent DM, there was a range of 17 days in age, suggesting that the Darset and 1133, both bird resistant (BR) varieties, dried faster than the Dwarf Redlan and Redlan (non-BR). Percent starch increased through about 55 to 60 percent DM although starch deposition (g starch/berry) continued to increase through 70 percent DM. Similar trends were noted for protein. Tannin content of the BR sorghums decreased rapidly through 70 percent DM and continued to decrease, although more slowly, through harvest. *In vitro* dry matter disappearance (IVDMD) decreased throughout maturity, especially for the Redlan and Darset varieties. These studies suggest that variety dependent changes in chemical composition and IVDMD occur throughout maturity, and that these changes may alter the results obtained with high moisture harvested sorghum grain.

## Introduction

Increased energy costs for processing sorghum grain have motivated cattle feeders to consider grain processing systems which are more energy efficient than steam flaking or micronizing. High moisture methods such as high moisture harvest require less energy than steam flaking yet produce similar animal performance. In order to fully utilize the potential benefits from high moisture harvest, the impact of many factors must be better understood. Different varieties of sorghum grain vary considerably in chemical composition and IVDMD when mature (12 to 15 percent moisture). These differences between mature sorghum grain varieties may be a reflection of variety specific changes in various kernel constituents that occur as the kernel matures. The magnitude of these varietal differences and their effect on IVDMD remains unknown. The objective of this study was to monitor changes in the chemical composition and IVDMD of several sorghum grain varieties as the grain matures.

[1]Assistant Professor [2]Professor of Animal Science [3]Assistant Professor [4]Professor of Agronomy

## Materials and Methods

Waxy (Dwarf Redlan), waxy bird resistant (1133), normal (Redlan) and normal bird resistant (Darset) varieties of sorghum grain were grown under similar conditions at the Agronomy Research Station, Perkins, OK (Table 1). Six heads representative of each variety were selected at random and harvested at weekly intervals for eight weeks starting August 28. Sorghum heads were threshed and ground through a 1 mm screen in a Wiley mill with the aid of dry ice. Samples were frozen immediately to minimize drying and fermentation until analysis.

Crude protein was measured as Kjeldahl N × 6.25 and starch as glucose polymers following an enzymatic digestion. Percent starch and protein were multiplied by berry size (dry weight/100 berries) to obtain amounts of starch and protein per kernel (g/berry). Tannin content (catechin equivalents/g) was determined with the vanillin — HCl assay. *In vitro* dry matter disappearance was measured after an 18-h digestion with strained and buffered rumen fluid obtained from a steer fed an 80 percent concentrate diet.

The data reported herein represent the second year of a study that was originally reported in the 1982 edition of this publication.

**Table 1. Descriptive characteristics of sorghum grain varieties**

| | | | Endosperm | | |
|---|---|---|---|---|---|
| Variety | Pericarp Color | Testa Layer[a] | Color | Starch | Classification |
| Dwarf Redlan | Red | Absent | White | Waxy | Waxy |
| 1133 | Brown | Present | Yellow | Waxy | Waxy - BR[b] |
| Redlan | Red | Absent | White | Normal | Normal |
| Darset | Brown | Present | White | Normal | Normal - BR[b] |

[a]Testa layer indicative of elevated tannin content.
[b]BR = Bird resistant.

## Results and Discussion

Initial collection of sorghum samples was initiated when the grain was approximately 35 percent dry matter (Figure 1). The Darset dried the fastest followed by the 1133, Dwarf Redlan and Redlan. As much as 17 days difference was noted between the Darset and the Redlan when each reached 70 percent dry matter. As maturity approached, dry seed weight increased until the grain was about 70 percent dry suggesting that physiological maturity (maximum dry matter deposition) was complete (Figure 1).

Percent starch increased through 50 to 55 percent dry matter for all but the Redlan (Figure 2). The Redlan peaked somewhat later (65 percent DM). Starch deposition (g/berry) continued to increase through about 70 percent DM which coincided with the peak in dry matter deposition. Increased starch deposition between 50 and 70 percent DM is probably a reflection of increased berry size because percent starch remained constant through this period.

Percent crude protein (N × 6.25) generally decreased through 55 to 60 percent DM (Figure 3). Similar to starch deposition, however, protein deposition (g/berry) continued to increase through 65 to 70 percent DM. As with starch, the increased protein deposition between 55 and 70 percent DM is probably due to increased berry size.

Tannin content (catechin equivalents/g) of the Darset increased rapidly in early maturity (Figure 4). During this same period, tannin content of the 1133 had begun to decline from an early peak. Both bird resistant varieties decreased in tannin concentration through about 60 percent DM after which tannin concentration remained relatively constant. High tannin content early in maturity may serve to discourage bird predation when the sorghum kernel is young and immature.

*In vitro* dry matter disappearance decreased as maturity progressed (Figure 4). The most dramatic change was observed for the Redlan and Darset varieties. Decreased IVDMD throughout maturation corresponded to increased protein content. As protein increases, the quantity of starch shielded from fermentation may also increase thus decreasing IVDMD. Changes in IVDMD in this study may appear contradictory to changes in tannin concentration. The tannins present in early maturity are probably composed of numerous small molecules that gradually polymerize during maturity to form more efficient protein binding complexes. Consequently, although tannin content in early kernel development may be high, the protein binding capacity is probably low resulting in little effect on IVDMD.

Most high moisture grain is normally harvested between 65 and 70 percent dry matter. Although digestibility (IVDMD) decreased throughout maturity, these studies reinforce the premise that the grain must reach 65 to 70 percent DM before dry matter yield is maximized. Substantial changes in chemical composition were observed as maturity progressed. The magnitude of these changes was highly dependent on variety which may affect the utilization of high moisture grain by beef cattle. Wise decisions about variety and harvest time should enhance the nutritional quality of high moisture harvested sorghum grain for ruminants.

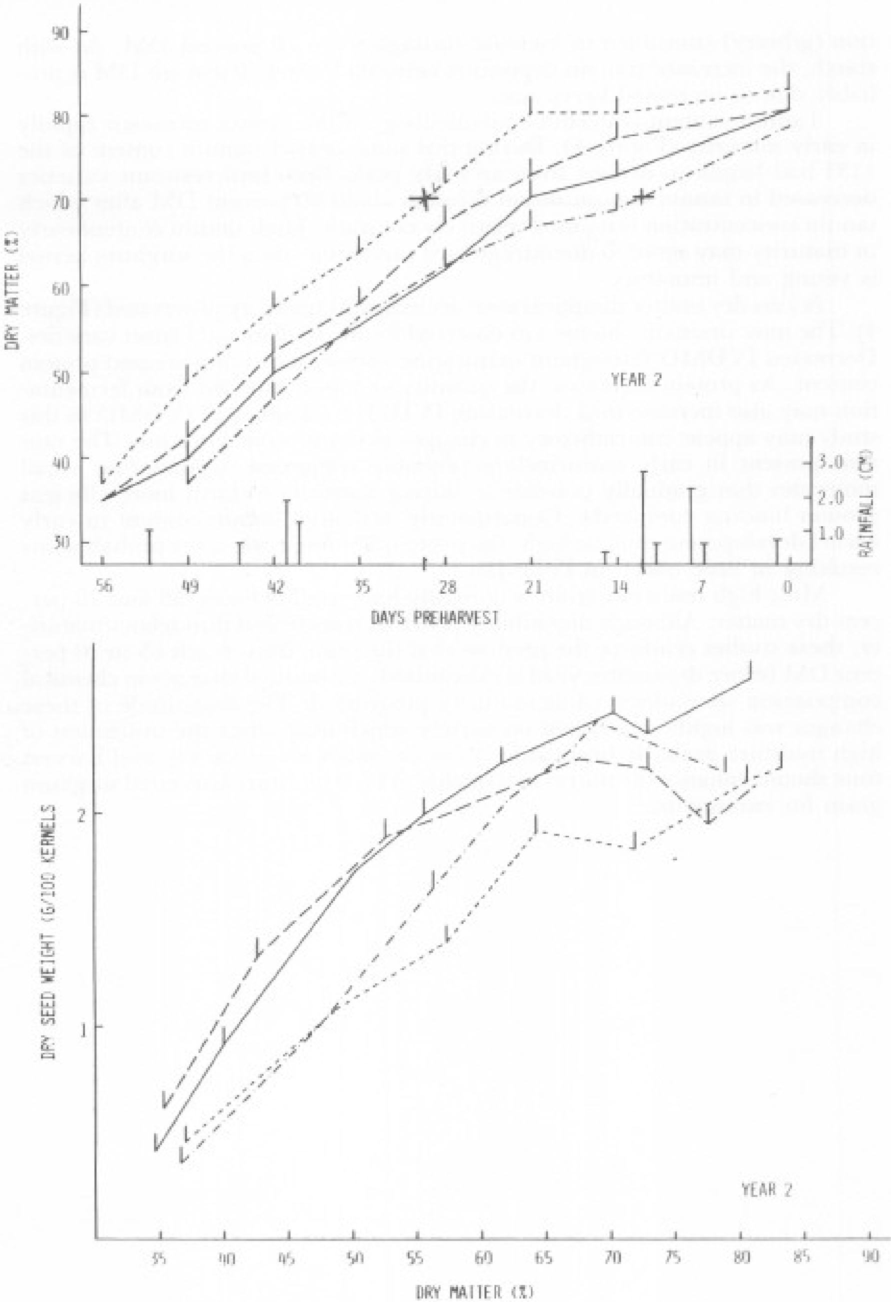



**Figure 1. Dry matter content and dry seed weight of maturing sorghum grain (—Dwarf Redlan, — —1133, —·—·Redlan,----Darset).**

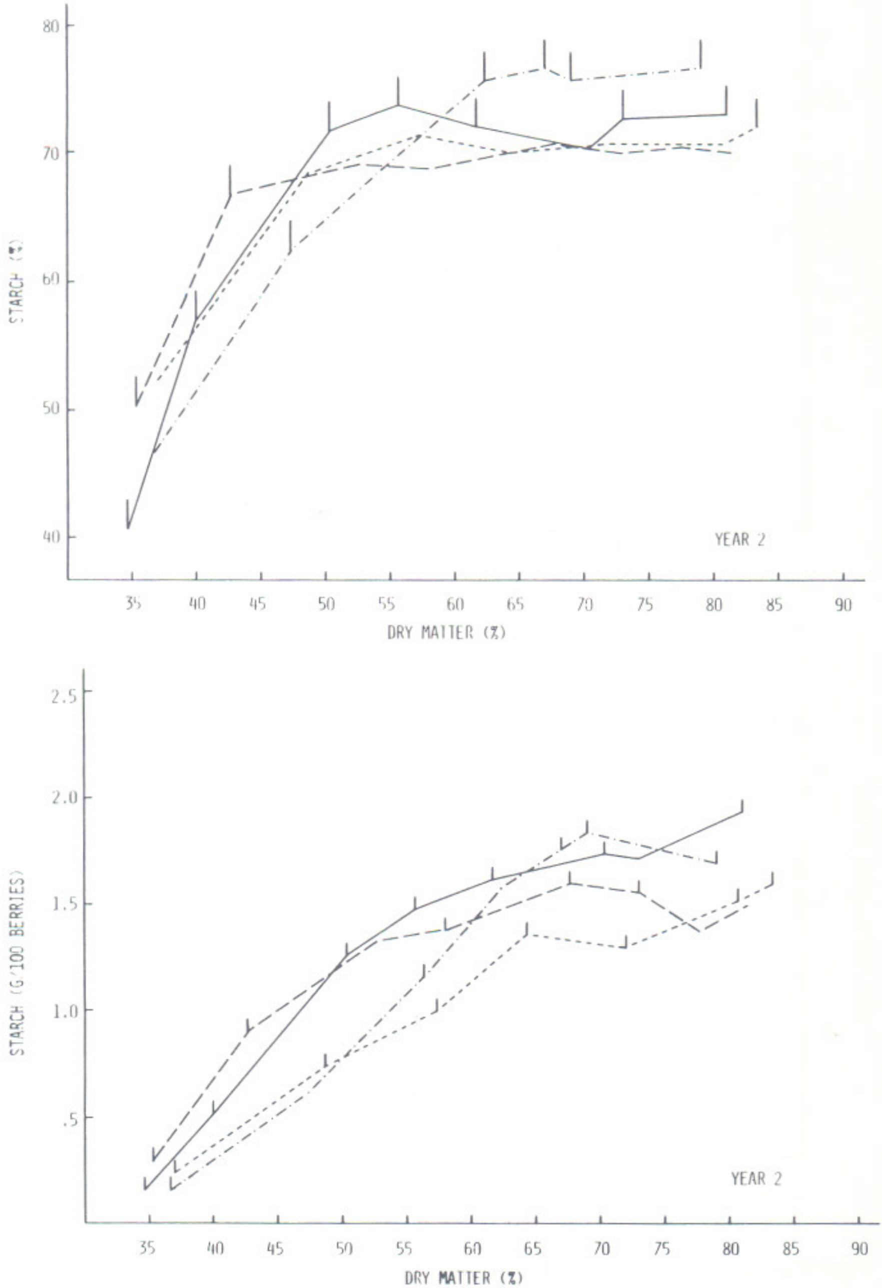
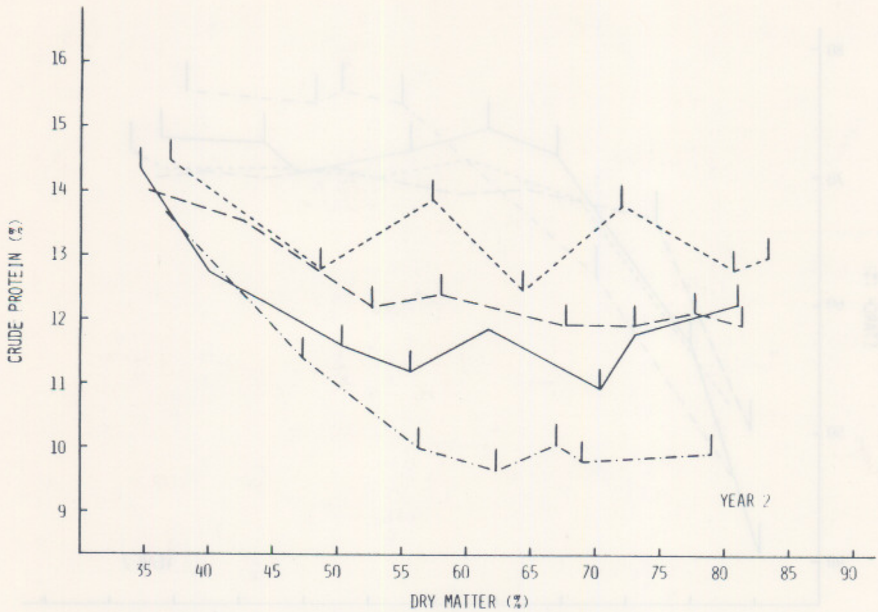



**Figure 2. Starch content (%) and deposition (g/100 berries) of developing sorghum grain (— Dwarf Redlan, – – 1133, —·—·Redlan,----Darset).**



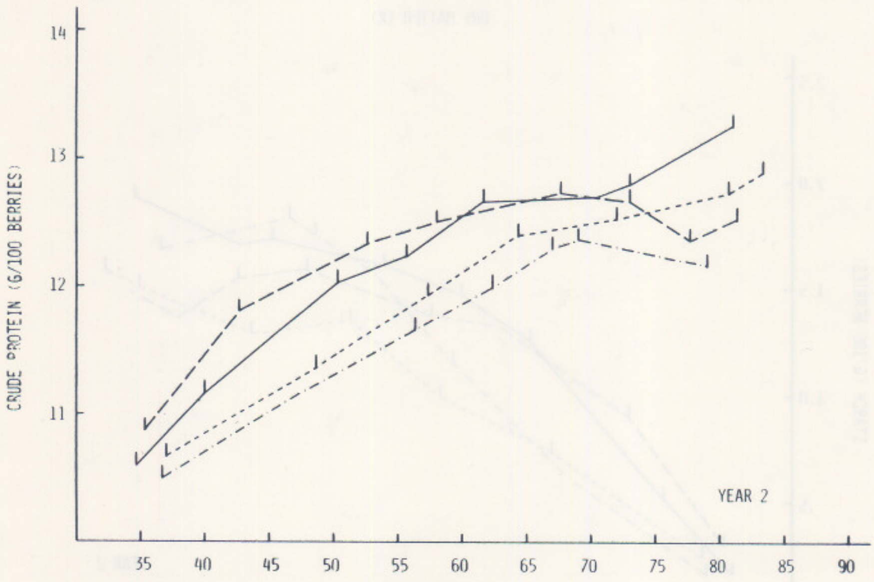




**Figure 3. Crude protein content (%) and deposition (g/100 berries) of maturing sorghum grain (–Dwarf Redlan, – –1133, –·–·Redlan,----Darset).**

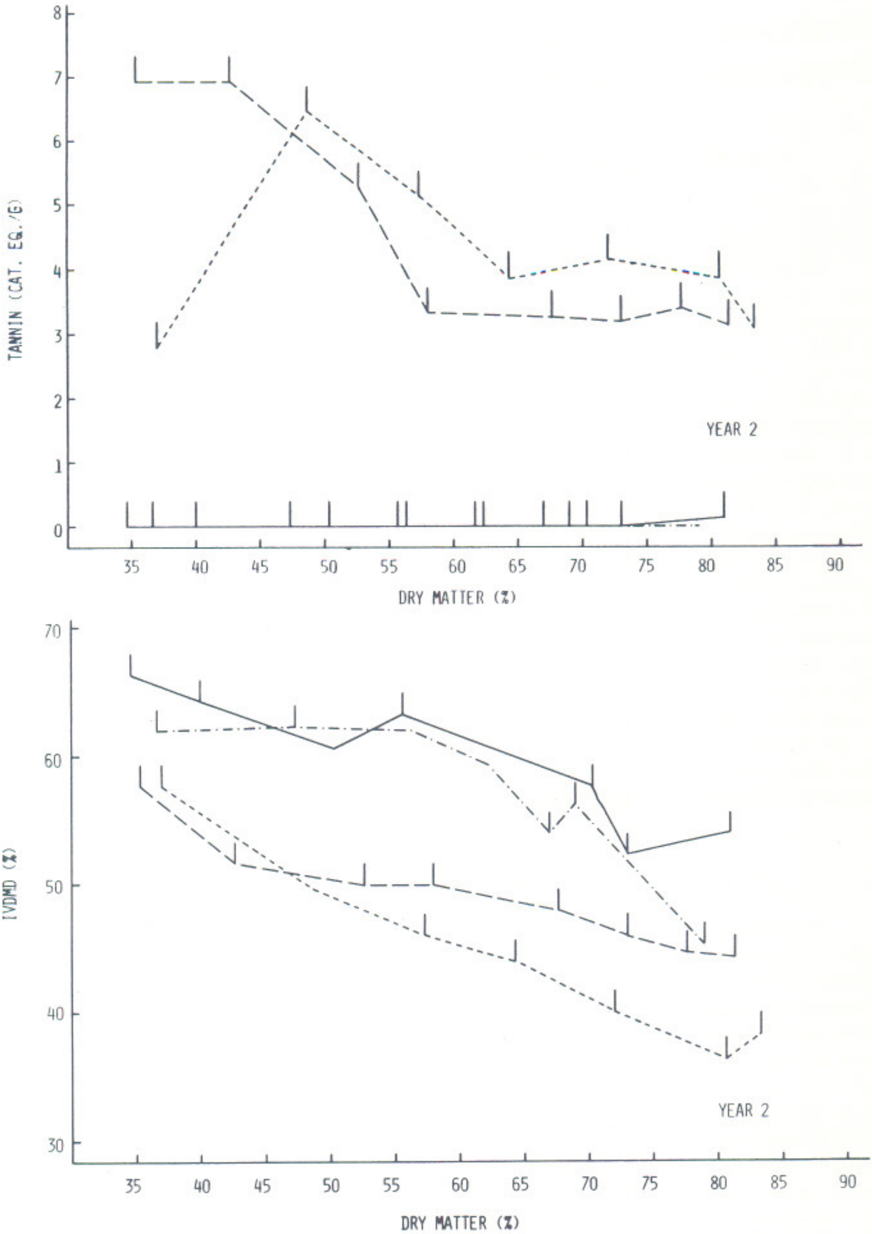



**Figure 4. Tannin content (catechin eq./g) and *in vitro* dry matter disappearance of maturing sorghum grains (—Dwarf Redlan— —1133, —·—·Redlan,----Darset).**

# Effect of Sorghum Grain Variety and Processing Method on the Site and Extent of Starch Digestion in Steers

C.A. Hibberd[1], D.G. Wagner[2], R.L. Hintz[3] and D.D. Griffin[4]

## Story in Brief

Hetero-yellow (H-Y), red (RED) and brown (BR) sorghum grain varieties were incorporated into 88 percent grain diets as either dry rolled or reconstituted-rolled (RED and BR only) grain to evaluate the effects of variety and processing (reconstitution) on the site and extent of starch digestion in steers. Five Hereford-Angus steers (750 lb) fitted with ruminal, duodenal and ideal T-type cannulae were utilized in a 5 x 5 latin square. Total tract starch digestion of the dry rolled sorghums ranged from 86.9 percent for the RED to 91.4 percent for the H-Y sorghum diet. Larger differences between dry rolled sorghums were observed in the rumen where starch digestion (percent of total) was 69.1 percent for the RED vs 82.7 percent for the BR. Reconstitution increased ($P < .05$) ruminal starch digestion of the RED sorghum from 69.1 percent to 91.1 percent of total with little effect on the BR. A significant quantity (626 g) of the ruminally undigested starch from the reconstituted BR diet was digested in the small intestine resulting in essentially complete (97.3 percent) starch digestion for both of the reconstituted sorghum diets by the time the digesta reached the ileum. Steers fed the dry rolled RED sorghum digested 622 g of starch in the large intestine suggesting that this organ may compenstate for incomplete starch digestion of poorly processed grain. Both sorghum grain variety and processing method appear to alter the site and extent of starch digestion in steers, differences that are probably translated into variation in animal performance.

## Introduction

Decreasing ground water supplies and escalating irrigation costs may increase the use of drought tolerant crops such as sorghum grain in the Great Plains. Many livestock producers tend to discriminate against sorghum grain because of highly variable quality and the fact that the grain must be processed before feeding. Previous studies in our laboratory have illustrated large variation in the chemical composition and IVDMD of different sorghum grain varieties. Additional studies in our laboratory have shown that different varieties of sorghum respond uniquely to reconstitution. How these differences in laboratory responses translate into animal parameters such as digestibility remains unknown. The following study was performed to determine how sorghum grain variety and processing method affect the site and extent of starch digestion in steers and the relationship of these parameters to laboratory analyses.

[1]Assistant Professor, [2]Professor of Animal Science, [3]Assistant Professor, [4]College of Veterinary Medicine

## Materials and Methods

Three varieties of sorghum, hetero-yellow (H-Y), red (RED) and brown (BR) were obtained from three locations in Oklahoma (Table 1). Dry sorghum grain was either dry rolled or reconstituted-rolled (RED and BR only) before incorporation into an 88 percent grain ration (Table 2). Reconstitution was performed by adding adequate water to raise the moisture level to 30 percent after which the grain was placed in large polyurethane bags (75 lb/bag) and stored for 21 days before rolling.

The five sorghum rations (3 dry rolled and 2 reconstituted-rolled) were fed to five Hereford-Angus steers (750 lb) fitted with ruminal, duodenal and ileal T-type cannulae using a 5 x 5 latin square design. Steers were fed equal portions twice daily at 2 percent (DM) of body weight. Experimental periods were 10 days in length; 7 days of adaptation and 3 days of sampling performed at 1000, 1400 and 1800 hours. Digesta samples were composited across time and day within each period and dried in a forced air oven at 130°F. Feed and digesta samples were ground through a 1 mm screen in a Udy mill prior to analysis.

Grain, feed and digesta samples were analyzed for dry matter, starch (glucose polymers), crude protein, tannin (catechin equivalents) and ash. Digestibility of starch was determined by chromic oxide ratios. *In vitro* dry matter disappearnce (IVDMD) of grain and feed samples was determined with an 18 hour incubation with buffered, strained rumen fluid. *In vitro* gas production (IVGP) was evaluated after a 12-hour incubation with an amyloglucosidase enzyme and commercial baker's yeast.

**Table 1. Descriptive characteristics of sorghum grains**

| Sorghum | Abbreviation | Pericarp color | Endosperm color | Testa layer[a] |
|---|---|---|---|---|
| Hetero-yellow | H-Y | Yellow | Hetero-yellow | Absent |
| Red | RED | Red | White | Absent |
| Brown | BR | Brown | White | Present |

[a]Presence of testa layer indicative of high tannin content and bird resistance.

**Table 2. Ingredient composition of experimental diets (dry matter basis).**

| Ingredient | IFN# | % |
|---|---|---|
| Sorghum grain | 4-04-383 | 88.0 |
| Cottonseed hulls | 1-01-599 | 8.0 |
| Supplement | | |
| Urea | 5-05-070 | 1.20 |
| Dicalcium phosphate | 6-01-080 | 0.44 |
| Calcium carbonate | 6-01-069 | 0.93 |
| Potassium chloride | 6-03-756 | 0.57 |
| Sodium sulfate | 6-04-292 | 0.36 |
| Sodium chloride | 6-04-152 | 0.25 |
| Chromic oxide | | 0.20 |
| Vitamin A | 7-05-143 | 2200 IU/kg |

## Results and Discussion

Crude protein content ranged from 10.37 percent for the RED to 14.08 percent for the H-Y sorghum (Table 3). Reconstitution had no effect ($P > .05$) on crude protein content. The RED sorghum contained more ($P < .05$) starch than the BR. Tannin content was highest ($P < .05$) for the BR sorghum. Eighteen-hour *in vitro* dry matter disappearance (IVDMD) was lower ($P < .05$) for the dry rolled BR than the dry rolled RED sorghum. Reconstitution increased ($P < .05$) the IVDMD of both the RED and BR sorghums for both the grain and complete feed. Reconstitution increased the starch availability (measured by *in vitro* gas production - IVGP), of the BR sorghum grain to a greater extent than the RED. For the complete feed, however, the greatest reconstitution response was noted for the RED sorghum.

Although daily dry matter intake was equalized across treatments, starch intake varied because starch content of the sorghums differed (Tables 3 and 4). Total tract starch digestibility of the dry rolled sorghums ranged from 86.9 percent for the RED to 91.4 percent for the H-Y (Table 4). Differences between varieties in ruminal starch disappearance were much greater ($P < .05$), from 69.1 percent for the RED to 82.7 percent for the BR sorghum. Disappearance in the small (668 g) and large intestine (622 g) compensated for low ruminal fermentation of RED sorghum starch.

Reconstitution increased ($P < .05$) ruminal starch disappearance (from 2899 to 4280 g/day) for the RED sorghum but not the BR (Table 4). In fact, the amount of digestible starch disappearing from the rumen increased ($P < .05$) from 69.1 to 91.1 percent for the reconstituted RED sorghum. Starch from the reconstituted sorghums was easily digested in the small intestine (70 percent for the RED and 67.5 percent for the BR). Consequently, disappearance of reconstituted sorghum starch was almost complete (97.3 percent) when the digesta reached the ileum.

Large quantities of starch (622 g for the RED sorghum) disappeared in the large intestine of steers fed the dry rolled sorghum diets (Table 4). Thus, the large intestine can compensâte to some extent for incomplete digestion of starch in the rumen and small intestine of steers fed poorly processed grain. Poor utilization of starch fermented in the large intestine due to altered fermentation patterns and poor absorption or organic compounds other than volatile fatty acids suggests that large intestinal fermentation should be avoided.

This study suggests that both variety and processing method can alter the site and extent of sorghum grain starch digestion. For example, decreased ruminal starch fermentation for the dry rolled RED sorghum resulted in larger quantities of starch disappearing in the small and large intestine (Figure 1). Reconstitution resulted in almost complete starch digestion in segments prior to the large intestine. The major response, however, occurred in the rumen for the reconstituted RED sorghum but in the small intestine for the reconstituted BR.

The observed differences between varieties and their response to reconstitution were substantial, even at an intake level of 2 percent of body weight. Higher intake levels typical of cattle on feed (2.5 percent of body weight or greater) may further increase the differences observed in this study.

Agreement between IVDMD patterns and actual ruminal starch disappearance was poor except for the reconstitution response of the RED sorghum. Inoculum for the IVDMD was obtained from a steer fed a low tannin diet while the steers in the digestion trial were allowed seven days to adapt to the tannin

**Table 3. Chemical characteristics, IVDMD and IVGP of processed sorghum grains and complete mixed feeds (dry matter basis).**

| | Dry-rolled | | | Reconstituted | | |
|---|---|---|---|---|---|---|
| | Het-yel | Red | Brown | Red | Brown | SE |
| Grain | | | | | | |
| Crude protein (%)[bd] | 14.08 | 10.37 | 13.35 | 10.76 | 13.22 | .28 |
| Starch (%)[b] | 68.44 | 70.79 | 64.97 | 72.92 | 65.70 | .66 |
| Tannin (cat. eq./g)[bd] | .06 | .03 | 1.31 | .04 | 1.21 | .06 |
| IVDMD, 18-h (%)[ab] | 48.6 | 50.1 | 36.6 | 54.7 | 42.6 | 1.9 |
| IVGP, 12-h (ml gas/g DM)[cdefgh] | 96.6 | 121.2 | 97.6 | 132.4 | 121.5 | 2.3 |
| Feed | | | | | | |
| Crude protein (%)[bd] | 16.88 | 13.31 | 15.47 | 13.39 | 15.31 | .14 |
| Starch (%)[ab] | 66.65 | 69.32 | 62.44 | 66.94 | 57.93 | 1.46 |
| Tannin (cat. eq./g)[cdfgh] | .03 | .04 | 1.22 | .04 | .86 | .02 |
| IVDMD, 18-h (%)[ab] | 49.5 | 52.7 | 39.2 | 54.4 | 44.3 | 1.7 |
| IVGP, 12-h (ml gas/g DM)[cdefgh] | 103.5 | 100.4 | 91.5 | 130.2 | 103.2 | 1.1 |

[a]Dry rolled (RED and BR only) vs. reconstituted ($P<.05$).
[b]RED vs. BR ($P<.05$).
[c]Variety X processing interaction ($P<.05$).
[d]HY vs. all others ($P<.05$).
[e]Dry rolled RED vs. reconstituted RED ($P<.05$).
[f]Dry rolled BR vs. reconstituted BR ($P<.05$).
[g]Dry rolled RED vs. dry rolled BR ($P<.05$).
[h]Reconstituted RED vs. reconstituted BR ($P<.05$).

**Table 4. Site and extent of starch digestion of dry rolled or reconstituted sorghum varieties.**

| | Dry-rolled | | | Reconstituted | | |
|---|---|---|---|---|---|---|
| | Het-yel | Red | Brown | Red | Brown | SE |
| Starch intake, | | | | | | |
| g/day | 4679 | 4822 | 4501 | 4762 | 4126 | 46 |
| Ruminal starch disappearnce, | | | | | | |
| g/day[bdf] | 3316 | 2899 | 3370 | 4280 | 3183 | 173 |
| Percent of total[bdef] | 77.8 | 69.1 | 82.7 | 91.1 | 81.2 | 3.2 |
| Small intestinal starch disappearance, | | | | | | |
| g/day[bdf] | 411 | 668 | 403 | 282 | 626 | 93 |
| Percent[ac] | 28.6 | 33.4 | 34.8 | 70.9 | 67.5 | 3.3 |
| Starch digestibility through ileum, | | | | | | |
| Percent of total[ac] | 87.5 | 85.5 | 92.6 | 97.3 | 97.3 | 1.8 |
| Large intestinal starch disappearance, | | | | | | |
| g/day[ac] | 543 | 622 | 305 | 125 | 102 | 80 |
| Percent[g] | 57.3 | 48.6 | 42.1 | 40.8 | 18.0 | 15.8 |
| Total tract starch digestibility, | | | | | | |
| Percent[bd] | 91.4 | 86.9 | 90.8 | 98.4 | 94.8 | 1.5 |

[a]Dry rolled (RED and BR only) vs. reconstituted ($P < .05$).
[b]Variety X processing interaction ($P < .05$).
[c]HY vs. all others ($P < .05$).
[d]Dry rolled RED vs. reconstituted RED ($P < .05$).
[e]Dry rolled RED vs. dry rolled BR ($P < .05$).
[f]Reconstituted RED vs. reconstituted BR ($P < .05$).
[g]No significant differences ($P > .05$).

levels in the BR sorghum. The IVGP data did a better job of predicting the observed reconstitution response but did not predict the differences between the RED and BR sorghums adequately.

The performance of the high tannin, brown sorghum in this study might tempt one to conclude that high tannin sorghums are not detrimental. There are sorghum varieties, however, with at least twice as much tannin which may yet affect utilization. Previous studies have shown decreased digestibility and performance with high tannin sorghums.

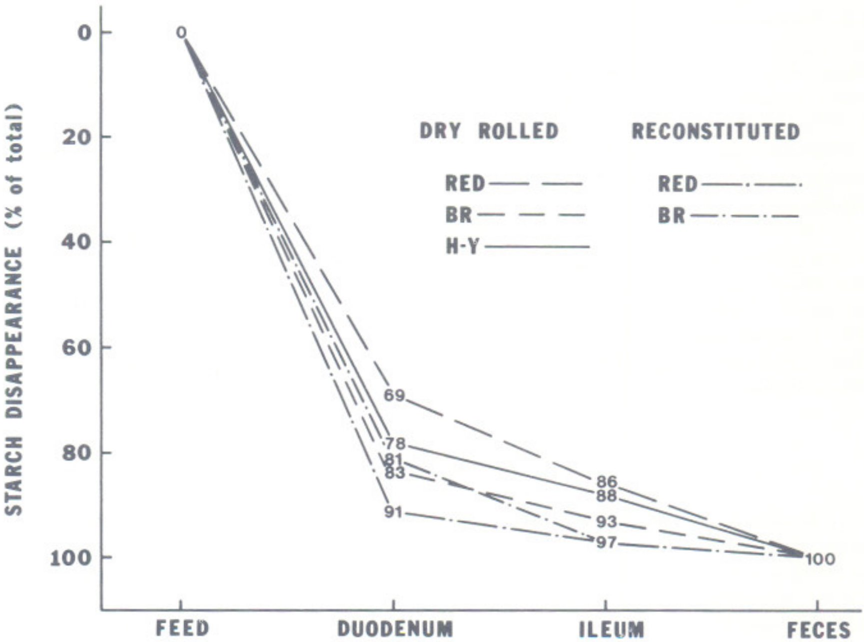



Figure 1. Disappearance of starch in various segments of the digestive tract of steers fed dry rolled or reconstituted sorghum grain varieties.

# Influence of Organic Acids on Microbial Protein Synthesis in the Rumen

D. C. Weakley[1] and F. N. Owens[2]

## Story in Brief

The influence of added acids (1.9 percent lactic and two percent acetic) on microbial protein synthesis was studied using four Angus steers (1150 lb) with ruminal and duodenal cannulas fed a concentrate diet. Average ruminal pH values obtained with each diet were only slightly reduced (6.27 vs 6.36) by addition of a total of 3.9 percent of these acids to the diet. No effects on digestibility of organic matter (OM) or nitrogen (N) in the rumen or total tract were apparent. Efficiency of microbial protein synthesis (range: 7.6 to 11.8 g N/kg OM truly digested in the rumen) was not altered by acid addition or differences between animals (pH from 5.9 to 6.7). A slight increase in ruminal digestion of organic matter (three percent) was observed at the higher ruminal ammonia levels.

A compilation of data from this and another related study indicated that at extremes in ruminal pH, ruminal organic matter digestion was depressed but efficiency of microbial protein synthesis tended to remain relatively unchanged. Altering ruminal pH up or down from 6.3 with a high concentrate diet may adversely affect ruminal OM digestion but has little influence on efficiency of microbial protein synthesis. Ruminal residence time of particles and dilution rate of liquids may be involved.

## Introduction

Ruminal pH influences ruminal fiber digestion, production of volatile fatty acids and protein solubility. These appear related to competition among microbial species, alterations in microbial metabolism or slight changes in the chemical nature of the feedstuff. Little information is available on the effect of ruminal pH on efficiency of synthesis of microbial protein. It is difficult to change ruminal pH while holding other ruminal conditions constant. The objective of this study was to determine how added acids influence ruminal pH, organic matter digestion and efficiency of microbial protein synthesis in the rumen.

## Materials and Methods

Four Angus steers (1150 lb) with ruminal and duodenal cannulas were fed a ground corn diet supplemented with nitrogen from urea or ammonium acetate ($NH_4AC$; Table 1) to alter ruminal pH while maintaining constant ruminal ammonia concentrations. Lactic acid also was added to the $NH_4AC$

[1]Graduate Assistant [2]Professor, Animal Science

**Table 1. Ration composition**

| Item | Diets | |
|---|---|---|
| | Urea | $NH_4AC$ |
| | —% of diet DM— | |
| Ground corn | 44.7 | 46.7 |
| Cottonseed hulls | 15.2 | 15.2 |
| Molasses | .46 | .46 |
| Chromic oxide | .20 | .20 |
| Supplement | 39.4 | 37.4 |
| Urea | 1.04 | -- |
| Ammonium acetate | -- | 2.75 |
| Lactic acid | -- | 1.90 |
| Ground corn | 35.46 | 30.0 |
| Dicalcium phosphate | .53 | .50 |
| Limestone | .91 | .86 |
| Trace mineralized salt | .45 | .43 |
| $Na_2SO_4$ | .45 | .43 |
| KCl | .54 | .51 |
| Vitamin A | .009 | .008 |
| Vitamin D | .002 | .002 |
| Crude protein, % of DM | 12.1 | 12.7 |

diet to suppress pH. Two animals were fed each diet every six hrs at a daily level equal to 1.1 percent of body weight. The animals were then switched to the other diet for study.

After animals had consumed their diets for five days, fecal and duodenal samples were collected twice daily (am and pm) for three days and analyzed for organic matter, nitrogen and total purines, an index of microbial protein. On the fourth day of sampling, rumen fluid was collected for ammonia and pH measurement and determination of purine to nitrogen ratio in isolated bacteria.

## Results and Discussion

Although individual ruminal pH values between animals on diets differed, (5.9 to 6.7), the average ruminal pH from each diet was similar (Table 2). Addition of three percent acid to the diet caused only a slight pH change, illustrating the strong buffering capacity of ruminal contents. Added acids had little effect on ruminal or total tract digestibility of organic matter, (Table 3),

**Table 2. Ruminal parameters**

| | Diets | |
|---|---|---|
| | Urea | $NH_4AC$ |
| Ammonia-N, mg/dl | 14.3 | 16.9 |
| pH | 6.36 | 6.27 |

**Table 3. Organic matter**

| Item | Diets | |
|---|---|---|
| | Urea | $NH_4AC$ |
| Intake, g/day | 5564 | 5543 |
| Leaving abomasum, g/day | | |
| Total | 2272 | 2264 |
| Non-microbial | 1719 | 1620 |
| Chyme, liter/day | 35.0 | 38.2 |
| Ruminal digestion, % | | |
| Unadjusted | 59.1 | 59.1 |
| Adjusted[a] | 69.0 | 70.8 |
| Ruminal digestion, % of total | 70.9 | 69.6 |
| Feces, g/day | 920 | 841 |
| Postruminal digestion, % of input | 59.5 | 62.3 |
| Total tract digestion, % | 83.4 | 84.8 |

[a]Adjusted for microbial organic matter.

**Table 4. Nitrogen**

| Item | Diets | |
|---|---|---|
| | Urea | $NH_4AC$ |
| Intake, g/day | 114[b] | 118[a] |
| Leaving abomasum, g/day | | |
| Total N | 85 | 84 |
| Microbial N | 34 | 36 |
| Nonammonia, nonmicrobial | 43[a] | 41[b] |
| Ruminal digestion, % | | |
| Unadjusted | 25.9 | 28.6 |
| Adjusted[c] | 62.1[b] | 65.8[a] |
| Microbial efficiency, g microbial N/kg OM truly digested in rumen | 8.8 | 9.1 |
| Ruminal digestion, % of total | 34.7 | 37.2 |
| Feces, g/day | 29 | 27 |
| Postruminal digestion, % of input | 65.7 | 67.8 |
| Total tract digestion, % | 74.6 | 77.0 |

[ab]Means in a row with different superscripts differ statistically ($P < .05$).
[c]Adjusted for microbial and ammonia nitrogen.

protein (Table 4) or on efficiency of microbial protein synthesis (Table 4). Detailed study of individual pH values failed to illustrate an influence of ruminal pH on these factors.

Ruminal ammonia concentrations, while similar for the two diets (Table 2), varied from 6.6 to 22 mg/dl rumen fluid in the experiment. Levels are above those suggested to meet the needs for microbial protein synthesis (Weakley and Owens, 1983). However, in this study efficiency of microbial protein synthesis was observed to increase slightly as ruminal ammonia increased from 6.6 to 22 mg/dl. The change, however, was quite small (7.6 to 11.8 g microbial N/kg OM truly digested in the rumen) and factors other than level of ammonia may be involved. A slight stimulation (three percent) in ruminal organic matter digestion also was observed at the higher ruminal ammonia concentrations.

Data from this and another related study were compiled to include observations of ruminal OM digestion and microbial efficiency over a wider range of ruminal pH (5.8 to 6.7; Figures 1 and 2). Both of these studies were conducted with high concentrate diets. Depression in ruminal OM digestion was observed at extremes in ruminal pH (Figure 1). However, efficiency of microbial protein synthesis appeared to be affected little by pH (Figure 2). This suggests that pH may be influencing residence time of solids in the rumen and liquid outflow, which would influence ruminal digestion, while affecting the bacterial metabolism very little. These results indicate a possible role for feeding buffers to maintain a ruminal pH around 6.2 to 6.4 conducive to optimum ruminal OM digestion on high concentrate diets.

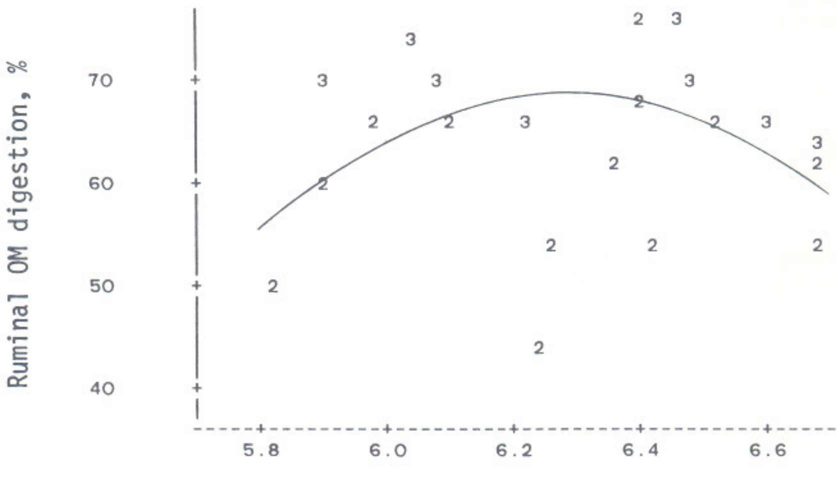



**Figure 1. Influence of ruminal pH on ruminal organic matter digestion in 2 experiments[a].**

[a]Quadratically related (P = .10).
[2]Data of Weakley and Owens, 1983.
[3]Data of present study.

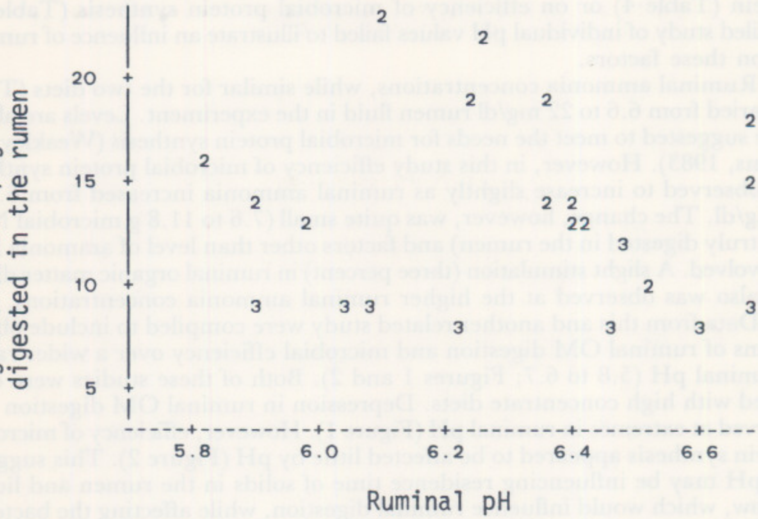



**Figure 2. Influence of ruminal pH on efficiency of microbial protein synthesis in 2 experiments[a].**

[a]No relationship (P>.30).
[2]Weakley and Owens, 1983.
[3]Present study.

## Literature Cited

Weakley, D. C. and F. N. Owens. 1983. Okla. Agr. Exp. Sta. Res. Rep. MP-114:

# Influence of Ammonia Concentration on Microbial Protein Synthesis in the Rumen

D. C. Weakley[1] and F. N. Owens[2]

## Story in Brief

The influence of ruminal ammonia supply on microbial protein synthesis was studied using four Angus steers (1080 lb) with ruminal and duodenal cannulas fed a concentrate based diet supplemented with 0, 1, 2 or 3 percent crude protein equivalent from non-protein nitrogen. Ruminal ammonia concentration values ranged from 1.2 to 13.1 mg ammonia nitrogen/dl rumen fluid. Efficiency of microbial protein synthesis appeared to be depressed at the lower ruminal ammonia concentrations. A compilation of this and another related study demonstrated no significant effect of ammonia concentration on efficiency of microbial protein synthesis at ruminal ammonia concentrations ranging from 1.2 to 22.1 mg/dl. Organic matter (OM) digestion in the rumen tended to increase ($P < .08$) as ruminal ammonia concentrations increased. For digestion of a high concentrate diet, ruminal ammonia levels above 3 mg/dl appear adequate for efficient protein synthesis by ruminal microbes but higher levels may increase digestion of organic matter in the rumen and total tract.

## Introduction

Slow release urea compounds were devised to match the supply of ammonia with the rate of digestion to maximize microbial protein synthesis and avoid ammonia deficiencies for microbes in the rumen. Such work is based on the suggestions that ruminal ammonia levels less than 3 to 5 mg/dl rumen fluid are inadequate for most efficient protein synthesis by ruminal microbes. Ammonia levels in the rumen below 3 mg/dl are frequently observed with cattle grazing native range in the winter and, in some cases, with feedlot cattle. When urea is added to a diet, it is generally beneficial only when digestibility or feed intake or both increase. These findings plus inconsistent responses to slow release urea compounds suggest that factors other than a direct effect of ammonia on efficiency of microbial protein synthesis are responsible for observed benefits to NPN supplementation. The objective of this study was to determine if ruminal ammonia supply influences organic matter digestion and efficiency of microbial protein synthesis in the rumen.

## Materials and Methods

Four Angus steers (1080 lb) fitted with ruminal and duodenal cannulas were fed a ground corn diet supplemented with 0, 1, 2 or 3 percent crude protein equivalent from non-protein nitrogen (NPN; Table 1). A mixture of am-

[1]Graduate Assistant, [2]Professor, Animal Science

**Table 1. Ration composition**

| Item | Diets | | | |
|---|---|---|---|---|
| | % Supplemental CPE | | | |
| | 0 | 1 | 2 | 3 |
| | % of diet DM | | | |
| Ground corn | 60.4 | 61.2 | 61.4 | 61.5 |
| Cottonseed hulls | 15.1 | 15.1 | 15.1 | 15.1 |
| Molasses | .45 | .45 | .45 | .45 |
| Chromic oxide | .22 | .22 | .22 | .22 |
| Supplement | 23.8 | 23.0 | 22.8 | 22.7 |
| Ammonium acetate | 0 | .53 | 1.05 | 1.57 |
| Urea | 0 | .14 | .28 | .41 |
| Ground corn | 20.8 | 19.4 | 18.6 | 17.8 |
| Dicalcium phosphate | .55 | .53 | .53 | .53 |
| Limestone | .95 | .91 | .91 | .90 |
| Trace mineralized salt | .47 | .45 | .45 | .44 |
| $NaSO_4$ | .47 | .45 | .45 | .44 |
| KCl | .56 | .54 | .54 | .54 |
| Vitamin A | .01 | .01 | .01 | .01 |
| Vitamin D | .002 | .002 | .002 | .002 |
| Crude protein, % of DM | 8.3 | 9.3 | 10.5 | 11.5 |

monium acetate and urea was used to avoid the elevation in ruminal pH often seen with urea supplementation. In this manner, ruminal ammonia levels could be altered without causing major changes in ruminal pH. Diets were fed in a 4 x 4 Latin square design, every 6 hr at a daily intake level of 1.2 percent of body weight. Chromic oxide was included as an indigestible marker.

After consuming the diet for 5 days, fecal and duodenal samples were collected twice daily (am and pm) for 3 days. Samples were composited, dried and ground for analysis. Daily duodenal purine flow was used as an indicator of microbial N production.

On the fourth day of sampling, rumen fluid was collected for ammonia and pH measurement and determination of purine to nitrogen ratio in isolated bacteria.

## Results and Discussion

Ruminal ammonia-N levels increased in response to added increments of NPN (Table 2). Individual values ranged from 1.2 to 13.1 mg ammonia-N/dl rumen fluid. Ruminal pH values on each diet were not increased with added NPN which should help avoid confounding of pH with ruminal ammonia effects.

Organic matter intake (Table 3) was slightly lower on the 0 and 3 percent diets due to feed refusal by one animal. Ruminal digestion of OM was not changed greatly by added NPN, though in this trial, added NPN tended to reduce ruminal digestion (Table 3). This was recovered post-ruminally so that digestion in the total tract was influenced little by added NPN. Flow of liquid

**Table 2. Ruminal parameters**

| Item | Diets | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Ammonia-N, mg/dl | 2.7[c] | 3.7[c] | 5.8[b] | 9.2[a] |
| pH | 6.40[ab] | 6.43[a] | 6.16[c] | 6.20[bc] |

[abc]Means in a row with different superscripts differ statistically ($P<.05$).

to the small intestine tended to increase with added NPN, possibly due to a stimulatory effect on salivary flow.

Total N leaving the rumen daily was in excess of N intake on all four diets (Table 4). This is due to substantial use of N recycled to the rumen with low feed N intakes and high energy diets. Digestibility of N tended to decrease as total N intake decreased, probably a result of dilution of metabolic fecal N loss. For comparison, digestibilities for N, calculated from the standard relationship (percent digestible protein = .9 x percent crude protein -3) are also presented in Table 4. This close check of values shows that protein level changes apparent digestibility. Efficiency of microbial protein synthesis tended to be depressed at the lowest ruminal ammonia levels with the low N diet ($P<.10$). Even though ruminal OM digestion was slightly higher on this diet, total microbial N production tended to be less than with the other three diets. Digestion of starch in the rumen and post-ruminally was relatively unchanged by ruminal ammonia supply (Table 5).

**Table 3. Organic matter**

| Item | Diets | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Intake, g/day | 5046 | 5353 | 5337 | 5193 |
| Leaving abomasum, g/day | | | | |
| Total | 2461 | 3140 | 2867 | 2735 |
| Non-microbial | 1851 | 2431 | 2156 | 1985 |
| Chyme, liter/day | 41.7 | 48.2 | 44.0 | 49.5 |
| Ruminal digestion, % | | | | |
| Unadjusted | 51.6 | 41.5 | 46.4 | 47.0 |
| Adjusted[c] | 63.8 | 54.8 | 59.7 | 61.3 |
| Ruminal digestion, % of total | 66.8 | 52.9 | 57.6 | 63.3 |
| Feces, g/day | 1148 | 1167 | 1076 | 1358 |
| Post-ruminal digestion, % of input | 52.3 | 61.3 | 60.0 | 50.3 |
| Total tract digestion, % | 77.1[ab] | 78.2[a] | 79.9[a] | 73.7[b] |

[ab]Means in a row with different superscripts differ statistically ($P<.05$).
[c]Adjusted for microbial organic matter.

## Table 4. Nitrogen

| Item | Diets | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Intake, g/day | 70[c] | 85[b] | 95[a] | 102[a] |
| Ruminal $NH_3$-N, mg/dl | 2.7[c] | 3.7[c] | 5.8[b] | 9.2[a] |
| Leaving abomasum, g/day | | | | |
| Total N | 88 | 110 | 108 | 109 |
| Microbial N | 39 | 50 | 52 | 51 |
| Non-ammonia, non-microbial | 46 | 56 | 52 | 53 |
| Ruminal digestion, % | | | | |
| Unadjusted | -25.9 | - 28.8 | - 12.7 | - 7.2 |
| Adjusted[f] | 35.0 | 35.2 | 46.0 | 48.3 |
| Microbial efficiency, g microbial N/kg OM truly digested in rumen | 12.3[d] | 17.6[e] | 16.7[e] | 16.1[e] |
| Ruminal digestion, % of total | -55.8 | - 49.5 | - 21.9 | - 14.7 |
| Feces, g/day | 35 | 36 | 37 | 38 |
| Post-ruminal digestion, % of input | 59.6 | 65.9 | 65.2 | 63.4 |
| Total tract digestion, % | 49.4[b] | 57.4[ab] | 60.7[a] | 62.1[a] |
| Expected total digestion[g], % | 53.8 | 57.7 | 61.4 | 63.9 |

[abc]Means in a row with different superscripts differ statistically (P<.05).
[de]Means in a row with different superscripts differ statistically (P<.10).
[f]Adjusted for microbial and ammonia nitrogen.
[g]Calculated from percent digestible protein = .9 (percent crude protein) -3.

## Table 5. Starch

| Item | Diets | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Intake, g/day | 3119 | 3308 | 3271 | 3200 |
| Leaving abomasum, g/day | 780 | 1203 | 968 | 785 |
| Apparent ruminal digestion, % | 75.3 | 63.8 | 70.8 | 75.3 |
| Ruminal digestion, % of total | 77.0 | 66.2 | 72.2 | 79.0 |
| Feces, g/day | 72[b] | 132[ab] | 65[b] | 148[a] |
| Post-ruminal digestion, % of input | 90.7[a] | 89.1[ab] | 91.5[a] | 81.4[b] |
| Total tract digestion, % | 97.7[a] | 95.9[ab] | 98.0[a] | 95.3[b] |

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

Individual values of ruminal ammonia concentration from this and another related study were compared with microbial efficiency (Figure 1) and ruminal OM digestion (Figure 2) to expand the number of observations. Microbial efficiency was not significantly altered by ruminal ammonia concentration (Figure 1) although variation was large. Ruminal OM digestion tended to be stimulated ($P < .08$) with ruminal ammonia concentrations greater than about 8-10 mg/dl (Figure 2). Results from this study indicate that ruminal ammonia concentrations in excess of 3 mg/dl are adequate to maximize efficiency of microbial protein sysnthesis. However, this level may be inadequate to maximize OM digestion in the rumen.

## Literature Cited


Weakley, D. C. and F. N. Owens. 1983. Okla. Agr. Exp. Sta. Res. Rep. MP-114:34.

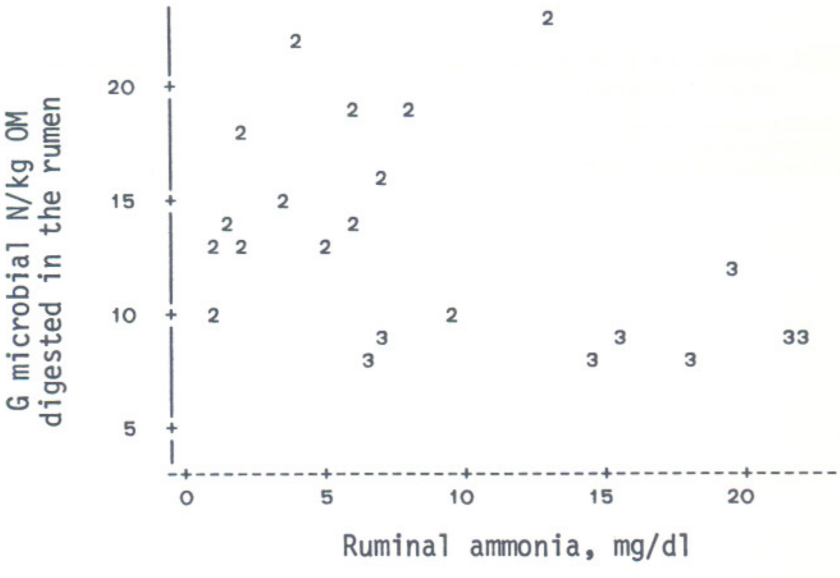




**Figure 1. Influence of ruminal ammonia on efficiency of microbial protein synthesis in 2 experiments[a].**

[a]No relationship ($P > .25$).
[2]Present study.
[3]Weakley and Owens, 1983.

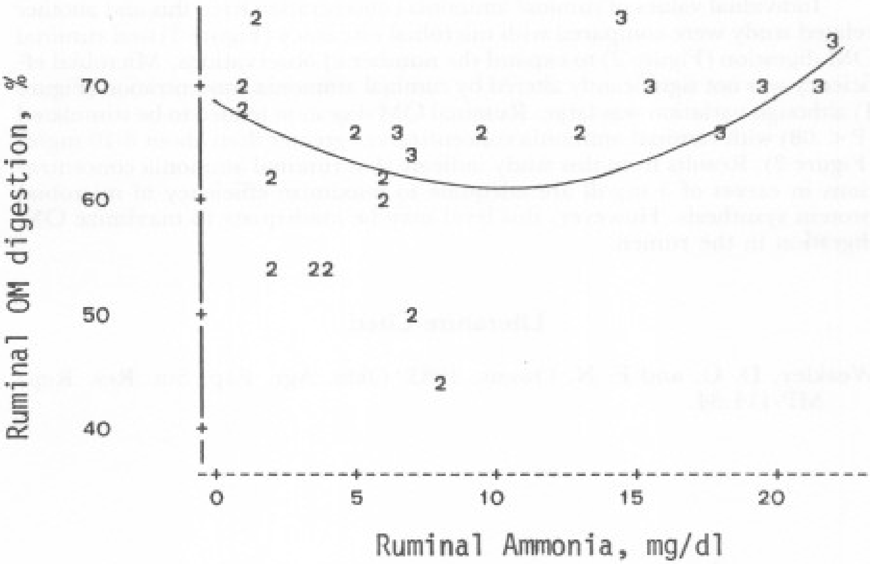



**Figure 2. Influence of ruminal ammonia on ruminal organic matter digestibility in 2 experiments[a].**

[a]Quadratically related (P<.08).
[2]Data of present study.
[3]Data of Weakley and Owens, 1983.

# Salinomycin Levels For Feedlot Steers and Heifers

**M. C. Ferrell[1], F. N. Owens[2] and D. R. Gill[3]**

## Story in Brief

A new feed additive, salinomycin, was fed to 70 finishing steers (initial weight of 772 lb) and 70 finishing heifers (initial weight of 495 lb) for 139 and 145 days, respectively. Salinomycin was fed at 0, 5, 10, 15, and 20 g per ton of a ground corn based diet. Averaged across salinomycin levels, gain was increased 2.6 percent and efficiency of feed use was improved by 7.8 percent. Feed intake was increased slightly with the lower levels of salinomycin. At the optimum drug level in the trial, 15 g per ton of feed, gain and feed efficiency were increased by 8.9 and 10.9 percent. Carcass measurements were not changed by salinomycin feeding. This drug shows excellent promise for improving efficiency and rate of gain of both feedlot steers and heifers.

## Introduction

Feed additives of a class called ionophores have proven to increase efficiency of feed use by feedlot cattle. Monensin, lasalocid and salinomycin are three ionophores. Monensin and lasalocid are widely fed today. Salinomycin has been evaluated previously in one study at Oklahoma State. In that study, gain and efficiency increases of 10 to 13 percent were reported for beef steers fed a 5 percent roughage diet. In this trial, salinomycin was fed at 5 levels to finishing steers to examine its effect on rate of efficiency of gain.

## Materials and Methods

Steers of mixed breeding which had commonly grazed pasture near Purcell, Oklahoma were sorted and trucked to Stillwater on November 1, 1981. Heifers were purchased at Oklahoma City Stockyards and trucked to Stillwater on November 13, 1981. On arrival, animals were ear taged and vaccinated for bovine rhinotracheitis, leptospirapomoma, bovine virus diarrhea, parainfluenza 3, blackleg and malignant edema. Cattle were held on pasture until December 4, 1981, and were then divided into four groups by sex and weight within sex. Cattle within each weight and sex group were randomly allocated to one of 5 pens. Five levels of salinomycin (0, 5, 10, 15 and 20 g/ton of feed) were randomly assigned to pens within each group. Cottonseed hulls, alfalfa pellets and corn comprised 92.31 percent of the ration with the percentage hulls and alfalfa pellets in the ration sequentially decreasing from 40 to 26 to 17 and 12 percent at 3-day intervals at the start of the trial until the final ration (Table 1) was being fed. Results of drug assays are presented in Table 1a.

[1]Graduate Assistant [2]Professor, Animal Science [3]Professor, Animal Science

**Table 1. Feed composition, dry matter basis[a].**

| Ration sequence<br>Ingredient | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Alfalfa, dehy-pellets | 29.63 | 16.35 | 7.36 | 7.31 |
| Cottonseed hulls | 10.00 | 10.00 | 10.00 | 5.00 |
| Corn, rolled | 54.51 | 64.69 | 75.22 | 80.81 |
| Soybean meal | 4.92 | 7.58 | 5.33 | 4.71 |
| Salt | .35 | .35 | .35 | .35 |
| Dicalcium phosphate | .46 | .38 | .43 | .40 |
| Potassium chloride | -- | -- | .06 | .15 |
| Urea | -- | -- | .30 | .30 |
| Calcium carbonate | .12 | .64 | .94 | .96 |
| Premix | .01 | .01 | .01 | .01 |

[a]Average analysis ration 4: 90.2% dry matter, 12.20% protein, ME = 2.79 on an as fed basis. Premix contained trace mineral, vitamin A (to supply 30,000 IU per day) and Salinomycin (0, 5, 10, 15, or 20 g active drug per as fed ton).

Cattle were weighed following withdrawal of feed and water at the start of the trial and on day 140 for steers and 146 for heifers. Other weights were taken full. Cattle were weighed full and a 5 percent pencil shrink was applied to calculate rate of weight gain. Hair coat length was visually appraised and rectal temperature was measured on day 112 of the trial. At slaughter, three heifers, two from pen 11 (15 g salinomycin) and one from pen 12 (control), were found to be pregnant and another heifer aborted during the trial. Data includes information for these animals. One heifer in pen 20 (salinomycin at 10 g per ton) died from acidosis during the trial. Salinomycin was withdrawn from the ration on day 139 for steers and 145 for heifers. On day 154 for heifers and day 160 for steers, cattle were trucked to Oklahoma City, Oklahoma and Booker, Texas, respectively, for slaughter and carcass evaluation. On day 112 of the trial, after steers had been weighed, the steer with the greatest and the steer with the least rate of gain for the trial in each of 10 pens received 20 g of chromic oxide in two gelatin boluses. Fecal samples were obtained after 30, 54, 78 and 102 hours after boluses were administered. Ruminal turnover of chromium was presumed to represent solids leaving the rumen. Turnover was calculated by regressing the natural logarithm of the chromium concentration of fecal dry matter against time.

## Results and Discussion

Daily gain and feed intake tended to increase with salinomycin added to the diet for both steers (Table 2) and heifers (Table 3). Efficiency of feed and energy use was maximized with 15 g salinomycin per ton with both steers and heifers. With this diet, gain and feed efficiency were improved an average of 8.4 and 10.8 percent. This compares with 12.9 and 9.5 percent improvements in a previous trial (Owens and Gill, 1982) with salinomycin at 10 g per ton of feed. The one higher salinomycin level gave slightly less response.

Carcass characteristics were obtained 21 and 9 days after withdrawal of the drug from the diet for steers and heifers, respectively (Tables 4 and 5).

**Table 1-A. Salinomysin Assay Results.**

| Theory Level g/t | | | | | | Sample | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | MEA.D. |
| 0 | <2.10 | <2.10 | <2.10 | <2.10 | <2.10 | <2.10 | <3.00 | <2.10 | <2.10 | <2.10 | <2.10 | <2.1 |
| 5 | 3.70 | 3.30 | 7.00 | 4.00 | 4.10 | 4.40 | 4.80 | 3.50 | 5.40 | 4.10 | 4.40 | 4.404 |
| 10 | 7.70 | 8.20 | 9.00 | 8.00 | 8.10 | 10.00 | 10.00 | 4.90 | 10.40 | 12.00 | 10.00 | 8.987 |
| 15 | 18.33 | 15.00 | 15.00 | 15.00 | 17.00 | 9.30 | 15.00 | 8.70 | 20.00 | 17.00 | 17.00 | 15.246 |
| 20 | 33.00 | 25.00 | 19.00 | 19.00 | 32.00 | 19.00 | 16.00 | 12.00 | 23.00 | 9.90 | 15.00 | 20.246 |

**Table 2. Performance data - steers.**

| Item | Salinomycin level, g/ton | | | | | SE |
|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | |
| Weight, lb | | | | | | |
| Initial, shrunk | 626 | 631 | 629 | 628 | 625 | 4.6 |
| 31 days, full | 763 | 785 | 763 | 777 | 772 | 11.9 |
| 56 days, full | 839 | 860 | 846 | 866 | 860 | 17.1 |
| 84 days, full | 921 | 966 | 943 | 949 | 931 | 20.7 |
| 112 days, full | 1016 | 1032 | 1034 | 1029 | 1008 | 18.2 |
| 140 days, shrunk | 1024 | 1081 | 1076 | 1074 | 1041 | 18.3 |
| 160 days, carcass/.62 | 1104 | 1163 | 1140 | 1119 | 1097 | 17.1 |
| Daily gains, lb | | | | | | |
| 0-56 days | 3.05 | 3.33 | 3.13 | 3.49 | 3.43 | .22 |
| 57-140 days | 2.70 | 3.15 | 3.23 | 2.99 | 2.66 | .13 |
| 0-140 days | 2.84 | 3.22 | 3.19 | 3.19 | 2.96 | .12 |
| 0-160 days | 2.99 | 3.32 | 3.20 | 3.09 | 2.95 | .09 |
| Feed intake, lb/day at 90% dry matter | | | | | | |
| 0-56 days | 21.5 | 23.2 | 21.8 | 21.3 | 21.9 | .78 |
| 57-140 days | 22.2 | 23.1 | 22.3 | 22.0 | 21.4 | .53 |
| 0-140 days | 21.9 | 23.1 | 22.1 | 21.7 | 21.6 | .48 |
| 0-160 days | 21.8 | 23.0 | 22.1 | 21.7 | 21.3 | .52 |
| Feed/gain | | | | | | |
| 0-56 days | 7.04 | 7.06 | 6.97 | 6.14 | 6.39 | .29 |
| 57-140 days | 8.20[a] | 7.34[ab] | 6.88[b] | 7.36[ab] | 8.10[a] | .25 |
| 0-140 days | 7.70[a] | 7.22[ab] | 6.91[b] | 6.83[b] | 7.29[ab] | .14 |
| 0-160 days | 7.29[a] | 6.92[c] | 6.91[c] | 7.01[bc] | 7.22[ab] | .06 |
| Metabolizable energy, mcal/kg feed | 2.58[b] | 2.68[ab] | 2.74[a] | 2.77[a] | 2.66[ab] | .03 |

[abc]Means with different superscripts differ ($P < .05$).

**Table 3. Performance data - heifers.**

| Item | Salinomycin level, g/ton | | | | | SE |
|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | |
| Weight, lb | | | | | | |
| Initial, shrunk | 495 | 488 | 494 | 499 | 500 | 3.5 |
| 31 days, full | 592 | 578 | 579 | 598 | 599 | 7.5 |
| 56 days, full | 646 | 643 | 644 | 662 | 667 | 11.3 |
| 84 days, full | 719 | 708 | 724 | 726 | 751 | 14.2 |
| 112 days, full | 790 | 766 | 782 | 797 | 791 | 9.9 |
| 140 days, full | 818 | 814 | 820 | 814 | 831 | 16.3 |
| 146 days, shrunk | 823 | 817 | 840 | 842 | 840 | 11.8 |
| 154 days, carcass/.62 | 847 | 821 | 854 | 844 | 859 | 10.7 |
| Daily gains, lb/day | | | | | | |
| 0-56 days | 2.13 | 2.19 | 2.10 | 2.33 | 2.40 | .20 |
| 57-146 days | 2.43 | 2.41 | 2.48 | 2.21 | 2.34 | .07 |
| 0-146 days | 2.25 | 2.26 | 2.37 | 2.35 | 2.33 | .09 |
| 0-154 days | 2.28 | 2.16 | 2.34 | 2.24 | 2.33 | .08 |
| Daily feed, lb/day | | | | | | |
| 0-56 days | 15.7 | 14.8 | 16.1 | 15.7 | 16.6 | .66 |
| 57-146 days | 17.0 | 17.2 | 17.5 | 15.4 | 16.3 | .80 |
| 0-146 days | 16.4 | 16.1 | 16.8 | 15.4 | 16.3 | .44 |
| 0-154 days | 16.4 | 16.0 | 16.7 | 15.5 | 16.4 | .50 |
| Feed/gain | | | | | | |
| 0-56 days | 7.57 | 6.72 | 7.64 | 6.75 | 7.00 | .71 |
| 57-146 days | 7.03 | 7.10 | 7.08 | 7.03 | 6.94 | .21 |
| 0-146 days | 7.32[a] | 7.16[ab] | 7.11[ab] | 6.56[b] | 7.00[ab] | .17 |
| 0-154 days | 7.18 | 7.40 | 7.14 | 6.90 | 6.99 | .18 |
| Metabolizable energy, mcal/kg | 2.79[b] | 2.82[b] | 2.82[b] | 3.00[a] | 2.88[ab] | .04 |

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

**Table 4. Carcass measurements - steers.**

| Item | Salinomycin, g/ton 0 | 5 | 10 | 15 | 20 | SE |
|---|---|---|---|---|---|---|
| Carcass weight, lb | 685 | 721 | 707 | 694 | 680 | 10.6 |
| Dressing percent | 63.6[a] | 63.0[ab] | 62.0[ab] | 61.3[b] | 62.1[ab] | .92 |
| Liver abscess Incidence, % | 21.4 | 28.6 | 28.6 | 29.8 | 28.6 | 12.4 |
| Ribeye area, | | | | | | |
| Square in. | 12.8[a] | 12.6[ab] | 12.1[b] | 11.9[b] | 12.5[ab] | .17 |
| Sq. in./cwt carcass | 1.89[a] | 1.74[ab] | 1.72[b] | 1.72[ab] | 1.85[ab] | .04 |
| Fat thickness, in. | .44 | .64 | .49 | .46 | .40 | .06 |
| KHP, % | 2.46[b] | 2.89[a] | 2.79[a] | 2.15[c] | 2.71[a] | .05 |
| Marbling score[d] | 11.7 | 12.8 | 12.1 | 12.2 | 12.1 | .79 |
| Federal grade[e] | 12.5 | 12.8 | 12.4 | 12.6 | 12.4 | .22 |
| Cutability, % | 50.8 | 48.9 | 49.6 | 50.1 | 50.7 | .56 |
| Percent choice | 42.9 | 71.4 | 42.9 | 42.9 | 28.6 | 19.1 |
| Hair coat[f] | 3.2[a] | 2.2[b] | 2.3[b] | 2.9[ab] | 2.9[ab] | .20 |
| Temperature[g] | 102.9 | 102.5 | 102.2 | 102.8 | 102.6 | .31 |

[abc]Means in a row with different superscripts differ ($P < .05$).
[d]Slight plus = 12; Small minus = 13.
[e]High good = 12; Low choice = 13.
[f]Short = 0; long = 5 on day 112.
[g]Rectal temperature on day 112.

**Table 5. Carcass measurements - heifers.**

| Item | Salinomycin level, g/ton | | | | | SE |
|---|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 | |
| Carcass weight, lb | 525 | 509 | 529 | 524 | 533 | 8.6 |
| Dressing percent | $62.6^{a}$ | $60.9^{b}$ | $61.6^{ab}$ | $61.7^{ab}$ | $62.0^{ab}$ | .31 |
| Liver abscess Incidence, % | 7.1 | 0 | 15.5 | 28.6 | 21.4 | 23.2 |
| Ribeye area | | | | | | |
| Square in. | 10.9 | 10.5 | 11.0 | 10.7 | 10.6 | .14 |
| Sq. in./cwt carcass | 2.09 | 2.08 | 2.10 | 2.05 | 2.01 | .04 |
| Fat thickness, in. | .51 | .46 | .52 | .50 | .52 | .05 |
| KHP, % | $2.89^{ab}$ | $2.36^{c}$ | $2.64^{bc}$ | $2.68^{abc}$ | $3.04^{a}$ | .09 |
| Marbling score[d] | 13.1 | 11.9 | 12.0 | 12.2 | 12.2 | .33 |
| Federal grade[e] | 12.6 | 12.4 | 12.5 | 12.6 | 12.6 | .04 |
| Cutability, % | 50.2 | 50.7 | 50.4 | 50.3 | 49.9 | .38 |
| Percent choice | 42.9 | 35.7 | 46.4 | 57.1 | 57.1 | 8.1 |
| Hair coat[f] | 5.6 | 5.1 | 5.0 | 5.2 | 5.1 | .59 |
| Temperature[g] | 102.4 | 102.4 | 102.5 | 102.3 | 102.0 | .36 |

[abc]Means in a row with different superscripts differ ($P<.05$).
[d]Slight plus = 12; Small minus = 13.
[e]High good = 12; Low choice = 13.
[f]Short = 0; long = 5 on day 112.
[g]Rectal temperature on day 112.

The incidence of liver abscesses tended to increase with this drug with both steers and heifers as in a previous trial (Owens and Gill, 1982). Rib eye area declined slightly for steers fed 10 and 15 g per ton levels of salinomycin. No such effect was apparent with heifers in this trial or steers in the previous trial. The percentage kidney, heart and pelvic fat of steers generally increased with added drug as occurred in an earlier trial though some spurious values are noted for certain drug levels with both steers and heifers. Cutability also tended to decline with added salinomycin, possibly due to heavier carcass weights. Marbling scores and percent choice carcasses also tended to be higher with heavier carcasses in this and the earlier trial. Haircoat length seemed slightly less and rectal temperature slightly lower with drug feeding.

Results indicate that efficiency of feed use of feedlot steers and heifers can be improved with added salinomycin. Optimal drug level from this trial for feed efficiency of both steers and heifers was 15 g per ton, though lower levels (5 and 10) produced more rapid gain. Responses to salinomycin feeding generally paralleled results of an earlier trial and, at the optimal level of the diet considerably exceeded gain and efficiency responses observed from other ionophores (Owens and Gill, 1982).

Chemical composition of feces was not significantly changed with added salinomycin though fecal ash appeared to increase slightly (Table 6). Dilution rate of chromium also tended to decrease with added salinomycin. Reduced rate of outflow of ruminal solids matches the effect of monensin on ruminal passage. Longer retention of solids in the rumen may help increase digestibility.

**Table 6. Composition of feces for steers fed salinomycin.**

| | Salinomycin level, g/ton | | | | |
|---|---|---|---|---|---|
| | 0 | 5 | 10 | 15 | 20 |
| Feces dry matter, % | 27.6 | 24.2 | 27.2 | 24.8 | 26.7 |
| Fecal starch, % of DM | 13.2 | 12.3 | 9.9 | 16.6 | 12.5 |
| Fecal ash, % of DM | 7.1 | 9.3 | 9.4 | 7.9 | 11.1 |
| Chromium dilution rate, % per hour | 4.4 | 3.8 | 4.3 | 3.2 | 3.9 |

Compared with slower gaining steers, steers gaining weight more rapidly had feces which were higher in dry matter and starch content (Table 7). In previous trials dry matter and starch content have been shown to increase to decrease together. Higher gains probably reflect higher levels of feed intake. Limiting feed intake usually decreases the concentration of starch in fecal dry matter (Teeter et al., 1981). Surprisingly, rate of passage of chromium and presumably solids from the rumen averaged the same for rapidly and slowly gaining steers. Possibly faster gaining steers eat more feed because they have a larger rumen than slower growing steers. Selection for feed intake may increase ruminal volume but reduce digestiblity.

**Table 7. Feces composition of slowly and rapidly gaining steers.**

| | Feces Composition | | | Cr Dilution Rate |
|---|---|---|---|---|
| Growth rate | Dry Matter | Starch | Ash | |
| | % | % of DM | % of DM | % per hour |
| Rapid | 27.2[a] | 16.6[a] | 8.4 | 3.9 |
| Slow | 25.0[b] | 9.2[b] | 9.5 | 3.8 |

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

## Literature Cited


Owens, F.N. and D.R. Gill. 1982. Salinomycin levels for feedlot steers. OSU MP-112:131

Teeter, R.G. 1981. OSU MP-108:161

# Potassium Levels and Ionophores for Feedlot Steers

M. C. Ferrell[1], F. N. Owens[2]
and D. R. Gill[3]

## Story in Brief

Five level of potassium (.43 to 1 percent of diet dry matter) were fed with monensin or lasalocid (30 g/ton) to 140 yearling steers for 150 days. Steers weighed 731 lb at the start of the trial and were fed a 95 percent concentrate diet with 5 percent cottonseed hulls for roughage. During the early part of the trial, potassium supplementation tended to increase rate of gain. But over the total trial, potassium supplementation at moderate levels (.70 to .85) tended to reduce feed intake and significantly decreased energy intake and rate of gain. Feed efficiency was unchanged by potassium level. Potassium levels in the .7 to .85 range decreased carcass weight, but had no effect on other carcass measurements. No effects of potassium on ruminal acid levels or ammonia concentration were apparent, but with higher potassium levels, rumination was less frequent.

Steers receiving monensin and lasalocid (30 grams per ton) had similar rates and efficiencies of gain though cattle fed lasalocid consumed slightly more feed during the first month on feed. The ruminal and carcass measurements for steers receiving the two ionophores were not different.

## Introduction

The estimated requirement for K for feedlot steers is .6 to .8 percent (NRC, 1976). Newly received cattle usually regain weight lost during shipment more rapidly when the diet contains higher levels of K (Hutchinson, 1980) though this effect often disappears when cattle are fed for longer than 56 days. Supplemental K increases the extent of fiber and starch digestion in the rumen (Zinn and Owens, 1980) and supplementation to a level of 1 percent of the diet has increased weight gain or feed efficiency in two previous trials. Since ionophores interact with Na and K, the need for and benefit of K supplementation of diets containing monensin or lasalocid needs to be reassessed. The objective of this trial was to determine the optimal level of K supplementation of diets containing ionophores.

## Materials and Methods

One hundred forty yearling crossbred steers with an initial weight of 732 lb were trucked 99 miles from Purcell, OK on May 21, 1982 for feeding in Stillwater. Steers were ear tagged and randomly alotted to 20 pens with 7 steers

[1]Graduate Assistant [2]Professor, Animal Science [3]Professor, Animal Science

**Table 1. Diet composition.**

| Ingredient | Percent of Dry Matter |
|---|---|
| Corn grain | 89.4 |
| Cottonseed hulls | 5.0 |
| Supplement[a] | 5.6 |
| Cottonseed meal | 3.26 |
| Limestone | 1.18 |
| Urea | .45 |
| Salt | .32 |
| Dicalcium phosphate | .31 |
| KCl[b] | 0-1.03 |
| Premix[c] | .08 |

[a]Not pelleted for first 69 days of trial; pelleted thereafter.
[b]To provide dietary K levels of .43, .55, .70, .85 and 1% of diet dry matter. KCl replaced corn grain at levels of 0, .22, .48, .76, and 1.03% of the diet.
[c]To provide vitamin A (2043 IU/lb of feed), trace minerals (.5 lb/ton), and monensin or lasalocid (30 g per ton of feed). Actual assays of ionophore levels are shown in Table 1A.

per pen following vaccination for IBR-BVD-P13 and blackleg. The final 5 percent roughage diet (Table 1) was diluted with cottonseed hulls to a level of 40 percent roughage for 3 days, 30 percent roughage for 3 days, 20 percent roughage for 2 days and 12.5 percent roughage for 2 days. The diets provided 5 different levels of potassium (.43, .55, .70, .85 and 1 percent of dry matter) with monensin or lasalocid at a level of 33 ppm (Table 1-A).

Steers were weighed shrunk initially and without feed and water restriction on days 21, 56, 84, 112 and 140 of the trial. On day 150, steers were trucked to Dodge City, KS, and slaughter and carcass data were obtained. Rumen fluid samples were obtained by stomach tube from two steers per pen on day 117 of the trial and analyzed for volatile fatty acid percentages, and ammonia-nitrogen. On day 144, feeding, lying and ruminantion behavior were monitored at 30 min intervals for 24 hours and fecal samples were obtained from 4 to 6 animals in each pen.

**Table 1A. Bovatec and Monensin Assay results.**

| Potassium level | Drug level | Found on Assay[1] | |
|---|---|---|---|
| | g/ton theory | Bovatec | Monensin |
| .43 | 30 | 26.8 | 27.9 |
| .55 | 30 | 24.9 | 30.9 |
| .70 | 30 | 25.2 | 26.6 |
| .85 | 30 | 27.1 | 26.3 |
| 1.00 | 30 | 25.9 | 30.2 |

[1]Grams per ton.

**Table 2. Performance of Steers fed various K Levels**

| | K Level, % of dry matter | | | | |
|---|---|---|---|---|---|
| Weights, lbs. | .43 | .55 | .7 | .85 | 1 |
| Initial | 730 | 735 | 731 | 722 | 741 |
| 21 days | 827 | 836 | 838 | 811 | 844 |
| 56 days | 902 | 904 | 905 | 869 | 903 |
| 85 days | 1018 | 1001 | 989 | 982 | 1006 |
| 112 days | 1078 | 1052 | 1041 | 1035 | 1074 |
| 128 days | 1143 | 1128 | 1107 | 1110 | 1143 |
| 131 days | 1163 | 1139 | 1131 | 1119 | 1165 |
| Total gain | 433 | 404 | 400 | 397 | 424 |
| Daily gain, lbs/day | | | | | |
| 0-21 day | 2.65 | 2.84 | 3.08 | 2.34 | 2.89 |
| 0-56 day | 2.26 | 2.21 | 2.3 | 1.85 | 2.08 |
| 57-140 day[a] | 2.73 | 2.53 | 2.28 | 2.73 | 2.72 |
| 0-140 day | 2.55 | 2.4 | 2.29 | 2.38 | 2.46 |
| 0-150 day[a] | 2.92 | 2.72 | 2.68 | 2.64 | 2.78 |
| Daily feed, lbs/day | | | | | |
| 0-56 day | 20.64 | 19.73 | 18.82 | 19.12 | 19.49 |
| 57-140 day | 22.36 | 21.68 | 21.14 | 21.5 | 21.78 |
| 0-140 day[a] | 21.56 | 20.79 | 20.05 | 20.51 | 20.74 |
| 0-150 day | 21.71 | 20.95 | 20.28 | 20.61 | 20.93 |
| Feed/Gain | | | | | |
| 0-56 day | 9.1 | 9 | 8.2 | 10.78 | 9.57 |
| 57-140 day | 8.25 | 8.61 | 9.28 | 7.92 | 8.02 |
| 0-140 day | 8.51 | 8.67 | 8.75 | 8.74 | 8.44 |
| 0-150 day | 7.47 | 7.71 | 7.58 | 7.8 | 7.52 |
| Met Energy content of feed mcal/kg | 2.79 | 2.76 | 2.79 | 2.72 | 2.81 |
| ME Intake mcal/day[a] | 27.5 | 26.2 | 25.7 | 25.5 | 26.7 |

[a]Quadratic effect of K level ($P < .05$).

## Results and Discussion

No interaction of potassium level and type of ionophore was evident. Effects will be discussed separately below. Potassium supplementation tended to increase live weight gain during the first 21 days of the trial (Table 2). This agrees with the short-term benefits of K supplementation for newly received cattle reported by Hutchinson (1980). Such response may be due to increased fluid retention in the gut or in tissues as suggested previously (Zinn et al, 1982). During the remainder of the trial, potassium supplementation reduced feed intake and rate of gain with little effect on feed efficiency of metabolizable energy content of the diet. Results do not match with previous suggestions (Zinn et al, 1982) of benefits of K supplementation in which steers or heifers received KC1 to provide 1 percent of K in the diet. In those shorter trials, supplemental K increased rate of weight gain and feed efficiency. An increase in ruminal digestion with KC1 supplementation, possibly through buffering action (Zinn and Owens, 1980), may prove more beneficial when diets contain a more digestible fiber source than cottonseed hulls as were used in this experiment.

Sorting of fine particles from the feed was observed with the higher KC1 levels prior to the time the supplement was pelleted. This may be due to the bitterness of KC1. Potassium at 0.85 percent of the diet depressed feed intake and gain to the greatest degree, but calculated metabolizable energy content of the diet was not reduced as drastically (3 percent) as energy intake (7 percent).

Ruminal, fecal and carcass characteristics of steers, except for carcass weight, were not influenced by K supplementation (Table 4). The reduced carcass weight of steers fed middle levels of K reflects the pattern of reduced feed intake for these steers mentioned previously. Animal behavior appeared to be slightly altered by potassium level. Though eating and laying times were not

**Table 3. Performance of Steers fed Monensin or Lasalocid**

| | Monensin | Lasalocid |
|---|---|---|
| Weights, lbs. | | |
| Initial | 726 | 738 |
| 28 days | 822 | 841 |
| 56 days | 891 | 902 |
| 85 days | 991 | 1006 |
| 112 days | 1048 | 1062 |
| 128 days | 1116 | 1135 |
| 131 days | 1134 | 1152 |
| Total gain | 408 | 414 |
| Daily gain, lbs/day | | |
| 0-21 day | 2.62 | 2.92 |
| 0-56 day | 2.14 | 2.13 |
| 57-140 day | 2.54 | 2.64 |
| 0-140 day | 2.39 | 2.43 |
| 0-150 day | 2.73 | 2.75 |
| Daily feed, lbs/day | | |
| 0-21 day | 18.02 | 18.26 |
| 0-56 day | 19.59 | 19.42 |
| 57-140 day | 21.54 | 21.8 |
| 0-140 day | 20.65 | 20.74 |
| 0-150 day | 20.81 | 20.91 |
| Feed/Gain | | |
| 0-56 day | 9.37 | 9.31 |
| 57-140 day | 8.53 | 8.31 |
| 0-140 day | 8.69 | 8.56 |
| 0-150 day | 7.65 | 7.6 |
| Met Energy content | | |
| mcal/kg | 2.76 | 2.79 |
| ME Intake | | |
| mcal/day | 26.1 | 26.4 |

Table 4. Ruminal and Carcass Characteristics of Steers Fed Various Potassium Levels

| K, % of DM | .43 | .55 | .7 | .85 | 1 |
|---|---|---|---|---|---|
| Ruminal VFA | | | | | |
| concentrations, mM/1 | | | | | |
| Total | 75.4 | 71.2 | 72.2 | 64.3 | 76.4 |
| Acetate % | 44.8 | 44.3 | 48 | 47.3 | 46.4 |
| Propionate % | 49.7 | 46.8 | 43.9 | 42.9 | 46 |
| Butyrate | 5.5 | 8.8 | 9 | 10.8 | 7.8 |
| Ruminal ammonia | | | | | |
| mg/dl | 6.5 | 7.9 | 6.9 | 6.8 | 6.9 |
| Carcass wt.[a] | 721 | 706 | 701 | 694 | 722 |
| Dress % | 61.8 | 61.8 | 61.9 | 60.7 | 61.4 |
| Rib eye area | | | | | |
| Sq. inches | 12.0 | 12.1 | 11.9 | 12.3 | 12.2 |
| In/cwt | 1.68 | 1.73 | 1.71 | 1.78 | 1.7 |
| Rib fat | .42 | .42 | .43 | .36 | .39 |
| Fed grade | 13 | 12.9 | 13.4 | 12.8 | 12.8 |
| % choice | 48 | 39 | 61 | 39 | 36 |
| Yield grade | 2.79 | 2.45 | 2.86 | 2.61 | 2.7 |

[a]Quadratic effect of K level ($P < .01$).

Table 5. Ruminal and Carcass Characteristics of Steers fed Monensin or Lasalocid

| | Drug | |
|---|---|---|
| | Lasalocid | Monensin |
| Ruminal VFA concentrations, mM/1 | | |
| Total | 72.3 | 71.2 |
| Acetate % | 46.3 | 46.2 |
| Propionate % | 44.7 | 46.5 |
| Butyrate % | 9.1 | 8 |
| Ruminal ammonia mg/dl | 7.6 | 6.5 |
| Carcass # | 714 | 703 |
| Dress % | 61.4 | 61.6 |
| Rib eye area | | |
| Sq. inches | 12.3 | 11.9 |
| In/cwt | 1.73 | 1.71 |
| Rib fat | .39 | .41 |
| Fed grade | 13 | 13 |
| % choice | 44 | 44 |
| Yield grade | 2.69 | 2.66 |

**Table 6. Animal behavior and fecal measurements with various dietary K levels.**

| | K level | | | | |
|---|---|---|---|---|---|
| | .43 | .55 | .70 | .85 | 1.00 |
| Percentage of total time | | | | | |
| Eating | 8.1 | 8.2 | 9.2 | 8.2 | 8.5 |
| Laying | 45.8 | 49.1 | 51.5 | 47.6 | 45.8 |
| Ruminating[a] | 9.4 | 5.7 | 7.5 | 5.5 | 4.9 |
| Fecal DM, % | 28.4 | 25.9 | 25.6 | 27.6 | 26.2 |
| Fecal starch, % | 22.4 | 24.2 | 19.0 | 22.1 | 19.8 |

[a]Significant decrease in rumination with added K.

altered, incidence of rumination was reduced by almost half by added K (Table 6). If steers eat more slowly and frequently when K is added to the diet as suggested previously (Zinn et al, 1982), they may chew their feed more thoroughly when eating, reducing the need for later rumination of whole corn particles. But the eating behavior in this trial does not support this suggestion. Differences in composition of feces were nonsignificant.

Differences over the total trial attributable to monensin or lasalocid feeding were very small (Table 3). During the first 21 days, however, gain was 12 percent greater and feed intake was about 1.5 percent more for steers fed lasalocid than steers fed monensin. For the total 150 days, lasalocid fed steers had less than 1 percent advantage in rate of gain and efficiency of feed use. Ruminal, fecal and carcass measurements (Table 5) and animal behavior (Table 7) did not differ with source of ionophore in the diet.

**Table 7. Animal behavior with various ionophores.**

| | Monensin | Lasalocid |
|---|---|---|
| | Percentage of total time | |
| Eating | 9.1 | 7.7 |
| Laying | 49.2 | 46.7 |
| Ruminating | 6.8 | 6.4 |
| | Fecal parameters, % | |
| Dry matter | 26.0 | 27.5 |
| Starch | 19.3 | 23.1 |

## Literature Cited


Hutchinson, D. P. 1980. Nutrition of Newly Arrived Cattle. Proceedings, 8th Annual Texas Beef Conference, Amarillo, Tx.

NRC. 1978. Nutrient Requirements of Beef Cattle. Number 4. National Academy of Sciences.

Zinn R. A., and F. N. Owens. 1980. Okla. State Agr. Exp. Sta. Rep. MP-107:131-137.

Zinn R. A. et al. 1982. State Agr. Exp. Sta. Rep. MP-112:158-161.

# Implants for Feedlot Bulls

D.R. Gill[1], J.J. Martin[2], F.N. Owens[3]
and D.E. Williams[4]

## Story in Brief

Ninety-six bulls, one-third each being Charolais (614 lb), Hereford (600 lb) and Hereford-Angus crossbreds (566 lb) were implanted with (1) nothing, (2) Compudose, (3) Synovex or (4) Ralgro. The latter two groups were re-implanted on day 75. Bulls were placed in 12 pens and were fed a high concentrate diet for 118 days. Impants increased liveweight gains by a mean of 34 pounds (6.2 percent) and carcass weights by 17 pounds. Feed intake was increased with Compudose and Synovex implants. Feed efficiencies by implant type adjusted to a dressing percentage of 62 percent were 4.85, 4.85, 5.14 and 4.64, indicating that intake, not utilization of energy, was the primary change induced by implants. Bulls with Ralgro implants appeared to have less internal and external carcass fat. Though all implants increased gain, only Ralgro improved efficiency of feed use by feedlot bulls. Liveweight daily gains and feed efficiencies by breed type were 3.74, 3.86 and 3.64 pounds per day and 5.24, 5.27 and 5.34, respectively. Herefords consumed about .85 pounds (5 percent) more feed per day than Charolais and crossbred bulls. Charolais bulls had less internal and external fat and larger rib eye areas than other breeds.

## Introduction

Bulls are used extensively for beef production in many other countries but, due to grading standards, only limited numbers of bulls are produced for beef in the U.S. Scientists at a recent conference in Kansas (Oltjen, 1982) reviewed aspects of management and handling of bulls. Most past experiment station studies have used bulls selected from purebred herds, which were subjected to selection pressure for performance. In contrast, most bulls available commercially are of nondescript origin and probably come from herds with less than average management and selection pressure. For this study, bulls of three breed types were selected for uniformity from a much larger group of commercial bulls.

As noted in the conference above (Oltjen, 1982), growth stimulating implants have not been developed for bulls. Hormonal differences between bulls and steers make direct application of steer implant data to bulls questionable. Though gain and feed efficiency responses of bulls to DES and Ralgro implants have been variable (Preston, 1972; 1973; Embry, 1972), in general, more favorable responses have been observed with sexually immature bulls. Brethour (1982) found that Ralgro implants increased both growth rate and efficiency of feed use by bulls. Compudose and Synovex S have not been evaluated extensively with bulls.

[1]Professor, Animal Science [2]Panhandle State University, Goodwell, Ok [3]Professor, Animal Science
[4]Hitch Enterprises, Guymon, Ok

The objectives of this experiment were to determine the influence of breed type and hormone implants on feedlot performance and carcass characteristics of growing-finishing commercial bulls. Carcasses from the bulls were evaluated by a taste panel at Texas A&M University. Atesticular development study from these same bulls is found on page 138 of this publication.

## Materials and Methods

Bulls were selected for uniformity from a large group of commercial bulls, which had been purchased in auction barns in the Southeast part of the United States and assembled at the Hitch Feedlot, Guymon. They were then transported to Panhandle State University on April 8, 1982. Three breed types — Charolais, Hereford and Hereford-Angus cross — were used. Bulls were estimate to be slightly over one year of age at the start of the trial. Within each breed, one pen (8 bulls) received one type of implant. These were (1) no implant, (2) a single Compudose implant at the start of the trial, (3) Ralgro implants at the start and on day 75 of the trial and (4) Synovex S at the start and on day 75 of the trial. Bulls not re-implanted were not disturbed on day 75. Bulls were fed a diet (Table 1) consisting primarily of whole shelled corn. Feed was available ad libitum with fresh feed added twice daily. Bulls were weighed on arrival (shrunk) and at 28-day intervals (unshrunk weights) during the 118-day study. Results present full weights whereas rate and efficiency of gain are calculated using a pencil shrink of 5 percent on final weight. Compudose implants were removed on day 112. On day 118 (August 4, 1982), bulls were trucked to Booker, Texas and slaughtered. Slaughter and carcass data were obtained from each bull.

Treatment effects (breed and implant) were compared by Duncan's Multiple Range Test using pen means. Breed by implant was used as the error term to evaluate main effects.

**Table 1. Diet composition[a]**

| Ingredient | Percentage |
|---|---|
| Corn, whole shelled | 89.0 |
| Cottonseed hulls | 5.0 |
| Pelleted supplement[b] | 6.0 |

[a]Dry matter basis. Also included monensin (22 g per ton), Tylan (8 g per ton) and Vitamin A.
[b]Commercial supplement from Moorman Mfg. Co.
Diet dry matter contained 12.3% protein, .53% calcium, .35% phosphorus, .66% potassium and calculated ME (kcal/g) of 3.09.

## Results and Discussion

**Implant Effects** — Implants increased liveweight gains by 21 to 47 pounds (Table 4) and carcass weights by 9 to 25 pounds per bull. Gains appeared equally increased by all implants the first half of the feeding trial, but were increased more during the second half of the trial by Compudose and the Ralgro reimplant.

**Table 2. Performance with different implants.**

| | Implant | | | |
|---|---|---|---|---|
| | None | Compudose | Synovex | Ralgro |
| Bull wt, lb | | | | |
| Initial | 593 | 594 | 593 | 594 |
| 29 day[d] | 740[b] | 756[a] | 751[ab] | 747[ab] |
| 56 day[d] | 866 | 890 | 887 | 882 |
| 84 day[d] | 967[b] | 1008[a] | 990[ab] | 990[ab] |
| 112 day[d] | 1040[b] | 1087[a] | 1061[ab] | 1076[ab] |
| 118 day[e] | 1048 | 1089 | 1063 | 1079 |
| Daily gain, lb | | | | |
| 0-56[f] | 4.11 | 4.49 | 4.46 | 4.35 |
| 57-112[f] | 2.95[b] | 3.35[a] | 2.94[b] | 3.30[a] |
| 0-112[f] | 3.53[b] | 3.92[a] | 3.70[ab] | 3.83[ab] |
| 0-118[e] | 3.86 | 4.20 | 3.98 | 4.11 |
| Daily feed, lb | | | | |
| 0-56 | 19.6[c] | 20.8[a] | 20.6[ab] | 19.8[bc] |
| 57-112 | 18.0[b] | 20.1[a] | 20.6[a] | 18.7[b] |
| 0-112 | 18.8[b] | 20.4[a] | 20.6[a] | 19.2[b] |
| 0-118 | 18.7[b] | 20.3[a] | 20.4[a] | 19.1[b] |
| Feed/Gain | | | | |
| 0-56 | 4.76 | 4.62 | 4.62 | 4.55 |
| 57-112 | 6.10[b] | 6.01[b] | 7.01[a] | 5.66[b] |
| 0-112 | 5.32[ab] | 5.21[b] | 5.57[a] | 5.03[b] |
| 0-118 | 4.85[ab] | 4.85[ab] | 5.14[a] | 4.64[b] |
| ME of diet[g], kcal/g | 3.29[ab] | 3.30[ab] | 3.17[b] | 3.40[a] |
| ME intake, mcal | 28.5 | 31.1 | 29.8 | 30.2 |

[a,b,c]Means with different superscripts differ ($P<.05$)
[d]Full weights
[e]Carcass weight/.62
[f]After 5% pencil shrink
[g]Calculated from weight, gain and feed intake using net energy equations designed for yearling steers.

Implants tended to increase gain the most when feed intake was increased. Synovex and Compudose increased intake more than Ralgro. Feed efficiency was not significantly altered by implant, but efficiency of feed use was 9.7 percent greater for bulls with Ralgro than those with Synovex implants. Had cattle been slaughtered at equal weights rather than after an equal feeding time, all implants probably would have increased efficiency of feed use.

Carcass characteristics remained largely unchanged by implants (Table 3). Internal fat (KHP) and external fat cover tended to be less with Ralgro than the other implants. Less fat deposition with Ralgro could explain why bulls treated with this compound were most efficient in feed use.

The typical response to estrogenic implants in steers is increased gain and increased feed intake. Such a response was noted with Synovex and Compudose in this trial. In contrast, gain and efficiency were increased with little feed in-

**Table 3. Carcass characteristics by implant.**

| | Implant | | | |
|---|---|---|---|---|
| | None | Compudose | Synovex | Ralgro |
| Carcass wt, lb | 650 | 676 | 659 | 669 |
| Dressing % | 64.4 | 63.9 | 64.0 | 64.0 |
| Liber abscess incidence | 4 | 8 | 4 | 0 |
| Rib eye area | | | | |
| Sq. inches | 13.6 | 13.8 | 13.1 | 13.6 |
| Sq./cwt | 2.11[a] | 2.05[ab] | 2.00[b] | 2.04[ab] |
| Marbling score[d] | 10.3 | 10.1 | 10.4 | 9.6 |
| KHP, % | 1.7 | 1.8 | 1.8 | 1.7 |
| Fat over rib, in[e] | .31[b] | .37[ab] | .41[a] | .32[b] |
| Cutability | 52.8[a] | 52.3[ab] | 51.7[b] | 52.6[a] |
| Maturity, bone[f] | 2.1 | 2.1 | 2.3 | 2.3 |
| Maturity, lean[f] | 1.8 | 1.7 | 1.9 | 1.8 |
| Sex class[g] | 1.2 | 1.3 | 1.4 | 1.3 |
| Federal grade[h] | 10.6 | 10.4 | 10.7 | 10.1 |
| Percent choice[h] | 16 | 4 | 12 | 4 |

[a,b]Means with different superscripts differ ($P<.05$)
[c]From estimate shrunk weight on day 118
[d]Slight = 11; slight minus = 10
[e]Adjusted for overall fat thickness
[f]A = 2; A minus = 3
[g]Bull = 1; steer type = 2
[h]Ignoring sex characteristics

take response with Ralgro. If the mechanism of action differs among implants, perhaps some combination or sequence would be more desirable than a single implant material. A single implant with Compudose proved as effective as implant with Synovex twice in this trial with less handling of cattle. Compudose should be especially useful when time and management of cattle make reimplanting difficult.

**Breed Effects** — Charolais bulls were heavier than Hereford bulls and Herefords were heavier than Hereford-Angus crossbred bulls at the start of the trial (Table 2). All bulls gained well. During the last half of the trial, Hereford bulls gained 9 percent more rapidly than Hereford-Angus crossbred bulls. Herefords also consumed 8 percent more feed than other breeds during the last half of the trial. For the total trial, Herefords consumed almost one pound of feed per day more than bulls of other breeds. Differences in feed efficiencies between breeds were not significant, but Charolais bulls gained slightly more rapidly and efficiently on a live basis (0.3 and 2 percent advantage over Hereford and black baldy) and on a carcass basis (5 and 3 percent advantage). Efficiency of energy use for gain was 6.6 percent greater for Charolais than crossbred bulls. The mean ME value of the feed, using yearling steer equations for NE content of gain, was 3.29 kcal/g. This is 6.5 percent above the ME of the diet calculated from table versus for feedstuffs.

Carcasses of Charolais bulls were heaviest. Dressing percentages were all high considering the low degree of marbling and carcass fat. A high degree of muscling or a small gastro-intenstinal weight may be responsible. Dressing percentage was lowest for Hereford bulls.

Many characteristics of Charolais bulls (greater rib eye area, lower marbling score, less fat cover, greater calculated cutability and lower Federal grade) differed from those of Hereford and black baldy bulls. These characteristics suggest that the Charolais bulls were more muscular, possibly due to breed selection or to being slaughtered at an earlier physiological age than the other breeds. But if Charolais bulls were physiologically younger, one would have expected greater rates of gain late in the feeding trial for this breed. Federal grades were all low due to lack of marbling. Whether a longer feeding would have greatly increase marbling is unknown. Based on carcass traits, about 20 percent of the Charolais and Hereford-Angus and .50 percent of the Herefords would have been classified as steers. Slaughter at heavier weights may increase the detectability of bull meat in the carcass.

**Table 4. Performance by breed type.**

| | Breed | | |
|---|---|---|---|
| | Charolais | Hereford | Hereford by Angus |
| Weight, lb | | | |
| Initial | 614[a] | 600[b] | 566[c] |
| 28 day[d] | 767[a] | 759[a] | 720[b] |
| 56 day[d] | 906[a] | 891[a] | 847[b] |
| 84 day[d] | 1013[a] | 1006[a] | 948[b] |
| 112 day[d] | 1098[a] | 1098[a] | 1025[b] |
| 118 day[e] | 1097[a] | 1080[a] | 1032[b] |
| Daily gain, lb | | | |
| 0-56[f] | 4.40 | 4.40 | 4.26 |
| 57-112[f] | 3.07[ab] | 3.32[a] | 3.02[b] |
| 0-112[f] | 3.74 | 3.86 | 3.64 |
| 0-118[e] | 4.10 | 4.07 | 3.95 |
| Daily Feed, lb | | | |
| 0-56 | 20.2 | 20.3 | 20.0 |
| 57-112 | 18.6[b] | 20.2[a] | 18.7[b] |
| 0-112 | 19.5[b] | 20.3[a] | 19.4[b] |
| 0-118 | 19.4[b] | 20.3[a] | 19.3[b] |
| Feed/Gain | | | |
| 0-56 | 4.60 | 4.62 | 4.70 |
| 57-112 | 6.10 | 6.12 | 6.20 |
| 0-112 | 5.24 | 5.27 | 5.34 |
| 0-118 | 4.73 | 4.98 | 4.89 |
| ME of diet[g], | | | |
| kcal/g | 3.40[a] | 3.28[ab] | 3.19[b] |
| ME intake | 30.6 | 30.3 | 28.7 |

[a,b,c]Means with different superscripts differ (P<.05)
[d]Full weights
[e]Carcass weight/.62
[f]After 5% pencil shrink
[g]Calculated from weight, gain and feed intake using net energy equations designed for yearling steers.

**Table 5. Carcass characteristics by breed.**

| | Breed | | |
|---|---|---|---|
| | Charolais | Hereford | Hereford by Angus |
| Carcass wt, lb | $680^a$ | $670^a$ | $640^b$ |
| Dressing %[c] | $64.5^a$ | $63.4^b$ | $64.3^a$ |
| Liver abscess incidence, % | 3 | 3 | 3 |
| Rib eye area | | | |
| Square inches | $14.5^a$ | $13.2^b$ | $13.0^b$ |
| Sq. in/cwt | $2.1^a$ | $2.0^b$ | $2.0^b$ |
| Marbling score[d] | $8.8^b$ | $10.5^a$ | $11.0^a$ |
| KHP, % | 1.6 | 1.7 | 1.9 |
| Fat over rib, in.[e] | $.24^b$ | $.40^a$ | $.42^a$ |
| Cutability | $56.6^a$ | $51.8^b$ | $51.7^a$ |
| Maturity, bone[f] | 2.0 | 2.0 | 2.6 |
| Maturity, lean[f] | 1.7 | 1.8 | 1.9 |
| Sex class[g] | 1.2 | 1.5 | 1.2 |
| Federal grade[h] | $9.7^b$ | $10.7^a$ | $11.0^a$ |
| Percent choice[h] | 3 | 9 | 15 |

[a,b]Means with different superscripts differ ($P < .05$)
[c]From estimated shrunk weight on day 118
[d]Slight = 11; slight minus = 10
[e]Adjusted for overall fat thickness
[f]A = 2; A minus = 3
[g]Bull = 1; steer type = 2
[h]Ignoring sex characteristics; Good minus = 10, Average good = 11.

## Literature Cited

Brethour, J.R. 1982. Beef from Young Intact Males. Kansas State University, Manhattan, p. 2 line 27.

Embry, L.B. 1972. 16th Annual Cattle Feeders' Day, South Dakota, pp 68.

Oltjen, R.R. 1982. Beef from Young Intact Males. Kansas State University, Manhattan.

Preston, R.L. 1972. Ohio Research Summary #63, Ohio Ag. Res. & Development Center, Wooster, pp 33.

Preston, R.L. 1973. Ohio Research Summary #68, Ohio Ag. Res. & Development Center, Wooster, pp 37.

# Methane Fermenter Residue or Decoquinate for Feedlot Steers

J.J. Martin[1], F.N. Owens[2],
R.P. Lake[3], and D.R. Gill[4]

## Story in Brief

Ninety-six steers (578 lb initially) were divided into 12 pens and fed a steam flaked corn-corn silage diet containing 0 or 6 percent residue from a methane generation plant for 153 days. Half of the cattle received Decoquinate (0.5 mg/kg body weight) for the first 29 days of the trial. Monensin and Tylosin were included in the diet from day 30 until cattle were slaughtered. Overall, rate of gain was not altered by either methane fermenter residue or Decoquinate, but feed intake was increased by about 3 percent with either material. This decreased efficiency of feed use by about 3 percent.

For the first 57 days of the test, cattle receiving Decoquinate consumed slightly more feed (16.1 vs 15.1) and tended to gain slightly more rapidly (3.12 vs 2.89), but by the end of the 153-day test, this advantage had disappeared. Monensin, which was fed at 26 g per ton of dry matter, may have replaced the need for a coccidiostat.

Cal-II, a by-product of methane production from feedlot manure, replaced portions of the corn and dehydrated alfalfa of the control diet to form a test diet containing 6 percent Cal-II. Rate of gain of cattle fed the control and Cal-III diets were similar (2.89 vs 2.87 lb per day), but feed efficiency favored the control diet (5.93 vs 6.12 lb of feed per lb of gain). This indicates that the available energy content of the Cal-II did not equal that of the mixture of corn and dehydrated alfalfa it replaced. Based on feed intake and performance of steers, the added methane fermenter residue had a metabolizable energy value of 0.6 to 1.2 mcal/kg for an $NE_m$ of 27 to 36 mcal per hundred lb and an $NE_g$ of -69 to -23 mcal per hundred lb. The large variation in these estimates is due to the low level of Cal-II used in the diet.

## Introduction

Some groups of newly arrived stressed cattle may respond to treatment with a drug to control coccidiosis (Rust et al., 1981). Decoquinate is approved as a coccidiostat for cattle. While ionophores such as monensin are effective coccidiostats (Horton and Brandt, 1981), they are frequently either not fed during the receiving period, since they suppress feed intake, or they are included in the diet at a level too low to be effective. The degree of reduction in animal performance during and after coccidial infections may be considerable.

Production of methane from feedlot waste yields a by-product which may be an economical ingredient for feedlot cattle. Cal-II is the trade name for the byproduct of a methane generation plant in Oklahoma. This byproduct con-

[1]Panhandle State University, Goodwell, OK [2]Professor, Animal Science [3]Master Feeders Inc., Hooker, Oklahoma [4]Professor, Animal Science

tains over 15 percent protein and is high in calcium, potassium, phosphorus and salt. Routine chemical analysis suggests that it could substitute for dehydrated alfalfa in supplements for cattle through digestibilities of protein and dry matter appeared low in one earlier trial (Zinn et al, 1979). The objective of this trial was to establish the value of this product at low levels in a feeding trial with finishing steers.

## Experimental Procedures

Ninety-six yearling steers (578 lb) were assembled by a cattle dealer in the Southeast U.S. and shipped to Goodwell, OK in September 1981 for feeding. Cattle were processed following normal processing procedures (OSU RP-9104)and randomly assigned to one of 12 pens. Six pens selected at random received Cal-II supplement, while 6 pens received the control supplement. Three of each of these pens also received Decoquinate in their supplement for the first 29 days of the trial. Experimental diets are presented in Table 1. Cattle received ration 1 for 11 days, ration 2 for the next 18 days and ration 3 thereafter. Feed intake was very low for the first few days of the trial so that a high percentage of the total ration was supplement. On day 29, cattle were switched to the lower roughage diet and Decoquinate was removed from the diet. Monensin and Tylosin were added after day 29 at rates of 26 and 8.38 grams per ton of dry matter, respectively. Rations were formulated to provide similar amounts of protein and calcium with Cal-II displacing both corn and alfalfa meal in the diet.

To ensure precise control of the administration of decoquinate, a fixed amount of supplement was fed each day for the first 11 days. Subsequently, diets were mixed on a percentage basis. During the first 11 days, cattle receiv-

**Table 1. Ingredient composition of experimental diets.**

| Ration Number | 1 | | 2 | | 3 | |
|---|---|---|---|---|---|---|
| Item | Cal-II | Cont | Cal-II | Cont | Cal-II | Cont |
| Corn Silage | 37.00 | 37.00 | 24.00 | 24.00 | 11.00 | 11.00 |
| S.F. Corn | 46.94 | 50.15 | 62.10 | 64.90 | 79.65 | 81.51 |
| Cal-II | 9.00 | — — | 7.79 | — — | 6.00 | — — |
| De Hy Alfa. | — — | 3.83 | — — | 3.31 | — — | 3.00 |
| Cotton Meal | 5.66 | 6.51 | 4.89 | 5.62 | 1.54 | 1.19 |
| Meat Meal | — — | .50 | — — | .43 | — — | .40 |
| Limestone | .35 | .64 | .30 | .55 | .84 | 1.00 |
| Dical. Phos. | — — | .33 | — — | .28 | .09 | .31 |
| Urea | .19 | .19 | .16 | .16 | .47 | .47 |
| KCL | .42 | .37 | .36 | .32 | .26 | .21 |
| Amon. Sulf. | .17 | .17 | .15 | .15 | .17 | .17 |
| Salt | .25 | .29 | .22 | .25 | .28 | .33 |
| Misc.[a] | .02 | .02 | .03 | .03 | .05 | .06 |

[a]Contains; all rations, vitamin A; rations 1 & 2 had either Decoquinate or none; ration 3 Monensin 26 grams per ton and Tylosin 8.38 grams per ton of dry matter.

ing the Cal-II supplement were fed 2.5 lb of supplement per day while control cattle were fed 1.77 lb. These amounts differ because the pelleted supplement carried the Cal-II.

Fecal samples were obtained from seven of the cattle on arrival for examination for internal parasites using both direct and flotation methods. The direct technique involved visually examining the feces for blood and mucus. Blood and mucus flecks were smeared onto glass slides with 1 N saline and examined at 400 X for parasitic oocysts. Only samples with blood and mucus flecks were examined using the direct technique. The flotation technique was conducted by mixing one to two grams of feces with 7 ml of concentrated sugar solution and placing a glass slide on top of the mixture. The solution was allowed to maintain contact with the slide for 30 minutes after which the slide was examined for coccidia oocysts at 400X.

Cattle were weighed full at 28-day intervals and fed a total of 153 days. For slaughter, cattle were trucked 50 miles to Liberal, KS and carcass data were obtained. Final shrunk weights were calculated by dividing the hot carcass weight by .62. Live weights, with the exception of the initial weight, were gross weights although all daily gains and feed efficiencies were expressed using gross weights less 5 percent, an estimate of live weight loss due to shrinkage.

## Results and Discussion

Rate of weight gain was not significantly altered by the coccidiostat or Cal-II feeding (Table 2). Effects of treatments on carcass measurements are shown in Table 3. Marbling score and federal grade tended to be lower for the steers fed Cal-II. The high incidence of flukes may have reduced overall performance, but appeared equally distributed among treatments.

Per pound of weight gain, more feed was required for steers fed the Cal-II diet than for steers fed the control diet. This indicates that the Cal-II had an available energy value lower than the feed ingredients which it replaced in the control diet. To calculate the energy value for Cal-II, several different methods can be used. The first involves calculating the amount of feed required per unit of weight gain with the two diets as shown in Table 4. This comparison suggests that 38 kg of Cal-II plus 5 kg of corn, 1 kg of corn silage and 1 kg of cottonseed meal provided an amount of energy equal to 18 kg of alfalfa meal plus 2 kg meat meal. Using the metabolizable energy (ME) value of the other feeds as listed by the NRC (1976) tables, one can calcuate the ME value of Cal-II. The value by this calculation was .65 mcal/kg which is equal to a NE for maintenance of 27 mcal/100 lb and a NE for gain of minus 69 mcal/100 lb of dry Cal-II. This estimate has a standard deviation of 61 percent indicating the probable range of ME is .25 to 1.06 mcal/kg. This is equal to an NE for maintenance of 22 to 33 and an NE for gain of -112 to -35 mcal/cwt.

Similar calculations may be made using efficiency of gain on a liveweight basis. The calculated ME value is slightly higher than that estimated based on carcass weight giving NE values of 30 and -52 mcal/cwt for maintenance and gain respectively. This value has a standard deviation of 49 percent giving a probably range of ME of .43 to 1.27 mcal/kg for NE range estimates of 24 to 37 and -92 to -20 mcal/cwt for maintenance and gain, respectively.

Another method of estimating the value of Cal-II is based on calculating ME of both diets based on feed intake and cattle performance (Owens & Gills,

**Table 2. Steer Performance**

| Weights | Cal-II | Control | Decox[a] | Control |
|---|---|---|---|---|
| Initial | 577 | 579 | 583 | 572 |
| 29 Days | 678 | 678 | 587 | 567 |
| 57 Days | 784 | 792 | 801 | 776 |
| 85 Days | 880 | 884 | 894 | 870 |
| 113 Days | 968 | 973 | 980 | 961 |
| 153 Days | 1058 | 1062 | 1068 | 1052 |
| Adjusted | 1016 | 1020 | 1023 | 1014 |
| Daily Gain | | | | |
| 0-57 Days | 2.95 | 3.05 | 3.12 | 2.98 |
| 58-153 Days | 2.71 | 2.67 | 2.64 | 2.74 |
| 0-153 Live | 2.80 | 2.81 | 2.82 | 2.79 |
| 0-153 Adj. | 2.87 | 2.89 | 2.87 | 2.89 |
| Daily Feed | | | | |
| 0-57 Days | 15.5 | 15.7 | 16.1 | 15.1 |
| 58-153 Days | 18.8 | 18.0 | 18.5 | 18.2 |
| 0-153 Live | 17.6 | 17.1 | 17.6 | 17.0 |
| 0-153 Adj. | 17.6 | 17.1 | 17.6 | 17.0 |
| + Weighback | 17.9 | 17.4 | 17.9 | 17.4 |
| Feed / Gain | | | | |
| 0-57 Days | 5.25 | 5.16 | 5.16 | 5.25 |
| 58-153 Days | 6.94 | 6.76 | 7.02 | 6.67 |
| 0-153 Live | 6.27 | 6.10 | 6.25 | 6.11 |
| 0-153 Adj. | 6.12 | 5.93 | 6.14[b] | 5.91[c] |
| Met. Energy | | | | |
| Adjusted Wts. | 2.93[c] | 2.99[b] | 2.94 | 2.99 |

[a]Decoquinate
[bc]Means in a row with different superscript differ statistically ($P < .10$).

1980). The ME of replaced feeds is then deducted from the ME of the control ration (Table 5). The difference between the control and test diet remaining is due to the test ingredient, Cal-II. Since this is present at 6.29 percent of the ration, the difference is all attributable to this fraction. Using this method of calculation, the ME of Cal-II in this trial was 1.22 mcal/kg. This equates to a NE for maintenance of 36 mcal/cwt and a NE for gain of negative 23 mcal/100 lb of dry Cal-II. This estimate has a standard deviation of 51 percent for a ME range of .59 to 1.84 mcal/kg dry matter which gives probability ranges in NE of 26 to 49 and -76 to +14 mcal/cwt for maintenance and gain, respectively.

By all calculations the available energy content of Cal-II is below that of low quality forages and is near that expected for a feed with a dry matter digestibility of 30 percent as reported previously for methane fermenter residue (Zinn et al, 1979). A report from Florida (Harris et al, 1981) also suggested that residue remaining from cattle waste after methane production was very low. In this trial, the accuracy of these estimates is limited by the level of Cal-II which was included in the diet.

## Table 3. Carcass Measurements

| | Cal-II | | Deccox[1] | |
|---|---|---|---|---|
| | Present | Absent | Present | Absent |
| Carcass Weight Lbs. | 630 | 633 | 629 | 634 |
| Dressing Percent | 59.5 | 59.6 | 59.7 | 59.4 |
| Fluke Incidence % | 29.2 | 29.2 | 22.9 | 35.4 |
| Rib Eye Area | | | | |
| Sq. Inches | 11.3 | 11.4 | 11.4 | 11.3 |
| Sq. In. / Cwt. | 1.80 | 1.81 | 1.81 | 1.80 |
| Fat Thickness, in | .44 | .51 | .47 | .48 |
| KHP, % | 2.60 | 2.59 | 2.49[a] | 2.70[b] |
| Cutability, % | 50.1 | 49.7 | 50.0 | 49.8 |
| Federal Grade | 12.2 | 12.6 | 12.3 | 12.5 |
| Marbling score | 12.6[d] | 13.7[c] | 13.0 | 13.3 |

[1]Decoquinate
[ab]P<.05
[cd]P<.10
[e]Closely trimmed lead cuts.
[f]Good plus = 12; Choice minus = 13.
[g]Slight plus = 12; Small minus = 13.

## Table 4. Energy calculations, model 1. Feed required per 100 kg gain (adjusted weights)

| | Diet | | Difference kg | Feed ME mcal/kg | Difference in ME, mcal |
|---|---|---|---|---|---|
| | Control | Cal-II | | | |
| Total | 593 | 612 | | | |
| Corn, SF | 465.0 | 469.6 | + 4.6 | 3.29 | +15.13 |
| Corn silage | 79.9 | 80.9 | + 1.0 | 2.53 | + 2.53 |
| Dehy alfalfa | 18.2 | 0 | − 18.2 | 2.24 | - 40.77 |
| Cal-II | 0 | 38.5 | +38.5 | x | +38.5x |
| Cottonseed meal | 11.2 | 12.4 | + 1.2 | 3.29 | + 3.95 |
| Meat meal | 2.4 | 0 | − 2.4 | 2.54 | - 6.10 |

$38.5x - 25.26 = 0$
$x$ = ME of Cal-II = .656 mcal/kg.
$NE_m$ = .59 kcal/g = 27 mcal/100 lb.
$NE_g$ = -1.53 kcal/g = -69 mcal/100 lb.

The initial gain response of steers to Decoquinate diminished as the feeding trail progressed. This may have been due to anticoccidial action of monensin which was present in the ration after the first 29 days on feed. Initial examination of fecal material revealed that three of the seven samples contained mucus flecks though no coccidial oocysts were detected by either examination method. The correlation between subclinical coccidiosis and fecal egg count has been suggested to be poor. Additional investigation is needed to develop techniques to determine the degree of coccidial infection and to predict the response of stressed cattle to anticoccidial therapy.

Table 5. Energy calculations, model 2. ME of rations, calculated from feed intake and gain.

| | Diet differences, % | Feed ME, kcal/g | Diet ME |
|---|---|---|---|
| Corn, SF | +1.69 | 3.29 | +.056 |
| Corn silage | + .26 | 2.53 | +.007 |
| Dehy alfalfa | +3.07 | 2.24 | +.069 |
| Cotton meal | − .14 | 3.29 | − .005 |
| Meat meal | + .41 | 2.54 | +.010 |
| Total | | | .126 |

Control diet ME = 2.99
Control diet minus ME of above feeds = 2.853
Cal-II diet ME = 2.93
Difference due to Cal-II = 2.93 - 2.853 = 0.077 mcal/kg

$$\text{ME of Cal-II} = \frac{0.077 \text{ mcal}}{.0629 \text{ kg}} = 1.22 \text{ mcal /kg}$$

$NE_m$ = .79 kcal/g = 36 mcal/100 lb.
$NE_g$ = -.51 kcal/g = -23 mcal/100 lb.

## Literature Cited


Harris, et al. 1981. J. Anim. Sci. 53:169. (Supp. 1).

Horton, G.M.S. and W.E. Brandt. 1981 Lasalocid or monensin for finishing steers fed a high silage diet. J. Animal Sci. 53 (Supp 1):406.

NRC. 1976. Nutrient Requirements of Beef Cattle. Number 4. National Academy of Sciences.

OSU-RP 9104, 1981. A Treatment Program for Sick Newly-Arrived Stocker Cattle. Oklahoma State University.

Owens F.N. and D.R. Gill. 1980. Digestive Physiology and Ruminant Nutrition. Volume 3, Feedlot Cattle, O & B Books, Inc., Corvallis, Oregon, p. 128.

Rust, S.R., D.R. Gill, and J.J Martin. 1981. Okla. Agr. Exp. Sta. Res. Rep. MP108:167.

Zinn, R.A., F.N. Owens and R.P. Lake. 1979. Sludge evaluation. OK Ag Exp Sta, Misc Pub 104:35.

# Ammonium Salts of Volatile Fatty Acids for Feedlot Steers

F. N. Owens[1], D. R. Gill[2],
L. E. Deetz[3] and J. J. Martin[4]

## Story in Brief

Seven levels (0 to .99 percent) of ammonium salts of volatile fatty acids (AS-VFA) were added to 77 to 82 percent concentrate diets for 192 yearling feedlot steers of mixed breeding. Steers weighed 797 lb initially and were fed for 131 days. Rate and efficiency of gain were not significantly altered by AS-VFA, although on a liveweight basis, AS-VFA on the average increased rate of gain by 2.4 percent and efficiency of feed use by 0.6 percent. Carcass cutability was increased with the middle levels of AS-VFA due to decreased kidney-heart-pelvic fat percentage and less fat over the ribeye. The mechanism for and repeatability of this effect on fat deposition need further examination since such a change may economically justify use of this new feed supplement.

## Introduction

Ammonium salts of volatile fatty acids (AS-VFA) are a new feed supplement produced by Eastman Kodak which may become available for feeding to ruminants in the future. With dairy cows fed diets consisting primarily of corn silage, AS-VFA has increased production of milk protein and milk solids (Cook and others, 1981). The optimal dose level for cows was 61 g ammonium caproate and 28 g ammonium isobutyrate per day (Papas and others, 1981). Intake of grain dry matter was increased slightly with added AS-VFA (Sniffen and others, 1981). With forages low in protein, supplementation with low levels of volatile fatty acids has sometimes increased fiber digestion and feed intake. With higher concentrate diets, ammonium salts of certain volatile fatty acids are useful sources of ammonia. This trial was conducted to determine the effects of various levels of AS-VFA on performance and carcass characteristics of feedlot steers fed a moderately high energy diet.

## Materials and Methods

One hundred ninety-two steers, primarily Hereford, Angus and Charolais crossbreds, with a mean initial weight of 797 lb received routine feedlot vaccinations and ear tags at Hitch Feedlot, Guymon, OK and were trucked to Goodwell, OK on April 4, 1982. Steers were weighed on arrival and subdivided by weight into two groups of 14 pens each with 8 steers per pen. Dietary treatments were randomly assigned to pens within weight groups with 2

[1]Professor, Animal Science [2]Professor, Animal Science [3]Eastman Kodak, Rochester, NY
[4]Panhandle State University, Goodwell, OK

liveweight and two heavier weight pens receiving each of the 7 diets. Steers were weighed following a period of 16 hrs without feed and water at the start and on day 128 of the feeding trial. At other weighings, feed was not withheld. Following 131 days on feed, steers were trucked to Booker, TX and slaughter and carcass data were obtained.

The diet (Table 1) contained levels of AS-VFA from 0 to .99 percent. Urea was added to equalize protein levels in all diets. Due to low rates of gain of the steers, the level of corn grain in the diet was increased to 71 percent, cottonseed hulls were increased to 18 percent, and prairie hay was deleted from the diet on day 84 of the trial. The AS-VFA levels were dropped by 20 percent at this time, as well. One steer fed .12 percent AS-VFA died on day 118 of the trial. Feed intake of this steer to subtract from intake of this pen of steers was calculated using initial and final weights of this steer plus net energy values for the diet calculated from intake and performance of steers in all other pens receiving this level of AS-VFA. Effects of AS-VFA were calculated by comparing each level with each other level of material and by examining the linear and quadratic effects of level of AS-VFA.

**Table 1. Diet composition**

| Ingredient | Percent |
|---|---|
| Corn, Ground | 66.0 |
| Prairie hay, ground | 8.0 |
| Cottonseed hulls | 15.0 |
| Supplement | 11.0 |
| Ground corn | 5.8-4.9 |
| Soybean meal | 2.0 |
| Limestone | 1.15 |
| Urea | .70-.58 |
| KC1 | .52 |
| AS-VFA[a] | 0-.99 |
| Dicalcium phosphate | .44 |
| Salt | .3 |
| Ammonium sulfate | .086 |
| Trace minerals | .013 |
| Vitamin A-30 | .011 |

[a]To provide AS-VFA levels of 0, .17, .34, .50, .66, .83 and .99% of the diet dry matter.

## Results and Discussion

Supplemental AS-VFA had no effect on weight gain, feed or metabolizable energy intake, feed efficiency or energy content of the diet. The potent, pungent, persistent and penetrating odor of the material and supplements containing the material appeared to be much more objectionable to humans mixing and feeding it than to steers consuming it. Rate of gain and feed intakes were slightly greater for steers receiving diets with .12 and .67 percent AS-VFA than for steers receiving other levels of the material, especially during the early portion

**Table 2. Performance of Steers fed AS-VFA.**

| | Initial AS-VFA Level, % | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | .17 | .34 | .50 | .66 | .83 | .99 |
| Weights, lbs | | | | | | | |
| Initial | 791 | 810 | 810 | 796 | 794 | 815 | 800 |
| 28 days | 889 | 933 | 927 | 904 | 907 | 934 | 915 |
| 56 days | 986 | 1032 | 1007 | 989 | 985 | 1039 | 995 |
| 85 days | 1037 | 1081 | 1049 | 1048 | 1038 | 1088 | 1054 |
| 112 days | 1101 | 1136 | 1116 | 1119 | 1104 | 1144 | 1116 |
| 128 days | 1126 | 1161 | 1139 | 1135 | 1129 | 1184 | 1136 |
| 131 days | 1141 | 1175 | 1150 | 1150 | 1129 | 1186 | 1150 |
| Total gain | 350 | 365 | 340 | 354 | 335 | 371 | 350 |
| Daily gain, lbs/day | | | | | | | |
| 0-56 day | 2.79 | 3.22 | 2.79 | 2.77 | 2.71 | 3.26 | 2.78 |
| 57-128 day | 2.5 | 2.37 | 2.4 | 2.57 | 2.54 | 2.59 | 2.51 |
| 0-128 day | 2.62 | 2.74 | 2.57 | 2.65 | 2.61 | 2.89 | 2.63 |
| 0-131 day | 2.67 | 2.78 | 2.59 | 2.7 | 2.55 | 2.83 | 2.67 |
| Daily feed, lbs/day | | | | | | | |
| 0-56 day | 24.23 | 25.29 | 24.84 | 24.34 | 24.36 | 25.93 | 24.66 |
| 57-128 day | 22.47 | 22.83 | 22.44 | 21.99 | 22.36 | 23.46 | 22.1 |
| 0-128 day | 23.24 | 23.9 | 23.49 | 23.02 | 23.24 | 24.54 | 23.22 |
| 0-131 day | 23.13 | 23.78 | 23.38 | 22.91 | 23.14 | 24.42 | 23.1 |
| Feed/Gain | | | | | | | |
| 0-56 | 8.72 | 7.95 | 8.95 | 8.82 | 9.03 | 8.07 | 8.91 |
| 57-128 day | 9.05 | 9.65 | 9.35 | 8.55 | 8.87 | 9.51 | 8.8 |
| 0-128 day | 8.87 | 8.74 | 9.14 | 8.69 | 8.92 | 8.55 | 8.84 |
| 0-131 day | 8.66 | 8.56 | 9.05 | 8.50 | 9.09 | 8.63 | 8.67 |
| Met Energy content of feed | | | | | | | |
| Mcal/kg | 2.61 | 2.64 | 2.58 | 2.65 | 2.56 | 2.63 | 2.63 |
| ME Intake | | | | | | | |
| Mcal/day | 27.4 | 28.6 | 27.4 | 27.6 | 26.9 | 29.2 | 27.6 |

of the trial. Averaged across AS-VFA levels, the material increased rate of gain on a liveweight basis by 2.4 percent and on a carcass basis by 0.6 percent. Feed intake was increased a mean of 1.4 percent. This calculates to an improvement in feed efficiency on a liveweight basis (0.6 percent) and a loss in efficiency (1 percent) based on carcass weights. Metabolizable energy (ME) content of the diet, calculated from mean weights and feed intakes, was increased a mean of 0.2 percent by the production while ME intake was increased a mean of 1.8 percent. If the product has its greatest benefit on fiber digestion, failure to find an intake and performance response to this material with the moderately high concentrate diet in this trial is not surprising. Further tests of this material for cows wintered on low protein range grass and for growing calves maintained on high roughage diets are needed.

Carcass weights, dressing percentage and liver abscess incidence and severity were not influenced by AS-VFA level (Table 3). Lung abnormalities including hardened and reddened areas were noted in some of the steers. Incidence was least with intermediate levels of the material. Rib eye area tended to be least with AS-VFA at 0.67 percent of the diet. Marbling score and Federal grade were not influenced by AS-VFA, but fat deposition internally (KHP) and externally (fat over the rib) were reduced with intermediate levels of AS-VFA. This change was reflected in the cutability or yield grade estimate. An increase in cutability of 1.2 percent with a 700 lb carcass will increase marketable product by 9.4 lb. This change was attained with 52 g per day of AS-VFA or a total of 15 lb of AS-VFA. Though this change would not benefit cattlemen selling cattle on a liveweight or grade-and-yield basis, it should be of interest to meatpackers. Mechanism for and repeatability of this effect deserves further testing.

Effects of initial weight grouping on performance and carcass traits are presented in Tables 4 and 5. Heavier cattle gained slightly more rapidly on a carcass basis due to an increased dressing percentage. Increased dressing percent is consistent with most earlier studies as summarized in Table 6.

Feed intake in this trial was increased by 2.5 lb (13 percent) for every 100 lb difference in initial weight. This is greater than in three previous studies (Table 6). Lighter weight cattle had a superior feed efficiency on a live weight basis similar to two of the three earlier trials. Net energy values of the feed, similar to all previous trials, favored the heavier cattle in previous trials. This suggests that the net energy question is consistently underestimating the gains of heavier cattle adjusted for carcass weight.

Dressing percent, rib eye area, fat thickness and marbling score were all greater for heavier cattle as in earlier studies. Rib eye area was increased by .6 square inches per hundred lb of carcass (5 percent, compared to 6 to 14 percent in other studies). Fat thickness per hundred lb of carcass increased by 12.9 percent vs 4 to 30 percent in our other studies. Cutability declined by .6 percentage units (1.3 percent) per hundred lb difference in carcass weight compared with 0 to 1.1 percentage points in other trials. How time on feed and initial weight interact and influence carcass composition need to be examined. Currently, most management and marketing decisions are based on efficiency of gain of live weight. In the future decisions should be based on efficiency of production of retail beef.

**Table 3. Carcass characteristics of steers fed AS-VFA.**

| | Initial AS-VFA Level, % | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | .17 | .34 | .50 | .66 | .83 | .99 |
| Carcass # | 707 | 728 | 713 | 713 | 700 | 735 | 713 |
| Dress % | 62.8 | 62.7 | 62.6 | 62.8 | 62 | 62.1 | 62.8 |
| Liver abscesses | | | | | | | |
| Percent | 15.6 | 28.6 | 12.5 | 31.2 | 25 | 12.5 | 31.2 |
| Severity | 1.78 | 2.38 | 1.67 | 1.25 | 2.17 | 1.75 | 1.5 |
| Lung abnr | .22 | .19 | .06 | .06 | 0 | .09 | .44 |
| Rib eye area | | | | | | | |
| Sq inches | 12.4 | 12.8 | 12.5 | 12.9 | 12.6 | 12.4 | 12.6 |
| In/cwt | 1.76 | 1.76 | 1.75 | 1.81 | 1.81 | 1.69 | 1.78 |
| KHP % | 2.27 | 2.03 | 2.14 | 1.97 | 1.88 | 2.23 | 1.92 |
| Rib fat | .43 | .34 | .35 | .34 | .38 | .44 | .39 |
| Marbling | 13.9 | 13.3 | 14 | 12.8 | 13.7 | 13.6 | 13.4 |
| Fed grade | 12.9 | 12.7 | 12.9 | 12.2 | 12.6 | 12.8 | 12.6 |
| % choice | 75 | 75 | 62 | 53 | 66 | 78 | 69 |
| Cutability, % | 49.7 | 50.6 | 50.3 | 50.9 | 50.7 | 49.5 | 50.4 |

**Table 4. Influence of initial weight on performance.**

| Weight | Light | Heavy |
|---|---|---|
| Initial weight | 784[a] | 840[b] |
| 56 days | 967[a] | 1052[b] |
| 128 days | 1106[a] | 1183[b] |
| 131 days | 1104[a] | 1204[b] |
| Daily gain, lbs | | |
| 0-56 days | 2.76 | 3.04 |
| 57-128 days | 2.59 | 2.40 |
| 0-128 days | 2.66 | 2.68 |
| 0-131 days | 2.59 | 2.78 |
| Daily feed, lbs | | |
| 0-56 days | 23.9[a] | 25.8[b] |
| 57-128 days | 21.9[a] | 23.1[b] |
| 0-128 days | 22.8[a] | 24.3[b] |
| 0-131 days | 22.7[a] | 24.1[b] |
| Feed/gain | | |
| 0-56 days | 8.56 | 8.71 |
| 57-128 days | 8.52[a] | 9.71[b] |
| 0-128 days | 8.58[a] | 9.06[b] |
| 0-131 days | 8.79 | 8.69 |
| ME content of the diet, based on performance mcal/kg | 2.57[a] | 2.66[b] |
| ME Intake, mcal/day | 26.5[a] | 29.1[b] |

**Table 5. Carcass data by initial weight group.**

| Weight group | Light | Heavy |
|---|---|---|
| Carcass weight, lb | 685 | 748 |
| Dressing percent | 61.9[a] | 63.1[b] |
| Abscesses, percent | 21.4 | 23.3 |
| severity | 1.86 | 1.73 |
| Ribeye area | | |
| Square inches | 12.4[a] | 12.8[b] |
| Sq in/cwt carcass | 1.82[a] | 1.71[b] |
| KHP, % | 2.01 | 2.11 |
| Fat over rib eye, in. | .37 | .40 |
| Marbling score | 13.2 | 13.9 |
| Federal grade | 12.5 | 12.8 |
| Percent choice | 62 | 75 |
| Cutability, % | 50.5[a] | 50.1[b] |

**Table 6. Effects of initial steer weights and carcass weights on performance and carcass characteristics**

| | Source[a] | | | | |
|---|---|---|---|---|---|
| | Current | MP-112:141 | MP-112:141 | MP-108:131 | MP-104:008 |
| | Percent change/100 lb increase in initial weight | | | | |
| Measurement | | | | | |
| Gain | +13.1 | − .4 | +1.5 | + 8 | ---- |
| F/G ratio | +11.0 | +4.3 | +5.6 | +10 | ---- |
| ME, mcal/kg | + 6.3 | +2.2 | +1.3 | + 3.4 | ---- |
| | Percent change/100 lb increase in carcass weight | | | | |
| Dressing % | + 3.1 | + 1.3 | + 4.0 | + 0.2 | + 2.2 |
| Rib eye, sq. in. | + 5.1 | + 6.6 | +10.0 | +14.1 | + 6.1 |
| $In^2$/cwt | − 9.6 | − 7.5 | − 3.0 | − 3.6 | ---- |
| Fat thickness, in. | +12.9 | +27.2 | +13.0 | + 4.0 | +30.0 |
| Marbling score | + 8.4 | +11.1 | +13.7 | +11.0 | + 5.5 |
| Cutability, % | − 1.3 | − 1.9 | − .7 | 0 | − 2.28 |

[a]From this trial or other OSU-Miscellaneous publications on pages listed.

## Literature Cited


Cook, et al. 1981. J. Dairy Sci. 64:139. (Supp. 1).
Gill, et al. 1981. OSU MP-108:131.
Owens and Gill. 1982. OSU MP-112:141.
Owens, et al. 1979. OSU MP-104:8.
Papas, et al. 1981. J. Dairy Sci. 64:139. (Supp. 1).
Sniffen, et al. 1981. J. Dairy Sci. 64:139. (Supp. 1).

# Effect of Animal Density, Coat Color And Heat Stress on Performance Of Feedlot Steers

S.C. Arp[1], F.N. Owens[2],
S.L. Armbruster[3] and Doug Schmidt[4]

## Story in Brief

The influence of confinement density and coat color on performance were measured in cooperation with a feedlot at Garden City, Kansas using 978 steers. One group of 454 cattle averaging 777 lb were sorted by color (red or black) and randomly allocated to four drylot pens (>70 ft²/animal) and four confinement pens (21 ft²/animal). A second group of 524 cattle of mixed color and breed (primarily English breeding) averaging 877 lb were randomly allotted to 6 pens, with a density of 21 ft²/animal in four pens and an animal density of 26 ft² in two pens. Initially, two of the four 21 square foot pens were to be sprinkled, but following four days after initiation of the trial, all groups of cattle in confinement were sprinkled to avoid further death losses. Animal density had no significant effect on daily gain, dressing percentage or the percentage of animals grading choice. But gain was 36 percent greater ($P<.01$) for cattle on drylot than in the confinement unit during the hottest months and 39 percent greater ($P<.05$) during the cooler weather. There was no significant effect of coat color on performance or dressing percentage.

## Introduction

A recent innovation in cattle production has been the advent of confinement feeding of cattle. In this study, a noncovered ''tear drop'' floor system was studied. Tear drop shaped crevices between slats of the concrete floor are constantly or intermittently flushed with recycled water. Wintertime performance may favor cattle in the confinement facility. However, summertime gains of cattle in dense pens (<21 ft²/animal) have been considerably less than cattle in neighboring dirt drylot pens. With the assumption that the differences may be due to greater heat stress of the cattle in confinement, we examined the problem from three angles. One approach was to test the effect of coat color on performance. Secondly we altered cattle density within confinement pens. The third comparison of interest was the effect of intermittent sprinkling on performance of steers in confinement pens. Air and black bulb temperature and relative humidity were monitored, and performance of groups divided by density and coat color were measured.

[1]Graduate Assistant, Animal Science. [2]Professor, Animal Science. [3]Nutrition Consultant, Stillwater.
[4]Manager, Brookover Feedlot, Garden City, Kansas.

## Materials and Methods

One group of 454 English bred steers averaging 777 lb were sorted by color (red or black) and randomly allocated to either drylot or confinement pens with duplicate pens of each color. Confinement pens had a density of 21 $ft^2$/animal with 100 red steers/pen and 50 black steers/pen. The open lot pens had a density of greater than 70 $ft^2$/animal with 40 red steers/pen and 37 black steers/pen. A second group of 524 steers of mixed color (red, black, and white) averaging 877 lb were randomly allotted to three replicated treatments. One group was intended to be nonsprinkled with a density of 26 $ft^2$/animal. A second group was intended to be nonsprinkled with an animal density of 21 $ft^2$. The third group was sprinkled with an animal density of 21 $ft^2$. Four days after initiation of treatments, ten animals on the nonsprinkled treatment died from heat stress. Nine of these ten animals had black hair color. Subsequently, all cattle were sprinkled to avoid death loss. Sprinklers were thermostatically controlled and operated for five minutes every half hour when the ambient temperature was above 80°F. Average daily gain was monitored in two phases. The first phase was from the beginning of the trial, July 18, 1982, until September 10. This was the hottest part of the summer. The second phase lasted from September 10 until the end of the trial on October 21 to determine if the confined animals would make compensatory gains. Dressing percent and the percentage of animals grading choice were calculated from final full pen weights minus 5 percent and information supplied by the meat packing plant.

**Table 1. Comparison of performance and slaughter data of confinement cattle.**

| Item | Treatment 21 $ft^2$/animal | 26 $ft^2$/animal |
|---|---|---|
| Early daily gain, lb | 2.73 | 2.54 |
| Late daily gain, lb | 1.22 | 1.32 |
| Overall daily gain, lb | 2.12 | 1.97 |
| Dressing percent | 64.7 | 64.3 |

**Table 2. Performance and carcass measurements across floor type and coat color.**

| | Treatment | | | |
|---|---|---|---|---|
| Item | Drylot black | Confinement black | Drylot red | Confinement red |
| Steers | 74 | 100 | 80 | 200 |
| Pens | 2 | 2 | 2 | 2 |
| Daily gain (7/18-9/10) | $4.16^a$ | $3.13^b$ | $4.15^a$ | $2.99^b$ |
| Daily gain (9/10-10/21) | $2.21^c$ | $1.53^d$ | $2.54^c$ | $1.88^d$ |
| Overall daily gain (7/18-10/21) | $3.24^a$ | $2.35^b$ | $3.39^a$ | $2.45^b$ |
| Dressing percent | 64.8 | 63.5 | 61.7 | 63.5 |

[ab]Means in a row with different superscripts differ ($P<.01$).
[cd]Means in a row with different superscripts differ ($P<.05$).

## Results and Discussion

Four days after initiation of the trial, ten animals died on the nonsprinkled treatment. Other feed yards near Garden City also lost cattle that afternoon. The temperature on the fatal day was highest at 6 pm (98 F) with a relative humidity of 23 percent, not markedly different from earlier days. Wind speed measured at Garden City was very low, averaging 2 miles per hour on this day. Death losses in this study indicate that sprinkling reduces heat stress since no cattle on the sprinkled treatments were lost.

Within the confinement unit, animal density had no significant effect on daily gain or dressing percent. No foot and leg problems were noted in any pens, although ease of movement was reduced by concrete floors.

During the hottest part of the summer, gain was 36 percent greater ($P < .01$) for cattle on drylot than in confinement and during slightly cooler weather, gain favored cattle on the dirt feedlot pens by 39 percent ($P < .05$). No compensatory gain during cooler weather was apparent. Reduced feed intake is probably responsible for the lower performance of confined steers and is being analyzed presently. Coat color had no significant effect on performance or dressing percentage although possibly the performance of red colored cattle was depressed more by confinement than performance of black cattle.

# Relationships of Coat Color, Body Surface Temperature and Respiration Rate in Feedlot Steers

S. C. Arp[1], F. N. Owens[2],
S. L. Armbruster[3] and Scott Laudert[4]

## Story in Brief

The relationships between coat color, body surface temperature and respiration rate were measured in an experiment using 978 steers in cooperation with a feedlot at Garden City, Kansas. Data were collected during different times of the day on three days throughout the trial. Respiration rates and body surface temperatures peaked at noon or slightly after. Respiration rates and body temperatures peaked much higher for black and red cattle than for white cattle, with red cattle usually being slightly lower than black cattle. Body surface temperatures followed a pattern similar to respiration rates except that differences due to coat color were less during the early morning and late evening. Comparison of predominantly black or predominately white Holstein steers in one pen indicated a direct correlation between respiration rate and surface temperature. The respiration rate of black Holstein steers was 35 percent greater ($P < .05$) and the surface temperature was 14 percent greater ($P < .05$ than for white Holstein steers.

## Introduction

Death losses due to heat stress of feedlot steers is a summertime problem in the Southern Great Plains. Heat stress is generally considered to be a problem of high temperature and humidity. Normal respiration rates for cattle are between 20 to 50 breaths per minute. Since many of the cattle which succomb to heat stress in non-sheltered, non-shaded feedlots are black in color, the purpose of this study was to evaluate relationships among coat color, body surface temperature and respiration rate.

## Materials and Methods

Steers were allotted to treatments as described in ''Effect of Density, Coat Color and Heat Stress on Performance of Feedlot Steers'' reported elsewhere in this publication. In addition, a group of Holstein steers in a confinement lot with no shade were used to examine the relationship of respiration rate and body surface temperature within a single breed to remove the influence of breed type and Brahman crossbreeding. Simultaneous measurements of respiration

[1]Graduate Assistant, [2]Professor, Animal Science, [3]Nutrition Consultant, Stillwater, [4]Area Feedlot Specialist, Garden City, KS

rate and surface temperature were made on predominantly white and predominantly black steers. Respiration rates and body surface temperature were measured on three different dates, 7/31/82, 8/21/82, 9/4/82. Respiration rates and surface temperatures were measured on five to ten animals per pen. Animals selected were those near enough to measure accurately, but measurements were not necessarily on the same animal within or between time periods. Body surface temperature was measured with a gun type, battery operated infra-red thermometer that collects infrared energy without contact. Respiration rates were calculated by stopwatch timing of the number of seconds required for an animal to inhale 30 times. Ambient air temperature and relative humidity were monitored continuously and black bulb temperatures measured intermittently. The diets were high energy feedlot diets and were the same for steers of all colors tested.

## Results and Discussion

Weather data are provided in Tables 1 to 3. These can be related to respiration rates and body surface temperatures in Tables 4 to 9. On July 31, in all five time periods, white cattle had significantly lower ($P < .05$) respiration rates than either black or red cattle (Table 4). Except for the first period, which was near sunrise, and the final period, near sundown, the respiration rate of black

**Table 1. Weather data (7-31-82)**

| Time | 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
|---|---|---|---|---|---|
| Ambient air temperature, F | 58 | 74 | 79 | 85 | 84 |
| Relative humidity, % | 90 | 44 | 32 | 30 | 41 |
| Black bulb temperature, F | -- | 104 | 110 | 110 | 88 |

**Table 2. Weather data (8-21-82)**

| Time | 8:00 am | 12:00 noon | 4:00 pm |
|---|---|---|---|
| Ambient air temperature, F | 66 | 69 | 80 |
| Relative humidity, % | 90 | 78 | 55 |
| Black bulb temperature, F | 77 | 111 | 104 |

**Table 3. Weather data (9-4-82)**

| Time | 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
|---|---|---|---|---|---|
| Ambient air temperature, F | 62 | 73 | 87 | 90 | 87 |
| Relative humidity, % | 64 | 55 | 37 | 34 | 36 |
| Black bulb temperature, F | 74 | 91 | 102 | 102 | -- |

**Table 4. Comparison of respiration rates among coat colors (7-31-82).**

| | Time | | | | |
|---|---|---|---|---|---|
| Coat color | 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
| | Respiration rates, breaths/min. | | | | |
| Red | 76.5[a] | 106.1[b] | 126.1[a] | 134.9[a] | 105.8[a] |
| Black | 75.3[a] | 113.8[a] | 129.6[a] | 138.0[a] | 103.5[a] |
| White | 59.1[b] | 67.3[c] | 98.1[b] | 87.6[b] | 66.3[b] |

[abc]Means in a column with different superscripts differ statistically ($P<.05$).

cattle was consistently greater than that of red cattle. Sprinklers began operating during the 1:30 time period which may confound the measurements. During the warmer part of the day and into the evening, white animals had lower body surface temperatures than red and black animals (Table 5). Black animals tended to have slightly greater surface temperatures than red animals throughout the day.

On August 21 and September 4, sprinklers were turned off while measurements were taken. On August 21, red animals tended to have higher respiration rates (Table 6), but lower surface temperatures than black animals (Table 7). Though white steers had lower surface temperatures than colored steers, respiration rate of white animals was equal to other cattle at noon. Surface temperatures on this particular day were subject to variation due to intermittent cloud cover. Surface temperature of one steer can vary from 10 to 15 F between the side exposed to the sun and the shaded side. Temperatures were generally taken on the sunny side the animal, however rate of change in surface temperature with time of exposure to the sun is unknown. A slight mist or fog at 8 am apparently aided evaporative cooling. September 4 was sunny all day. Respiration rates were very low at 7:30 am (Table 8) and except at the peak time, 1:30 pm, were lower for white than colored cattle. Black cattle tended to have slightly higher respiration rates than red cattle except at 4:30 pm. During four of the five periods when they were observed, white cattle had significantly lower ($P<.05$) body surface temperatures than either red or black cattle (Table 9). Black cattle tended to have slightly higher surface temperatures throughout the day as compared to red cattle.

**Table 5. Comparison of body surface temperatures among coat colors (7-31-82).**

| | Time | | | | |
|---|---|---|---|---|---|
| Coat color | 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
| | Surface temperature, F | | | | |
| Red | 89.0 | 104.3[b] | 107.1[a] | 102.1 | 84.1[ab] |
| Black | 92.3 | 113.1[a] | 111.7[a] | 103.3 | 86.5[a] |
| White | 88.7 | 96.6[c] | 90.8[b] | 91.8 | 82.4[b] |

[abc]Means in a column with different superscripts differ statistically ($P<.05$).

**Table 6. Comparison of respiration rates among coat colors (8-21-82).**

| Coat color | Time 8:00 am | 12:00 noon | 4:00 pm |
|---|---|---|---|
| | Respiration rate, breaths/min | | |
| Red | 70.1 | 138.7 | 134.0[a] |
| Black | 59.0 | 132.9 | 126.2[ab] |
| White | 62.8 | 137.1 | 109.9[b] |

[ab]Means in a column with different superscripts differ statistically (P<.05).

**Table 7. Comparison of body surface temperatures among coat colors (8-21-82).**

| Coat color | Time 8:00 am | 12:00 noon | 4:00 pm |
|---|---|---|---|
| | Surface temperature, F | | |
| Red | 85.8 | 104.9[b] | 107.9[a] |
| Black | 88.1 | 114.9[a] | 109.4[a] |
| White | 86.8 | 96.1[b] | 97.1[b] |

[ab]Means in a column with different superscripts differ statistically (P<.05).

**Table 8. Comparison of respiration rates among coat colors (9-4-82).**

| Coat color | Time 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
|---|---|---|---|---|---|
| | Respiration rate, breaths/min | | | | |
| Red | 40.4[ab] | 95.3 | 131.8 | 113.3 | 82.9 |
| Black | 43.9[a] | 97.1 | 134.5 | 106.2 | 86.1 |
| White | 28.8[b] | 79.4 | 132.1 | 102.7 | 77.9 |

[ab]Means in a column with different superscripts differ statistically (P<.05).

**Table 9. Comparison of body surface temperatures among coat colors (9-4-82).**

| Coat color | Time 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
|---|---|---|---|---|---|
| | Surface temperature, F | | | | |
| Red | 84.4 | 102.3[a] | 107.3[a] | 103.7[a] | 86.2[a] |
| Black | 85.7 | 105.7[a] | 109.0[a] | 106.8[a] | 86.5[a] |
| White | ---- | 92.0[b] | 98.1[b] | 94.0[b] | 84.7[b] |

[ab]Means in a column with different superscripts differ statistically (P<.05).

**Table 10. Comparison of black versus white Holstein (9-4-82).**

| | Treatments | |
|---|---|---|
| Item | Black | White |
| Breaths/min | 114.1[a] | 84.4[b] |
| Body surface temperature, F | 106.3[a] | 93.6[b] |

[ab]Means in a row with different superscripts differ statistically ($P < .05$).

Twelve Holstein steers were used to directly compare respiration rate and body surface temperatures by measuring both on six predominantly black animals and six predominantly white animals. This was at 6:00 pm, the hottest part of the day (92F). Respiration rate of black animals was 35 percent greater than that of white animals and body surface temperature of the black animals was 14 percent greater than that of white animals (Table 10). In summary, using respiration rate as an index of heat stress, black cattle appear more subject to heat stress than either red or white cattle, and white cattle appear least subject to heat stress. Surface temperatures of white cattle were consistently lower than colored cattle. With exposure to sun, light colored cattle should be more adapted to tropical or subtropical conditions or possibly to confinement situations where heat stress could be increased due to reduced air movement and radiation from other cattle.

# Effect of Eating and Rumination on Gain and Fecal Characteristics of Steers

F. N. Owens[1] and M. C. Ferrell[2]

## Story in Brief

Rumination and eating behavior of 139 steers fed a 95 percent concentrate, whole shelled corn diet were checked each half hour during a 24-hour period. Over 80 percent of the steers were observed to be ruminating during this time. Steers ruminating more frequently gained weight more rapidly ($P < .05$). Number of meals decreased with increased rumination. Fecal pH and dressing percentage tended to decline with frequency of eating.

## Introduction

Generally, gain, feed intake and feed efficiency are the only measurements obtained from feedlot cattle on research trials. Eating and rumination behavior may alter performance and digestion. One earlier study (Gill, 1981) indicated that non-ruminating animals gained faster than ruminating steers. This study was conducted to observe the relationship between eating and rumination behavior and gain, fecal measurements, and certain carcass characteristics.

## Materials and Methods

One hundred thirty-nine steers consumed feed ad libitum and were observed every half hour during a 24-hour period on day 120 of a feeding trial reported elsewhere in this publication (Ferrell, 1983). One person identified which animals were eating, ruminating or lying down in each of 20 pens of 7 head each. Fecal samples were obtained from 90 of the 140 steers after behavior was monitored. Performance and fecal measurements were regressed against frequency of eating and rumination following removal of potassium and ionophore source effects.

## Results and Discussion

Rumination behavior of steers in this trial is presented in Table 1. During the 48 observations, 84 percent of the steers were detected ruminating one or more times. Even with 95 percent concentrate in the diet, the abrasiveness of the whole corn apparently stimulated rumination. For statistical analysis, the effects of ionophore and K level were removed. Steers which ruminated more times gained weight more rapidly in this trial, however, gain may have reached a plateau at higher frequencies of rumination. Number of meals per

---

[1]Professor, Animal Science [2]Graduate Assistant

**Table 1. Rumination behavior**

| Item | Times observed ruminating | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
| No. of steers | 26 | 37 | 29 | 29 | 17 | 6 | 9 |
| ADG, lb/day | 2.67 | 2.65 | 2.78 | 2.71 | 2.80 | 3.19 | 2.47 |
| Eating, % | 3.7 | 3.0 | 3.6 | 3.4 | 3.3 | 3.2 | 2.4 |
| Fecal pH | 6.18 | 6.27 | 6.21 | 6.41 | 6.07 | 5.89 | 6.13 |
| Fecal ash, % | 7.0 | 7.5 | 6.4 | 6.9 | 6.0 | 5.2 | 5.3 |
| Fecal DM, % | 26.9 | 24.0 | 28.1 | 27.2 | 26.6 | 30.3 | 30.4 |
| Fecal starch, % | 21.4 | 19.5 | 21.2 | 19.6 | 19.8 | 30.3 | 27.3 |

day tended to decline with frequency of rumination while fecal dry matter and starch tended to increase with more frequent rumination.

Eating behavior of steers is presented in Table 2. Steers eating more meals per day may be consuming more feed, however with more than 6 meals observed during the 48 observations, rate of gain and frequency of rumination declined. Fecal pH also tended to decline with more frequent meals while dressing percentage tended to decline with meal frequency except at the highest meal frequency. If gastrointestinal fill was greater with less frequent and presumably larger meals, the reverse effect on dressing percent would be expected. Fat thickness over the rib tended to increase with meal frequency. This is the opposite of some research in humans, pigs, chicks and rats where ''meal eating'' results in greater fat deposition than a ''nibbling'' feeding pattern.

## Literature Cited

Gill, D. R. et al. 1981 Okla. Agr. Exp. Sta. Res. Rep. MP-108:141.

**Table 2. Eating behavior**

| Item | Times observed eating | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| No. of steers | 12 | 16 | 39 | 23 | 21 | 21 | 12 | 5 | 7 |
| ADG, lb/day | 2.36 | 2.49 | 2.64 | 2.87 | 2.73 | 2.91 | 3.00 | 2.48 | 2.80 |
| Ruminating, % | 3.2 | 1.9 | 2.2 | 2.1 | 2.2 | 2.7 | 2.3 | 0.6 | 1.3 |
| Fecal pH | 6.20 | 6.29 | 6.22 | 6.54 | 6.13 | 6.26 | 6.01 | 6.04 | 6.08 |
| Fecal ash, % | 6.6 | 6.2 | 6.5 | 7.8 | 6.9 | 6.6 | 6.6 | 7.9 | 6.4 |
| Fecal DM, % | 26.2 | 22.5 | 27.0 | 25.5 | 26.5 | 28.8 | 28.2 | 25.0 | 28.4 |
| Fecal starch, % | 20.5 | 22.2 | 22.0 | 18.0 | 18.3 | 21.9 | 24.0 | 21.5 | 28.5 |
| Dressing, % | 62.5 | 62.1 | 61.3 | 62.0 | 60.8 | 61.0 | 61.4 | 60.3 | 62.5 |
| Fat thickness, in. | .38 | .35 | .42 | .41 | .37 | .36 | .52 | .28 | .54 |

# Effect of Moisture Addition on Fermentation of High Moisture Corn

E. Aguirre[1], F. N. Owens[2],
D. R. Gill[2] and J. H. Thorton[3]

## Story in Brief

High moisture corn harvested at 21 to 33 percent moisture was ensiled following addition of various amounts of water and fermented for 60 days. With greater moisture, solubility of protein increased and pH decreased. Whether moisture was present in the grain at harvest or added to the ground grain prior to fermentation did not influence pH, protein solubility, starch content or availability. Results indicate that when corn grain harvested as dry as 21 percent moisture is rewetted to 30 percent moisture prior to fermentation, it possesses all the chemical properties of grain harvested at 30 percent moisture.

## Introduction

During the last 20-24 years, ensiling corn and sorghum grain has become popular. High moisture corn harvested and stored at 20 to 24 percent moisture is markedly inferior in digestibility and feed efficiency to corn harvested at 28 to 30 percent moisture. Unfortunately, it is impossible to harvest all the grain at the ideal moisture level, although water often can be added to grain at ensiling time to increase moisture content. The purpose of this study was to determine if water addition to drier grain prior to fermentation would cause the dry corn to ensile similarly to grain harvested at a higher moisture level.

## Materials and Methods

Samples of corn grain from the Southern High Plains, upon delivery of truckloads to one feedlot in Garden City, Kansas, was subdivided by moisture content and compiled to form seven different moisture levels: 21, 23, 25, 27, 29, 31, and 33 percent. Each of these samples was ground and reconstituted with water to form all possible final moisture levels for fermentation at 25, 27.5, 30, 32.5 and 35 percent moisture. Each sample was placed in a plastic bag and stored anaerobically at 102°F for 60 days of fermentation. Initial frozen samples and final samples were analyzed for pH, dry matter, total protein, soluble protein, starch, and available starch (not gelatinized prior to adding amylase). Available starch should be an index of the amount of carbohydrate which is soluble and not bound in particles which limit attack by ruminal microbes.

[1]Graduate Student, Animal Science, [2]Professor, Animal Science, [3]Feed Manager, Master II Feedlot, Garden City, Kanas

## Results and Discussion

All the variables were found to be related to final, not initial dry matter content of the corn grain. Plots (Figures 1, 2 and 3) show these relationships. In Figure 1, the relationship of pH and dry matter is shown. The final pH was reduced with added water or higher moisture in the grain. This probably is due to dilution of acid permitting more lactic acid to be produced which causes pH to decline (Thornton et al., 1977). For every 1 percent added moisture, pH decreased a mean of .06 units. Figure 2 shows that as grain moisture increased, the percent of total protein which was soluble increased. For every 1 percent increase in final moisture content, percent of protein which was soluble increased by 1.9 percent.

Available starch as percent of total starch (Figure 3) also tended to increase as the amount of water in the corn to be fermented increased. This trend would support the finding of increased starch digestibility for wetter high moisture corn.

Results indicate that final, not harvest moisture level, alters fermentation of corn grain. All chemical properties of ground grain reconstituted from as low as 21 percent moisture were similar to corn harvested at higher moisture levels. Animal experiments are needed to examine changes with moisture levels on feed intake, site of digestion and efficiency of utilization.

## Literature Cited

Thornton, J.H. et al. 1977. Okla. Agr. Expt. Sta. MP-101:56.

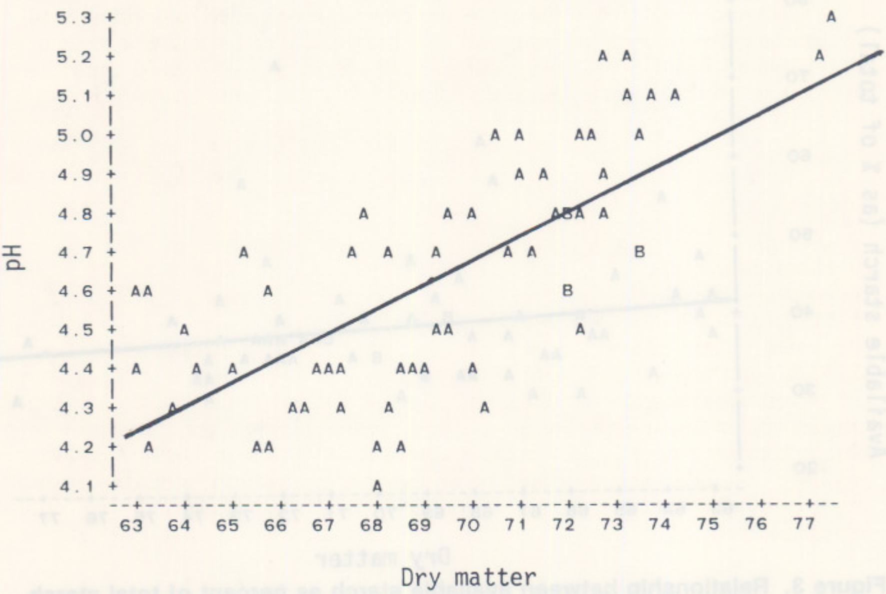



**Figure 1. Relationship between pH and dry matter**

**$Y = .179 + .064 X$ N = 62 $R^2 = .538$ $SE_{yx} = .008$**

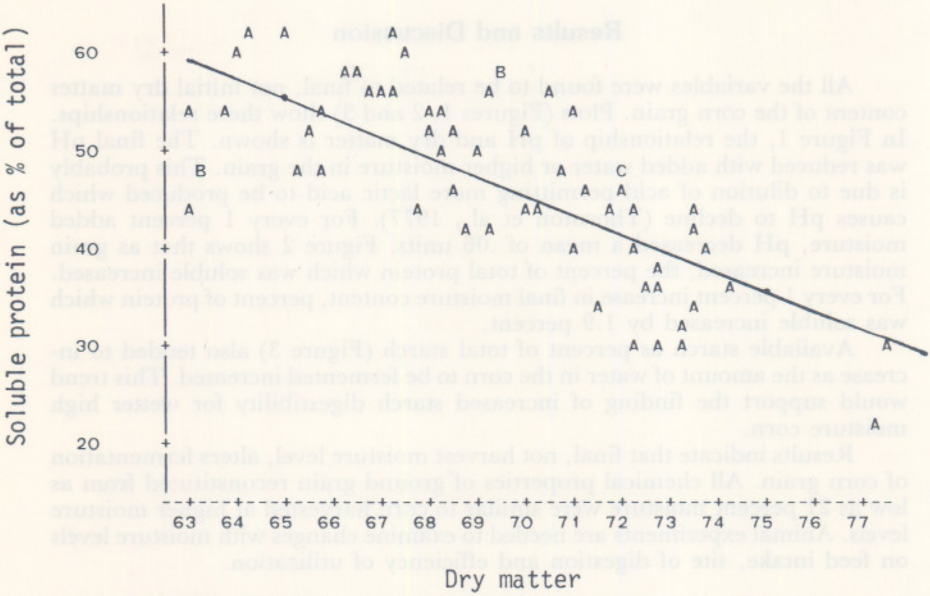



**Figure 2. Relationship between soluble protein as percent of total protein and dry matter.**

**Y = 180.981 - 1.930X N = 62 $R^2$ = .520 $SE_{yx}$ = .239**

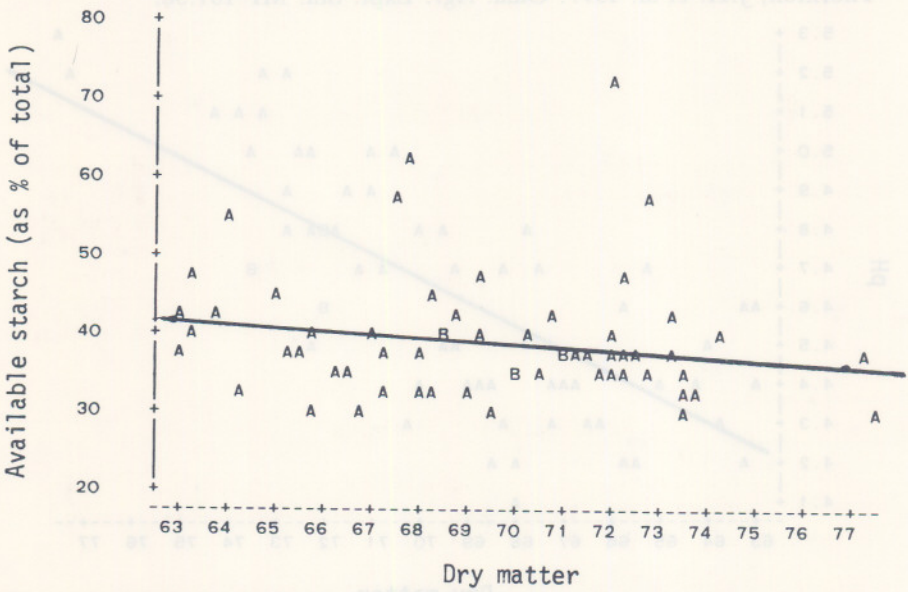



**Figure 3. Relationship between available starch as percent of total starch and dry matter.**

**Y = 61.424 - .320X N = 60 $R^2$ = .019 $SE_{yx}$ = .299**

# Effects of Lot Type and Coat Color on Respiration Rate, Surface Temperature and Feeding Behavior of Feedlot Steers

S. C. Arp[1], F. N. Owens[2],
Steve Armbruster[3] and Y. Kojima[4]

## Story in Brief

The influence of pen type (confinement or dirt pens) and coat color on respiration rate, body surface temperature and feeding behavior of 978 feedlot steers at Garden City, Kansas were measured. Respiration rates during the hottest part of the day on three different days were consistently higher (mean of 9.8 percent or 19 breaths per minute) for steers confined in "teardrop" floor pens than steers in more spacious dirt-floor feedlot pens. Surface temperatures of cattle were consistently higher (mean of 6.2 percent or 6.6 F) for steers with black than steers with red coat color. Feeding behavior of steers on concrete floors appeared to be slightly different from steers in drylot pens, with a higher percentage of steers eating overnight and fewer eating during the middle of the day (10 am to 3 pm) for more confined steers. Black steers, compared with red steers, were at the feed bunk more in the morning and less in the afternoon and evening.

## Introduction

Heat stress can reduce performance and cause death loss of cattle in the Southern Great plains. Floor or pen type (density) and coat color may influence response to hot weather. The objective of this experiment was to determine the relationships of floor type (concrete "Teardrop" confinement with 21 to 26 square feet per steer versus drylot pens with over 70 square feet per steer) and coat color (red versus black) to respiration rate, surface temperature and feeding behavior.

## Materials and Methods

Steers used and measurements taken are described in another report in this publication entitled "Relationships of Coat Color, Body Surface Temperature and Respiration Rate in Feedlot Steers."

[1]Graduate Student, Animal Science [2]Professor, Animal Science [3]Feedlot Nutrition Consultant, Stillwater, OK [4]Visiting Professor from Kyoto University, Kyoto, Japan

## Results and Discussion

On July 31, respiration rates were 28 percent greater ($P < .05$) for cattle in confinement than for cattle on drylot (Table 1). Confined cattle tended to have higher respiration rate throughout the day although body surface temperature appeared to be variable (Table 2), probably due to sprinkling of the cattle after 1 pm. Sprinklers were turned off on subsequent dates temperature and respiration measurements were taken.

**Table 1. Comparison of respiration rates between lot types on 7/31/1982.**

| Treatment | Time 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
|---|---|---|---|---|---|
| | Respiration rate, breaths per minute | | | | |
| Drylot | 74.1 | $100.1^{a}$ | 120.5 | 132.6 | 109.4 |
| Confinement | 76.6 | $127.9^{b}$ | 131.9 | 141.4 | 106.9 |

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

**Table 2. Comparison of body surface temperature between lot types on 7/31/1982.**

| Treatment | Time 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
|---|---|---|---|---|---|
| | Surface temperature, F | | | | |
| Drylot | $83.9^{a}$ | $105.4^{a}$ | $115.6^{a}$ | $113.5^{a}$ | 86.7 |
| Confinement | $93.9^{b}$ | $109.9^{b}$ | $102.6^{b}$ | $95.6^{b}$ | 84.6 |

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

On August 21, respiration rate was 10 percent greater for confined cattle at noon (Table 3), but no coat color effect on respiration rate was evident. Body surface temperature at 8 am was 11 percent greater ($P < .05$) for cattle in confinement with no effect of coat color (Table 4), but by noon, black cattle in drylot had higher body surface temperatures than either group of red cattle. Surface temperature of black cattle in confinement was 10 percent greater ($P < .05$) than that of confined red cattle, and overall, the surface temperature of drylot cattle was 5 percent greater than that of cattle in confinement.

On September 4, respiration rates were greater for cattle in confinement throughout the day except at 7:30 am and no effects of coat color were detected. Lot type had no significant effect on body surface temperature (Table 5) although cattle in confinement had slightly higher values except at 4:30 pm.

Based on respiration rate measurements, steers in confinement apparently are more heat stressed than cattle in drylots. This may be due in part to greater cattle density. Constant flushing in the teardrop system might increase the humidity locally, but no humidity or temperature difference was apparent between unoccupied concrete and dirt floors 4 feet above the surface. Constant flushing of recycled water held the concrete surface temperature below 105 F compared with a maximum soil surface temperature of 130 to 140 F. Recycled water used to flush the floor was generally 2 to 3 F higher in temperature after it had flushed through the system than at the source. Flushing

**Table 3. Comparison of respiration rates between low types and coat color on 8/21/1982.**

| Treatment | Coat color | Time | | |
|---|---|---|---|---|
| | | 8:00 am | 12 Noon | 4:00 pm |
| | | ---- Respiration rate, breaths per minute ---- | | |
| Drylot | Black | 60.4 | 132.2[a] | 128.3 |
| Confinement | Black | 57.9 | 144.6[b] | 126.1 |
| Drylot | Red | 57.6 | 131.3[a] | 129.3 |
| Confinement | Red | 82.6 | 146.2[b] | 138.7 |
| Drylot | Overall | 59.0 | 131.7[a] | 128.8 |
| Confinement | Overall | 70.3 | 145.4[b] | 132.4 |

[a,b]Means in a column and set with different superscripts differ ($P<.05$).

**Table 4. Comparison of body surface temperatures between lot types and coat color on 8/21/1982.**

| Treatment | Coat color | Time | | |
|---|---|---|---|---|
| | | 8:00 am | 12 Noon | 4:00 pm |
| | | -------------- Surface temperature, F -------------- | | |
| Drylot | Black | 84.2[a] | 117.7[a] | 109.9 |
| Confinement | Black | 92.0[b] | 112.2[ab] | 108.1 |
| Drylot | Red | 80.6[a] | 107.6[bc] | 107.6 |
| Confinement | Red | 90.9[b] | 102.2[c] | 108.3 |
| Drylot | Overall | 82.4[a] | 112.6 | 108.8 |
| Confinement | Overall | 91.4[b] | 107.2 | 108.2 |

[a,b,c]Means in a column and set with different superscripts differ ($P<.05$).

may hold the night temperature of the floor higher than that of soil since temperature of the water was generally above night air temperature. Black bulb temperature reached 111°F suggesting that coat color could influence uptake of heat by radiation.

Feeding behavior subdivided by floor type measured at half-hour intervals from midnight to midnight is illustrated in Figure 1. Peaks were higher for steers in drylot pens than steers on the teardrop floor. This suggests that bunk space availability may limit access to feed for cattle in confined pens. Decreasing animal density will increase both space at the bunk and space in the pen. Decreased density may prove desirable to increase performance in this facility, although this may not be economically feasible. Bunk space, watering space and floor area all need consideration in newly designed facilities. Time of eating appeared changed as well, with a lower percent of the steers in confinement than in drylot pens eating during the middle of the day (10 am to 3 pm). Possibly to compensate, a higher percent of steers in confinement than in drylot pens were eating before sunrise.

The feeding pattern of steers classified by red and black coat color is presented in Figure 2. More black steers tended to eat from 7 am until noon, while from noon to 7:30 pm, more red steers were at the feed bunk. Higher surface temperatures and respiration rates for black than red cattle may have reduced their desire to eat during the hotter hours of the day.

**Table 5. Comparison of respiration rates between lot types on 9/04/1982.**

| Treatment | Coat color | Time 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
|---|---|---|---|---|---|---|
| | | Respiration rate, breaths per minute | | | | |
| Drylot | Black | 49.8 | 70.5$^{a}$ | 116.9$^{a}$ | 95.9$^{a}$ | 63.6$^{a}$ |
| Confinement | Black | 43.7 | 100.4$^{b}$ | 138.7$^{b}$ | 116.0$^{b}$ | 90.2$^{b}$ |
| Drylot | Red | 43.4 | 71.6$^{a}$ | 109.3$^{a}$ | 99.7$^{a}$ | 58.5$^{a}$ |
| Confinement | Red | 49.7 | 105.8$^{b}$ | 149.8$^{b}$ | 131.4$^{b}$ | 104.0$^{b}$ |
| Drylot | Overall | 46.6 | 71.0$^{a}$ | 113.1$^{a}$ | 97.8$^{a}$ | 61.0$^{a}$ |
| Confinement | Overall | 46.7 | 103.1$^{b}$ | 144.3$^{b}$ | 123.7$^{b}$ | 97.1$^{b}$ |

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

**Table 6. Comparison of surface temperatures between lot types on 9/04/1982.**

| Treatment | Coat color | Time 7:30 am | 10:30 am | 1:30 pm | 4:30 pm | 7:30 pm |
|---|---|---|---|---|---|---|
| | | Surface temperature, F | | | | |
| Drylot | Black | 83.2 | 105.6$^{a}$ | 109.4 | 110.9 | 86.1 |
| Confinement | Black | 88.2 | 106.1$^{a}$ | 111.9 | 104.9 | 86.2 |
| Drylot | Red | 82.2 | 100.4$^{b}$ | 106.2 | 105.9 | 85.9 |
| Confinement | Red | 86.5 | 100.0$^{b}$ | 108.9 | 103.9 | 86.6 |
| Drylot | Overall | 82.7 | 103.0 | 107.8 | 108.4 | 86.0 |
| Confinement | Overall | 87.4 | 103.1 | 110.4 | 104.4 | 86.4 |

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

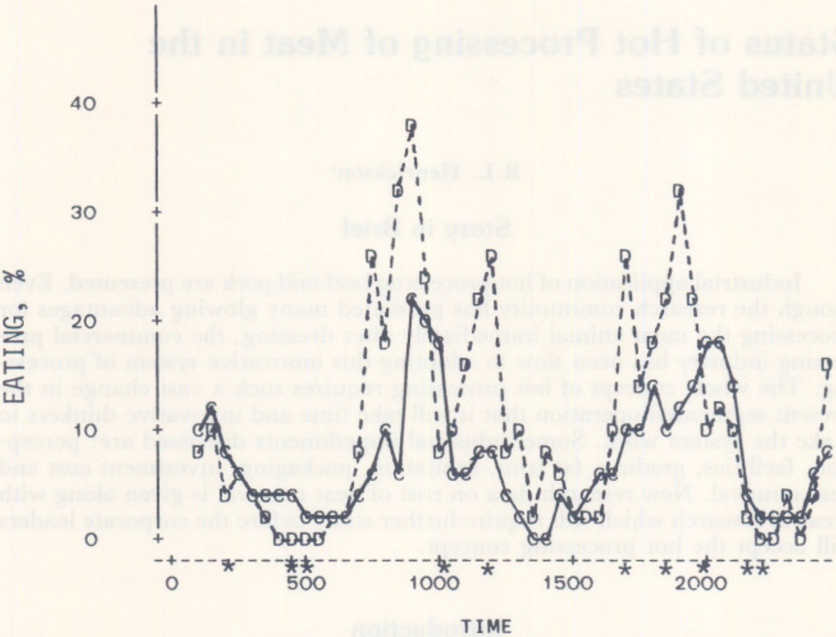



**Figure 1. Percentage of steers on teardrop floor (C, solid line) or in dirt floors pens (D, dotted line) eating at different times of a day.**

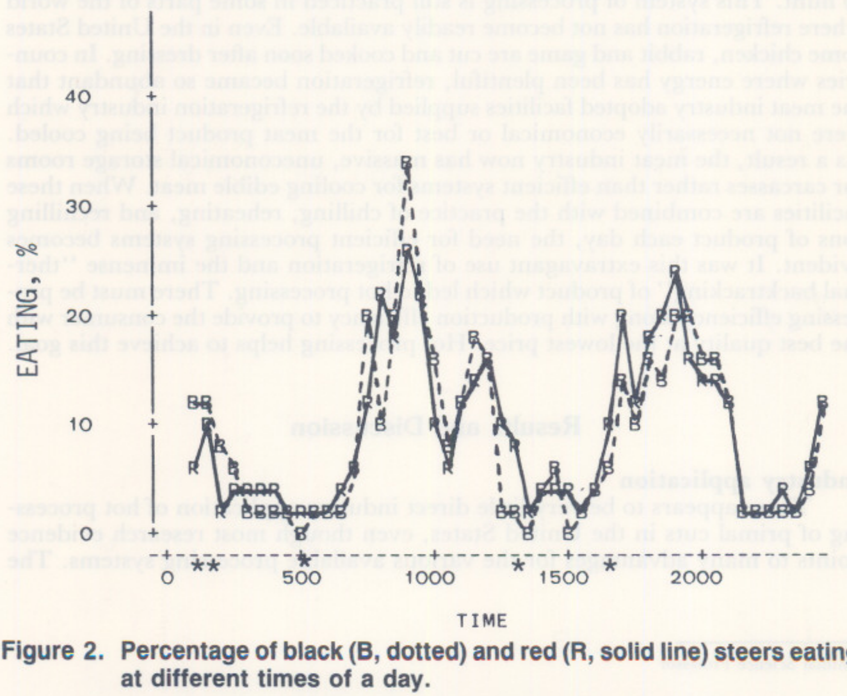



**Figure 2. Percentage of black (B, dotted) and red (R, solid line) steers eating at different times of a day.**

# Status of Hot Processing of Meat in the United States

R.L. Henrickson[1]

## Story in Brief

Industrial application of hot processing beef and pork are presented. Even though the research community has presented many glowing advantages for processing the meat animal immediately after dressing, the commercial processing industry has been slow in adopting this innovative system of processing. The whole concept of hot processing requires such a vast change in the present segmented operation that it will take time and innovative thinkers to make the system work. Some industrial impediments discussed are: perception, facilities, grading, fat trim, sanitation, packaging, investment cost and heat removal. New research data on cost of heat removal is given along with areas of research which will require further study before the corporate leaders will accept the hot processing concept.

## Introduction

Man has cut and cooked meat soon after slaughter ever since he learned to hunt. This system of processing is still practiced in some parts of the world where refrigeration has not become readily available. Even in the United States some chicken, rabbit and game are cut and cooked soon after dressing. In countries where energy has been plentiful, refrigeration became so abundant that the meat industry adopted facilities supplied by the refrigeration industry which were not necessarily economical or best for the meat product being cooled. As a result, the meat industry now has massive, uneconomical storage rooms for carcasses rather than efficient systems for cooling edible meat. When these facilities are combined with the practice of chilling, reheating, and rechilling tons of product each day, the need for efficient processing systems becomes evident. It was this extravagant use of refrigeration and the immense "thermal backtracking" of product which led to hot processing. There must be processing efficiency along with production efficiency to provide the consumer with the best quality at the lowest price. Hot processing helps to achieve this goal.

## Results and Discussion

### Industry application

There appears to be very little direct industry application of hot processing of primal cuts in the United States, even though most research evidence points to many advantages for the various available processing systems. The

[1]Animal Science Professor

success of the pork sausage industry can be attributed directly to the short processing period from slaughter to the chilled or frozen package. The system makes raw seasoned sausage available to the consumer in less than 90 minutes after slaughter. This process not only takes advantage of economics in processing and chilling, but provides the consumer with a sanitary, longer shelf-life product. The major bulk of the raw pork sausage industry now uses pre-rigor pork.

The raw pork sausage industry uses young sows with the proper ratio of fat to lean. This careful selection of the animal makes it possible to blend a product without a great amount of excess fat. Lean meat and fat are separated from the bone, chopped into uniform pieces, partially cooled, seasoned, ground, and stuffed into one and two pound grease-proof casings in a matter of minutes. The chubs are then cooled, using an ethylene glycol bath system. Pork sausage links can be extruded with or without casing directly onto a liquid nitrogen enclosed endless belt. By the time each link reaches the end of the belt it has absorbed sufficient refrigeration to be case frozen. The case hardened links are then packaged and tempered to 0°F for marketing.

Pork tissue (lean and fat) to be used for further manufacture is generally salted (2-4 percent) during the coarse chopping step and then placed in 50-60 pound boxes to be frozen. The pre-salted meat is used in sausage manufacture because of its ability to yield myosin for binding.

Even though pre-rigor pork has been shown to have numerous advantages, the industry has been reluctant to process animal cuts directly from the slaughter floor without some cooling. The prospect of cutting hog carcasses directly from the dressing line prior to chilling makes the average packing house worker shudder. The reason most often given is that one cannot trim hot cuts to presentable standards of appearance. This, of course, is invalid since most the of the primal cuts do not require a high standard appearance value. All pork cuts except the loin and spare rib are subjected to some manner of forming either by can, package, stockinette, casing or press. Therefore, the only primal cut which may require some form of smoothness is the loin. Smoothness of the loin can even be attained by leaving the back fat intact, conveyorizing the loin through a blast chill and then trimming. A few minutes in a blast chill at -50°F should provide ample firmness for the necessary trim. An alternative would be to market a completely boneless loin, since the consumer is now discriminating against fat and bone. The whole concept of hot processing not only requires converting practices of plant and market, but the thinking of personnel. Some progress has been made in this regard during the past thirty years. Perhaps the process will gain more rapid adoption during the next decade.

Even though the pork industry has been reluctant to adopt hot processing for primal cuts, it has reduced the period from kill to package. High volume (880 hogs per hour) ham production (kill to can in three days) has been practiced since 1965. Pickle solution is automatically injected into the meat and the cure is equalized in a matter of hours. A flexible vacuum wrapper makes the product ready for shipment and distribution in less than three days. Hot processing could reduce this time by an additional day.

**Beef**

The beef industry has been equally slow to adopt hot processing. At present the only beef plants hot-boning are those which produce meat for further manufacturing. Three plants are known to be hot-boning cow beef carcasses. On-the-rail boning of young cow carcasses appears to be the most economical system. This system can provide cow tenders, rounds, and meat pieces for further manufacturing. All products are generally boxed (60 lbs) and palatized for air blast chilling or freezing. Air blast chilling requires 24 hours, while the freezing period takes 48 hours. When meat is placed in a 2000 pound combo, it is chilled with cryogenic compounds. It takes one pound of dry ice (carbon dioxide) to reduce five pounds of meat from 85°F to 35°F. Carbon dioxide at a cost of 12.5 cents per pound would equate to a cooling cost of 2.5 cents per pound of meat. Since many processing plants are accustomed to receiving meat for further processing by combo, it would be more economical to conveyorize meat during chilling using an air blast system. However, few of these systems are now being used.

**Industry impediments**

On-the-rail hot de-boning of the beef carcass has not been readily accepted, even though many potential advantages appear evident. A move toward hot processing of the beef carcass would cause great change in the slaughter and processing industries. At present, much of the livestock is slaughtered in one plant and the products processed within another plant. This industry segmentation has caused the corporate leaders to worry about systems of operation, new products, and consumer satisfaction with the new product forms.

**Perception**

The whole concept of hot processing requires such a vast change in the present segmented operating concept that it will take time and innovative thinkers to make the system work. Perhaps the major obstacle to hot processing is the need to change the thinking of people. Not only does the market manager think that the consumer would not accept hot processed meat, but the plant foreman visualizes operating problems. Plant workers trained to cut cold meat perceive difficulties in trimming soft warm meat. When this is coupled with the use of equipment designed specifically for cold meat, perhaps there are reasons for their concern. Quality and sanitary control personnel feel that microbial problems will prevent hot processing systems from being used. Research evidence suggests that hot processing could provide a more sanitary product. The plant manager, while ready to accept new economical, energy-saving methods of processing, immediately perceives labor relation problems. When hot processing was first conceived by our research team in 1957, attempts were made to include the labor unions as consultants. They were not at all interested in making the process work. People dealing in the futures market were also very outspoken against the hot processing concept. It was perceived by the brokers as a hindrance to the future trading of bellies and hams. While this marketing system deals in only a small part of the total carcass, it does represent a large dollar segment of the industry. These are but a few examples of how the attitudes of people make the difference. Many people still perceive hot processing as a viable system, and some of the industry innovators have risen to the challenge.

**Facilities**

A major impediment faced by the industry is its financial status and the money needed to construct new facilities or retrofit the old plant for handling a slaughter-processing system within the same plant. Processing would involve boneless uniform cuts, along with a range of comminuted and reformed products that may include mechanically deboned meat. A new beef plant doing hot-boning must be capable of handling over 400 beef per hour, while a hog processing plant must consider a capacity of 1000 head per hour. This slaughter capability would challenge present material handling systems. It would not only require conveyorized cooling, but robotic handling of some products. These added new processing systems would require additional skilled labor to handle the unfrozen and frozen retail vacuum packaged products.

**Grading**

A third impediment relates to the industrial tie to a grading system. Since grading is based on marbling, lean area, maturity and fat cover, it is obvious that marbling level, the one factor difficult to measure in unchilled meat, is the limiting main concern. The price differential between the choice and good grade continues to influence the importance of grading. These factors, along with industry's concept of the sales value of the term "choice" and the need to reeducate the consumer, have delayed the acceptance of hot processing.

**Fat trim**

Fat trim on the individual meat cuts must be uniformly close in order to provide the consuming public with lean, palatable meat. The trend toward leaner meat favors hot-boning since it is easier to remove fat from the warm cut. In this attempt to meet the demand for lean meat, care must be taken to maintain palatability. It will be important to reduce fat variability rather than cause it to increase.

On-the-rail hot de-boning would provide a greater amount of fat to render and more bone to be placed through the mechanical de-boner. Both of these products will cause a need for larger facilities.

**Sanitation**

Warm, sticky meat, due to high surface moisture, favors microbial growth. Therefore, greater awareness of facilities and handling hygiene will be required. Not only will there be more pieces to handle, but the cut surface area will be greater. A sanitation program must be provided with slaughtering, de-boning, and processing lines. It is these material handling systems that must be clearly outlined before hot-boning can be fully implemented.

**Packaging**

Packaging the de-boned cuts or muscle systems to retain their shape and fiber orientation suitable for consumer acceptance has caused some concern to those considering hot-boning of the choice beef carcass. The difficulty of placing warm meat in a vacuum barrier bag has presented a challenge to the packaging industry. Vacuum packaging hot-boned beef presents numerous problems, including loss of vacuum, higher leak rate, shape distortion, and color loss. Meat to be placed in a box also provides some concern. Not only must the box have strength, but it must allow for a rapid means of cooling the product. This means that holes for air flow and a box of suitable dimension must be provided. Since the edible product from hot-boning would be several more pieces than the bone-in boxed beef, one must consider the additional handling cost.

**Investment cost**

A large-scale adoption of the hot processing technology will be delayed while the interest rate on money is high. There may be little justification for a company to borrow money at 14 to 16 percent interest while the margin of profit is low. The cost to retrofit an old plant may not be economical, even though one may save 50 percent in energy and reduce the in-plant storage period by one day. Even though there are other economical advantages to the system, it may cost several million dollars to fully adapt the process. Consequently, the dollar savings may not be enough to cover the short-term cost, and industry innovators are now looking at the total concept of hot processing and its advantages to their long term profit margin.

**Heat removal**

In view of the rapid increase in energy cost of refrigeration and freezing, improved design of the cooling system, based on the heat transfer characteristics of a food, is a very important factor in keeping the processing costs low. In addition, the efficiency of cooling can be improved by altering the geometry of the products without changing their quality characteristics. For the chilling of beef carcasses, both of these factors were duly explored in a series of studies by Ferguson and Henrickson, 1979.

The thermodynamic considerations of heat exchange systems suggest that a counter-flow design is relatively more effective than other systems. Three energy inputs are involved in this design. One energy source is used to create a temperature potential for energy transfer, the second provides a pressure difference to maintain circulation, and the third must involve the energy necessary to conveyorize the product through the chamber. A counter-flow conveyorized design was shown by Ganni, 1979, to have the highest effectiveness with regard to optimum heat transfer, energy expenditure and uniformity in the quantity and velocity of cooling air flow at minimum cost. This design is thought to be very close to the ideal system. Factors considered in this design were product geometry, energy consumption, and plant location.

## Research Needs

Research evidence advanced to date provides many advantages for hot processing systems. Among them are space, energy savings, low refrigeration cost, lower transportation cost, greater product yield, one day less ownership, lower operating cost, good color meat with high functional properties, etc. However, there remain research problems to be answered. Among these are the best methods for dividing the choice beef carcasses. It may be that initially one should hot-bone only the forequarter and flank, leaving the remaining higher priced sections attached to the skeleton for cooling and cold processing. The facilities required and the economics of such a dual processing system must be determined. There needs to be more information assembled on the functional characteristics of hot beef for the manufacturing of restructured meat products and ground beef. A means of removing dense connective tissue from the low value meat will be needed; suitable particle reduction equipment for ground beef and formed meat will be important. Since ground beef and restructured meat items are destined to become one of the major products from the choice beef carcass, future studies should include product shelf life. Not only must this research involve particle definition, texture, flavor, water binding, and appearance, but some concern must be given to evidence of rigor in the meat used for these products. Appearance and shelf life may not be a major problem with hot processed ground meat, but it would be of interest to know the advantages of using ingredients like nitrite or a starter culture for controlling microbial growth. Can warm meat be ground, flaked or chopped for immediate delivery to the pattie former? If not, what temperature will be best suited for each meat formulation?

In large volume plants, material handling and smooth flow of each meat item will be important. While it appears from the computer model that a multiple conveyorized cooling system would be useful for the different size subprimal boneless cuts, further material handling studies would be needed.

## Conclusion

The advantages offered by hot processing are significant and will be given serious consideration by the meat processing industry. It will be necessary for a large major processor to adopt the concept and show by innovative example the commercial advantages. This will take place first using pork, since ''thermal back-tracking'' is prevalent. Chilling, reheating, and rechilling tons of product each day is expensive and wasteful. Suitable facilities, refrigeration, material handling, packaging systems, and interest rates will all be integrated in a new facility.

The meat industry has been gradually making changes over the past three decades. Hot processing will take its rightful place as a few more facts are exposed and more commercial people accept the basic concept.

## Literature Cited


Ferguson, E.J. and Henrickson, R.L. 1979. *U.S. Department of Energy,* Contract E4-76-5-05-5097

Ganni, V. 1979. *Ph.D. Thesis.* Oklahoma State University, Stillwater, OK.

# A Method to Obtain True Muscle Fiber Area

**J.J. Guenther,[1] R.V. Felber[2] and K.K. Novotny[3]**

## Story in Brief

A technique was developed for measuring the angle through which muscle fibers are sliced, during transverse sectioning, from a true perpendicular to their longitudinal axis. Angles which muscle fibers are displaced from a true perpendicular to their longitudinal axis appeared to be uniformly distributed between 0 and 15 degrees in thaw rigor tissue which was aligned, before sectioning, to obtain transverse tissue slices. An equation of stereology was modified for use with muscle fibers to improve the precision and accuracy of muscle fiber area determination. Knowing the angular distribution of sectioned muscle fibers, the equation derived can be used to obtain true fiber area; particularly on fibers from muscles like the Longissimus dorsi which is comprised of fibers that area parallel to the longitudinal axis of the muscle. The equation derived precludes the tedious aligning of muscle fibers prior to sectioning and would improve the efficiency and accuracy of obtaining data in muscle growth studies where a change in myofiber size is used as the basic muscle growth parameter.

## Introduction

The measuring of skeletal muscle fiber cross-sectional area or diamter has been a popular technique to assess genetic and treatment effects during the muscle growth process in beef cattle. To measure cross-sectional area or diameter, investigators usually attempt to obtain a tissue slice perpendicular to the longitudinal axis of the muscle fibers. Muscle fibers not sliced perpendicular to their longitudinal axis will have an apparent cross-sectional area which is greater than the true cross-sectional area, yielding inaccurate data.

Other techniques involve separating individual muscle fibers and measuring the projection diameter or width of the fibers. However, muscle fibers are not true cylinders but appear, in cross-section, to be primarily irregular polygons. Consequently, the projection diameter technique may also give biased results.

The actual diameter of a muscle fiber is related to the apparent diameter multiplied by he cosine of the angle $\theta$. The angle $\theta$ is the angular displacement from a true perpendicular to the longitudinal axis of a muscle fiber.

The common problem encountered in determining muscle fiber area is the angle $\theta$. Angle $\theta$ is now known for the experimental material. Many investigators of fiber area or diameter eventually conceded that true crosssections perpendicular to the longitudinal axis of muscle fibers are difficult to obtain. Swatland (1975) measured the maximum endomysial sheath width parallel to the mean diameter axis. The arc sine of the ratio of the minimum endomysial sheath width to the maximum endoymysial sheath width gives the angle $\theta$. This

[1]Professor of Animal Science [2]Former Graduate Student [3]Laboratory Technician

method of assessing the angle $\theta$ is tedious and highly subjective to the researcher's judgement in determining the minimum and maximum endoymysial sheath widths.

A method to determine the angle $\theta$ easily and accurately could improve the precision of studies on changes in muscle fiber area during the growth process in beef cattle. Thus, the objective of this study was to develop a technique to determine the angle $\theta$.

## Materials and Methods

From a 15 day old Holstein calf, the lateral head of the Triceps brachii was removed, wrapped in aluminum foil and frozen, pre-rigor, by immersion in liquid nitrogen. The muscle was sectioned perpendicular to its longitudinal axis and four, 6.35 mm cores were taken parallel with the longitudinal axis. Core length was adjusted to be less than or equal to the diameter of the core. The core was then placed in a phosphate-buffered saline solution at 24°C and allowed to enter thaw rigor. The core was then positioned on a chilled microtome chuck and refrozen.

Tissue slices, 60 microns in length, were taken from each core and transferred to a vial containing 10 ml of buffered saline. Slices were then disrupted into individual fiber rods by sonification.

A random sample of the small fiber rods was transferred to a microscope slide. Photomicrographs of the fiber rods were taken (Figure 1). The negatives of the fiber rods were projected onto white paper and the fiber rods were trac-

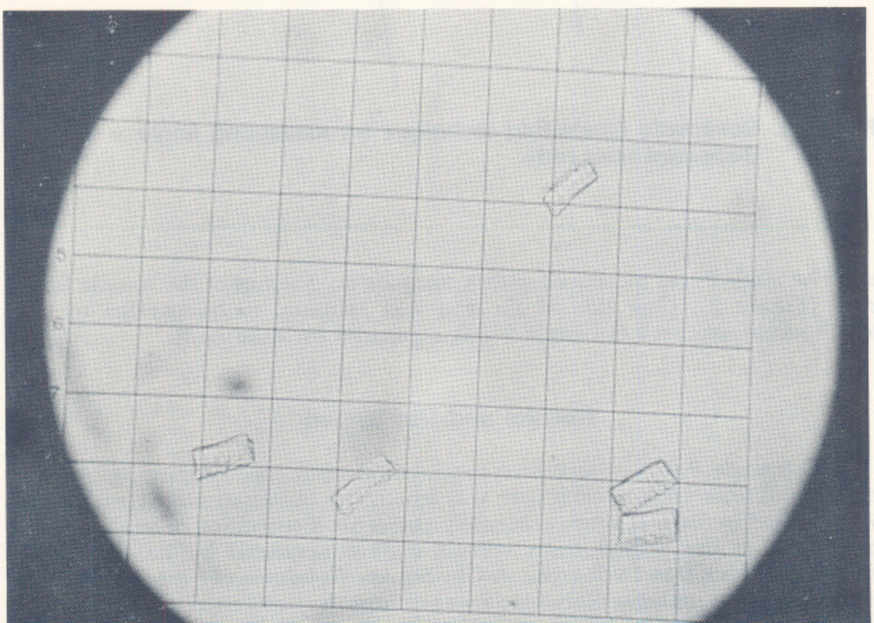


**Figure 1. Photomicrograph of dispersed fiber rods.**

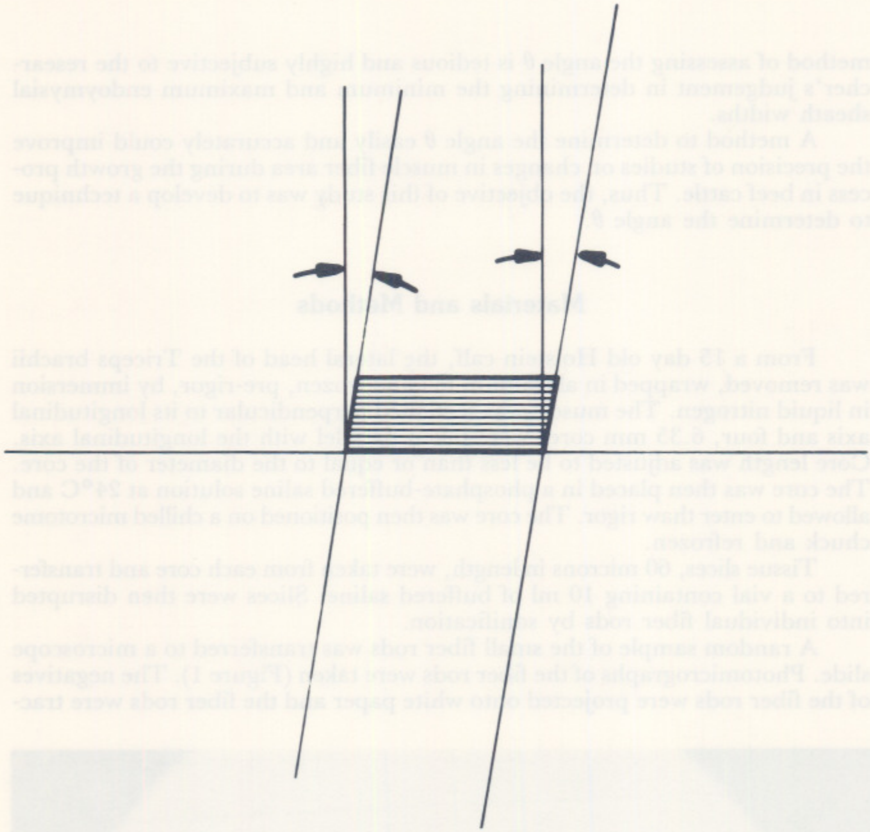


**Figure 2. Schematic illustrating technique for measuring angle θ on the dispersed fiber rods.**

ed. The angle $\theta$ was measured with a compass on tracings of the muscle fiber rods (Figure 2). One side of the rod was assumed to be parallel to the longitudinal axis and the angle $\theta$ was measured for both ends.

## Results and Discussion

The angle $\theta$ was observed to vary within each core (Figure 3). As the number of fiber rods in each core was small, the observations for each core were pooled in order to more accurately assess the distribution of angle $\theta$. The histogram of the pooled cores versus angle $\theta$ appeared by be uniformly distributed from 0 to 15 degrees. A Chi-Square Goodness of Fit test was used in testing the hypothesis that angle $\theta$ was uniformly distributed on the interval 0 to 15 degrees. The test was not significant at the 1 percent level of probability.

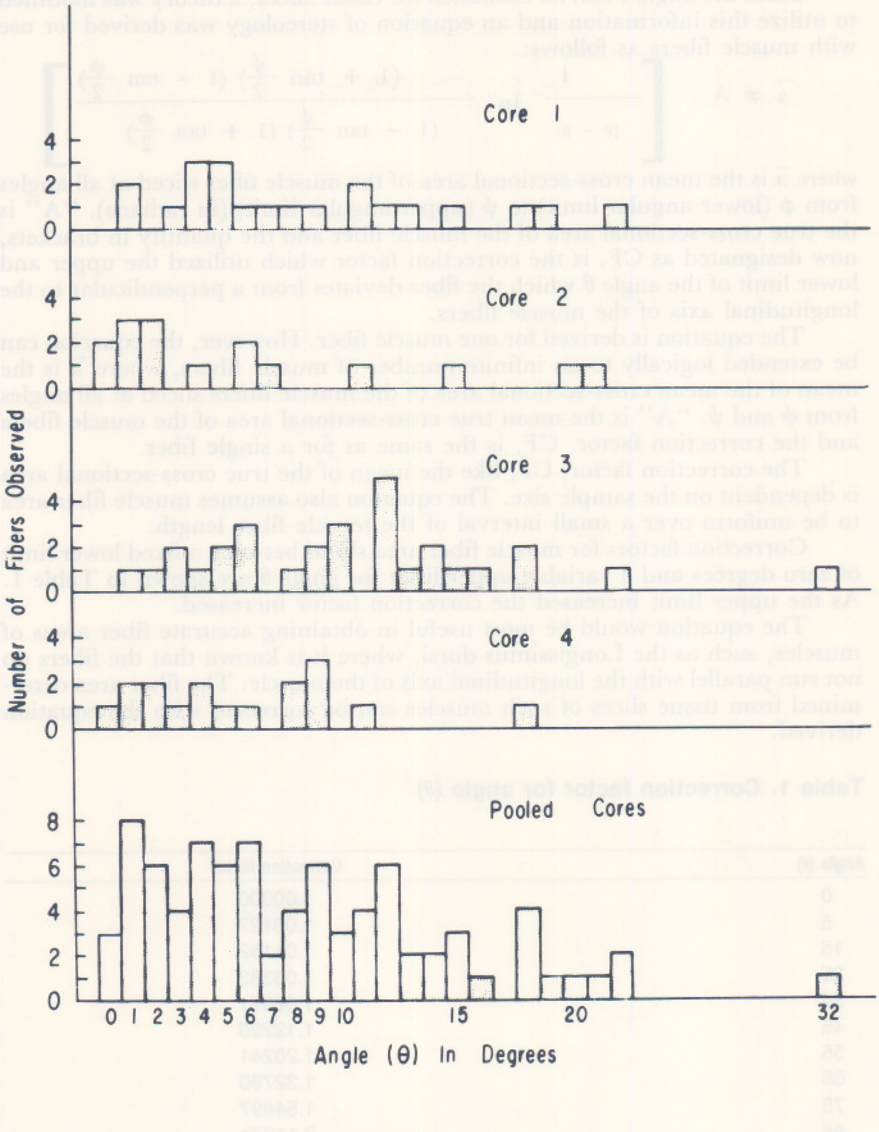



Figure 3. Number of fibers observed versus angle (θ).

Since the angle $\theta$ can be estimated for tissue slices, a theory was modified to utilize this information and an equation of stereology was derived for use with muscle fibers as follows:

$$\bar{a} \neq A \left[ \frac{1}{(\psi - \phi)} \ln \frac{(1 + \tan \frac{\psi}{2})(1 - \tan \frac{\phi}{2})}{(1 - \tan \frac{\psi}{2})(1 + \tan \frac{\phi}{2})} \right]$$

where $\bar{a}$ is the mean cross-sectional area of the muscle fiber sliced at all angles from $\phi$ (lower angular limit) to $\psi$ (upper angular limit) (in radians). "A" is the true cross-sectional area of the muscle fiber and the quantity in brackets, now designated as CF, is the correction factor which utilized the upper and lower limit of the angle $\theta$ which the fiber deviates from a perpendicular to the longitudinal axis of the muscle fibers.

The equation is derived for one muscle fiber. However, the equation can be extended logically to an infinite number of muscle fibers, where $\bar{a}$ is the mean of the mean cross-sectional area of the muscle fibers sliced at all angles from $\phi$ and $\psi$. "A" is the mean true cross-sectional area of the muscle fibers and the correction factor, CF, is the same as for a single fiber.

The correction factor, CF, like the mean of the true cross-sectional area is dependent on the sample size. The equation also assumes muscle fiber area to be uniform over a small interval of the muscle fiber length.

Correction factors for muscle fiber area sliced between a fixed lower limit of zero degrees and a variable upper limit for angle $\theta$ are shown in Table 1. As the upper limit increased the correction factor increased.

The equation would be most useful in obtaining accurate fiber areas of muscles, such as the Longissimus dorsi, where it is known that the fibers do not run parallel with the longitudinal axis of the muscle. The fiber area determined from tissue slices of such muscles can be corrected with the equation derived.

**Table 1. Correction factor for angle ($\theta$)**

| Angle ($\theta$) | Correction factor |
|---|---|
| 0 | 1.00000 |
| 5 | 1.00127 |
| 15 | 1.01162 |
| 25 | 1.03333 |
| 35 | 1.06871 |
| 45 | 1.12220 |
| 55 | 1.20241 |
| 65 | 1.32790 |
| 75 | 1.54897 |
| 85 | 2.11071 |

## Literature Cited

Swatland, H.J. 1975. J. Animal Sci. 41:78-86.

# Prediction of Yield Grade from Time on Feed, Final Weight and Daily Gain

D. Hale[1], R.L. Hintz[2],
L.E. Walters[3] and F.N. Owens[3]

## Story in Brief

Equations developed for predicting beef carcass yield from average daily gain, days on feed and final weight were tested using data from 1670 British, 315 Exotic X British crossbreds, and 138 Exotic breed type steers. These animals were from a variety of sources and had been used in nutrition trials.

Yield grades predicted from days on feed, final weight and daily gain were reasonably close to the yield grades determined by carcass measurements. However, when small groups of cattle were tested, correlation coefficients were lower indicating that equations were not as reliable. For groups of cattle which had yield grade values of 3.0 − 4.0, the difference between actual and predicted was less than .5 yield grade. Both overestimated and underestimated of carcass yield grade occurred with extreme yield grades (< 2.5 or > 4.5). Efforts to more accurately estimate yield grades of slaughter cattle with these extremes are needed.

## Introduction

The demand for leaner beef continues to increase. By 1985, over 50 percent of the beef consumed in the United States is projected to be in the form of ground beef (80 percent lean, 20 percent fat).

To produce cattle this lean, management practices to efficiently produce acceptable lean beef need to be identified. Yield grade is an indicator of carcass cutability and reliability estimates the amount of lean and fat in a beef carcass. Identification of live animal characteristics which predict yield grade would be helpful in the production and market of lean beef.

Walters and Hintz (1981) developed two equations to predict carcass yield grade from live cattle traits. Many variables such as final weight, days on feed, average daily gain, birth weight, weaning weight (these variables squared and cubed), breed of sire, breed of dam, and interactions were considered as sources of variation. However, based on the coefficient of determination ($R^2$), the following two equations were developed. One is for British and one is for exotic X British breed type cattle.

The equations are as follows:

British (B):

$$YG = -7.1527 + .068 \times Day - .000234 \times Day^2 + .000000263 \times Day^3 + .0042 \times FWT + .2257 \times ADG;$$

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

Exotic X British (ExB):

$$YG = -8.4625 + .068 \times Day - .000234 \times Day^2 + .000000263 \times Day^3 + .0042 \times FWT + .2257 \times ADG;$$

where Day = Days on Feed;
FWT = Final Live Weight in lb; and
ADG = Average Daily Gain in lb per day

The purpose of this study was to test the validity of these equations, using means and correlations to examine relationships between actual yield grade and the yield grade derived from the prediction equations, among cattle of various backgrounds, types and nutritional treatments.

## Materials and Methods

Data sets used to test the effectiveness (validity) of the equations came from 16 independent OSU feedlot trials (Source I) and from progeny data from a 7-year beef cattle milk production study conducted at the Southwestern Livestock and Forage Research Station (Source II).

Source I included 2015 head of cattle representing 26 breeds or crosses, which were fed different energy and protein levels and feed additives. These steers entered the feedlot weighing from 440 to 880 lbs. and were fed from 110 to 201 days.

Source II consisted of 108 Herford X Angus and Hereford X Charolais crossbred steers, which had been weaned at 240 days of age and placed directly in the feedlot. Their feedlot rations ranged from 75 percent to 92 percent concentrates. All cattle had free access to feed and were slaughtered when their carcasses were estimated to grade low choice, which resulted in a range of feeding time from 87 days to 308 days.

## Results and Discussion

More observations were available from Source I than from Source II (Table 1). Steers from Source II were placed in the feedlot at weaning, whereas the pre-feedlot history of Source I cattle is unknown. This explains why the initial weight is lighter for Source II than Source I cattle. Cattle from the milk level studies (Source II) were slaughtered when their carcasses were estimated to quality grade low choice while cattle from the OSU feedlot trials (Source I) were slaughtered in a group after a given number of days on feed. This explains why days on feed differ between the two sources.

The mean yield grade (PYG) predicted from live cattle traits was similar to the measured carcass yield grade (AYG) (Table 2). The smallest difference between PYG and AYG was within Source I when the ExB equation was used with ExB cattle. In both data sources the ExB equation underestimated actual carcass yield grade and the B equation overestimated AYG.

Although the mean PYG and the mean AYG are similar, the low simple correlation coefficients (Table 2) indicate that these equations are not valid for predicting the yield grade.

**Table 1. Feedlot traits for steers in Source I and Source II by breed type**

| Breed type | N | Beginning weight lbs. | ADG lbs. | Days on feed | Final weight lbs. |
|---|---|---|---|---|---|
| Source I | | | | | |
| B[a] | 1608 | 660 ± 2.7[c] | 3.2 ± .01 | 138 ± .61 | 1115 ± 2.6 |
| ExB | 269 | 696 ± 3.7 | 3.3 ± .03 | 130 ± .56 | 1120 ± 5.5 |
| E[b] | 138 | 681 ± 5.8 | 3.3 ± .04 | 133 ± .09 | 1109 ± 8.4 |
| Source II | | | | | |
| B | 62 | 593 ± 10.9 | 2.6 ± .06 | 168 ± 5.6 | 1043 ± 21.1 |
| ExB | 46 | 588 ± 6.6 | 2.4 ± .06 | 190 ± 4.9 | 1057 ± 14.8 |

[a]B = British
[b]E = Exotic
[c]Standard Error

**Table 2. Predicted vs actual yield grades and standard errors on British (B), Exotic X British (ExB) and Exotic (E) breed type cattle**

| | Breed type | N | Predicted yield grade (PYG) | Actual yield grade (AYG) | PYG-AYG | Correlation (actual vs predicted) |
|---|---|---|---|---|---|---|
| Source 1 | | | | | | |
| | B | 1608 | 3.77 ± .01 | 3.27 ± .02 | .5 | .21 |
| | ExB | 269 | 2.43 ± .02 | 2.63 ± .04 | −.2 | .22 |
| | E[a] | 138 | 2.43 ± .04 | 2.86 ± .06 | −.43 | .19 |
| Source 2 | | | | | | |
| | B | 62 | 3.55 ± .13 | 3.07 ± .18 | .42 | .10 |
| | ExB | 46 | 2.61 ± .10 | 3.30 ± .14 | −.69 | .18 |

[a]Predicted yield grades were calculated from the equations developed from Exotic X British crossbred cattle.

The low simple correlation coefficients between PYG and AYG are partially explained by the data presented in Table 3 for cattle within Source 1 subdivided by yield grades. The difference between PYG and AYG was lowest for cattle with yield grades of 3.0 to 4.0. As the AYG increased, it was increasingly underestimated by the equation and as AYG decreased, it was increasingly overestimated. These results seem logical since the greater part of the cattle used to develop the original equations were within the 3.0 to 4.0 yield grade range. Overestimating and underestimating at the outer extremes may to be due to the small number of observations with high and low AYG, though the bias suggests that another equation might prove superior. Because of the low correlation coefficients between actual and predicted yield grade, it is felt that the existing equations would not be an adequate tool for estimating the yield grade of small groups of cattle. We therefore plan to refine the original equations by including additional live traits, such as initial weight, diet protein levels and ration energy levels, which were not available when the original equations were developed. Non-linear regression techniques may also be used in this refinement process.

**Table 3. The predicted yield grade (PYG) and actual yield grade (AYG) for source I cattle over a range of yield grades averaged over breed types**

| N | AYG | PYG | PYG-AYG |
|---|---|---|---|
| 11 | 1.5 | 2.90 ± .18 | 1.4 |
| 64 | 2.0 | 3.15 ± .09 | 1.15 |
| 82 | 2.5 | 3.12 ± .08 | .58 |
| 111 | 3.0 | 3.51 ± .06 | .49 |
| 101 | 3.5 | 3.70 ± .06 | .2 |
| 62 | 4.0 | 3.87 ± .06 | −.13 |
| 23 | 4.5 | 3.82 ± .12 | −.68 |
| 4 | 5.0 | 4.00 ± .22 | −1.00 |

## Literature Cited

Walters, L. E. and R. L. Hintz. 1981. Okla. Agr. Exp. Sta. Res. Report MP-108:49.

# Influence of Yogurt Containing Live Starter Culture on Lactose Utilization in Humans

Stanley E. Gilliland[1] and H. S. Kim[2]

## Story in Brief

The appearance of hydrogen in the breath following consumption of milk is an indication of "lactose malabsorption". The amount of hydrogen is a measure of the severity or intensity of the malabsorption or inability to digest the lactose in the small intestine. Breath hydrogen production was determined following the consumption of both heated and nonheated cultured yogurt. Significantly less hydrogen was produced when the subjects consumed the nonheated cultured yogurt than when they consume the heated product. This suggests that lactose hydrolysis was improved in the small intestine of the individuals consuming the nonheated cultured yogurt containing live starter bacteria. The yogurt starter bacteria do not survive and grow in the intestine, however, increased lactase activity in the presence of bile indicates that these bacteria could function as a source of an enzyme to hydrolyze lactose in the small intestine.

## Introduction

Milk consumption by persons who lack the ability to digest lactose (lactose malabsorbers) often results in development of symptoms such as cramps, flatulence and diarrhea. This discourages the consumption of milk products by such individuals. Thus, they tend to eliminate milk, a major source of calcium and high quality protein, from the diet.

Fermented or cultured dairy products such as yogurt and buttermilk have been suggested for use by persons lacking the ability to utilize lactose. It was suggested that the starter culture bacteria in these products might exert lactase activity in the intestines after the products were consumed. The bacteria in these starter cultures do not normally grow in the intestinal tract, thus, their only means of providing an improvement in lactose utilization would be to supply the enzyme to hydrolyze lactose.

In the dairy industry, at present, there is some controversy over whether or not cultured yogurt should be pasteurized after the fermentation process. The advantage for pasteurizing such a product would be to extend shelf life of the product. However, such a thermal process would result in reducing the lactase activity in the product. The product then would presumably be of no benefit with regard to improving lactose utilization in the human. No research has been reported to date to present objective data showing whether or not viable starter culture bacteria in yogurt would influence the utilization of lactose in humans who normally cannot digest lactose.

---

[1]Professor [2]Former Graduate Student

The objectives of this study were to determine whether the presence of viable culture bacteria in yogurt is useful in improving lactose utilization in persons classified as lactose malabsorbers and to determine whether bile enhances the ability of yogurt cultures to hydrolye lactose.

## Material and Methods

Cultured yogurt was made in the laboratory in one liter portions. To prepare the heated or pasteurized yogurt, one liter of cultured yogurt was heated in a hot water bath to 65 C and held for 3 min with frequent stirring. It was then immediately cooled in an ice-water mixture. Examination of the heated yogurt revealed no viable bacteria. The yogurt preparations were stored under refrigeration until used. They were used within 48 hr of preparation.

Lactose malabsorption in humans was measured using a breath hydrogen test (BHT). Following an overnight fast, (12 hr) the test subjects consumed yogurt at a rate of 4 g/kg body wt. Breath samples were then collected initially and at one-half hr intervals for 3-4 hr. The samples were collected and assayed for hydrogen by gas chromatography.

Test subjects who indicated that they had problems digesting lactose were screened for the ability to hydrolyze lactose using the BHT in which direct acidified yogurt was used as the test dose. This was done to confirm if lactose malabsorption did occur and if an acid product could be used as a test dose. Only those test subjects which exhibited an increase breath hydrogen of at least 30 ppm during the test period were accepted as test subjects (Use of human test subjects was approved by the Oklahoma State University Institutional Review Board for the Protection of Rights of Human Subjects).

After the initial BHT to confirm that the subjects were lactose malabsorbers, they were subjected, at 7-day intervals, to the BHT using both the cultured or heated cultured yogurt as the test dose.

An enzymatic method described by Taylor (1970) was used to quantitate lactose in the yogurt samples. This assay not only permitted quantitation of lactose but also permitted us to measure any free glucose which might have been in the yogurt preparations.

Lactose hydrolyzing activity of the yogurt preparations was measured using o-nitrophenyl-$\beta$-D-galactopyranoside (ONPG) as a substrate as described by Citti et al (1965).

## Results

Breath hydrogen excretion data for the six test subjects after consuming either heated or nonheated cultured yogurt are summarized in Table 1. For the unheated cultured yogurt, breath hydrogen values ranged from 2.9 to 15.7 ppm (average of 9.9 ppm) and for heated yogurt they ranged from 5.8 to 43.1 ppm (average of 22.8 ppm). There was significantly less breath hydrogen excreted when the subjects consumed the nonheated yogurt than when they consumed the heated yogurt ($P < .05$).

The lactose content of the heated and nonheated cultured yogurt was 4.36 percent and 4.23 percent respectively (Table 2). The uninoculated yogurt mix contained 6.26 percent lactose. Thus, it appears that the starter culture reduced the lactose content of the yogurt mix by approximately 2 percent during the culturing process. The enzymatic method used for measuring lactose in these samples was designed to permit the measurement of free glucose as well. However, no free glucose was detected in any of the samples.

The lactose hydrolyzing activity of the cultured yogurt containing viable starter bacteria was greatly increased in the presence of oxgall (Table 3). In the absence of bile the nonheated yogurt exhibited 6.8 units of enzyme activity compared to only 0.6 units for the heated yogurt. The addition of .5 and 1 percent oxgall increased the activity to 19.8 and 16.7 units respectively for the nonheated yogurt ($P < 0.01$). The same levels of oxgall added to the pasteurized yogurt had little or no effect on lactose hydrolyzing activity ($P > 0.05$).

**Table 1. Influence of viable starter culture in yogurt on breath hydrogen production following ingestion of yogurt.**

| | ppm $H_2$ in breath[a] | |
|---|---|---|
| Subject | Heated Yogurt[b] | Unheated Yogurt |
| 1 | 43.1 | 15.7 |
| 2 | 5.8 | 6.7 |
| 3 | 23.7 | 2.9 |
| 4 | 22.5 | 13.5 |
| 5 | 20.9 | 5.4 |
| 6 | 20.7 | 15.3 |
| MEAN | 22.8[c] | 9.9[c] |

[a]Increase above basal level
[b]Three min at 65 C after culturing process (starter culture killed)
[c]Significantly lower for unheated yogurt ($P < 0.05$)

**Table 2. Lactose content of yogurt and uninoculated yogurt mix**

| Sample | % Lactose[a] |
|---|---|
| Mix | 6.26 |
| Unheated Yogurt | 4.23 |
| Heated Yogurt[b] | 4.36 |

[a]Each value represents the average from three batches; lactose determined enzymatically.
[b]Three min at 65 C after culturing process.

**Table 3. Influence of oxgall on lactase activity of yogurt.**

| Concentration Oxgall | Units of lactase activity/g[a] | |
|---|---|---|
| (Percent) | Unheated Yogurt | Heated Yogurt |
| 0 | 6.8[b] | 0.6[d] |
| 0.5 | 19.8[c] | 0.9[d] |
| 1.0 | 16.7[c] | 1.2[d] |

[a]1 unit = 1 u mole o-nitrophenol released from ONPG per min; each value represents an average from four trials; values in same column followed by different superscripts are significant ($P < 0.01$), others not different ($P > 0.05$).

## Discussion

It has been suggested that individuals suffering from lactose malabsorption might be able to consume yogurt without developing the symptoms normally associated with lactose malabsorption. However, no supporting data was presented. Data in the present study show that consumption of yogurt containing viable starter culture bacteria by lactose malabsorbers resulted in reductions in the amount of breath hydrogen produced. Thus, it appears that lactose utilization was improved by the presence of these viable bacteria in the yogurt.

The comparison of the heated and nonheated cultured yogurts shows that the presence of viable starter bacteria at the time of consumption is very important in improving lactose hydrolysis (for reducing lactose malabsorption) in the digestive tract of humans. This points out a real advantage for not pasteurizing cultured yogurt after the culturing process to kill the starter bacteria. By pasteurizing the cultured yogurt, we would eliminate or greatly reduce one of the highly desirable roles of yogurt in the diet, especially for those persons who can not properly digest lactose.

Since the starter culture bacteria *(Lactobacillus bulgaricus* and *Streptococcus thermophius)* used for the manufacture of yogurt do not survive and grow in the intestinal tract, we may assume that the organisms only serve as a source of an enyzme for hydrolyzing the lactose. However, results from other experiments have shown that the culture does not utilize or hydrolyze lactose except as needed for growth. This indicates that the culture must be growing if it is to hydrolyze any lactose in milk. The lactose hydrolyzing enzyme of these bacteria is intracellular and thus lactose must be transported into the cell before it can be hydrolyzed. Because of this, if the organisms are unable to grow in the intestines, they should be unable to hydrolyze the lactose in the yogurt after ingestion. However, after being consumed, yogurt is exposed to bile in the intestines which could alter the premeability of the bacterial cells so that lactose could enter the nongrowing cells and be hydrolyzed. This effect of bile on yogurt starter bacteria was demonstrated by the experiments which showed that the presence of oxgall increased the ability of the yogurt culture to hydrolyze lactose. Thus, nongrowing cells could easily function as a source of the enzyme in the intestinal tract.

If yogurt is to be beneficial to persons who are unable to utilize lactose, it is important that we insure that the yogurt contains adequate enzyme activity. This means that if it is to function in this capacity, the yogurt should not be sterilized by heating after manufacture. Additionally, the yogurt should not be mistreated in other ways such that the enzyme activity would be reduced.

## Literature Cited

Citti, J. E., W. E. Sandine, and P. R. Elliker. 1965. J. Bacteriol. 89:937.
Taylor, G. C. 1970. Australian J. Dairy Tech. 25:7.

# Inhibition of Spoilage Microorganisms in Refrigerated Raw Milk by Maillard Reaction Products

R.C. Lara[1] and S.E. Gilliland[2]

## Story in Brief

Different amounts (0, 0.21, 0.42 and 0.63 percent) of a "crude" mixture of Maillard reaction products (MRP) were added to refrigerated raw milk to evaluate their effect on growth of psychrotrophic microorganisms naturally present in raw milk. The samples containing 0.42 and 0.63 percent MRP had significantly lower numbers of microorganisms following four days of storage at 5C than did the samples containing 0 and 0.21 percent MPR ($P < .05$). The 0.63 percent MRP was significantly more inhibitory than the 0.42 percent MRP ($P < .05$).

## Introduction

Despite considerable discussion in recent years about the possibility of hazards from the use of food additives, the world-wide crisis in the food supply demands that losses be reduced to a minimum. Consequently, the use of chemical preservatives alone, or as a supplement of other means of preservation is essential. Since the MRP are known to possess antioxidative properties and some evidence indicates they may play a role as inhibitors of microbial growth, this opens the feasibility of using these products as additives for improving the self-life of foods. The fact that the Maillard reaction is common in many processed foods, and people have been exposed for many years to the consumption of its products, encouraged us to assay these substances for antimicrobial activity in refrigerated raw milk.

Psychrotrophic microorganisms are present in almost all raw milk supplies. During growth in the milk, some psychrotrophs produce heat stable enzymes that can cause degradation of certain milk products after pasteurization. These heat resistant enzymes are of concern in the production of sterile milk products. They are much more resistant to heat than bacterial spores and can survive the heat treatment used to manufacture sterile milk. Thus, research looking for means of preventing or reducing the growth of psychrotrophs in raw milk takes on added significance.

The primary objective of this study was to find out if the addition of MRP to raw milk can prevent/or retard the growth of psychrotrophs during refrigerated storage.

## Material and Methods

A crude mixture of Maillard reaction products, obtained by autoclaving (two hr at 121 C) an aqueous sugar-amino acid solution containing 0.2 M D-

[1]Graduate assistant [2]Professor

glucose (Fisher Scientific Co.) and 0.2 M D-L-Histidine, was used without any further fractionation for evaluation of its antimicrobial activity in raw milk. Based on the molar concentration, this solution contained seven percent solids.

Raw milk obtained from the Oklahoma State University Dairy Cattle Center was aseptically placed into a sterile 2000 ml flask in an ice-water bath for transport to the laboratory. Two sets of four sub-samples each were obtained from the original batch of milk. For each set, the sub-samples were prepared by aseptically delivering 90 ml portions of milk into each of four sterile 250 ml Erlenmeyer flasks containing respectively 0, 3, 6 and 9 ml of sterile MRP and sufficient sterile distilled water to make 10 ml volumes. Based on the molarity of ingredients in the MRP solution, the concentrations of MRP in the milk were 0, 0.21, 0.42 and 0.63 percent. After mixing, one set of samples was stored statically at 5 C and the other one was stored at 5 C in a water bath shaker adjusted to 120 RPM.

Samples for enumeration of microorganisms were taken prior to storage (day 0) and on the fourth day of storage (with or without agitation). The enumeration was done by plating the appropriate dilutions with Plate Count Agar (PCA; Difco Lab.) using the pour plate method (Speck, 1976) and incubation of 32 C for 48 hr. The results were statistically analyzed by means of an analysis of variance for a 2 x 4 factorial arrangement of treatment factors in a complete randomize block design. Further analysis for significantly different means was carried out using an accepted statistical procedure.

## Results and Discussion

On day 0, no significant ($P>0.05$) difference was observed among the means for the samples containing MRP when compared to the mean count for the control samples (Table 1). This indicated that such products did not have an immediate deleterious effect on the microorganisms in the raw milk.

**Table 1. Influence of the addition of MRP on growth of psychrotrophs in raw milk during storage at 5 C.**

| | | Mean of $Log_{10}$ Counts/ml[A] | | | |
|---|---|---|---|---|---|
| | | Added MRP (%) | | | |
| Storage Condition | Day | 0 (Control) | 0.21 | 0.42 | 0.63 |
| Agitated[C] | 0 | 3.37 (a)[B] | 3.38 (a) | 3.34 (a) | 3.34 (a) |
| | 4 | 5.86 (a) | 5.57 (a) | 5.37 (b) | 5.11 (c) |
| Static[C] | 0 | 3.43 (a) | 3.45 (a) | 3.45 (a) | 3.44 (a) |
| | 4 | 6.34 (a) | 6.10 (a) | 5.63 (b) | 5.04 (c) |

[A] Each value represents the mean $log_{10}$ count/ml from 8 trials.
[B] Numbers in same row followed by different letters are significantly different ($P<0.05$).
[C] Counts for the static samples were all significantly higher than for the agitated samples ($P<0.05$).

After four days of storage, the numbers of organisms in the milk were significantly ($P < 0.05$) less numerous in agitated than in static samples, probably due to a decrease in the action of the inhibitory agent as a result of its interaction with the oxygen incorporated by continuous agitation. Based on the counts obtained on the fourth day samples, microbial growth decreased as the MRP concentration increased. The means of the $\log_{10}$ counts/ml from agitated milk were: 5.86 for the control, and 5.57, 5.37 and 5.11 for the samples containing respectively 0.21, 0.42 and 0.63 percent added MRP. For the corresponding static samples, the means of the $\log_{10}$ counts/ml were respectively 6.34, 6.10, 5.63 and 5.04. The fact that 0.63 percent MRP was significantly ($P < 0.05$) more inhibitory than 0.42 percent MRP while 0.21 percent MRP was statistically similar ($P > 0.05$) to the control indicated that there is a limiting concentration level below which the inhibitor(s) loses its effectiveness.

Failure of microorganisms to grow in culture media submitted to heat has been attributed to distruction and/or unavailability of amino acids or other nutrients due to the Maillard reaction rather than to the formation of inhibitory substances in this reaction (Rose and Peterson, 1949; Horn et al., 1968; Hagan et al., 1970). In the present work, neither destruction nor unavailability of nutrients appeared to be the cause of growth inhibition since the MRP used were performed materials incorporated into milk which should be nutritionally adequate to support microbial growth.

Although present studies suggest the feasibility of the use of MRP as preservatives to reduce the growth of psychrotrophs in refrigerated raw milk, further investigation is needed. Purification of the inhibitory agent(s) might provide a way to increase its effectiveness. Association, if any, of the inhibitor with brown-colored components needs to be investigated since browth discoloration would be a problem in a product such as milk.

## Literature Cited

Hagan, S.N. et al. 1970. J. Agr. Food Chem. 18:273.

Horn, M.J. et al. 1968. J. Agr. Food Chem. 16:741.

Rose, D. and R. Peterson. 1949. Can. J. Res. B. 27:428.

Speck, M.L. 1976. *Compendium of Methods for the Microbiological Examination of Foods.* Am. Pub. Health Assoc.

# Changes in Bacterial Counts on Hot Boned Boxed Beef Trimmings

**Orange Lara[1] and R.L. Henrickson[2]**

## Story in Brief

Total aerobic, psychrotrophic, and anaerobic bacterial counts were determined on meat samples placed at three positions (top, middle, and bottom) within boxes of different depth (4, 8, and 12 inches) filled with hot boned beef trimmings, after cooler storage of the boxed meat for each of the following periods: 0, 24, 48, 72, and 96 hours. The counts were lower in the 4-inch than in the 8 or 12-inch depth boxes, and increased as the depth of the box increased. These results were attributed to the faster decline in meat temperature with decreased box depth.

After the 0-hour storage period, total aerobic and psychrotrophic counts were higher on the meat at the top position within the boxes than at the middle position, where the temperature decline was slower. In contrast, anaerobic counts were higher at the middle position in the 8 and 12-inch depth boxes. These results were likely produced by a higher oxygen availability at the top position than at the middle position within the boxes. Rapid chilling of the meat seemed to have a more significant effect than aerobic condition in determining growth of anaerobic bacteria after 24 hours of storage within the 4-inch depth boxes.

## Introduction

Raw beef is increasingly being distributed in a box. Currently, about 50 percent of all choice beef is marketed in the form of boxed vaccum packaged primal cuts (Ayres et al., 1980). Additionally, beef trimmings used for preparation of ground beef or hamburger are also being distributed boxed.

On the other hand, hot boning of the beef carcass (boning of the carcass while the meat is still warm) and then boxing of the meat has several advantages. Removal of excess fat and bone results in considerable savings in refrigeration energy, cooler space, and transportation costs (Henrickson, 1975). When hot boning is combined with electrical stimulation of the carcass there is also a saving in time because the meat can be chilled faster with reduced risk of cold shortening. However, hot boning has some disadvantages, one of which is the possibility for increased microbial growth due to the high temperature and high surface moisture of the warm tissues.

The objective of this study was to ascertain changes in total aerobic, psychrotrophic, and anaerobic bacterial counts at three different positions inside boxes of electrically stimulated hot boned beef trimmings, chilled aerobically for different periods of time.

[1]Graduate Assistant [2]Professor of Animal Science

## Materials and Methods

Fifteen commercial Hereford steers of approximately 900 lb live weight were slaughtered at weekly intervals. Each animal was electrically stimulated immediately after exsanguination by using an "Electro-Stem" electrical stimulator (Doube J Products, Wichita, KS) which supplied an electrical alternating current of 48 volts and less than 0.5 amperes, with a pulsation time of one second, during a 90-second period, through a spring loaded clamp attached to the nostril and positive ground probes inserted into the tissues near the hocks of the animal.

After dressing, splitting, and washing of each carcass, one of the sides was randomly designated to be hot boned within three hours after slaughtering. Using a sterile knife, the semitendinosus muscle was excised and sectioned transversally so that twelve slices approximately two cm in thickness were obtained (Figure 1). Three of the meat slices were randomly designated for analysis to determine the initial bacterial load on the muscle surface. The remaining nine meat slices were randomly assigned to three different positions (top, middle, and bottom) within each of three single-wall cardboard boxes differing only in depth (12x12x4, 12x12x8, and 12x12x12 inches, respectively). The boxes were filled respectively with 20, 40, and 60 pounds of meat trimmings obtained from the side forequarter. Before filling, the interior of each box was lined with Cryovac film in order to avoid adherence of the meat to the walls of the box.

After filling, the boxes were sealed and stored in a cooler (36$^0$F) at the O.S.U. Meat Laboratory for one of the following randomly assigned storage periods: 0, 24, 48, 72 or 96 hours. Thus, meat boxes from three beef sides were randomly assigned to each storage period. At each storage period, the temperature at each position within each box was determined at different time intervals (0, 6, 12, 24, 48, 72 or 96 hours, depending upon the storage period) by inserting a thermocouple close to each meat slice. A free thermocouple was used to record the air temperature.

After the respective storage period, the boxes were removed from the cooler, and the meat slices were aseptically removed from the boxes. For the zero-hour storage period the meat slices in each box were left in contact with the rest of the meat trimmings for five minutes before being removed from the boxes for analysis. The slices were individually placed in sterile pre-weighed Mason jars (1-qt capacity) and their weight was determined. The jars were then placed in ice to prevent or delay additional bacterial growth on the meat slices, and transported to the laboratory, where microbiological analysis was immediately initiated.

A pre-measured volume of sterile 0.1 percent peptone water equal to twice the weight of the meat slice was delivered into each jar. The jar was then shaken, making 25 back-and-forth movements of about one foot in seven seconds to permit removal of bacteria from the meat surface. Each ml of "rinse" thus prepared represented C.5g of sample. Serial dilutions, as needed, were prepared from each jar using sterile 99 ml dilution bottles containing 0.1 percent peptone water as diluent. Preparation of the dilutions and further platting and bacterial enumeration were made according to the *Compendium of Methods for the Microbiological Examination of Foods* (Speck, 1976).

The total aerobic, psychrotrophic, and anaerobic bacterial counts were determined for each of the meat slices in duplicate Petri dishes by the pour plate technique using plate count agar. Total aerobic and psychrotrophic counts

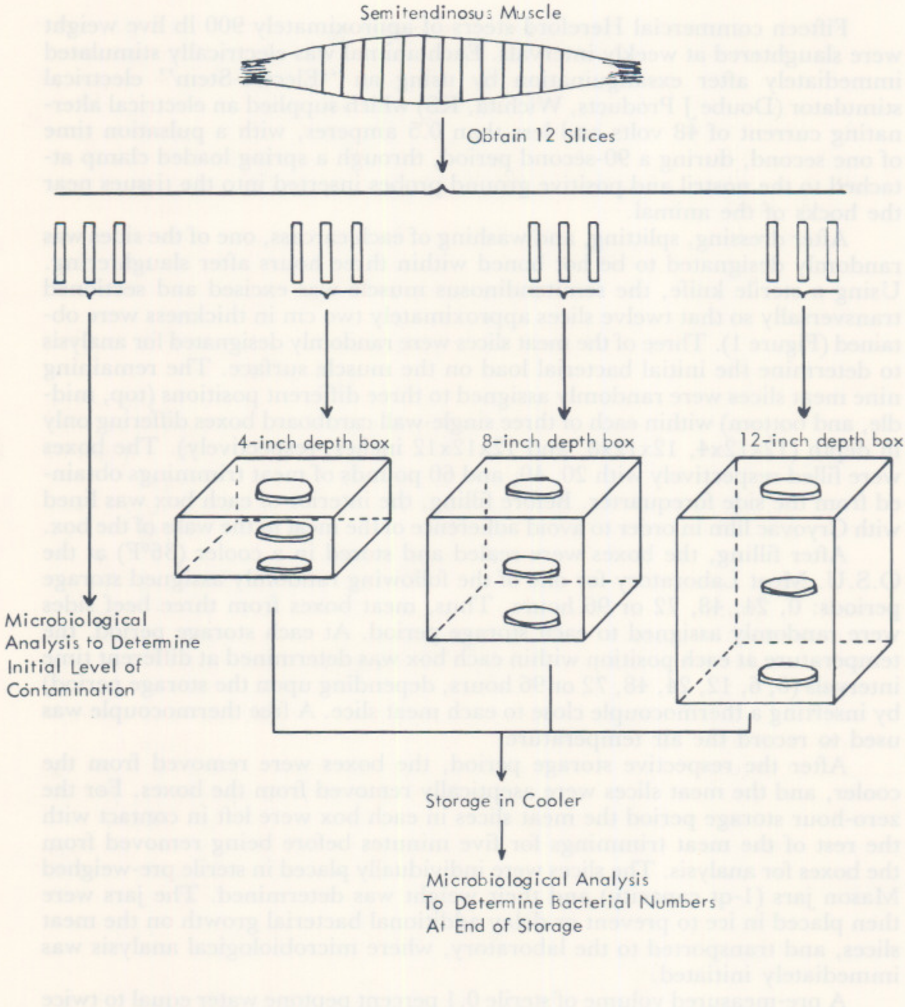



**Figure 1. Schematic drawing of meat slices utilized for microbiological analysis and their position within the boxes during storage.**

were obtained after incubation of the plates at 32°C for 48 hours, and at 5°C for seven days, respectively. The anaerobic count was determined by incubating the plates in anaerobic Gas-Pak jars at 32°C for 48 hours. After the respective incubation period, the colonies were counted using a Quebec colony counter. The average number of colonies on the selected plates was multiplied by the appropriate dilution factor, multiplied by two, and referred to as count per gram (count/g). The bacterial counts thus obtained were converted to common logarithms ($Log_{10}$) for statistical analysis. Bacterial counts on the meat slices utilized for determination of the initial level of contamination were not considered further in this study because they were similar to those obtained at the zero-hour storage period.

## Results and Discussion

Mean $\log_{10}$ bacterial counts determined on the meat within the boxes at different storage periods are presented in Table 1. Except for the counts at 72 hours of storage, statistically significant differences ($P<0.05$) in mean $\log_{10}$ total aerobic and anaerobic counts were found among box sizes after the 0-hour storage period. Mean $\log_{10}$ psychrotrophic counts were significantly different ($P<0.05$) among box sizes only at the 24- and 48-hour storage periods. However, after 0 hours, all bacterial counts were lower on meat in the 4-inch deep boxes than on meat in the 8-inch deep boxes and these in turn had lower bacterial counts than meat in the 12-inch deep boxes. These results are associated with a faster temperature decline observed in the meat as the depth of the box decreased (Figures 2, 3, and 4 respectively), which allows for a more effective control of bacterial growth.

Tables 2 and 3 contain the mean $\log_{10}$ total aerobic and psychrotrophic bacterial counts, respectively, determined at each position within the boxes at all storage periods. Total aerobic and psychrotrophic bacteria were more abundant (but not necessarily statistically different) on meat at the top than at the middle or bottom positions within the boxes at all storage periods beyond 0 hours. These results were more noticeable as the depth of the boxes increas-

**Table 1. Bacterial counts[1] in boxes of hot boned beef trimmings.**

| Bacterial Count | Box Depth (inches) | Storage (hours) 0 | 24 | 48 | 72 | 96 |
|---|---|---|---|---|---|---|
| | 4 | 2.94a[2] | 3.44a | 4.64a | 4.80a | 5.35a |
| Total aerobic | 8 | 3.04a | 4.31b | 5.11a | 5.70a | 5.99ab |
| | 12 | 3.14a | 5.01c | 6.25b | 6.43a | 6.57b |
| | 4 | 1.70a | 3.29a | 4.39a | 4.80a | 5.46a |
| Psychrotrophic | 8 | 2.02a | 3.93b | 5.10ab | 5.69a | 6.10a |
| | 12 | 2.19a | 4.72c | 6.02b | 6.30a | 6.25a |
| | 4 | 2.35a | 2.82a | 3.98a | 4.00a | 4.15a |
| Anaerobic | 8 | 2.47a | 3.91b | 4.98ab | 4.79a | 5.38b |
| | 12 | 2.47a | 5.07c | 5.84b | 5.68a | 5.79b |

[1]Each value is the average $\log_{10}$ count/g of 3 determinations.
[2]Means within each group followed by the same letter are not significantly different ($P>0.05$) according to Duncan's Multiple Range test.

**Table 2. Total aerobic bacteria[1] on meat at three positions within boxes of hot boned beef trimmings.**

| Box Depth (inches) | Position[2] | Storage (hours) 0 | 24 | 48 | 72 | 96 |
|---|---|---|---|---|---|---|
| | T | 2.74a[3] | 3.66a | 4.73a | 5.23a | 5.95a |
| 4 | M | 3.08a | 3.74a | 4.67a | 4.64a | 5.28a |
| | B | 3.00a | 3.59a | 4.51a | 4.51a | 4.81a |
| | T | 3.19a | 4.70a | 6.21a | 6.81a | 6.26a |
| 8 | M | 2.99a | 4.47a | 5.34a | 5.72b | 6.23a |
| | B | 2.94a | 3.77b | 4.45a | 4.58c | 5.48a |
| | T | 2.94a | 5.71a | 7.09a | 7.26a | 7.29a |
| 12 | M | 3.13a | 5.22a | 6.47b | 6.68a | 6.53a |
| | B | 3.37a | 4.10b | 5.19c | 5.34a | 5.88a |

[1]Each value is the average $\log_{10}$ count/g of 3 determinations.
[2]T = top position, M = middle position, B = bottom position.
[3]Means within each group followed by the same letter are not significantly different (P > 0.05) according to Duncan's Multiple Range test.

**Table 3. Psychrotrophic bacteria[1] on meat at three positions within boxes of hot boned beef trimmings.**

| Box Depth (inches) | Position[2] | Storage (hours) 0 | 24 | 48 | 72 | 96 |
|---|---|---|---|---|---|---|
| | T | 1.65a[3] | 3.51a | 4.61a | 5.26a | 6.09a |
| 4 | M | 1.77a | 3.41a | 4.29a | 4.53a | 5.47a |
| | B | 1.69a | 2.94a | 4.28a | 4.61a | 4.81a |
| | T | 2.35a | 4.62a | 6.27a | 6.90a | 6.81a |
| 8 | M | 1.77a | 3.94b | 4.89b | 5.61b | 6.11a |
| | B | 1.93a | 3.25c | 4.14c | 4.56c | 5.39a |
| | T | 1.95a | 5.63a | 7.16a | 7.29a | 7.23a |
| 12 | M | 2.23a | 4.78b | 6.08b | 6.29b | 6.06b |
| | B | 2.38a | 3.76c | 4.83c | 5.32c | 5.45c |

[1]Each value is the average $\log_{10}$ count/g of 3 determinations.
[2]T = top position, M = middle position, B = bottom position.
[3]Means within each group followed by the same letter are not significantly different (P > 0.05) according to Duncan's Multiple Range test.

ed. Thus, the meat at the top position had higher total aerobic and psychrotrophic counts than at the middle position, where the decline in temperature was slower than at the other positions (Figures 2, 3, and 4). Although the most important single factor governing microbial growth is temperature, bacterial population density may be determined by the rate at which oxygen becomes available to the cells (Gill and Newton, 1977). Therefore, it is likely that the aerobic environment favored a higher oxygen tension in meat at the top position within the boxes, producing a more significant effect upon bacterial growth than that expected to be produced by the higher temperature at the middle position. The results obtained at 0 hours of storage may be explained by the fact that bacteria had not yet grown and increased in numbers.

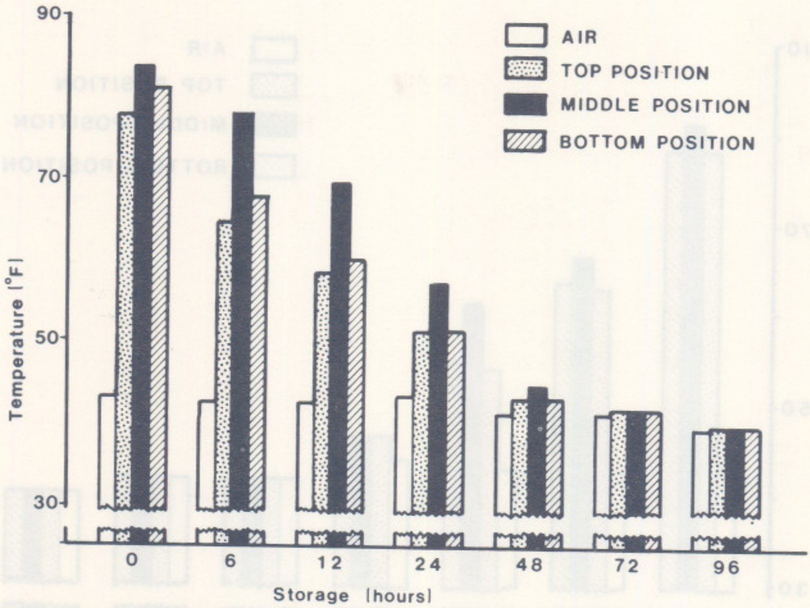



**Figure 2. Average temperature change during storage of hot boned beef trimmings in 12-inch depth boxes.**

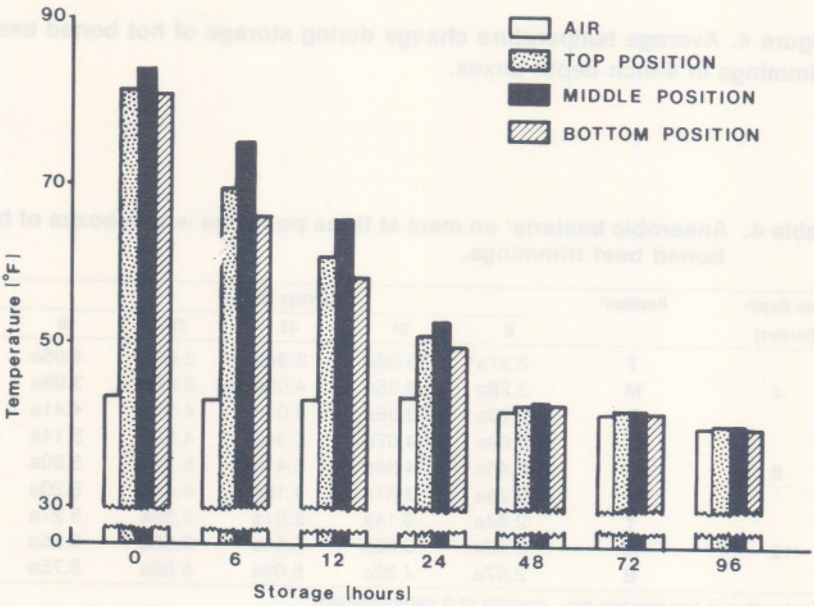



**Figure 3. Average temperature change during storage of hot boned beef trimmings in 8-inch depth boxes.**

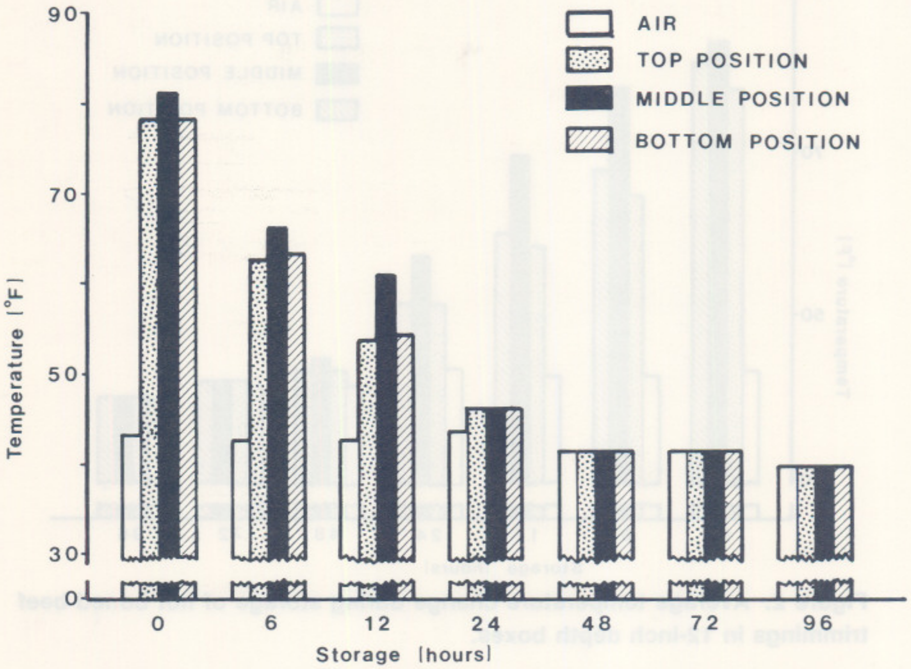



**Figure 4. Average temperature change during storage of hot boned beef trimmings in 4-inch depth boxes.**

**Table 4. Anaerobic bacteria[1] on meat at three positions within boxes of hot boned beef trimmings.**

| Box Depth (inches) | Position[2] | Storage (hours) 0 | 24 | 48 | 72 | 96 |
|---|---|---|---|---|---|---|
| | T | 2.27a[3] | 3.02a | 3.94a | 3.83a | 4.05a |
| 4 | M | 2.28a | 3.26a | 4.00a | 3.85a | 3.99a |
| | B | 2.50a | 2.86a | 4.01a | 4.31a | 4.41a |
| | T | 2.69a | 4.07a | 5.34a | 4.82a | 5.14a |
| 8 | M | 2.45a | 4.36a | 5.41a | 5.11a | 5.80a |
| | B | 2.28a | 3.31a | 4.18b | 4.44a | 5.20a |
| | T | 2.44a | 5.14a | 5.91a | 5.38a | 5.27a |
| 12 | M | 2.40a | 5.83b | 6.53a | 6.56a | 6.35a |
| | B | 2.57a | 4.22c | 5.09a | 5.09a | 5.75a |

[1]Each value is the average $\log_{10}$ count/g of 3 determinations.
[2]T = top position, M = middle position, B = bottom position.
[3]Means within each group followed by the same letter are not significantly different ($P > 0.05$) according to Duncan's Multiple Range Test.

Unlike total aerobic and psychrotrophic bacteria, anaerobic bacterial numbers were higher (but not necessarily statistically different) on the meat at the middle position than at the top or bottom positions within the 8 and 12-inch deep boxes at all storage periods except at 0 hours (Table 4). Again, oxygen availability would explain these results. At the middle position, the amount of oxygen may be reduced in such a way that it may provide partial anaerobic conditions when combined with the higher temperature at this position. This condition would favor the growth of facultative anaerobes and/or microaerophilic bacteria. In contrast, the faster meat temperature decline seemed to be responsible for the different growth pattern within the 4-inch deep boxes, where after 24 hours of storage, the anaerobic count on the meat was higher at the bottom than at the middle or top positions.

## Literature Cited

Ayres, J.C. et al. 1980. Microbiology of Foods.
Gill, C.O. et al. 1977. J. Appl. Bact. 43:189.
Henrickson, R.L. 1975. Proc. Meat Ind. Res. Conf.
Speck, M.L. 1976. Compendium of Methods for the Microbiological Examination of Foods.

# Biochemical and Quality Characteristics of Ovine Muscle as Affected by Electrical Stimulation, Hot Boning, and Mode of Chilling

N.H. Rashid[1], R.L. Henrickson[2], A. Asghar[3] and P.L. Claypool[4]

## Story in Brief

The combined effects of electrical stimulation and carcass holding temperature were evaluated on some biochemical and quality characteristics of intact and hot-boned ovine muscles. Twenty-four lamb sides were randomly assigned to 4 treatments. Electrical stimulation was performed within 15 minutes postmortem (350 V with 10 Hz) for 4 minutes. Electrically stimulated and slowly chilled (5 hr at 14 ± 2°C) sides exhibited significantly more rapid pH decline in the longissimus dorsi (LD) muscle, less cold shortening in the semitendinosus (ST) muscle, and greater tenderness in both LD and ST muscles than sides at 2°C. None of the treatments had an effect on the cooking loss in ST and LD muscles. Lean color and solubility of the different protein fractions, as well as, the swelling factor of the stroma protein of LD muscles did not change during a 4-day retail display treatment.

## Introduction

It is generally accepted that cold shortening will cause muscle toughness when lamb and beef carcasses are chilled or frozen in the prerigor state. Cold shortening can be minimized by delaying the exposure of the carcass to cold temperatures until the muscle pH has reached a value of 6.0 and approximately 50 percent of the adenosine triphosphate (ATP) has been depleted.

However, this problem can be resolved by electrical stimulation of the carcass which ensures a fast drop in pH and a rapid depletion of muscle ATP. Even though electrical stimulation has been adopted, little information is available regarding its combined effect with the mode of chilling. Some of the biochemical-biophysical changes which take place may be related to meat quality. Hence, the aim of this study was to investigate the combined effect of electrical stimulation and slow chilling of lamb carcasses at 14 ± 2°C for 5 hours postmortem on some biochemical and quality characteristics of specific ovine muscles.

## Materials and Methods

Twelve Suffolk wether lambs were slaughtered, skinned, eviscerated, and divided into sides. Twenty-four sides were randomly assigned to 4 treatments. Accordingly, a total of 12 sides, selected at random, were electrically stimulated

[1]Former graduate student [2]Professor of Animal Science [3]Post Doctoral Research Associate
[4]Professor, Statistics Department

(ES) while 12 sides were kept as unstimulated (US) or control. In each case, 6 sides, at random, received a rapid chilling (RC) treatment and the other 6 sides were subjected to slow chilling. The sides were electrically stimulated (350 volts, 10 pulse per second, and 20% duty cycle) within 15 minutes postmortem using a direct current with a square wave pulse for 4 minutes. The electrical current was applied by two wires each terminated with a clamp. One clamp was attached to the neck region at the level of the 5th and 6th cervical vertebrae as the negative charge and the other clamp was attached to the achilles tendon as the positive charge to complete the circuit.

Two muscles, namely the LD and ST muscles were used to study the changes in some biochemical and quality characteristics. The ST muscle was hot-boned from both the ES and US sides immediately after electrical stimulation and the LD muscles remained attached to the skeleton. The extent of cold shortening and cooking loss on hot-boned ST muscle were determined at 24-hour postmortem. Postmorten pH and temperature changes were monitored (at 0, 2, 4, 6, 8, and 24 hr postmortem) on intact LD muscles. Thereafter, fresh samples were taken to measure the lean color during a 4-day retail display using a Hunterlab Tristimulus Colorimeter and recorded as L, a, and b values as well as a/b color ratio, solubility of different protein fractions (sarcoplasmic, myofibrillar, acid soluble, and insoluble stromal proteins as well as the swelling factors of the stroma protein), and cooking loss. The shear force value for LD and ST muscles was determined at 48 hr postmortem.

## Results and Discussion

Stimulated sides, whether rapid or slow chilled, had a significantly lower pH than the respective control muscles at 2, 4, 6 and 8 hours postmortem (Figure 1). Muscle from electrically stimulated slow chilled sides (ES + SC) experienced a greater pH decline than the rapid chilled (ES + RC) sides. On the other hand, postmortem pH decline in the unstimulated sides whether slow or rapid chilled (US + SC) and (US + RC) was almost identical. However, there was no significant variation in temperature decline between the stimulated and control sides for any given chilling procedures (rapid or slow). Hence, differences in the rate of pH decline for the LD muscle between stimulated and control cannot be ascribed to difference in carcass temperature decline. Activation of glycolytic enzymes by electrical stimulation may be one of the causative factors accounting for the rapid pH fall in electrically stimulated carcasses. Whether or not electrical stimulation increased the glycolytic enzymes activities per se in muscle has not been completely defined.

The muscle from stimulated and slow chilled sides (ES + SC) had significantly less ($P<0.05$) shortening than the control groups (Table 1). However, there was no significant difference ($P>0.05$) in the percent of shortening of the ST strips from electrically stimulated sides, whether they were rapid or slow chilled. On the other hand, ST strips from control sides shortened significantly more when rapidly chilled than when slow chilled. The present study shows that ES reduced the percent of muscle shortening. Rapid depletion of the energy rich phosphate compounds (adenosine triphosphate and phosphocreatine), which determine the degree of muscle fiber shortening during chilling or freezing of carcasses may be attribued to ES.

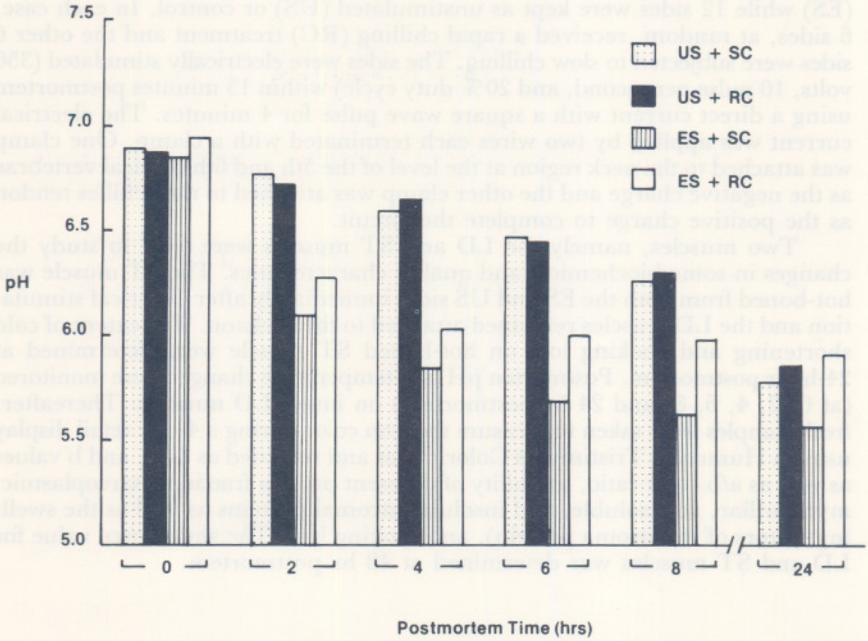



**Figure 1. Postmortem pH decline for LD muscle as affected by electrical stimulation and mode of chilling.**

**Table 1. Muscle shortening (%), shear force (Kg) and cooking loss (%) values for ST and LD muscles as affected by electrical stimulation and mode of chilling.**

| Treatment[1] | Muscle shortening (%)[2] | Shear force, (kg)[3] | | Cooking loss (%)[2] | |
|---|---|---|---|---|---|
| | ST | ST | LD | ST | LD |
| ES + SC | 10.6[a] | 5.0[a] | 4.1[a] | 13.2[a] | 19.7[a] |
| ES + RC | 13.1[ab] | 5.6[b] | 4.0[a] | 16.1[a] | 18.9[a] |
| US + SC | 15.7[b] | 6.3[c] | 5.1[b] | 16.3[a] | 19.7[a] |
| US + RC | 19.6[c] | 6.4[c] | 5.4[b] | 14.3[a] | 19.0[a] |
| S.D. of Adj. Mean | 0.99 | 0.13 | 0.13 | 0.52 | 0.50 |

[1]See Table 1 for treatment.
[2]Each muscle shortening and cooking loss value is averaged from 12 samples in both ST and LD muscles
[3]Each shear force value is averaged from 48 samples for ST muscle and from 72 samples for LD muscles.
Means within a column followed by different letters are significantly different ($P < 0.05$).

Electrical stimulation significantly ($P<0.05$) decreased shear force value as compared to those from the control regardless of the postmortem chilling procedure for both ST and LD muscles (Table 1). Most investigators have shown that electrical stimulation of carcasses produced a tenderizing effect on the musculature. With respect to the cooking loss, the data indicated no significant differences ($P>0.05$) in either ST and LS muscles as affected by electrical stimulation and chilling temperature (Table 1).

The lean color measurements using Hunterlab L, a and b values and the a/b color ratio of LD loin chops at 24-hour intervals for 4 days were not significantly different among all treatments. Most of the studies, based on panel evaluation, have found the meat from stimulated carcasses generally to be brighter with a more youthful lean color than that from unstimulated carcasses. However, several workers agreed that electrical stimulation did not improve lean color.

Neither electrical stimulation nor the chilling rate had any significant effect ($P>0.05$) on the solubility of the sarcoplasmic protein fraction as compared to the control. No change was noted in the solubility of myofibrillar proteins extracted sequentially with unbuffered 0.3 M NaCl solution followed by 0.6 M KI in 0.1 M phosphate buffer. Acid-soluble protein (freshly synthesized collagen) and acid-insoluble stromal proteins (biologically mature collagen and some elastin) were not significantly affected by electrical stimulation and carcass chilling. The swelling factor which is used as an indicator of changes in the extent of crosslinkage of collagen was also not affected by electrical stimulation. As a matter of fact, very limited information is available on the influence of electrical stimulation of carcasses on the connective tissue (extracellular) proteins, and more information is needed.

# Influence of Prepartum Nutrition on Concentrations of Estrone, Estradiol, Estone Sulfate and Progesterone in the Plasma of Range Cows

J.S. Mobley[1], R.P. Wettemann[2], K.S. Lusby[3],
B.R. Pratt[4], and E.J. Turman[5]

## Story in Brief

Seventy-nine mature, pregnant Hereford cows were used to examine the influence of prepartum nutritional intake on plasma concentrations of reproductive hormones. Starting November 19, 1979, 60 cows were assigned to a low level of supplemental feed, so as to lose about 10% of their November weight by calving; 19 cows were fed a moderate level of supplement to maintain body weight during pregnancy. Low cows were further divided into 3 groups on January 21, 1980; one-third remained on low (low-low), one-third received moderate (low-moderate) and one-third was increased to a high level (160% of moderate; low-high). All animals were treated the same following calving. Blood samples were taken every two weeks from 45 days before calving until parturition. Cows on the moderate treatment gained about 1% of their fall weight before calving, and cows on the low-low, low-moderate and low-high treatment lost 11, 4 and 6%, respectively, of their fall weights. Plasma concentrations of estrone, estradiol, estrone sulfate and progesterone were affected by treatment. Moderate cows had greater concentrations of progesterone and estrone while cows in the low-low group had higher plasma concentrations of estradiol and estrone sulfate. The changes in hormone concentrations may influence the hypothalamus or pituitary and alter the synthesis and secretion of gonadotropic hormones. The results suggest a possible mechanism by which prepartum nutrition may regulate the interval from calving until the first estrus.

## Introduction

Level of nutrition during the wintering period has been repeatedly demonstrated to influence the interval from calving to first extrus and subsequent ovulation in beef cows. Cows losing weight and body condition have longer intervals from calving to first estrus. During the last trimester of pregnancy, the fetus and placenta are growing rapidly. Since many of the hormones regulating reproductive functions are produced by the placenta and fetus, it seems likely that the influence of prepartum nutrition on subsequent postpartum reproductive performance may be mediated by changes in endocrine function. Estrone, estradiol, estrone sulfate and progesterone are hormones pro-

[1]Graduate Student [2]Animal Science Professor [3]Associate Professor [4]Research Associate [5]Animal Science Professor

duced during late gestation that are involved in regulation of reproductive function in cows. This experiment was designed to determine if reduced nutrition, as reflected by changes in body weight and body condition, influences the pattern of secretion of these hormones by beef cows during late gestation.

## Materials and Methods

Seventy-nine pregnant, mature Hereford cows were grazed on native tallgrass range at the Lake Carl Blackwell Range Cow Research Center. Beginning November 19, 1979, one-fourth of the cows were randomly assigned to a moderate level of nutrition so as to maintain their November body weight until calving (moderate group). The remaining cows were assigned to a low level of nutrition so that they would lose about 10% of their November weight by calving. On January 21, 1980 (approximately 45 days before calving) nutritional intake for some of the cows was altered. One-third of the cows on the low level remained on low (low-low group); one-third were fed the same amount of supplement as the cows on the moderate treatment (low-moderate group); another one-third were supplemented with 160% of the amount fed to the moderate group so as to gain weight (low-high group). Feed levels are summarized in Table 1.

Body condition scores of the cows, based on visual appraisal, were determined by at least two individuals every two months during the experiment. The scores were based on a scale from 1 = very thin, to 9 = very fat. Blood samples were collected every two weeks beginning February 7, 1980. Plasma concentrations of estrone, estradiol, estrone sulfate and progesterone were quantified by radioimmunoassay. Hormone concentrations were analyzed by polynomial regression equations.

## Results and Discussion

Winter weight changes are summarized in Table 2. Moderate cows gained 1 percent of their fall weight prior to calving, low-low cows lost 11 percent of their fall weight, low-moderate cows lost 5 percent of their fall weight and low-high cows lost 6 percent of their fall weight.

**Table 1. Feeding program**

| | Nutritional Treatment | | |
|---|---|---|---|
| Date | Moderate | Low | High |
| Nov. 19, 1979 | 21 lb of 41% protein CSM[a] pellets/week | 6 lb of 41% protein CSM pellets/week | |
| Jan. 24, 1980 | 21 lb of 41% protein CSM pellets/week | 6 lb of 41% protein CSM pellets/week | 35 lb of 41% protein CSM pellets/week |
| Postpartum | ---------- 28 lb of 41% protein CSM pellets/week ---------- | | |

[a]41% protein cottonseed meal pellet.

**Table 2. Percent weight change at 45 days prepartum[a] and at calving[b]**

| Nutritional treatment | 45 Days prepartum | Calving |
|---|---|---|
| Moderate | + 1.2 ± .7 | + .8 ± .5 |
| Low-low | − 11.0 ± .5 | − 11.0 ± 1.1 |
| Low-moderate | − 12.4 ± .4 | − 4.6 ± .9 |
| Low-high | − 11.3 ± .4 | − 5.7 ± 1.0 |

[a]Weight change from November
[b]Weight change from November prior to calving, does not include calving loss.

**Table 3. Body condition score[a] for cows on different nutritional treatments**

| | Nutritional Treatment | | | |
|---|---|---|---|---|
| Date | Moderate | Low-low | Low-moderate | Low-high |
| Nov. 19, 1979 | 6.5 ± .7 | 6.3 ± .2 | 6.4 ± .2 | 6.4 ± .1 |
| Jan. 24, 1980 | 6.0 ± .2 | 4.9 ± .1 | 4.9 ± .1 | 5.1 ± .1 |
| Mar. 13, 1980 | 5.3 ± .2 | 3.9 ± .2 | 4.3 ± .2 | 5.0 ± .2 |

[a]1 = very thin, 9 = very fat

Body condition score changes closely paralleled body weight changes (Table 3). Body condition scores were similar for all groups on November 19. By March 13 (the average calving date for all cows was March 6) the moderate cows had decreased by approximately 1 unit, low-low cows had decreased by 2.4 units, low-moderate cows had decreased by 2.1 units and the low-high cows had decreased by 1.4 units.

Response curves for plasma progesterone concentrations were significantly different for cows on moderate vs. low-low, low-moderate and low-high treatments ($P < .05$). Plasma progesterone concentrations were greater in moderate cows from day 30 prepartum to about day 8 prepartum. At day 15 before calving, progesterone in the plasma of moderate cows averaged 9 ng/ml compared to 8 ng/ml for low-low, low-moderate and low-high cows (Figure 1).

Concentrations of estrone in the plasma of cows on the moderate treatment were not significantly different from cows on low-low, low-moderate and low-high treatments. However, cows on the low-low treatment had a significantly different response curve than cows on low-moderate and low-high ($P < .05$). Plasma estrone concentrations were less for low-low cows from about day 16 prepartum till the day of calving (Figure 2).

Cows on the moderate treatment had reduced concentrations of estradiol from about day 18 prepartum until calving (Figure 3). Plasma concentrations of estradiol were similar for cows on low-low, low-moderate and low-high treatments. In addition, cows in the moderate group had reduced concentrations of estrone sulfate compared to cows in the low-low, or low-high groups ($P < .05$; Figure 4).

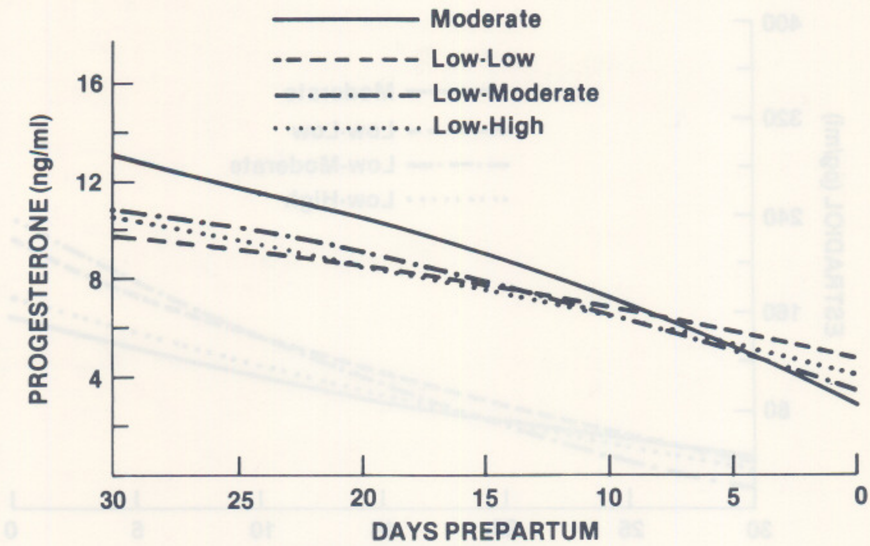



Figure 1. Least Squares Regressions of Progesterone Response to Four Nutritional Treatments

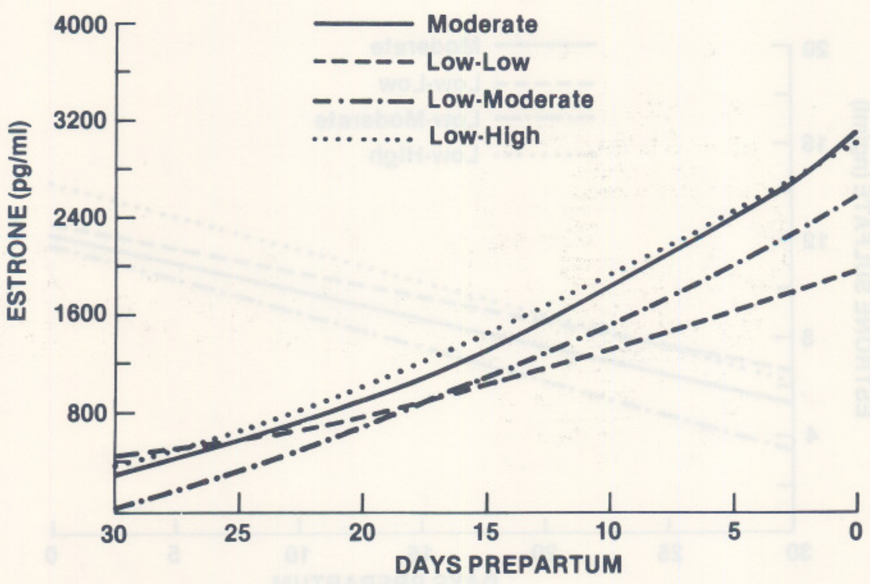



Figure 2. Least Squares Regressions of Estrone Response to Four Nutritional Treatments

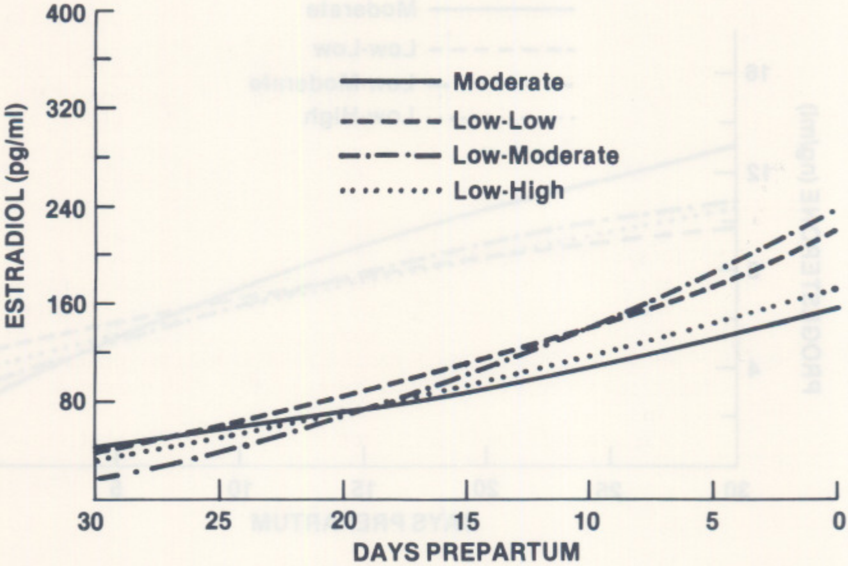



**Figure 3. Least Squares Regressions of Estradiol Response to Four Nutritional Treatments**

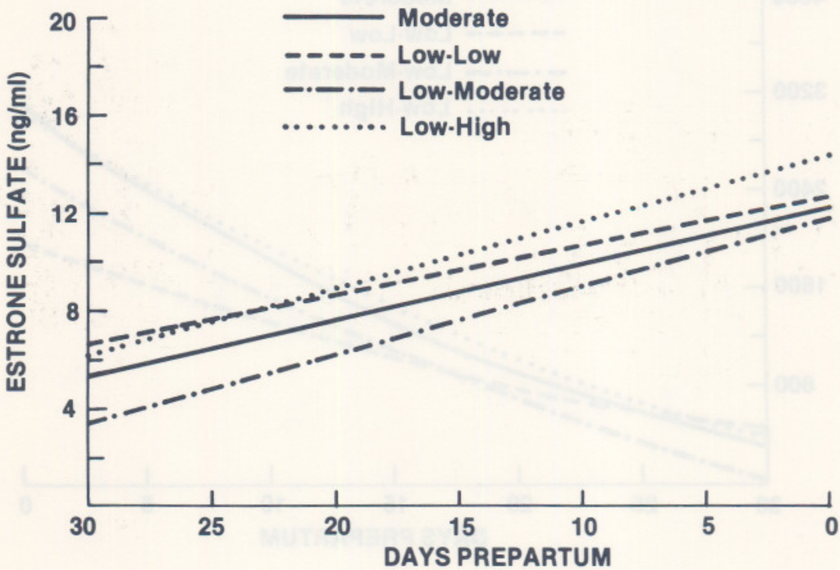



**Figure 4. Least Squares Regressions of Estrone Sulfate Response to Four Nutritional Treatments**

Conception rates during a 75 day breeding period, commencing May 15, were 58, 21, 40 and 39%, respectively, for the moderate, low-low, low-moderate and low-high treatments. This reproductive performance is less than desirable and is probably related to poorer than optimum body condition of the cows at calving. For instance, in a subsequent year, cows on the moderate treatment calved with a body condition score of 6.2, compared to 5.3 for the moderate cows in this experiment, and 92% of the cows conceived during the breeding period.

The differences in hormone concentrations indicate that nutrition of the cow alters the synthesis or metabolism of steriod hormones during the last 30 days of gestation. The changes in steriod hormone concentrations produced by the placenta and ovary may influence the hypothalamus or pituitary and alter the synthesis and secretion of gonadotropic hormones. These results suggest a possible mechanism by which prepartum nutrition, as reflected in body weight change, may regulate the interval from calving until the onset of ovarian activity and first estrus.

The excellent assistance of David Krohn and Marian Ringwall is gratefully acknowledged.

# Effect of Implants and Breed Type on Testicular Function of Feedlot Bulls

**R.P. Wetteman[1], D.R. Gill[2], J.J. Martin[3], F.N. Owens[4], and D.E. Williams[5]**

## Story in Brief

Forty-eight yearling bulls of Charolais, Hereford and Hereford x Angus breeding (one-third per breed group) that weighed about 600 pounds were implanted with (1) nothing, (2) Compudose, (3) Synovex S or (4) Ralgro. Bulls were fed a high concentrate diet for 118 days and the latter two groups were reimplanted on day 75. Testes and epidiymides were evaluated at slaughter. Implants increased live weight gains by about 6 percent. Neither implant treatment nor breed significantly influenced testicular or epididymal weights or sperm numbers. These data indicate that implanting bulls with growth stimulants that are estrogens or have estrogenic activity after the time of puberty does not influence testicular growth and sperm production or epididymal sperm reserves.

## Introduction

Much interest exists in the feeding of young bulls. Gill et al. (1983) reviewed the variable responses observed in growth and feed efficiency when young bulls are implanted with growth stimulants. Implanting heifer calves with Ralgro will suppress pubertal development (Muncy et al., 1980) but implanting postpubertal bulls may not affect the function of the testis (Juniewicz et al., 1981). Testicular function of bulls implanted after puberty with Synovex or Compudose is not clear. The objectives of this experiment were to evaluate the influence of breed type and hormone implants on testicular function of bulls.

## Materials and Methods

One half of the bulls of each breed and implant treatment that were used in a study described by Gill et al (1983) were evaluated in this experiment. Bulls estimated to be slightly over one year of age were selected for uniformity in weight from a large group of commercial animals. The bulls weighed about 600 pounds at the start of the 118 day feeding period and about 1075 pounds at slaughter. The implant treatments were (1) no implant, (2) a single Compudose implant at the start of the trial, (3) Ralgro implant at the start and on day 75 of the trial and (4) Synovex at the starts and on day 75 of the trial. Four bulls of each of the breed types (Charolais, Hereford, Hereford x Angus)

---

[1]Animal Science Professor [2]Animal Science Professor [3]Panhandle State University, Goodwell, OK [4]Animal Science Professor [5]Hitch Enterprises, Guymon, OK

were randomly allotted and evaluated for each treatment. Bulls were fed a diet consisting primarily of whole shelled corn ad libitum. Compudose implants were removed 6 days before slaughter.

One testis and epididymis from each bull was removed and frozen at slaughter. After thawing, the weights of the trimmed testis, testicular parenchyma, head and body of the epididymis and the tail of the epididymis were determined. After homogenization of the tissues in Saline-Triton-Mertholiate solution, testicular and epididymidal sperm numbers were quantified, using a hemocytometer and phase contrast microscopy. Data were analyzed by a two-way analysis of variance.

## Results and Discussion

Testicular weights and sperm concentrations were not influenced by implanting yearling bulls with Compudose, Synovex-S or Ralgro (Table 1). Average testicular weights for the four treatments ranged from 165 to 184 g and sperm concentrations ranged from 77 million to 89 million sperm per gram of testicular tissue. Total sperm per testis averaged 13 billion. The influence of growth stimulants on the reproductive endocrine system of cattle may be related to the age at which animals are treated. We have demonstrated previously (Muncy et al., 1980) that implanting heifers before puberty with Ralgro will delay the onset of sexual maturity. The lack of an effect of implants on testicular function of the bulls in this experiment may be related to the age of the bulls. Since these bulls were about a year of age and weighed 600 pounds at treatment, puberty probably had occurred. Thus it appears that treatment of bulls with implants after puberty may not alter sperm production.

Weights of the head-body and tail of the epididymides were not altered by implant treatment (Table 1). Similarly, sperm reserves in the epididymides were not altered by implanting the bulls. This suggests that sperm maturation and transport in the epididymis was not altered.

**Table 1. Testicular and Epididymidal Characteristics of Yearling Bulls Implanted with Nothing, Compudose, Synovex or Ralgro.[a].**

| Criteria | Implant Treatment: None | Compudose | Synovex-S | Ralgro | Std. Error of mean |
|---|---|---|---|---|---|
| Testicular Weight (g) | 168 | 184 | 181 | 165 | 14 |
| Sperm Conc. ($\times 10^6$/g) | 77.43 | 88.72 | 81.64 | 81.38 | 7.90 |
| Total Sperm ($\times 10^9$) | 13.13 | 14.31 | 12.93 | 11.58 | 1.60 |
| Head-Body Epididymidal | | | | | |
| Weight (g) | 12.7 | 13.4 | 13.1 | 12.6 | .8 |
| Total Sperm ($\times 10^9$) | 4.18 | 5.12 | 4.00 | 3.67 | .72 |
| Tail Epididymidal | | | | | |
| Weight (g) | 7.2 | 7.2 | 6.7 | 6.6 | .6 |
| Total Sperm ($\times 10^9$) | 5.00 | 5.35 | 4.86 | 3.07 | 1.11 |

[a]No significant treatment effects.

**Table 2. Testicular and Epididymidal Characteristics of Yearling Charolais, Hereford and Hereford x Angus Bulls.**[a]

| Criteria | Charolais | Hereford | Hereford x Angus | Std. Error of mean |
|---|---|---|---|---|
| Testicular weight (g) | 176 | 172 | 175 | 12 |
| Sperm Conc. ($x10^6$/g) | 83.06 | 77.18 | 86.64 | 6.92 |
| Total Sperm ($x10^9$) | 13.31 | 12.02 | 13.63 | 1.41 |
| Head-Body Epididymidal | | | | |
| Weight (g) | 13.4 | 12.2 | 13.2 | .7 |
| Total Sperm ($x10^9$) | 4.22 | 4.05 | 4.45 | .63 |
| Tail Epididymidal | | | | |
| Weight (g) | 6.9 | 7.0 | 7.0 | .5 |
| Total Sperm ($x10^9$) | 3.90 | 4.38 | 5.44 | .95 |

[a]No significant breed type effects.

Breed type of bull did not significantly influence testicular weights or total testicular sperm (Table 2). Testicular weights averaged 174 g for these breed types of commercial bulls and the concentration of sperm in the testicular parenchyma ranged from 77 to 86 million per gram. Epididymidal weights and total sperm content were similar for the breed types.

These data indicate that implanting yearling bulls with Synovex-S, Ralgro or Compudose, after pubertal development has occurred, does not significantly alter testicular growth or sperm production. However, the influence of estrogenic implants on bulls before puberty, may be different from that which we observed with older bulls.

The excellent assistance of Marian Ringwall, Ginger Yoeman and Bill Womack is gratefully acknowledged.

## Literature Cited

Gill, D.R., J.J. Martin, F.N. Owens and D.E. Williams. 1983. Okla. Agr. Exp. Sta. Res. Rep. (in press).

Juniewicz, P.E., T.H. Welsh and B.H. Johnson. 1981. J. Animal Sci. (Suppl. 1) 51:336.

Muncy, C.D., R.P. Wettemann, E.J. Turman and K.S. Lusby. 1979. Okla. Agr. Exp. Sta. Res. Rep. MP-104:152.

# Calcium: Ruminal Concentrations and Digestibility of Feedstuffs by Lambs

F. N. Owens[1] and S. C. Arp[2]

## Story in Brief

Adding available calcium (calcium chloride) to a low calcium lamb diet sequentially increased calcium concentration in ruminal fluid and tended to depress ruminal pH. It would appear feasible to estimate calcium availability in the rumen from limestone and other feedstuffs based on calcium content of rumen fluid samples. Added calcium chloride did not alter digestibility but increased dry matter and ash content of feces. In vitro digestion of prairie hay was not altered by dietary calcium level or addition of calcium to ruminal fluid. But digestion of corn grain tended to increase with calcium added to rumen fluid from calcium deficient lambs. Digestion of corn grain also tended to be depressed with addition of calcium to rumen fluid from lambs fed an adequate level of calcium. These results suggest that there may be an optimal ruminal calcium level for starch digestion and excesses can be deleterious.

## Introduction

Calcium supplementation of feedlot diets is widely discussed, but the site of action of limestone remains undecided despite many studies. Bryant (1973) indicated that cellulose digesting microbes require 50 ppm calcium but 350 ppm proved toxic to the bacteria. Hubbert (1958) found additions up to 300 ppm increased cellulose digestion by ruminal microbes while 450 ppm inhibited digestion. In contrast, Bales (1978) found that 10 ppm was adequate for digestion of milo stalks. Saliva, containing 16 to 30 ppm, therefore seems marginal in calcium so dietary supplementation is useful. Ruminal concentration has been estimated by various workers at level from 50 to 360 ppm, although these measurements may include suspended as well as soluble calcium. Levels of calcium in the rumen appear to be dependent on the diet, so possibly ruminal concentration could be used as an index of ruminal availability. The objectives of this experiment were to examine the influence of dietary calcium on 1) concentration of calcium in ruminal fluid and 2) digestion by growing lambs.

## Materials and Methods

Twelve growing lambs (42 kg) housed in metabolism stalls were subdivded into 4 groups and fed one pound of feed twice daily of a basal diet for a total of 2 pounds per day (67.5 percent cracked corn, 20 percent cottonseed hulls, 12.5 percent soybean meal) or this diet with supplemental calcium chloride to form diets containing .18, .28 and .38 percent calcium. Calcium chloride

[1]Professor, Animal Science [2]Graduate Assistant, Animal Science

was used instead of calcium carbonate due to its greater solubility and lack of buffering action which could alter fermentation. After 10 days, ruminal samples were obtained by stomach tube, centrifuged (10,000 g) and the supernatant fluid analyzed for pH and soluble calcium.

In a second study, six of the lambs above were fed the basal diet and six were fed the .38 percent calcium diet for 14 days. Feces were collected the final 5 days of the trial and digestibilities of dry matter, organic matter and starch were determined. On the last day of the study, ruminal fluid was obtained by stomach tube from 10 of these lambs (5 deficient and 5 adequately fed) and incubated with or without added calcium (to provide 280 ppm calcium during incubation) with either ground corn grain (12 hours) or prairie hay (18 hours).

## Results and Discussion

Ruminal pH was decreased with addition of calcium to the diet (Table 1). Although calcium chloride is acid, it was surprising that addition of 1.4% calcium chloride to the diet would reduce ruminal pH unless it was increasing production of fermentation acids in the rumen. Calcium concentration in ruminal fluid increased linearly with intake of calcium. This suggests that availability of calcium from limestone and feedstuffs might be determined from a standard curve and ruminal concentrations.

Added calcium did not statistically alter digestibility of dry matter, organic matter or starch (Table 2). Starch digestibility was very high. This is probably

**Table 1. Ruminal fluid concentrations of calcium.**

| Dietary Calcium, % | Ruminal Measurements: pH units | Soluble Ca ppm |
|---|---|---|
| .08 | 6.38[ab] | 11.0[a] |
| .18 | 6.71[a] | 19.6[ab] |
| .28 | 6.31[ab] | 31.1[bc] |
| .38 | 5.93[b] | 37.0[c] |

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

**Table 2. Digestibility and feces composition.**

| | Dietary Ca, % | |
|---|---|---|
| | .08 | .38 |
| Digestibility, % | | |
| Dry matter | 83.2 | 84.3 |
| Organic matter | 83.7 | 84.8 |
| Starch | 99.5 | 99.7 |
| Feces composition | | |
| Dry matter, % | 41.1[a] | 49.8[b] |
| Ash, % of DM | 7.7[a] | 10.6[b] |

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

because lambs chew their food much more thoroughly during eating than cattle. Feces of lambs fed the higher calcium level contained more ash and dry matter than feces of lambs fed the low calcium diet.

Extent of digestion of corn grain and hay were not significantly altered either by dietary calcium level or by addition of calcium at the start of the incubation period (Table 3). Supplementing the diet with calcium did not influence digestion. However, the interaction between the dietary calcium level and the addition of calcium at the start of fermentation approached significance, with addition increasing digestion with rumen fluid from deficent lambs, and decreasing digestion with rumen fluid from adequately supplemented lambs. This would suggest that there may be a critical range of calcium for maximizing starch digestion. Further study of ruminal calcium concentrations and rate of starch digestion are needed since both deficient and excessive levels appeared to reduce digestion of corn grain (primarily starch) in a fashion similar to the effect of calcium on cellulose digestion. Variable digestion and efficiency responses to calcium supplementation may be due to different ruminal calcium concentrations from various supplemental and feed sources of calcium.

**Table 3. In vitro digestion.**

| Dietary Ca, % | Ca Added at incubation | Feedstuff Corn Grain | Prairie Hay |
|---|---|---|---|
| | | Digested, % | |
| .08 | None | $41.8^{ab}$ | 24.5 |
| .08 | Yes | $43.4^{a}$ | 24.6 |
| .38 | None | $41.9^{ab}$ | 25.4 |
| .38 | Yes | $36.8^{b}$ | 25.6 |

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

## Literature Cited

Bales, G. L., et al. 1978. J. Anim. Sci. 47:561.
Bryant, M. P. 1973. Federation Proceedings 32:1809.
Hubbert, F. Jr., et al. 1958. J. Anim. Sci. 17:559.

# Evaluation of Pepsin-Insoluble Nitrogen as a Marker for Determination of Digestibility of Forages

I. Londoño[1] and L. J. Bush[2]

## Story in Brief

Digestibility of the different nutrient components of hay from four selections of Old World bluestems was estimated by a conventional method and use of pepsin insoluble nitrogen (PIN) as an internal marker. Digestibility values obtained by the conventional method were higher than those obtained by using PIN. Average recovery of PIN in the feces of lambs averaged 78.6 and varied from 72.1 to 86 percent for different varieties of the hay. This component of the forage would not be a satisfactory internal indicator for estimation of digestibility of various nutrient components of hay.

## Introduction

Various materials have been used as markers to estimate the digestibility of different nutrient components of feeds. Less labor is required than for determination of digestibility by the conventional total colleciton method, and estimates often can be made under conditions more similar to those common for producing animals. These advantages are partially offset, however, by certain factors which tend to limit the usefulness of markers. Some of the more important limiting factors include difficulty with analytical procedures, uneven distribution of some markers in the digesta, consumption of extraneous sources of a marker, and lack of complete recovery in the feces.

Acid insoluble ash is a natural marker useful for determination of digestibility under conditions where feed refusals are minimal and the animals do not have access to extraneous sources of the ash. Several researchers have evaluated lignin as a marker in digestibility studies of forages; however, variation in recovery of the material has been observed, possibly because of problems in the analytical procedures used. Other internal markers tested include plant chromogens and fecal nitrogen. The former are essentially limited to fresh green forages, and problems relating to specificity of the compounds actually measured have been noted. Efforts to develop equations to relate fecal nitrogen to digestibility of forages have not been entirely successful.

The purpose of this study was to evaluate pepsin insoluble nitrogen (PIN) as an internal marker for determining the digestibility of various nutrient components of hay.

## Materials and Methods

The samples for this study were collected during a conventional digestion trial in which digestibility of hays from four selections of Old World bluestems

[1]Graduate Student [2]Professor of Animal Science

was determined (Londoño et at., 1982). The varieties compared using 16 young lambs in sequences of a replicated 4 × 4 Latin Square design were:

| Variety code | Scientific name |
|---|---|
| WW-506 | Bothriochloa ischaemum var. sangarica |
| WW-573 (WW Spar) | Bothriochloa ischaemum var. ischaemum |
| WW-477 | Bothriochloa ischaemum var. sangarica |
| WW-517 | Bothriochloa intermedia var. indica |

Each hay was chopped and fed to the animals twice daily in sufficient quantity to allow some feed refusal in most instances. Soybean meal (75 g. per head per day) was added to assure adequate protein intake for maintenance. A mineral supplement containing 13 to 15 percent calcium, 7 percent phosphorus, and 30 to 36 percent salt was fed at the rate of 10 g. head per day. In addition, a trace mineral supplement was available for ad libitum consumption. Experimental periods were 2 weeks, with feed refusals and feces collections during the last six days of each period. Feces samples were dried in the oven (95°C) and next were ground through a 1 mm screen in a Wiley mill and kept for future composites. Pepsin-insoluble nitrogen was determined by method of Goering and Van Soest (1970).

## Results and Discussion

The chemical composition of the four varieties of hay fed in the digestibility trial was similar (Table1). Crude protein content was relatively low, whereas acid detergent fiber (ADF) and neutral detergent fiber (NDF) were high, reflecting an advanced stage of maturity of the material at harvest.

Recovery of the pepsin insoluble nitrogen (PIN) consumed by the lambs averaged 78.6 percent. Presumably, a portion of the PIN in the hays was digested during passage through the digestive tract of the lambs. As noted above, the fecal samples were dried at 95°C which is higher than the recommended temperature for materials to be analyzed for PIN; however, drying at a lower temperature could only have resulted in even lower PIN values for the feces and a lower percentage recovery.

The percentage of the PIN intake recovered in the feces was lower than the value, i.e., 90 percent or higher, generally considered acceptable for a substance to be used as a marker in digestibility studies. Moreover, there was

**Table 1. Chemical composition of Old World bluestem hays[a]**

| Variety | Crude protein | Acid detergent fibr | Neutral detergent fiber | Lignin | Cellulose | Pepsin insoluble nitrogen |
|---|---|---|---|---|---|---|
| | | | % | | | |
| WW-506 | 6.7 | 45.6 | 74.0 | 6.1 | 35.8 | .54 |
| WW-573[b] | 6.6 | 44.0 | 72.8 | 5.8 | 34.3 | .48 |
| WW-477 | 7.0 | 43.6 | 70.8 | 5.7 | 34.0 | .54 |
| WW-517 | 6.1 | 44.3 | 73.4 | 5.6 | 35.1 | .45 |

[a]Dry matter basis.

[b]Released for production as WW-Spar.

considerable variation among varieties of the hay in the extent of PIN recovery in the feces of the lambs in this trial (Table 2). The low recoveries of PIN were reflected in considerably lower estimates of digestibility of different components of the forages (Table 3). After calculation of digestibility coefficients for different nutrient components using a correction factor for PIN in the feces based on the average recovery, significant differences ($P < .05$) remained between methods of determination. Also, estimates of digestibility by the PIN method did not rank the varieties of hay in the same order as did estimates by the total collection method.

Based on the results of this trial, it was concluded that unless some change in the analytical procedure or other factor were to eliminate the variation among varieties of forage in PIN recovery in the feces of test animals, this component of forage would not be a satisfactory internal indicator of nutrient digestibility. Further research would be required to determine whether this component of feed could be used as a marker for determination of digestibility of other types of feeds.

## Literature Cited

Londoño, I., et al. 1982. Okla. Exp. Station. MP-112:123-126.

**Table 2. Total intake and excretion of pepsin insoluble nitrogent (PIN) by lambs**

| Variety | PIN intake | PIN in feces | Recovery[a] |
|---|---|---|---|
| | (g) | (g) | (%) |
| WW-506 | 20.1 | 14.5 | 72.1 |
| WW-573 | 18.4 | 15.0 | 81.5 |
| WW-477 | 20.0 | 15.0 | 75.0 |
| WW-517 | 17.1 | 14.7 | 86.0 |

[a]Pooled standard error for treatment mean was .94.

**Table 3. Digestibility of dry matter and crude protein using total collection method (TCM)and pepsin insoluble nitrogen (PIN) as a marker.**

| | Dry matter | | | Crude protein | | |
|---|---|---|---|---|---|---|
| Variety | TCM | PIN | Adj. PIN[a] | TCM | PIN | Adj. PIN[a] |
| | | | % | | | |
| WW-506[b] | 61.1 | 46.2 | 57.7 | 70.2 | 59.1 | 67.9 |
| WW-573 | 60.7 | 51.7 | 62.0 | 69.6 | 62.6 | 70.6 |
| WW-477[b] | 61.4 | 48.6 | 59.6 | 71.4 | 61.9 | 70.0 |
| WW-517[b] | 59.0 | 52.1 | 62.3 | 68.7 | 63.5 | 71.3 |

[a]Values adjusted on basis of average recovery of pepsin insoluble nitrogen.
[b]Within nutrient components, differences between means for TCM and Adj. PIN statistically significant ($P < .05$).

# Effect of Feeding Choline and Dichlorvos to Gestating Gilts

**W. G. Luce[1], D. S. Buchanan[2], C. V. Maxwell[3], H. E. Jordan[4] and R. Vincl[5]**


## Story in Brief

Two trials involving 170 crossbred gilts were conducted to study the effect of feeding choline and dichlorvos during gestation on subsequent reproductive performance. Gilts receiving choline farrowed pigs with significantly larger birth weights. No significant response from feeding choline and/or dichlorvos to gestating gilts was noted for number of live pigs born, number alive at both 21 and 42 days, percent survival rate, litter birth weight, individual pig and litter weights at 21 and 42 days and the incidence of spraddle leg pigs. There was no evidence of any interactive effect for choline and dichlorvos in this study.


## Introduction

Reproductive efficiency, the number of pigs marketed per sow kept for breeding, is the most important economic factor in swine production. Therefore, it is essential that all breeding females conceive promptly, farrow large litters and wean a high percentage of pigs farrowed. The feeding of nutritional supplements is one plausible method of improving reproductive efficiency.

Previous research at the Oklahoma Agricultural Experiment Station and other institutions has shown that supplementing the sow gestation diet with approximately 350 mg of choline per pound of diet to sows throughout the gestation period may result in increased litter size at birth and weaning and heavier litter weights at weaning (Maxwell *et. al.*, 1978 and N.R.C.-42, 1976). Research at other institutions has also shown that feeding of the anthelmintic, dichlorvos (2,2 dichlorvinyl dimethyl phosphate) at approximately 250 mg per pound of diet during the last 30 days of gestation may result in similar improved reproductive performance that is not the result of its anthelmintic effect (Siers *et. al.*, 1974 and Young *et. al.*, 1979).

There appeared to be no previous research conducted that presented any information as to whether an interactive effect would occur on reproductive performance if both choline and dichlorvos were fed to gestating females. Thus an experiment was conducted to determine if there was an interactive effect on litter size at birth, litter size at weaning, birth weights and weaning weights when supplementing diets for gestating gilts with choline and/or dichlorvos.


[1]Professor of Animal Science [2]Assistant Professor of Animal Science
[3]Associate Professor of Animal Science [4]Professor, Parasitology, Microbiology & Public Health
[5]Swine Herdsman, SLAFR, USDA-ARS.

## Experimental Procedure

This study was conducted at the Southwestern Livestock and Forage Research Station, El Reno, Oklahoma in the 1981 spring and fall farrowing seasons. A total of 170 crossbred gilts bred to purebred Duroc boars were randomly allotted to four treatments. Treatments were: (1) a 14 percent crude protein sorghum — grain soybean meal diet, (Table 1) (2) diet 1 + 350 mg of choline per pound of diet fed throughout gestation, (3) diet 1 + 250 mg of dichlorvos per pound of diet fed the last 30 days of gestation and (4) diet 1 + 350 mg of choline per pound of diet fed throughout gestation and 250 mg of dichlorvos fed during the last 30 days of gestation. All diets were started at the initiation of the breeding season.

All gilts were housed in outside dirt lots during gestation and group fed five pounds of feed per head per day. At day 110 of pregnancy, gilts were moved to individual farrowing crates, and litters were penned separately until weaned at 42 days. Beginning at day 110, all gilts were fed a 16 percent crude protein lactation ration (Table 1). They were self-fed the lactation ration after day three of the lactation period.

An examination of feces of all sows for gastrointestinal parasites was made approximately 30 days before farrowing prior to the sows on treatments three and four receiving dichlorvos. Fecal examination was also conducted on each sow and two randomly selected pigs from her litter when the pigs were 42 days of age.

## Results and Discussion

The effect of feeding choline and/or dichlorvos to gestating gilts on the number of live pigs born, number at 21 and 42 days and percent survival rate is shown in Table 2. No significant differences ($P < .05$) were noted in these

**Table 1. Composition of basal diets.**

| Ingredient | Gestation | Lactation |
|---|---|---|
| Sorghum grain | 76.95 | 71.30 |
| Soybean meal, 44% | 14.50 | 20.20 |
| Ground alfalfa hay | 5.00 | 5.00 |
| Calcium carbonate | 1.00 | 1.05 |
| Dicalcium phosphate | 1.60 | 1.50 |
| Salt | .50 | .50 |
| Vitamin trace mineral mix[a] | .25 | .25 |
| Tylan 10 | .20 | .20 |
| Total | 100.00 | 100.00 |
| Protein, % | 14.00 | 16.00 |
| Lysine, % | .62 | .77 |
| Calcium, % | .85 | .85 |
| Phosphorus, % | .61 | .60 |

[a]Supplied 800,000 IU vitamin A, 80,000 IU vitamin D, 3,400 IU Vitamin E, 800 mg riboflavin, 4,000 mg pantothenic acid, 5,400 mg niacin, 4 mg vitamin B12, 660 mg menadione sodium bisulfite, .8% manganese, 3.0% iron, .004% selenium, .008% iodine, .4% copper and 4.0% zinc per lb. of premix.

traits. Gilts on treatments receiving choline and/or dichlorvos (2, 3 and 4) did tend to farrow more live pigs than those on the control diet (treatment 1). The difference in litter size disappeared by the time the pigs were 21 days of age. This is in contrast to previous work reported here and other research stations.

The effect of feeding both choline and dichlorvos upon pig birth weight and gain is shown in Table 3. Gilts on treatments receiving choline (2 and 4) farrowed pigs with significantly higher birth weights (P < .01) than the other two treatments. Pigs from gilts on treatments 2 and 4 had average birth weight of 2.92 and 2.98 pound respectively vs 2.88 and 2.85 pound for treatments 1 and 3. No significant differences were noted for litter birth weight and pig and litter weights at 21 or 42 days. However, the litter birth weight of pigs farrowed for gilts receiving choline and/or dichlorvos (treatments 2, 3 and 4) tended to be heavier than those farrowed by the gilts on the control diet (treatment 1).

The lack of improvement in all the reproductive traits measured by feeding choline to the gestating gilts except for birth weight is in contrast to previous research reported by Maxwell *et al*, 1978, N.R.C., 1976 and others. Likewise the lack of improvement in all the reproductive traits measured by feeding

**Table 2. The effect of feeding choline and dichlorvos to gestating gilts upon litter size and survival rate.**

| | Treatments[a] | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Choline | 0 | + | 0 | + |
| Dichlorvos | 0 | 0 | + | + |
| Avg. No. of live pigs at birth | 9.7 | 10.2 | 10.3 | 9.9 |
| Avg. no. of live pigs at 21 days | 8.1 | 7.8 | 7.9 | 7.4 |
| Survival rate, % | 84.5 | 78.4 | 78.1 | 76.3 |
| Avg. no. at 42 days | 7.8 | 7.7 | 7.7 | 7.1 |
| Survival rate, % | 82.0 | 77.2 | 76.4 | 73.7 |

[a]No significant differences (P < .05) were noted among treatments

**Table 3. The effect of feeding choline and dichlorvos to gestating gilts upon pig birth weight and gain**

| | Treatments | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Choline | 0 | + | 0 | + |
| Dichlorvos | 0 | 0 | + | + |
| Pig birth wt., lb. | 2.88 | 2.92[a] | 2.85 | 2.98[a] |
| Litter birth wt., lb. | 27.75 | 29.95 | 29.33 | 29.58 |
| Pig 21 day wt., lb. | 11.30 | 11.53 | 11.21 | 11.05 |
| Litter 21 day wt., lb. | 91.26 | 89.85 | 88.29 | 82.18 |
| Pig 42 day wt., lb. | 24.04 | 24.18 | 23.76 | 23.93 |
| Litter 42 day, lb. | 188.05 | 185.68 | 182.00 | 172.77 |

[a]Treatments containing choline had significantly higher birth weights (P < .01).

dichlorvos is in contrast to several research studies previously conducted such as Siers *et al*, 1974 and Young *et al*, 1979. There was no evidence of any interactive effect for choline and dichlorvos in this study.

It has been reported in the popular press based on field observations that the feeding of supplemental choline to bred gilts would decrease the incidence of spraddle leg pigs. A low incidence of spraddle leg pigs (6.6 to 9.0 percent) was noted in this study as shown in Table 4 with no significant differences among treatments. This is in agreement with research previously reported by Maxwell *et al*, 1978, N.R.C., 1976 and others.

Prevalence of parasite eggs were extremely low in the feces of both the gilts and their respective offspring in all treatments as shown in Tables 5 and 6. Only Ascarid and Trichuris eggs were recovered in the feces of both gilts and weanling pigs. Coccidia was not demonstrated in the gilts examined but a few of the offspring were passing eggs as is shown in Table 6.

**Table 4. The effect of feeding choline and dichlorvos to gestating gilts on the spraddle leg condition in newborn pigs.[a]**

| | Treatments | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Choline | 0 | + | 0 | + |
| Dichlorvos | 0 | 0 | + | + |
| No. of gilts | 42 | 49 | 37 | 42 |
| No. gilts with one or more spraddle leg pigs | 15 | 15 | 13 | 21 |
| No. of live pigs | 402 | 484 | 376 | 408 |
| No. farrowed with spraddle legs | 29 | 43 | 25 | 37 |
| % | 7.2 | 8.9 | 6.6 | 9.0 |

[a]No significant differences (P<.05) were noted among treatments

**Table 5. The effect of feeding choline and dichlorvos to gestating gilts on the prevalence of fecal parasite eggs.**

| | Treatments | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Choline | 0 | + | 0 | + |
| Dichlorvos | 0 | 0 | + | + |
| No. of gilts | 42 | 49 | 37 | 42 |
| No. with Ascarids (roundworm) | 1 | 2 | 0 | 0 |
| No. with Trichuris (whipworm) | 0 | 3 | 0 | 0 |
| No. with Coccidia | 0 | 0 | 0 | 0 |
| No. with Spiruids | 0 | 0 | 0 | 0 |
| No. with Strongyles (nodular worm) | 0 | 0 | 0 | 0 |
| No. with Stongyloides (threadworm) | 0 | 0 | 0 | 0 |

**Table 6. Effect of feeding choline and dichlorvos to gestating gilts on prevalence of fecal parasite eggs from the offspring.**

| | Treatments | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Choline | 0 | + | 0 | + |
| Dichlorvos | 0 | 0 | + | + |
| No. of pigs sampled | 84 | 98 | 74 | 84 |
| No. with Ascarids (roundworms) | 2 | 0 | 0 | 0 |
| No. with Trichuris (whipworm) | 0 | 2 | 0 | 0 |
| No. with Coccidia | 4 | 1 | 5 | 0 |
| No. with Spiruids | 0 | 0 | 0 | 0 |
| No. with Strongyles (nodular worm) | 0 | 0 | 0 | 0 |
| No. with Strongyloides (threadworm) | 0 | 0 | 0 | 0 |

## Literature Cited

Maxwell, C. V. *et al* 1978. Ok. Agr. Exp. Sta. Rpt. MP-103:117
N.R.C. — 42. Committee on Swine Nutrition, 1976 J. Anim. Sci. 42:1211
Siers, D. G. *et al* 1974. J. Anim. Sci. 39:189
Young, R. Jr. *et al* 1979. J. Anim. Sci. 48:45

# Wheat vs Corn for Growing-Finishing Swine

C. V. Maxwell[1], D. S. Buchanan [2], W. G. Luce[3]
R. O. Bates[4] and Rex Vencl[5]

## Story in Brief

A feeding trial utilizing 473 growing-finishing pigs was conducted to compare corn vs wheat as a feedstuff for swine and to determine the effect of replacing a portion of the soybean meal in wheat rations with lysine or lysine and methionine on performance. During the growing period, pigs fed corn or wheat-soybean meal diets had similar gain and pigs fed a reduced protein wheat diet with added lysine tended to gain faster than pigs fed either the corn or wheat-soybean meal diets. The addition of methionine to the reduced protein wheat diet with added lysine tended to reduce gain, feed intake and feed efficiency. During the finishing period, pigs fed the corn-soybean meal diet grew faster than pigs fed either wheat diet. Pigs fed the reduced protein wheat diet with added lysine tended to grow faster than pigs fed the wheat-soybean meal control diet during both the growing and finishing periods. During the finishing period, gain and feed efficiency were similar for swine fed all wheat diets. This study suggest that wheat is comparable with corn as a feedstuff for the growing, but not the finishing pig.

## Introduction

In recent years, wheat has often been competitively priced with other cereal grains as a feedstuff for swine. When wheat becomes competitively priced with other cereal grains, it becomes especially attractive to Oklahoma swine producers since Oklahoma is a major wheat producing state. Although most research would indicate that wheat will compare favorably with other feed grains, some studies have reported reduced and less efficient gains when wheat was substituted for grain sorghum or corn. The factors responsible for this variability in performance in swine fed wheat diets have not been determined. This study was conducted to compare the performance of growing-finishing swine fed wheat or corn based diets formulated on an equal lysine basis and to determine the effect of replacing a portion of the soybean meal in wheat rations with the first limiting amino acid, lysine or the first and second limiting amino acids, lysine and methionine on performance.

## Materials and Methods

This trial was conducted at the Southwestern Livestock and Forage Research Station near El Reno, Oklahoma, and consisted of 473 pigs in 34 pens. All pigs were housed in indoor concrete pens equipped with self-feeders

[1]Associate Professor, Animal Science Dept. [2]Assistant Professor, Animal Science Dept.
[3]Professor, Animal Science Dept. [4]Graduate Student [5]Herd Manager, Ft. Reno Research Station

and waterers. Pigs from various breed groups in the animal breeding herd were randomly allotted within breed group to the four experimental treatments (Table 1). All diets were formulated to contain 0.75 percent lysine during the growing phase (37.6 to 121.3 lb) and 0.62 percent lysine during the finishing phase (121.3 to 220.9 lb). The four treatments consisted of: (1) control corn-soybean meal diet; (2) control wheat-soybean meal diet; (3) wheat-soybean meal diet formulated to meet the minimum requirement of the third limiting amino acid, and supplemented with lysine hydrochloride to provide lysine levels equivalent to the wheat control diet; (4) Treatment 3 supplemented with methionine to provide methionine levels equivalent to the wheat control diet.

## Results and Discussion

During the growing period (37.6-121.3 lb; Table 1), pigs fed corn or wheat-soybean meal diets had similar gains. Pigs fed wheat with reduced protein supplemented with lysine (Treatment 3) grew 4.2 percent faster than pigs fed either the corn ($P<.11$) or wheat-soybean meal ($P<.15$) diets. Pigs fed wheat with reduced protein supplemented with both lysine and methionine (Treatment 4) had reduced gains ($P<.01$) when compared to any other treatment. Average daily feed intake and feed efficiency was similar in pigs fed either the corn or wheat-soybean meal diets (Treatment 1 or 2) or the wheat diet with reduced protein supplemented with lysine (Treatment 3). The further addition of methionine to the low protein wheat plus lysine diet (Treatment 4) reduced average daily feed intake ($P<.05$) when compared to the wheat control diet (Treatment 2) and resulted in reduced feed efficiency ($P<.01$) when compared to any other treatments. The reason for this reduced performance with added methionine is unknown since methionine supplementation at higher levels than those used in this experiment with corn based diets has not resulted in reduced performance (Katz et al., 1973 and Grimson and Bowland, 1971). Wheat appears to be comparable with corn as a feedstuff for the growing pig when diets are formulated on an equivalent lysine basis.

During the finishing phase (121.3 to 220.9 lb; Table 3), pigs fed the corn-soybean meal diet (Treatment 1) grew an average of 6.4 percent faster ($P<.05$) than pigs fed the wheat diets. Average daily feed intake was higher ($P<.05$) in pigs fed the corn diet (Treatment 1) than those fed either the wheat control diet (Treatment 2) or the wheat diet with reduced protein supplemented with both lysine and methionine (Treatment 4). Reducing soybean meal and supplementing with lysine alone (Treatment 3) resulted in an average daily feed intake similar to that observed in pigs fed the corn-soybean meal diet (Treatment 1). Feed efficiency was similar among the four dietary treatments.

Means for average daily gain, average daily feed intake, feed efficiency and backfat during the entire growing-finishing period (37.6 to 220.9 lb) are presented in Table 4. Overall average daily gains were not significantly affected by dietary treatment although pigs fed the reduced protein wheat diet with added lysine (Treatment 3) tended to gain faster ($P<.1$) than pigs fed the wheat-soybean meal diet (Treatment 2). Similarly, pigs fed the corn-soybean meal diet (Treatment 1) tended to gain faster ($P<.11$) than pigs fed the wheat-soybean meal diet (Treatment 2) but not the reduced protein wheat diet with added lysine (Treatment 3). Luce et al (1972) observed improved gains in growing-finishing swine when either 0.1 or 0.2 percent lysine was added to a wheat-soybean meal diet containing 0.51 percent lysine. As was observed

**Table 1. Composition of experimental rations.**

| | % Composition (as-fed) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Starter | | | | Finisher | | | |
| Ingredient | 1 corn | 2 wheat | 3 wheat + Lys | 4 wheat + Lys + Met | 1 corn | 2 wheat | 3 wheat + Lys | 4 wheat + Lys + Met |
| Corn, yellow | 77.12 | | | | 82.65 | | | |
| Wheat, hard red winter | | 81.00 | 89.00 | 88.92 | | 86.80 | 94.20 | 94.12 |
| Soybean meal (44%) | 19.03 | 15.37 | 7.00 | 7.00 | 14.06 | 10.15 | 2.00 | 2.00 |
| Dicalcium phosphate | 1.84 | 1.46 | 1.60 | 1.60 | 1.68 | 1.25 | 1.38 | 1.38 |
| Calcium carbonate | 0.76 | 0.92 | 0.90 | 0.90 | 0.76 | 0.95 | 0.92 | 0.92 |
| Salt | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 | 0.50 |
| Vitamin trace mineral mix[a] | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| Lysine hydrochloride | | | 0.25 | 0.25 | | | 0.25 | 0.25 |
| DL methionine | | | | 0.08 | | | | 0.08 |
| Tylan 10 | 0.50 | 0.50 | 0.50 | 0.50 | 0.10 | 0.10 | 0.10 | 0.10 |
| Total | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |
| Calculated analysis | | | | | | | | |
| % Protein | 15.16 | 16.64 | 13.94 | 13.93 | 13.46 | 15.06 | 12.37 | 12.36 |
| % Lysine | 0.75 | 0.75 | 0.75 | 0.75 | 0.62 | 0.62 | 0.62 | 0.62 |
| % Met + cys | 0.53 | 0.48 | 0.41 | 0.48 | 0.49 | 0.44 | 0.36 | 0.44 |
| % Threonine | 0.60 | 0.59 | 0.46 | 0.46 | 0.52 | 0.51 | 0.39 | 0.39 |
| % Cálcium | 0.75 | 0.75 | 0.76 | 0.76 | 0.70 | 0.70 | 0.71 | 0.71 |
| % Phosphorus | 0.65 | 0.65 | 0.65 | 0.65 | 0.60 | 0.60 | 0.60 | 0.60 |

[a]Supplied 4,000,000 IU vitamin A, 300,000 IU vitamin D, 4 g riboflavin, 20 g pantothenic acid, 30 g niacin, 800 g choline chloride, 15 mg vitamin $B_{12}$, 10,0000 IU vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.

in the growing period, pigs fed the reduced protein diet supplemented with lysine and methionine (Treatment 4) had reduced gains ($P<.01$) when compared to the other treatments. As was observed with average daily gain, the overall average daily feed intake was similar for swine fed the corn or wheat-soybean meal diets or the wheat diet with reduced protein supplemented with lysine (Treatments 1, 2 and 3) but was reduced when lysine and methionine was added to the reduced protein wheat diet (Treatment 4; $P<.01$). The overall feed efficiency was not significantly affected by dietary treatment. Scan backfat measurements at 220 lbs were lower ($P<.05$) in pigs on treatment 4 than those on treatments 1 or 3 and lower ($P<.05$) in pigs on treatment 2 than those on treatment 3. These reduced backfat measurements may be due to the decreased rate of gain observed in pigs on treatments 2 and 4.

**Table 2. The effect of choice of grain and level of soybean meal and amino acids on performance of growing swine.**

| Item | Treatments 1 corn | 2 wheat | 3 wheat + Lys | 4 wheat + Lys + Met |
|---|---|---|---|---|
| Pigs per treatment, no. | 121 | 118 | 106 | 132 |
| Pens per treatment, no. | 9 | 9 | 7 | 9 |
| Avg. initial wt., lb | 35.5 | 38.3 | 40.5 | 36.3 |
| Avg. final wt., lb | 123.0 | 119.7 | 123.6 | 119.3 |
| Avg. daily gain, lb | 1.41[a] | 1.41[a] | 1.47[a] | 1.19[b] |
| Avg. daily feed intake, lb | 3.72[cd] | 3.80[c] | 3.70[cd] | 3.48[d] |
| Feed per lb gain, lb | 2.69[a] | 2.67[a] | 2.61[a] | 2.94[b] |

[ab]Values in the same row with different superscripts differ ($P<.01$).
[cd]Values in the same row with different superscripts differ ($P<.05$).

**Table 3. The effect of choice of grain and level of soybean meal and amino acids on performance of finishing swine.**

| Item | Treatments 1 corn | 2 wheat | 3 wheat + Lys | 4 wheat + Lys + Met |
|---|---|---|---|---|
| Pigs per treatment, no. | 125 | 110 | 106 | 131 |
| Pens per treatment, no. | 9 | 9 | 7 | 9 |
| Avg. initial wt, lb | 123.0 | 119.7 | 123.6 | 119.3 |
| Avg. final wt, lb | 223.5 | 221.0 | 223.5 | 216.2 |
| Avg. daily gain, lb | 1.82[a] | 1.69[b] | 1.73[b] | 1.70[b] |
| Avg. daily feed intake, lb | 6.21[a] | 5.86[b] | 6.02[ab] | 5.45[c] |
| Feed per lb gain, lb | 3.36 | 3.48 | 3.44 | 3.35 |

[abc]Values in the same row with different superscripts differ ($P<.05$).

**Table 4. The effect of choice of grain and level of soybean meal and amino acids on performance of growing-finishing swine.**

| Item | Treatments 1 corn | 2 wheat | 3 wheat + Lys | 4 wheat + Lys + Met |
|---|---|---|---|---|
| Pigs per treatment, no. | 125 | 110 | 106 | 131 |
| Pens per treatment, no. | 9 | 9 | 7 | 9 |
| Avg. initial wt., lb | 35.5 | 38.3 | 40.4 | 36.3 |
| Avg. final wt., lb | 223.5 | 221.0 | 223.5 | 216.2 |
| Avg. daily gain, lb | 1.60[b] | 1.55[b] | 1.60[b] | 1.42[c] |
| Avg. daily feed intake, lb | 4.88[b] | 4.83[b] | 4.86[b] | 4.37[c] |
| Feed per lb gain, lb | 3.05 | 3.11 | 3.07 | 3.17 |
| Backfat, in.[a] | 0.95[de] | 0.92[ef] | 0.96[d] | 0.90[f] |

[a]Backfat measurements were taken on 124, 104, 105 and 123 pigs for the corn, wheat, wheat + Lys and wheat + Lys + Met treatments respectively.

[bc]Values in the same row with different superscripts differ (P < .01).

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

## Literature Cited

Grimson, R. E. and J. D. Bowland. 1971. J. Anim. Sci. 33:58.
Katz, R. S. et al. 1973. J. Anim. Sci. 37:1665.
Luce, W. G. et al. 1972. J. Anim. Sci. 35:947.

# Effect of Probiotic Supplementation on Performance, Fecal Parameters and Digestibility in Growing-finishing Swine

C. V. Maxwell[1], D. S. Buchanan[2], F. N. Owens[3]
S. E. Gilliland[4], W. G. Luce[5] and R. Vencl[6]

## Story in Brief

To evaluate two commercial probiotics (Feed-Mate 68 and Primalac), 581 crossbred pigs were allotted within breed to 36 pens and to 3 treatment groups. Effects on performance, fecal parameters and digestibility of growing and finishing swine were measured. Daily gain was improved ($P<.05$) by feeding either probiotic during the growing period. During the finishing phase, pigs fed Feed-Mate 68 grew faster ($P<.05$) than those fed Primalac. For the overall feeding period, pigs fed Feed-Mate grew 2.6 percent faster ($P<.05$) than pigs fed either the negative control diet or Primalac. Though feed efficiency and feed intake were not significantly improved by probiotic feeding, both tended to be superior in the growing and finishing periods when probiotics were added to the diet. Lactobacillus and coliform counts on pooled fecal samples (3 pigs per pen) indicated that lactobacilli and coliform populations were similar among treatments one week prior to the initiation of the trial, at the initiation of the trial and at the end of the trial. Likewise, fecal ammonia, pH and urease activity were similar among treatments. Apparent digestibility of dry matter and nitrogen, estimated with chromic oxide as pigs approached 100 kg, was 6.0 and 7.8 percent greater ($P<.05$), respectively in pigs fed both probiotics compared to the control diet.

## Introduction

Probiotic products are being manufactured commercially in the United States and a number are being offered for sale to swine producers in Oklahoma. Very little research information is available concerning the effectiveness of these products for growing-finishing pigs. This study was conducted to determine the effect of probiotics on gain and efficiency of gain in growing-finishing swine. In addition, the effect of probiotics on digestibility and fecal pH, urease activity and ammonia concentration, indicators of microbial activity, was evaluated.

## Materials and Methods

A total of 581 pigs from the Southwestern Livestock and Forage Research Station near El Reno, OK were used to evaluate two commercial probiotic

[1]Associate Professor, Animal Science Dept. [2]Assistant Professor, Animal Science Dept.
[3]Professor, Animal Science Dept. [4]Professor, Animal Science Dept. [5]Professor, Animal Science Dept.
[6]Herd Manager, Ft. Reno Research Station

products. All pigs were housed in indoor concrete pens equipped with self-feeders and waterers. Pigs from various breed groups were randomly allotted within breed group to the three experimental treatments (Table 1). Effects of probiotics on performance, fecal parameters and digestibility of growing (41.4 to 120.1 lb) and finishing (120.1 to 224.6) swine were measured. Treatments were (1) a ground wheat-soybean meal diet (2) diet 1 plus 2.5 lbs of Feed-Mate 68[7] per ton of feed during both the growing and finishing periods and (3) diet 1 plus 2.2 lb of Primalac[8] per ton of feed during both the growing and finishing periods. To ensure that all pigs were exposed to the bacteria present in the probiotics in sufficient quantities, both probiotics were included in the diet at twice the recommended level (5.0 and 4.4 lb of Feed-Mate 68 and Primalac per ton of feed for treatments 1 and 3, respectively) for one week prior to the initiation of the growth study. In addition, special precautions were taken to avoid cross contamination of feed with either probiotic during mixing or transport of feed. Feed supplement samples were obtained at intervals throughout the study for determination of viable microbial counts. The samples were diluted and plated on MRS agar and on LBS agar. Fecal samples were obtained from 3 pigs from each pen at one week prior to the initiation of the trial, at the initiation of the trial and at the end of the trial and pooled for determination of numbers of facultative lactobacilli and coliforms. Samples were chilled immediately after they were obtained and counting procedures were

**Table 1. Composition of experimental rations.**

| Ingredient | Growing % | Finishing % |
|---|---|---|
| Wheat | 81.48 | 86.90 |
| Soybean Meal | 15.40 | 10.15 |
| Dicalcium phosphate | 1.40 | 1.25 |
| Calcium carbonate | 0.97 | 0.95 |
| Salt | 0.50 | 0.50 |
| Vitamin-trace mineral mix[a] | 0.25 | 0.25 |
| Feed-Mate 68 and Primalac[b] | ---- | ---- |
| Total | 100.00 | 100.00 |
| Lysine, % | .75 | .62 |
| Calcium, % | .75 | .70 |
| Phosphorus, % | .65 | .60 |

[a]Supplied 4,000,000 IU vitamin A, 300,000 IU vitamin D, 4 g riboflavin, 20 g pantothenic acid, 30 g niacin, 800 g choline chloride, 15 mg vitamin $B_{12}$, 10,000 IU vitamin E, 2 g menadione, 200 mg iodine, 90 g iron, 20 g manganese, 10 g copper, 90 g zinc and 100 mg selenium per ton of feed.

[b]Feed-Mate 68 was added at the rate of 2.5 lbs per ton and Primalac was added at the rate of 2.2 lbs per ton for treatments 2 and 3, respectively.

[7]Anchor Labs, Inc., St. Joseph, Missouri - Contains *Streptococcus faecium* strain Cernell 68, *Lactobacillus acidophilus* and *Lactobacillus Plantarum*.

[8]Star Labs, St. Joseph, Missouri - Contains *Lactobacillus acidophilus, Lactobacillus casei, Bifidobacterium bifidum, Torulophsis* and *Aspergillus oryzae*.

initiated the same day samples were obtained. Coliforms were enumerated on Violet Red Bile Agar and facultative lactobacilli were enumerated on Lactobacillus Selection (LBS) Agar incubated in a $CO_2$ enriched atmosphere.

A digestion trial with five randomly selected pigs from each pen was conducted as pens of pigs approached 220 lbs. Chromic oxide was added to the feed and each diet was available ad libitum for a 4-day presampling period. Pens were washed down daily to minimize copraphagy. Fecal samples were obtained from the first 3 pigs defecating after the initiation of fecal collection on day 5 of the digestion trial and pooled for pH determination. Samples were chilled for subsequent determination of urease activity and ammonia concentrations the day of sampling and then frozen for subsequent dry matter, nitrogen and chromic oxide determinations.

Backfat was estimated on each pig using an ultrasonic instrument as pigs were weighed off test at 220 lbs.

## Results and Discussion

To determine if viable organisms were maintained in the feed supplements, microbial counts were made on samples obtained under field storage conditions at three time intervals during the experiment (Table 2). The experiment was initiated on May 12, 1981. Viable lactobacilli were present in both probiotics used in this study although viability declined during the course of the experiment. *Streptococcus faecium* present in Feed-Mate 68 also will form colonies on the lactobacillus selection agar. Thus the decline in numbers on LBS agar may also indicate a decline in numbers of *S. faecium.* The counts on MRS agar also indicated a decline of microbial numbers during storage. If probiotics are to produce improvements in growing and finishing swine due to their content of viable microorganisms, it is important that those microorganisms remain alive during storage of the supplement and feed. Greater differences may have been observed in this study if the numbers of microorganisms had not declined during storage of the supplements. The decline in numbers of live microorganisms which we observed points out a problem that must be overcome if we are to realize full benefit from supplementing livestock feed with live microbial cultures.

Results for the growing, finishing and growing-finishing periods are presented in Table 3. Average daily gain was improved ($P<.05$) by feeding either probiotic during the growing period. During the finishing period, pigs fed Feed-Mate 68 grew faster ($P<.05$) than pigs fed either the negative con-

**Table 2. Viable microbial counts in the feed supplements during storage.**

| | Counts/g | | | |
|---|---|---|---|---|
| | Feed-Mate 68 | | Primalac | |
| Date | LBS[a] | MRS[b] | LBS[a] | MRS[b] |
| 5-22-81 | $3.2x10^7$ | $6.4x10^7$ | $3.0x10^5$ | $1.4x10^6$ |
| 6-9-81 | $7.8x10^6$ | $2.4x10^7$ | $2.8x10^4$ | $5x10^5$ |
| 10-19-81 | $2.4x10^4$ | $2.0x10^6$ | $10^3$ | $5x10^3$ |

LBS[a] = Lactobacillus selection agar.
MRS[b] = Mann Rogosa and Sharp agar (non selective).

**Table 3. Effect of probiotics on performance of growing, finishing and growing-finishing swine.**

| Item | 1 Control | 2 Feed-Mate 68 | 3 Primalac |
|---|---|---|---|
| | Treatments | | |
| Pigs per treatment, no.[a] | 135 | 223 | 223 |
| Pens per treatment | 8 | 14 | 14 |
| Growing (41.4 to 120.1 lb) | | | |
| Avg. initial wt, lb | 42.1 | 41.4 | 40.9 |
| Avg. final wt, lb | 117.0 | 121.4 | 120.7 |
| Avg. daily gain, lb | 1.35[b] | 1.41[c] | 1.40[c] |
| Avg. daily feed intake, lb | 3.66 | 3.74 | 3.72 |
| Feed per lb gain, lb | 2.76 | 2.68 | 2.71 |
| Finishing (120.1 to 224.6 lb) | | | |
| Avg. initial wt, lb | 117.0 | 121.4 | 120.7 |
| Avg. final wt, lb | 225.7 | 225.0 | 224.3 |
| Avg. daily gain, lb | 1.73[bc] | 1.76[b] | 1.71[c] |
| Avg. daily feed intake, lb | 5.82 | 6.04 | 5.94 |
| Feed per lb gain, lb | 3.56 | 3.49 | 3.39 |
| Growing-finishing (41.4 to 224.6 lb) | | | |
| Avg. daily gain, lb | 1.55[b] | 1.59[c] | 1.55[b] |
| Avg. daily feed intake, lb | 4.80 | 4.90 | 4.86 |
| Feed per lb gain, lb | 3.21 | 3.13 | 3.09 |
| Avg. adj. backfat, in. | 0.85 | 0.85 | 0.86 |

[a]During the finishing period, a total of 132, 214 and 221 pigs were on treatments 1, 2 and 3, respectively.
[bcd]Values in each row with different superscripts differ ($P < .05$).

trol diet or Primalac. For the overfall feeding period, pigs fed Feed-Mate 68 grew faster ($P < .05$) than those fed either the negative control diet or Primalac. There was a trend during the combined growing and finishing periods for improved average daily feed intake and feed efficiency when probiotics were added to the diet, although these differences were not significant. Adjusted backfat thickness was similar for all treatments.

Lactobacillus and coliform counts on pooled fecal samples (3 pigs from each pen, Table 4) indicated that the numbers of lactobacilli and coliforms were not different among treatments at one week prior to the initiation of the trial, at the initiation of the trial and at the end of the trial.

The effect of probiotics on fecal parameters and digestibility of dry matter and nitrogen are presented in Table 5. Fecal pH tended to be lower in feces from pigs fed probiotics, although these differences were not significant. Similarly urease activity was 20 percent lower in pigs fed Primalac than those fed the untreated control diet and fecal ammonia was reduced by 11.2 percent when probiotics were added to the diet, but these differences were not significant. Visek (1978) has suggested that a decrease in ammonia either with urease immunization or antibacterial agents alters the histology of the gastrointestinal tract. Both nitrogen and dry matter digestibility were higher ($P < .01$) in pigs fed probiotics.

**Table 4. Effect of probiotics on fecal lactobacilli and coliforms.**

| | Treatments | | |
|---|---|---|---|
| | 1 Control | 2 Feed-Mate 68 | 3 Primalac |
| $Log_{10}$ lactobacilli per g of dry feces | | | |
| Sample 1, 1 week prior to trial initiation | 9.93 | 9.90 | 10.08 |
| Sample 2, trial initiation | 10.08 | 10.01 | 9.89 |
| Sample 3, end of trial | 9.41 | 8.96 | 9.28 |
| $Log_{10}$ coliforms per g of dry feces | | | |
| Sample 1, 1 week prior to trial initiation | 6.96 | 7.16 | 7.42 |
| Sample 2, trial initiation | 7.66 | 7.20 | 7.27 |
| Sample 3, end of trial | 6.88 | 6.63 | 6.77 |

**Table 5. The effect of probiotics on fecal measurements and digestibility of dry matter and nitrogen.**

| | Treatments | | |
|---|---|---|---|
| Item | 1 Control | 2 Feed-Mate 68 | 3 Primalac |
| pH | 6.28 | 6.15 | 6.18 |
| Urease, summer units[a] | 1.58 | 1.54 | 1.26 |
| Ammonia Mg/100 g wet feces | 69.3 | 61.4 | 61.6 |
| Nitrogen digestibility, % | 65.39[b] | 69.76[c] | 71.16[c] |
| Dry matter digestibility, % | 67.7[a] | 71.0[b] | 72.5[b] |

[a]Release of 1 mg of ammonia per 5 min.
[bc]Values in each row with different superscripts are different (P<.01).

## Literature Cited

Visek, W. J. 1978. Jl Anim. Sci. 46:1447.

# Adaptation problems with the Finn-Dorset line

J.V. Whiteman[1], K.A. Ringwall[2]
and Guy Robson[3]

## Story in Brief

During the period between 1975 and 1981, a group of 1/2 Dorset, 1/2 Finnish Landrace (Finn) rams and ewes were either produced or purchased to serve as a base for a special line of sheep to be selected to be fertile and highly prolific when mated in May and June for October-November lambing. These ewes were initially mated to rams of the same breeding during at least two spring breeding seasons after which they were mated during the fall season in order to produce a larger number of second generation ($F_2$) ewes. About 120 $F_2$ ewes over one year of age are currently in the flock. These ewes have been mated only during the spring and were mated first at 7 or 12 months of age. From them there are currently about 30 $F_3$ ewes most of which are less than two years of age. Observations during the spring breeding season indicate that 50 to 75 percent of Finn x Dorset ewes and rams are fertile in April; less are fertile in May, and the majority of them go into anestrous sometime in June. The birth weights of fall born single and twin lambs average between 5 and 6 pounds and the birth weights of spring born lambs, of which there are more litters of 3 to 5 average between 6 and 7 pounds. The mortality rate of these lambs due to both stillbirths and lack of vigor has varied from 15 to 40 percent with the mortality of $F_2$ lambs being higher than for $F_1$'s and of the $F_3$'s even higher than $F_2$'s. It is obvious that these $F_2$ and $F_3$ lambs are not biologically well adapted to the production conditions at Ft. Reno and for this reason, this selection project is being phased out.

## Introduction

Sheep are very efficient producers of meat under certain production conditions. Their productivity could be tremendously increased if they were fertile on a yearlong basis. It has been shown that the ewes are physiologically capable of lambing every 8 months, but their inherent lower fertility during the period between February or March and July or August makes such an accelerated lambing program unfeasible with the currently available breeds or breed crosses of sheep. Since some breeds of sheep such as the Dorset and Rambouillet are much less seasonally anestrous than other breeds, it seems likely that it would be possible over time to select a line of sheep that is less seasonal in their fertility than any breeds that now exist.

A small flock of 1/4 Dorset, 1/4 Finn, 1/2 Rambouillet ewes at the Southwest Livestock and Forage Research Station (obtained by crossing 1/2 Finn, 1/2 Dorset rams on Rambouillet ewes) contained some individual ewes

[1,2]Professor, Graduate Assistant, Animal Science Department respectively.
[3]Herd Manager, sheep breeding research, Southwest Livestock and Forage Research Station, El Reno.

that were among the most productive ewes ever maintained at the station. This suggested that if there were a line of 1/2 Finn, 1/2 Dorset sheep from which males could be selected to mate to Rambouillet ewes, commercial sheepmen could produce a highly productive cross that were 1/4 Finn, 1/4 Dorset, 1/2 Rambouillet to use as commercial ewes in Oklahoma. The purpose of this project was to determine if it were feasible to combine the out-of-season breeding characteristics of the Dorset with the early sexual maturity and high prolificacy of the Finnish Landrace to produce such a highly fertile prolific line of sheep to be used to produce such rams.

## Materials and Methods

The foundation for this line of sheep was 1/2 Finnish Landrace (Finn) x 1/2 Dorset. It was deemed important to have a broad base for the line and therefore the flock was put together slowly over a period of time and from many sources. The first sheep were bought in 1975 and involved 10 crossbred ewes and 2 crossbred rams from two different sources. In 1976, 25 crossbred ewes were produced by mating purchased Finn rams to Dorset ewes from 4 different Oklahoma flocks. In 1977 twenty-nine aged crossbred ewes were purchased in Nebraska and added to the flock. In 1978 and 1979 twenty-three Finn x Dorset ewe lambs and several ram lambs were raised from Finn ewes purchased from Kansas and bred to Oklahoma State University Dorset rams. Additional 1/2 Finn x 1/2 Dorsets were raised in 1980 and subsequently so that in total there were over 100 ewes and 20 rams that had an opportunity to make a contribution to the line.

Very little was known about these 1/2 Finn x 1/2 Dorset sheep and therefore the early years were devoted to trying different mating plans in order to learn about them. The general plan involved mating all of the crossbred ewes during the spring at least twice in order to get an indication of how readily they mated and whether or not they would conceive during the spring and lamb the following fall. Since the spring matings did not produce a large number of lambs, it was decided to follow this testing program by mating the ewes during the fall in order to produce a greater number of replacement ewes from these crossbreds more quickly (For the purpose of this discussion, first cross Dorset x Finn or Finn x Dorset animals are designated $F_1$ animals and when these first cross or $F_1$ animals were mated to each other the resulting generation are $F_2$ animals. The third generation, resulting from mating $F_2$ rams to $F_2$ ewes, are called $F_3$ animals. This is normal genetic terminology.).

All second generation ($F_2$) ewes were mated as soon as possible, but were mated only in the spring. This meant that fall born ewes were mated the following spring when they were about 7 months old and spring born ewes were mated the following year when they were about 12 months old. Because the $F_2$ ewes were mated only in the spring, all $F_3$ lambs were born in the fall.

Initially half of the ewes were exposed for mating the first of April and the other half exposed the first of May. This was to determine at which time the ewes tended to be more fertile. It was determined rather quickly that the ewes were more fertile in April than in May and since it was the intent of the project to develop a line of sheep that were fertile in May, the subsequent matings were made in May and June.

An additional problem that arose involved determining which of the available rams were more fertile. By rotating several rams through several small groups of ewes and recording the time that each ewe was exposed to each ram, it was determined rather quickly that some of the rams were apparently incapable of impregnating ewes in April or May and others had a much greater capability. In order to ascertain that each ewe that was capable of conceiving had an opportunity to become pregnant, a plan of group matings was followed such that groups of ewes were exposed to groups of rams, and it was impossible to determine which sire produced each lamb born.

During the past two years, 1981 and 1982, a study has been under way in which an effort was made to predict which rams were most fertile by measuring the ram's scrotal circumference during the fall, winter and spring months and then classifying rams on the basis of how much their testicular size changed. The idea was that those rams whose testicles shrunk most during the winter period would likely be least fertile and those whose testicles tended to maintain a more constant size might also maintain a more constant level of fertility. During the 1981 and 1982 seasons, selected rams, based on testicular size changes, were mated to random samples of ewes in order to determine how well testicular size changes were related to apparent ram reproductive proficiency. These results are reported elsewhere in the 1982 Animal Science Research Reports, but did indicate that a certain amount of predictability was involved in the testicular size changes.

The mating plan followed resulted in lambs being born during the fall and spring. In both seasons, the usual records were obtained at lambing time and the lambs were moved to a feeding area where there was a creep available, and the lambs were given an opportunity to grow in a normal fashion. It was apparent that the 1/2 Finn x 1/2 Dorset lambs were smaller at birth than the normal commercial 1/2 Blackface type lambs that have been routinely raised at the Southwest Livestock and Forage Research Station and that there were some problems associated with getting the lambs to compete in the creep feeder and to grow in a satisfactory manner between birth and weaning. The lambs were not vigorous and were quite timid by nature so that they did not compete well with the larger lambs in the lot. Because of this, some of them were isolated to improve their opportunities to maintain a reasonable growth pattern.

Because they were relatively small and lacking in vigor and often came in relatively large litters, they actually received more care and attention from the shepherd than was normally given to the other lambs in the experimental flock. In spite of that, as results will show, there was a relatively high mortality rate at birth and during the first two weeks following birth. Excess lambs were often placed on an artificial milk diet in order to try to raise those that were in excess of what the ewes could normally be expected to raise.

The management of the ewe flock during the initial years of the project was similar to that normally given to the rest of the experimental flock. It became apparent that these ewes were not good foragers and that the growing ewe lambs needed special diets and the young ewes needed to be supplemented more than was true of the normal ewes in the flock. Extra supplementation was provided in order to try to maintain the breeding flocks in satisfactory condition for reproduction.

## Results and Discussion

The principle concern in this project was to develop a line of sheep based on a 1/2 Finn, 1/2 Dorset foundation that would breed readily in May and June and lamb during the fall. The results that have accrued during the course of the project involved the lambing performance of spring bred first cross ($F_1$) ewes plus the spring lambing performance of these ewes after they had had two opportunities to lamb during the fall. These results have been reported in the 1980 and '81 Animal Science Research Reports.

It was not until a fairly large group of second cross ($F_2$) ewes had been produced and observed that it was possible to get a fairly decent estimate of the potentiality of this project. These $F_2$ ewes have been mated only in the spring and the only progeny produced were from ewes and rams that were fertile in the spring. These progeny of the $F_2$ matings constitute the $F_3$ generation, and it is their characteristics that largely determine the feasibility of the proposed Finn x Dorset line.

From the beginning, it has been apparent that the Finn x Dorset lambs are smaller in size at birth than most commercial lambs and that they grow more slowly. Once a reasonable number of $F_2$ lambs had been studied, it became apparent that they were even smaller than the $F_1$ lambs and less viable. The $F_3$ lambs were even smaller and less viable than the $F_2$ lambs. This report presents some information relative to the birth weights of the fall vs spring born lambs as well as the birth weights of lambs born in different size litters and also a comparison of the size and mortality rate of the $F_2$ and $F_3$ generation lambs.

Previous research and observations by many sheepmen indicated that lambs born during the fall are not as large as those born during the spring. Table 1 presents a comparison of the birth weights of the Finn x Dorset $F_2$ generation lambs that were born during the spring and during the fall. The presentation gives the average weight of single lambs, twins, triplets, quadruplets and quintuplets. It is apparent from these data that the spring born lambs are about 1 3/4 pounds heavier than the fall born lambs in each of the litter size classifications. This compares to a difference of about 2 1/2 pounds that has been found when comparing the birthweights of lambs out of Blackface sires and Whiteface ewes that are born during the fall as compared to the winter. Since there is usually a relationship between birth weights and liveability, it would be expected that liveability of fall born lambs would be slightly less than that of winter or spring born lambs.

**Table 1. Birth weights of Finn x Dorset $F_2$ generation spring- and fall-born lambs by litter size.**

| Litter size | Spring born No. | Spring born Wt (lb) | Fall born No. | Fall born Wt (lb) |
|---|---|---|---|---|
| Singles | 22 | 8.37 | 35 | 6.55 |
| Twins | 125 | 7.25 | 152 | 5.59 |
| Triplets | 126 | 6.52 | 33 | 4.93 |
| Quadruplets | 19 | 6.56 | 4 | 4.25 |
| Quintuplets | 10 | 5.06 | | |

In these discussions of birth weights, it is well to keep in mind that the values that are presented are averages and within any group, there is a lot of variation. As an example: If we take the 7.25 average birth weight of the twin lambs born in the spring and study the variation, we find that about 2/3 of those twin, spring-born lambs weighed within 1 1/2 pounds of the average—that is, about 2/3 of the lambs weighed between 5.75 and 8.75 pounds. About 1/6 of the lambs were smaller than 5.75 pounds and about 1/6 were larger than 8.75. If we remember that this same kind of variation existed for the 33 fall born triplet lambs, we will realize that about 1/6 of those lambs weighed less than 3.4 pounds at birth and only about 1/6 weighed 6.4 or more pounds at birth.

If one studies the average weights of the average singles, twins, triplets, etc., and thinks through the previous discussion about variation, it is easy to see that in these large litters where there are triplets, quadruplets and quintuplets, there were many lambs born that were quite small. This accounts for some of the lack of viability and poor growth rates observed in these lambs.

The project is concerned primarily with fall born lambs and, therefore, the summary was made that is presented in Table 2 where the weights of $F_2$ Finn x Dorset, $F_3$ Finn x Dorset and some FinnDorset x Rambouillet lambs were compared. It can be seen that the $F_2$ lambs were between .5 and 1.4 lbs heavier at birth than the $F_3$ lambs. The tendency for smaller birth weights for lambs in larger litters also existed. It should be especially noted that the $F_3$ Finn x Dorset lambs that were multiple born lambs were quite small and this accounted for a lack of viability in these lambs also. Also presented in Table 2 are the birth weights of fairly large numbers of single and twin born lambs that were out of Rambouillet ewes that were mated to the same rams that produced the $F_3$ lambs. The size of the mature Rambouillet ewes was similar to the size of the Finn x Dorset ewes, yet the lambs born out of these Rambouillet ewes when bred to the same rams as the Finn x Dorset ewes that produced the $F_3$ lambs were on the order of 3 pounds heavier for singles and about 1.7 pounds heavier for twins. The results for the $F_2$ and $F_3$ Finn x Dorset lambs in Table 2 strongly suggests that these fall born lambs are not very large and helps to explain the difficulty that the shepherds had in trying to raise them.

The genetic explanation for a part of what happened as illustrated in the Finn x Dorset lambs in Table 2 is that the $F_2$ Finn x Dorset lambs were produced by $F_1$ ewes that exhibited some heterosis as far as the ewes ability to conceive and produce a lamb was concerned. The lambs themselves as far as individual heterosis was concerned have only one-half as much as would be found in $F_1$ lambs. This probably accounts in some small measure for the small

**Table 2. Birth weights (by litter size) of fall-born $F_2$ and $F_3$ Finn x Dorset and Finn Dorset x Rambouillet lambs.**

| | $F_2$ Finn x Dorset | | $F_3$ Finn x Dorset | | FD x Ramb. | |
|---|---|---|---|---|---|---|
| Litter size | No | Wt (lb) | No | Wt (lb) | No | Wt (lb) |
| Singles | 35 | 6.55 | 33 | 5.73 | 210 | 8.67 |
| Twins | 152 | 5.59 | 86 | 5.01 | 152 | 6.71 |
| Triplets | 33 | 4.93 | 13 | 3.51 | | |
| Quadruplets | 4 | 4.25 | 4 | 3.55 | | |

birth weights and the lower viability of $F_2$ lambs. The $F_3$ lambs were produced by $F_2$ ewes that had lost half of their heterosis as females and the actual amount of heterosis in the lamb was down to 1/4 of what one would expect to find in $F_1$ lambs. Therefore, the direction indicated in these results relative to birth weights and liveability are not surprising, but the extent of those differences is surprising.

In order to study the relationships between birth weights and viability of the various kinds of lambs, the summaries presented in Table 3 were developed. This table presents, by single, twin, triplet and quadruplet classes the birth weights of lambs that were stillborn, died within 2 weeks of age or survived beyond 2 weeks of age. The data are presented for both $F_2$ and $F_3$ Finn x Dorset lambs. It is quite apparent that within each litter size those lambs that survived were, on the average, larger than those that were stillborn or died during the first 2 weeks. It is especially apparent among the $F_3$ lambs that the lambs that did not survive to 2 weeks were quite small in size.

The last line in Table 3 summarizes the mortality through 2 weeks of age and shows that 15 percent of the $F_2$ lambs were either stillborn or died before they were 2 weeks old; whereas, 33 percent of the $F_3$ lambs did not survive to 2 weeks. These figures compare to the flock of sheep involving Rambouillet ewes mated to the same rams that produced the $F_3$ lambs wherein 7 percent of the lambs did not survive to 2 weeks of age.

To date there have been 12 $F_4$ lambs born with an average birth weight of less than 5 pounds and a mortality rate before 2 weeks of 33 percent also.

The average growth rate of these $F_2$ and $F_3$ lambs has been impossible to measure accurately because some lambs were raised on the bottle and some other lambs did not compete well when they were in groups of commercial type lambs. Nevertheless, there are sufficient observations to cause us to con-

**Table 3. The relationship of birth weight to lamb livability of $F_2$ and $F_3$ generation fall born lambs.**

| Litter size and livability class | $F_2$ Finn x Dorset No | $F_2$ Finn x Dorset Wt (lb) | $F_3$ Finn x Dorset No | $F_3$ Finn x Dorset Wt (lb) |
|---|---|---|---|---|
| Single | | | | |
| stillborn | 2 | 5.6 | 2 | 2.50 |
| died w/in 14 da | 2 | 3.9 | 6 | 3.52 |
| survived | 31 | 6.79 | 25 | 6.52 |
| Twins | | | | |
| stillborn | 11 | 4.14 | 11 | 3.57 |
| died w/in 14 da | 10 | 4.36 | 13 | 3.79 |
| survived | 131 | 5.80 | 62 | 5.52 |
| Triplets | | | | |
| stillborn | | | 8 | 2.99 |
| died w/in 14 da | 2 | 4.10 | 2 | 4.80 |
| survived | 27 | 5.13 | 5 | 4.24 |
| Quadruplets | | | | |
| stillborn | 2 | 2.00 | 4 | 3.55 |
| died w/in 14 da | 0 | | | |
| survived | 2 | 6.50 | | |
| Mortality to two wks | 15% | | 33% | |

clude that under conditions where 1/2 Blackface lambs out of Whiteface Dorset x Rambouillet type ewes will average about 55 pounds at 10 weeks of age, these lambs will average between 40 and 45 pounds. Part of this difference is due to the fact that there are more twin, triplet and quadruplet lambs among the Finn x Dorsets than among the commercial lambs. This however does not account for nearly all of the difference in growth rate. Although it was never intended that the Finn x Dorsets be a commercial line as such, it is necessary that they have sufficient vigor at birth and growth rate to develop normally so that they can come into productivity at a year of age.

## Conclusion

The various generations of lambs and ewes included in this project have been studied rather carefully, and it is apparent that this particular line is biologically ill-adapted to the production conditions found at Ft. Reno, Oklahoma. Even though it appears that the $F_3$ ewes are a bit more fertile than the $F_2$'s on the average, the extreme difficulty in keep these sheep alive and in rearing their lambs has forced the conclusion that there are many other types of sheep research activities that would be more beneficial to the state of Oklahoma than a continuation of this project. This does not mean that the time and effort was wasted. Much as been learned about the problems of trying to develop new lines and the apparent severe loss of heterosis that occurs when one produces an $F_2$ generation from an $F_1$ generation or when one produces an $F_3$ generation from an $F_2$ generation when the genetic base of the line is fairly narrow as it was in the case of this experiment.

The results and observations from this experiment will be developed and published in order than other people thinking about trying to do something similar will have the benefits of the experiences that have evolved during the course of this study.

# Relationships of Hip Height Measurements with Growth and Carcass Traits of Crossbred and Angus Cattle

P.J. Zerbino[1], R.R. Frahm[2] and J.W. Castree[3]

## Story in Brief

Hip heights were measured on 286 three-breed cross calves at weaning, yearling and slaughter time and on 199 Angus calves at yearling time to study the relationships of hip height with growth, feedlot performance and carcass traits when cattle are slaughtered at an anticipated grade of low choice.

Correlations between hip height and weaning, yearling and slaughter weight averaged .56. Yearling hip height (YHT) was more closely associated with feedlot ADG in crossbred cattle than was weaning hip height (WHT), .29 vs .14. The correlation of YHT with feedlot ADG was higher in Angus (.46). Hip height at slaughter (SHT) was not associated with rate of gain in the feedlot ($r = .02$). The correlations for Angus YHT with slaughter age and days on feed ($-.32$ and $-.33$) suggested taller Angus cattle at yearling time generally reached low choice with fewer days in the feedlot and were thus younger at slaughter. This relationship was not nearly as strong in the crossbred cattle (respective correlations of $-.04$ and $-.05$). Correlations of hip heights with carcass traits were generally low with a tendency for correlations to be higher in Angus cattle. Hip height was more highly correlated with carcass weight-per-day (averaged .31) than for other carcass traits.

Prediction equations were developed for feedlot ADG, days on feed, slaughter weight and rib eye area based on weight and hip height measurements. Comparisons among prediction equations were based on comparing coefficients of determination ($R^2$) which indicate the proportion of the variation in the predicted trait that is accounted for by the respective prediction equations. On average of crossbred and Angus groups, the order of predictability was slaughter weight ($R^2 = .78$), feedlot ADG ($R^2 = .66$), days on feed ($R^2 = .41$) and rib eye area ($R^2 = .23$). In general, weight was a more reliable predictor that hip height and combining hip height with weight yielded little practical improvement in predictability.

## Introduction

Since the early 1900's, there has been considerable change in the concept of profitable type of beef cattle. The large, late maturing animal gave way to a smaller, earlier maturing type. More recently the trend has reversed with larger, later maturing cattle being favored. Several experiments have been conducted to compare performance and carcass traits on cattle of different breeds or types utilizing linear measurements. Few reports have been specifically con-

[1]Graduate Student, [2]Professor [3]Herd Manager, Ft. Reno

cerned with the relationships between body measurements recorded early in life and subsequent growth, feedlot performance and carcass traits. This study was conducted to determine the correlations of hip height with growth, feedlot performance and carcass traits of three-breed cross and Angus calves when slaughtered at an estimated low choice carcass grade and to develop prediction equations for certain growth, feedlot performance and carcass traits using weight and height measurements.

## Materials and Methods

The crossbred calves involved in this study were produced during the spring of 1980 as part of an extensive crossbreeding study currently in progress at the Oklahoma Agricultural Experiment Station to evaluate lifetime productivity of various two-breed cross cows. In 1979 Hereford × Angus reciprocal cross, Simmental x Angus, Simmental x Hereford, Brown Swiss x Angus, Brown Swiss x Hereford, Jersey x Angus and Jersey x Hereford cows were randomly mated to Charolais and Limousin bulls to produce 131 bull and 155 heifer calves. For purpose of this particular study, the data were combined and analyzed as four crossbred dam groups: Hereford x Angus reciprocal crosses, Simmental crosses, Brown Swiss crosses and Jersey crosses.

The Angus calves were part of a selection study initiated in the early 1960's to compare the response to selection for increased weaning or yearling weight. At the termination of the selection project four bulls per line were selected based on the respective selection criteria from the 1978 calf crop and randomly mated to all cows to produce 98 heifer and 101 bull calves during the spring of 1980.

Crossbred and Angus calves remained with their dams on native range without creep feeding until weaning at an average age of 205 days. Immediately after weaning all calves were placed in the feedlot and fed ad lib a corn based finishing ration. All calves were individually removed from the feedlot and slaughtered when an estimated low choice carcass grade was attained.

For the crossbred cattle, hip height was measured at weaning and adjusted to 205 days (WHT), at yearling and adjusted to 365 days (YHT) and at slaughter time (SHT). Hip height was measured only at yearling time (YHT) for the Angus calves. In all cases, the hip heights involved in the analyses were the average of two measurements taken on each individual.

Weaning and yearling weights were adjusted to 205 days and 365 days, respectively, and weights for Angus calves were also adjusted for age of dam. Age of dam adjustments were not necessary for crossbred calf weights because all cows were mature. Slaughter weights were taken at the time individual animals were removed from the feedlot for slaughter as they attained an anticipated low choice carcass grade.

## Results and Discussion

Correlations of hip measurements with growth and feedlot traits are presented in Table 1. These correlations have been adjusted for breed of sire, crossbred dam group and sex of calf for crossbred cattle and for sex of calf and age of dam for Angus cattle. Positive moderate to high correlations were

**Table 1. Correlations of hip height measurements with growth and feedlot traits[a,b]**

| | Weaning weight | Yearling weight | Slaughter weight | W-Y ADG | W-S ADG | Slaughter age | Days on feed |
|---|---|---|---|---|---|---|---|
| *Crossbred:* | | | | | | | |
| WHT | .70** | .50** | .45** | .11 | .14* | −.05 | −.05 |
| YHT | .53** | .57** | .53** | .35** | .29** | −.04 | −.05 |
| SHT | .36** | .32** | .59** | .14* | .02 | .40** | .35** |
| WYGTH | −.20 | .17** | .04 | .39** | .28** | −.22** | .01 |
| WSGTH | −.23** | .09 | .05 | .31** | .32** | −.27** | .00 |
| *Angus:* | | | | | | | |
| YHT | .51** | .68** | .59** | .53** | .46** | −.32** | −.33** |

*P<.05, **P<.01.
[a]W = weaning, Y = yearling, S = slaughter, HT = hip height, GTH = growth in hip height.
[b]Correlations adjusted for breed of sire, crossbred dam groups and sex of calf for crossbred cattle and sex of calf and age of dam for Angus cattle.

observed for weaning height (WHT) and yearling height (YHT) with weaning, yearling and slaughter weight (average .56), suggesting that taller cattle at weaning or yearling were generally heavier at all ages. A correlation of .59 was observed between slaughter height (SHT) and slaughter weight, however, correlations were lower between SHT and weaning and yearling weight (averaged .34). The correlation between YHT and feedlot ADG was higher in Angus (.46) than in crossbred cattle (.29). The low correlation between SHT and rate of gain between weaning to slaughter (.02) indicated that taller cattle at slaughter was not related with gaining ability in the feedlot. The correlations for Angus YHT with slaughter age and days on feed (−.32 and −.33) suggested that taller Angus cattle at yearling time generally attained low choice carcass grade in shorter feeding periods and thus were younger at slaughter. This relationship was not nearly as strong in the crossbred cattle (−.04 and −.05). In crossbred cattle, the correlations between SHT and slaughter age and days on feed (.40 and .35) indicate that taller cattle at slaughter tended to be in the feedlot longer and thus were older at slaughter. Correlations of growth in height from weaning to yearling (WYGTH) and weaning to slaughter (WSGTH) with feedlot ADG (averaged .30) and slaugher age (averaged .25) suggest that cattle that grew faster in height were generally gaining and attained slaughter condition at a younger age.

Correlations between hip height measurements and carcass traits are presented in Table 2. Angus cattle tended to have higher correlations of hip height with carcass traits than crossbred cattle. Among carcass traits, hip height was more strongly related to carcass weight per day (average .31). Taller cattle at weaning, yearling and slaughter time were generally associated with larger rib eye areas (average correlation .18). Taller yearling Angus cattle tended to have higher dressing percentage (.23) and lower cutability (−.15). The low, non-significant correlations observed with the remaining carcass traits suggested that when cattle are slaughtered at a constant degree of finish, hip height is mostly unrelated to carcass traits.

Prediction equations for feedlot daily gain, days on feed, slaughter weight and rib eye area are presented in Tables 3, 4, 5 and 6, respectively. The values in the upper part of the tables are partial regression coefficients and thus represent the expected change in the predicted trait for each unit change in that particular trait in the prediction equation. For example in Table 3, equation

**Table 2. Correlations of hip height measurements with carcass traits[a,b]**

| | Carcass wt/day | Rib eye area | Cutability | Dressing percent | Marbling | Single fat | Carcass conformation |
|---|---|---|---|---|---|---|---|
| *Crossbred:* | | | | | | | |
| WHT | .36** | .10 | −.05 | −.04 | −.08 | −.02 | .01 |
| YHT | .40** | .14* | −.10 | −.05 | −.10 | .04 | .03 |
| SHT | .17** | .26** | −.03 | .01 | .04 | .01 | .02 |
| WYGTH | .15* | .01 | −.05 | −.07 | −.11 | .08 | −.05 |
| WSGTH | .18** | .07 | −.03 | −.03 | −.04 | .10 | .03 |
| *Angus:* | | | | | | | |
| YHT | .62** | .23** | −.15 | .23** | −.03 | .08 | .01 |

*P<.05, **P<.01.
[a]W = weaning, Y = yearling, S = slaughter, HT = hip weight, GTH = growth in hip height.
[b]Correlations adjusted for breed of sire, crossbred dam groups and sex of calf for crossbred cattle and sex of calf and age of dam for Angus cattle.

**Table 3. Prediction equations for feedlot daily gain[a]**

| | Crossbred cattle | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Weaning age equations | | | Yearling age equations | | | Angus cattle equations | | |
| Trait | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Weaning weight | .001* | .001* | — | −.005** | −.005** | — | −.003** | — | — |
| Weaning hip height | .022** | — | .041 | .041 | — | −.066* | — | — | — |
| Yearling weight | — | — | — | .005** | .005** | — | .004** | .002** | .003** |
| Yearling hip height | — | — | — | .026 | — | .128** | .028 | .023 | — |
| $R^2$[b] | .34 | .34 | .34 | .73 | .73 | .40 | .58 | .52 | .52 |

*P<.05, **P<.01.
[a]Partial regression coefficients included only for the traits of interest. Prediction for an individual animal would also require the appropriate coefficients for crossbred group and sex for crossbred cattle and age of dam and sex of calf for Angus cattle.
[b]$R^2$ = coefficient of determination which represents the proportion of the variation in the trait being predicted that is accounted for by the respective prediction equations.

1, feedlot average daily gain is predicted by .001 (weaning weight) + .022 (weaning hip height). The .001 indicates that for each pound heavier in weaning weight an individual average daily gain is expected to increase by .001 lb/day and each inch increase in hip height is expected to increase average daily gain by .022 lb/day. In order to complete the prediction of feedlot average daily gain for an individual it is necessary to also include appropriate coefficients for crossbred group and sex of calf for crossbred cattle and age of dam and sex of calf for Angus cattle. These partial regression coefficients are included solely to indicate the form of the respective prediction equations and will not be discussed further.

Comparisons between different prediction equations can be made by comparing the respective coefficients of determination ($R^2$), which represents the proportion of the variation in the predicted trait that is accounted for by the respective prediction equations. The most useful prediction equation is the one that accounts for the largest proportion of the variation in the predicted trait. Considering the average for crossbred and Angus cattle, the order of predictability among traits considered was slaughter weight ($R^2 = .78$), feedlot ADG ($R^2 = .66$), days on feed ($R^2 = .41$) and rib eye area ($R^2 = .23$).

In crossbred cattle, the predictability of feedlot daily gain based on traits measured at weaning (Table 3) was low ($R^2 = .34$). Equations 2 and 3 indicated that weaning weight and WHT were about equally useful in predicting feedlot daily gain ($R^2 = .34$) and there was no improvement by including both (equation 1). At yearling time, weaning and yearling weights were more useful predictors of feedlot daily gain (equations 5, $R^2 = .73$) than WHT and YHT (equation 6, $R^2 = .40$). Including hip height measurements with weight measurement did not improve predictability (equation 4, $R^2 = .73$).

In Angus cattle, yearling weight alone (equation 9, $R^2 = .52$) was as good a predictor of feedlot daily gain as yearling weight and YHT (equation 8, $R^2 = .52$) and nearly as good as the equation which also included weaning weight (equation 7, $R^2 = .58$).

In general, predictability of days on test (Table 4) is low with at best only 46 percent of the variation in days on test being accounted for by the prediction equation (equation 7). At weaning time in the crossbred cattle weaning weight (equation 2, $R^2 = .25$) was a better predictor of days on test than WHT (equation 3, $R^2 = .21$). Combining weight and height yielded little improvement (equation 1, $R^2 = .26$) at yearling time, weaning and yearling weight (equation 5, $R^2 = .32$) was a better predictor than WHT and YHT (equation 6, $R^2 = .21$). Combining weight and height yielded little improvement (equation 4, $R^2 = .35$). In Angus cattle yearling weight (equation 9, $R^2 = .45$) was a better predictor than in crossbred cattle, but as with the crossbred cattle, including YHT did not improve predictability (equation 8, $R^2 = .46$).

Prediction equations for slaughter weight of cattle slaughtered at an anticipated grade of low choice is presented in Table 5. Both weight and height appear to be very useful as predictors of slaughter weight. At weaning time, weaning weight (equation 2) and WHT (equation 3) are equally useful as predictors of slaughter weight ($R^2 = .68$). Combining weight and height resulted in little improvement (equation 1, $R^2 = .70$). At yearling time a similar pattern existed with weight being more useful as a predictor than hip height with little practical improvement from combining both weight and hip height in a prediction equation.

**Table 4. Prediction equations for days on feed[a]**

| | Crossbred cattle | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Weaning age equations | | | Yearling age equations | | | Angus cattle equations | | |
| Trait | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Weaning weight | −.211** | −.14** | — | .007 | .05 | — | .020 | — | — |
| Weaning hip height | 3.73* | — | −1.36* | .300 | — | −.46* | — | — | — |
| Yearling weight | — | — | — | −1.87** | −.16** | — | −.211** | −.203** | −.173** |
| Yearling hip weight | — | — | — | 4.16* | — | −1.07* | 2.29* | 2.33* | — |
| $R^2$[b] | .26 | .25 | .21 | .35 | .32 | .21 | .46 | .46 | .45 |

*P<.05, **P<.01.

[a]Partial regression coefficients included only for the traits of interest. Prediction for an individual animal would also require the appropriate coefficients for crossbred group and sex for crossbred cattle and age of dam and sex of calf for Angus cattle.

[b]$R^2$ = coefficient of determination which represents the proportion of the variation in the trait being predicted that is accounted for by the respective prediction equations.

**Table 5. Prediction equations for slaughter weight[a]**

| | Crossbred cattle | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Weaning age equations | | | Yearling age equations | | | Angus cattle equations | | |
| Trait | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Weaning weight | .73** | 1.02** | — | −.14 | .05 | — | .50** | — | — |
| Weaning hip height | 14.43** | — | 32.03** | 5.69 | — | 6.09 | — | — | — |
| Yearling weight | — | — | — | .76** | .83** | — | .26** | .46** | .61** |
| Yearling hip height | — | — | — | 9.61* | — | 30.98** | 10.90** | 11.69** | — |
| $R^2$[b] | .70 | .68 | .68 | .80 | .79 | .70 | .75 | .72 | .70 |

*P<.05, **P<.01.

[a]Partial regression coefficients included only for the traits of interest. Prediction for an individual animal would also require the appropriate coefficients for crossbred group and sex for crossbred cattle and age of dam and sex of calf for Angus cattle.

[b]$R^2$ = coefficient of determination which represents the proportion of the variation in the trait being predicted that is accounted for by the respective prediction equations.

In general, predictability of rib eye area (Table 6) is very low with only 24 percent of the variation in rib eye area being accounted for by the best prediction equation (equation 4) which combines all weight and height measurements available at yearling time. As with the other traits, weight is a more useful predictor than hip height and there is little practical improvement in predictability from including hip height with weight.

In general, these data suggest that although there appears to be some association of weaning and yearling hip height with growth, feedlot and carcass traits, it is not as strong as weaning and yearling weight. Consequently, weight was a more reliable predictor than hip heights, and combining hip heights with weight in prediction equations yielded little practical improvement in predictability.

**Table 6. Prediction equations for rib eye area[a]**

| | Crossbred cattle | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Weaning age equations | | | Yearling age equations | | | Angus cattle equations | | |
| Trait | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Weaning weight | .037* | .007** | — | .027** | .001 | — | .009** | — | — |
| Weaning hip weight | −.148 | — | .138** | −.152 | — | .013 | — | — | — |
| Yearling weight | — | — | — | .004** | .005* | — | −.0002 | .003* | .004** |
| Yearling hip height | — | — | — | .021 | — | .147 | .035 | .048 | — |
| $R^2$[b] | .20 | .18 | .15 | .24 | .21 | .15 | .22 | .15 | .15 |

*$P<.05$, **$P<.01$.

[a]Partial regression coefficients included only for the traits of interest. Prediction for an individual animal would also require the appropriate coefficients for crossbred group and sex for crossbred cattle and age of dam and sex of calf for Angus cattle.

[b]$R^2$ = coefficient of determination which represents the proportion of the variation in the trait being predicted that is accounted for by the respective prediction equations.

# Relationships of On-Test Hip Height With Growth and Carcass Traits of Hereford Calves

P.J. Zerbino[1] and R.R. Frahm[2]

## Story in Brief

A total of 571 Hereford calves were measured at the hips to study the relationships of on-test hip height with growth, feedlot performance and carcass traits of cattle slaughtered at a constant final weight of 1150 pounds.

On-test hip height was moderate to highly correlated with weaning weight, yearling weight and weight per day of age (average .59), suggesting that taller on-test cattle were generally heavier at all stages. Taller cattle on-test tended to gain more rapidly (r = .18) and to remain fewer days on feed (r = − .51), thus were younger at slaughter (r = − .52). Taller cattle on-test also tended to have less fat at slaughter (r = − .19 and − .17 for fat thickness and marbling, respectively).

The ranking of three traits in terms of predictability based on weight and height measurements was days on feed ($R^2 = .73$), weight per day of age ($R^2 = .69$) and feedlot ADG ($R^2 = .24$). Weight was a more useful predictor of performance than height and including height in addition to weight yielded little if any improvement.

## Introduction

Historically there has been considerable controversy as to what type of beef cattle are most profitable. Consequently, at different times both small, early maturing cattle types and larger, later maturing types have been favored by producers. The current trend seem to favor larger framed, later maturing cattle and thus many producers are currently interested in increasing the height of their cattle. Research is needed to more clearly determine the relationships of height measurements with economically important traits in order to more effectively utilize height in developing selection criteria to produce more efficient cattle. The purpose of this study was to estimate the correlation of on-test hip height with growth, feedlot performance and carcass traits and to determine the predictability of certain traits using weight and height measurements on Hereford calves when slaughtered at a constant final weight of 1150 pounds.

## Materials and Methods

Data involved in this study were provided by the American Hereford Association from herds that were enrolled in their Total Performance Record Keeping Program (TPR). Calves were born in the spring of 1979 and consisted of 417 steer and 154 heifer calves from 10 different herds. Following a

[1]Graduate Student [2]Animal Science Professor

variable period of time (from 9-70 days) after weaning calves were placed in the feedlot and fed a finishing ration until a constant final weight of 1150 pounds was attained.

Data supplied by the American Hereford Association for each of the 577 calves were: hip height and age of calves at the start of the feeding period, 205-day adjusted weaning weight, 365-day adjusted yearling weight, weaning to yearling ADG, feedlot ADG, age at slaughter, days on feed, weight per day of age, fat thickness, percent cutability and marbling score. Since the average age of the calves at the beginning of the feeding phase was 280 days, hip heights were adjusted for 280 days for purposes of this analysis.

## Results and Discussion

Correlations of on-test hip height with various growth, feedlot and carcass traits are presented in Table 1. These correlations indicate that taller cattle at the start of the feeding period were heavier at weaning (r = .66) and yearling time (r = .56) and had higher weight per day of age at slaughter time (r = .55). Although the relationship was not as strong, tall cattle on test tended to gain more rapidly in the feedlot (r = .18). When the intended slaughter weight of approximately 1150 pounds was reached, taller cattle on-test were generally in the feedlot fewer days (r = −.51) and were younger at slaughter (r = −.52). These results are in agreement with the relationships described in the growth curve for cattle of different mature sizes. Taller, larger framed cattle would generally gain more rapidly and thus be younger at constant weights. Correlation of hip height with fat thickness (−.19) and marbling (−.17) indicated that taller cattle on-test attained final weight with less backfat and lower stage of maturity than shorter cattle. Consequently, taller cattle on-test tended to have higher cutability (r = .16). Even though the cattle were to be slaughtered at a constant weight of 1150 pounds, taller cattle on test tended to have heavier slaughter weights (r = .25).

Prediction equations for feedlot daily gain, days on feed and weight per day of age based on weight and height measurements are presented in Table 2. The values in the upper part of the table are partial regression coefficients and thus represent the expected change in the predicted trait for each unit change in that particular trait in the prediction equation. For example in equa-

**Table 1. Correlations of on-test hip height with various growth, feedlot and carcass traits[a]**

| Trait | On test hip height | Trait | On test hip height |
|---|---|---|---|
| Weaning weight | .66** | Slaughter age | −.52** |
| Yearling weight | .56** | Wt/day of age | .55** |
| Wn to Yrlg ADG | .19** | Fat thickness | −.19** |
| Feedlot ADG | .18** | Cutability | .16** |
| Days on feed | −.51** | Marbling | −.17** |
| Slaughter weight | .25** | | |

**P<.01.

[a]Correlations adjusted for sex of calf, age of dam and location (herd of origin).

**Table 2. Prediction equations for feedlot daily gain, days on feed and weight per day of age[a]**

| | Feedlot average daily gain | | | Days on feed | | | Weight per day of age | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Weaning weight | –.0012** | | | –.075** | | | 0.0005** | | |
| Yearling weight | 0.0017** | 0.0014** | 0.0014** | –.214** | –.233** | –.266** | 0.0011** | 0.0012** | 0.0015** |
| On-test hip height | 0.0157 | –.0007 | | –2.069* | –3.137** | | 0.0237** | 0.0307** | |
| $R^2$[b] | .24 | .23 | .23 | .72 | .71 | .69 | .68 | .65 | |

*P<.05, **P<.01.

[a]Partial regression coefficients included only for the traits of interest. Prediction for an individual animal would also require the appropriate coefficient for herd location, sex of calf and age of dam.

[b]$R^2$ = coefficient of determination which represents the proportion of the variation in the trait being predicted that is accounted for by the respective prediction equations.

tion 8, weight per day of age is predicted by .0012 (yearling weight) + .0307 (on-test hip height). The .0012 indicates that for each pound heavier in yearling weight an individual is weight per day of age is expected to increase by .0012 lb and each inch increase in hip height is expected to increase weight per day of age by .0307 lb. In order to complete the prediction of weight per day for an individual, it is necessary to also include appropriate coefficients for herd location, sex of calf and age of dam. These partial regression coefficients are included solely to indicate the form of the respective prediction equations and will not be discussed further.

The usefulness of different prediction equations can be compared by making comparisons among the coefficients of determination ($R^2$) which gives the proportion of the variation in the predicted trait that is accounted for by the respective prediction equations. The higher the $R^2$ value is the more accurate that equation is in predicting performance with regard to a particular trait. The ranking of the three traits in terms of predictability was days on feed ($R^2 = .73$), weight-per-day-of-age ($R^2 = .69$) and feedlot ADG ($R^2 = .24$).

The predictability of feedlot ADG was too low to be of practical value since only 24 percent of the variation in feedlot ADG could be accounted for by the best prediction equation ($R^2 = .24$, equation 1). Yearling weight alone ($R^2 = .23$, equation 3) was as good a predictor as yearling weight plus hip height ($R^2 = .23$, equation 2).

Days on feed was much more predictable. Yearling weight alone ($R^2 = .71$, equation 6) was nearly as good as those equations that also included hip height ($R^2 = .72$, equation 5) or hip height and weaning weight ($R^2 = .73$, equation 3).

A similar pattern was exhibited for predicting weight per day of age. Yearling weight alone ($R^2 = .65$, equation 9) accounted for 65 percent of the variation in weight-per-day-of-age. Little practical improvement was attained by adding hip height and weaning height to the prediction equation ($R^2 = .69$, equation 7).

Although hip height of Hereford cattle at the start of the finishing period does have some association with rate of gain during the finishing period, it is not as high as weight traits. Weight traits appear to be more useful as indicators of growth, feedlot and carcass traits. Thus, if weight measurements are available, there would be little practical value from including hip heights in the evaluation.

# Preliminary Report on the Effect of Different Proportions of Brahman Breeding on Calf Growth and Development of Heifers Through First Breeding

D.K. Aaron[1], R.R. Frahm[2] and S.W. Coleman[3]

## Story in Brief

Preweaning growth of calves and subsequent growth and reproductive development of heifers were evaluated on the first Brahman crosses produced as part of a long term project to evaluate overall productivity of crossbred cows with different proportions of Brahman breeding. Angus, Hereford, Brahman, Brahman-Angus and Brahman-Hereford bulls were mated to Hereford and Angus cows to produce crossbred calves that were O Brahman (Angus-Hereford, Herford-Angus), ¼ Brahman (¼ Brahman: ¼ Angus: ½ Hereford, ¼ Brahman: ¼ Hereford: ½ Angus) and ½ Brahman (Brahman-Hereford, Brahman-Angus). A total of 176 crossbred calves were produced in the spring of 1981. Following weaning at 205 days of age, all heifer calves were developed to calve at two years of age when bred to Limousin bulls.

At birth ¼ Brahman and ½ Brahman calves were heavier ($P < .01$) by 5 and 9 lb, respectively, and at weaning by 18 ($P < .10$) and 41 lb ($P < .01$), respectively. Also, ¼ Brahman and ½ Brahman calves were 2 and 3.3 in. taller ($P < .01$), respectively, and had condition scores .5 and .7 units lower ($P < .01$), respectively, then O Brahman calves. At a year of age ¼ Brahman and ½ Brahman heifers were 35 ($P < .05$) and 60 lb ($P < .01$) heavier, respectively, and 1 and 2.2 in. taller ($P < .01$), respectively, than O Brahman heifers. The average age at puberty for those heifers cycling prior to the start of breeding was 22 and 24 days younger ($P < .01$) for ¼ Brahman and ½ Brahman, respectively, than O Brahman heifers. However, weight at puberty was similar for all three crossbred groups. Also, prebreeding weights and condition scores were similar for all three crossbred groups. Conception rate was good for all three crossbred groups with 94 percent of all heifers exposed conceiving.

These date indicate that calves with some proportion of Brahman breeding may perform better through weaning and that reproductive performance of Brahman cross heifers is at least equal to that of crossbred heifers with no Brahman breeding.

## Introduction

In recent years, there has been an increased interest in Brahman cross cattle. In order to produce calves with a ''little ear and hump'' some cattlemen have incorporated Brahman cross cows into their herds. Therefore a project was initiated at the Oklahoma Agricultural Research Station to evaluate overall productivity of Brahman cross cows and to determine what proportion of the cow should be of Brahman breeding to achieve maximum production efficien-

[1]Graduate Assistant [2]Professor, Animal Science [3]Research Nutritionist, USDA-ARS

cy. The objective of this particular study was to evaluate the effect of different proportions of Brahman breeding on preweaning growth of calves and the subsequent growth and reproductive performance of the heifers that were produced as part of this extensive project.

## Materials and Methods

The data utilized in this study were collected in the initial stage of a long term project designed to evaluate productivity of crossbred cows with different proportions of Brahman breeding when managed under spring vs fall calving programs. Angus, Hereford, Brahman, Brahman-Angus and Brahman-Hereford bulls were mated to Angus or Hereford cows to produce 176 crossbred calves in the spring of 1981 that were O Brahman (Angus-Hereford, Herford-Angus), ¼ Brahman (¼ Brahman: ¼ Hereford: ½ Angus, ¼ Brahman: ¼ Angus: ½ Hereford) or ½ Brahman (Brahman-Angus, Brahman-Hereford).

Cows were managed on native and bermuda grass pastures at the Southwestern Livestock and Forage Research Station at El Reno. Calves were born from early February through April and birth weights were recorded within 24 hours after birth. Calves were allowed to run with their dams on pasture and received no creep feed. After weaning at an average age of 205 days, steer calves were allotted to trials to evaluate basic biological differences between crossbred groups while all heifers were developed to calve at two years of age.

After weaning, heifers were maintained as a separate group on native and bermuda grass pasture. In addition they received a corn based concentrate mix and oat/alfalfa silage. Puberty of the heifers was defined to be the time of the first observed standing heat. Heifers were exposed to marker bulls which had deflected penises and were observed at least twice daily for heat detection. At approximately fifteen months of age, heifers were randomly mated to four Limousin bulls during a 60-day breeding season and were pregnancy checked approximately 65 days after bulls were removed from the pastures.

Preweaning growth of calves and subsequent growth and development of heifers were evaluated using least squares procedures.

## Results and Discussion

Performance through weaning of calves with different proportions of Brahman breeding is presented in Table 1. Average birth and weaning weights for O Brahman calves were 77 and 475 lb, respectively. At birth, ¼ Brahman and ½ Brahman calves were heavier ($P<.01$) by 5 and 9 lb, respectively, and at weaning by 18 and 41 lb ($P<.01$), respectively. Also, ¼ Brahman and ½ Brahman calves were 2 and 3.3 in. taller ($P<.01$), respectively, at weaning than O Brahman calves. Conformation scores were similar for all three crossbred groups; however, average condition score of 5.8 units for O Brahman calves was .5 and .7 units higher ($P<.01$) than for ¼ Brahman and ½ Brahman calves, respectively.

Postweaning growth and reproductive performance were evaluated on 73 heifers. Performance through a year of age is presented in Table 2. At a year of age, O Brahman heifers weighed an average of 637 lb and were 44.5 in. tall at the hip and ¼ Brahman heifers and ½ Brahman heifers were 35 ($P<.05$)

**Table 1. Preweaning performance of calves with different proportins of Brahman breeding**

| Proportion Brahman | No. of calves | Birth wt (lb) | Preweaning ADG (lbs/day) | Weaning Wt (lb) | Weaning Ht (in) | Weaning Conf.[1] | Weaning Cond.[2] |
|---|---|---|---|---|---|---|---|
| 0 | 44 | $77^c$ | $1.9^b$ | $475^b$ | $40.7^c$ | $12.9^a$ | $5.8^a$ |
| ¼ | 92 | $82^b$ | $2.0^{ab}$ | $493^b$ | $42.7^b$ | $12.7^a$ | $5.3^b$ |
| ½ | 40 | $86^a$ | $2.1^a$ | $516^a$ | $44.0^a$ | $12.9^a$ | $5.1^b$ |

[abc]Means not sharing at least one common superscript differ at the .05 probability level.
[1]Conformation: 12 = low choice, 13 = average choice.
[2]Condition: 1 = thin to 9 = fat with 5 = average fat.

**Table 2. Yearling performance of heifers with different proportions of Brahman breeding**

| Proportion Brahman | No. of heifers | Weaning to yearling ADG (lb/day) | Yearling Wt (lb) | Yearling Ht (in) | Yearling Conf.[1] | Yearling Cond.[2] |
|---|---|---|---|---|---|---|
| 0 | 18 | $.94^b$ | $637^b$ | $44.5^c$ | $13.5^a$ | $5.5^a$ |
| ¼ | 37 | $1.16^a$ | $672^a$ | $45.5^b$ | $13.4^a$ | $5.4^a$ |
| ½ | 18 | $1.27^a$ | $697^a$ | $46.7^a$ | $13.0^b$ | $4.9^b$ |

[abc]Means not sharing at least one common superscript differ at the .05 probability level.
[1]Conformation: 13 = average choice, 14 = high choice.
[2]Condition: 1 = thin to 9 = fat with 5 = average fat.

and 60 lb ($P<.01$) heavier, respectively, and 1 and 2.2 in. taller ($P<.01$), respectively.

Reproductive performance of heifers with different proportions of Brahman breeding is summarized in Table 3. The heifers were observed for detection of heat as described earlier with 88, 68 and 72 percent of the 0, ¼ and ½ Brahman heifers, respectively, observed to be cycling. At time of puberty, all three crossbred groups had similar weights, although ½ Brahman heifers were 1.6 in. taller than O Brahman heifers (46.2 vs 44.6 in., $P<.01$). Although a higher proportion of the O Brahman heifers were detected as cycling prior to the start of breeding, the average age at puberty for those heifers cycling was less ($P<.01$) for the ¼ Brahman and ½ Brahman heifers by 22 and 24 days, respectively. Prebreeding weights and condition scores were similar for all three crossbred groups. Conception rate was good for all three crossbred groups with 94 percent of all heifers exposed conceiving.

In summary, based on these data it appears that it may be advantageous to producers to have some proportion of Brahman breeding in calves for growth through weaning and that reproductive performance of Brahman cross heifers is at least equal to that of "black baldy" type heifers. However, evaluation of future crossbred calf crops is necessary before further conclusions can be made.

**Table 3. Reproductive performance of heifers with different proportions of Brahman breeding**

| Proportion Brahman | No. of heifers | Percent cycling[2] | Trait: Puberty Age (days) | Puberty Wt (lbs) | Puberty Ht (in) | Prebreeding Wt (lbs) | Prebreeding Cond.[1] | Conception rate, %[2] |
|---|---|---|---|---|---|---|---|---|
| 0 | 18 | 88 | $384^{a}$ | $655^{a}$ | $44.6^{b}$ | $780^{a}$ | $6.3^{a}$ | 88 |
| ¼ | 37 | 68 | $362^{b}$ | $670^{a}$ | $45.7^{ab}$ | $781^{a}$ | $6.1^{a}$ | 100 |
| ½ | 18 | 72 | $360^{b}$ | $678^{a}$ | $46.2^{a}$ | $786^{a}$ | $6.2^{a}$ | 89 |

[ab]Means not sharing at least one common superscript differ at the .05 probability level.
[1]Condition: 1 = thin to 9 = fat with 5 = average fat.
[2]Differences not significant as per Chi Square test.

# A Comparison of Progeny Sired by High Indexing and Low Indexing Duroc Boars

R. O. Bates,[1] D. S. Buchanan[2] and
R. Vencl[3]

## Story in Brief

Data was collected on 1032 progeny of high and low indexing Duroc boars. Boars were purchased from test stations in pairs, each pair containing one high and one low indexing boar. The index used to evaluate these boars included average daily gain, feed efficiency and backfat thickness. Offspring were evaluated for post-weaning performance to compare the use of high vs low indexing boars. Pigs sired by high indexing boars consumed more feed (4.88 vs 4.73 lb per day) and grew faster (1.60 vs 1.52 lb per day) than pigs sired by low indexing boars. Progeny of high indexing sires were also leaner and had better feed efficiency when compared to progeny of low indexing boars, however these differences were small and non-significant. In general, this study showed that the use of boars with superior performance should result in improved performance in commercial swine herds.

## Introduction

The selection index advocated by the National Swine Improvement Federation has been created so that swine producers would have a more accurate means of selecting boars. The index includes average daily gain, feed efficiency and backfat thickness. These traits have been shown by numerous research programs to respond favorably to selection, but, the animals in these studies were managed under rigorous experimental conditions which may not exist for boars in a test station. This study was initiated to compare offspring of boars that had above average performance at a central test station with offspring of boars that had performed below average.

## Materials and Methods

The National Swine Improvement Federation test station index is $I = 100 + 60 (G-\bar{G}) - 75 (F-\bar{F}) - 70 (B-\bar{B})$ where G is the average daily gain, F is the feed efficiency (lb feed/lb gain) and B is the backfat thickness. $\bar{G}$, $\bar{F}$ and $\bar{B}$ are the test group averages for the three traits. The index has been derived so that an average boar will have an index of 100 and that 68 percent of the boars in a test group will have an index between 75 to 125. It is recommended that boars with an index less than 80 be excluded from the sale.

Twelve Duroc boars were purchased for each of two breeding seasons from test stations in Missouri, Nebraska and Oklahoma. These stations test three

[1]Graduate Assistant, [2]Assistant Professor, [3]Herd Manager, Ft. Reno

boars per pen all of whom have the same sire. Boars were purchased in pairs with one boar indexing more than 118 and the other less than 90. At several sales more than one pair of boars was purchased. The performance of the Duroc boars used is summarized in Table 1. The high vs low indexing boars were separated by 54 index units in the fall of 1980 and by 46 index units in the spring of 1981.

The twelve boars each season were randomly mated to 100 gilts which were the progeny of high and low indexing Hampshire boars as described by Buchanan et al (1982). Litters were farrowed in a central farrowing barn and transferred to nursery pens 3-7 days after farrowing. Piglets were weaned at 42 days of age and transferred to finishing pens at approximately 56 days of age. Finishing pens contained 12 to 18 pigs with offspring of the same sire grouped together when possible. Pigs were fed a 16 percent crude protein growing ration until average pig weight in a pen was 120 pounds when the ration was switched to a 14 percent crude protein finishing ration. This was fed to the end of the finishing period. Pigs were weighed weekly and were removed from the pen as they reached 220 pounds. At this time an ultrasonic fat measurement was taken at the shoulder, last rib and last lumbar vertebrae and average backfat thickness was calculated. Average daily gain, for each pig, was measured from when pigs were put in finishing pens to when they reached 220 pounds. Feed efficiency (lb feed/lb gain) was determined on a pen basis. There were 1032 barrows and gilts that completed the test period. Data were analyzed so that offspring of high vs low boars could be compared with the effects of season, sex and breeding of the dam removed.

**Table 1. Performance of Duroc Boars Purchased from Test Stations**

| Season | Average Daily Grain | Feed Efficiency lb feed/lb gain | Backfat in | Index units |
|---|---|---|---|---|
| | | High Indexing boars | | |
| Fall 1980 | 2.27 | 2.25 | .77 | 137 |
| Spring 1981 | 2.38 | 2.52 | .74 | 129 |
| | | Low Indexing boars | | |
| Fall 1980 | 1.91 | 2.59 | .87 | 83 |
| Spring 1981 | 1.96 | 2.68 | .85 | 83 |

## Results and Discussion

The performance of barrows and gilts sired by high and low indexing Duroc boars is presented in Tables 2 and 3. The sire line by season interaction was significant for average daily feed consumption and average daily gain (Table 2). Average daily feed consumption, was significantly greater for offspring of high indexing boars in the fall of 1981 but there was no difference in the previous season. Offspring sired by high indexing boars gained faster ($P < .01$) than those sired by low indexing boars. No significant differences were detected when comparing progeny of high and low indexing boars for feed efficiency and backfat thickness (Table 3).

**Table 2. Average Daily Gain and Feed Consumption of Barrows and Gilts Sired by Duroc Boars Purchased from Test Stations**

| Season | Line of Sire | Number of Offspring | Average Daily Feed Consumption 15 day | Average Daily Gain 15 day |
|---|---|---|---|---|
| Spring 1981 | High | 279 | 4.87[a] | 1.60[a] |
| | Low | 281 | 4.86[a] | 1.54[b] |
| Fall 1981 | High | 211 | 4.88[a] | 1.59[a] |
| | Low | 261 | 4.59[b] | 1.49[c] |

[abc]Means in column that have different superscripts differ significantly.

**Table 3. Backfat thickness and Feed Efficiency of Barrows and Gilts Sired by Duroc Boars Purchased from Test Stations**

| Line of Sire | Number of Offspring | Backfat in | Feed Efficiency lb feed/lb gain |
|---|---|---|---|
| High | 490 | .822 | 3.11 |
| Low | 542 | .889 | 3.12 |

The expected heritability of the performance index, based on the heritabilities of .30, .35 and .50 for average daily gain feed efficiency and backfat, is .36. The actual or realized heritability computed from the high vs low comparison was .12. The reason for the difference between the expected heritability and actual heritability can be partly attributed to the different pre-test conditions that the boars were exposed to.

These results show that progeny sired by boars that had superior post-weaning performance grew faster than those sired by boars with inferior post-weaning performance.

It can be recommended that high indexing boars at central test stations are a good source of potential seedstock. This practice, as well as purchasing farm-tested boars with good performance, should lead to a gradual increase in overall herd performance. Increases in performance will accumulate over time and can be more rapid if selection pressure for these traits is applied when selecting breeding females as well. Growth rate and backfat thickness can be accurately measured by seedstock producers so that breeding animals purchased by purebred and commercial producers will more likely increase performance in existing herds which will allow the industry to produce pork more efficiently.

# The Effect of Crossbred vs Purebred Boars on Conception Rate in Swine

**D. S. Buchanan,[1] R. K. Johnson[2] and R. Vencl[3]**

## Story in Brief

Conception rate and the number of services per conception were evaluated for 764 crossbred females mated to 161 purebred and crossbred boars (Duroc, Yorkshire, Spotted, Landrace and two-breed crosses). Matings took place during five consecutive (fall and spring) eight-week breeding seasons beginning in fall of 1977. No significant differences between female breeding groups were observed. Crossbred boars had significantly higher first service conception rate and fewer services per conception. The crossbred boar advantage was 17.9 percent for first service conception rate, 5.3 percent for conception rate during the breeding season and 9.0 percent for number of services per conception.

## Introduction

Boars with a greater ability to get sows pregnant will improve efficiency in a commercial swine herd in a variety of ways. Fewer females awaiting breeding are required since a larger proportion of them will become pregnant. Sows will be out of production for a shorter time following weaning and farrowing facilities can be kept full more dependably if conception rate is high. An additional expense that could be reduced is that of returning boars to the seedstock producer that are outright failures as breeders.

Previous research at the Oklahoma Agricultural Research Station and elsewhere has shown that young crossbred boars reach puberty earlier, show more testicular development and sperm numbers and are more active breeders than their purebred contemporaries.

This study was conducted to evaluate the conception rates of crossbred females when mated to purebred and crossbred boars (Duroc, Yorkshire, Spotted and Landrace).

## Materials and Methods

Data on conception rate were obtained from 764 crossbred females that were hand-mated to 161 purebred and crossbred boars (Duroc, Yorkshire, Spotted, Landrace and two-breed crosses). These matings took place during five consecutive eight-week breeding seasons (fall and spring) beginning in the spring of 1977 at the Southwest Livestock and Forage Research Station, El Reno, Ok. Only gilts were used in the first season, but a random sample of sows were retained for each of the following seasons. Boars were approximately eight months old when breeding began.

---

[1]Assistant Professor, [2]Professor, Animal Science, Nebraska, [3]Herd Manager, Ft. Reno

A sample of gilts was slaughtered 30 days post-breeding each season. The remaining females that did not recycle were allowed to carry their litters to term. A mating resulted in a conception only if there were embryos at 30 days or evidence of pigs in the females allowed to carry their litters.

Conception rate was evaluated for first service and for the eight-week breeding season and the number of services per conception was measured. The breeding of the female and of the boar were analyzed with adjustment for season, parity, female's weight at first mating and several interactions.

## Results and Discussion

Breeding of boar and breeding of female least squares means for conception rate and services per conception are presented in Table 1 along with the number of attempted matings for each breed group combination. There were no significant differences among the female breeding groups for any of the three traits. The ranges for the female breeding groups were 70.4 percent (Duroc-Spotted) to 81.2 percent (Landrace-Spotted) for first service conception rate, 90.0 percent (Duroc-Yorkshire) to 97.0 percent (Yorkshire-Spotted) for breeding season conception rate and 1.14 (Landrace-Spotted) to 1.23 (Duroc-Yorkshire) services per conception.

The breeding of the boar within female breeding group was a significant source of variation for first service conception rate and number of services per conception. For first service conception rate, crossbred boars were superior to each of the corresponding purebred boars in every direct comparison. The average paternal heterosis for first service conception rate was 17.9 percent. The crossbred boar advantage was less for the entire breeding season (5.33 percent), but crossbred boars were still better than the average of the corresponding purebreds in each comparison. The number of services per conception provides an additional measure of a boar's breeding efficiency. It differs from conception rate in that it removes those females that are unable to conceive during the breeding season. The results for number of services per conception were similar to those for first-service conception rate.

Producers that use young crossbred boars should expect a higher conception rate than those using young purebred boars. This will result in a decrease in the number of females needed in the breeding herd to keep farrowing facilities full. The larger advantage at first service than for the entire breeding season suggests that the differences may be due to more advanced sexual maturity. If this is so, similar advantages may not result if older boars are used.

A problem associated with using crossbred boars is a lack of availability. This could be alleviated easily if those seedstock producers with more than one breed would produce some crossbred litters and leave some males intact. This would be fairly simple since many are already selling crossbred gilts.

**Table 1. Least-squares means for reproductive performance of purebred and crossbred boars mated to crossbred females.**

| Breeding of Female | Breeding of Boar | Number of females | Conception Rate (%) First Service | Conception Rate (%) Breeding Season[a] | No. of Services per Conception |
|---|---|---|---|---|---|
| Duroc-Yorkshire | Landrace | 32 | 64.1 | 83.4 | 1.27 |
| | Landrace-Spotted | 46 | 86.1[b] | 93.7 | 1.09[b] |
| | Spotted | 37 | 67.5 | 93.0 | 1.33 |
| | Average | 115 | 72.5 | 90.0 | 1.23 |
| Duroc Landrace | Yorkshire | 41 | 72.4 | 97.0 | 1.25 |
| | Yorkshire-Spotted | 58 | 81.5 | 96.3 | 1.16 |
| | Spotted | 41 | 78.9 | 92.2 | 1.16 |
| | Average | 140 | 77.6 | 95.2 | 1.19 |
| Duroc-Spotted | Yorkshire | 40 | 74.8 | 95.1 | 1.28 |
| | Yorkshire-Landrace | 56 | 76.1 | 93.6 | 1.20 |
| | Landrace | 42 | 60.4 | 90.0 | 1.36 |
| | Average | 138 | 70.4 | 92.8 | 1.28 |
| Yorkshire-Landrace | Duroc | 35 | 71.2 | 87.3 | 1.20 |
| | Duroc-Spotted | 50 | 85.9 | 99.4[b] | 1.16 |
| | Spotted | 34 | 83.2 | 89.2 | 1.09 |
| | Average | 119 | 80.1 | 91.9 | 1.15 |
| Yorkshire-Spotted | Duroc | 38 | 66.9 | 96.5 | 1.30 |
| | Duroc-Landrace | 49 | 89.7[b] | 98.9 | 1.09 |
| | Landrace | 37 | 78.4 | 95.5 | 1.23 |
| | Average | 124 | 78.3 | 97.0 | 1.21 |
| Landrace-Spotted | Duroc | 41 | 84.2 | 91.8 | 1.09 |
| | Duroc-Yorkshire | 50 | 92.2[b] | 96.0 | 1.05 |
| | Yorkshire | 37 | 67.3 | 87.5 | 1.28 |
| | Average | 128 | 81.2 | 91.8 | 1.14 |

[a]breeding season was eight weeks
[b]crossbred boar means that were significantly ($P<.05$) better than corresponding purebreds

**Rex Vencl – Herd Manager of Swine Research at Southwestern Livestock and Forage Research Station, El Reno, OK.**

# Sire Ranking Based Upon Purebred vs Crossbred Progeny Performance in Swine

D. G. McLaren[1], D. S. Buchanan[2] and R. L. Hintz[3]

## Story in Brief

Genetic correlation between purebred and crossbred progeny of the same sire and the correlation between sire ranks based upon breeding value for purebred and crossbred progeny were estimated. Expected responses in crossbred populations from selection within purebreds and selection based upon crossbred progeny performance were evaluated.

Data from two experiments were analyzed separately. In total, these data represented records on 2,258 purebred and 4,815 crossbred progeny of 32 Duroc, 22 Hampshire, 9 Landrace, 8 Spotted and 31 Yorkshire boars. Pig weight at birth, 21-, and 42-days-of-age, postweaning average daily gain, and probed backfat thickness were investigated.

Weighted average correlations of sire breeding values (genetic correlations) and sire ranks were, respectively, .39 and .36 for birth weight, .45 and .53 for 21-day weight, .47 and .43 for 42-day weight, .48 and .49 for postweaning average daily gain, and .85 and .85 for probed backfat thickness. Comparison of the expected responses in crossbred populations, based upon genetic parameter estimates obtained in this study, suggested no clear practical advantage of selection based upon crossbred progeny performance over selection within the pure breeds themselves for the traits studied.

## Introduction

It has been estimated that 90 percent or more of hogs marketed in the United States are crossbred. Given the importance of crossbreeding to the swine industry, it seems reasonable that the primary criterion of genetic value in breeds of swine should be the performance of the crossbred offspring rather than performance of the purebreds themselves.

This poses the question as to whether, in order to achieve continued genetic improvement in the market hog population, selection of purebred parents should be based upon their own performance, or upon the performance of their crossbred progeny. Selection based upon crossbred progeny performance, however, necessitates progeny testing. It is unlikely to increase, and may indeed decrease progress unless selection based upon individual performance is relatively inaccurate as compared to using progeny records.

If selection based upon purebred performance is to be effective in improving performance of the crossbred population, the genetic correlation between performance in the purebreds and crossbreds must be relatively high. In addition, the correlation between sire ranking based upon purebred and crossbred

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

progeny should be high. Low or negative genetic and rank correlations might suggest that some system of selection based upon crossbred progeny performance should be considered in order to obtain maximum genetic progress.

The objectives of this study were: 1) to estimate genetic and rank correlations for pig birth weight, 21-day weight, 42-day weight, postweaning average daily gain, and probed backfat thickness at 220 pounds; and 2) to evaluate the expected response in crossbred populations from selection within purebreds vs selection based upon crossbred progeny performance for the above traits.

## Materials and Methods

The data used in this study were from two projects carried out by the Oklahoma State University Agricultural Experiment Station in cooperation with the USDA. The two data sets, designated 1444 and 1620, were analyzed separately.

The first data set (1444) consisted of 1184 purebred and 2275 crossbred progeny sired by 22 Duroc, 22 Hampshire and 23 Yorkshire boars at the Fort Reno Experiment Station during the spring and fall farrowing seasons of 1971 and 1973. Each of approximately six boars of each breed were mated to two females of each breed each season to produce purebred and two-breed cross litters. A different group of boars was used each breeding season.

The second data set (1620) consisted of 1074 purebred and 2540 crossbred litters sired by 10 Duroc, 9 Landrace, 8 Spotted and 8 Yorkshire boars at the Stillwater Experiment Swine Farm during the fall of 1976 and the spring and fall of 1977 and 1978. Approximately four boars of each breed were mated at random to females of each breed to produce a total of approximately six purebred litters and four of each of the possible two-breed cross litters each season. Boars were used between one and four breeding seasons.

In both experiments, the breeding season extended over an eight-week period starting in mid-May and mid-November each year. Females were hand mated and maintained throughout gestation in pasture lots. Litters were farrowed in confinement and weights of all fully-formed piglets were recorded within 12 hours of birth. Piglets were allowed access to creep feed from 21 days of age and were weaned at approximately 42 days of age. Individual pig weights were recorded at approximately 21 and 42 days of age in experiment 1444, and at 42 days of age only in experiment 1620.

Pigs were moved to a confinement finishing home for gain test at approximately two weeks postweaning in experiment 1444 and penned in groups of approximately 15 pigs per pen by breeding group. A 16 percent crude protein milo-soybean meal ration was self-fed until average pig weight per pen was approximately 120 pounds. A 14 percent crude protein ration was self-fed for the duration of the test period. Pigs were weighed off test weekly at 220 pounds, at which time gilts were probed for backfat thickness. The average of three ultra-sonic probes taken at the first rib, last rib, and last lumbar vertebrae were used. Backfat thickness records on barrows were obtained by averaging carcass measurements taken at these three points. Approximately 10 purebred and 46 crossbred barrows representing all possible breed groups were slaughtered each season.

In experiment 1620, pigs were moved to either an open front confinement building with either 10 gilts or 10 boars to a pen, or to pasture lots with approximately 50 gilts and barrows per lot. Pigs were weighed on gain test when moved at approximately two weeks postweaning (eight weeks of age). A 14 percent crude protein corn or milo based ration was self-fed for the duration of the test period. Gilts were weighed off test at 200 pounds and boars and barrows at 220 pounds. All pigs were probed for backfat thickness as described for the gilts in experiment 1444.

Postweaning performance traits investigated in this study were average daily gain from the first day on test to 220 pounds, and probed backfat thickness at 220 pounds. Actual off test live weight, age, and backfat thickness were adjusted to a 200-pound basis.

Predictions of sire breeding values for purebred and crossbred progeny were obtained for the above pre- and postweaning traits. The genetic correlation between purebred and crossbred progeny of the same sire was estimated as the correlation between sire breeding values for purebred and crossbred progeny. Sires were also ranked based upon their breeding values for purebred and crossbred progeny, and rank correlations calculated.

## Results and Discussion

Weighted average genetic and rank correlations were, respectively, .39 and .36 for birth weight, .45 and .53 for 21-day weight, .47 and .43 for 42-day weight, .48 and .49 for postweaning average daily gain, and .85 and .85 for probed backfat thickness (Table 1.)

A correlation coefficient of 1.0 would indicate complete agreement between sire breeding values or ranking based upon purebred vs crossbred progeny. While the correlations obtained in this study are in general considerably lower than 1.0, the question is whether they are low enough to warrant changing existing selection practices.

If, for any particular trait, we consider crossbred progeny performance as the criterion of selection, then selection based upon crossbred progeny performance may be regarded as direct selection, and selection based upon

**Table 1. Genetic and Rank Correlations.**

| Trait[a] | Data Set | Genetic Correlation | Rank Correlation |
|---|---|---|---|
| BW | 1444 | .53 | .55 |
| BW | 1620 | .27 | .17 |
| W21 | 1444 | .45 | .53 |
| W42 | 1444 | .46 | .43 |
| W42 | 1620 | .48 | .42 |
| ADG | 1444 | .54 | .51 |
| ADG | 1620 | .40 | .46 |
| BF | 1444 | .80 | .85 |
| BF | 1620 | .90 | .86 |

[a]BW = Birth Weight; W21 = 21-day Weight; W42 = 42-day Weight; ADG = Postweaning Average Daily Gain; BF = Probed Backfat Thickness at 220 lb.

purebred performance as indirect selection. Using genetic correlation and heritability estimates obtained in this study, it was possible to estimate the relative expected genetic change in the crossbred population from each of these two selection procedures. Allowing for the decrease in selection intensity and increase in generation interval associated with progeny testing, indirect selection based upon purebred performance was indicated to be superior to selection based upon crossbred progeny performance for all traits with the possible exception of birth weight in one data set.

Therefore, provided heritability within purebred populations is high, and the genetic correlation between purebred and crossbred performance is at least moderately high, it would seem unlikely that selection based upon crossbred progeny performance has very much to offer to practical swine breeding.

# Litter Performance for Various Types of Crossbred Females in Swine

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

## Story in Brief

Crossbred females were mated to purebred boars to obtain 493 litters representing all possible three-breed and four-breed cross litters involving Duroc, Yorkshire, Spotted and Landrace breeds. Litters were evaluated for size, weight and survival rate. There were significant differences between crossbred female groups for litter size at 42 days and litter weight at birth, 21 and 42 days. Yorkshire-Landrace females generally had the largest and heaviest litters and other females that were one-half Landrace also had large, heavy litters, particularly at 21 and 42 days. There were no significant differences between litters sired by purebred vs crossbred boars.

## Introduction

Sow productivity is a major contributor to production efficiency in a commercial swine enterprise. It is well established that crossbred females are preferred for increased litter size and mothering ability. Evidence concerning the choice of breeds and the effect of the breeding of the boar is less clear. This is particularly true for breeds such as Spotted and Landrace.

The purpose of this study was to evaluate sow productivity for crossbred females of Duroc, Yorkshire, Landrace and Spotted breeding. Matings were made so that the effect of using crossbred vs purebred boars could also be measured.

## Materials and Methods

Crossbred females were mated to purebred and crossbred boars to produce all possible three-breed (sired by purebred boars) and four-breed (sired by crossbred boars) cross litters involving Duroc, Yorkshire, Spotted and Landrace breeding. There were 493 litters born during five consecutive farrowing seasons (fall and spring) beginning in the fall of 1977. All litters born during the first season were out of first parity gilts but both gilts and sows were used each of the subsequent seasons.

Litters were born in a farrowing house with individual farrowing crates with wood slatted floors and were moved into concrete floor nursery pens three to seven days post-farrowing. Creep was provided at about 14 days, male pigs were castrated at 21 days and sows were removed from the litters at 42 days.

Litter size and weight were measured at birth, 21 and 42 days. All fully formed pigs were counted and weighed at birth and all live pigs were included

[1]Assistant Professor, [2]Professor, Animal Science, Nebraska, [3]Herd Manager, Ft. Reno

at 21 and 42 days. Survival rate at 21 and 42 days was the number of live pigs divided by the number of fully formed pigs at birth.

The effects of the breeding of the dam and the sire were analyzed so that season, parity, the dam's weight when she conceived and the interaction of breeding of dam and parity were accounted for.

## Results and Discussion

The litter size, weight and survival rate means for the female breeding groups are shown in Table 1. Yorkshire-Landrace females had the largest litters at birth, 21 and 42 days, the heaviest litters at 21 and 42 days their litters had the highest survival rate to 42 days. Duroc-Landrace females had the heaviest litters at birth. The smallest litters at 42 days were out of Yorkshire-Spotted dams who also had the lightest litters at birth, 21 and 42 days. It is interesting that those females which were one-half Landrace had the heaviest litters at 21 and 42 days and had litters with the highest survival rates. This, as well as the general superiority of the Yorkshire-Landrace female, generally agrees with previous work at the Oklahoma Agricultural Experiment Station and elsewhere.

Litter performance was relatively unaffected by the breeding of the sire (Table 2). Crossbred sired litters were slightly larger at birth, but had slightly lower survival rates. None of the differences were significant.

These results demonstrate the importance of making correct decisions concerning breeds when breeding stock is selected. Yorkshire-Landrace females appear to be the best, but other groups also have large, heavy litters. This provides some flexibility since the commercial swine producer is dependent upon what is available in his area. These results do not decrease the importance of choosing high quality breeding stock. The comparisons are close enough that there is unquestionably considerable overlap which means that highly productive females could be found representing any of several breeds.

The choice of the breeding of the sire does not appear to have much impact on litter performance. The breeding of sire does affect subsequent performance and conception rate so fast growing boars that have the potential to be agressive breeders should be used. It is also important that the boar represent a breed (or breeds) that is different from the breeding of the females so that maximum heterosis is utilized.

**Table 1. Litter Size, Weight and Survival Rate for Different Types of Crossbred Dams**

| Breeding of Dam | Number of litters | Litter size | | | Litter weight (lb) | | | Survival rate % | |
|---|---|---|---|---|---|---|---|---|---|
| | | birth | 21 days | 42 days | birth | 21 days | 42 days | 21 days | 42 days |
| Duroc-Yorkshire | 76 | 10.13 | 7.90 | 7.74$^{b}$ | 31.41$^{bc}$ | 90.95$^{bc}$ | 197.34$^{b}$ | 79.59 | 78.17 |
| Duroc-Landrace | 93 | 10.18 | 8.13 | 7.92$^{bc}$ | 32.21$^{c}$ | 92.05$^{bc}$ | 199.30$^{b}$ | 81.56 | 79.71 |
| Duroc-Spotted | 84 | 10.04 | 7.60 | 7.53$^{ab}$ | 31.15$^{bc}$ | 88.18$^{ab}$ | 195.65$^{b}$ | 77.52 | 76.89 |
| Yorkshire-Landrace | 79 | 10.34 | 8.39 | 8.30$^{c}$ | 30.56$^{b}$ | 95.24$^{c}$ | 204.40$^{b}$ | 81.58 | 80.84 |
| Yorkshire-Spotted | 80 | 9.86 | 7.37 | 7.13$^{a}$ | 28.20$^{a}$ | 84.63$^{a}$ | 181.17$^{a}$ | 76.77 | 74.54 |
| Landrace-Spotted | 81 | 9.80 | 7.91 | 7.72$^{b}$ | 30.60$^{b}$ | 94.05$^{c}$ | 199.94$^{b}$ | 81.84 | 79.87 |

$^{a,b,c,d}$means in a column with different superscripts are significantly different ($P < .05$)

**Table 2. Litter Size, Weight and Survival Rate for Litters Sired by Crossbred and Purebred Boars**

| Type of sire | Number of litters | Litter size | | | Litter weight (lb) | | | Survival rate % | |
|---|---|---|---|---|---|---|---|---|---|
| | | birth | 21 days | 42 days | birth | 21 days | 42 days | 21 days | 42 days |
| Crossbred | 194 | 10.17 | 7.76 | 7.63 | 30.69 | 89.11 | 191.39 | 77.99 | 76.76 |
| Purebred | 299 | 10.00 | 7.94 | 7.77 | 30.69 | 91.35 | 198.75 | 80.79 | 79.13 |

# Factors Related to Ram Fertility During May and June

K. A. Ringwall[1], J. V. Whiteman[2],
R. P. Wettemann[2], and G. A. Robson[3]

## Story in Brief

A flock of 450 ewes and 64 rams is being utilized to measure the breeding effectivenss (aggressiveness and fertility) of rams. Rams that decreased 2 inches in scrotal circumference following fall breeding were classified as seasonal and those that did not decrease 2 inches were classified as non-seasonal. The most seasonal and most non-seasonal rams were tested to determine if change in scrotal circumference was related to ram effectiveness in May and June. Other rams were subjected to reduced light for 10 weeks before the breeding season and their breeding effectiveness was compared to random non-treated rams. The summary is preliminary, but several trends are evident. The predicted non-seasonal rams made considerably more matings (79.1% vs 50.3%), settled almost twice as many ewes (59.8% vs 32.9%), and had a higher conception rate (75.6% vs 65.4%) than the seasonal rams. The seasonal rams did not appear to regain sexual desire soon enough to breed adequately in May and June. The evidence is inconclusive as to the effect of shortening the daylength. Rams subjected to 8 hours of light mated more ewes (82.5% vs 71.4%) and had a similar conception rate (65.9% vs 67.5%) when compared to the normal daylength rams.

## Introduction

A major problem in the sheep industry is the lack of yearlong fertility. Sheepmen that attempt to lamb their ewes from late summer to early winter experience a lower percent of ewes lambing (fertility) and fewer lambs born per ewe lambing (prolificacy). Only two sheep breeds (Dorset and Rambouillet) have acceptable fertility in the spring which allows for the fall lambing program in Oklahoma.

An effective breeding system requires a combination of a fertile, aggressive ram and a regularly cycling ewe. The type of sheep, nutrition level and quality of management all influence the results, and become more important during spring breeding than fall breeding. Even the best management and nutrition, however, cannot produce fertility in most sheep outside the normal fall breeding season.

The reasons are not fully understood how daylength can override domestic sheep management and set the fertility patterns in both the ewe and the ram thereby timing the resulting lamb crop. A thorough understanding of both the ewe and the ram is required to develop natural programs to improve sheep fertility throughout the year.

[1]Graduate Assistant [2]Professor, Animal Science [3]Herd Manager, Ft. Reno

## Materials and Methods

During 1981 and 1982, 142 $F_2$ Finn x Dorset ewes, 64 $F_2$ Finn x Dorset rams and 308 western white-faced ewes were involved in a spring breeding program to help understand the seasonal breeding habits of rams. The western white-faced ewes consisted of 170 Rambouillet ewes and 138 ewes of various combinations of Finnish Landrace (Finn), Dorset and Rambouillet. The $F_2$ Finn x Dorsets were all produced at the station from the $F_1$ flock composed of 15 different sources of Finn and Dorset breeding. No selection was practiced on the $F_1$ sheep, and every attempt was made to allow the different sources to interbreed. Only rams over one year of age were used in the study and only rams with severe structural problems were culled.

The same experimental procedure was used as reported in the 1981 Animal Science Research Report. Both 1981 and 1982 results were combined for this report and the rams and ewes involved are shown in Table 1. A total of 22 single sire mating groups were used, and the ewes were randomly allotted making sure each group had an equal representation of the various ewe breeds and ages. The total number of rams in Table 1 represents the number of rams that were available to select rams from for each mating group. Test A was concerned with the ability to select *more* vs *less* fertile rams on the basis of change in scrotal circumference following the fall season. Test B was concerned with whether reduced light for 10 weeks prior to the breeding season (May 5-June 30) would increase the breeding effectiveness of rams.

All rams underwent a routine monthly evaluation. Two independent scrotal circumference measurements were made. To be evaluated, a ram was placed on his rump, and the holder supported the ram with his knee. The holder then grasped the upper portion of the scrotum with one hand and pushed both testes semi-firmly against the lower scrotum. The scrotal circumference was determined, the testes palpated for testicular or epididymidal abnormalities, and then a second independent circumference was determined. The measurements were taken with a fiberglass tape measure. All rams were weighed and condition scored using a score system of 1-9. Testes tone and sexual flush (inguinal cutaneous hyperemia) were also monitored. Only the scrotal circumference measurements are reported here.

The procedure of Test A involved classifying the rams with the most size change as seasonal (less fertile) or those with the least size change as non-season (more fertile). The seasonal ram was expected to settle less ewes during May and June breeding. Rams were classified using the scrotal circumference measurements taken after the rams were one year of age. Seasonal rams were those rams that lost more than 2 inches in scrotal circumference between the fall breeding season of October and November and the winter period, usually in January. Rams that did not lose 2 inches were considered less responsive to the change in seasons and were called non-seasonal rams. Two inches was an arbitrary point to divide the two groups of rams. Table 1 indicates the total number of rams in each group. The extreme rams in each group (those rams that lost the most in scrotal circumference and those that lost the least) were selected to represent each ram type during the spring breeding tests.

The procedure for Test B was that the rams must be fall born $F_2$ rams that are at least one year old. The rams are randomly allotted to either an 8-hour daylight treatment in which the rams are confined to a blackout chamber for 16 hours per day for 10 weeks before May 5th or a normal daylight (control) treatment. A random sample from each treatment group was taken to determine which rams were more effective for spring breeding. The total number of rams in the treatments is shown in Table 1. All rams were fitted with marking harnesses to record daily mating activity using rump marks for both tests.

**Table 1. Allotment of rams and ewes in 1981 and 1982 for spring breeding tests involving ram selection based on scrotal circumference and artifical daylength.**

| Test | Ram Type | Total Number Rams Available | Number Rams Exposed to Ewes | Number Ewes Exposed |
|---|---|---|---|---|
| A | Seasonal | 14 | 8[1] | 244[1] |
| A | Non-seasonal | 26 | 8 | 255 |
| B | 8-hrs daylight | 10 | 8 | 202 |
| B | Normal daylight | 10 | 8[1] | 198[1] |

[1]Includes one ram from which the data was later removed since the ram would not breed and was replaced 10 days after the start of the breeding season.

## Results

The summary of the reproductive performance of $F_2$ Finn x Dorset rams used in the two tests is preliminary but several trends are evident.

The average seasonal trend in scrotal circumference is shown in Fig. 1 for all $F_2$ rams over one year of age. October and November (the normal breeding season) are the months of peak scrotal circumference as well as observed sexual activity or desire in the ram flock. The scrotal circumference remains lower until late summer at which time the ram commences preparation for the annual breeding season.

To test the extent that change in scrotal circumference can predict the fertility level of a ram breeding in May and June, rams were divided into two groups. (Table 1 shows the numbers used). Figure 2 shows the average scrotal circumference pattern of all the rams in each classification, the extreme of which were used in the test. The large fluctuations in scrotal circumference in seasonal vs non-seasonal rams is demonstrated in Figure 2. The seasonal rams recover fairly fast from the large drop in January and have larger scrotal circumference than the non-seasonal rams during May and June breeding. The non-seasonal rams are more constant and do not show the large fluctuations as seen in the seasonal rams.

Figure 2 shows why one scrotal circumference measurement taken only once is of little value. Scrotal circumference must be measured over a period of months to obtain the correct information. If rams are selected for large scrotal circumference, different rams would be selected depending on the time of year or natural variation from ram to ram.

Eight extreme rams were selected out of each group to evaluate the breeding effectiveness of the two types of rams (Test A). The breeding effectiveness of the two ram types is shown in Table 2. The non-seasonal rams settled

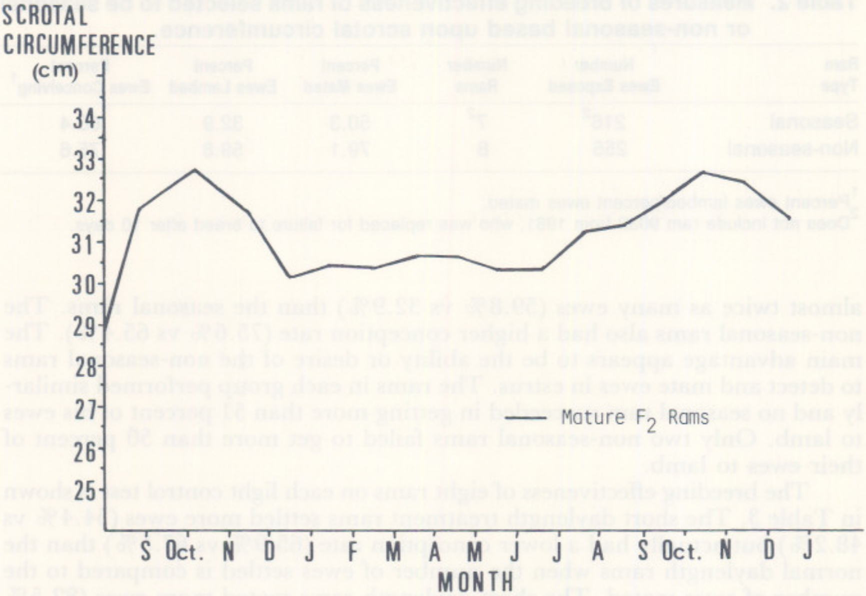



**Figure 1. Scrotal circumference at monthly intervals of $F_2$ Finn x Dorset rams over one year of age.**

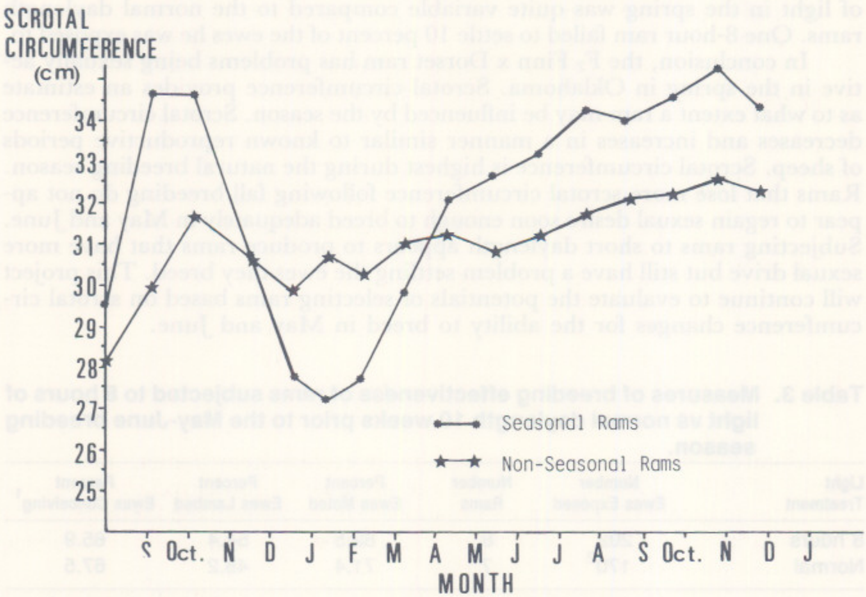



**Figure 2. Scrotal circumference at monthly intervals of seasonal and non-seasonal $F_2$ *Finn x Dorset* rams over one year of age.**

**Table 2. Measures of breeding effectiveness of rams selected to be seasonal or non-seasonal based upon scrotal circumference.**

| Ram Type | Number Ewes Exposed | Number Rams | Percent Ewes Mated | Percent Ewes Lambed | Percent Ewes Conceiving[1] |
|---|---|---|---|---|---|
| Seasonal | 216[2] | 7[2] | 50.3 | 32.9 | 65.4 |
| Non-seasonal | 255 | 8 | 79.1 | 59.8 | 75.6 |

[1]Percent ewes lambed/percent ewes mated.
[2]Does not include ram 9032 from 1981, who was replaced for failure to breed after 10 days.

almost twice as many ewes (59.8% vs 32.9%) than the seasonal rams. The non-seasonal rams also had a higher conception rate (75.6% vs 65.4%). The main advantage appears to be the ability or desire of the non-seasonal rams to detect and mate ewes in estrus. The rams in each group performed similarly and no seasonal ram succeeded in getting more than 51 percent of his ewes to lamb. Only two non-seasonal rams failed to get more than 50 percent of their ewes to lamb.

The breeding effectiveness of eight rams on each light control test is shown in Table 3. The short daylength treatment rams settled more ewes (54.4% vs 48.2%) but actually had a lower conception rate (65.9% vs 67.5%) than the normal daylength rams when the number of ewes settled is compared to the number of ewes mated. The short daylength rams mated more ewes (82.5% vs 71.4%) than the normal daylength rams. The implication of these results is that the 10 weeks of 8-hour light produced an increase in desire to mate but did not materially improve fertilizing capabilities. Ram response to 8 hours of light in the spring was quite variable compared to the normal daylength rams. One 8-hour ram failed to settle 10 percent of the ewes he was exposed to.

In conclusion, the $F_2$ Finn x Dorset ram has problems being sexually active in the spring in Oklahoma. Scrotal circumference provides an estimate as to what extent a ram may be influenced by the season. Scrotal circumference decreases and increases in a manner similar to known reproductive periods of sheep. Scrotal circumference is highest during the natural breeding season. Rams that lose more scrotal circumference following fall breeding do not appear to regain sexual desire soon enough to breed adequately in May and June. Subjecting rams to short daylength appears to produce rams that have more sexual drive but still have a problem settling the ewes they breed. This project will continue to evaluate the potentials of selecting rams based on scrotal circumference changes for the ability to breed in May and June.

**Table 3. Measures of breeding effectiveness of rams subjected to 8 hours of light vs normal daylength 10 weeks prior to the May-June breeding season.**

| Light Treatment | Number Ewes Exposed | Number Rams | Percent Ewes Mated | Percent Ewes Lambed | Percent Ewes Conceiving[1] |
|---|---|---|---|---|---|
| 8 hours | 202 | 8 | 82.5 | 54.4 | 65.9 |
| Normal | 170[2] | 7[2] | 71.4 | 48.2 | 67.5 |

[1]Percent ewes lambed/percent ewes mated.
[2]Does not include ram 9032 from 1981, who was replaced for failure to breed after 10 days.

Currently, ewes that do not lamb when the producer desires can be culled. No selection is put on ram fertility in the spring since ewes are exposed to several rams and a ram of low fertility cannot be identified. High ram to ewe ratios to ensure effective breeding are an added expense to a producer breeding in the spring and results in reduced selection pressure.

Artifical programs are being developed to improve sheep fertility utilizing the fact that daylength regulates sheep reproduction. Reducing the amount of light in the spring simulates normal fall daylength and initiates the reproductive cycle in most sheep. Involving the ewes in such a system requires considerable facilities, but recent reports suggest that exposing the rams will increase flock fertility.

The purpose of this report is to give some preliminary results obtained from research designed to: 1) estimate the improved breeding performance of rams subjected to light control and 2) estimate the differences in performance of untreated rams selected on the basis of changes in scrotal circumference measurements to be more vs less fertile.

# Simulation of Calf Gain from Birth to Weaning in Oklahoma

M. Cannon[1] and R. L. Hintz[2]

## Story in Brief

A computer simulation model to predict calf growth from birth to weaning has been developed from OSU data. Variable inputs include type of pasture, cow age, level of milk production, month born, month weaned, sex of calf, birth weight and whether creep pasture is available. Simulated and actual milk production and calf forage intake were not significantly different ($P > .1$). Simulated calf gain followed seasonal trends of data collected in OSU studies, and was not significantly different from actual calf gain ($P > .5$). Important factors influencing calf weaning weight for a given date are: date of birth, availability of high quality forage and milking ability.

## Introduction

The most profitable management of land and animal resources depends on proper management and fertilization of pasture and range land, improved nutrition and management of farm animals, and utilization of superior genetics. Producers must decide what levels of these inputs are optimum for maximizing profits. With simulation models different management schemes can be evaluated and compared for biological and economical efficiency.

The purpose of this study is to contribute to a larger study, which, when complete, should be able to simulate a complete cow/calf system with varying management alternatives. This segment deals with calf production from birth to weaning simulated under varying animal and land management schemes.

## Model Development

Equations to predict calf milk and forage intake were developed from data collected in Oklahoma State University (OSU) studies. Milk yield predictions for each month are based on forage digestibility for that month and cow average milk production. Forage digestibility values (Brorsen, 1980) for bermudagrass, native tall grass, native short grass, weeping lovegrass and fescue, with wheat pasture and sudangrass as creep pastures, are available to simulate different management schemes. Calf forage intake is based on the ratios of calf milk consumption and body weight to forage digestibility. Calf growth is simulated by computing energy intake from the predicted milk and forage intake and using the California Net Energy System (CNES) equations, with modifications, to predict calf gain from energy intake. The modifications, developed from data collected in OSU studies, were needed so that the CNES equations, which

[1]Graduate Assistant [2]Assistant Professor of Animal Science

were developed for older, fattening feedlot steers and heifers, would predict the gain of very young calves.

## Results and Discussion

Simulated milk yield and forage intake (Tables 1 and 2) were not significantly different from actual observations ($P > .1$). Actual and predicted average daily gain are compared in Figure 1. Predicted and actual gain were not significantly different ($P > .5$). Records of simulations of 686 calves (with varying months of birth and types of pasture) were averaged to see if differences between ages of dam and sexes seemed reasonable. At 210 days of age, steer calves were about five percent heavier than heifer calves. Simulated weaning weights for calves of 2-yr-old, 3-yr-old, 4-yr-old and 11-yr-old or older cows averaged 14 percent, eight percent, four percent and five percent, respectively, less than for calves of mature cows (five to 10-yr-olds). These figures are similar to industry-wide accepted differences of 15 percent, 10 percent, five percent, and five percent for two, three, four, and older than 10-year-old cows, respectively.

An example of the model output from a TRS-80 Model 16 micro computer (Tables 3 to 6) shows predicted weaning weights by sex, cow age and month of birth for a specified weaning date. The effect of a short calving season (two versus four months) is illustrated in these examples. The model can illustrate the effects of the type of pasture, availability of creep pasture, varying heifer replacement rates, cow milk yield, calf sex, season of birth and birth weight.

**Table 1. Simulation of milk yield**

| Source | Actual | Predicted |
|---|---|---|
| Velasco, 1962 | 8.3 | 7.4 |
| Pope et al., 1963 | 10.3 | 10.5 |
| Deutscher, 1970 | 8.5 | 8.9 |
| Kropp, 1972 | 12.1 | 12.6 |
| Lusby et al., 1974 | 12.5 | 13.1 |
| Omar, 1974 | 10.4 | 9.8 |
| Omar, 1974 | 15.0 | 15.0 |
| Wyatt et al., 1977 | 10.1 | 10.7 |
| Average | 10.9 | 11.0 |

**Table 2. Simulation of forage intake**

| Source | Actual | Predicted |
|---|---|---|
| Kartchner, 1975 | 5.36 | 6.08 |
| Lusby et al., 1976 | 2.88 | 5.08 |
| Wyatt et al., 1977 | 7.02 | 6.30 |
| Barnes et al., 1978 | 8.52 | 8.11 |
| LeDu and Baker, 1979 | 3.31 | 3.52 |
| Weighted average | 6.56 | 6.52 |

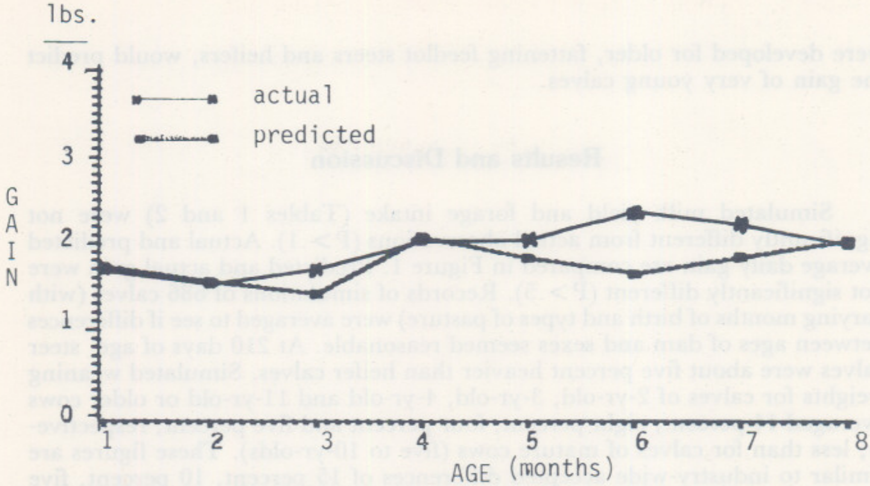



**Figure 1. Actual and predicted calf average daily gain.**

**Table 3. Example of output from TRS-80 Model 16.**

**Simulation of Calf Gain From Birth to Weaning Adapted From Thesis of Margy Cannon, Oklahoma State University**

| Milk Prod | Birth Wt | Month of Weaning | Type of Cow Pasture | Type of Creep Pasture |
|---|---|---|---|---|
| 11 | 75 | November | Tall Native | None |

**Weaning Weight By Age of Dam and Month of Birth**

**STEERS**

| | Month of Birth | |
|---|---|---|
| Cow Age | February | March |
| 2 Years | 442 | 424 |
| 3 Years | 461 | 448 |
| 4 Years | 504 | 462 |
| 5 to 10 | 517 | 473 |
| Over 10 | 494 | 453 |
| CALF AGE | 275 | 244 |

**HEIFERS**

| | Month of Birth | |
|---|---|---|
| Cow Age | February | March |
| 2 Years | 428 | 402 |
| 3 Years | 456 | 432 |
| 4 Years | 470 | 455 |
| 5 to 10 | 499 | 466 |
| Over 10 | 462 | 437 |
| CALF AGE | 275 | 244 |

## Table 4. Example of output from TRS-80 Model 16

Herd Averages Based On Herd Composition

| Milk Prod | Birth Wt | Month Of Weaning | Type of Cow Pasture | Type of Creep Pasture |
|---|---|---|---|---|
| 11 | 75 | November | Tall Native | None |

Herd Composition

| Cow Age | Percent | Month of Birth | Percent |
|---|---|---|---|
| Two Year Olds | 15 | February | 65 |
| Three Year Olds | 12 | March | 35 |
| Four Year Olds | 10 | | |
| Five To Ten Year | 60 | | |
| Over Ten | 3 | | |

Average Weaning Weights

| Cow Age | Steers | Heifers | Overall |
|---|---|---|---|
| Two Year Olds | 436 | 419 | 427 |
| Three Year Olds | 457 | 447 | 452 |
| Four Year Olds | 489 | 465 | 477 |
| Five To Ten Years | 501 | 488 | 494 |
| Over Ten | 480 | 453 | 466 |
| HERD AVERAGE | 484 | 469 | 477 |

## Table 5. Example of output from TRS-80 Model 16.

Simulation of Calf Gain From Birth to Weaning
Adapted From Thesis of Margy Cannon, Oklahoma State University

| Milk Prod | Birth Wt | Month of Weaning | Type of Cow Pasture | Type of Creep Pasture |
|---|---|---|---|---|
| 11 | 75 | November | Tall Native | None |

Weaning Weight by Age of Dam and Month of Birth

STEERS

| | Month of Birth | | | |
|---|---|---|---|---|
| Cow Age | February | March | April | May |
| 2 Years | 442 | 424 | 402 | 385 |
| 3 Years | 461 | 448 | 419 | 400 |
| 4 Years | 504 | 462 | 431 | 433 |
| 5 to 10 | 517 | 473 | 440 | 441 |
| Over 10 | 494 | 453 | 423 | 403 |
| CALF AGE | 275 | 244 | 214 | 183 |

HEIFERS

| | Month of Birth | | | |
|---|---|---|---|---|
| Cow Age | February | March | April | May |
| 2 Years | 428 | 402 | 382 | 371 |
| 3 Years | 456 | 432 | 408 | 383 |
| 4 Years | 470 | 455 | 419 | 392 |
| 5 to 10 | 499 | 466 | 428 | 400 |
| Over 10 | 462 | 437 | 412 | 387 |
| CALF AGE | 275 | 244 | 214 | 183 |

**Table 6. Example of output from TRS-80 Model 16**

| Milk Prod | Herd Averages Based on Herd Composition<br>Birth Wt | Month of Weaning | Type of Cow Pasture | Type of Creep Pasture |
|---|---|---|---|---|
| 11 | 75 | November | Tall Native | None |

| | Herd Composition | | |
|---|---|---|---|
| Cow Age | Percent | Month of Birth | Percent |
| Two Year Olds | 15 | February | 45 |
| Three Year Olds | 12 | March | 25 |
| Four Year Olds | 10 | April | 20 |
| Five to Ten Year | 60 | May | 10 |
| Over Ten | 3 | | |

| | Average Weaning Weights | | |
|---|---|---|---|
| Cow Age | Steers | Heifers | Overall |
| Two Year Olds | 424 | 407 | 415 |
| Three Year Olds | 443 | 433 | 438 |
| Four Year Olds | 472 | 449 | 460 |
| Five to Ten Years | 483 | 467 | 475 |
| Over Ten | 460 | 438 | 449 |
| HERD AVERAGE | 467 | 451 | 459 |

## Literature Cited


Barnes, K. C. et al., 1978. Proc. Am. Soc. Anim. Sci., (Abstr.).
Brorsen, B. W. 1980. M.S. Thesis. Oklahoma State University, Stillwater.
Deutscher, G. H. 1970. M.S. Thesis. Oklahoma State University, Stillwater.
Kartchner, R. J. 1975. Ph.D. Dissertation. Oregon State University, Corvallis.
Kropp, J. R. 1972. M.S. Thesis. Oklahoma State University, Stillwater.
LeDu, Y.L.D. and L. D. Baker. 1979. J. Agr. Sci. 92:443.
Lusby, K. S. et al., 1974. Res. Rep. MP-92 Okla. Agr. Exp. Sta.
Omar, M. A. 1974. M.S. Thesis. Oklahoma State University, Stillwater.
Pope, L. S. et al., 1963. Res. Rep. MP-70:69 Okla. Agr. Exp. Sta.
Velasco, M. 1962. M.S. Thesis. Oklahoma State University, Stillwater.
Wyatt, R. D. et al., 1977. J. Anim. Sci. 45:1138.
Wyatt, R. D. et al., 1977. J. Anim. Sci. 45:1120.

# Energy vs Protein Supplementation of Steers Grazing Native Range in Late Summer

K.S. Lusby[1] and G.W. Horn[2]

## Story in Brief

Thirty-six Hereford and Hereford X Angus crossbred calves weighing about 350 lb were grazed on native range from July 20 to September 15, 1982. Steers were divided into four groups and fed no supplement (control), .8 lb/day of protein supplement with and without Monensin®, and 3.0 lb/day of a 10 percent protein corn-based supplement. Soybean meal was the protein source. Supplements were fed on Monday, Wednesday and Friday. Average daily gains for the 56-day period were 1.35, 1.72, 1.77 and 1.38 pounds, respectively. Pounds of supplement per pound of added gain were 2.16, 1.90 and 60.0 for the .8 lb with and without Monensin®, and for the 10 percent protein supplements, respectively. These results are in agreement with a similar study conducted in 1981 and show that supplemental protein efficiently improves gains on native range in late summer. The small amount of supplemental protein apparently increases forage intake and digestibility.

## Introduction

Feeding small amounts of high protein meals to ruminants consuming low quality roughages has been shown to increase forage digestibility and intake. A previous study at OSU showed a .4 lb/day increase in daily gain from feeding .8 lb of a protein meal to 575 lb steers from mid-July to mid-October. If efficient increases in weight gains can be accomplished with small amount of protein, the costs of summer grazing could be reduced. The objective of this research was to verify the effectiveness of supplementation with small amounts of protein with and without Monensin® vs an energy supplement fed to lightweight steers grazing native range in late summer.

## Experimental Procedures

Thirty-six Hereford and Hereford X Angus crossbred steers, about nine months old, were allotted by breed to four treatments. Treatments were: (1) control, no supplement; (2) .8 lb per day of a 39 percent protein supplement; (3) .8 lb per day of a 39 percent supplement to provide 80 mg Monensin® per head per day; and (4) 3.0 lb per day of a 10 percent protein supplement. Composition of the supplements is shown in Table 1. Treatments 2, 3 and 4 provided the same amounts of supplemental protein, but treatment 4 provided additional supplemental energy. Each supplement provided about 9 g. of calcium, phosphorus and potassium per day. All supplements were fed on

[1]Associate Professor of Animal Science [2]Professor of Animal Science

**Table 1. Supplement composition (percentage as fed).**

| | Treatment | | |
|---|---|---|---|
| | 2 | 3 | 4 |
| | .8 lb/day 39% protein | .8 lb/day 39% protein with Monensin® | 3.0 lb/day 10% protein |
| Ingredients, % | | | |
| Soybean meal | 87.5 | 87.5 | 4.0 |
| Corn | — | — | 92.85 |
| Limestone | 1.5 | 1.5 | .6 |
| Dicalcium phosphate | 10.0 | 10.0 | 1.8 |
| Potassium chloride | 1.0 | 1.0 | .75 |
| Rumensin 60® (60 gm/lb) | — | 3.3 lb/ton | — |

Monday, Wednesday and Friday with supplement amounts prorated to give the prescribed daily amount. Salt and minerals were provided free-choice for control steers.

The trial was conducted at the Lake Carl Blackwell Range 10 miles west of Stillwater in North Central Oklahoma. Liberal stocking rates (9 acres/steer) and 2-week pasture rotation between treatments were used to reduce chances of pasture effects. Weights of the steers were taken after the steers were held off pasture and water overnight.

## Results and Discussion

Gains of steers and pounds of supplement required per pound of added gain are shown in Table 2. Steers fed no supplement gained 1.35lb/day. Feeding .8 lb/day of protein supplement increased daily gains over the 56-day period to 1.72 lb/day with a conversion of 2.16 lb supplement per pound of added gain. Feeding Monensin® increased daily gain an additional .05 lb/day and improved the conversion of supplement to gain to 1.90 pounds of supplement per pound of added gain. Steers fed 3.0 lb/day of the 10 percent protein supplement gained 1.38 lb/day, only slightly more than the control steers.

**Table 2. Weight gains of steers fed protein and energy supplements.**

| | Treatments[a] | | | |
|---|---|---|---|---|
| | Control No Supp. | .8 lb 39% Prot. | .8 lb 39% Prot. with Monensin® (80 mg/day) | 3.0 lb 10% Prot. |
| No. steers/treatment | 9 | 9 | 9 | 9 |
| Initial wt., 7/20/82 | 335 | 361 | 339 | 339 |
| Final wt., 9/15/82 | 411 | 457 | 438 | 416 |
| Total gain, lb. | 76[a] | 96[b] | 99[b] | 77[a] |
| Daily gain, lb. | 1.35[a] | 1.72[b] | 1.77[b] | 1.38[a] |
| lb supp./lb added gain | | 2.16 | 1.90 | 60.0 |

[a,b]Means with different superscript letters differ ($p<.05$).

Results of this study are in close agreement with a similar study in which the same .8 lb/day protein supplement and 3.0 lb/day energy supplement were fed to 575 lb steers on native range from mid-July to mid-October (Lusby, et. al., 1982). In the previous study gains for the control, .8 and 3.0 lb/day treatments were 1.46, 1.91 and 1.78 lb/day.

The efficient improvements in added gain for the protein supplement strongly suggests an increase in both forage intake and digestibility. Forage samples clipped to estimate forage being consumed by the steers are shown in Table 3. Range forage contained 7.7 percent crude protein (CP) and 52.3 percent in vitro dry matter digestibility (IVDMD) on August 6 and only 4.7 percent CP and 35.6 percent IVDMD on September 15. Both forage samples would have been deficient for light-weight steers to gain over 1 lb/day. The low protein content of the forage also explains the poor response to the energy supplement because protein would have been the first limiting nutrient in the diet. The response to Monensin® was lower than seen in many studies and may have been due to the Monensin® being fed in a protein supplement. One of the effects of Monensin® is to spare protein, and this effect would not be observed in a high protein supplement.

**Table 3. Crude protein and in vitro dry matter digestibility (IVDMD) of native forage grazed by steers**

| | Crude Protein (% of DM) | IVDMD (%) |
|---|---|---|
| Sampling date: | | |
| August 6 | 7.7 | 52.3 |
| September 15 | 4.7 | 35.6 |

In order to observe the efficient increases in gain with the high protein supplements, there must be adequate range forage. The principle effect of protein with this type of forage is probably to increase forage intake and digestion and there must, therefore, be ample forage for the cattle. The application of these data to other forages such as fescue and bermuda is less clear and needs to be researched further.

If supplements used in this study were priced at $245/ton, $253/ton and $135/ton for the .8 lb/day supplements with and without Monensin® and the 3.0 lb/day supplement, respectively, feed costs for each pound of added gain would have been $0.26, $0.24 and $4.05, respectively.

## Literature Cited

Lusby, K.S., et. al. 1982. Okla. Agr. Exp. Sta. Rep. MP-112:36.

# Effect of Ammoniation on Weight Gains and Straw Intake of Yearling Steers

**D. W. Pace[1], G. W. Horn[2] and K. S. Lusby[3]**

## Story in Brief

Forty-four crossbred yearling steers that weighed 514 lb were fed untreated wheat straw and 0.8, 1.0 and 1.2 lb supplemental crude protein per day or ammoniated wheat straw and 1.0 lb supplemental crude protein per day during a 100-day study. Gains of steers fed untreated wheat straw were about .57 lb/day and were not influenced by amount of supplemental crude protein. Steers fed ammoniated wheat straw and 1.0 lb of supplemental crude protein per day gained 1.25 lb/day. Ammoniation of wheat straw increased intake of straw by 27 percent. The use of ammoniated wheat straw would be an alternative feeding strategy in emergency feeding programs for yearling stocker cattle.

## Introduction

Because of the high quality of wheat forage, gains of stocker cattle on wheat pasture are potentially good. A common problem of wheat pasture stocker enterprises, which was faced by many stocker operators during the fall of 1982, is inadequate amounts of wheat forage for fall grazing. Producers who purchase cattle well ahead of the wheat pasture turn-out date frequently must turn to alternative feeding strategies until adequate forage is available for grazing.

Large amounts of crop residues (primarily wheat straw in Oklahoma) are available as a potential feedstuff. Both the digestibility and crude protein content of wheat straw are generally low, and can be increased by treatment with ammonia. The objective of this study was to compare weight gains and straw intake of yearling steers fed untreated and ammoniated wheat straw and varying amounts of supplemental crude protein.

## Experimental Procedure

The study was conducted from January 5 to April 15, 1982 (100 days) at the Range Cow Research Center, Stillwater, Oklahoma. Forty-four crossbred (mixed British breeds) yearling steers with a mean initial weight of 514 ± 45 lb were randomly assigned to four treatments of 11 steers each in a completely random design. Treatments are shown in Table 1.

Large round bales of untreated and ammoniated wheat straw were fed on a free-choice basis in panel-type feeders on concrete pads. About 3.5 lb (as-fed) of corn and soybean meal based supplements, which contained 24.8, 31.8 or 38.5 percent crude protein (dry basis) and 4.3 percent dicalcium phosphate, 1.4 percent trace-mineralized salt and 5700 I.U. of vitamin A/lb of supple-

[1]Graduate Assistant [2]Professor of Animal Science [3]Associate Professor of Animal Science

**Table 1. Treatments**

| Straw: | Untreated wheat straw | | | Ammoniated wheat straw |
|---|---|---|---|---|
| Treatment: | 1 | 2 | 3 | 4 |
| Supplement, lb DM/hd/day | 3.12 | 3.15 | 3.23 | 3.15 |
| Crude Protein content of supplement, % of DM | 24.84 | 31.83 | 38.48 | 31.83 |
| Supplemental crude protein, lb/hd/day | .80 | 1.0 | 1.2 | 1.0 |

ment, were fed to the steers daily in individual feeding stalls. Actual amounts of supplements that were fed were varied as shown in table 1 according to crude protein analyses of the supplements. Steers fed ammoniated straw received 1.0 lb supplemental crude protein (i.e., supplement number 2) in an attempt to gain some information in regard to the "feeding value" of the increased crude protein of ammoniated wheat straw.

The wheat straw was ammoniated by the "stack method" similar to that described by Sundstøl et al. (1978). Twenty-eight large round bales of straw (two rows of 14 bales placed end-to-end per row) were rolled onto one edge of a 40 ft × 100 ft sheet of black plastic (.20 mm thick). The remaining free portion of the plastic sheet was pulled over the bales and the edges were rolled together and sealed. The ends of the stack were tied off with nylon cord after a one-half inch (O.D.) black pipe had been placed into the stack. Anhydrous ammonia (3.5 percent w/w of straw DM) was injected into the sealed stack through the black pipe that opened into half an empty 55 gal oil drum in the middle of the stack. The stack remained sealed for 30 days after injection of ammonia.

Untreated and ammoniated bales of straw were sampled with a forage probe immediately prior to placing the bales in the panel-type feeders. Samples were stored in double plastic bags in a freezer until analyses were completed. Crude protein content of the samples was determined by the macro-Kjeldahl procedure prior to drying to avoid loss of ammonia. In vitro dry matter digestibility (IVDMD) was determined by the Tilley and Terry (1963) procedure with urea (.5 g/liter) added to the buffered rumen fluid (1 part strained rumen fluid:1 part McDougall's buffer, 1948) and a 24 h acid-pepsin digestion phase. Residual DM was collected by use of a Buchner funnel fitted with pre-weighed, oven-dried Whatman No. 4 filter papers.

Steers were weighed after being held off straw, supplements and water for 24 hours. To minimize differences in fill of steers among treatments, a maintenance level of good-quality alfalfa hay was fed to all steers for 5 days at the end of the trial. The steers were reweighed after an 18-hour shrink without feed and water.

Voluntary consumption of wheat straw by steers of treatments 2 and 4 was measured during days 55 through 68 of the trial. Steers were fed 6 grams chromic oxide in their daily allotment of supplement during 9-day preliminary and 5-day fecal collection periods. Fecal samples were collected from the rectum each time the steers were fed supplement, and were composited across days, within steers, on an equal wet weight basis for drying at 60 C and subsequent analyses. Fecal outputs were estimated by chromium dilution.

## Results and Discussion

Crude protein content and IVDMD of untreated and ammoniated wheat straw are shown in Table2. Crude protein content of wheat straw was increased from 6.03 to 13.56 percent by ammoniation. Calculated recovery of ammonia injected into the stack during ammoniation was 34.4 percent, which is similar to 33 percent reported by Sundstøl et al. (1978). The IVDMD of wheat straw was increased about 29 percent by ammoniation.

Gains of steers (Table3) fed untreated wheat straw (i.e., treatments 1, 2 and 3) were about .57 lb/day and were not ($P > .01$) influenced by amount of supplemental crude protein that was fed. The similar gains of steers fed untreated wheat straw indicate that gains were limited by energy consumption rather than amount of supplemental crude protein. Gains of steers fed ammoniated wheat straw and 1.0 lb of supplemental crude protein per day were 1.25 lb/day, and were about 2.2-fold greater than gains of steers fed untreated straw. Gains of steers (calculated after feeding alfalfa hay for 5 days at the end of the trial) were .73 lb/day (mean of treatments 1, 2 and 3) and 1.39 lb/day for steers fed ammoniated wheat straw. Ammoniation of wheat straw increased gains about 1.9-fold. Consumption of straw by steers was increased about 27 percent (2.17 vs 1.71 percent of body wt) by ammoniation (table 3). The increased consumption of straw as a result of ammoniation is a major factor in the improved performance of cattle fed ammoniated crop residues.

**Table 2. Compostion of straw**

| Item | Untreated straw | Ammoniated straw |
|---|---|---|
| Crude protein, % of DM | 6.03 | 13.56 |
| IVDMD, % | 33.8 | 43.6 |
| Recovery of ammonia-nitrogen, % | — | 34.4 |

**Table 3. Weight gains and wheat straw intake of steers**

| | Untreated straw | | | Ammoniated straw |
|---|---|---|---|---|
| Treatment: | 1 | 2 | 3 | 4 |
| Supplemental crude protein, lb/hd/day | .80 | 1.0 | 1.2 | 1.0 |
| Initial wt of steers, lb | 517 | 513 | 517 | 509 |
| Daily gain of steers, lb | | | | |
| 1/5/82-4/15/82 (100 days) | .53[a] | .61[a] | .56[a] | 1.25[b] |
| 1/5/82-4/20/82* | .67[a] | .80[A] | .71[a] | 1.39[b] |
| Straw DM intake | | | | |
| lb | | 9.49 | | 13.04 |
| Percentage of body wt | | 1.71 | | 2.17 |

*After feeding alfalfa hay for 5 days.
[ab]Means with different superscripts are different ($P < .01$).

While the gains of steers fed ammoniated wheat straw would be on the low end of profitable gains of stocker programs, they would exceed gains of many emergency feeding programs. Utilization of ammoniated wheat straw would be one alternative feeding strategy in emergency feeding programs for yearling stocker cattle.

## Literature Cited


McDougall, E. I. 1948. Biochem. J. 43:49.

Sundstol, F. et al., 1978. World Animal Review. 26:13.

Tilley, J. M. A. and R. A. Terry. 1963. J. Brit. Grassl. Soc. 18:104.

# Comparison of Cottonseed Hulls, Rice Mill Feed, Soybean Hulls and Beet Pulp as Roughages

Robert N. Streeter[1] and G. W. Horn[2]

## Story in Brief

Intake and digestibility of dry matter (DM) and acid-detergent fiber (ADF) of cottonseed hulls, rice mill feed, soybean hulls and beet pulp by mature crossbred wethers was measured. Intake and DM and ADF digestibility of rice mill feed were the lowest. The data indicate that soybean hulls and/or beet pulp would be much better alternative roughages to cottonseed hulls to decrease the energy density of grain fed free-choice to stocker cattle on pasture.

## Introduction

Stocker cattle on wheat pasture are frequently given free-choice access to supplemental feed in self-feeders. If grain is fed, it is usually necessary to decrease the energy density with a roughage such as cottonseed hulls. Because of decreased availability of cottonseed hulls and cost, there has been interest in alternate roughage sources that are suitable for this use. Intake and digestibility of dry matter (DM) and acid-detergent fiber (ADF) of cottonseed hulls, rice mill feed, soybean hulls and beet pulp fed to mature sheep were measured in this study.

## Experimental Procedure

Twenty crossbred wethers with a mean initial weight of 92 pounds were allotted by weight to four treatments. The lambs had been fed cottonseed hulls and .44 lb/day of a soybean meal based supplement for 10 days prior to allotment to treatments. Lambs were individually fed cottonseed hulls, rice mill feed, soybean hulls or beet pulp ad libitum and .44 lb/day of a supplement that consisted of soybean meal, 92 percent; dicalcium phosphate, 7 percent; trace-mineralized salt, 1 percent; and supplemental vitamins A and D. Consumption of roughages by the lambs was measured for 14 days. Total fecal excretion of the lambs was measured by use of fecal collection bags during the last 5 days of the trial. The roughages were limit fed at a level of 2 percent of body weight for 2 days prior to the fecal collection period and during the fecal collection period. Digestibility of roughage DM and ADF was calculated by "difference" (Schneider and Flatt, 1975). Digestibilities of supplement DM and ADF of 83 and 70 percent, respectively, were assumed in the calculations. The lambs were weighed at the beginning and end of the trial after feed and water were withheld for 24 and 18 hours, respectively.

---

[1]Undergraduate in Animal Science [2]Professor of Animal Science

## Results and Discussion

Crude protein and ADF contents of the roughages are shown in Table 1. Roughage intake, digestibility of roughage DM and ADF and weight gains of the lambs are shown in Table 2. Consumption of rice mill feed was lowest and consumption of soybean hulls was highest. Digestiblity of DM and ADF of rice mill feed was lower than that of the other roughages. Digestibility of DM and ADF of soybean hulls and beet pulp were good and much higher than that of cottonseed hulls. Weight gains of lambs fed soybean hulls and beet pulp were two-fold greater than lambs fed cottonseed hulls. Gains of lambs fed rice mill feed were the lowest. The results indicate that soybean hulls and beet pulp would be excellent alternative roughages to cottonseed hulls to decrease the energy density of grain fed free-choice to stocker cattle on pasture. Prices of soybean hulls and beet pulp vary markedly with season and location. There are times in which they can economically be used for this purpose.

**Table 1. Crude protein and acid-detergent fiber (ADF) content of roughages**

| | Roughage | | | |
|---|---|---|---|---|
| | Cottonseed hulls | Rice mill feed | Soybean hulls | Beet pulp |
| Crude protein, % of DM | 5.54 | 8.98 | 13.32 | 10.63 |
| ADF, % of DM | 67.2 | 48.3 | 47.2 | 31.2 |

**Table 2. Roughage intake, digestibility of roughage dry matter (DM) and acid-detergent fiber (ADF) and weight gains of lambs**

| | Roughage | | | |
|---|---|---|---|---|
| | Cottonseed hulls | Rice mill feed | Soybean hulls | Beet pulp |
| Number of lambs | 5 | 5 | 5 | 5 |
| Roughage intake | | | | |
| lb DM/day | 2.75[a] | 2.09[b] | 3.00[a] | 2.65[a] |
| % of body wt | 2.75[ab] | 2.33[b] | 3.12[a] | 2.77[ab] |
| DM digestibility[d], % | 41.1[a] | 30.9[b] | 75.0[c] | 81.4[d] |
| ADF digestibility[d], % | 34.9[a] | 3.2[b] | 73.4[c] | 76.4[c] |
| Weight gain of lambs, lb | 5.5[a] | 1.6[a] | 11.5[b] | 13.7[b] |

[abc]Means with common lettered superscripts are not different (P>.05).
[d]Roughages limit-fed at a level of 2% of body weight during fecal collection period.

## Literature Cited

Schneider and Flatt. 1975. The Evaluation of Feeds Through Digestibility Experiments. p. 165.

# Effects of Postpartum Weight Loss on Performance of Fall Calving Cows

J. Rakestraw[1], K.S. Lusby[2], R.P. Wettemann[3] and J.J. Wagner[4]

## Story in Brief

In each of two years, 54 mature Hereford cows in good body condition were allotted to one of 3 nutritional treatments at the time of calving in September and October. Treatments were (1) maintain weight from calving through breeding, (2) lose 10 percent of their post-calving weight from calving to the beginning of breeding and (3) maintain weight from calving to breeding but lose 10-15 percent of their body weight during the breeding season (December 1 — February 1). Due to forage and weather conditions, weight losses during the first year were less than anticipated and greater than planned during the second year.

Weight loss before breeding tended to delay the interval to estrus. Cows that lost weight during the breeding season had lower conception rates. Weight loss during breeding was especially detrimental to rebreeding when it followed weight loss before breeding as occurred during the second year. These results show that good condition at calving is not enought to guarantee good reproductive performance of fall calving cows.

## Introduction

It has been shown that cows losing weight after calving tend to have longer postpartum intervals from calving to estrus than cows that are gaining weight. Most cows in Oklahoma, whether spring of fall calving, will lose weight from calving to breeding. Fall calving cows and early spring calving cows frequently lose weight during the breeding season as well. It is important, therefore, that the effect of weight loss before and during the breeding season on cow reproduction and calf performance be measured so that feed resources might be more effectively allocated. The objective of this research was to determine the effects of weight loss before and during the breeding season on rebreeding of cows and performance of calves.

## Experimental Procedure

This report covers the first two years of this study conducted during the 1980-81 and 1981-82 breeding seasons. All cows were mature Herefords that calved from mid-September to late October. The cows grazed bermuda pastures until calving and were moved to native grass shortly after calving.

[1]Graduate Assistant, Animal Science Department. [2]Associate Professor, Animal Science Department.
[3]Associate Professor, Animal Science Department. [4]Graduate Assistant, Animal Science Department.

One day each week, cows with calves at least 2 days old were weighed (1st postpartum weight), scored for body condition (1 = very thin to 9 = very fat) and allotted by block to one of three treatments based on date of calving. Treatments were: (1) maintain weight from calving though breeding, (2) lose about 10 percent of their postcalving weight from calving to the beginning of breeding and be fed the same as Group 1 during breeding and (3) maintain weight from calving to breeding followed by a loss of 10-15 percent of their body weight during the breeding season.

Supplemental feed for both years consisted of cottonseed meal at the rate of from 2 to 3 lb/head/day from calving to breeding for Groups 1 and 3 and no cottonseed meal before breeding for Group 2. During the breeding season Groups 1 and 2 were fed 4 lb/head/day of cottonseed meal while Group 3 was fed none. Hay was fed only when snow or ice covered the dormant forage. Year 1 was very mild but year 2 was cold with extended periods of rain and ice. Following breeding, all cows were fed together at the rate of 4 lb/hd/day of cottonseed meal with hay fed when snow or ice covered available forage.

All calves were weighed, and males were castrated by banding at birth. Calves were weighed at the beginning and end of the breeding season and at weaning in mid-May. Cows were weighed and scored for body condition at 2-week intervals from calving to the end of breeding and at 28-day intervals to weaning. The breeding season was 60 days from about December 1 to February 1 each year. Estrus was detected by sterile bulls with chin-ball markers before breeding and by marker-equipped fertile Hereford bulls during the breeding season.

## Results and Discussion

Results of year 1 are shown in Table 1 and results of year 2 are shown in Table 2. Since significant treatment X year interactions were found, the data will be presented by year.

### Year 1

Due to mild winter and abundant forage, Group 2 lost less weight before breeding than anticipated. During the breeding season, cows in Group 3 lost an average of 149 lb or about 15 percent of their body weight. Weight losses following the breeding season were the inverse of weight losses from calving to the end of breeding. Group 1 cows were the heaviest at the end of breeding and lost the most weight from February to May. Group 3 cows were the thinnest at the end of breeding, but lost the least from February to May. Group 2 cows were intermediate. Since all groups were pastured together from February to May and fed the same amount of supplement, this would suggest that some compensatory gain response may occur in cows on low quality roughage diets. Body condition changes were similar to weight changes throughout the study.

Cows were in excellent condition at calving and all cows were observed in heat during the breeding season of year 1. Cows in Group 2 tended to have a longer interval from calving to first estrus than in Groups 1 or 3. Pregnancy rates were similar for cows in Groups 1 and 2 (79 and 88 percent), but were

**Table 1. Cow and calf performance: Year 1**

| | Treatment 1 | 2 | 3 | Prob. |
|---|---|---|---|---|
| Number of cows | 19 | 17 | 18 | |
| Cow wt, lb | | | | |
| After calving | 1041 | 1021 | 1027 | NS |
| Change to breeding | −6 | −32 | −9 | NS |
| Change during breeding | $-51^{a}$ | $-67^{a}$ | $-149^{b}$ | <.01 |
| Change from breeding to weaning | $-118^{a}$ | $-85^{b}$ | $-54^{c}$ | <.01 |
| Total change | −175 | −184 | −208 | NS |
| Cow condition score | | | | |
| After calving | 6.4 | 6.2 | 6.5 | NS |
| Change to breeding | −.27 | −.25 | −.38 | NS |
| Change during breeding | $-.36^{a}$ | $-.20^{a}$ | $-.93^{b}$ | <.01 |
| Change from breeding to weaning | −.24 | −.25 | .12 | NS |
| Reproductive performance | | | | |
| % pregnant | $79^{a}$ | $88^{a}$ | $50^{b}$ | <.05 |
| Days from calving to first estrus (number in heat) | 52(19) | 70(17) | 58(18) | NS |
| Calf wt, lb | | | | |
| Birth wt | 73 | 70 | 73 | — |
| Adjusted 205 day wt | 352 | 344 | 321 | NS |

[a,b,c]Means on the same line with different superscript letters differ (P<.05).
[d]Condition score based on scale of 1 through 9 where 1=very thin and 9=very fat.

**Table 2. Cow and calf performance: Year 2**

| | Treatment 1 | 2 | 3 | Prob. |
|---|---|---|---|---|
| Number of cows | 15 | 19 | 20 | |
| Cow wt, lb | | | | |
| After calving | 1015 | 1020 | 997 | NS |
| Change to breeding | $-45^{a}$ | $-175^{b}$ | $-69^{c}$ | <.01 |
| Change during breeding | $-86^{a}$ | $-4^{b}$ | $-106^{c}$ | <.01 |
| Change from breeding to weaning | −70 | −61 | −56 | NS |
| Total change | −200 | −241 | −231 | NS |
| Cow condition score | | | | |
| After calving | 6.3 | 6.3 | 6.2 | NS |
| Change to breeding | $-.4^{a}$ | $-1.4^{b}$ | $-.3^{a}$ | <.01 |
| Change during breeding | $-.37^{a}$ | $0.05^{b}$ | $-1.37^{c}$ | <.01 |
| Change from breeding to weaning | −.87 | −.55 | −.32 | NS |
| Reproductive performance | | | | |
| % pregnant | 87 | 53 | 65 | NS |
| Days from calving to first estrus (number in heat) | 46(15) | 61(13) | 45(13) | NS |
| Days from calving to conception | 82 | 86 | 84 | .07 |
| Calf wt, lb | | | | |
| Birth wt | 81 | 79 | 73 | — |
| Adjusted 205 day wt | 286 | 296 | 290 | NS |

[a,b,c]Means on the same line with different superscript letter differ (P<.05).
[d]Condition score based on a scale of 1 through 9 where 1=very thin and 9=very fat.

reduced for cows in Group 3 (50 percent). These results suggest that even if cows calve in good condition, reducing the level of nutrition before or during breeding can have detrimental effects on reproduction.

Calf weaning weights were low, reflecting the fact that calves were weaned in May without creep feed. Calves of Group 1 cows were the heaviest while calves of Group 3 cows were the lightest.

## Year 2

Cows calved in slightly lower body condition during year 2 compared to cows in year 1 and the cows in the second year had greater weight losses before and during the breeding season. Forage conditions were poorer and the weather was much more severe during the second year.

Group 2 cows lost 175 lbs and 1.4 condition units from calving to the beginning of the breeding season and exhibited estrus about 15 days later than cows in Groups 1 or 3. During the breeding season, Group 3 cows, which were fed no supplemental feed, lost 106 lbs while cows in Group 1 lost 86 lbs and cows in Group 2 lost only 4 lbs. Under the forage and weather conditions experienced in the second year, protein supplement and standing forage were inadequate to maintain weight in these lactating cows. More supplemental hay has been fed in the third year of this study to more closely control weight changes. The greater weight loss for cows in Group 1 than for Group 2 during the breeding season when both groups were fed alike is in agreement with postbreeding weight changes in the first year. It would appear than cows can readily mobilize energy stores to a point and then retain weight more efficiently. This may be due to reduced milk production, more efficient digestion or metabolism or other factors.

Rebreeding rates for cows that lost large amounts of weight either before or during the breeding season were reduced. Pregnancy rates were 87, 53 and 65 percent for Groups 1, 2 and 3, respectively. The low rebreeding rate for Group 2 is inconsistent with the first year. The 175 lb weight loss for Group 2 cows during year 2 was apparently enough to suppress estrus even in cows that calved in good condition. Only 13 of 19 cows in Group 2 were detected in heat compared to all cows in Group 1. Similar to results of year 1, rebreeding performance was reduced for cows in Group 3. The days from calving to first estrus were similar for cows in Groups 1 and 3, although less Group 3 cows were detected in estrus. Several cows were detected in estrus by teaser bulls before the breeding season. Apparently the 106 lb weight loss during breeding coupled with the 69 lb weight loss before breeding was enough nutritional stress that some Group 3 cows never cycled and some that cycled once before breeding did not cycle again.

It was possible in year 2 to compute the actual days from calving to conception. Conception was computed by subtracting 282 days from the next calving date. Calving intervals were 82, 86 and 84 days for Groups 1, 2 and 3. The apparent discrepancy between days to first estrus and days to conception is due to the number of cows in estrus before the breeding season and not due to breedings per conception. Even though less cows in Groups 2 and 3 were pregnant at the end of the breeding season, those cows that conceived did so early in the breeding season. Very few cows were in heat in January. Calf weights at 205 days were lower than in year 1, reflecting the greater weight loss of the cows in year 2.

## Conclusion

Cows in Group 1, which had the least weight and condition loss from calving though breeding, had the greatest percent of cows in heat and the most cows rebred in the first 2 years of this study. These data show that good condition at calving is not enough to guarantee good rebreeding rates. Weight loss before the breeding season can reduce the number of cows in estrus and lengthen the interval from calving to estrus in those cows that do cycle. A severe weight loss during breeding can reduce the rebreeding rate and is especially critical if there has been weight loss before the breeding season.

# Affect of Various Anthelmintics on Rate of Gain and Fecal Egg Count of Steers Grazing Wheat Pasture

J.A. Winder[1], K.S. Lusby[2]
D.R. Gill[3] and T.L. Evicks[4]

## Story in Brief

One hundred forty-two steers were randomly assigned to four treatment groups. One group received no anthelmintic treatment and served as a negative control. The steers in the remaining three groups were treated with one of the following commercial anthelmintics: Rumatel[2] (morantel tartrate), Thiabendazole[3] or Tramisol[4] (levamisole). The steers were individually weighed at the beginning of the test, at day 39 and at day 103 (final weight). Fecal samples were taken from approximately one-third of the steers at each weighing. Fecal egg counts were established for each sample.

Fecal egg counts were reduced by all anthelmintic treatments ($P < .05$) at both 39 and 103 days post treatment. Overall weight gains were not affected by deworming.

## Introduction

Internal parasites have been shown to be indigenous to essentially all of Oklahoma (Young, 1963). The degree to which parasitism effects productivity of winter stocker cattle has not been firmly established. The purpose of this study was to evaluate the efficacy of three commercial anthelmintics. Both rate of gain and fecal egg counts were evaluated.

## Materials and Methods

One hundred forty-two steers were randomly assigned to four treatment groups. One group received no anthelmintic treatment and served as a negative control. Each of the remaining groups were dewormed with one of the following commercial boluses: Morantel tartrate, levamisol or thiabendazole. The steers were individually weighed prior to treatment for day 1 to day 39 (period 1, December 11-January 19), day 39 to day 103 (period 2, January 19-March 18) and for the entire study (103 days). Fecal samples were taken from approximately one-third of the steers in each treatment group (fifty head) at the time of weighing. Fecal egg counts were later established for each sample by a private laboratory.

[1]Area Special Agent [2]Associate Professor [3]Professor of Animal Science [4]Extension Agent [5]Pfizer Inc. [6]Merck and Company [7]American Cyanamid

Financial assistance provided by Pfizer Inc. Appreciation to Mr. Bill Allford, McAlester, Oklahoma for providing cattle and pasture for this study.

**Table 1. Affect of anthelmintic on average daily gain.**

| Treatment | N | ADG, lb Period 1[c] | ADG, lb Period 2[d] | Overall ADG |
|---|---|---|---|---|
| Control | 39 | 2.37 | .58[a] | 1.26 |
| Rumatel | 36 | 2.27 | .41[b] | 1.11 |
| Thiabendazole | 33 | 2.38 | .56[ab] | 1.24 |
| Tramisol | 34 | 2.26 | .51[ab] | 1.18 |

[ab]Means with different superscripts are different ($P < .10$).
[c]December 11, 1982 - January 19, 1982.
[d]January 19, 1982 - March 18, 1982.

Following the initial treatment, the steers were placed on winter wheat pasture (December 11, 1982 until March 18, 1982). During this period, the steers received 2 lb of corn daily containing 50 mg of monensin per lb.

## Results and Discussion

Only minor differences were observed in average daily gain. The non-treated group gained slightly more ($P < .10$) than those steers receiving the Rumatel boluses in period 2 (day 29 to day 103). No treatment differences existed for overall gain (day 1 to day 103). Low daily gains during period 2 were due to inclimate weather for grazing and forage growth.

Pre-treatment fecal egg counts were similar for all treatments groups. However, sharp reductions in egg counts were noted in both post-treatment evaluations of samples taken from steers receiving anthelmintics (Table 2). Fecal egg counts were less ($P < .05$) in all treated groups at both 39 and 103 days post-treatment.

These data indicate that all three anthelmintics were effective in reducing the parasitic load. The lack of treatment differences in average daily gain indicate that the degree of parasitism was not severe enough to suppress growth rate. Had the parasitic load been heavier, a treatment response might have been expected. This is supported by the low correlations between fecal egg counts and average daily gain (Table 3).

**Table 2. Affect of anthelmintic of fecal egg count.**

| Treatment | N | Pretreatment | Post Treatment 39 days | Post Treatment 103 days |
|---|---|---|---|---|
| Control | 14 | 66.7 | 259.5[a] | 252.9[a] |
| Rumatel | 12 | 79.4 | 13.8[b] | 52.5[b] |
| Thiabendazole | 11 | 70.8 | 10.7[b] | 56.3[b] |
| Tramisol | 13 | 78.0 | 12.6[b] | 135.7[b] |

[ab]Means with different superscripts are different ($P < .05$).

**Table 3. Linear correlations between fecal egg counts and rate of gain.**

| | Pretreatments Egg Count | 39 Day Egg Count | 103 Day Egg Count |
|---|---|---|---|
| 39 Day Egg Count | .24 | | |
| 103 Day Egg Count | .29 | .36 | |
| ADG Period 1 | .21 | .08 | -.19 |
| ADG Period 2 | .17 | .01 | -.10 |
| ADG Total Period | .26 | .07 | -.23 |

## Literature Cited

Young, J. 1963. Internal parasites of cattle. OSU Circular E-750.

# Supplementation of Wheat Pasture and Bermudagrass Stocker Cattle With Silage

M. J. Ford[1], W. A. Phillips[2],
G. W. Horn[3] and Ann K. Worthington[4]

## Story in Brief

Ninety-six fall-weaned steer calves grazed wheat pasture and subsequently bermudagrass and were fed no supplemental feed (treatment 1) or were fed silage (treatments 2, 3 and 4) in amounts slightly in excess of what they would consume daily. Stocking rates on wheat pasture were about 2, 2, 1.5 and 1 acres/steer for treatments 1 through 4 respectively, and 1, 1, .75 and .5 acres bermudagrass/steer. Mean daily silage intakes of steers of treatments 2, 3 and 4 on wheat pasture were 1.77, 3.27 and 4.66 lb dry matter (DM) and 6.82, 6.98 and 7.33 lb DM on bermudagrass. Daily gains of steers during the December to March grazing period on wheat pasture were 2.04, 2.03, 1.81 and 1.53 lb. The decreased gains of steers of treatment 4 would be partially due to very low amounts of available wheat forage (i.e., about 10 percent of treatment 2) during the mid-winter and early spring grazing periods. Gains of steers of all treatments on bermudagrass were similar. Results indicate that steers substituted silage for bermudagrass forage, and that silage should not be fed continuously to stocker cattle on bermudagrass. Use of silage only during periods of low bermudagrass availability appears to be one means of adding stability to bermudagrass stocker enterprises.

## Introduction

Average daily gain is a key figure that affects the profitability of stocker cattle enterprises. Wheat forage is high quality, and gains of stocker cattle on wheat pasture were potentially good. However, gains of stocker cattle on wheat pasture are frequently decreased due to (1) inadequate amounts of fall and/or winter wheat forage and (2) stockers being "out of feed" because of snow and/or ice cover of wheat forage. Identification of sound feeding programs for wheat pasture stockers, therefore, has the potential of increasing total beef production from wheat pasture and adding *stability* to wheat pasture stocker operations.

It is sometimes more profitable to graze-out wheat rather than harvest a grain crop. If 2.5 and .67 acres of wheat will provide forage for a 400 lb steer from November 15 to March 15 and during the graze-out period, respectively, only about 27 percent of the area grazed during the fall and winter would be needed during the graze-out period. Stocker operators who elect to carry cattle through a graze-out program would need to purchase additional cattle or be able to carry more cattle during the November 15 to March 15 period. One approach would be to feed silage on wheat pasture throughout the wheat

---

[1]Graduate Assistant; [2]Research Scientist, USDA, ARA; [3]Professor, Animal Science; [4]Herdsman, Supervisor

pasture grazing period, and increase stocking rate during the November 15 to March 15 period. Feeding silage to wheat pasture stockers would have an additional advantage in that a relatively high quality feed would be available to sustain gains during periods of snow and/or ice cover of wheat pasture. At present, hay is commonly fed during snow and/or ice cover of wheat forage; and, at best, stocker weights are probably only maintained.

Large fluctuations in forage production also represent a major management problem in bermudagrass stocker programs. A project was begun in the fall of 1981 with the following objectives:

1. Determine the effect of feeding silage to stocker cattle grazed on wheat and subsequently bermudagrass pasture on:
   A. Stocker weight gains and total beef production per acre.
   B. Quantity of forage produced, and quality of available forage.
   C. Wheat and bermudagrass forage intake.
   D. Total ration (wheat or bermudagrass forage alone or forage *plus* silage) utilization.
2. Economics of producing beef on wheat and bermudagrass pasture alone or wheat and bermudagrass pasture plus silage.

Cattle performance data obtained during the first year of the project are reported herein.

## Experimental Procedure

Fifty-six fall-weaned Hereford and 40 Brahman crossbred steers (1/4 Brahman and 3/4 Hereford and Angus) with mean weights of 369 and 534 lb, respectively, were randomly allotted (within breed) to 4 treatments of 24 steers each in a randomized complete block design with 2 blocks of wheat pasture. The steers were grazed on wheat pasture followed by bermudagrass. Treatments were as follows:

| Treatment: | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Silage: | - | + | + | + |
| Acres wheat pasture/steer: | 2 | 2 | 1.5 | 1 |
| Acres bermudgrass/steer: | 1 | 1 | .75 | .5 |

During December 2, 1981 to March 25, 1982 (wheat pasture phase) and May 21, 1982 to September 3, 1982 (bermudagrass phase) steers of treatments 2, 3 and 4 were fed silage slightly in excess of what they would consume each day. Wheat silage, harvested in the soft-dough stage of maturity, was used initially. Corn silage was fed beginning July 19, 1982 because of a shortage of wheat silage. Silage was not fed during the wheat pasture graze-out period (March 26 through May 20, 1982), and steers of all treatments grazed a single wheat pasture within each block. Stocking rate during the wheat pasture graze-out period was about .6 acres/steer.

Hay was fed to steers of treatment 1 during periods of snow and/or ice cover of wheat pasture. Because of the mild winter, it was necessary to feed hay only one day (February 9, 1982).

Silage consumption was measured daily and samples were taken twice each week for analyses. Initial, intermittent and final shrunk live weights (over-night stand without feed or water) of the steers were measured to coincide with major changes in climatic growing conditions for wheat.

Available forage of all pastures was estimated by hand-clipping 3 randomly selected one-half square meter plots of each pasture 4 times during the grazing period on wheat and 5 times on bermudagrass.

## Results and Discussion

Silage consumption and amounts of available wheat forage during the period of feeding wheat silage on wheat pasture are shown in Figures 1 and 2, respectively. Daily silage consumption of steers of treatments 2, 3 and 4 was about 2.5 lb DM/head through the week of January 18. Consumption of silage by steers of treatments 3 and 4 increased markedly during the week of February 8 when available wheat forage was, respectively, only about 440 and 75 lb DM/head on February 8. These forage availabilities are equivalent to about 293 and 75 lb wheat forage DM/acre for treatments 3 and 4, respectively. For perspective, 6-inch tall wheat forage, planted on 12-inch row spacings, will yield about 500 lb forage DM per acre. Therefore, wheat of pastures of treatment 4 was extremely short at this time.

Gains of steers of treatments 1 and 2 were similar (Table 1) during the December to March grazing period on wheat pasture, whereas daily gains of steers of treatment 3 were .22 lb less. Daily weight gains of steers of treatment 4 were 0.5 lb lower than steers of treatment 1 and 2. The decreased gains of steers of treatment 4 were partially attributable to the low wheat forage availabilities (i.e., about 10 percent of treatment 2) during the late January

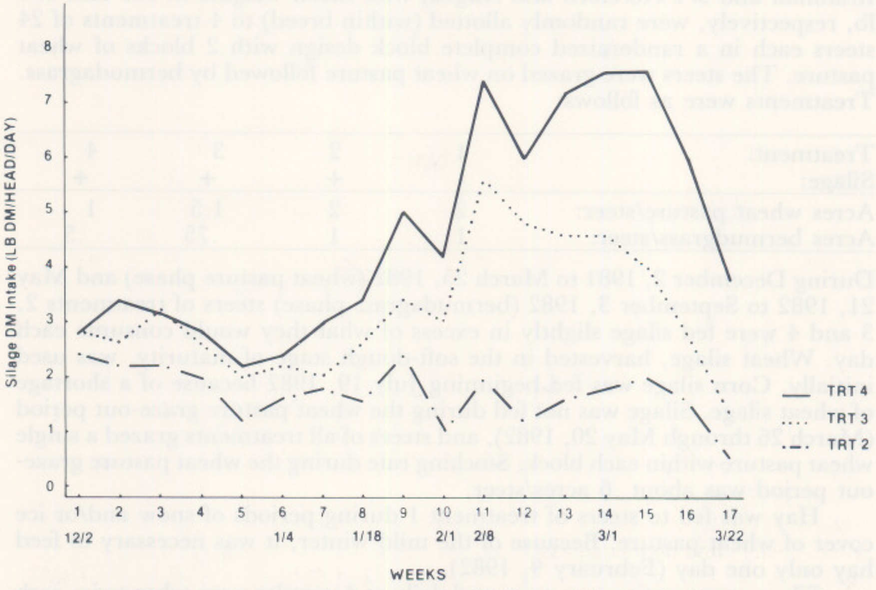



**Figure 1. Silage consumption (pounds DM/steer/day) of steers on wheat pasture. Mean DM and crude protein contents and IVDMD of wheat silage were: 35.3, 9.2 and 51.0%, respectively.**

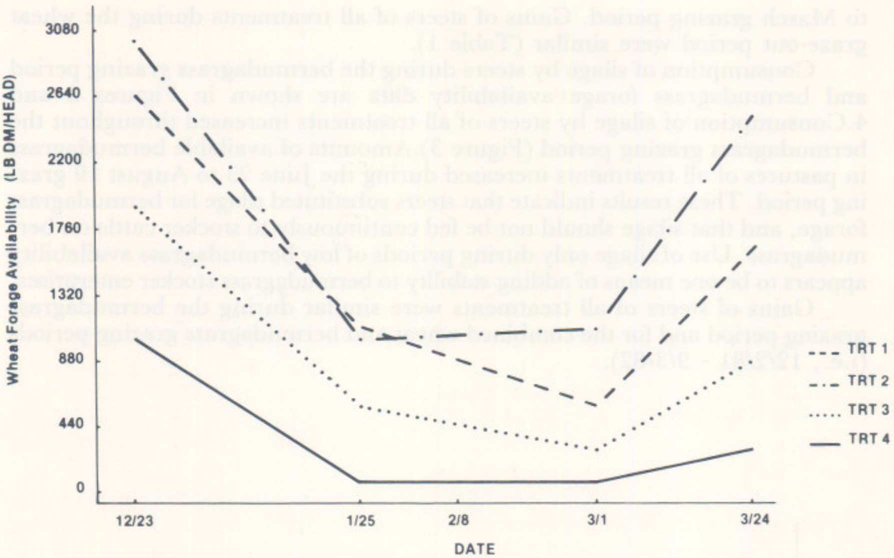



**Figure 2. Wheat forage availability (pounds DM/steer).**

## Table 1. Daily weight (wt) gains of steers

| Grazing phase | Treatment 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| Number of steers: | 24 | 23* | 23* | 24 |
| Wheat pasture | | | | |
| Initial wt of steers, lb | 443 | 442 | 442 | 431 |
| Daily gain of steers, lb | | | | |
| 12/2/81-3/25/82 (113 days) | 2.04[a] | 2.03[a] | 1.81[a] | 1.53[a] |
| 3/26/82-5/21/82[b] (Graze-out period, 57 days) | 1.96[a] | 1.91[a] | 2.08[a] | 2.19[a] |
| Bermudagrass | | | | |
| Initial wt of steers, lb | 785 | 780 | 765 | 728 |
| Daily gain of steers, lb | | | | |
| 5/22/82-9/3/82 (105 days) | 1.11[a] | 1.12[a] | 1.23[a] | 1.05[a] |
| Wheat pasture and bermudagrass | | | | |
| 12/2/81-9/3/82 (275 days) | 1.67[a] | 1.66[a] | 1.64[a] | 1.48[a] |

*One steer died of respiratory disease at beginning of wheat pasture grazing phase.
[a]Means are not different (P>.05).
[b]Silage was not fed during wheat graze-out period.

to March grazing period. Gains of steers of all treatments during the wheat graze-out period were similar (Table 1).

Consumption of silage by steers during the bermudagrass grazing period and bermudagrass forage availability data are shown in Figures 3 and 4.Consumption of silage by steers of all treatments increased throughout the bermudagrass grazing period (Figure 3).Amounts of available bermudagrass in pastures of all treatments increased during the June 23 to August 19 grazing period. These results indicate that steers substituted silage for bermudagrass forage, and that silage should not be fed continuously to stocker cattle on bermudagrass. Use of silage only during periods of low bermudagrass availability appears to be one means of adding stability to bermudagrass stocker enterprises.

Gains of steers of all treatments were similar during the bermudagrass grazing period and for the combined wheat and bermudagrass grazing periods (i.e., 12/2/81 - 9/3/82).

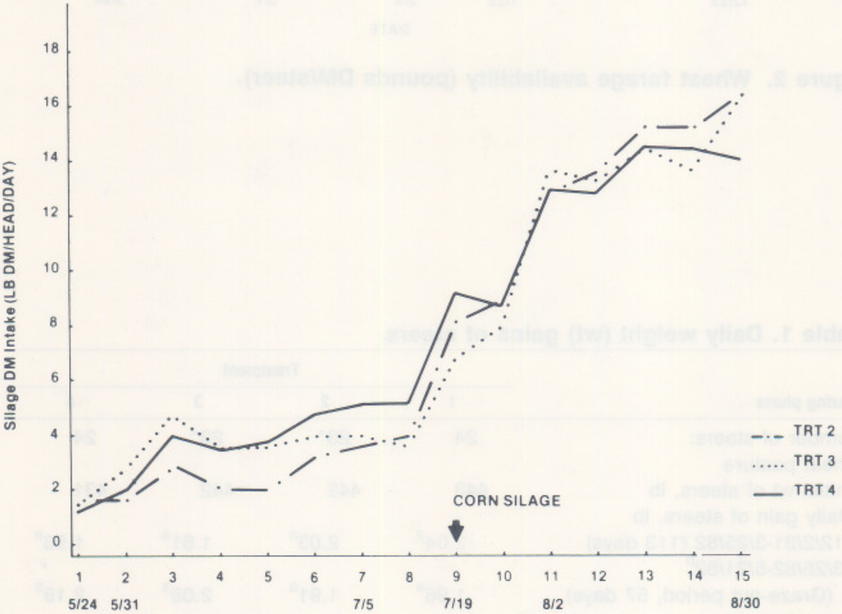



**Figure 3. Silage consumption (pounds DM/steer/day) of steers on bermudagrass. Mean DM and crude protein contents and IVDMD of silages were: (wheat silage) 35.7, 9.5 and 43.8%; (corn silage) 34.0, 10.3 and 58.1%.**

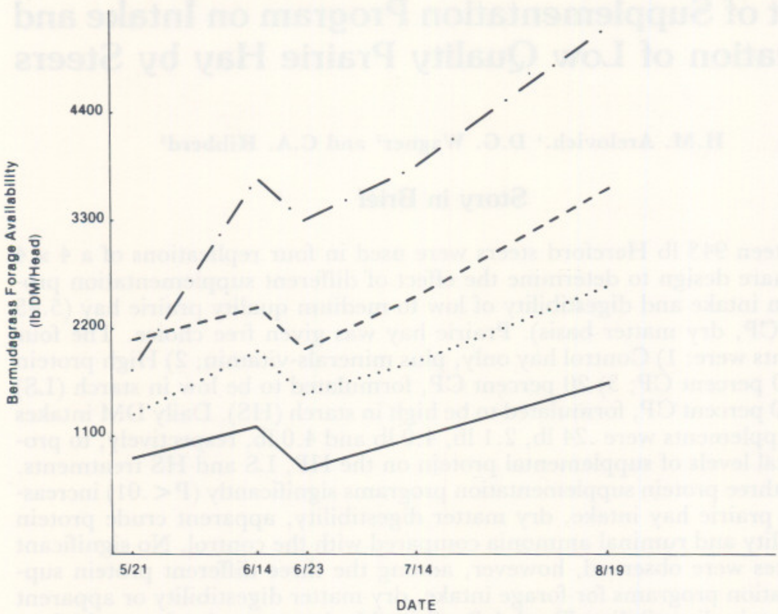



**Figure 4. Bermudagrass forage availability (pounds DM/steer).**

**In cooperation with USDA, Agricultural Research Service.**

# Effect of Supplementation Program on Intake and Utilization of Low Quality Prairie Hay by Steers

H.M. Arelovich.[1] D.G. Wagner[2] and C.A. Hibberd[3]

## Story in Brief

Sixteen 943 lb Hereford steers were used in four replications of a 4 x 4 latin square design to determine the effect of different supplementation programs on intake and digestibility of low to medium quality prairie hay (5.45 percent CP, dry matter basis). Prairie hay was given free choice. The four treatments were: 1) Control hay only, plus minerals-vitamin; 2) High protein (HP), 40 percent CP; 3) 20 percent CP, formulated to be low in starch (LS) and 4) 20 percent CP, formulated to be high in starch (HS). Daily DM intakes of the supplements were .24 lb, 2.1 lb, 4.0 lb and 4.0 lb, respectively, to provide equal levels of supplemental protein on the HP, LS and HS treatments.

All three protein supplementation programs significantly ($P<.01$) increased daily prairie hay intake, dry matter digestibility, apparent crude protein digestibility and ruminal ammonia compared with the control. No significant differences were observed, however, among the three different protein supplementation programs for forage intake, dry matter digestibility or apparent crude protein digestibility. Total daily digestible dry matter intake was highest on the 20 percent CP-LS and HS treatments. Rumen $NH_3$ concentration was very low ($P<.01$) on the control diet compared to the three protein supplement treatments, with ruminal $NH_3$ levels also being lower on the LS vs HS treatments.

## Introduction

A positive effect of protein supplementation on low quality forage intake and utilization has been widely recognized. Protein supplements often vary greatly in protein content and can be formulated from a wide variety of feeds. Supplements containing from 20 percent to 40 percent all natural crude protein are often fed to beef cattle (stockers, replacement heifers and cows, dry or lactating) grazing or being fed low quality roughages. This is especially true during the wintertime when protein supplementation is common. Low quality forages commonly used include winter range pasture, marginal quality grass hays or cereal straws. While protein supplementation has been shown to beneficial in improving forage intake and utilization of low quality forages, limited data has been reported about the effects of different types of protein supplementation programs (e.g. high vs low protein supplements fed at equal daily supplemental protein intakes; high vs low starch levels in the supplements; etc.). In addition to the effects of protein, starch content of the supplement might effect the rumen environment, altering activity of the ruminal microbial

[1]Graduate Student, Animal Science Dept. [2]Professor, Animal Science Dept.
[3]Assistant Proessor, Animal Science Dept.

population. Forage intake, forage utilization and/or animal performance may be altered. Some feeds, which can be used to formulate low protein cubes (e.g. 20 percent CP) may be high in starch, such as grains, or low in starch, such as by-product feeds.

The objective of this study was to investigate the effects of high protein (40 percent) or low protein (20 percent) supplements, fed at equal supplemental protein intakes, on forage intake, digestibility, rumen ammonia and rumen pH using low to medium quality prairie hay with the low protein supplements being formulated to be either low or high in starch. Prairie hay, plus supplemental minerals and vitamins, was used as a control.

## Materials and Methods

Sixteen mature Hereford steers (934 lb) were randomly allocated to metablolism stalls. A 4 x 4 latin square design was used with four replications (periods) and four treatments. There were four simultaneous replications of the latin square. The treatments were: Prairie hay, plus 1) minerals and Vitamin A (Control); 2) 40 percent CP, high protein supplement (HP); 3) 20 percent CP, low starch (LS) and 4) 20 percent CP, high starch (HS).

The ingredient composition of the supplements is shown in Table 1 and nutrient composition of the hay and supplements in Table 2. Low to medium quality prairie hay was fed "ad libitum" daily in all treatments. The HP, LS and HS supplements were fed twice daily to provide 2.1, 4.0 and 4.0 lb per day (DM basis), supplying equal levels of supplemental protein. Prairie hay, with only supplemental minerals and vitamin A, served as a control.

Each period in the Latin square was 17 days with days 1-7 being an adaptation period. Prairie hay, fed and rejected, was weighed on days 3-14, with total feces being collected on days 10-16. The rumen was sampled on day 17 within 4-8 hours after supplement was fed. Body weight was recorded at the end of each period.

Prairie hay (fed and rejected), supplements and feces were weighed and sampled for moisture and nitrogen determinations. All samples were also analyzed for acid detergent fiber, cellulose, lignin, starch and ash, although these

**Table 1. Ingredient composition of the supplements (DM basis).**

| Ingredient | Control % | 40% High Protein % | 20% CP-Low Starch % | 20% CP-High Starch % |
|---|---|---|---|---|
| Ground wheat | -- | -- | -- | 69.28 |
| Wheat midds | -- | -- | 84.16 | -- |
| Cottonseed meal | -- | 92.00 | 9.91 | 23.60 |
| Molasses | -- | 2.60 | 5.00 | 5.00 |
| KC1 | 37.81 | 1.60 | -- | .34 |
| Dicalcium phosphate | 54.02 | 2.80 | -- | 1.28 |
| $CaCO_3$ | -- | -- | .43 | -- |
| TM Salt | 7.57 | .93 | .46 | .46 |
| Vitamin A (30,000 IU/g) | .60 | .07 | .04 | .04 |

**Table 2. Dry matter and crude protein content of prairie hay and supplements.**

| Item | Control[b] % | 40% High Protein % | 20% CP-Low Starch % | 20% CP-High Starch % |
|---|---|---|---|---|
| | | Treatment | | |
| Dry matter, % | 87.5 | 90.0 | 88.8 | 87.3 |
| Crude protein, %[a] | 5.54 | 40.5 | 20.2 | 22.1 |

[a]DM basis
[b]Composition of hay

are not to be reported herein. The pH of the rumen fluid was determined immediately after sampling and the ruminal liquor was strained and frozen for ammonia determination.

## Results and Discussion

Daily intake of prairie hay was significantly higher ($P<.01$) on all three protein supplementation treatments (40 percent HP, 20 percent CP-LS, 20 percent CP-HS) compared to the control (Table 3). There were no significant differences, however, in forage intake among the three protein supplementation programs with all values being very similar. Dry matter digestibility was increased ($P<.01$) from 45.9 percent on the control treatment to 54.2, 56.7 and 56.1 percent on the HP, LS and HS treatments, respectively. Moreover, intake of total digestible dry matter was increased substantially on the three supplementation programs, with digestible dry matter intakes being 3.7, 6.6, 7.9 and 7.9 lb per day on the control, HP, LS and HS treatments, respectively. Apparent digestibilities of the crude protein were very low ($P<.01$) on the control diet, with little difference among the three protein supplementation treatments. Corrections for metabolic fecal nitrogen would yield higher protein digestion coefficients. Ruminal $NH_3$ concentrations were generally low on all treatments, and were very low ($P<.01$) on the control diet. A lower ruminal $NH_3$ concentration on the LS treatment compared to the HP and HS treatments ($P<.01$ for HS) may be related to source of protein in the supplements since the LS supplement contained the least CSM. No significant differences existed in the pH of the rumen fluid among any of the treatments, averaging 6.74, 6.68, 6.69 and 6.63 on the control, HP, LS and HS treatments, respectively.

In generaly, feeding a lower protein supplement (20 percent CP) in a larger quantity to provide equal supplemental protein intakes did not appear to have any detrimental effects upon either forage intake or ration digestibility in this trial compared to feeding a 40 percent supplement. Moreover, starch level in the 20 percent CP supplements did not appear to have any effect on forage intake or dry matter digestibility. Possibly, different results may have been observed with different types or qualities of forages, supplement levels or management procedures. Further studies are needed to determine the importance of such variables. The lower protein supplements fed in larger quantities, were effective in increasing total energy intake compared to the 40 percent CP treatment.

**Table 3. Daily dry matter intake of prairie hay and supplement, apparent digestiblity of dry matter and protein and rumen ammonia concentration.**

| Item | Control | 40% High Protein | 20% CP-Low Starch | 20% CP-High Starch | SE |
|---|---|---|---|---|---|
| | Treatment | | | | |
| Hay intake, lb[a] | 7.8 | 10.1 | 9.9 | 10.1 | .35 |
| Supplement intake, lb | .24 | 2.1 | 4.00 | 4.00 | 0 |
| Dry matter dig, %[a] | 45.9 | 54.2 | 56.7 | 56.1 | 2.04 |
| Digestible dry matter intake, lb | 3.7 | 6.6 | 7.9 | 7.9 | -- |
| Apparent crude protein dig, %[a] | 7.2 | 54.9 | 54.6 | 52.0 | 3.10 |
| Ruminal [$NH_3$], mg/100 ml[a,b] | .35 | 3.56 | 2.64 | 4.44 | .37 |

[a]Control vs all supplement treatments ($P<.01$)
[b]LS vs HS ($P<.01$)

# The Influence of Postpartum Nutrition and Weaning Age of Calves On Cow Body Condition, Estrus, Conception Rate and Calf Performance of Fall-Calving Beef Cows

J.R. Kropp[1], K. Hancock[2], K.S. Lusby[3], R.P. Wetteman[4],
R.L. Hintz[5], and C. Worthington[6]

## Story in Brief

Data combining the first two years of a four-year study were collected on 112 fall-calving Angus x Hereford cows, ranging in age from 3 to 6 years, to determine the influence of postpartum nutrition on cow and calf performance. The cows were either fed a Moderate (maintain a body condition score 6) or Low (10 percent greater weight loss than Moderate) level of supplementation from calving to the start of the breeding season. From the start of the 63-day breeding season until warm season grasses began to grow, all cows were fed the Moderate level of supplementation.

Moderate level cows lost less body weight and body condition to the start of the breeding season than the Low level cows. As a result, Moderate level cows had a 6.9 percent higher return to estrus (90.8 vs. 83.9 percent), exhibited postpartum estrus an average of 17.6 days sooner (46.6 vs. 64.2 days) and had a 19.4 percent higher conception rate (90.8 vs. 71.4 percent) than Low level cows. Feeding the Moderate level of supplementation to the Low level cows during the breeding season increased their body condition score, but the Low level cows were still lighter in weight and thinner in condition at the end of the breeding season than the Moderate level cows. Weaning the calves at 285 days appeared to have little effect on cow weight or cow body condition score. Adjusted weaning weight of the calves was not affected by the dam's level of supplementation prior to breeding, but definitely was affected by breed of sire, month of birth and weaning date. Calves born later in the fall had heavier adjusted 210 and 285 day weights than calves born early in the fall. Calves weaned at 285 days were 61 and 82 lb heavier for the Moderate and Low levels, respectively, than calves weaned at 210 days and grazed on native pasture for 75 days. Weaning at 285 days resulted in 160 lb additional selling weight than weaning and selling at 210 days. Charolais-sired calves were 53 and 79 lb heavier at 285 days than Beefmaster-sired and Herefored-sired calves, respectively, regardless of weaning method.

## Introduction

Approximately 30 to 40 percent of the beef cows in Oklahoma calve in the fall (September-December). Fall-calving cows vary considerably in body

---

[1]Associate Professor [2]Graduate Assistant [3]Associate Professor
[4]Professor of Animal Science [5]Assistant Professor [6]Herd Manager

condition at calving due to differences in forage availability and level of protein supplementation. Many producers wean fall-born calves late (9-10 months of age) to take advantage of summer grasses and thus wean heavier calves. However, late weaning may have an adverse effect on cow condition.

Research with spring-calving cows indicates that cows on an adequate plane of nutrition prior to calving and in moderate flesh at calving have short postpartum intervals to first estrus and high conception rates. Fall-calving cows are typically in better condition going into the calving season than spring calving cows; however, little is known about the combined effects on condition at calving and postpartum level of nutrition on the reproductive performance of fall-calving cows, especially when the availability and quality of forage is decreased. While it may be possible to increase the pay weight of the calves by extending the weaning period to 9-10 months, the effect on cow condition and reproductive performance is unknown.

The purpose of this study is to determine the influence of postpartum nutrition and weaning age of calves on cow body condition, postpartum interval to first estrus, conception rate and calf performance of fall-calving beef cows.

## Experimental Procedure

Data combining the first two years of a four-year study were collected on 112 fall calving Angus x Hereford cows, ranging in age from 3 to 6 years, at the Southwestern Livestock and Forage Research Station. The range on the research station, classified in excellent condition, is little bluestem *(Andropogon scorparius)* predominantly and has a carrying capacity of approximately 7 acres per cow-calf unit on a year-long basis. The range forage is normally dormant from early November (first frost) to late April.

Two postpartum nutritional levels were evaluated. The Moderate level consisted of abundant forage plus 5 lb of cottonseed meal (41 percent CP) per head per day from calving to the start of the breeding season. This amount of supplemental feed is typically believed necessary for fall-calving cows to maintain a body condition score 6 from calving (approximately October 1) to the start of the breeding season (January 1). The Low level of nutrition consisted of heavily grazed forage and 0 to 2 lb of cottonseed meal from calving to the start of the breeding season. The supplemental protein was varied to approximate a 10% greater weight loss from calving to the start of the breeding season in the Low level cows as compared to the Moderate cows.

At the start of the breeding season (January 1), all cows were fed 5 lb of cottonseed meal daily to April 30. Throughout the study, all cows were fed three times per week (daily allowance x 7 ÷ 3). After April 30, all cows grazed common pasture through weaning.

Individual cow weights and body condition scores were taken after a 12-hour shrink biweekly from September 1 to March 3 (end of the breeding season) and monthly from March 3 to September 1. The condition scores were based on a scale of 1 (very thin) to 9 (very fat).

All calves were weighed and identified by ear tag within 24 hours after birth. The calves remained with their dams on native pasture until weaning and did not receive creep feed. Calf weights were obtained after a 6-hour shrink biweekly until the end of the breeding season and monthly thereafter. To determine the effect of weaning age on calf performance as well as to create a 1.0 to 1.5 unit difference in cow body condition going into the subsequent calving season, calves were weaned from their dams at 210 or 285 days of age, ± 7 days, by weaning biweekly from April 1 to August 17. Assignments to weaning age within postpartum nutrition level were made on the basis of calving date to equalize the effects within treatment groups. The age-corrected weaning weights were adjusted for age of dam by Beef Improvement Federation Guidelines and all heifer calves were corrected to a steer equivalent by multiplying by 1.05. Calves weaned at 210 days were fed a high roughage weaning ration *(ad-libitum)* for two weeks to reduce weight loss associated with the stress of weaning. After the two-week period, the weaned calves were placed on native pasture similar to that grazed by the nursing calves and received no additional feed. Steer calves were implanted with Ralgro in February and reimplanted in June.

From calving to the start of the breeding season, teaser bulls, equipped with chin-ball markers, were placed with the cows. Teaser bull activity and visual observation twice daily were used for detection of estrus. During the breeding season (January 1 to March 3), the cows were divided into four breeding groups on the basis of post-partum nutrition level and weaning age of the calf. All cows were purchased bred to Charolais and Hereford bulls. During the subsequent breeding seasons, all cows were exposed to Beefmaster bulls which were rotated biweekly among pastures. Cows were observed for breeding activity twice daily and herd bulls were equipped with chin-ball markers to assist in determination of breeding dates.

## Results and Discussion

### Cow weight and condition

From calving to the start of the breeding season, the Moderate level cows lost less body weight and body condition with 5 lb of cottonseed meal daily than those fed the Low level (Table 1). The Moderate level cows were in moderate flesh (5.4 condition score) at the start of the breeding season. However, the Low level cows, fed 0-2 lb of cottonseed meal daily and over grazed pasture to the start of the breeding season lost almost a full body condition score. The use of 5 lb of cottonseed meal daily from the start of the breeding season (January 1) to the end of the breeding season (March 3) was not adequate to maintain the weight of either treatment group. The Moderate level cows lost an average of 82 lbs during the 63-day period while the Low level cows lost 70 lbs. The additional supplement fed the Low level cows during the breeding season tended to improve their body condition (4.8 to 5.0 body condition score). However, the Low level cows were still lighter in weight and thinner in condition at the end of the breeding season than the Moderate level cows.

With the advent of warm season grass growth in April and May, all cows were able to regain considerable weight and body condition to weaning.

The effect of weaning age of calves on cow body weight and cow body condition score is presented in Table 2. Weaning the calves at 285 days had very little effect on cow body weight or cow body condition score. All treatment groups gained weight (range = 104 to 137 lbs) and body condition (.4) from 210 days post-calving to 285 days post-calving. Therefore no detrimental effects on cow weight or body condition were noted by delaying weaning by 75 days. It showed to be noted that these were fall-calving cows and the additional 75 days were during the peak nutritional period for native grass. Under

**Table 1. Cow weights, percent weight change and body condition socres.**

| | Postpartum Nutrition Levels | |
|---|---|---|
| | Moderate | Low |
| No. of cows | 109 | 112 |
| Initial wt, post calving | 1009 | 996 |
| Wt, start of breeding season | 970 | 930 |
| Wt, end of breeding season | 888 | 860 |
| Wt, at weaning | | |
| Calf weaned at 210 days | 1045 | 1000 |
| Calf weaned at 285 days | 1113 | 1119 |
| Wt change, % | | |
| Initial to start of breeding | -3.9 | -6.6 |
| Initial to end of breeding | -12.9 | -13.7 |
| End of breeding to weaning | | |
| Calf weaned at 210 days | +17.6 | +16.3 |
| Calf weaned at 285 days | +25.3 | +30.1 |
| Initial to weaning | | |
| Calf weaned at 210 days | +3.6 | +0.4 |
| Calf weaned at 285 days | +10.3 | +12.3 |
| Condition score | | |
| Initial | 5.8 | 5.5 |
| Start of breeding | 5.4 | 4.8 |
| End of breeding | 5.2 | 5.0 |
| Weaning | | |
| Calf weaned at 210 days | 6.3 | 6.0 |
| Calf weaned at 285 days | 6.0 | 6.0 |

**Table 2. Effect of weaning age of calves on cow weight and cow body condition.**

| | Days post-calving | |
|---|---|---|
| Postpartum Nutriton | 210 | 285 |
| Moderate | | |
| Calves weaned at 210 days | | |
| Cow weight, lbs | 1045 | 1182 |
| Cow condition score | 6.3 | 6.7 |
| Calves weaned at 285 days | | |
| Cow weight, lbs | 985 | 1113 |
| Cow condition score | 5.6 | 6.0 |
| Low | | |
| Calves weaned at 210 days | | |
| Cow weight, lbs | 1000 | 1113 |
| Cow condition score | 6.0 | 6.4 |
| Calves weaned at 285 days | | |
| Cow weight, lbs | 1015 | 1119 |
| Cow condition score | 5.6 | 6.0 |

a spring calving regime, an additional 75 days would mean weaning in December, January and February, the poorest months in terms of nutritive value for the forage.

**Reproductive performance**

The reproductive performance of fall-calving cows was definitely affected by level of postpartum nutrition (Table 3). Cows on the Moderate level of nutrition postpartum had a 6.9 percent higher return to estrus and returned to normal estrus activity 17.6 days sooner than the Low level cows. As a result of the long postpartum interval to first estrus for the Low level cows and only a 63-day breeding season, 19.4 percent fewer cows conceived as compared to the Moderate level cows.

**Calving data**

The mean adjusted birth weights and adjusted 210 and 285 day weights are presented in Table 4. The level of postpartum nutrition had little affect on the weaning performance of the calves. However, breed of sire, month of birth and weaning age had marked influences on calf performance.

Beefmaster-sired calves were heaviest at birth, but Charolais-sired calves were 53 and 79 lb heavier at 285 days than Beefmaster-sired and Herefored-sired calves, respectively, regardless of weaning method. Even though the Beefmaster-sired calves were somewhat large at birth, only 3 calves required assistance at birth.

Month of birth had a significant effect on 210 day and 285 day weights. As month of birth increased from September to December, adjusted 210 day and adjusted 285 day weights also increased, apparently due to the influence of spring and summer grazing by the calves.

Delaying the weaning of fall-born calves until 9-10 months of age to take advantage of the high quality summer forage apepars to result in a major improvement in selling weight. The weaning of calves at 285 days resulted in an average of 160 lbs additional selling weight than weaning and selling at 210 days. The market price for 300-500 lb feeder steers at Oklahoma City from April 15, 1982 to June 15, 1982 (approximately 210 days) average $73/cwt. Since the average of all calves at 210 days was 412 lbs, the gross return to calves weaned and sold at 210 days was $300.76. The market price for 500-700 lb feeder steers at Oklahoma City from June 27, 1982 to August 27, 1982 (approximately 285 days) averaged $66/cwt. Since the average of all calves at 285 days was 571 lbs, the gross return for calves weaned and sold at 285 days was $376.86. The resulting increase in revenue was $76.10 per calf simply by delaying weaning by 75 days. Since weaning the calves at 285 days appeared to have very little effect on cow body weight gain or cow body condition score (Table 2) the limiting factor seems to be sufficient forage to allow grazing by both cows and calves without depleting the forage reserve for winter grazing.

In addition, leaving the calves on the cow until 285 days rather than weaning at 210 days and running the calves on grass for 75 days appears to be advantageous. Calves weaned at 285 days were 61 and 82 lb heavier for the Moderate and Low levels, respectively, than calves weaned at 210 days and grazed on native pasture for 75 days. The reduction of stress at weaning plus the additional milk of the dam resulted in in an added 1 lb per day gain. This management practive alone resulted in an increase revenue of $47 per calf.

**Table 3. The effect of postpartum nutrition on reproductive performance of fall-calving cows.**

| | Postpartum nutrition levels | |
|---|---|---|
| | Moderate | Low |
| No. of cows | 109 | 112 |
| No. exhibiting estrus | 99 | 94 |
| Days postpartum to first estrus | 46.6 | 64.2 |
| No. of cows bred | 99 | 80 |
| Percent cows exposed actually bred | 90.8 | 71.4 |

**Table 4. The effect of weaning age and breed of sire on calf weights.**

| Dam's postpartum nutrition level | Moderate | | | Low | | |
|---|---|---|---|---|---|---|
| Breed of sire | Charolais | Hereford | Beefmaster | Charolais | Hereford | Beefmaster |
| No. of calves | 31 | 19 | 59 | 29 | 22 | 59 |
| Adjusted birth wt, lbs | 85.2 | 75.3 | 87.5 | 82.8 | 77.9 | 89.8 |
| Adjusted 210 day wt, lbs | | | | | | |
| Calves weaned at 210 days | 462 | 370 | 423 | 437 | 357 | 408 |
| Calves weaned at 285 days | 469 | 379 | 395 | 464 | 381 | 398 |
| Adjusted 285 day wt, lbs | | | | | | |
| Calves weaned at 210 days | 593 | 510 | 545 | 553 | 482 | 528 |
| Calves weaned at 285 days | 658 | 582 | 591 | 654 | 569 | 586 |

# The Effect of Yeast Culture on the Performance of Two Poultry Types Fed under Various Regimes

M. S. Edmonds[1] and R. G. Teeter[2]

## Story in Brief

Two studies were conducted utilizing 270 chickens to evaluate the efficacy of yeast culture (YC) for both broiler and layer avian types. In the first experiment, three dietary levels (0, 1.25, 2.50 percent) of YC were included in a nutritionally complete ration and fed to 14-day-old broiler chicks for 8 days. Body weight gain, feed consumption (g) and feed efficiency were not influenced by yeast culture supplementation.

In the second experiment, YC was fed at two dietary levels (0, 2.5 percent) to 14-week-old Shaver pullets receiving two ration types varying in nutrient density. Rations evaluated with and without YC included: 1) a low fiber ration; 2) a high fiber ration and 3) a low phosphorus ration. Body weight gain, feed consumption, and dry matter and phosphorus digestibility were not influenced by YC addition.

## Introduction

Many Oklahoma producers utilize yeast culture, which is a feed product formed by fermenting mixtures of grains, sugar and live yeast. The product has been reported to stimulate gut microflora to increase microbial enzyme levels and thereby digestion efficiency and to also provide unidentified poultry growth factors (Tonkinson et al., 1964). Thornton (1960) fed YC levels of 0, 1.5 and 2.5 percent to broilers receiving a 7.5 percent crude fiber ration and found fiber digestibility to increase by 163 and 225 percent respectively for the 1.5 and 2.5 percent YC additions. It has also been suggested that the increased enzyme levels attributed to YC enhance phosphorus digestibility (Thayer et al., 1978). The studies reported herein were conducted to evaluate YC effects on growth of broilers and digestion efficiency of pullets fed high and low quality diets.

## Materials and Methods

Yeast culture was added to the basal ration (Table 1) used in the first experiment by substituting YC levels (0, 1.25, 2.50 percent) for cornstarch and soybean meal such that diets remained isonitrogenous and isocaloric. Two hundred and ten 14-day-old New Hampshire X Columbian crossbred chicks were randomly assigned to three treatment groups creating 7 replicates per treatment with ten chicks per replicate. The chicks were raised for 8 days in starter batteries housed in an environmentally controlled room with experimental ra-

[1]Graduate Student, Univ. of Illinois [2]Assistant Professor, Animal Science

**Table 1. Ration Composition (%)**

| Ingredient | YC Level (%) 0 | 1.25 | 2.50 |
|---|---|---|---|
| Ground corn grain | 53.4 | 53.4 | 53.4 |
| Soybean meal (44%) | 33.8 | 33.4 | 33.0 |
| Corn starch | 1.7 | 0.85 | — |
| Yeast culture | — | 1.25 | 2.50 |
| Meat and bone meal | 5.2 | | |
| Alfalfa meal | 3.1 | | |
| Dicalcium phosphate | 1.0 | | |
| Calcium Carbonate | 0.9 | | |
| Vitamin mix | 0.4 | | |
| Salt | 0.3 | | |
| dl methionine | 0.1 | | |
| Trace mineral | 0.1 | | |

tions and water provided *ad libitum*. Body weight gain, feed consumption, and feed/gain ratios were used as a criteria to evaluate performance.

The basal ration (Table 2) used in the second experiment was modified via the addition of 20 percent ground alfalfa hay or by deleting phosphorus to create diets varying in fiber level and phosphorus content. Two Yeast Culture levels (0, 2.5 percent) were added to the nutritionally complete, high fiber and the phosphorus deficient diets creating six treatment groups. Yeast Culture additions were made as described in the first experiment so that YC levels within a ration classification were isocaloric and isonitrogenous. Sixty 21-week-old Shaver pullets were randomly divided into 6 groups of 10 pullets each and fed the respective experimental rations. All pullets were individually caged and raised in an environmentally controlled house with a mean temperature of 86 F. The test period lasted 35 days with feces being collected on days 9-13 so that dry matter digestibility on all treatment and phosphorus digestibility on the phosphorus deficient rations could be estimated.

## Results and Discussion

In the first experiment (Table 3), broiler chicks fed a chick starter ration with 0, 2.5 or 5.0 percent supplemental YC had similar ($P > .1$) feed consumption, rate of gain and efficiency of gain. Yeast culture addition apparently did

**Table 2. Ration Composition (%)**

| Ingredient | Control | High Fiber | Phosphorus Deficient |
|---|---|---|---|
| Ground Corn grain | 71.6 | | |
| Soybean meal | 21.9 | | |
| Alfalfa meal (17%) | 4.0 | +20.0 | |
| Dicalcium phosphate | 0.5 | | −0.5 |
| Calcium Carbonate | 1.3 | | |
| Vitamin mix | 0.5 | | |
| Salt | 0.4 | | |
| Trace mineral | 0.1 | | |
| dl methionine | 0.2 | | |

**Table 3. Results, Experiment 1**

| | YC Level (%) | | |
|---|---|---|---|
| | 0 | 1.25 | 2.50 |
| Gain per chick (g) | 334.8[a] | 325.1[a] | 331.2[a] |
| Feed per chick (g) | 512.9[a] | 516.8[a] | 520.7[a] |
| Feed/Gain | 1.53[a] | 1.59[a] | 1.57[a] |

[a]Means in a row with same superscript do not differ (P>.10).

not supply unidentified growth factors that were supplied by the starter ration. Feed efficiency was not improved by YC additions and in fact was reduced 3.3 percent. The lack of YC effect upon feed efficiency questions the hypothesis of YC enhancing gastrointestinal tract digestive processes. However, YC could provide unidentified growth factors and/or increase digestive efficiency of birds fed lower quality rations. The second experiment was conducted to evaluate these possibilities.

In experiment 2 (Table 4), the addition of YC to the standard diet had no significant effect upon body weight gain, feed consumption, feed efficiency, dry matter digestibility or phosphorus digestibility of pullets fed the three ration types. Addition of 20 percent alfalfa meal increased feed consumption 3 percent and reduced feed efficiency by a mean of 24 percent reflecting the low energy availability from alfalfa. This data does not support the hypothesis that YC improves gut microflora ability to digest fiber and phosphorus. In previous work Tonkinson (1965) and Thornton (1960) reported that YC additions significantly increased fiber digestibility. However, these studies were conducted using relatively low fiber rations that varied in fiber source and the effect may have been due to fiber source and not YC. Thayers study (1960) incorporated dicalcium phosphate in the basal ration used across all treatments. Positive effects of YC upon phosphorus availability could be due to YC interactions with dicalcium phosphate and not phytin bound phosphorus. Corn grain, the principle source of phosphorus in the phosphorus deficient ration evaluated in experiment 2, contains much of its phosphorus in the phytate form but no improvements in phosphorus digestibility were observed with YC addition. These contradictions warrant further investigations of YC efficacy.

**Table 4. Results, Experiment 2**

| | Control | | High Fiber | | Phosphorus Deficient | |
|---|---|---|---|---|---|---|
| | −YC | +YC | −YC | +YC | −YC | +YC |
| Gain/pullet (g) | 277.4[a] | 305.0[a] | 237.8[a] | 262.0[a] | 235.3[a] | 232.9[a] |
| Feed/pullet (g) | 2212[a] | 2403[a] | 2336[a] | 2395[a] | 2021[a] | 1858[a] |
| Feed/gain | 8.2[a] | 8.3[a] | 10.4[b] | 10.1[b] | 8.2[a] | 8.1[a] |
| Dry matter digestibility (%) | 68.3[a] | 68.8[a] | 60.7[b] | 59.3[b] | 70.3[a] | 69.9[a] |
| Phosphorus digestibility (%) | — | — | — | — | 31.4[a] | 30.9[a] |

[a]Means in a row with same superscript do not differ (P>.10).

## Literature Cited

Thayer, R. H. et al. 1978. Okla. Agr. Exp. Sta. Res. Rep. MP-103:173.
Tonkinson, et al. 1965. Poultry Science 44:159.
Thornton, E. J. 1960. Yeast Culture Research Brief. Diamond V Mills, Inc.

# Starch Blocker Evaluation Using Laying Hens

**C. F. Hanson[1], F. N. Owens[2]
and R. G. Teeter[3]**

## Story in Brief

Special Legume Protein Concentrate (starch blocker) was added to the diet of ten adult laying hens in an attempt to reduce starch digestibility. The material was fed at a level advertised to totally inhibit the digestion of starch in this diet. Feed intake, weight gain, digestibility of dry matter, organic matter and starch were unchanged by addition of starch blocker to the diet. Rate of passage through the intestinal tract was increased a mean of 67 percent by feeding this material.

## Introduction

Starch blockers, composed of proteins isolated from kidney beans, are reported to inhibit amylase activity, reducing starch digestion in laboratory tests. Promoted as a dieting aid for humans, starch blockers have received limited testing in controlled animal studies. Compounds which block amylase activity are present in kidney beans and wheat. They might also occur in other foods and feeds, thus are deserving of attention by nutritionists. The objective of this experiment was to determine the influence of starch blockers on feed intake, digestion and passage rate in laying hens.

## Materials and Methods

One ground starch blocker tablet (Nature's Bounty, Inc., Bohemia, NY) which supposedly blocks digestion of 100 g of starch was added to each 150 g of poultry feed which contained 88.9 per cent dry matter and 32 percent starch. This diet and a control with no added starch blocker were available ad libitum for 10 days to 10 individually caged laying hens (5 per diet) averaging 1600 g. Total excreta were collected during the final 5 days. After the first period, hens were switched to opposite diets and the process repeated. Feed and excreta were dried, ground and analyzed for organic matter and starch. Apparent digestibilities were calculated. Passage rate was estimated as time from oral dosing of ferric oxide until appearance of the marker in feces.

## Results and Discussion

Measuring starch in feces of most species is not an adequate index of digestion in the small intestine due to bacterial action in the large intestine. Fermentation capacity in the large intestine of humans and various other species is

[1]Graduate Assistant, Human Nutrition [2]Professor, Animal Science [3]Assistant Professor, Animal Science

considerable. However, with birds, this fermentation is limited. Addition of starch blocker to the diet for laying hens did not significantly alter feed intake, weight gain, dry matter content of feces, or apparent digestibilities of dry matter, organic matter and starch (Table 1). On the average, hens fed starch blocker gained slightly more weight than those not receiving starch blocker. However, weight changes of birds on a treatment differed markedly. During the period on starch blockers, hens ranged from gaining 20.3 g/day to losing 7.7 g/day, whereas on the control diet, the range was from 17 g/day to −11 g/day. Passage rate was increased by 67 percent with addition of this feed additive.

Starch digestion can be limited in various species by (1) passage time, (2) enzyme activity, (3) particle size and other factors. For instance, carnivores supposedly have less ability to digest non-galatinized starch than do poultry and most other domestic animals. Failure of starch blockers to reduce starch digestion in this experiment, despite their use at levels sufficient to block more than twice the amount of starch in the diet, questions the value of starch blockers as a dieting aid for humans. A recent study with humans with a dosage claimed adequate to block digestion of three times the amount of starch consumed also resulted in no detectable effect on digestion of starch (Bo-Linn et al., 1982).

Reasons for the faster rate of passage with the starch blocker remain to be determined. But, in humans, a faster rate of passage could flush slowly digested nutrients to the large intestine for fermentation and subsequent digestive discomfort as bacteria in the large intestine rapidly utilize the starch and produce gas.

**Table 1. Influence of starch blocker on digestive measurements.**

| | Diet | |
|---|---|---|
| | Control | Starch blocker |
| Feed intake, g/day | 98.7 | 100.2 |
| Weight gain, g/day | 0.39 | 2.94 |
| Feces, DM % | 24.6 | 26.9 |
| Apparent digestibility,% | | |
| Dry matter | 73.5 | 71.7 |
| Organic matter | 78.4 | 76.9 |
| Starch | 98.7 | 98.7 |
| Passage rate, min. | 386[b] | 258[b] |

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

## Literature Cited

Bo-Linn, G. W., et al. 1982. New England Journal of Medicine 307:1413.

# Ionophores for Growing Broiler Chicks

M. C. Ferrell[1], F. N. Owens[2]
and R. G. Teeter[3]

## Story in Brief

To determine the possible influence of ionophores on maintenance energy requirements of animals, broiler chicks were fed monensin, lasalocid and salinomycin in two experiments. In trial 1, chicks (3 weeks of age) were fed diets containing .3 or 2 percent NaCl with monensin, lasalocid and salinomycin added at 0 or 30 g per ton of feed for 8 days. In trial 2, chicks (8 days of age) were fed ionophores at 0 or 30 g per ton or monensin at levels of 15, 60 and 120 g per ton. No differences were observed in either trial for weight gain or efficiency of feed use with ionophore additions to the feed.

## Introduction

Ionophores are commonly used as coccidiostats in rations for poultry. Monensin and lasalocid are approved at levels of 90-110 g/ton and 68-113 g/ton (Anonymous, 1979) of the diet, respectively, to prevent coccidiosis in poultry. For cattle, monensin, lasalocid and salinomycin are fed at 5 to 30 g per ton to increase energetic efficiency through reduced loss of methane and increased energy digestibility as reviewed by Owens (1980). Monensin increased the energetic efficiency of maintenance by 5.7 percent without increasing the efficiency of energy use for growth according to Byers (1980). He suggested that monensin may reduce the energy requirements for maintenance. Monensin will alter sodium flux in tissues and pumping sodium is one of the major energy costs of muscular tissue. However, feeding monensin at 110 g/ton or 150 g/ton tended to reduce efficiency of energy use in growing chicks (Parsons and Baker, 1982). These experiments were designed to test the effect of three ionophores, monensin, lasalocid and salinomycin at 30 g/ton on rate and efficiency of growth of chicks at an age before coccidiosis should be encountered.

## Materials and Methods

In experiment 1, 192 commercial broiler chicks were subdivided into 24 pens of 8 chicks each at 3 weeks of age. Chicks were fed a diet (Table 1) without ionophores or with 30 g per ton of feed as monensin, lasalocid or salinomycin plus NaCl at either .3 or 2.0 percent of the diet. Chicks were weighed following 12 hr without feed and water initially (21 days of age) and after 8 days on test diets.

In experiment 2, 192 chicks of the same breeding, but 8 days of age were subdivided into 24 pens of 8 chicks each. Chicks were fed the same diet without ionophores or with 30 g per ton from monensin, lasalocid, or salinomycin. In

[1]Graduare Assistant [2]Professor, Animal Science [3]Assistant Professor

**Table 1. Diet composition[a]**

| Ingredient | % |
|---|---|
| Corn | 47.69 |
| SBM (44%) | 34.20 |
| Corn oil | 5.00 |
| Meat and bone meal | 4.75 |
| Alfalfa meal (17%) | 2.85 |
| Live yeast culture (14%) | 2.85 |
| dl methionine | .095 |
| Calcium carbonate | .855 |
| Phosphorus supplement (Ca 20-P 18) | .950 |
| Trace mineral | .095 |
| Salt | .285 |
| Vitamin mix (turkey breeder) | .380 |

[a]Ionophores or salt (1.7%) added to form test diets.

addition, monensin was fed at levels of 15, 60 and 120 g per ton of feed. Chicks were weighed following a 5-hour shrink initially (8 days of age) and after 7 days on test diets. Feed and water were available and libitum during both trials and feed intake was monitored.

## Results and Discussion

Daily gain and gain to feed ratios were not significantly altered by ionophore addition in the first experiment (Table 2) though daily dry matter intake was slightly increased by ionophore addition.

Added NaCl had no significant effect on feed intake, rate of gain, or gain to feed ratio (Table 3) and did not interact with ionophores. In experiment 2, daily gain, daily intake and gain to feed were not changed by added ionophores or by various levels of monensin.

Results indicate that these ionophores do not decrease energy requirements for growth and maintenance of growing chicks. This suggests that ionophores did not reduce the energy requirement for maintenance. Since sodium and potassium metabolism of chicks differs from that of mammals (Robbins, 1982), extrapolation of results to mammals may be misleading. Nevertheless, results do not support the theory that ionophores decrease the energy requirement for maintenance.

**Table 2. Ionophore effect on gain, trial 1**

| | | Ionophore | | |
|---|---|---|---|---|
| Item | 0 | Mon | Las | Sal |
| Initial weight, g | 288 | 296 | 301 | 301 |
| Daily gain, g | 24.0 | 24.8 | 24.1 | 24.5 |
| Daily DM intake, g | 55.0 | 57.9 | 58.0 | 57.5 |
| Gain/feed | .42 | .43 | .41 | .43 |

**Table 3. Increased salt effect on gain, trial 1**

| Item | NaCl level .3 | NaCl level 1.7 |
|---|---|---|
| Initial weight, g | 297 | 295 |
| Daily gain, g | 24.6 | 24.1 |
| Daily DM intake, g | 57.2 | 57.0 |
| Gain/feed | .43 | .42 |

**Table 4. Ionophore effect upon gain, trial 2**

| | | Ionophore (30 g/ton) | | |
|---|---|---|---|---|
| Item | 0 | Mon | Las | Sal |
| Initial weight, g | 120 | 123 | 121 | 120 |
| Daily gain, g | 25.1 | 24.2 | 24.8 | 24.5 |
| Daily DM intake, g | 35.3 | 35.8 | 36.0 | 35.3 |
| Gain/feed | .70 | .67 | .68 | .68 |

**Table 5. Increased monensin effect on gain, trial 2**

| | | Monensin level | | | |
|---|---|---|---|---|---|
| Item | 0 | 15 | 30 | 60 | 120 |
| Initial weight, g | 120 | 123 | 123 | 123 | 123 |
| Daily gain, g | 25.1 | 24.8 | 24.2 | 25.2 | 24.2 |
| Daily DM intake, g | 35.3 | 35.5 | 35.8 | 35.5 | 34.3 |
| Gain/feed | .70 | .69 | .67 | .70 | .69 |

## Literature Cited

Anonymous. 1979. Feed Additive Compendium. (Miller Publ. Co., Minneapolis, MN).
Byers, Floyd. 1980. J. Anim. Sci. 51:158.
Owens, F. N. 1980. Georgia Nutr. Conf. p. 17.
Parsons, C. M. and D. H. Baker. 1982. Poultry Sci. 61:2083.
Robbins, K. R. et al. 1982. J. Nutr. 112:2122.

# The Effects of Fiber Source and Level Upon Chick Growth

W.N. Cannon[1], R.G. Teeter[2], and C.V. Maxwell[3]

## Story in Brief

Two experiments were conducted utilizing 300 chicks to evaluate the effects of dietary fiber source and level on feed intake, weight gain, body shrink, starch digestibility, rate of digesta passage and intestinal tract size. In the first experiment three semi-purified fiber sources (mucilose flakes, polyethylene and wood cellulose) were added by weight on top of the basal diet. Chicks increased feed intake and maintained weight gain with the increasing levels of polyethylene. However, with wood cellulose, feed intake increased only slightly and weight gain was depressed. Including mucilose flakes in the diet decreased feed intake and severly depressed body weight gain. Dietary fiber addition tended to reduce digesta retention time but had only a minimal effect upon percent body shrink with fasting, starch digestibility and intestinal tract size. These results demonstrate that fiber source and level can have a quite varied impact upon poultry productivity. In the second experiment, eight natural fiber sources varying in composition and digestibility were added to the basal ration at the 30 percent level. As in the first experiment, fiber source influenced weight gain, feed intake and feed efficiency. The additional of fiber had little effect on starch digestion indicating that fibers under normal conditions have little impact upon starch utilization in poultry rations.

## Introduction

The question of utilizing non-traditional high fiber feed sources in least cost ration formulation is being increasingly raised due to their availability and cost advantage in certain regions of the world. These feed sources such as tomato seeds and turf grass clippings are often high in fiber, but nonetheless contain useful amino acids, energy, vitamins and minerals. Characteristically, by-product feeds vary widely in fiber composition which posses no problem if one can assume that composition of indigestible bulk plays little role in influencing poultry productivity. The following experiments were conducted to evaluate this assumption.

## Materials and Methods

In the first experiment, 14-day-old, New Hamp x Columbian chicks were allotted to treatment groups. Treatments were formed by the addition of the following fiber sources to the semi-purified basal diet (Table 1): mucilose flakes,

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

**Table 1. Composition of the basal diet.**

| Ingredient | % of Diet |
|---|---|
| Casein | 21.00 |
| Dried egg solids | 13.00 |
| Cornstarch | 53.35 |
| Arginine | .90 |
| Dl methionine | .50 |
| Glumatic acid | 5.26 |
| Glysine | .12 |
| Mineral mix | 5.37 |
| Vitamin mix | .40 |
| Chromic oxide | .10 |
| | 100.00 |

a semi-purified source of hemicellulose; solka floc, a purified source of wood cellulose; and finely ground plyethylene. The mucilose flakes were evaluated at the 5, 10, 15 and 20 percent levels, while the solka floc and polyethylene treatments were added at 10, 20, 30, 40, 50 and 60 percent levels. Treatments were replicated twice and consisted of two pens with six birds each. Birds were fed their respective ration for a 7-day feeding period with feces being collected continuously so that ration and starch digestibility could be estimated.

At the conclusion of the feeding period birds, were weighed, fasted for 12 hours and reweighed so that body weight gain independent of gut contents could be determined. The percent shrink (fasted body weight ÷ body weight prior to fasting x 100) was calculated and used to define true weight gain.

Digesta retention time was estimated by withdrawing feed for 2 hours to synchronize appetite and feeding rations containing 1 percent ferric oxide as a colored marker. The number of colored droppings occurring every 15 minutes thereafter was recorded and retention time calculated as the time required for the appearance of 6 red droppings.

To evaluate the effects of fiber on gastrointestinal tract size, 4 birds from each treatment were sacrificed and their tracts bisected at the crop, proventiculus, gizzard, small intestine, cecum, colon and cloaca. The tissue and digesta contents of each segment was determined.

In the second experiment, the influence of alfalfa, amaranth, beet pulp, corn bran, rice bran, wheat straw, sugar cane residue and wheat bran upon body weight gain, feed efficiency, ration digestibility and starch digestibility were evaluated as in the first experiment.

## Results and Discussion

The influence of dietary fiber upon feed intake and body weight gain is shown in Figures 1 and 2. Birds responded to polethylene by increasing feed intake above the basal compensating for the reduced nutrient density. Hense, body weight gain was not influenced by polyethylene addition. With the addition of solka floc feed intake declined slightly and weight gain declined markedly since total nutrient intake was not maintained. When mucilose flakes were added to the basal ration, a large reduction in intake occurred, and body weight gains

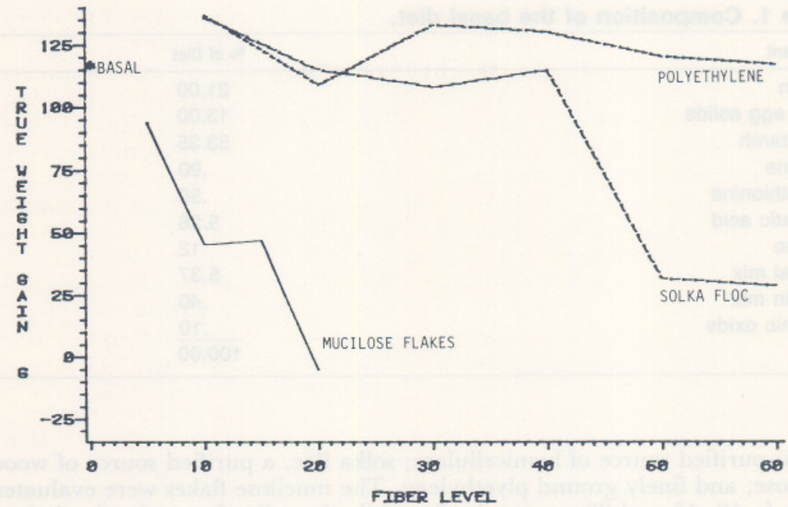



**Figure 1. Influence of fiber source and level(%) on true weight gain(grams)**

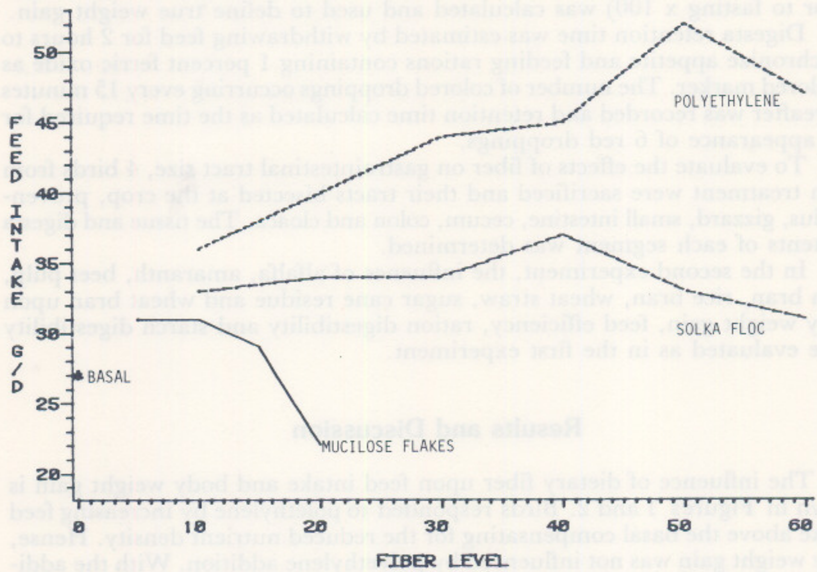



**Figure 2. Influence of fiber source and level(%) on feed intake(grams/day)**

declined 86 percent. This demonstrates that level and composition of dietary bulk can have a significant effect upon feed intake and weight gain.

In an effort to explain fiber effects, several physiological measurements were made. Retention time averaged 240 ± 15 minutes for birds receiving the basal ration and 192 ± 20 minutes with the fiber addition. Reduced retention time could limit digestion and animal efficiency if time is a limitation for digestive processes. However, in these studies, starch digestion was nearly complete indicating that time was not limiting for starch, the nutrient of greatest dietary concentration, though it could be for other nutrients. Reduced retention time should allow the animal to consume greater quantities of feed as more feed units would be able to pass through the animal each day. Physiological adjustment to increase tract size could also permit greater feed consumption. Measurements of empty tract weight after adjustment for body weight, in this experiment, indicated no significant effects of fiber on tract size or dry matter content. Indeed, body shrink averaged 16 percent and was not significantly different between rations. Therefore, passage rate modification may constitute the only physiological response available to broilers exhibiting increased feed intake. A passage rate ceiling evidently exists as birds fed mucilose were not able to elevate rate of passage enough to compensate for the 230 percent enhancement in digesta water content. The greater digesta water content observed with mucilose inclusion apparently distended the gastrointestinal tract to the point that bulk fill (water fill) limited feed consumption. Fiber water binding capacity may be associated with fiber bulk effects.

The productivity of chicks fed 30 percent natural fiber sources are shown in Table 2. With the exceptions of an increase in gain with wheat bran and a decrease with wheat straw, fiber source did not signficantly effect weight gain, feed intake or feed/gain ratio compared to the basal ration. The percent ration digestibility (Table 3) varied with fiber source suggesting differences in fiber utilization. Starch digestion ranged from 95-99 percent and was not affected by the addition of fiber. This indicates that starch utilization is not influenced by the fiber sources examined although mucilose flakes constituted one exception and starch digestibility was reduced to 89 percent.

This study provides documentation that the level and composition of dietary fibers can have a significant effect upon poultry feed intake and productivity.

**Table 2. Performance of chicks.**

| Treatment | True Gain | Feed Intake | Feed/Gain |
|---|---|---|---|
| | lb/100 birds/day | | |
| Basal | 3.68 | 5.60 | 1.52 |
| Alfalfa | 3.39 | 7.05 | 2.08 |
| Amaranth | 3.55 | 7.20 | 2.12 |
| Beet pulp | 2.60 | 7.11 | 2.73 |
| Corn bran | 4.18 | 8.99 | 2.15 |
| Rice hulls | 3.74 | 8.41 | 2.25 |
| Sugar cane residue | 3.21 | 6.74 | 2.10 |
| Wheat bran | 4.87 | 8.50 | 1.74 |
| Wheat straw | 2.22 | 7.60 | 3.42 |

**Table 3. Percent ration digestibility.**

| Source | % Digestibility |
|---|---|
| Basal | 86 |
| Amaranth | 82 |
| Wheat bran | 78 |
| Alfalfa hay | 75 |
| Rice hulls | 73 |
| Corn bran | 73 |
| Beet pump | 73 |
| Sugar cane R | 72 |
| W straw | 72 |

# Feeding Value of Reconstituted High-Tannin Sorghum in a Practical Ration in a Chick Trial

**S. Sarani[1], Karla Kovak[2], R.G. Teeter[3] and C.A. Hibberd[4]**

## Story in Brief

The effects of reconstituting a high-tannin sorghum grain variety were studied in a chick feeding trial utilizing 96 commercial broiler chicks. Sorghum grain was reconstituted by the addition of water to increase grain moisture content to 30 percent and incubating at 35°C for 1, 2, 4, and 8 days. Reconstituting sorghum grain decreased its tannin content by 74, 73, 78 and 85 percent for the 1, 2, 4, and 8 day incubation periods respectively. Sorghum grain reconstituted for 4 days promoted similar rates of gain compared to the corn and sorghum grain control diets. Reconstitution increased feed efficiency by a mean of 8.6 percent. The basal diet contained 8.2 percent more protein than dictated by NRC requirements which may have masked any gain response. Reconstituting sorghum grain may reduce the tannin content and enhance feeding value of high-tannin sorghum grain. More studies, however, are needed to better understand these effects.

## Introduction

Although sorghum grain is a human staple in many developing countries where it grows well under stressful climatic conditions, most sorghum produced in the United States is consumed by livestock. Brown sorghum varieties containing a high tannin content have been reported to have production advantages such as higher per acre yield and better storage properties than white or yellow grain types. However, sorghum tannin may decrease nutritive value of the grain by irreversibly binding to dietary proteins. Such tannin-protein complexes are probably not digested by poultry and may render sorghum protein amino acids unavailable.

Reconstituting sorghum grain via the addition of water to bring the grain to 70 percent dry matter and subsequent incubation at 35°C has been demonstrated to decrease the detectable tannin content by up to eighty-five percent and may provide a means to detoxify high tannin sorghum grain. The purpose of this experiment was to evaluate the reconstitution process in a chick feeding trial.

## Material and Methods

Sorghum grain was reconstituted by addition of water to bring the grain moisture content to 30 percent. A commercial mold inhibitor product[a] was added with the water to inhibit fungi growth. The grain and water mixture

[1]Assistant Professor [2]Instructor of Dairy Science [3]Professor of Dairy Science [4]Animal Technician

were combined in a rotary mixer until all water was absorbed, placed in polyethylene air tight bags and incubated at 32°C for 1, 2, 4 and 8 days.

Normal and 4-day reconstituted sorghum grain was added to the corn based ration (Table 1) by substitution for corn on a weight basis. Laboratory analysis indicated that the sorghum and corn grain had similar protein levels and served as a basis to consider them nutritional equivalents. Ninety-six 3-day old commercial broiler chicks were randomly assigned to the three treatment groups such that there were four replicates per treatment with eight chicks per replicate. During the ensuing four-week experimental period, all chicks received feed and water ad libitum. Random fecal grab samples were taken every two days and composited for ration and starch digestibility estimates determined by chromium ratio.

**Table 1. Ration composition**

| Ingredients | Corn | High-tannin Sorghum | Reconstituted Sorghum |
|---|---|---|---|
| | % | % | % |
| Corn, ground | 53.15 | — | — |
| Sorghum (high-tannin) | — | 53.15 | — |
| Sorghum (reconstituted) | — | — | 53.15 |
| Soybean meal (44%) | 35.95 | 35.95 | 35.95 |
| Meat + bone meal (55%) | 5.00 | 5.00 | 5.00 |
| Alfalfa meal (17%) | 3.00 | 3.00 | 3.00 |
| Dicalcium phosphate | 1.00 | 1.00 | 1.00 |
| Calcium carbonate | 0.90 | 0.90 | 0.90 |
| Vitamin mix | 0.40 | 0.40 | 0.40 |
| Salt | 0.30 | 0.30 | 0.30 |
| DL-methionine | 0.10 | 0.10 | 0.10 |
| Trace minerals | 0.10 | 0.10 | 0.10 |
| Chromic oxide | 0.10 | 0.10 | 0.10 |

## Results and Discussion

Reconstituting sorghum grain reduced tannin content (Figure 1) by 85 percent after 8 days incubation with the bulk of the reduction occurring after just 1 day. However, reconstitution of sorghum grain had no effect ($P > .10$) on body weight gain (Table 2) indicating that both rations satisfied chick protein requirements. The sorghum ration used in this experiment contained about 25.2 percent protein which is approximately 9.6 higher than the NRC protein requirement for this class of poultry when expressed per unit metabolizable energy. The excess dietary protein would tend to neutralize any tannin toxicity as excess protein would bind to tannin without precipitating a protein deficiency. Such rations are not representative of least cost rations where protein level is held nearer to the requirement and would thus be more sensitive to tannin content.

Feed intake (Table 2) was 8.6 percent higher for the high-tannin sorghum compared to the basal corn diet and reflects the lower metabolizable energy content of sorghum. However, reconstituting sorghum reduced feed intake by

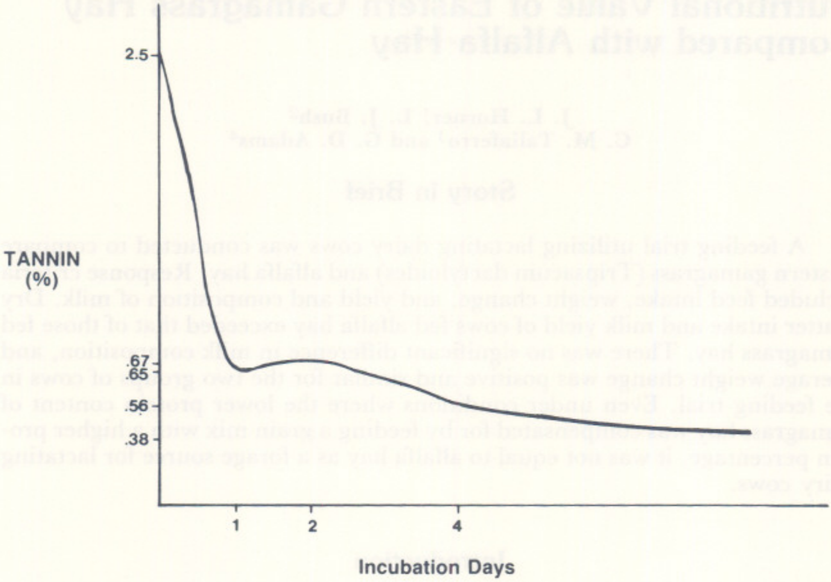



**Figure 1. Reconstitution effect upon tannin content of sorghum grain.**

**Table 2. Results**

| | Tannin | Nutrition Parameters | | | |
|---|---|---|---|---|---|
| Treatments | (Catechin eq./g) | Weight gain (g) | Feed Intake (g) | Feed/gain | Digestibility Ration (%) |
| Basal (Corn-soy) | — | 896.0 | 11743 | 1.70 | 66 |
| High-Tannin Sorghum | 2.5 | 891.0 | 12758 | 1.80 | 63 |
| Reconstituted Sorghum | 0.56 | 891.0 | 11314 | 1.60 | 62 |

13 percent when compared to high-tannin sorghum and 3.7 percent below the corn ration. This suggests that reconstituting sorghum grain may increase energy availability as body weight gains were similar across treatments and feed efficiency increased 8.6% upon the reconstitution. However, ration and starch digestibility estimates did not account for the enhanced feed efficiency. Whether the increased feed efficiency observed in this study was due to chance on increased energy availability from dietary constituent other then starch is not certain. Nonetheless, reconstituting sorghum grain reduces chemically detectable tannins and may provide a mean for detoxifying sorghum tannin. Additional studies are underway.

# Nutritional Value of Eastern Gamagrass Hay Compared with Alfalfa Hay

J. L. Horner[1], L. J. Bush[2]
C. M. Taliaferro[3] and G. D. Adams[4]

## Story in Brief

A feeding trial utilizing lactating dairy cows was conducted to compare Eastern gamagrass (Tripsacum dactyloides) and alfalfa hay. Response criteria included feed intake, weight change, and yield and composition of milk. Dry matter intake and milk yield of cows fed alfalfa hay exceeded that of those fed gamagrass hay. There was no significant difference in milk composition, and average weight change was positive and similar for the two groups of cows in the feeding trial. Even under conditions where the lower protein content of gamagrass hay was compensated for by feeding a grain mix with a higher protein percentage, it was not equal to alfalfa hay as a forage source for lactating dairy cows.

## Introduction

Eastern gamagrass is a warm-season, perennial, tall grass usually found in the eastern half of the United States and in all regions of Oklahoma. This native grass grows best on moist, well-drained, fertile soils and with proper management may average four to five tons of hay per acre. It may have potential as a forage source in dairy rations; however, very little information is available regarding its relative nutritional value. Since many dairymen utilize alfalfa hay as a forage source in their feeding programs, the objective of this study was to compare Eastern gamagrass with alfalfa hay as an energy source in the dairy ration.

## Materials and Methods

Sixteen lactating cows (11 Holsteins, 5 Ayrshires) ranging from 7 to 8 weeks postpartum, were utilized in a feeding trial to compare Eastern gamagrass and alfalfa hay. A switchback design was used with three 4-week periods consisting of a 2-week adjustment followed by 2 weeks of data collection.

The cows were divided into 2 blocks, with each block representing the cutting of hay to be fed. All cows were randomly assigned to one of two feeding sequences and one of the two blocks, with each block consisting of 8 cows. The forages were compared as energy sources in this trial with protein intake equalized by feeding grain mixtures containing 12, 15, or 18 percent crude protein with alfalfa hay, first cutting gamagrass and second cutting gamagrass, respectively (Table 1).

---

[1]Graduate Assistant [2]Professor of Dairy Science [3]Professor of Agronomy [4]Instructor of Dairy Science

**Table 1. Composition of concentrate mixtures**

| Item | Protein Level | | |
|---|---|---|---|
| | Low | Medium | High |
| Ingredients, % as fed | | | |
| Corn, ground | 73 | 64 | 55 |
| Soybean meal | 9 | 18 | 27 |
| Oats | 10 | 10 | 10 |
| Molasses | 5 | 5 | 5 |
| Dicalcium phosphate | 2 | 2 | 2 |
| Salt | 1 | 1 | 1 |
| Protein content, % air dry | 12.0 | 15.0 | 18.0 |

Prior to initiation of the study, the cows were adjusted to rations consisting of a 50:50 concentrate-to-forage ratio and continued on rations with this ratio throughout the trial. Response criteria included feed intake, weight change, and yield and composition of milk. Cows were fed in individual stalls twice daily, with grain and hay refusals being recorded daily. Hay and grain were sampled weekly and analyzed for protein, dry matter, acid detergent fiber, and neutral detergent fiber. Cows were weighed on 3 consecutive days at the beginning of the trial and at the end of each experimental period. Individual cow milk yields were recorded twice daily, and samples were collected at four consecutive milkings each week for analysis of milk fat content.

## Results and Discussion

Intake of dry matter and protein by cows consuming gamagrass was lower than for those fed alfalfa hay (Table 2). There was also a tendency among the cows to consume more of the first cutting grass than the second cutting. This was probably due to the presence of various types of weeds found in the second cutting which accounted for reduced palatability, although both cuttings of grass were harvested at approximately the same stage of maturity.

It was planned that protein intake would be equalized by feeding grain mixtures of different protein levels. The cows consuming gamagrass did have a higher intake of protein from the grain; however, due to a reduction in the consumption of the gamagrass, these cows did not receive as much total protein as those fed alfalfa. But, the amount of total protein consumed was adequate to meet NRC requirements even at the highest level of production during the first period.

Milk yield was highest for the cows fed alfalfa hay (Table 2). This can be attributed partly to the fact that dry matter intake of cows consuming alfalfa was somewhat higher than that of those fed gamagrass hay. This amount of difference in dry matter intake could easily account for the additional milk yield by cows fed alfalfa hay. The alfalfa was slightly more mature than the gamagrass, but the fiber and protein analyses would indicate an overall lower feeding value for gamagrass than for alfalfa (Table 3). This provides another possible explanation for the decrease in milk yield when gamagrass was fed. Milk fat content was similar for all cows and average weight change was positive

**Table 2. Response of cows fed two different hays**

| Variable | Hay: Alfalfa | Hay: Eastern gamagrass |
|---|---|---|
| Feed intake | | |
| Dry matter, lb/day | 44.2 | 42.3 |
| Crude protein, lb/day | 7.6 | 6.9 |
| Protein, % of DM | 17.2 | 16.3 |
| Weight change, lb/day | .11 | .37 |
| Milk yield | | |
| Milk, lb/day | 53.0 | 50.5 |
| Fat, % | 4.1 | 4.2 |

**Table 3. Chemical composition of the hays**

| Hay | Crude protein | Acid detergent fiber | Neutral detergent fiber |
|---|---|---|---|
| | %, dry matter basis | | |
| Alfalfa, 1st cut | 21.4 | 35.3 | 55.6 |
| Alfalfa, 2nd cut | 16.5 | 36.6 | 51.2 |
| Gamagrass, 1st cut | 13.8 | 37.6 | 70.1 |
| Gamagrass, 2nd cut | 9.1 | 39.7 | 73.3 |

and similar for both groups, although weight change varied considerably within groups.

The data in this study provides more evidence that alfalfa is an excellent forage source. Even when the deficiency in protein content of the gamagrass was compensated for by use of a higher protein grain mix, performance still was lower than when alfalfa was fed. One would expect forage intake and milk yield to be somewhat less if gamagrass replaced alfalfa hay in a feeding program. With proper management including harvesting at optimum stage of maturity, application of fertilizer, and prevention of weed infestation, Eastern gamagrass does have agronomic characteristics that make it suitable for hay or silage production where deeper, moist soils would favor its development. Further study would be needed concerning its relative nutritional value in comparison with other grasses utilized as common forage sources.

# A System for Evaluating the Body Condition of Dairy Cows

E. P. Aalseth[1], G. D. Adams[2],
L. J. Bush[3] and K. Jones[4]

## Story in Brief

A system for quantifying the body condition of dairy cows has been developed. Cows were evaluated on a scale of 1 to 9, with 1 representing a very thin, emaciated cow, whereas 9 denoted an excessively fat cow. Scores on a group of 45 cows over a period of approximately 5 months after calving will be related to various measures of performance.

## Introduction

The nutritional status of dairy cows has been related to reproductive efficiency, milk yield, susceptibility to disease and metabolic disorders. It is generally accepted that the amount of fat cover or body condition of a cow is a direct indicator of her energy reserves and that changes in condition reflect shifts in energy balance. However, body condition has been evaluated in a very general, vague manner such that it is difficult to apply the information to other groups of cows with precision. Estimates of changes in energy status are often based on body weight changes over time. Weight changes do not take into account animal frame size and muscle conformation, and may be a poor indicator of total adipose reserves because of exchange of water and fat with changes in energy balance. A system to define the amount of adipose tissue carried by different types of dairy cows would be helpful in characterizing their energy reserves.

Quantitative descriptions of body condition of beef cattle have been used to help define the relationship between adipose reserve and reproductive performance (Cantrell et al., 1982; Wettemann et al., 1982). Body condition was scored on a 9 point scale with 1 being very thin and 9 very fat. A body condition scoring system has been described recently for dairy cattle (Wildman et al., 1982). This was a 5 point scale with 1 indicating severe undercondition and 5 severe overcondition.

There was a need for a reliable system for scoring cows on body condition in our dairy cattle nutrition and reproduction research at OSU. The 5 point system for dairy cattle developed by Wildman et al. (1982) was considered inadequate to describe all the possible degrees of body condition that could be perceived by an evaluator. Thus, that system did not provide the maximum resolution that could be attained in describing the energy reserves of a dairy cow. The objective of this paper is to describe a 9 point system for characterizing the body condition of dairy cows.

---

[1]Assistant Professor of Dairy Science [2]Professor of Dairy Science [3]Instructor of Dairy Science [4]Animal Technician

## Evaluation Procedure

The scale developed for scoring cows on body condition related the amount of fat cover in different locations of the body to a numerical rating (Table 1). In general, it was observed that dairy cows tend to accumulate fat first in the lower rib and thigh areas, followed later by deposition over the ribs, chine, loin and rump. As these areas become more filled with fat it also accumulates in the brisket, neck, shoulders, thighs and rump. Examples of cows with different amounts of body condition are shown in Figure 1 for purposes of illustration.

This body condition scoring system is being utilized in our current research. At regular weekly intervals four individuals are scoring each of 45 cows independently during the first 20 weeks after calving. The four scores are averaged to provide a condition score that will be related to various performance criteria, e.g., weight change, milk production, feed efficiency and reproductive performance.

## Discussion

This report mainly concerns a description of the body condition scoring system that was developed. Information on the relationship of the condition scores to cow performance will be reported at a later date.

After scoring cows for three or four weeks, the four individuals involved assigned scores that varied little for specific cows. The difference between the high and low scores given to a cow was often only ½ point and seldom more than 1 point. Factors that contributed to variation were degree of rumen fill, bloat, body frame size and conformation and the manner in which the cow deposited body fat. Degree of rumen fill or bloat can be compensated for to some extent by evaluating the right side of the cow. Experience and multiple evaluations also help achieve the proper score for cows that differ from the norm in their pattern of adipose deposition, frame size and degree of muscling.

Visual appraisal of dairy cattle for body condition is a feasible means of estimating adipose reserves. It is a system that could be followed easily and used in the field, provided meaningful relationships with various performance criteria are established in future research. In research studies where body condition of cows is an important criterion of response to different dietary or managerial treatments this system should provide a basis for quantifying treatment effects. A definite relationship between body condition of beef cows and conception in the postpartum period has been established (Wettemann et al., 1982). Wildman et al. (1982) noted a negative relationship between body condition of dairy cows and dairy merit (milk production/lb of metabolic body weight). This indicates that the more efficient milk producers preferentially deposit nutrients in milk and not body tissue. However, the body condition favoring overall long-term productivity of dairy cows, including re-breeding performance, has not been established in an objective well-defined manner.

As the relationships between body condition score and various cow performance criteria are evaluated, it may be possible to describe the ideal or most efficent body condition for a cow at different stages of the lactation cycle.

**Table 1. Body condition characteristics for each unit of the dairy cow condition scoring system.**

| Group | Score | Body condition characteristics |
|---|---|---|
| Thin | 1 | EXTREMELY THIN - Prominent ribs, transverse processes, hip bones and obviously thin thighs with skin stretched tightly over the skeleton with no visible subcutaneous fat. |
| | 2 | THIN - Visible ribs, transverse processes, slight amount of fleshing between the hooks and pins, adequate tissue on hind legs, and chine-shoulder area is thin. There is a slight amount of fat cover over the lower ribs. |
| | 3 | MODERATELY THIN - Some flesh covering over the ribs (especially lower ribs) and transverse processes with minimum fleshing between hooks and pins and in the chine-shoulder area. |
| Moderate | 4 | LOW MODERATE - Some fleshing over the ribs and transverse processes, yet they are still visible. Sufficient fleshing between hooks and pins such that there is only a moderate depression in this area. Light fat covering over the loin and chine-shoulder area. |
| | 5 | MODERATE - Lower ribs are not visible. Upper rear ribs are distinguishable, evident fleshing along sides of chine and in loin area with transverse processes barely visible. Evident fat cover over hooks and pins with a small depression in the rump area. The brisket area is thin. |
| Excellent | 6 | EXCELLENT CONDITION - Obvious flesh covering over the shoulder-chine area extending down the top line; the hooks, pin bones and transverse processes have rounded appearance, the ribs are not visible, thighs are moderately thick; only a slight depression exists between hooks and pins and there is some fat deposition in the brisket. |
| Fat | 7 | FAT - Smooth but moderate fat covering over entire body with crop and chine area filled with fat, patchy fat around the tailhead and pin bones; thighs are obviously thick. The brisket is moderately full of fat. |
| | 8 | EXTREMELY FAT - Excessive fat covering over entire body with patchy fat deposition over most bone structures. |
| | 9 | OVERCONDITIONED - Extremely thick fat cover over entire body, especially in the neck, shoulders, loin, hind quarters and lower barrel. Dewlap is not easily distinguishable. |

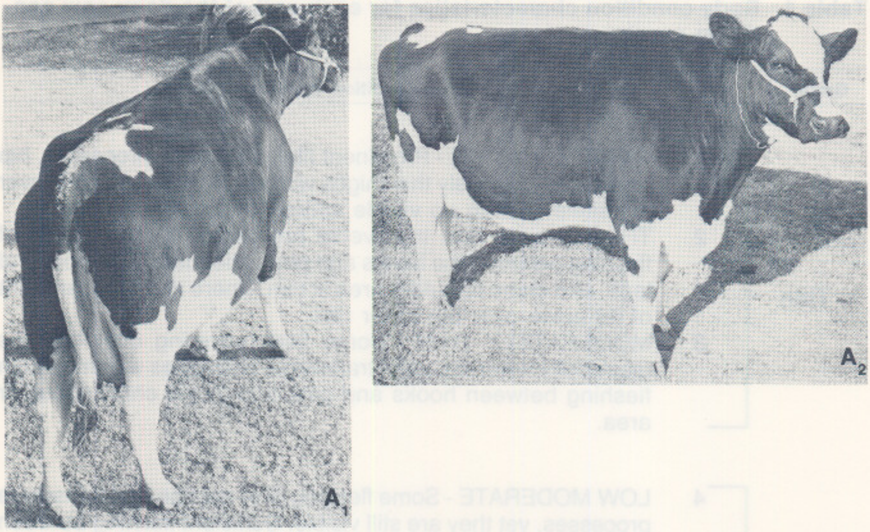
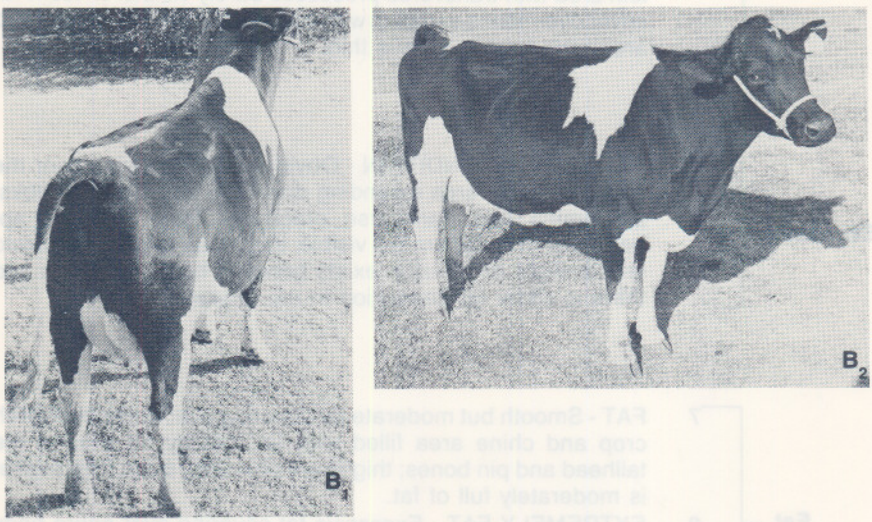



**Figure 1 (A). Cow given a score of "8" on the dairy cow condition score system.**




**(B). Cow given a score of "5" on the dairy cow condition scoring system.**

Moreover, after more data are accumulated, it should be possible to predict the outcome of feeding dairy cows to achieve different condition scores. Condition scores may become another criterion to be used along with data on milk yield and composition in selection and management of dairy herds.

## Literature Cited

Cantrell, J. A. et al. 1982. Okla. Agr. Exp. Sta. MP-112:53-58.
Wettemann, R. P. et al. 1982. Okla. Agr. Exp. Sta. MP-112:12-15.
Wildman, E. E. et al. 1982. J. Dairy Science. 65:495-501.

# Utilization of Bovine Hide Protein for Food

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

Collagen is available in the form of hide protein from animals slaughtered for food. Animal hide is a major byproduct of the meat packing industry. The use of hide, in addition to manufacturing leather, as a protein supplement in traditional foods improves the economy of animal agriculture. Another source of collagen is the trimmings of connective tissue from meats used for manufacturing restructured meat products. Mechanically deboned meat both from conventionally chilled meat animal carcasses and hot boned carcasses is yet another source of collagen. Therefore, food uses of this abundantly available protein are an important challenge to the food scientist.

Sausage and other comminuted meats are a good way of utilizing this protein for food. Sausage makers use meat containing large quantities of connective tissue (collagen) to reduce processing costs. But many processors limit the amount of collagen containing meat to avoid such defects in the final product as gel caps, gel pockets, poor peelability, etc. However, research reports have shown that connective tissue proteins (collagen) bind water similar to meat myofibrillar proteins and only the soluble fraction of collagen is responsible for gel pockets in the finished product when heat processed above 70 °C. Nonfat dried milk (NFDM) is often used in sausage as a binder and research has pointed out that hydrolyzed collagen preparations from limed bovine hide splits could be used to replace NFDM in sausage emulsions.

An earlier report provided information on the use of wet bovine hide collagen in bologna formulations to replace the lean meat at a 20% level. Such a product was found quite acceptable. Bovine hide protein is also available in a freeze dried form. Advantages of the dried product over wet hide collagen are many fold; lightweight, needs no refrigeration, can be stored at room temperature, less microbiological problems, ease of handling, etc.

A research project was initiated to study the functional characteristics of freeze dried and air dried bovine hide protein when incorporated in a bologna formulation at the permissable levels stipulated by meat inspection regulations of USDA. The research plan was to use low bind meats high in connective tissue with freeze dried bovine hide protein (FDBHP) as a binder, moisturizer and stabilizer and to:

1. Compare the finished product with all meat product without extenders and with NFDM as an extender.
2. Analyze the raw meats and the FDBHP for total collagen, different fractions of collagen like heat soluble, salt soluble, acid soluble to determine their role in binding stability, water holding capacity, texture, color, etc. of the finished product.
3. Determine the effect of FDBHP on the salt solubility and heat denaturation of meat proteins in the bologna meat mixture.
4. Determine the nutritive value of the product by amino acid analysis.
5. Determine the economics of incorporating FDBHP in sausage formulations.

---

[1]Research Associate [2]Professor of Animal Science

# Reproductive Development and Performance of Hereford Heifers Calving at 24 and 30 Months of Age

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

Two major problems are associated with calving heifers at 24 months of age: (1) the large number of heifers requiring assistance and (2) poor rebreeding performance. Research has shown that these problems can be greatly reduced by delaying calving until the heifers are 36 months of age. However, it is very difficult, on an economic basis, to justify delaying the onset of a heifer's productive life by a year. Calving at 30 months of age may reduce the problems associated with earlier calving and also be economically feasible, but there has been very little research conducted to date on calving at this age.

This study was initiated at the Southwestern Livestock and Forage Research Station, El Reno (Fort Reno) in the fall of 1979 and will continue until December 31, 1983. The objectives are: 1) to compare the reproductive performance heifers calving at 30 months of age with heifers fed at a high level of winter supplemental feeding of protein and energy and calving in the spring at 24 months of age; and 2) to determine the effects of a low and moderate level of winter supplemental feeding on the growth, development and reproductive performance of heifers calving in the spring at 30 months of age. Reproductive performance traits being measured include breeding performance as heifers, incidence and magnitude of calving difficulties and rebreeding performance following their first calving.

The heifers being utilized in this study are produced in experimental cow herds at the Lake Carl Blackwell Range Area. The total number of heifers that are available to be placed on experiment in a given year is limited. Therefore, in order to obtain sufficient numbers of heifers for the results to be meaningful, the study will consist of three replications. Three groups of weaner and yearling heifers were obtained in the falls of 1979, 1980 and 1981. They will remain in the study until they wean their first calf. When the third replicate is completed in the fall of 1983, the results for all three replicates will be combined, analyzed and published.

The heifers of replicate 2 calved during spring, 1982, weaned their calves last fall, thus completing replicate 2. Heifers of replicate 3 were bred during a 60-day period beginning May 7, 1982, and will calve in spring, 1983.

[1]Animal Science Professor [2]Animal Science Professor [3]Associate Professor

# Dietary Crude Protein and Reproductive Efficiency of High Producing Dairy Cows

**E.P. Aalseth[1] L.J. Bush[2] G.D. Adams[3] and L.E. Rice[4]**

The goal of the feeding program for high producing dairy cows is to provide sufficient dietary constituents for reproduction and to maximize milk production. During the first two to three months of lactation, high producing dairy cows cannot consume enough feed to meet the demands of lactation. A negative nutritional balance is induced by the rapid increase in milk production which peaks four to six weeks postpartum and the slow increase in energy intake that maximizes a few weeks later. Consequently, lactating dairy cows normally lose weight during the first several weeks of lactation as they mobilize adipose tissue and body protein in an attempt to meet the metabolic demands of lactation. Dairy cows may utilize as much as 25-27 percent of their total protein to support lactation. Mobilized protein is thought to provide constituents for both milk protein and lactose synthesis. In an effort to compensate for these nutritional deficits, the percent of crude protein in the diet of dairy cows is often increased. Increased feed consumption and digestibility seem to be some of the mechanisms by which higher levels of crude protein facilitate increased milk production. Current NRC crude protein recommendations for high producing dairy cows (66 to 110 lb milk/day) range from 14 to 22 percent of the diet on a dry matter basis.

Recently, there has been some limited evidence that feeding 16 percent or greater crude protein may impair the rebreeding of dairy cows. Greater amounts of crude protein appeared to increase services per conception and days open. Thus, high crude protein may interfere with fertilization and/or cause early embryonic mortality. It is important to definitely establish whether a high level of dietary protein affects reproductive performance. If reproductive efficiency is reduced, then future research will be devoted to resolve such an important conflict between the nutritional and reproductive management programs of dairy cows.

The objectives of this research are to evaluate the effect of dietary crude protein concentration on: 1) fertility and the onset and length of the estrous cycle, 2) plasma urea and $\beta$-hydroxybutyrate concentrations, 3) body condition and body weight changes and 4) milk production of dairy cows during the first 145 days of lactation.

The experiment is being conducted over three years at the OSU Dairy Cattle Center. Ayrshire and Holstein cows producing at least 45 lb milk/day by the start of the second week of lactation, are being used in the experiment. Cows are alternately assigned within breed to receive either 15 or 20 percent crude protein diets. Major dietary components include alfalfa hay, ground corn and soybean meal. The diets are fed three times daily on an individual cow basis. Feed intake is recorded daily. Cows are fed these diets until 145 days postpartum.

---

[1]Assistant Professor [2]Animal Science Professor [3]Instructor [4]Professor, College of Veterinary Medicine

The following characteristics are being measured from the time cows go on the experimental diets until 145 days postpartum to evaluate the effects of diet on overall performance. Weight change is determined at regular weekly intervals. Body condition scores, another indicator of nutritional status, are obtained at weekly intervals. A scale of 1 to 9 has been established with 1 being a very emaciated cow and 9 being a cow with excessive fat cover. Blood plasma levels of urea and $\beta$-hydroxybutyrate are indicators of protein level in the diet and nutritional stress, respectively. These blood constituents are measured every other week. Milk production is recorded twice daily. The percent milk fat is determined weekly.

Crude protein effects on reproductive performance is being evaluated with the following criteria. Collectively, rectal palpation of ovarian activity, weekly changes in plasma progesterone and daily observation of estrus activity are providing information on the postpartum estrous cycle onset and length of estrous cycles. Semen from a single collection of one bull per breed is being used for artificial insemination at the first three estrus periods greater than 55 days postpartum. The effects of these diets on days from parturition to conception, total percent of cows pregnant after three breedings and the percent that become pregnant from the first, second and third services will be determined.

# ACKNOWLEDGEMENTS

Many companies, organizations and individuals have contributed money, materials and(or) services to aid Animal Science Research. These contributions were instrumental in furthering the programs of the department and are gratefully acknowledged. On campus, the cooperation of staff in other colleges and other departments in the College of Agriculture was important in the design and implementation of several projects.

Studies at the Southwestern Livestock and Forage Research Station at El Reno, Oklahoma, were conducted in cooperation with USDA-ARS Texas-Oklahoma Area. Several studies were part of regional research projects.

The following is a listing of those who have contributed to the research program of the Animal Science Department during the preceding year.

AGRIMERICA, INC., Northbrook, Illinois
ALFALFA COUNTY FEED YARDS, Cherokee, Oklahoma
A.H. ROBBINS, INC., Richmond, Virginia
AMERICAN CYANIMID, Princeton, New Jersey
AMERICAN DEHYDRATORS ASSOCIATION, Shawnee Mission, Kansas
AMERICAN GELBVIEH ASSOCIATION, Denver, Colorado
AMERICAN HEREFORD ASSOCIATION, Kansas City, Missouri
AMERICAN HOECHST CORPORATION (Animal Health Divisions) Somerville, New Jersey
ANCHOR LABORATORIES, St. Joseph, Missouri
BAUR & SONS PACKING CO., Tulsa, Oklahoma
BOOKER CUSTOM PACK, Booker, Texas
BROOKOVER RANCHES, Garden City, Kansas
CALVIN BAIRD COMPANY, Chattanooga, Tennessee
COBA SELECT SIRES, INC., Tyler, Texas
COOPERATIVE STATE RESEARCH SERVICE, Washington, D.C.
CORNETT PACKING CO., Oklahoma City, Oklahoma
DIAMOND SHAMROCK CORP., Cleveland, Ohio
EAST CENTRAL OKLAHOMA STATE UNIV., Ada, Oklahoma
EASTERN REGIONAL RESEARCH CENTER, Philadelphia, Pennsylvania
EASTMAN KODAK, Rochester, New York
ELANCO PRODUCTS COMPANY, Division of Eli Lilly and Company, Greenfield, Indiana
FARR BETTER FEEDS, Guymon, Oklahoma
GRAIN UTILIZATION RESEARCH, Guymon, Oklahoma
HITCH FEEDLOTS, Guymon, Oklahoma
HOFFMAN-LaROCHE, INC., Nutley, New Jersey
IMC CHEMICAL GROUP, INC., Terre Haute, Indiana
MARSCHALL PRODUCTS, MILES LAB., INC., Madison, Wisconsin
MASTER FEEDERS, INC., Hooker, Oklahoma
MASTER FEEDERS II, INC., Garden City, Kansas

MASTER VETERINARY SERVICE, Guymon, Oklahoma
MERCK COMPANY, INC., Rahway, New Jersey
MOORMAN MANUFACTURING CO., Quincy, Illinois
MONSANTO INDUSTRIAL CHEMICALS CO., St. Louis, Missouri
NAMOLCO, INC., Willow Grove, Pennsylvania
NATIONAL COTTONSEED PRODUCERS ASSOCIATION, Memphis, Tennessee
NATIONAL LIVESTOCK COMMISSION COMPANY, Oklahoma City, Oklahoma
NATIONAL PORK PRODUCERS COUNCIL, Des Moines, Iowa
NICHOLAS TURKEY BREEDING FARMS, INC., Sonoma, California
NORTH AMERICAN LIMOUSIN FOUNDATION, Denver, Colorado
OKLAHOMA CATTLEMEN'S ASSOCIATION, Oklahoma City, Oklahoma
OKLAHOMA DAIRY HERD IMPROVEMENT ASSOCIATION, INC., Stillwater, Oklahoma
OKLAHOMA ECONOMIC DEVELOPMENT ADMINISTRATION
OKLAHOMA FEED MANUFACTURERS ASSOCIATION, Stillwater, Oklahoma
OKLAHOMA LIMOUSIN BREEDERS ASSOCIATION, Davis, Oklahoma
OKLAHOMA SWINE BREEDERS ASSOCIATION, Stillwater, Oklahoma
PANHANDLE STATE UNIVERSITY, Goodwell, Oklahoma
PFIZER AGRICULTURAL DIVISION, Lee's Summit, Missouri
RALPH'S PACKING CO., Perkins, Oklahoma
RALSTON PURINA, St. Louis, Missouri
RHONE-POULENE CHEMICAL CO., Atlanta, Georgia
RODEO MEATS, INC., Beef Division, Arkansas City, Kansas
S. B. FOOT TANNING CO., Cactus, Texas
SCHWAB AND CO., Oklahoma City, Oklahoma
SETON LEATHER CO., Newark, New Jersey
SMITH KLINE ANIMAL HEALTH PRODUCTS, Philadelphia, Pennsylvania
STAR LABS, St. Joseph, Missouri
TEXAS A&M UNIVERSITY, College Station, Texas
THE KERR FOUNDATION, INC., Oklahoma City, Oklahoma
UPJOHN COMPANY, Kalamazoo, Michigan
USDA AGRICULTURAL RESEARCH SERVICE, Southern Region
USDA SCIENCE AND EDUCATIONAL ADMINISTRATION, Western Region
U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, Washington, D.C.

**Supplied bulls for research at Ft. Reno**

Wayne Barnes, Owasso, Oklahoma
Paul Brown, Duncan, Oklahoma
Bill Clark, Duncan, Oklahoma
David Foster, Davis, Oklahoma
Ken Holloway, Chattanooga, Oklahoma
Erd Johnson, Midland, Texas
Mickey Johnson, Comanche, Oklahoma
Joe Kreger, Tonkawa, Oklahoma
L. E. Lansden, Wetumka, Oklahoma
Dr. W.T. McCollum, Oklahoma City, Oklahoma
Ellis-Vantrease, Blanchard, Oklahoma
Clay Wilson, Chickasha, Oklahoma

**College of Veterinary Medicine (Medicine & Surgery)**

D. D. Griffin
Marshall R. Putnam

**College of Arts and Sciences (Statistics Department)**

Ronald W. McNew
David L. Weeks
Robert Morrison

**ERRATA**

**Animal Science Research Report. 1982. MP 112. Pg. 121.**

**Dry matter values reported in Table 1., on page 121, are incorrect. Moreover, because of sampling errors, true values cannot now be determined. Please disregard the results in this entire table. — U. G. Bokhari**