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# 1999 CATTLEMEN'S DAY

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## MEATS AND BEEF SAFETY



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# EFFECTS OF REPETITIVE HIGH ENERGY PULSED POWER (RHEPP) IRRADIATION ON SENSORY ATTRIBUTES, COLOR, AND SHELF LIFE OF GROUND BEEF

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## Summary

We investigated the effects of packaging atmosphere and three levels of irradiation dose (Repetitive High Energy Pulsed Power, - RHEPP) on microbial populations, vitamin retention, and display color attributes of ground beef patties stored either chilled or frozen. Beef knuckles and beef fat were coarsely ground, sampled and analyzed to achieve 20% fat, mixed, ground through a 1/8 in. plate, and processed into 1/4-lb patties, which were sealed either aerobically or nitrogen-flushed. Patties were not irradiated or irradiated to 1.5 or 3.0 kGy, chilled, and displayed at 37 ± 4EF for 6 days under 150 foot-candles of Deluxe Warm White fluorescent lighting in an open-top display case defrosted at 12 hour intervals. Hunterlab Instrumental color was measured daily. The experiment was replicated three times. Aerobically packaged patties were lighter, more yellow, more discolored, and less red (all P<.05) than nitrogen-flushed patties over the 6-day display. Nitrogen-flushing for irradiated patties resulted in higher (P<.05) retention of thiamin, but riboflavin was not affected (P>.05). At $ 1.5 kGy, aerobic and lactic acid bacteria were reduced (P<.05), and no *E. coli* and coliforms survived. Nitrogen-flushing combined with irradiation resulted in more stable, intensely red colored patties, which retained more thiamin. The effect of irradiation on various flavor notes was minimal and generally diminished in nitrogen-flushed compared to aerobic packages.

(Key Words: Irradiation, Ground Beef, Color, Vitamin Retention.)

## Introduction

An estimated 45% of the total beef produced in the United States is consumed as ground beef, which is utilized widely in households and institutional establishments such as school lunch programs, fast food chains, and hospitals.

The effectiveness of irradiation in controlling microorganisms in meat is well documented. A dose of 2.5 kGy theoretically should kill 4.10 $\log_{10}$ *Listeria monocytogenes* and 5.12 $\log_{10}$ *Staphylococcus aureus* per gram of ground beef. A 3 log kill means 99.9% kill. A dose of 2.5 kGy would be sufficient to kill 8.1 $\log_{10}$ *Escherichia coli* O157:H7, 3.1 $\log_{10}$ *Salmonella*, and 10.6 $\log_{10}$ *Campylobacter jejuni*, thus, resulting in a high probability of complete inactivation of microbial pathogen populations likely to be present in ground beef patties.

Other researchers have shown that in ground beef with an initial total plate count (TPC) of 7.0 log CFU/g, an irradiation dose of .80 kGy reduced TPC by 1.5 log and 2.0 kGy reduced TPC by 3 log. These researchers concluded that meat samples with higher microbial loads such as ground meat required a higher dose of irradiation to effectively extend shelf life.

Quality concerns such as sensory and color changes have been studied less extensively. Some researchers have reported that irradiation causes detrimental changes to flavor and aroma, whereas others have reported minimal effects. Some of these differences may have been due to different levels of oxygen in the packages.

Because meat quality affects consumer acceptance, our objective was to determine sensory attributes, thiamin and riboflavin retention, color, and shelf life of ground beef patties in two packaging systems (aerobic or nitrogen atmosphere) and two holding temperatures (30EF or 0EF) exposed to two irradiation dose levels (1.5 or 3.0 kGy of RHEPP) or not irradiated (control).

## Experimental Procedures

Beef knuckles from a commercial source and beef fat trim from Kansas State University (KSU) Meat Laboratory were coarsely ground separately through a 3/8 in. plate, mixed to obtain a fat level of 20%, then ground twice through a 1/8 in. plate. Quarter pound patties were crust frozen (!40EF for 15-20 minutes) and either aerobically packaged in oxygen-permeable polyethylene bags or nitrogen packaged in high oxygen barrier packages.

Products were transported to Sandia National Laboratories, Albuquerque, NM for irradiation. Frozen cooler packs were used to control the temperature of the product during transportation, and product temperature was monitored by a temperature logger.

Dosimeters were used to verify radiation doses. Patties were arranged on an aluminum base plate and irradiated using RHEPP. One pass of the beam provided 1.5 kGy of irradiation and two passes provided 3.0 kGy. Control samples were treated in a similar fashion without the beam turned on. Base plate temperature and air temperature were monitored at 1-minute intervals. A maximum to minimum dose ratio of <1.7 was our target.

Descriptive flavor, aroma, and texture analyses were conducted 48 to 60 hours (chilled ground beef patties) and 6 to 8 days (frozen ground beef patties) after irradiation, using a professional panel at The Sensory Analysis Center (Kansas State University, Manhattan, KS). No more than six samples of ground beef patties were presented in a simple 1.5-hour test session. Products were evaluated independently for various flavor and texture attributes by five panelists. Each panelist had 120 hours of training in flavor and texture analysis, over 2,000 hours of sensory testing experience, and extensive experience in testing meat products. Before product testing, panelists were oriented to flavor, texture, and aroma attributes of this beef and were given irradiated beef samples to identify the aroma, texture, and flavor attributes to be evaluated.

Descriptive testing was performed in an environmentally controlled room. Thirteen flavor/texture attributes were assessed using a 15-point scale with .5 increments (0=none to 15=very intense) for each descriptor.

Aromatic attributes were determined prior to cooking, during cooking, and immediately following removal from the oven. Immediately prior to broiling, in-package raw aromas were determined by panelist(s) placing their noses about 2 in. from the sample and sniffing the released aroma. Cooked aroma was determined immediately upon removal of patties from the oven. Five raw patties per treatment per replication were broiled (3 in. from the heating element) to 165EF internally (about 4 minutes per side).

Each flavor panelist received one patty that had been cut into six wedges. After the patties cooled to approximately 155EF internally, panelists evaluated them for texture and flavor attributes.

Chilled patties were displayed at 38+2EF for 6 days under 150 foot-candles of Deluxe Warm White fluorescent lighting in an open-top display case defrosted at 12-hour intervals. Instrumental color data were collected during the 6-day display. Thiamin and riboflavin were determined by AOAC procedures.

Chilled and frozen studies were each replicated three times. Ground beef data were analyzed as a strip-strip-split-plot design using the maximum likelihood, mixed model analysis of the Statistical Analysis System. The whole plot was package type × dose with the split plot being panelist. Random effects were included to account for

variability in the batch of meat, patty, and panelist. Least square means were used to separate means at P<.05. Color data were analyzed using SAS Proc Univariate and Proc Mixed.

## Results and Discussion

In chilled patties, no differences (P<.05) were noted in any of the aromatic attributes before, during, or after cooking, irrespective of irradiation dose or packaging. Nitrogen-flushing reduced (P<.05) oxidized flavor and other off-notes associated with irradiation. Irradiation had minimal effects on tenderness, beef identification, and browned/ roasted flavor for all treatments.

In frozen patties packed in nitrogen, there were no differences (P>.05) in animal hair aroma, irrespective of irradiation level. Animal aroma during cooking was less (P<.05) in nitrogen-flushed patties than in those packaged aerobically. Juiciness, tenderness, beef identification, and browned/roasted flavor were not affected (P>.05) by irradiation. Barrier packaging and flushing with nitrogen reduced (P<.05) off-notes associated with irradiation. Furthermore, ground beef, juiciness, and tenderness were not affected adversely by RHEPP irradiation.

Aerobically packaged patties had a lighter, yellower (P<.05), more discolored instrumental color, whereas nitrogen-packaged patties had more redness (P<.05) compared to aerobically packaged patties over the 6-day display. Patties irradiated at 3.0 kGy were redder (P<.05) than control patties. The redness values of nitrogen-packaged patties irradiated at 0.0 and 1.5 kGy were not different (P>.05) at any display day. For all display days, instrumental discolorations for nitrogen-packaged patties irradiated at 3.0 kGy were similar (P>.05). Irradiation combined with nitrogen-flushing resulted in more stable, intensely red colored patties.

Irradiated patties had a longer (P<.05) display life compared to the nonirradiated samples. Nitrogen flushing for irradiated patties resulted in greater (P<.05) retention of thiamin than aerobic packaging. Riboflavin was not affected (P>.05) by any treatments.

# ANTIBACTERIAL EFFECTIVENESS OF A SECOND GENERATION STEAM PASTEURIZATION™ SYSTEM FOR BEEF CARCASS DECONTAMINATION

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## Summary

The original commercial Steam Pasteurization™ System (SPS 400) involved a sealable moving car by which carcass sides were carried through the steam chamber at standard line speeds. A second generation "static chamber" system (SPS 400-SC) eliminates the mechanical moving car and has been installed in a large beef slaughter facility. We collected data to verify SPS 400-SC's effectiveness at chamber temperatures from 185 to 205EF in a batch process mode (only test carcasses passing through the unit at variable intervals to facilitate collection of research samples) and at 190EF with the system running continuously. Tissue samples were obtained from different carcass anatomical locations to evaluate the uniformity of thermal treatment. Batch-type steam treatment at 185 and 190EF did not consistently produce significant bacterial reductions on the five anatomical locations sampled. Batch processing at 195, 200, and 205EF provided increasingly greater total bacterial reductions, ranging from 1.0 to 2.0 log colony forming units (CFU)/cm$^2$. Under continuous operation at 190EF, typical of commercial operation, total bacterial reductions at the carcass midline averaged 1.6 log CFU/cm$^2$. The new SPS design is substantially simplified in terms of moving components and should offer highly efficient operation and less mechanical upkeep, extremely important in Hazard Analysis Critical Control Point (HACCP) programs, which require assurance of virtually 100% system operation. The new SPS 400-SC design will provide beef processors a very effective and reliable means of assuring that microbiologically clean carcasses enter the holding cooler, thus substantially reducing the risk of pathogenic contamination.

(Key Words: Steam Pasteurization, Beef Carcass Decontamination, Antibacterial.)

## Introduction

Recent widely publicized outbreaks of *Escherichia coli* O157:H7 and other pathogens in the U.S. meat supply have forced researchers, regulators, and the meat industry to examine methods to reduce foodborne pathogens in meat products. Focus has been on developing intervention technologies to reduce bacterial contamination on carcasses prior to chilling. One intervention technology, fast becoming an industry standard, is Steam Pasteurization™. The original commercial-scale unit, designed by Frigoscandia Food Processing Systems (Redmond, WA) for inline processing, consisted of a stainless steel cabinet enclosing an overhead rail that housed a moving internal compartment ("car"), into which carcass sides were collected and exposed to steam. A new generation of that unit eliminates the internal moving compartment. This new design is intended to increase line efficiency, and by simplifying mechanical and electrical components, reduce the potential for breakdown.

We conducted studies to verify that the new static chamber prototype (SPS 400-SC) was effective in reducing bacteria on beef carcass sides. In addition, we compared anatomical locations in terms of bacterial contamination before and after steam treatment. We also compared batch-type processing at several temperatures and a continuous pasteurization at 190EF.

## Experimental Procedures

In batch-type studies, the SPS 400-SC unit was adjusted and held at the target chamber temperature. Randomly selected carcass sides (4-6) were railed onto the approach rail and held at the entrance of the unit for collection of before-pasteurization (B) tissue samples. The carcasses then were allowed to pass through the SPS 400-SC unit at typical line speed and were released into the chilling cooler on a dedicated sampling rail where after-pasteurization samples (A) were collected. In the 190EF continuous test, production line carcass sides passed through the SPS 400-SC unit at operational line speed. Random sides were tagged for identification as they approached the unit. An anatomical midline sample (B) was excised, the carcasses proceeded through the SPS 400-SC unit, and an after pasteurization sample (A) was taken immediately adjacent to the previous excision site. For the 185EF batch-type test, 30 carcasses were evaluated. For all other tests, 20 carcasses were tested.

Carcass tissue samples (21 $cm^2$ of surface area) were excised at five anatomical locations [neck, midline, inside round exterior, rope muscle (sternoman dibularis), and inside round cut muscle surface], using a sterile coring device, scalpel, and forceps. Samples were placed in plastic bags, transferred to an insulated cooler with cold packs, and shipped overnight to the analytical laboratory. Adjacent samples were collected from the same carcass immediately prior to entering the SPS unit and within 5 min of exiting the chamber.

All tissue samples were analyzed on the day of receipt. Total aerobic bacteria, coliform, generic *E. coli*, and *Enterobacteriaceae* counts were determined on 3M Petrifilm plates specific for each population. Mean $log_{10}$ CFU/$cm^2$ were calculated, and statistical analyses were performed to determine differences between (B) and (A) counts, reductions at different anatomical sites, and batch processing at various temperatures vs. 190EF continuous steam processing.

## Results and Discussion

Batch type processing at 185EF provided only minimal bacterial reductions at all anatomical sites. The midline of carcasses were substantially more contaminated than other locations. The 185EF batch-type thermal treatment was not equivalent to the same temperature setting in our earlier studies, as evidenced by less lean surface discoloration.

We compared batch-processing temperatures of 190, 195, 200, and 205EF and sampled neck, midline, and inside round sites. Total bacterial reductions increased as temperatures increased to 200EF. At 195EF, total reductions (all anatomical sites combined) were 1.4 $log_{10}$ CFU/$cm^2$. These reductions increased to 1.6 $log_{10}$ at 200EF. A 1 log reduction is 90%, and 2 log represents 99% reduction. Table 1 shows significant *Enterobacteriaceae* reductions at all temperatures except 185EF. Coliform and *E. coli* results were very similar (data not presented).

Thermal treatment effects were compared between the SPS 400-SC operating in a batch vs continuous mode at 190EF. The batch-type carcasses exhibited only slight graying of lean and cut surfaces. Continuous process carcass lean appeared more extensively gray, more typical of earlier SPS verification studies with original design. This color reverts to a natural red color after a short chilling period. Total aerobic bacterial reductions on continuously treated carcasses were superior to those on batch processed carcasses at 190EF (1.6 vs .7 $log_{10}$ CFU/$cm^2$, respectively). No continuously treated carcass was found positive for any of the Gram negative bacterial groups evaluated (Table 1).

**Table 1. Effectiveness of SPS 400-SC Steam Pasteurization in Reducing *Enterobacteriaceae* Bacteria Populations on Beef Carcasses**

| | | Carcass *Enterobacteriaceae* Distributions (CFU/cm$^2$) | | | | | |
|---|---|---|---|---|---|---|---|
| Anatomical Site | Positives/ Ranges | 185EF[c] | 190EF[d] | 195EF[d] | 200EF[d] | 205EF[d] | 190EF CON |
| Neck | B+[a] | 11 | 3 | 4 | 13 | 7 | |
| Neck | A+[a] | 4 | 0 | 2 | 0 | 7 | |
| Neck | B*[b] | 181.6 | .8 | 5 | 42.9 | 6.6 | |
| Neck | A*[b] | 42.1 | 0.4[f] | 0.8 | 0.4[f] | .8 | |
| Midline | B+ | 15 | 15 | 9 | 12 | 9 | 8 |
| Midline | A+ | 13 | 3 | 1 | 3 | 2 | 0 |
| Midline | B* | 35.5 | 18.2 | 42.9 | 85.9 | 39.6 | 19 |
| Midline | A* | 150.2 | 1.7 | 0.8 | 53.7 | 14.9 | 0.4[f] |
| Inside Round | B+ | 6 | 7 | 10 | 6 | 5 | |
| Inside Round | A+ | 2 | 1 | 1 | 1 | 1 | |
| Inside Round | B* | 9.1 | 40.5 | 107.3 | 84.2 | 26.4 | |
| Inside Round | A* | 379.7 | 0.8 | 0.4[f] | 9.9 | .8 | |
| All sites | B+ | 11 | 8 | 8 | 10 | 7 | 8 |
| combined | A+ | 6 | 1 | 1 | 1 | 2 | 0 |
| | B* | 75.4 | 19.8 | 51.7 | 71 | 24.2 | 19 |
| | A* | 190.7 | 0.8 | 1.9 | 21.2 | 5.5 | 0.4[f] |

[a]B+ and A+ = number of carcasses testing positive before and after SPS 400-SC.

[b]B* and A* = highest observed count (CFU/cm$^2$) before and after SPS 400-SC.

[c]N = 30 carcass sides per anatomical site, 90 total observations across three sites.

[d]N = 20 carcass sides per anatomical site, 60 total observations across three sites.

[e]N = 20 carcass sides per anatomical site, 20 total observations at one site (midline); carcass sides were pasteurized continuously.

[f]Half the detection limit was used in place of a value of 0.

# LACTIC ACID, HOT WATER, AND MICROWAVE TREATMENT TO REDUCE NATURAL MICROFLORA AND PATHOGENS IN VACUUM-PACKAGED BEEF

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## Summary

Combined lactic acid (2%), hot water, and microwave treatments were used to reduce natural microflora and the pathogens *Escherichia coli* O157:H7, *Salmonella typhimurium*, and *Listeria monocytogenes* in vacuum-packaged beef. Hot water at 158EF followed by vacuum packaging and 5 sec. of microwave were acceptable for microbial reduction. Dipping inoculated meat for 20 sec. into 2% room temperature lactic acid prior to that treatment at 158EF reduced *E. coli* O157:H7 by 1.05 log CFU/cm$^2$, *S. typhimurium* by .7 log CFU/cm$^2$, and *L. monocytogenes* by .85 log CFU/cm$^2$ (CFU is colony forming unit). One log equals a 90% reduction, and 2 log a 99% reduction. With this treatment, meat color reverted to an acceptable value after 14 hr of storage at 39EF. Part 3 of the experiment combined 2% lactic acid and hot water treatments into one step. Dipping for 20 sec. in 176EF, 2% lactic acid then vacuum packaging and microwaving for 5 sec. reduced natural microflora by 1.8 log CFU/cm$^2$, *E. coli* O157:H7 by 1.18 log CFU/cm$^2$, *S. typhimurium* by 1.5 log CFU/cm$^2$, and *L. monocytogenes* by 1.5 log CFU/cm$^2$, with acceptable color values after 14 hr storage at 40EF. This combination was the most effective in reducing both natural and inoculated microorganisms and provides a low-cost alternative for decontamination of meat surfaces.

(Key Words: Beef, Pathogens, *E. coli* O157:H7, *S. typhimurium*, *L. monocytogenes*.)

## Introduction

Much carcass decontamination research has been done using hot water, lactic acid, and microwave treatments. A combined carcass washing followed by a hot water spray (203EF) reduced inoculated pathogens on the surface of the carcasses. Using hot water decontamination cabinets (176EF, 10 and 20 sec.) significantly reduced pathogens of the surface of beef briskets. Steam Pasteurization™ reduces surface microorganisms, but it is not cost effective for small plants. Organic acids such as lactic acid may injure bacterial cells and make them more susceptible to hot water and microwave treatments. Use of microwaves also may reduce natural microflora and pathogens on meat surfaces. This experiment was performed to achieve the optimal combination of heat, lactic acid, and microwave treatment for microbial reduction. The goal was to reduce natural microflora, *E. coli* O157:H7, *S. typhimurium*, and *L. monocytogenes*, while maintaining fresh meat color.

## Experimental Procedures

*Escherichia coli* O157:H7, *S. typhimurium*, and *L. monocytogenes* from the Food Microbiology Culture Collection at Kansas State University were inoculated into Brain Heart Infusion (BHI, Difco, Detroit, MI) broth and incubated at 100EF for 24 hr.

Beef sirloin steak from local grocery stores was cut into uniform pieces (2 3/4 × 2 3/4 in.) using a knife sterilized in an alcohol flame for 2 sec. In the first experiment, meat samples were not inoculated, and only natural microflora was enumerated. In experiments 2 and 3, meat samples were inoculated

with *E. coli* O157:H7, *S. typhimurium*, or *L. monocytogenes*, then vacuum packaged, dipped into hot solution (water or 2% lactic acid), and microwaved. Each pathogen was tested separately. The meat was immersed into a 2.0 liter beaker containing 1.0 liter of the appropriate inoculum (ca. 8.0-9.0 log CFU/ml). For experiment 2, meat was soaked in the inoculum for 10 sec. and held for 10 min at room temperature (77EF). Meat samples then were dipped into 2% lactic acid; placed into a nylon film bag (7 × 12 in.); and vacuum packaged with 100 mbar pressure. All vacuum packaging was performed in a bacteriological safety hood.

**Experiment 1: Hot Water and Microwave Treatments**. This experiment tested 140, 158, 176, and 194EF hot water treatments, followed by vacuum packaging and microwave treatment of 5, 7, and 10 sec. Meat samples were exposed to 140EF hot water for 10, 25, 40, or 55 sec.; to 158EF water for 5, 10, 15, or 20 sec.; to 176EF water for 3, 5, and 7 sec. or to 194EF hot water for 1, 2, or 3 sec. Each water treatment then was followed by 5, 7, or 10 sec. of microwave treatment. During each treatment, the immediate meat color change was monitored visually. If it changed to a cooked color during treatment, the sample was removed immediately, and a viable cell count (VCC) for natural microflora was performed. After treatment, color was assessed immediately using a scale of 1 to 5: 1=bright red fresh meat color, 2=red fresh meat color, 3= intermediate color, 4= cooked color, 5=very cooked color. Any treatment that caused an irrecoverable cooked color was considered unacceptable. Controls were used to monitor actual microbial reduction. To check the VCC, the center of each treated sample was cored with a sterile coring device (1.75 $in^2$). Then the core surfaces were removed aseptically and transferred to a sterile stomacher bag containing 56 ml of .1% sterile peptone diluent. The samples were stomached for 2 min, and 9 ml dilutions were prepared in .1% sterile peptone diluent. Natural microflora was enumerated by plating onto Plate Count Agar (PCA, Difco), and incubating at 90EF for 25 hr. Water temperatures of 158 and 176EF were chosen for further research.

**Experiment 2: 2% Lactic Acid, Hot Water, and Microwave Treatments**. After inoculation, samples were dipped into 2% room temperature lactic acid solution for 20 sec., then vacuum packaged and dipped into 158EF water for 30 sec., followed by 5 sec. of microwave treatment. Color was evaluated visually during and after treatment and after 15-18 hr of refrigerator storage. The vacuum bags were opened, and color recovery was examined every 2 hr up to 14 hr and also at 24 hr. VCCs were performed using procedures from experiment 1. *E. coli* O157:H7 was enumerated using MacConkey Sorbitol Agar (MSA, Difco), *S. typhimurium* was plated on Brilliant Green Agar (BGA, Difco), and *L. monocytogenes* was enumerated using Modified Oxford agar media (MOX, Difco).

**Experiment 3: 2% Lactic Acid (176EF) Followedby Microwave Treatments**. Based on antimicrobial activity and acceptable color values, meat samples were inoculated, dipped into 2% lactic acid solution (176EF) for 20 sec., then vacuum packaged and microwaved for 5 sec. After treatment, samples were stored at 40EF for 24 hr. After the bags were opened, color was evaluated every 2 hr up to 14 hr and at 24 hr. This combined the hot water and 2% lactic acid treatments into one step. Microbial counts were performed as in experiment 2.

## Results and Discussion

**Experiment 1: Hot Water and Microwave Treatments**. Table 1 shows a typical data set for time, temperature, and microwave treatments with one hot water temperature (158EF). After treatment, the vacuum bags were opened, color changes were evaluated, and VCCs were taken. For 140EF hot water, 40 sec. was the maximum time with acceptable meat color, but this temperature/time did not reduce microbial numbers. At 158EF, 15 sec. was optimal with acceptable color changes. Natural microorganisms were reduced from 8.0 × $10^2$ to 4.5 × $10^2$ CFU/$cm^2$ (.3 log reduction). When the time was increased to 20 sec. in 158EF water, natural microorganisms were reduced by .6 log CFU/$cm^2$, but this 5 sec.

increase caused immediate cooked color. With 176EF hot water, 5 sec. was the maximum time of exposure with acceptable color, but this treatment did not reduce microorganisms (data not shown). For 194EF water, maximum dip time with acceptable color changes was 2 sec. Natural organisms were reduced from $1.6 \times 10^2$ to $7.0 \times 10^1$ (.4 log reduction). For microwave treatment of 7 sec., optimal times for each temperature were as follows: 40 sec. for 140EF, 15 sec. for 158EF, 5 sec. for 176EF, and 2 sec. for 194EF. Of these, the most microbial reduction (.3 to .5 logs) was seen with 176EF for 5 sec.

Temperatures of 140, 158, 176, and 194EF were tested with a microwave time of 10 sec. Maximum times for each hot water submersion were 40 sec., 10 sec., 3 sec., and 1 sec. for those temperatures. When 10 sec. or less of microwave treatment was used, microbial reduction was not significant.

Based on preliminary experiments, 158EF was chosen as the best temperature to use in further studies.

**Experiment 2: 2% Lactic Acid, Hot Water, and Microwave Treatments**. Samples exposed to 158EF water for 15 sec recovered good color after 6 hr of storage (Table 2), but samples exposed to 158EF for 30 sec. recovered only barely acceptable color values after 24 hr of storage. However, dipping those samples in 2% lactic acid before packaging reduced natural microflora (1.8 log CFU/cm$^2$) with recoverable color values (data not shown).

With the combination of 2% lactic acid dip for 20 sec., 158EF water for 15 sec., and microwave for 5 sec., pathogen reductions were as follows: .8 log CFU/cm$^2$ for *E. coli* O157:H7, .7 for *S. typhimurium*, and .7 for *L. monocytogenes*. For 158EF water for 30 sec., pathogen reductions were similar: 1 log CFU/cm$^2$ for *E. coli*, 12 for *S. typhimurium*, and .9 to 3.50 log for *L. monocytogenes*. Using these three treatments of lactic acid, hot water, and microwave killed 90% of foodborne pathogens (data not shown).

**Experiment 3: 2% Lactic Acid (176EF) Followed by Microwave Treatments**. The color of meat subjected to 2% lactic acid (176EF) for 15 and 20 sec. immediately changed to 5 (very cooked color, Table 3). When the opened meat samples were stored at 40EF, the color recovered to 3 (intermediate), which was acceptable. For 15 and 20 sec. treatments, color recovered in 8 hr and 14 hr, respectively. Natural microorganisms were reduced by 1.8, *E. coli* O157:H7 by 1.6, and *S. typhimurium* and *L. monocytogenes* by 1.5 log CFU/cm$^2$ (data not shown).

In conclusion, dipping meat in 2% lactic acid (176EF) for 15 sec., vacuum packaging the meat, and then treating the meat in a microwave for 5 sec. gave 90 to 99% reduction of pathogens and still allowed the meat to have acceptable color.

**Table 1. Evaluation of Meat Surface Color and Microbial Counts after Hot Water (158EF) and Microwave (MW) Treatments**

| Item | Meat Color Score | Before Trt CFU/cm$^2$ | After Trt CFU/cm$^2$ |
|---|---|---|---|
| Control | 1.0 | $8.0 \times 10^2$ | $8.0 \times 10^2$ |
| 5 sec. hot water, 5 sec. MW | 1.3 | $8.0 \times 10^2$ | $1.6 \times 10^3$ |
| 10 sec. hot water, 5 sec. MW | 2.3 | $8.0 \times 10^2$ | $6.6 \times 10^2$ |
| 15 sec. hot water, 5 sec. MW | 3.0 | $8.0 \times 10^2$ | $4.5 \times 10^2$ |
| 20 sec. hot water, 5 sec. MW | 5.0 | $8.0 \times 10^2$ | $2.0 \times 10^2$ |

Color scores: 1=bright red fresh meat color, 2=red fresh meat color, 3=intermediate, 4=cooked color, and 5=very cooked color.

**Table 2. Mean Color Scores[a] during Storage at 40EF after Combined Treatment of Lactic Acid, Hot Water (158EF), and Microwave (5 sec.)**

| | Treatments[b] | | |
|---|---|---|---|
| Conditions | Control | L,15H,5M | L,30H,5M |
| After treatment | | | |
| 0 hr | 1 | 3.2 | 5 |
| Open | | | |
| 0 hr | 2.6 | 5 | 5 |
| 2 hr | 2 | 4.2 | 4.8 |
| 4 hr | 1 | 3.2 | 4.2 |
| 6 hr | 1 | 2.2 | 4 |
| 8 hr | 1 | 2.2 | 3.6 |
| 10 hr | 1 | 2 | 3.2 |
| 12 hr | 1 | 2 | 3.2 |
| 14 hr | 1 | 1.8 | 3.2 |
| 24 hr | 1 | 1.4 | 3 |

[a]Color scores: 1 = bright red fresh meat color, 2 = red fresh meat color, 3 = intermediate, 4 = cooked color, and 5 = very cooked color.
[b]L = 2% lactic acid spray, 15 H and 30 H = 15 and 30 sec. dip in 158EF water, 5M = 5 sec. in microwave.

**Table 3. Color Changes[a] during Storage at 40EF after Combined Treatment of Hot 2% Lactic Acid (176EF) Solution and Microwave (5 Sec.)**

| | Treatments[b] | | | | |
|---|---|---|---|---|---|
| Conditions | Control | 5L, 5M | 10L,5M | 15L,5M | 20L,5M |
| After treatment | | | | | |
| 0 hr | 1 | 2.2 | 3.6 | 5 | 5 |
| Open | | | | | |
| 0 hr | 1 | 2.2 | 3.6 | 4.8 | 4.6 |
| 2 hr | 1 | 1.6 | 3.0 | 4.8 | 4.6 |
| 4 hr | 1 | 1.6 | 2.6 | 4.6 | 4.4 |
| 6 hr | 1 | 1.6 | 2.2 | 3.6 | 3.6 |
| 8 hr | 1 | 1.8 | 2.2 | 3.0 | 3.8 |
| 10 hr | 1 | 1.4 | 1.6 | 2.8 | 3.4 |
| 12 hr | 1 | 1.4 | 1.6 | 2.0 | 3.2 |
| 14 hr | 1 | 1.4 | 1.8 | 1.8 | 3.0 |
| 24 hr | 1 | 1.2 | 1.4 | 1.6 | 2.8 |

[a]Color scores: 1 = bright red fresh meat color, 2 = red fresh meat color, 3 = intermediate, 4 = cooked color, and 5 = very cooked color.
[b]L = 2% lactic acid; 5H, 10H, 15 H, and 20H are sec. application in 176EF; 5M = 5 sec. in microwave.

*Cattlemen's Day 1999*

# INCIDENCE OF PREMATURE BROWNING DURING COOKING IN GROUND BEEF PURCHASED AT RETAIL

*M. C. Hunt, K. M. Killinger, and R. E. Campbell*

## Summary

We measured the incidence of premature browning during cooking in ground beef that was purchased from retail supermarkets and prepared using common household procedures. Patties made from meat on the outer portion of the packages purchased in the morning had the highest incidence of premature browning (62.5%). Patties from inner portions of packages purchased in the afternoon, refrigerated, and prepared the next morning were more ($P<0.05$) purple and had the lowest incidence (25%) of premature browning. Overall incidence of premature browning averaged 47%. Because internal cooked color of ground beef is such an unreliable indicator of doneness, temperature measurements should be used to verify that safe endpoint temperatures have been reached.

## Introduction

Internal cooked color of beef steaks and roasts changes from red to pink to brown as their doneness increases. Unfortunately, the internal cooked color of ground beef is not a reliable indicator of doneness. Sometimes patties may appear brown, slightly pink, or have a persistent pink/red color even though cooked to the same temperature. ***Premature browning*** is a vitally important food safety issue, because patties may appear fully cooked (brown) even though they have not reached an internal temperature high enough to kill pathogens that might be present. The USDA (1997) recommends that ground beef patties be cooked to160EF, with no reference to internal color. The FDA (1993) recommends that food service establishments cook ground beef to 155EF and hold for 15 sec. However, these combinations of time-temperature may result in patties that are fully cooked but have a pink internal cooked color that consumers think is unsafe.

Because no data are available on the occurrence of premature browning, we determined its incidence in ground beef purchased from retail supermarkets and prepared using common household procedures.

## Experimental Procedures

Ground beef (1 lb packages, 20% fat) was purchased from two retail stores twice each day for 8 days. Product was purchased in the morning (<2 hr after grinding, based on information provided by the store meat managers), formed into patties, and cooked within 1 hour of purchase. Ground beef packages purchased in the afternoon were refrigerated (36EF) overnight, and patties were formed and cooked on the following morning. One 1/4 lb. patty was made from the surface layer (outer 5/8 in.) of each package. This portion appeared bright red (predominantly oxymyoglobin) in packages purchased in the morning, but both oxy- and metmyoglobin (the brown pigment) were present in packages purchased in the afternoon. A second patty was made with meat from the inner, central-bottom portions of the packages. The pigments seen in the inner patties from the morning purchases appeared to be a combination of oxy- and metmyoglobin, whereas the internal samples from afternoon purchases seemed to contain more deoxymyoglobin with small amounts of metmyoglobin. All patties were cooked to an internal temperature of 131EF (an unsafe endpoint that measures premature browning) on an electric griddle at a surface tempera-

ture of 350EF. Internal temperature of the patties was measured by intermittently inserting an 18-gauge hypodermic thermocouple into their centers.

Prior to cooking, the outer surfaces of each patty were visually scored for color, using a scale of: 1=purple-red, 2=dark reddish purple, 3=bright red, 4=brownish-red, 5=very brown. Visual scoring was done under 100 foot-candles of deluxe warm-white fluorescent lighting. The interior color of the patties was assumed to be the same as the exterior, because cooking occurred immediately after patty formation. In addition, exterior color was measured using a portable Minolta colorimeter to determine CIE L*a*b* values.

Cooked patties first were cut perpendicular to the flat surface, and the interiors were scored visually. Then the half-circles of the patties were cut in the center parallel to the flat surface, and visual scores and three instrumental readings were taken. The scale for internal cooked visual color was: 1=very dark red to purple, 2=bright red, 3=very pink, 4=slightly pink, 5=tan (no evidence of pink). Data were analyzed as a factorial, split-plot design.

## Results and Discussion

Patties cooked to 131EF and showing a visual color score of 4.0 or higher were considered prematurely brown; in this experiment, 47% (30 of 64) (Fig. 1 totals). The highest incidence of premature browning (62.5%) was found in patties made from the outer portions of packages purchased in the morning (Fig. 1); patties made from the inner portions of those packages had a 43.8% incidence. Of patties made from packages purchased in the afternoon, 56.3% made from the outside were prematurely brown, but only 25% of patties made from the inner portions. Refrigerated overnight storage of ground beef packages reduced the incidence of premature browning by 10 to 40%.

Cooked patties showed significant purchase time by tissue location interactions for a*, saturation index, and hue angle values (Table 1). Patties made from the inner portion of packages purchased in the afternoon and stored overnight had the highest ($P<0.05$) a* (redness) and the lowest hue angle values (less brown). These patties were less likely to appear prematurely brown, probably because more bright red oxymyoglobin had reduced to purple red deoxymyoglobin in the inner portion of the ground beef during overnight storage. In addition, patties made from the outer portion of the packages purchased in the morning had higher ($P<0.05$) hue angle values (more brown) than patties made from the inner portion of packages purchased in either the morning or the afternoon.

Uncooked patty color differed by store (data not shown), but these differences did not affect cooked patty color and the incidence of premature browning.

Visual scores and a* and hue angle values for uncooked patties showed a significant interaction of purchase time by package location (Table 1). Raw patties made from the inner portion of the afternoon-purchased packages were scored visually more ($P<0.05$) purplish-red than patties from other purchase time and location combinations and, thus, had the lowest incidence of premature browning. Ground beef in the inner portion of those packages would be expected to have a change in pigments from oxymyoglobin to metmyoglobin and eventually to deoxymyoglobin and become more purple than meat from either the outer or inner portion of packages purchased in the morning shortly after grinding. Patties formed from ground beef purchased in the afternoon and taken from either the outer or inner package location had lower ($P<0.05$) a* values (redness) than patties formed from ground beef purchased in the morning. Raw patties made from ground beef purchased in the afternoon and formed from the outer portion of the packages had higher ($P<0.05$) hue angle values (indicates more brown) than patties from any other purchase time and location combination.

Incidence of premature browning during cooking of ground beef varied by package

location and time of purchase, as well as home storage time. Our study suggests that a predominance of oxymyoglobin and metmyoglobin, as opposed to deoxymyoglobin, in raw ground beef can lead to premature browning upon cooking. Any practices at stores or during home storage that encourage the formation of deoxymyoglobin should reduce premature browning. The 47% incidence of premature browning in our study indicates that ground beef patty doneness should not be judged by color. The chance of leaving viable pathogenic bacteria was nearly 1 in 2 when a ground beef patty was cooked to a brown color endpoint. This level of risk is unacceptable; thus, consumers must use some form of temperature measurement to determine doneness of ground beef patties.

**Table 1. Effects of Purchase Time and Package Location on Visual Color Scores, a* Values, Saturation Index, and Hue Angle of Uncooked and Cooked Ground Beef Patties**

| | | Package Location | | |
|---|---|---|---|---|
| Trait | Purchase Time | Outer | Inner | SE |
| Uncooked | | | | |
| Visual[d] | Morning | 3.0[a] | 3.1[a] | |
| | Afternoon | 2.9[a] | 1.8[b] | .20 |
| a* value (redness) | Morning | 22.9[a] | 21.9[a] | |
| | Afternoon | 18.5[b] | 19.3b | .37 |
| Hue angle | Morning | 25.8[b] | 26.0[b] | |
| | Afternoon | 27.6[a] | 26.2[b] | .35 |
| Cooked | | | | |
| a* value (redness) | Morning | 11.7[b] | 12.7[b] | |
| | Afternoon | 11.9[b] | 14.3[a] | .33 |
| Hue angle | Morning | 41.3[a] | 38.6[b] | |
| | Afternoon | 40.1[ab] | 34.9[c] | .85 |

[a,b,c]Means within a trait, both morning and afternoon, with a different superscript letter differ P<0.05.
[d]Visual score 1=purple-red, 2=dark reddish purple, 3=bright red.

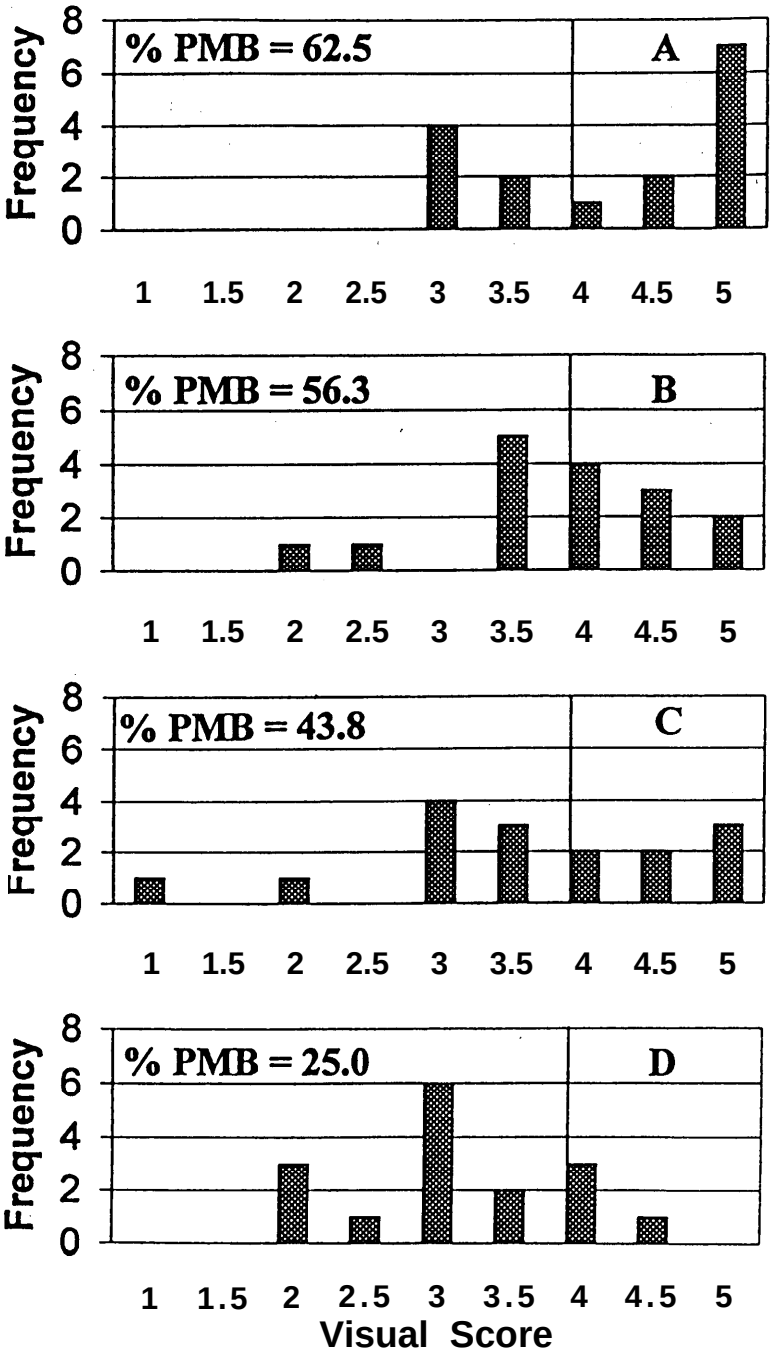


**Figure 1. Frequency of Premature Brown Visual Scores (≥ 4.0) for Internal Cooked Color of Ground Beef Patties to 131 ° F. A = ground beef purchased in the morning, patties made from outer 1.5 cm of package; B = ground beef purchased in the afternoon and stored overnight, patties from outer portion of package; C = ground beef purchased in the morning, patties from the inner, central-bottom portion of package; D = ground beef purchased in the afternoon and stored overnight, patties from the inner portion of package.**

# INHIBITION OF HETEROCYCLIC AMINE FORMATION IN GROUND BEEF

*J. S. Smith and B. G. Abdulkarim*

## Summary

The natural antioxidant carnosine, moisture retention by covered cooking, and low temperature cooking were evaluated as ways to inhibit heterocyclic amine (HCA) formation in fried ground beef. Samples were fried at 375EF for 5 min/side, 300EF for 5 min/side, or 250EF for 8 min/side, with surface browning enhanced by applying a caramel solution (Maillose®) near the end of cooking times. Analysis for HCAs was performed on both the crust and the whole patties. Carnosine reduced 4,8-DiMelQx, a major HCA, to below its detection limit (.31 ng/g). HCAs were reduced when the cooking temperature was lowered from 375 to 300 or 250EF even with caramel applied on the surface. Cooking in a covered pan reduced levels of most HCAs but less than carnosine addition.

(Key Words: Ground Beef, Heterocyclic Amine, Inhibition.)

## Introduction

Meat cooked at high temperature may contain mutagens and animal carcinogens called heterocyclic amines (HCAs). To inhibit the formation of these compounds, naturally occurring antioxidants can be added to the meat before cooking. Carnosine, a Beta-alanine-histidine-containing dipeptide present in skeletal muscle, may be effective through a combination of free radical scavenging and metal chelation. Thus, we added carnosine to meat samples to detect its effect in reducing HCA formation. Water movement during cooking may carry HCA precursors from inner portions of the meat patties to outer surfaces. Consequently, we studied minimizing water loss and consequent movement by covered cooking. Lower cooking temperatures may reduce levels of HCAs formed, so we also studied effects of longer cooking at lower temperatures.

## Experimental Procedures

Raw ground beef from eye round steaks (2.9% fat) was formed into 100 g patties, 1.5 cm (.59 in.) thick and 10 cm (3.9 in.) in diameter. Meat patties for control (no additive), carnosine added (1.5%), and moisture retention (covered cooking) treatments were fried in a thermostat-controlled Teflon-coated frying pan at 375EF for 5 min/side. For low cooking temperatures, meat samples were fried at 300EF for 5 min/side or 250EF for 8 min/side. Surface browning was enhanced by applying caramel solution (Maillose®) near the end of cooking times. The internal temperature was recorded by inserting a probe thermocouple into the center of the patty at a 45E angle. Final internal temperatures were 160EF for all treatments.

Solid phase extraction was followed by high pressure liquid chromatography (HPLC) with a Hewlett-Packard 1090 A, series II HPLC system. A photodiode array ultraviolet detector and a fluorescence detector were used to monitor the separations. A TSKgel ODS80 (TosoHaas, Montgomeryville, PA), 25 cm × 4.6 mm I.D. (5 Fm particle size) column protected by a Supelguard ODS-80™ (TosoHaas) precolumn was used for separation of HCAs.

The mobile phase consisted of three solvents: solvent A, .01 M triethylamine (pH 3.2); solvent B, .01 M triethylamine (pH

3.6); solvent C, acetonitrile. The gradient profile was linear, and the program was 0-10 min, 5-15% C in A; 10-10.1 min, exchange of A with B; 10.1-20 min, 15-25% C in B; 20-30 min, 25-55% C in B, followed by 15 min for column equilibration.

Abbreviations for reporting HCAs are as follows:

IQ=2-amino-3-methylimidazo [4,5-*f*]quinoline;

MelQ=2-amino-3,4-dimethylimidazo [4,5-*f*]quinoline;

MelQx=2-amino-3,8-dimethylimidazo [4,5-*f*]quinoxaline;

4,8-DiMelQx= 2-amino-3,4,8-trimethyl-imidaxo[4,5-*f*]quinoxaline;

PhIP=2-amino-methyl-6-phenyl-imidazo [4,5-*b*]pyridine;

harman=1-methyl-9H-pyrido[3,4-*b*];

norharman=9H-pyrido[3,4-*b*]-indol.

## Results and Discussion

Adding carnosine lowered levels of HCAs formed on the meat patty crust. Both MelQ and 4,8 DiMelQx (specific HCAs) were reduced below their corresponding detection limits (.28 ng for MelQ and .31 ng for 4,8-DiMelQx). The highest reduction in MelQx (43.00%) was with added carnosine as contrasted to the controls. However, carnosine increased PhIP 60% compared to the controls. This increase probably was due to alanine in the carnosine molecule, which may contribute to PhIP formation.

When moisture was retained in the meat patties by covering the cooking pan, the effect on HCAs was variable, some were reduced, MelQ (to nondetectable), DiMelQx (57%), harman (12%), and norharman (30%), whereas some were increased; MelQx (7.0%) and PhIP (9.0%). The final internal temperature of the moisture retained patties (181EF) was higher than the control (173EF), which might account for the increase in MelQx and PhIP.

Caramel (Maillose) added near the end of cooking increased HCAs in patties cooked at 300 or 250EF, but levels were still lower than those in patties cooked at 375EF.

# EFFECTS OF POST-BLEEDING VASCULAR INFUSION OF CATTLE WITH A SOLUTION OF SUGARS, SODIUM CHLORIDE, AND PHOSPHATES OR WITH CALCIUM CHLORIDE ON CARCASS TRAITS AND MEAT PALATABILITY[1]

***M. E. Dikeman, T. E. Dobbels, M. C. Hunt, and J. J. Schoenbeck***

## Summary

We evaluated the effects of post-exsanguination vascular infusion at 10% of live weight of a solution of sugars, sodium chloride, and phosphates (MPSC) or of calcium chloride on carcass traits and meat palatability. Dressing percentages were 4% higher for carcasses infused with the MPSC and 2.5 % higher for carcasses infused with calcium chloride than for controls. USDA quality grades were not affected by vascular infusion. Infusion with calcium chloride caused undesirable intermuscular fluid accumulation and two-toned color in several muscles. It also caused higher Warner-Bratzler shear values and lower trained sensory panel scores ($P<.05$). MPSC infusion may offer financial benefits by increasing dressing percent, but it has no other major effects.

(Key Words: Vascular Infusion, Meat Quality, Meat Palatability.)

## Introduction

Vascular infusion near the end of bleeding is a relatively new technique developed to improve and reduce variation of meat quality. The process involves stunning, exsanguination by severing the jugular veins, and infusion of fluids containing sugars and minerals through the right carotid artery. These fluids are delivered using a pumping system at pressures slightly below the blood pressure of resting live cattle. In several studies reported in the literature, vascular infusion has increased tenderness, decreased carcass weight loss, accelerated pH decline postmortem, and increased chilling rates of muscle. In other studies, injection of .3M calcium chloride into muscles at 24 to 48 hours postmortem has improved tenderness.

Our objectives were to determine dressing percentages, carcass shrink, by-product weights, yield and quality grade information, Warner-Bratzler shear force, and trained sensory panel scores of steaks from cattle that had received carcass infusion treatments.

## Experimental Procedures

Grain finished Hereford × Angus steers (n=36) were obtained from a commercial feedlot where they had been fed a typical corn-based diet for 140 to 155 days. Cattle were shipped approximately 310 miles to the Kansas State University Beef Research Unit where they were provided feed and water until 12 hr prior to slaughter. The animals were slaughtered in two groups of 18, about 70 days apart (three head in each of two treatments and a control group) on 2 consecutive days. The average live weight at slaughter was 1181 ± 75 lb. Steers were slaughtered at the KSU Meat Laboratory by humane procedures. They were stunned with a captive bolt, the jugular veins were severed, and bleeding continued for approximately 3 min. Then the carcass was infused to 10% of its live weight via the right carotid artery using a delivery system developed by

[1]Appreciation is expressed to the National Cattlemen's Beef Association, Greenwood Village, CO; North American Meat Processors Association, Reston, VA; and MPSC, Inc., Eden Prairie, MN for their financial support of this research.

the Meat Processing Service Corporation, Inc. (MPSC, Inc.) of Eden Prairie, MN. Cattle were assigned randomly to one of the following treatment groups: 1) noninfused, control (Con); 2) infused with the standard MPSC solution containing 98.52% water, .97% sugars, .23% sodium chloride, and .28% phosphate blend (MPSC-infused); and 3) infused with .3 M (3.3%) $CaCl_2$ in water ($CaCl_2$-infused). The infusion process was conducted by employees of MPSC who developed the technology, specialized equipment, and technique over the last decade. It delivers fluids at pressures slightly below the normal blood pressure of cattle. Cattle were weighed on a rail scale prior to bleeding and after vascular infusion. They were dressed using standard procedures and chilled at 36EF using a 1 min cold water spray every 15 min for 8 hr after cooler entry. Carcasses were ribbed at 24 hr postmortem, and USDA yield and quality grade traits were obtained. Carcasses were regraded at 48 hr postmortem. *Longissimus lumborum* and *semitendinosus* muscles were removed and vacuum aged for 13 days, at which time they were cut into 1-inch-thick steaks and frozen for later Warner-Bratzler shear force and descriptive attribute evaluation by a trained sensory panel. After thawing, steaks were cooked in a Blodgett modified broiling oven to 150EF and cooled for 2 hours; then ½-inch-diameter cores (parallel to muscle fibers) were evaluated for Warner-Bratzler shear force on an Instron Universal Testing Instrument. Steaks for sensory panel evaluation were cooked and cooled the same way. No more than eight samples (representing different treatments) were presented in one panel session. Steaks were cut into ½ × ½ × 1 inch cubes for evaluation and scored on a scale of 8 = extremely tender, extremely flavorful, extremely juicy, no connective tissue; 1 = extremely tough, extremely bland, extremely dry, abundant connective tissue.

## Results and Discussion

The mean dressing percentage was about 4 % higher (P<.05) for MPSC-infused cattle and about 2.3 % higher (P<.05) for $CaCl_2$-infused cattle than for Con cattle (Table 1). Using a carcass price of $1/lb and an average carcass weight of 725 lb, carcasses from cattle infused with the MPSC solution had a $30 advantage over noninfused cattle. Carcass cooler shrink was not different between Con and MPSC-infused cattle, but cattle infused with $CaCl_2$ showed greater (P<.05) cooler shrinkage. No differences in hide, tongue, or head weights were found among treatment groups, but hearts and livers were heavier for steers infused with the MPSC solution. At 24 hours postmortem, lean was firmer and finer textured (P<.05) for Con carcasses than for those infused with either solution (Table 2). Percentage of purge from vacuum-packaged muscles was similar among treatments after 14 days of aging (Table 2). Infusion had no effect on USDA yield and quality grade traits (Table 3).

Muscles from carcasses infused with $CaCl_2$ had markedly higher (P<.05) Warner-Bratzler shear force values and lower scores for sensory panel tenderness (less tender), connective tissue (more abundant), and juiciness (drier) than those from MPSC-infused or Con carcasses (P<.05; Table 4).

Several muscles from carcasses infused with $CaCl_2$ were in a tetany contraction when rolled into the cooler. This contraction likely was the reason for significant toughening. Several studies had shown that injecting .3M $CaCl_2$ into muscles at 24 or 48 hours postmortem resulted in a tenderness improvement. Our .3M $CaCl_2$ infusion apparently incorporated enough calcium to cause extensive muscle contraction but not tenderization. No differences in tenderness or palatability traits were noted between carcasses infused with the MPSC solution and Con carcasses.

In conclusion, vascular infusion at 10% of live weight with the MPSC solution increased dressing percentage and had minimal effects on meat palatability of grain-fed steers. Infusion with .3 M $CaCl_2$ increased dressing percentage but caused undesirable intermuscular fluid accumulation, toughness, and lower flavor and juiciness scores.

**Table 1. Effects of Vascular Infusion of Hereford × Angus Cattle with the MPSC Solution or Calcium Chloride on Carcass Weight, Dressing Percentage and Organ and By-Product Weights**

| Item | CON | MPSC | $CaCl_2$ | SE |
|---|---|---|---|---|
| Live weight, lb | 1166.9 | 1222.9 | 1156.1 | 44.2 |
| Hot carcass weight, lb | 727.9[b] | 811.9[a] | 747.7[b] | 27.9 |
| Dressing percentage | 62.4[a] | 66.4[b] | 64.7[ab] | 44.0 |
| Carcass shrink percentage (24 h) | !.24 | !.02 | .70 | .27 |
| Chilled carcass weight (48 h), lb | 725.0 | 807.0 | 759.0 | 11.5 |
| Carcass shrink percentage (48 h) | .38[a] | .66[a] | 1.28[b] | .28 |
| Hide weight, lb | 95.3 | 90.6 | 95.7 | 13.6 |
| Tongue weight, lb | 2.4 | 3.5 | 3.3 | .2 |
| Head weight, lb | 27.8 | 31.3 | 29.3 | 9.3 |

[a,b]Means within the same row with different superscript letters differ (P<.05).

**Table 2. Effects of Vascular Infusion of Hereford × Angus Cattle with MPSC Solution or Calcium Chloride on Longissimus Muscle Quality Attributes**

| Item | CON | MPSC | $CaCl_2$ | SE |
|---|---|---|---|---|
| Lean color, 24 h[a] | 5.0 | 3.6 | 4.8 | .37 |
| Lean color, 48 h[a] | 4.3 | 4.2 | 4.7 | .37 |
| Color uniformity, 24 h[b] | 4.7 | 3.8 | 3.4 | .37 |
| Color uniformity, 48 h[b] | 4.7 | 4.4 | 4.1 | .37 |
| Lean firmness, 24 h[c] | 6.5[g] | 4.5[g] | 5.9[h] | .42 |
| Lean firmness, 48 h[c] | 5.7 | 5.8 | 5.9 | .42 |
| Lean texture, 24 h[d] | 5.8[i] | 4.7[h] | 3.8[g] | .54 |
| Lean texture, 48 h[d] | 5.7 | 5.5 | 5.0 | .54 |
| Surface moisture, 24 h[e] | 1.2 | 1.6 | 2.5 | .24 |
| Surface moisture, 48 h[e] | 1.1 | 1.2 | 2.1 | .24 |
| Heat ring, 24 h[f] | 1.4 | 1.5 | .13 | .21 |
| Heat ring, 48 h[f] | 1.3 | 1.2 | 1.3 | .21 |
| Longissimus muscle purge, % | 2.3 | 3.2 | 3.5 | .5 |
| Semitendinosus muscle purge, % | 2.7 | 3.8 | 3.1 | .5 |

[a]1 = bleached red; 4 = cherry red; 8 = very dark red.
[b]1 = uniform; 5 = extreme two-toning.
[c]1 = very firm; 8 = extremely soft.
[d]1 = very fine; 8 = extremely coarse.
[e]1 = very dry; 8 = extremely moist.
[f]1 = none; 5 = extreme heat ring.
[g,h,i]Means within the same row with different superscript letters differ (P<.05).

**Table 3. Effects of Vascular Infusion of Hereford × Angus Cattle with MPSC Solution or with Calcium Chloride on USDA Yield Grade and Quality Grade**

| Item | CON | MPSC | $CaCl_2$ | SE |
|---|---|---|---|---|
| Hot carcass weight, lb | 727.9[b] | 811.9[a] | 747.7[b] | 12.6 |
| Preliminary yield grade (PYG) | 3.2 | 3.4 | 3.3 | .11 |
| Adjusted PYG | 3.3 | 3.5 | 3.4 | .10 |
| REA, $in.^2$ | 12.2 | 12.9 | 11.9 | .24 |
| Kidney and pelvic fat, % | 1.6 | 1.5 | 1.6 | .18 |
| USDA YG | 3.0 | 3.2 | 3.3 | .17 |
| Fat cover score | 3.8 | 3.8 | 3.6 | .24 |
| Bone maturity, 24 h | A[62] | A[51] | A[62] | 5.0 |
| Lean maturity, 24 h | A[68 b] | A[45 a] | A[70 b] | 5.0 |
| Overall maturity, 24 h | A[65] | A[48] | A[66] | - |
| Marbling 24 h | Slight[73] | Slight[67] | Slight[61] | 1.0 |
| USDA QG, 24 h | Select[73] | Select[67] | Select[61] | - |
| Lean maturity, 48 h | A[53] | A[54] | A[64] | 5.0 |
| Marbling, 48 h | Slight[72] | Slight[72] | Slight[91] | 1.0 |

[a,b]Means within the same row with different superscript letters differ (P<.05).

**Table 4. Effects of Vascular Infusion of Hereford × Angus Cattle with MPSC Solution or with Calcium Chloride on Warner-Bratzler Shear Force and Descriptive Attribute Sensory Panel**

| Item | CON | MPSC | $CaCl_2$ | SE |
|---|---|---|---|---|
| Longissimus muscle | | | | |
| Shear force, kg | 3.4[a] | 4.0[a] | 5.8[b] | .39 |
| Myofibrillar tenderness[c] | 4.9[b] | 5.9[b] | 4.7[a] | .13 |
| Connective tissue[c] | 7.0[b] | 7.1[b] | 6.2[a] | .14 |
| Overall tendereness[c] | 6.1[b] | 6.2[b] | 4.9[a] | .14 |
| Juiciness[c] | 5.8[b] | 5.8[b] | 5.5[a] | .12 |
| Flavor intensity[c] | 5.9 | 5.9 | 5.7 | .11 |
| Off flavor[c] | 7.7[b] | 7.4[ab] | 7.4[a] | .10 |
| Semitendinosus muscle | | | | |
| Shear force, kg | 4.9 | 4.6 | 4.8 | .13 |
| Myofibrillar tenderness[c] | 5.4 | 5.5 | 5.5 | .13 |
| Connective tissue[c] | 6.1[a] | 6.5[b] | 6.1[a] | .14 |
| Overall tenderness[c] | 5.5 | 5.7 | 5.6 | .14 |
| Juiciness[c] | 5.5[b] | 5.3[a] | 5.5[ab] | .12 |
| Flavor tenderness[c] | 5.7 | 5.5 | 5.4 | .11 |
| Off flavor[c] | 7.6 | 7.7 | 7.7 | .10 |
| Ground beef shear force, kg | 2.0 | 1.9 | 2.1 | .18 |

[a,b]Means within the same row with different superscript letters differ (P<.05).
[c]8 = extremely tender, no connective tissue, extremely juicy, extremely flavorful, and no off flavor. 1= extremely tough, abundant connective tissue, extremely dry, extremely bland, and extensive off flavor.

# COLOR STABILITY OF STEAKS FROM CARCASSES VASCULARLY INFUSED IMMEDIATELY AFTER EXSANGUINATION

***M. C. Hunt, J. J. Schoenbeck, M. E. Dikeman, T. E. Dobbels, and S. L. Stroda***

## Summary

Hereford × Angus carcasses were infused with a solution of either sugar/phosphate or calcium chloride immediately after exsanguination to determine effects on color stability during retail display. A calcium chloride solution darkened the cuts and reduced color stability. A sugar/phosphate blend made steaks appear lighter red (more desirable), and their color stability was equal to that of the noninfused control.

(Key Words: Beef, Infusion, Display, Color Stability.)

## Introduction

Vascular infusion of carcasses immediately after bleeding can increase yields, cause faster chilling, and improve meat tenderness. Infusion could affect meat color, because pumping aqueous solutions through the vascular system may change pH decline and dilute or remove muscle pigments and create a "lighter" than normal appearance. Conversely, accelerated chilling by chilled infusion solutions may improve color stability. Our objective was to determine the effects of vascular infusion of two different solutions immediately after bleeding on the initial color, uniformity of muscle color, and display color stability of steaks.

## Experimental Procedures

Thirty-six Hereford × Angus steers, which had been fed for 140-155 days to an avg BW 1181 lb, were stunned, shackled by a rear leg, and exsanguinated through the severed jugular veins. Cattle were infused to 10% of live weight via the carotid artery using a technique developed by the Meat Processing Service Corporation of Eden Prairie, MN. They were assigned randomly to one of the following treatments: 1. noninfused, control; 2. infused with a water solution containing a mixture of sugars and phosphate; and 3. infused with water and 0.3M $CaCl_2$. After infusion, cattle were processed using normal procedures and placed in a 36° F cooler with a spray-chill system. Muscle pH decline was measured at 1, 2, 4, 8, 16, and 24 hr postmortem in the *triceps brachii (TB), longissimus thoracis,* and inside (deep) *semimembranosus* (ISM). Carcass temperature decline in these three muscles also was monitored continuously for 24 hr after cooler entry. At 48 hr postmortem, the *longissimus lumborum* (LL), *psoas major* (PM), and *semimembranosus* (SM) muscles were excised, trimmed practically free of fat, vacuum packaged in barrier bags, and vacuum aged for 12 days at 36° F. One-inch-thick steaks from these muscles were packaged in permeable film for display in an open-topped case at 35° F with two defrost cycles daily and illumination at 150 foot- candles of Deluxe Warm White fluorescent lighting. Steaks were evaluated by a six-member, trained, color panel for initial color, color uniformity, and color stability over 4 or 5 days of display. The SM typically has a light-red inside portion (ISM) and a darker red outside portion (OSM). Thus, these two muscle areas were scored separately. Color was evaluated instrumentally throughout display. Significant differences ($P<.05$) were determined using analysis of variance.

## Results and Discussion

**Carcass pH Decline**: A more rapid pH decline (Table 1) occurred in the three muscles

from the infused carcasses versus pH decline in noninfused carcasses. It took 16 h for pH decline in noninfused longissimus thoracis (LT) to equilibrate with pH decline in the two infused treatments. In the TB and ISM muscles, pH decline in control carcasses equaled the pH decline in the infused carcasses by 4 hr postmortem. All treatments within a muscle had essentially the same muscle pH at 24 hr postmortem. The accelerated pH declines of both infusion treatments while carcass temperatures were high (1-4 hr postmortem) created conditions favorable for protein denaturation, which could result in a lighter color and softer muscle.

**Muscle pH**: No differences in 48 hr pH occurred among treatments for the LL (5.71), ISM (5.74), and OSM (5.69) muscles. The PM from carcasses infused with sugar/phosphate had a higher ($P<.05$) pH (5.89) than PM from noninfused carcasses (5.78). The pH of PM steaks from carcasses that were $CaCl_2$-infused (5.83) was not different ($P>.05$) from that of PM steaks.

**Initial Color and Uniformity of Color**: LL and OSM muscles from carcasses infused with sugar/phosphate had lighter, more cherry red, initial color scores ($P<.05$) than steaks from the $CaCl_2$-infused or noninfused carcasses (Table 2). Differences in initial scores likely were due to increased light scatter caused by water added during infusion and/or the more rapid pH declines, not muscle pigment dilution.

The LL from noninfused carcasses was most uniform in color ($P<.05$), and both the sugar/phosphate-infused and $CaCl_2$-infused treatments had more two-toning. The $CaCl_2$-infused treatment created a speckled or mottled brownish-red appearance that would not be acceptable for meat purveyors or consumers.

**Display Color Stability**: The obvious trend was for visual color stability scores to increase (more discoloration) as time progressed (Table 3). On day 0, LL steaks from the sugar/phosphate treatment had the lightest-red ($P<.05$) appearance. These steaks discolored faster but to the same final color as the control. In the LL, the $CaCl_2$-infused and noninfused treatments were not different for visual scores at day 0, but at day 1 of display and over the display period, the $CaCl_2$-infused treatment resulted in more discoloration than did the sugar/phosphate and noninfused treatments. Apparently, the $CaCl_2$-infusion caused a faster conversion of the bright-red pigment to enough of the brown form of myoglobin to be perceptible to color panelists. Treatment differences in display color stability were not as pronounced in the ISM and OSM muscles (data not shown), but they tended to follow the differences found in the LL. Instrumental color evaluations confirmed the visual scores for discoloration. Muscles from the sugar/phosphate treatment were lighter-red and discolored similarly to steaks from non-infused carcasses, whereas the $CaCl_2$ infusion increased discoloration.

Infusion treatment differences were found for the LL, so infusion solutions must have reached that muscle. Pumping aqueous solutions to areas nearer the infusion site should be easier than pumping to muscles located in posterior portions of the carcass. Some treatment differences due to infusion were found in the ISM and OSM. Thus, vascular infusion apparently delivered substrates to these posterior muscles of the carcass, although faster pH decline postmortem may have contributed. Vascular infusion of beef carcasses is not approved currently by the USDA, but it has potential to positively alter some carcass and muscle traits.

**Table 1. pH Decline Means by Treatment and Muscle from Carcasses that Were Vascularly Infused with Sugar/Phosphate or $CaCl_2$ Immediately after Bleeding**

| | Muscle | | |
|---|---|---|---|
| Time × treatment | *Triceps brachii* | *Longissimus thoracis* | Inner *Semimembranosus* |
| 1 h | | | |
| $CaCl_2$-infused | 5.96[b] | 6.23[b] | 6.44[b] |
| Sugar-infused | 6.12[b] | 6.21[b] | 6.23[c] |
| Noninfused | 6.58[a] | 6.87[a] | 6.67[a] |
| 2 h | | | |
| $CaCl_2$-infused | 5.64[c] | 5.84[b] | 6.01[b] |
| Sugar-infused | 5.84[b] | 5.96[b] | 5.90[b] |
| Noninfused | 6.25[a] | 6.50[a] | 6.20[a] |
| 4 h | | | |
| $CaCl_2$-infused | 5.56 | 5.63[c] | 5.61 |
| Sugar-infused | 5.69 | 5.81[b] | 5.73 |
| Noninfused | 5.69 | 6.13[a] | 5.68 |
| 8 h | | | |
| $CaCl_2$-infused | 5.59 | 5.58[b] | 5.57 |
| Sugar-infused | 5.65 | 5.64[ab] | 5.55 |
| Noninfused | 5.58 | 5.81[a] | 5.56 |
| 16 h | | | |
| $CaCl_2$-infused | 5.64 | 5.69 | 5.65 |
| Sugar-infused | 5.60 | 5.64 | 5.58 |
| Noninfused | 5.56 | 5.66 | 5.63 |
| 24 h | | | |
| $CaCl_2$-infused | 5.66 | 5.62 | 5.54 |
| Sugar-infused | 5.68 | 5.64 | 5.58 |
| Noninfused | 5.64 | 5.65 | 5.64 |
| SE | 0.09 | 0.09 | 0.09 |

[a,b,c]Means within a muscle and postmortem time with a different superscript letter differ ($P<.05$).

**Table 2. Least Square Means for Initial Color Score, Color Uniformity Score, a*, and %R630-580nm of Steaks from Carcasses Vascularly Infused with Sugar/ Phosphate or $CaCl_2$ Immediately after Bleeding**

| | Visual Color[d] | | Instrumental Color[d] | |
|---|---|---|---|---|
| Muscle × Treatment | Initial[e] | Uniform[f] | a* | %R630-580 nm |
| Inside semimembranosus (ISM) | | | | |
| $CaCl_2$-infused | 2.4 | 1.3 | 13.8 | 19.5 |
| Sugar-infused | 1.9 | 1.2 | 13.8 | 22.5 |
| Noninfused | 2.3 | 1.3 | 15.2 | 20.7 |
| SE | 0.34 | 0.14 | 0.77 | 1.50 |
| Outside semimembranosus (OSM) | | | | |
| $CaCl_2$-infused | 4.4[a] | 1.4 | 18.2 | 19.8 |
| Sugar-infused | 3.5[b] | 1.4 | 17.7 | 22.3 |
| Noninfused | 4.4[a] | 1.3 | 18.3 | 20.2 |
| SE | 0.34 | 0.14 | 0.77 | 1.50 |
| Longissimus lumborum (LL) | | | | |
| $CaCl_2$-infused | 4.0[a] | 2.2[a] | 15.6[c] | 19.3[b] |
| Sugar-infused | 3.1[b] | 1.8[b] | 18.9[b] | 27.0[a] |
| Noninfused | 4.2[a] | 1.2[c] | 20.7[a] | 24.5[a] |
| SE | 0.34 | 0.14 | 0.77 | 1.50 |
| Psoas major (PM) | | | | |
| $CaCl_2$-infused | 4.3 | 1.7 | 12.4 | 12.9 |
| Sugar-infused | 3.9 | 1.6 | 13.3 | 15.7 |
| Noninfused | 4.2 | 1.5 | 12.8 | 14.1 |
| SE | 0.34 | 0.14 | 0.83 | 1.61 |

[a,b,c]Means within a muscle group for a given trait with a different superscript letter differ ($p<.05$).

[d]These visual scores and instrumental data had a two-way interaction ($p<.05$) with treatment and muscle and no significant three-way interactions (treatment x muscle x display day), both a* and %R630-580 nm indicate redness.

[e]Initial color scale for d 0 only: 1=pale red or bleached red, 2=very light cherry red, 3= moderately light cherry red, 4=cherry red, 5=slightly dark cherry red, 6=moderately dark red, 7=dark red, and 8=very dark red.

[f]Color uniformity scale for d 0 only: 1=uniform, 2=slight two-toning, 3=small amount of two-toning, 4=moderate amount of two-toning, 5=extreme two-toning.

**Table 3. Least Square Means for Visual Display Color, L*, and b* for the *Longissimus Lumborum* from Carcasses Vascularly Infused with Sugar/Phosphate or $CaCl_2$ Immediately after Bleeding**

| Display Day/Treatment | Visual Display Color[d] | L* | b* |
|---|---|---|---|
| d 0 | | | |
| $CaCl_2$-infused | 2.5[a] | 40.9[ab] | 23.0[ab] |
| Sugar-infused | 1.9[b] | 43.4[a] | 24.0[a] |
| Noninfused | 2.4[a] | 38.7[b] | 22.4[b] |
| d 1 | | | |
| $CaCl_2$-infused | 3.2[a] | 40.5[ab] | 20.9[b] |
| Sugar-infused | 2.2[b] | 43.2[a] | 22.5[a] |
| Noninfused | 2.6[b] | 38.1[b] | 21.8[ab] |
| d 2 | | | |
| $CaCl_2$-infused | 3.9[a] | 40.3[ab] | 19.8[b] |
| Sugar-infused | 2.8[b] | 42.6[a] | 22.2[a] |
| Noninfused | 2.9[b] | 37.9[b] | 21.4[a] |
| d 3 | | | |
| $CaCl_2$-infused | 4.2[a] | 39.8[ab] | 19.0[b] |
| Sugar-infused | 3.1[b] | 41.9[a] | 22.0[a] |
| Noninfused | 3.2[b] | 37.4[b] | 21.0[a] |
| d 4 | | | |
| $CaCl_2$-infused | 4.3[a] | 41.1[ab] | 17.4[b] |
| Sugar-infused | 3.4[b] | 43.5[a] | 20.2[a] |
| Noninfused | 3.2[b] | 38.8[b] | 19.5[a] |
| d 5 | | | |
| $CaCl_2$-infused | 4.5[a] | 41.4[ab] | 18.3[b] |
| Sugar-infused | 3.6[b] | 42.7[a] | 20.5[a] |
| Noninfused | 3.4[b] | 38.8[b] | 19.8[a] |
| SE | 0.16 | 1.33 | 0.53 |

[a,b]Means within a column on a given day with a different superscript letter differ (P<.05).
[c]The OSM, ISM, and LM were the only muscles were significant (P<.05) differences were found for visual display scores, L* and b* values.
[d]1= very bright cherry red or pale red, 3 = slightly dark red to tan or brown, 5 = dark red to tan or brown.

# EFFECTS OF POST-BLEEDING VASCULAR INFUSION OF CATTLE WITH A SOLUTION OF SUGARS, SODIUM CHLORIDE, AND PHOSPHATES WITH OR WITHOUT VITAMIN C ON CARCASS TRAITS, WARNER-BRATZLER SHEAR FORCES, AND PATALABILITY

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## Summary

Two groups of grain-finished, crossbred Charolais steers were utilized to determine the effects of post-bleeding vascular infusion on dressing percentages, USDA quality and yield grades, Warner-Bratzler shear force values, and flavor. Nine steers from one group of 18 were infused with a solution containing sugars, sodium chloride, and a phosphate blend (MPSC), and the remaining nine steers served as noninfused controls. Nine in the second slaughter group of 18 were MPSC-infused, and nine were infused with the MPSC solution plus 500 ppm vitamin C (MPSC+C). The MPSC cattle had a 2.9% higher mean dressing percentage (P<.05) than control cattle. Vascular infusion had no effect (P>.05) on Warner-Bratzler shear force or USDA quality and yield grades. Results from a descriptive flavor profile sensory panel showed some significant differences in flavor profile characteristics, but these differences were small and inconsistent. Vascular infusion with MPSC or MPSC+C increased carcass weights, had few effects on USDA quality or yield grades or shear force, and had no consistent effects on flavor profile characteristics of cooked beef.

(Key Words: Beef, Vascular Infusion, Flavor Profile Analysis.)

## Introduction

Vascular infusion near the end of bleeding is a relatively new technique developed to improve and reduce variation in meat quality. The process involves stunning and bleeding by severing the jugular veins and then infusing substrates through the right carotid artery, using a pumping system at pressures slightly below the blood pressure of resting live cattle.

Vascular infusion has increased tenderness, decreased carcass weight loss, accelerated postmortem pH decline, and allows faster chilling in several studies. None of the vascular infusion studies have evaluated the effects of incorporating an antioxidant such as vitamin C on flavor profiles of cooked beef. Antioxidants delay the onset of lipid oxidation and prevent off-flavors, such as warmed-over flavor. Therefore, our objectives was to determine dressing percentages, carcass traits, Warner-Bratzler shear force, and flavor profile characteristics of cooked ground beef and steaks from cattle that had been infused with or without vitamin C.

## Experimental Procedures

Two groups of 18 grain-finished, crossbred Charolais steers were slaughtered using conventional means. Nine from one group were infused via the carotid artery immediately after jugular vein bleeding, at 10% of live weight with a solution containing 98.52% water, .97% sugars, .23% sodium chloride, and a .28% phosphate blend (MPSC, Inc. Eden Prairie, MN). The remaining nine served as noninfused controls (Con). Steers in the second group of 18 were infused after bleeding with either the MPSC solution (n=9) or the MPSC solution + 500 ppm vitamin C (MPSC+C) (n=9). Carcasses

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were chilled conventionally in a spray chill cooler.

Carcasses were evaluated at 24 and 48 hours postmortem for USDA quality and yield grades and fabricated 48 hours postmortem. Sections of the longissimus lumborum (LL) and semitendinosus (ST) were vacuum packaged and aged at 35EF in a research cooler until 14 days postmortem. Steaks 1 in. thick were cut from the LL and ST, vacuum packaged, and frozen until evaluation. Quadriceps muscles were vacuum packaged, frozen, and later thawed and combined with subcutaneous fat for fabrication into ground beef with 15% fat.

Steaks were cooked to an internal temperature of 150EF in a Blodgett gas oven and cooled for 2 hr; then ½-in.-diameter cores (parallel to muscle fibers) were evaluated for Warner-Bratzler shear force by an Instron universal testing machine.

Cooked steaks and ground beef patties were held at 36EF for 3 days after cooking, then reheated in a Blodgett gas oven at 325EF to an internal temperature of 150EF for steaks or 160EF for ground beef. A highly trained flavor profile sensory panel evaluated both freshly cooked and warmed over LL, ST, and ground beef for beef flavor identification, brown-roasted, bloody/serumy, metallic, soapy/chemical, cardboard, oxidized/painty, and fishy flavors, using a 15 point scale (0 = none, 15 = very intense).

## Results and Discussion

The MPSC-infused cattle had a 2.9% higher mean dressing percentage (P<.05) than Con cattle. Vascular infusion had no effect on USDA quality and yield grades or Warner-Bratzler shear force. The flavor profile sensory panel determined that beef flavor identification and soapy/chemical flavor were more apparent (P<.05) for the freshly cooked LL from MPSC-infused cattle than for that from Con. Beef flavor identification, bloody/serumy flavor, and cardboard flavor were more perceptible (P<.05) and soapy/chemical flavor was lessened (P<.05) in the warmed-over LL from MPSC-infused cattle than in that from Con (Table 1). The freshly cooked ST from MPSC-infused cattle had less (P<.05) soapy/chemical flavor than that from Con, and the warmed-over ST from MPSC-infused cattle had less (P<.05) cardboard flavor than that from Con (Table 2). The ground beef from MPSC-infused cattle had less (P<.05) soapy chemical flavor than that from Con.

Incorporation of vitamin C into the MPSC solution had no effect (P>.05) on Warner-Bratzler shear force. Freshly cooked ST from MPSC-infused cattle had less (P<.05) soapy/chemical flavor than ST from MPSC+C infused cattle (Table 2). Warmed over ST from MPSC-infused cattle had more (P<.05) beef flavor identification than that from MPSC+C. Warmed over ground beef from MPSC-infused cattle had more (P<.05) brown roasted flavor, less (P<.05) oxidized/ painty flavor, and more (P<.05) soapy/ chemical flavor than that from MPSC+C infused cattle (Table 3).

Vascular infusion with the MPSC solution or MPSC+C had no effects on Warner-Bratzler shear force and USDA quality and yield grades. Vascular infusion with either the MPSC or MPSC+C solution resulted in some inconsistencies in flavor profile but increased dressing percentage.

**Table 1. Effects of Vascular Infusion with the MPSC Solution (MPSC) and the MPSC Solution plus Vitamin C (MPSC+C) on Warner-Bratzler Shear Force and Descriptive Flavor Profile Analysis Scores for the Longissimus Lumborum Muscle**

| Item | | MPSC[a] | Control[a] | SE | MPSC[b] | MPSC+C[b] | SE |
|---|---|---|---|---|---|---|---|
| Warner-Bratzler shear, kg | | 3.7 | 4.0 | .26 | 3.8 | 3.4 | .18 |
| **Freshly Cooked** | | | | | | | |
| Beef flavor identification | | 10.7[c] | 10.2[d] | .15 | 9.8 | 9.7 | .42 |
| Brown roasted flavor | | 8.5 | 8.4 | .13 | 7.9 | 8.0 | .33 |
| Bloody/serumy | | 4.1 | 4.0 | .14 | 3.0 | 3.0 | .18 |
| Metallic | 3.7 | | 3.8 | .11 | 3.2 | 3.3 | .17 |
| Soapy/chemical | 2.2[c] | | 1.2[d] | .20 | 1.1 | 1.4 | .19 |
| Cardboard | | 0.0 | 0.0 | .10 | 0.0 | 0.0 | .13 |
| Oxidized/painty | 0.0 | | 0.0 | .15 | 0.0 | 0.0 | .08 |
| Fishy | | 0.0 | 0.0 | .06 | 0.0 | 0.0 | .00 |
| **Warmed Over** | | | | | | | |
| Beef flavor identification | | 8.6[c] | 8.3[d] | .14 | 7.9 | 8.0 | .42 |
| Brown roasted flavor | | 7.8 | 7.6 | .13 | 7.5 | 7.5 | .34 |
| Bloody/serumy | | 1.8[c] | 1.5[d] | .15 | 1.4 | 1.3 | .18 |
| Metallic | 2.3 | | 2.3 | .12 | 2.4 | 2.3 | .17 |
| Soapy/chemical | 1.5[d] | | 2.3[c] | .21 | 1.5 | 1.8 | .18 |
| Cardboard | | 2.9[d] | 2.7[c] | .10 | 3.3 | 3.3 | .13 |
| Oxidized/painty | 0.4 | | 0.3 | .14 | 0.2 | 0.2 | .07 |
| Fishy | | 0.1 | 0.0 | .06 | 0.0 | 0.0 | .00 |

[a]Comparison of MPSC-infused and control treatments only. [b]Comparison of MPSC-infused and MPSC + vitamin C infused treatments only. [c,d]Means in the same row within the MPSC-infused and control treatments with different superscript letters are different (P<.05).

**Table 2. Effects of Vascular Infusion with the MPSC Solution (MPSC) and the MPSC Solution plus Vitamin C (MPSC+C) on Warner-Bratzler Shear Force and Descriptive Flavor Profile Analysis Scores for the Semitendinosus Muscle**

| Item | | MPSC[a] | Control[a] | SE | MPSC[b] | MPSC+C[b] | SE |
|---|---|---|---|---|---|---|---|
| Warner-Bratzler shear, kg | | 4.4 | 4.2 | .26 | 4.4 | 4.6 | .14 |
| **Freshly Cooked** | | | | | | | |
| Beef flavor identification | | 10.0 | 9.9 | .13 | 10.1 | 9.9 | .42 |
| Brown roasted flavor | | 8.2 | 8.2 | .13 | 8.0 | 7.9 | .33 |
| Bloody/serumy | | 3.8 | 3.8 | .14 | 3.2 | 3.2 | .18 |
| Metallic | 3.7 | | 3.8 | .11 | 3.1 | 3.2 | .17 |
| Soapy/chemical | 1.5[d] | | 2.1[c] | .20 | 1.1[f] | 1.9[e] | .18 |
| Cardboard | | 0.0 | 0.0 | .09 | 0.0 | 0.0 | .13 |
| Oxidized/painty | 0.0 | | 0.0 | .14 | 0.0 | 0.0 | .07 |
| Fishy | | 0.0 | 0.0 | .05 | 0.0 | 0.0 | .00 |
| **Warmed Over** | | | | | | | |
| Beef flavor identification | | 8.5 | 8.2 | .13 | 8.5[e] | 8.3[f] | .51 |
| Brown roasted flavor | | 7.8 | 7.7 | .13 | 7.8 | 7.6 | .41 |
| Bloody/serumy | | 1.4 | 1.4 | .14 | 1.4 | 1.3 | .21 |
| Metallic | 2.1 | | 2.2 | .11 | 2.4 | 2.2 | .20 |
| Soapy/chemical | 1.8 | | 1.6 | .20 | 1.5 | 1.5 | .19 |
| Cardboard | | 3.0[d] | 3.3[c] | .10 | 3.0 | 3.2 | .15 |
| Oxidized/painty | 0.2 | | 0.4 | .14 | 0.0 | 0.2 | .08 |
| Fishy | | 0.0 | 0.0 | .05 | 0.0 | 0.0 | .00 |

[a]Comparison of MPSC-infused and control treatments only. [b]Comparison of MPSC-infused and MPSC+vitamin C treatments only. [c,d]Means in the same row within the MPSC-infused and control treatments with different superscript letters are different (P<.05). [e,f]Means in the same row within the MPSC-infused and MPSC + vitamin C treatments with different superscript letters are different (P<.05).

**Table 3. Effects of Vascular Infusion with the MPSC Solution (MPSC) and the MPSC Solution plus Vitamin C (MPSC+C) on Descriptive Flavor Profile Sensory Panel Scores for Ground Beef**

| Item | MPSC[a] | Control[a] | SE | MPSC[b] | MPSC+C[b] | SE |
|---|---|---|---|---|---|---|
| **Freshly Cooked** | | | | | | |
| Beef flavor identification | 8.4 | 8.3 | .13 | 8.3 | 8.2 | .51 |
| Brown roasted flavor | 8.0 | 7.9 | .13 | 7.8 | 7.7 | .40 |
| Bloody/serumy | 2.2 | 2.2 | .14 | 2.2 | 2.3 | .21 |
| Metallic | 2.5 | 2.4 | .11 | 2.8 | 2.6 | .20 |
| Soapy/chemical | 1.6[d] | 2.2[c] | .20 | 1.8 | 1.8 | .19 |
| Cardboard | 0.0 | 0.0 | .10 | 0.0 | 0.0 | .15 |
| Oxidized/painty | 0.0 | 0.0 | .14 | 0.0 | 0.0 | .08 |
| Fishy | 0.0 | 0.0 | .05 | 0.0 | 0.0 | .00 |
| **Warmed Over** | | | | | | |
| Beef flavor identification | 6.3 | 6.3 | .13 | 6.9 | 6.6 | .53 |
| Brown roasted flavor | 6.4 | 6.4 | .13 | 6.9[e] | 6.7[f] | .42 |
| Bloody/serumy | 2.2 | 1.5 | .14 | 1.3 | 1.3 | .22 |
| Metallic | 2.0 | 2.0 | .11 | 1.9 | 1.9 | .21 |
| Soapy/chemical | 2.1 | 2.1 | .20 | 2.1[e] | 1.6[f] | .20 |
| Cardboard | 3.9 | 3.9 | .10 | 3.0 | 3.2 | .16 |
| Oxidized/painty | 3.2 | 3.0 | .14 | 2.4[f] | 2.9[e] | .09 |
| Fishy | 0.3 | 0.3 | .05 | 0.0 | 0.0 | .00 |

[a]Comparison of MPSC-infused and control treatments only.

[b]Comparison of MPSC-infused and MPSC + vitamin C only.

[c,d]Means in the same row within the MPSC-infused and control treatments with different superscript letters are different (P<.05).

[e,f]Means in the same row within the MPSC-infused and MPSC+C treatments with different superscript letters are different (P<.05).

# EVALUATIONS OF BEEF TENDERNESS BY WARNER-BRATZLER SHEAR FORCE, A DESCRIPTIVE-TEXTURE PROFILE SENSORY PANEL, AND A DESCRIPTIVE ATTRIBUTE SENSORY PANEL

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## Summary

This study examined interrelationships among Warner-Bratzler shear force (WBSF), evaluation by a highly trained descriptive-texture-profile (DTP) sensory panel, and evaluation by a trained descriptive attribute (DA) sensory panel as affected by muscle fiber orientation of samples. Eighteen longissimus lumborum and 18 semitendinosus muscles from Choice and Select carcasses were cut into 1-inch steaks and cooked to 150EF. Cores were obtained by two methods (parallel to the muscle fiber orientation and perpendicular to the cut steak surface) for WBSF determinations. Cubes ½ × ½ × 1 in. were presented to the DTP and DA sensory panels. Cores taken parallel to the longissimus muscle fiber orientation had a 1.4 lb. higher (P<.05) mean WBSF than cores taken perpendicular to the cut steak surface. Both panels detected carcass differences; however, a panelist × carcass effect (P<.05) occurred for the DA panel. Both panels detected differences (P<.05) between muscle fiber orientations for attributes related to tenderness. Muscle fiber orientation of samples may need to be parallel for WBSF but perpendicular to the steak surface for sensory panel evaluation.

(Key Words: Tenderness, Shear Force, Sensory Panels, Muscle Fiber Orientation.)

## Introduction

Controversy has existed concerning the method of removing cores from cooked steaks for Warner-Bratzler shear force (WBSF) testing. Guidelines published by the American Meat Science Association (1995) recommended that cores be taken parallel to the muscle fiber orientation instead of perpendicular to the cut steak surface as previously recommended (1978). However, the recommendation for meat samples for sensory evaluation has not changed; samples should be cut into cubes perpendicular to the steak surface, but muscle fiber orientation is not mentioned.

The relationship between shear force and sensory texture data is of major concern in evaluating the relevance and significance of tenderness research data. The two most common types of sensory panels for research are: 1) semitrained and 2) highly trained, experienced panels. How well either interprets meat palatability data and how well either relates to WBSF values are unanswered questions.

Our objective was to elucidate the effects of muscle fiber orientation on tenderness as evaluated by WBSF, a highly trained, descriptive-texture-profile (DTP) panel, and a trained, descriptive attribute (DA) panel. We also evaluated the effects of muscle fiber orientation of samples on WBSF results.

## Experimental Procedures

Short loins and eye of rounds from 12 Choice and six Select grade carcasses were obtained from a commercial processor. The two muscles were not likely to have been

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from the same sides. At 3 to 5 days postmortem, subprimal cuts were frozen (-40EF) and cut into 1-inch-thick steaks with individual subprimal identification maintained. Each steak was vacuum packaged. Steaks from each subprimal for both the longissimus lumborum (LL) (shortloin) and semitendinosus (ST) (eye of round) muscles were assigned randomly to the following WBSF treatment groups: one steak cored parallel to the muscle fiber orientation and sheared, and one steak cored perpendicular to the steak surface and sheared. All steaks were frozen (!40EF) until thawing at 0EF for 48 hr prior to cooking in a Blodgett modified broiling oven to 150EF internally.

After cooking, steaks were cooled for 2 hr at room temperature, cores were made either perpendicular to the steak cut surface or parallel to the muscle fiber orientation using a 1/2-inch-diameter core on a drill. WBSF values were measured using an Instron Universal testing machine with a 50 kg compression load cell and a cross head speed of 100 in/min.

The DTP sensory analyses were conducted on the 18 replications of each muscle using a six-member, highly trained, experienced panel from the Sensory Analysis Center at Kansas State University. The same procedures for thawing, cooking, and cooling were used for sensory analysis as for WBSF determination. DTP panelists had over 120 hr of training by professional sensory analysts in the evaluation of texture characteristics, over 2,000 hr of sensory testing experience, and extensive experience in testing meat products.

Three texture attributes were assessed: firmness, fibrousness, and chewiness. All attributes, descriptions, and references were generated by the DTP panelists. They had access to reference samples during each test session. Three cooked steaks from each subprimal were cut into 1 in.× ½ in.×1/2 in. cubes either perpendicular to the cut surface or parallel to muscle fiber orientation. Panelists placed each sample horizontally on their molars for evaluation. Panelists scored the three texture attributes using a structured 15-point scale (0 = none to 15 = very intense).

Descriptive attribute (DA) sensory evaluations were conducted for all replications of each muscle using a 10-member panel trained according to AMSA (1995) guidelines. Three attributes were assessed: myofibrillar tenderness, connective tissue amount, and overall tenderness. Two cooked steaks from each subprimal were cut into 1 in. × ½ in. × ½ in. cubes either perpendicular to the cut surface or parallel to muscle fiber orientation. Panelists placed each sample (parallel or perpendicular) horizontally on their molars to evaluate the three texture attributes using an 8-point number scale.

The statistical design was a type of split plot. Statistical analyses for WBSF data and DA and DTP panel data were performed by using a SAS PROC MIXED ANOVA procedure. Pearson correlation coefficients were calculated for WBSF data with DA or DTP panel data with the same sample orientation.

## Results and Discussion

The mean WBSF value for LL cores taken parallel with the muscle fiber orientation was higher ($P<.05$) than the mean for those sheared perpendicular to the cut steak surface (4.08 vs 3.42 lb.) (Figure 1). No difference ($P>.05$) occurred for ST cores, because cores taken perpendicular to the cut steak surface are also parallel to the muscle fibers. The mean WBSF value was higher for the ST muscle than for the LL muscle.

A mix of Choice and Select grade carcasses was utilized to provide variation, but grade differences were not of interest. The DTP sensory panel detected differences ($P<.05$) among replications (carcass source) for each muscle (LL and ST) for each attribute (chewiness, fibrousness, and firmness). No differences occurred among DTP panelists for any of the three attributes ($P>.05$) (panelist effect), and no ($P>.05$) panelist by replication interaction occurred. These results suggest that the panelists could detect differences consistently.

The DA sensory panel also detected differences (P<.05) among replications for each muscle (LL and ST) for each of the three attributes (myofibrillar tenderness, connective tissue amount, and overall tenderness. However, some differences (P<.05) occurred among panelists for each of the three attributes (panelist effect). In addition, a panelist by replication interaction (P<.05) suggests that DA panelists were somewhat inconsistent in their evaluations. This could be partly due to the 7-wk evaluation period versus a 3-wk period for the DTP panel.

Our results also indicate that, in terms of reproducibility, extent of training may be more important than experience. Both panels were experienced in sensory testing of meat; however, the DTP panel was more highly trained. The DTP panel detected differences (P<.05) between samples taken parallel to the muscle fiber orientation and samples taken perpendicular to the cut steak surface in the LL muscle for the attributes of chewiness, fibrousness, and firmness (Table 1). The DA panel scored LL samples lower (P<.05) (less tender) for myofibrillar tenderness and overall tenderness when they were taken parallel to the muscle fiber orientation than when taken perpendicular to the cut steak surface (Table 1).

For both panels, the correlations between sensory scores and WBSF values were relatively low (P>.05) for LL samples taken parallel to the muscle fiber orientation (Table 2). On the other hand, correlations were meaningful between WBSF and DA panel scores of myofibrillar tenderness (r = -.59), connective tissue amount (r = -.58), and overall tenderness (r = -.55) when LL cores were removed perpendicular to the steak surface.

With LL samples, relationships between scores for tenderness-related attributes and WBSF values were better for the DA panel than for the DTP panel. With ST samples, scores of tenderness-related attributes by the two panels had similar relationships with WBSF values. However, muscle fiber orientation was less important for the DA panel than for the DTP panel.

Tenderness-related attributes, such as myofibrillar tenderness, connective tissue amount, overall tenderness, firmness, and chewiness, can be correlated significantly (Table 2) to WBSF values, but not all with the same muscle fiber orientation. Our results did not show higher correlations between sensory attributes and WBSF values when cores were removed parallel to the muscle fibers rather than perpendicular to the cut steak surface.

Both panels were effective in detecting differences in tenderness that were related to WBSF values. Overall, relationships between tenderness scores and WBSF values were somewhat higher for the DA panel than for the DTP panel. DTP attributes of fibrousness and chewiness may relate to characteristics that are not measured by WBSF. A highly trained DTP sensory panel might detect more subtle differences among treatments because panelist variation is less. Scores for attributes evaluated by the DA sensory panel showed higher correlations with WBSF values than those for attributes evaluated by a DTP sensory panel, regardless of muscle fiber orientation of samples. The appropriate type of panel should be selected to meet research objectives. Cores should be removed parallel with muscle fiber orientation for WBSF determinations, but cubes for sensory evaluation should be removed perpendicular to the steak surface.

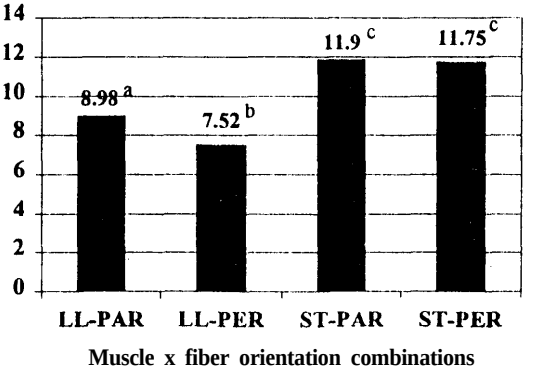


**Figure 1. Mean WBSF Values for LL and ST Muscles Using Parallel (PAR) and Perpendicular (PER) Cores. Means are displayed at the top of each treatment. Means with different superscript letters within a muscle are different (P<.05).**

**Table 1. Descriptive-Texture-Profile (DTP) and Descriptive-Attribute (DA) Sensory Panel Interaction Means between Parallel and Perpendicular Samples for Each Attribute within Each Muscle (Longissimus, LL; and Semitendinosus, ST)**

| | Treatments | | | |
|---|---|---|---|---|
| Attribute | LL Parallel | LL Perpendicular | ST Parallel | ST Perpendicular |
| DTP panel[a] | | | | |
| Chewiness | 7.9 [c] | 7.6[d] | 8.3. [e] | 8.4 [e] |
| Fibrousness | 9.3 [c] | 8.9 [d] | 9.4 [e] | 9.4 [e] |
| Firmness | 7.6 [c] | 7.3 [d] | 8.4 [e] | 8.4 [e] |
| DA panel[b] | | | | |
| Myofibrillar tenderness | 6.1 [c] | 6.3 [d] | 5.6 [e] | 5.8 [f] |
| Connective tissue amount | 6.6 [c] | 6.7 [c] | 5.4 [e] | 5.5 [e] |
| Overall tenderness | 6.3 [c] | 6.5 [d] | 5.4 [e] | 5.6 [f] |

[a]DTP scale: 0 = none to 15 = very intense.
[b]DA scale: 1 = extremely tough, abundant connective tissue, or extremely tough; 5 = slightly tender, moderate amount of connective tissue, or slightly tender; 8 = extremely tender, no connective tissue, or extremely tender.
[c,d]Means in the same row within a muscle lacking a common superscript letter differ (P<.05).
[e,f]Means in the same row within a muscle lacking a common superscript letter differ (P<.05).

**Table 2. Correlations of Descriptive-Texture-Profile (DTP) and Descriptive-Attribute (DA) Sensory Panel Scores for Individual Attributes to Warner-Bratzler Shear Force (WBSF) Values when Samples Were Removed with the Same Fiber Orientation for Both Sensory Panels and WBSF Determinations for Longissimus (LL) and Semitendinosus (ST) Muscles**

| | Treatments | |
|---|---|---|
| Panel and attribute | LL - Parallel | LL - Perpendicular |
| DTP panel | r | r |
| Firmness | .28 | .49 |
| Fibrousness | .14 | -.07 |
| Chewiness | -.02 | .47 |
| | LL - Parallel | LL - Perpendicular |
| DA panel | r | r |
| Myofibrillar tenderness | -.42 | -.59 [a] |
| Connective tissue amount | -.18 | -.58 [a] |
| Overall tenderness | -.35 | -.55 [a] |
| | ST - Parallel | ST - Perpendicular |
| DTP panel | r | r |
| Firmness | .65 [a] | .54 [a] |
| Fibrousness | -.02 | .18 |
| Chewiness | .18 | .32 |
| | ST - Parallel | ST - Perpendicular |
| DA panel | r | r |
| Myofibrillar tenderness | -.64 [a] | -.53 [a] |
| Connective tissue amount | -.43 | -.31 |
| Overall tenderness | -.60 [a] | -.46 |

[a]Correlation values are significant (P<.05).

# MODELED, MULTISTAGE CONVECTION COOKING OF BEEF SEMITENDINOSUS ROASTS TO DENATURE COLLAGEN AND TO OPTIMIZE TENDERNESS

*T. H. Powell, M. E. Dikeman, and M. C. Hunt*

## Summary

In order to predict and establish cooking times and temperatures of beef to optimize tenderness and cooked yield, a computer model was developed utilizing heat and mass transfer theories. We cooked beef *semitendinosus* (eye of round) roasts in a forced-air convection oven using conventional or modeled, multistaged cooking. Conventional cooking was defined as cooking at 325EF to a core endpoint of 150EF. The model method was developed using a computer algorithm that predicted heat and moisture (mass) transfer during a three-stage cooking process that included preheating, holding, and finishing. The model was accurate in predicting actual cooking times and temperatures during cooking; temperature profile curves tracked closely between predicted and observed values. Roasts cooked by the modeled cooking regimen had lower Warner-Bratzler shear values than those cooked by conventional convection cooking. Collagen total unaltered fraction was lower (P<.05; 44 vs. 55%) and enzyme labile fraction was higher (56 vs. 45%, P<.05) in model cooked than in conventionally cooked samples. Cooking yield was not different for the modeled and conventional procedures. These results show that the modeled multi-stage cooking method was superior to the conventional cooking method.

(Key Words: Tenderness, Modeling, Cooking, Semitendinosus, Collagen.)

## Introduction

Mathematical models have been developed to predict cooking times and cycles of various kinds of meat products. We developed a model for cylindrical roasts from the *semitendinosus* (eye of round) muscle, known for its moderately high content of connective tissue. Conventional dry-heat cooking of high-connective tissue cuts, such as those from beef *semitendinosus* muscles, results in less tender meat in comparison to low-connective tissue cuts such as those from beef *longissimus* muscles. The model was targeted for a forced-air-convection oven and was designed for easy adaption to software and computer equipment. We then used the model to assist in determining proper dry cooking times and temperatures to maximize tenderness of semitendinosus roasts. In previous work, we found a time-dependent denaturation of the insoluble portion of collagen that began at 131EF, with maximal denaturation occurring within 60 min at that temperature. This denaturation process resulted in tenderer meat. Above 131EF, the process occurred more quickly. On the other hand, tenderness can decrease at 158EF and above, largely due to myofibrillar hardening.

The purpose of our study was to develop and test a model to predict a dry-heat cooking regimen for beef *semitendinosus* roasts that would optimize tenderness by maximizing denaturation of the total unsolubilized fraction of collagen to the enzyme labile fraction of collagen and avoid myofibrillar toughening.

## Experimental Procedures

We used six vacuum-packaged, A-maturity, USDA Choice, semitendinosus roasts to develop the mathematical prediction model. Ends were removed to make them cylindrical, and they were trimmed free of fat. The

finite-difference method, a numerical technique, was used to solve the simultaneous heat and mass transfer equations in developing the model. The model was used to predict a cooking cycle for each roast. The model accomplished the following objectives. The roasts were to be cooked in three cycles: preheating, holding, and finishing. The constraints of the preheating cycle were to heat the roasts as rapidly as possible until a point 1/4 of the distance from the end and surface of the roast reached 160EF. During the holding cycle, the oven temperature was lowered to 150EF. Heating at this temperature continued for 60 min. after the core of the roasts reached 130EF. During the finishing cycle, the core temperature was raised to the endpoint of 150EF.

Thermocouples were placed in four locations to monitor temperature during cooking in a 325EF gas oven until the endpoint temperature was reached. Cooking yields were calculated. To determine whether cooking using traditional roasting at a constant temperature in a forced-air-convection oven or the model-assisted- cooking was more effective, 12 A-maturity, USDA Choice semitendinosus roasts were prepared as described previously, and diameter and length were measured for use in the prediction model. Approximately 3.5 oz. of meat were obtained before cooking and frozen for chemical analyses. The control method of cooking consisted of placing an individual roast in a 325EF convection oven until the core temperature reached 150EF. Roasts were assigned randomly to either the modeled or conventional (control) cooking method and cooked individually. Temperature readings were obtained every 30 seconds. Cores (1/2 inch diameter) were taken from the cooked roasts to determine Warner-Bratzler shear force.

Two 1-inch-thick slices were obtained from the centers of the roasts, and five ½-inch cores parallel to muscle fiber orientation were obtained from each slice (total of 10 cores per roast). Cores were sheared using a Warner-Bratzler shear attachment on an Instron Universal Testing Instrument. Peak shear force, peak energy, and total energy were determined for each core and then averaged to create one value per roast. Approximately 3.5 oz. of meat were obtained from the remainder of the roast for chemical analysis. An effort was made to keep samples free of seam fat, connective tissue and crust. Total chemical fat and moisture were determined for both raw and cooked products. To determine the effects of modeled cooking on collagen denaturation, Ringer's- soluble fraction (RSF), enzyme-labile fraction (ELF), and total unaltered fraction (TUF) of collagen were determined.

## Results and Discussion

Our model predicted cooking time within 4 min for all roasts except one. Additionally, temperature profile curves at the core and surface tracked closely between observed and predicted values (Figure 1). The model underpredicted moisture loss, because it did not account for physical water loss from myofibrillar contraction during heating. Peak shear force and total energy were lower ($P<.05$) in roasts cooked according to the model (Table 1). The model cooking technique takes advantage of the denaturation of collagen that occurs at 131EF and above, but keeps meat below the temperature (<149EF) where myofibrilla toughening occurs. Even with a much longer cooking time, cooking yields were the same as with conventional cooking (Table 2), apparently because of a relatively high air moisture content in the oven during the holding cycle.

**Table 1. Effect of Cooking Method on Shear Force Measurements of Beef *Semitendinosus***

| Variable | Model | Control | *P > F* |
|---|---|---|---|
| Peak force (kg) | 3.3±.5 | 4.7±.2 | >.001 |
| Peak height (mm) | 19.1±2.7 | 16.8±.7 | .067 |
| Peak energy (J) | 16.4±5.0 | 14.5±2.5 | .430 |
| Total energy (J) | 36.7±5.4 | 47.8±3.4 | .002 |

The predicted cooking and holding times for the model roasts were very close to the observed values. Variance from the predicted values, particularly in the surface temperature measurements, can be attributed partially to the precision of the oven thermostat at low temperatures (below 210EF). In

some cases, short-term ventilation was required to cool the cooking environment, resulting in a loss of moisture in the oven, thereby slightly altering the actual cooking conditions from those predicted. Nevertheless, a reasonable estimate of cooking time was obtained from the computer model.

No differences were found in fat or moisture content between cooking methods (Table 2). Percentages of TUF were lower ($P<.05$) and those of ELF were higher ($P<.05$) for the model roasts than for the controls (Table 3). No differences were found in RSF between the two cooking methods. Shear force measurements, particularly peak force and total energy, were highly correlated (- .79 and - .80, respectively) with TUF.

**Table 2. Effect of Cooking Method on Cooking Yields and Proximate Composition of Beef *Semitendinosus* Roasts**

| Variable | Model | Control | *P>F* |
|---|---|---|---|
| Cooked yield, % | 74.3 ± 3.6 | 73.0 ± 2.6 | .46 |
| Moisture (raw), % | 72.3 ± .7 | 73.0 ± .7 | .11 |
| Fat (raw), % | 2.6 ± .8 | 2.8 ± .8 | .67 |
| Moisture (cooked), % | 63.4 ± 1.4 | 63.1 ± .8 | .84 |
| Fat (cooked), % | 4.6 ± 1.4 | 3.4 ± .8 | .28 |

The increased tenderness of the model roasts was due to a decrease in TUF collagen. Some of the other observed effects may have been related to the activity of collagenase.

These results suggest a mechanism for the improved tenderness of high-collagen meats with long-time, low temperature cooking. Changing the focus to the composition of the much larger insoluble collagen fraction was very informative with regards to the tenderness of the cooked product. The model multistage cooking method was superior to the control cooking method.

**Table 3. Effect of Cooking Method on Collagen Denaturation of Beef *Semitendinosus***

| Collagen Fraction | Model | Control | *Pr>F* |
|---|---|---|---|
| RSF, % | 8.0 ± .9 | 8.6 ± l.l | .335 |
| ELF, % | 56.l ± 8.9 | 44.7 ± 4.3 | .030 |
| TUF, % | 43.9 ± 8.9 | 55.3 ± 4.3 | .030 |

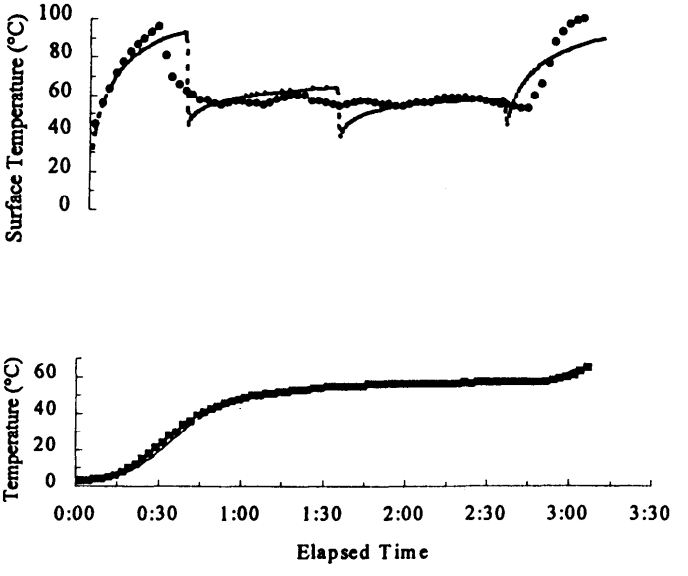


**Figure 1. Temperature Histories ( ■ Core, Observed; - Core, Predicted; ● Surface, Observed; - - - Surface, Predicted) for a Representative Beef *Semitendinosus* Roast Cooked in a Forced-air Convection Oven According to Model Specifications.**

# USE OF LINEAR MEASUREMENTS IN A REGRESSION EQUATION TO PREDICT RIBEYE AREA

*A. T. Waylan, J. A. Unruh, and R. E. Campbell*

## Summary

Thirty beef carcasses were used to test the accuracy of three regression equations to predict ribeye area (REA) and to compare several strategies to rapidly estimate REAs. Linear measurements, USDA grids, and Video Image Analysis (VIA) were used to determine REA from both right and left carcass sides. Ribeye areas measured by USDA grids and estimated by regression equations were highly correlated (r>.94) with REA measured by VIA. Regression equations using linear measurements and USDA grids were equally (P=.73) accurate in predicting VIA REA. Furthermore, REA from either the left or the larger (right or left) carcass sides accurately predicted the VIA REA from the larger carcass side. Therefore, in commercial packing facilities where chain speed may limit the opportunity to accurately grid or measure ribeyes, the linear measurements of left side ribeye length and widest-width can be collected and used in a regression equation to accurately predict the larger REA to be used in calculating yield grade.

(Key Words: Ribeye Area, Beef, USDA Ribeye Grids, Linear Measurements.)

## Introduction

Ribeye area (REA) is the muscling factor used to calculate USDA yield grade. If both sides of a carcass are ribbed, the larger REA is used to determine yield grade. At current chain speeds in large commercial packing plants, time is insufficient to accurately measure ribeye area of one or both sides with a USDA grid. Video Image Analysis (VIA, a computerized system to measure REA) consistently and accurately measures REA and was the base against which we compared other measurements. Regression equations using linear measurements were developed previously to predict REA. The objective of our study was to evaluate the accuracy of three regression equations and ribeye grids in predicting REA and simple measurement strategies to accurately predict REA from the largest side (right or left).

## Experimental Procedures

At a commercial packing facility, REAs from both right and left sides of 30 randomly selected beef carcasses were measured in three ways: (1) USDA grid, (2) linear measurements of ribeye length, mid-width, and widest-width (nearest .01 in.); and (3) tracing ribeyes onto acetate tracing paper at the packing facility and later measuring by VIA (a method utilizing a digital camera and computer). Linear measurements were used in three regression equations previously published in the 1997 Cattlemen's Day Report of Progress, to estimate REA. The three regression equations used to predict REA were:

(1) REA = -9.604 + 2.404(L) + 3.317(MW), $R^2$=.85

(2) REA = -10.911 + 2.443(L) +3.347(WW), $R^2$=.86

(3) REA = -11.011 + 2.216(L) + 1.837(MW) + 2.145(WW), $R^2$=.91

where REA is ribeye area (in.$^2$)

L = length of ribeye (in.)

MW = width of ribeye at mid-length (in.)

WW = width of ribeye at the widest point (in.)

The 60 REAs from the right and left sides of 30 carcasses were used to compare (T-tests) the three regression equations and the USDA grid to the REA measured by VIA. Because the larger ribeye from the two sides is used to determine USDA yield grade, different strategies were evaluated using T-tests to determine which could most accurately predict the larger REA. Right side REA only, left side REA only, or the larger REA (either the right or left carcass side) using either linear measurements or a USDA grid were compared.

To determine which strategy most accurately predicts larger VIA carcass side (right or left) REA, the predicted REA from each strategy was subtracted from the larger side REA. The differences were analyzed in a 2 × 3 factorial arrangement of treatments with carcass as the blocking factor. Simple correlations were determined among the different measurement strategies.

## Results and Discussion

Paired T-tests indicated that REAs predicted from equations 2 and 3 were similar (P$.13) to REA measured by VIA (actual REA, Table 1). The REA predicted from using USDA grids tended (P=.06) to be similar to REA measured by VIA. Equation 2 was selected for further study, because it had a high correlation (.95) and a similar ribeye mean to VIA, and used only two dependent variables to estimate REA.

Because the USDA yield grade equation uses the larger side, paired T-tests were performed (Table 2) to compare the larger side (right or left) REA measured by VIA to right, left, or larger side REA predicted from regression equation 2 or measured by USDA ribeye grids. Both left side REA and larger side REA predicted by equation 2 were similar (P>.20) to the larger VIA REA. Furthermore, the larger grid REA tended to be similar (P=.07) to the larger VIA REA. As expected, correlations (Table 3) were high (r≥.93) among all measurement strategies.

In the 2 × 3 factorial difference analysis, no interaction (P=.26) was detected for measurement method (equation 2 and USDA grid) and carcass side (right, left, or larger). No difference (P=.73) occurred between equation 2 and USDA grid for measuring REA. However, the differences from the VIA REA were significantly smaller (P<.001) for ribeyes from carcass left (.29 $in.^2$) and larger side (.14 $in.^2$) than for ribeyes from the right side (.65 $in.^2$). Equation 2 and the USDA grid were equally accurate in predicting REA. However, either the left or larger side REA should be used to accurately predict the REA to be used in the yield grade equation.

In commercial packing plants where chain speeds cause a time constraint, two simple measurements of length and widest-width of the left carcass side ribeye can be collected and incorporated into an equation to accurately predict REA.

**Table 1. Means (n=60), Pearson Correlations, and P-Values for Ribeye Area Measured by VIA Compared to Ribeye Areas Predicted from Regression Equations Using Linear Measurements or USDA Ribeye Grid Areas**

| Item | Mean, in.$^2$ | Correlation[a] | P-Value |
|---|---|---|---|
| VIA[b] | 14.19 | - | - |
| Equation 1[c] | 13.86 | .94 | .01 |
| Equation 2[d] | 14.05 | .95 | .20 |
| Equation 3[e] | 14.04 | .96 | .13 |
| USDA Grid | 14.06 | .98 | .06 |

[a]Pearson correlations (r) of VIA with measurement methods.
[b]Video Image Analysis.
[c]y = -9.604 + 2.404(Length, in.) + 3.317(Mid-Width, in.) .
[d]y = -10.911 + 2.443(Length, in.) + 3.347(Widest-Width, in.).
[e]y = -11.011 + 2.216(Length, in.) + 1.837(Mid-Width, in.) + 2.145(Widest-Width, in.).

**Table 2. Means (n=30), Pearson Correlations, and P-Values for the Larger Side (Right or Left) Ribeye Area Measured by VIA Compared to Left, Right, or Larger Side Ribeye Areas Predicted from a Regression Equation Using Linear Measurements or USDA Ribeye Grids**

| Measurement Method | Carcass Side[a] | Mean, in.$^2$ | Correlation[b] | P-Value |
|---|---|---|---|---|
| VIA[c] | Larger | 14.53 | - | - |
| Equation[d] | Right | 13.79 | .95 | .001 |
| Equation[d] | Left | 14.32 | .93 | .20 |
| Equation[d] | Larger | 14.44 | .94 | .36 |
| USDA grid | Right | 13.96 | .98 | .0001 |
| USDA grid | Left | 14.16 | .97 | .01 |
| USDA grid | Larger | 14.34 | .98 | .07 |

[a]Ribeye area measured on the right, left, or larger (right or left) carcass side.
[b]Pearson correlations (r) of VIA with measurement method and carcass side ribeye.
[c]Video Image Analysis.
[d]y = -10.911 + 2.443(Length, in.) + 3.347(Widest-Width, in.).

**Table 3. Correlations among Different Strategies to Measure Ribeye Area**

| Measurement Method | Carcass Side[a] | VIA[b] Larger | Equation[c] Right | Equation[c] Left | Equation[c] Larger | Grid Right | Grid Left |
|---|---|---|---|---|---|---|---|
| Equation[c] | Right | .95 | 1 | | | | |
| Equation[c] | Left | .93 | .93 | 1 | | | |
| Equation[c] | Larger | .94 | .95 | .99 | 1 | | |
| USDA grid | Right | .98 | .96 | .96 | .96 | 1 | |
| USDA grid | Left | .97 | .93 | .96 | .96 | .97 | 1 |
| USDA grid | Larger | .98 | .95 | .96 | .96 | .99 | .99 |

[a]Ribeye area measured on the right, left, or larger (right or left) carcass side.
[b]Video Image Analysis of the larger (right or left) carcass side.
[c]y = -10.911 + 2.443(Length, in.) + 3.347(Widest-Width, in.).

# RUNOFF COMPLIANCE FOR KANSAS CATTLE FEEDLOTS

*J. P. Murphy[1] and J. P. Harner[1]*

## Summary

As the demand grows for cleaner water, feedlots will need to reduce and control the nutrient and sediment loading of runoff. Existing confined feedlots will need to evaluate their runoff potential. Costs of controlling the runoff must be weighed against new lot construction on an alternate location. New feedlot facilities will need to address current regulations and be designed for compliance with future regulations.

(Key Words: Feedlot, Runoff Control, Pollution.)

## Introduction

The environmental issues concerning beef cattle production continue to evolve because of increased public interest in all environmental matters. Cattle productivity, quality control, marketing, and profitable operations have resulted in cattle feedlots being accepted in the United States. However, cattle producers have the responsibility to maintain the quality of surface or groundwater near their production units. Outdoor dirt lots for confinement of cattle or calves often are overlooked as areas that need water pollution control facilities. Potential pollution problems can be minimized when operators design, construct, and manage rainfall runoff systems.

## Present Kansas Laws

The Kansas beef industry has adapted to increased environmental concerns over the last 30 yrs. Current regulations start at 300 animal units. Beef cattle less than 700 lbs each are .5 animal unit; beef cattle greater than 700 lbs each are 1.0 animal unit. Operations from 300 to 999 animal units are subject to Kansas Department of Health and Environment (KDHE). Operations greater than 1,000 animal units must obtain an Environmental Protection Agency (federal) permit, which also is administered by KDHE. Separation distance from habitable structures on new feedlots with a maximum design capacity of 300-999 animal units is 1,320 ft. On feedlots with greater than 1,000 animal units, the separation distance is increased to 4,000 ft.

## Runoff Management Systems

The regulations for operations between 300 and 999 animal units allow for either discharging or nondischarging systems, depending on the size of operation and location of lots in relationship to waterways and potential pollution problems. A discharging system separates the solids from the liquids by using settling basins, terraces, grass filter strips, or sedimentation structures. After separation, the water is discharged into a grassed waterway, pasture, or cropped field. A nondischarging system may include a method for separating liquids and solids but the liquid portion of the runoff or all runoff is contained in a holding pond. Little or no breakdown of solids occurs before dispersal. The pond liquid is later pumped onto cropland or pasture.

[1]Department of Biological and Agricultural Engineering.

Operations that have more than 5 acres of confinement lots or 500 cattle probably will be required in the future to have a nondischarging type of waste control facility, particularly if the pens are within 2,000 ft of surface water. A discharging system could be utilized for those with less than 5 acres of drainage area or under 500 head. The use of a discharging system for operations with 500 to 999 head will depend on the available filter area, number of days on feed; uniformity of drainage area; and proximity of creeks, roads, and neighbors. Production units with a capacity of 1,000 head or more are required to contain all runoff from lots in a holding pond.

Figure 1 shows some of the options that are available for controlling runoff from dirt lots. In each case, certain restrictions will apply and certain design specifications will have to be met. Some of the criteria are:

1. Feedlots and runoff control facilities cannot be within 100 ft of the property line.
2. Water-pollution control facilities must be able to handle the runoff generated by a 10 yr- or 25 yr- 24 hr, storm which is equal to about 5 inches in western Kansas, 6 inches in central Kansas, and 7 inches in eastern Kansas.
3. The lowest elevation of the feeding area or waste control facilities must be a minimum of 10 ft above groundwater aquifers or seasonal perched tables.
4. The lots must be located a minimum of 100 ft from wells or reservoirs (preferably downslope of water sources) and 50 ft from rural water district lines.
5. Sedimentation structures are needed, with the type depending on the drainage area.
6. If a holding pond or lagoon is used, then provisions for pumping the water must be available, including land requirements and pumping equipment.

The system shown in Figure 1a is normally used with operations of less than 300 head or 1 acre in size. As the capacity increases, then the options shown in Figures 1b and 1c can be used. In both of these designs, the sedimentation channel may be a terrace or channel and sized to hold the runoff for a minimum of 30 min prior to discharging onto the land. The 30-min retention time results in large sedimentation structures as the acreage of the lots increase. Figures 1d and 1e are examples of nondischarging systems. A nondischarging, serpentine, terrace system is shown in Figure 1d. The total capacity of the terrace channels has to be able to contain the 10 yr-24 hr storm runoff from the dirt lots and any additional drainage area. Figure 1e shows a sedimentation channel with the runoff draining into a lagoon or holding pond. The sedimentation structure is optional for small lots but required if the drainage area is more than 5 acres. If wastewater from a building also is draining into the pond, then a sedimentation structure should be considered.

## Grassed Filter Strips

Grassed waterways are similar to infiltration ponds, except that the water can be discharged and need not be contained totally. A grassed waterway typically is limited to 400 ft in length and requires a grade less than 4.0 percent. Grassed waterways are sized based on nutrient loading and crop nutrient utilization. Therefore, if pens are used year round for finishing cattle (800 to 1,200 lbs), 1 acre of grass filter is required per 80 head in confinement. In a feeder operation where the calves (400 to 600 lbs) are in confinement only 150 days, 1 acre of filter area is required per 400 head. The filter has to be sized for a minimum of 30 min of retention time prior to water discharging from the waterway. A sedimentation pond is required ahead of the grass waterway to remove some of the nutrients.

KDHE guidelines require that the grass waterway below the pens have a uniform slope between 1 and 4 %. The minimum length of the filtering area is 200 ft per 1 % slope. Therefore, if the grass filter area has a 2 % slope, then 400 ft is required from the back fence line to the nearest waterway. With this type of system, it is important to recognize that runoff from the pens must be dispersed uniformly across the filtering area,

which often requires laser-guided earth-moving equipment. The guidelines for size include meeting the nitrogen limitations for the acres of grass filter and then the minimum filter length based on the slope of the terrain. Based on the requirements for filtering area, year-round feeding or finishing feedlot operations generally opt to use one of the other alternatives.

## Holding Ponds

Holding ponds are used commonly for larger operations or where space is limited. For feedlots greater than 10 acres, the sedimentation channel is required prior to the holding pond. The pond is required to have a capacity to store the runoff created by a 10 yr-24 hr storm, storage capacity for a 25 yr-24 hr storm onto the pond surface, and an allowance for sediment. In some cases, additional storage may be needed to handle runoff from normal rains, if the evaporation will not offset the collected liquid. After the pond size is determined, an additional 2 ft of free board is added to the top of the pond. This allows the runoff from two consecutive storms to be retained, if the pond cannot be pumped before the second storm occurs. The minimum allowed storage period is 120 days.

A holding pond or lagoon should be constructed with side slopes of 3 to 1 and minimum berm width of 10 ft and have a minimum of 12 in. of clay around the sides and in the bottom. The earthen structures cannot have a seepage rate greater than 1/4 in. per 24 hr. KDHE guidelines for separation distance, flooding frequency, distance to water, and other factors should be utilized during the planning stages.

## Sediment Channels

Sediment channels are used to separate the nutrients from the liquid prior to discharging the runoff into an infiltration pond, holding pond, lagoon, or grassy filter strip. Normally, a sediment channel will remove about 50 % of the nitrogen leaving the pens. Sediment channels can be trapezoidal or V-shaped terraces or ponds. Sediment channels are sized based on a 10 yr-1 hr storm, which is equal to approximately 2.6 in. in Kansas. As a minimum, a sediment channel should able to contain 2 in. of runoff per acre of feedlot (includes all area draining into the pond plus the pond). The discharge from the sediment channel is sized based on a minimum retention time of 30 min. The discharge rate will be approximately 1.3 cubic ft per second (cfs) per acre of feedlot. This results in large-diameter pipes or channels between ponds. For some feedlots, sizing the sediment channel to contain 3 in. of runoff per acre of feedlot may be more economical. The discharge rate then can be sized based on a 10 yr-2 hr storm and will be approximately 0.5 cfs per acre of feedlot. The actual discharge rate may have to be increased depending on the surface area of the sediment pond.

Operations that are less than 5 acres are not required to have a sediment structure. However, the pond capacity needs to be increased by 1.5 acre-in. per acre of feedlot to provide some storage for sediment. If the drainage area is between 5 and 10 acres, then a channel, terrace, or diversion can be used as a sedimentation structure. Above 10 acres, a sediment pond is required. If a sediment structure is used, then the capacity of the structure containing the runoff has to have an allowance of only 0.5 acre-in./acre of feedlot for sediment.

## Conclusions

The actual type of system that may receive approval by KDHE depends on the site, drainage area, proximity of streams or ground water, number of cattle being fed, and other factors. Because of the variability between farms, stating exactly what will work in all situations is difficult. However, cattle operators should not locate feeding pens near streams or running water or in areas such as a ravine where cropland or pasture may drain through the pens. Any water draining from adjacent fields through a lot must be controlled using either a discharging or nondischarging pollution-control system. Therefore, it is important to divert runoff from cropland or pasture around the pens using terraces or channels. In some

some cases, relocating the pens may be easier than controlling the excess runoff. For new operations, lots should be located on upland. rather than bottomland to minimize the drainage and potential pollution problems.

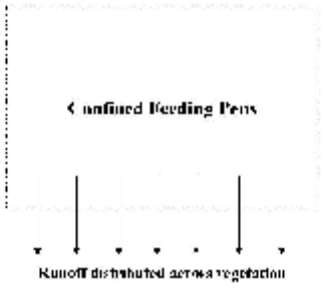


Figure 1. Controlling runoff from small confined animal feeding operations using pastures or grassland and existing land terrain.

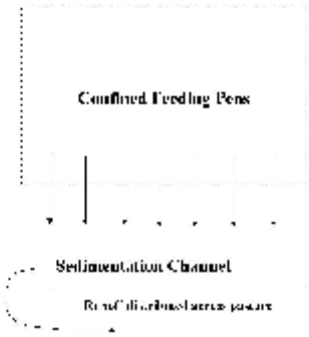


Figure 2. Controlling runoff from small confined animal feeding operations using sedimentation and grass filters.

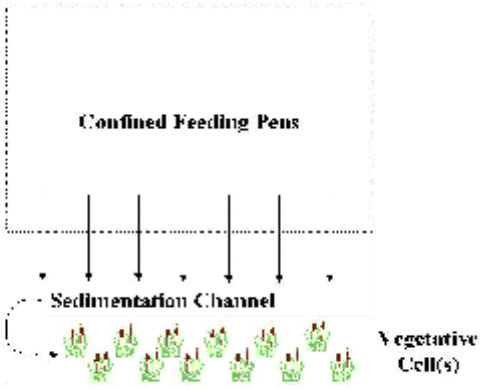


Figure 3. Controlling runoff from small confined animal feeding operations using a sediment basin discharging into vegetative system using filter strips or wetland cells.

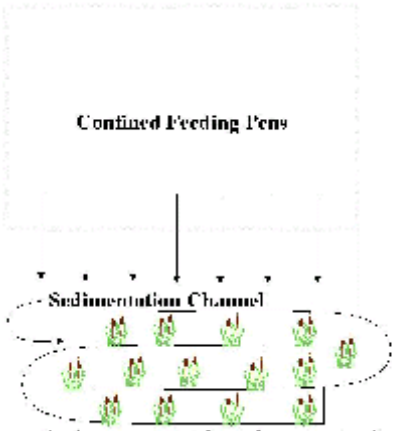


Figure 4. Serpentine terraces as a total containment system for controlling runoff from small confined animals feeding operations.

**Figures 1-5 Examples of Discharging and Nondischarging Systems for Runoff Management.**

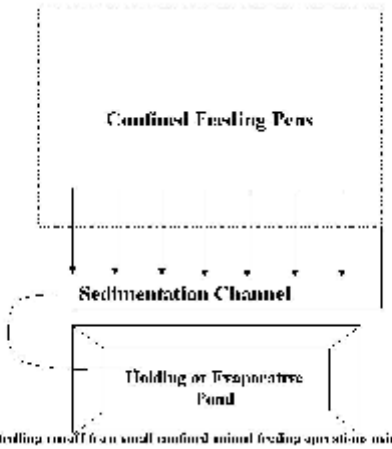


Figure 5. Controlling runoff from small confined animal feeding operations using controlled total containment detention such as holding pond, lagoon or evaporative pond.

*Cattlemen's Day 1999*

# VEGETATIVE FILTERS FOR IMPROVING ENVIRONMENTAL QUALITY

*J. P. Harner[1] and P. K. Kalita[1]*

## Summary

Nonpoint source pollution from agricultural areas has been recognized as a major contributor of surface and groundwater quality problems. Sediments, pesticide and nutrient runoffs, and microbial pathogens from farmlands may severely affect quality of water resources. A majority of Kansas river basins contains high concentrations of fecal coliforms, nitrogen, phosphorus, and sediments. The use of vegetative filters strips (VFS) has been identified as one of the best management practices to reduce pollutant concentrations in surface water sources. Vegetation planted between pollutant sources and receiving water accomplishes this by filtration, deposition, infiltration, adsorption, volatilization, plant uptake, and decomposition processes. The effectiveness of VFS in reducing nonpoint source pollution is being evaluated at four Kansas watersheds. Water samples are being collected at inlets and outlets of the VFS and analyzed for nutrients, sediments, and fecal coliform concentrations. Total nitrogen and phosphorus concentrations were reduced 26 and 14%, respectively, in one watershed and by 73 and 71%, respectively, in another. On a mass basis, total nitrogen and phosphorus reductions were 51 and 42%, respectively, in one and 60 and 52%, respectively, in the other. In the third watershed, mass flow rate of fecal coliform was reduced significantly by the VFS. If maintained properly, VFS can be used to improve water quality in agricultural areas.

(Key Words: Environment, Feedlot, Nutrients, Vegetation.)

## Introduction

Health-related problems and other environmental degradation associated with water quality have been major concerns for decades. Nonpoint source pollution from agricultural production sites has been recognized as a major contributor to surface and groundwater quality problems. Sediments, pesticide and nutrient runoffs, and microbial pathogens from farmlands and feedlots may severely affect quality of water resources. A majority of 12 major river basins in Kansas contain high concentrations of fecal coliform, nitrogen, phosphorus, and sediments. High nitrate-N concentrations in surface and groundwater in agricultural areas have been documented. Several lakes and streams are in the process of eutrophication because of high annual loading with nitrogen and phosphorus from runoffs from agricultural areas. Sources of coliforms include runoff from animal feedlots, livestock grazing lands, wildlife, and other waste handling systems.

Among other technological advances, vegetation has been identified as a natural filter for several pollutants. Vegetative filter strips (VFS) are bands of planted or indigenous vegetation that can be situated between pollutant sources and receiving water to filter pollutants out of drinking water sources. A VFS can remove sediment and other pollutants contained in runoff or wastewater by filtration, deposition, infiltration, absorption, volatilization, plant uptake, and decomposition.

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## Experimental Procedures

Effectiveness of VFS in reducing sediments, nutrients, and fecal coliform bacteria in Kansas is being investigated at four different watersheds. These studies started in 1996 and will continue for several years for long-term evaluation. These watersheds have received wide attention because of *C. parvum*, *E. coli*, and other non-point source pollutants (mainly N, P, and sediments) in drinking water sources, and VFS have been installed at those sites.

**Cheney Reservoir**. This watershed is located in south central Kansas (North Fork Ninnescah watershed, Reno County) near Wichita. The soil is Shellabarger fine sandy loam, and the average annual rainfall is about 30-35 in. Cheney Reservoir is essential to the inhabitants of south-central Kansas as a public water source, wildlife area, and recreational site. The City of Wichita draws 40 to 60% of its water supply from this reservoir. About 600 acres of the Cheney Reservoir's watershed are animal confinement areas. Runoff from these feedlots with high concentrations of nutrients, sediments, and microorganisms has been identified as a major pollution source of the reservoir water.

**Herington Reservoir**. This watershed is located in central Kansas (Dickinson County) near Herington. Soil in this area is Crete silty clay loam, and the average annual rainfall is 25-30 in. This reservoir supplies drinking water for Herington. Several pastures and cattle feedlots of 30 to 1,000 head occur within its watershed. The major pollutant entering the reservoir has been identified as livestock waste runoff that contains nutrients, sediment, and microorganisms.

**Hillsdale Lake**. This watershed is located in eastern Kansas (Miami County) near Kansas City. The soil is clay loam, and the average annual rainfall is about 40 in., so this area has the highest runoff potential in the state of Kansas. This recreational lake has been used as a drinking water source. Agricultural nonpoint source pollution and nutrient contribution from several pastures and feedlots in the watershed have been the major water quality problems in this area. In addition to these three sites, another site at Gypsum (near Salina), Kansas was selected recently.

**Establishment of VFS.** At the Cheney Reservoir site, a VFS was installed in the summer of 1996. A 300-head cattle feedlot discharges into a settling basin just above the strip. Overflow from the basin passes through the filter strip before discharging into a stream that contributes runoff to Cheney Reservoir. Total length of the strip is 775 ft, which is divided into three segments: the upper 440 ft is 50 ft wide on a 1.0% slope, the middle 245 ft is 30 ft wide on a 0.3% slope, and the lower 90 ft is 20 ft wide on a 4.0 % slope. Brome was seeded during the summer of 1996 and was fully established by the end of summer 1997.

At the Herington Reservoir site, several VFS were installed during 1993-1994. Most of the filter strips are well maintained and are in very good condition. One of those strips were selected for use in this study. The filter strip is 1,200 ft long and 96 ft wide and was installed below a 300-head cattle feedlot. The strip has two distinct slopes; 0.5% for the first 500 ft length, and 1.2% for the rest. Brome grass was seeded and fully established in 1995. Among all the filter strips, this one has the highest percent of land covered by vegetation. The vegetation grows up to several feet in height but is harvested two to three times a year.

Three parallel VFS have been established side by side in the Hillsdale Lake site. These strips are 650 ft long and 50 ft wide, below a holding basin receiving runoff from a 300- head cattle feedlot. This strip has a uniform slope of about 2%. Fescue grass was seeded in the summer of 1995 and was fully established by the end of summer 1996.

**Runoff Samples**. For collecting runoff water samples, automatic ISCO samplers have been installed at the entrance and exit of the VFS at all four watershed sites. Those samplers are programmed to automatically turn on when a runoff event occurs, and to collect runoff samples at predetermined time

intervals during the event. Automatic flow measurement systems have been installed to measure runoff rates and volumes for all events. Rainfall amount and intensity at all these areas have been recorded with tipping bucket rain gauges.

Water samples were removed from sites within 48 hours of a runoff event, packed in ice coolers, and transported to Kansas State University. At the laboratory, they were analyzed for total N, $NH_4$-N, $NO_3$-N, total P, Ortho P, total dissolved solids (TDS), and total suspended solids (TSS). For *E. coli* assays, water samples were filtered onto membranes and plated on mFC agar. Plates were incubated at 112EF for 24 hr. Filters then were transferred to MUG-EC medium, incubated for an additional 24 hr at 98.6°F and examined with a hand-held UV light. Fluorescing colonies were counted as *E. coli*.

Vegetation samples were taken during the 1997 season for moisture content and chemical analysis, including total N and total P.

## Results and Discussion

Results from three sites have partly been analyzed. Water samples from Cheney and Herington watersheds have been analyzed for nutrient and sediment concentrations and the samples from Hillsdale watershed have been analyzed for fecal coliform concentrations. The results from all the three sites indicate that vegetative filter strips can significantly reduce nutrient, sediment, and coliform levels in runoff from small feedlots. In addition, the soil sample data from the filter strips indicate little nutrient accumulation if plant nutrient uptake is high.

Statistical analysis of the Cheney watershed data revealed significant differences between the inlet and outlet masses for total N, total P, $NH_4$-N, $NO_3$-N, Ortho P, and total suspended solids ($P<.05$), as well as total dissolved solids ($P<.10$). On an average over five storms at this site without cattle present, the VFS reduced total N, $NH_4$-N, $NO_3$-N, total P, Ortho P, and TSS by approximately 26, 44, 2, 14, 18, and 65%, respectively, on a concentration basis. The reductions on a mass basis were 50, 63, 34, 42, 45, and 76%, respectively. Soil total nitrogen did not vary statistically between the three different time periods. However, a general decreasing trend occurred over time, especially in the top 3 ft of the soil profile. Plant total N concentrations did not vary throughout the filter, whereas total P concentrations varied with distance from the filter inlet. On a mass basis, total P and total N both varied with distance from the inlet ($P<.10$).

Statistical analysis of data from the Herington site revealed significant differences between the inlet and outlet masses for total N, total P, $NH_4$-N, $NO_3$-N, Ortho P, and TSS ($P<.05$) as well as TDS ($P<.10$). On an average over four runoff events in the Herington watershed without cattle present, the VFS reduced concentrations of total N, $NH_4$-N, $NO_3$-N, total P, Ortho P, and TSS by approximately 73, 74, 95, 71, 64, and 78%, respectively. The reductions were 59, 74, 87, 52, 44, and 83%, respectively, on a mass basis. Plant total N concentrations varied with distance from the filter inlet, but total P concentrations did not. On a mass basis, both N and P varied significantly with distance from the filter inlet.

During a runoff event in May, 1998, the bacterial concentrations were higher at the beginning of the event. The concentrations of fecal coliform were reduced significantly by the VFS. Similar trends were observed at the same site in June. Although the concentrations did not seem to decrease at the outlet of the VFS, the total mass of coliform bacteria significantly decreased. This clearly demonstrates that the VFS increases the infiltration rate and reduces the runoff rate and volume.

Results of this study clearly support the findings of other researchers that VFS effectively reduce nutrient, sediment, and bacteria from agricultural areas. The efficiency of vegetation in reducing the pollutant concentration and mass depends on vegetation type, filter strip design, and watershed conditions. Nutrient uptake by vegetation was much higher at the Herington watershed site than at the Cheney Watershed (North Fork Nin-

nescah) site, most likely because of the difference in the quality of vegetation. At the Herington site, vegetation was established several years ago and excellent growth was observed. At the Cheney site, vegetation was established in 1996 and only a fair cover was established. At the Hillsdale watershed site, the vegetation also was fully established and a high percent reduction in coliform was observed. Regardless of the vegetation differences, good management is required to maintain the VFS. If properly managed, VFS can be used to improve environmental quality in agricultural areas.

# SOURCES OF VARIABILITY IN FED-CATTLE GRID PRICING

*J. L. Graff[1] and T. C. Schroeder[1]*

## Summary

Price variability among carcasses increases with a change from live-weight to dressed-weight to grid pricing. Grid pricing has the largest price variability, because the price for each carcass is influenced by all of the components of the grid, rather than all cattle selling for the same live or dressed price. Therefore, producers selling on a grid need to have knowledge about the expected carcass merit of their cattle. We used data on 11,703 head of cattle to determine which grid pricing components influence price variability the most and to measure how much price variability increases from grid pricing, relative to live and dressed pricing, at the individual-carcass and individual pen levels. The Choice-to-Select price spread has the largest influence on price variability per hundredweight, and average carcass weight had the largest influence on price variability per head. Whether price variability increased for both individual-head and individual-pen levels depended on the quality of the cattle sold and the grid on which they are sold. To manage the increased price risk created by pricing, producers must first manage that risk on an individual-head level through genetics, management, and sorting methods. The more knowledge producers have about the expected merit of their cattle, the more profit can be enhanced through grid pricing.

(Key Words: Grid Pricing, Value-Based Pricing, Price Variability.)

## Introduction

Consumer demand for leaner, more consistent, higher quality beef has motivated the beef industry to move toward a more value-based pricing system. To improve price signals to producers, packers have developed grid-pricing systems that value each carcass based on its own merit, as opposed to one price for an entire pen of cattle weight. By using grid-pricing systems, producers who market high quality cattle are rewarded with premiums, whereas producers who market low quality cattle receive sizeable discounts, relative to average market prices.

Previous studies have confirmed that on an individual basis, variability in price increases with a change from live weight to dressed weight to grid pricing. As price variability increases across these methods, price risk faced by the producer also increases. Therefore, producers must determine before the cattle are slaughtered whether those carcass have characteristics that will be rewarded by selling on a grid. If cattle sold on the grid do not fit specifications, they may be discounted severely and receive a price lower than if they were sold on a live-weight basis. The purposes of this study were to assist producers in determining which quality characteristics affect price variability the most and to determine if price variability from grid pricing increases relative to live and dressed pricing.

[1]Department of Agricultural Economics.

## Experimental Procedures

To determine what grid factors most affect price variability and to compare price variability on individual-head and individual-pen levels, data on 11,703 head of cattle (71 pens) marketed from January 1997 to December 1997 were collected from a large cattle feeding operation. Data consisted of cattle sold using a grid and included the quality grades, yield grades, carcass weights, and prices received for each carcass. Also, the dressing percentages, total live weights of the pens and the dates they were delivered to the packer were included. The cattle graded Choice (63.5%) and Select (27.5%), standard/no roll (7.5%), Prime (1.5%), and .2% heiferettes. Approximately 43% were yield grade 3, 33% were yield grade 2, and 6% were yield grade 4 or 5. The dressing percentage ranged from 61.8% to 65.3% and averaged 63.6%. The average carcass weight was 798 lbs.

To determine which components of grid pricing had the largest effect on price variability, the standard deviation of price/cwt among carcasses within a pen was regressed on grid-pricing components. These components included the percentage of carcasses from a pen that weighed less than 525 lbs, the percentage of carcasses weighing more than 950 lbs, the standard deviation of the average live weight of the cattle in a pen, the standard deviation of the quality and yield grade in a pen, and the Choice-to-Select price spread. To compare pricing methods and determine if price variability increased when cattle were sold using a grid, the same cattle were priced on live- and dressed-weight methods and on an actual Midwestern packer grid. The variability in price/cwt received in each of these pricing methods was compared.

Weekly live and dressed, fed cattle prices were determined based on the percentage of Choice cattle in the pen and were collected from the United States Department of Agriculture (USDA). The Choice-to-Select price spread collected from weekly boxed beef prices from the USDA averaged $6.62/cwt, with a standard deviation of $1.90/cwt.

## Results and Discussion

The grid pricing component that had the largest effect on price variability was the Choice-to-Select price spread (Table 1). However, on a revenue-per-head basis, the average carcass weight had the largest influence on variability.

As the Choice-to-Select price spread increased by 1%, the standard deviation of price increased by 0.77% (Table 1). Similarly, as the standard deviation of live or carcass weight increased by 1%, the standard deviation of revenue per head increased by 0.77%.

Price variability increased when moving from live-weight to dressed-weight to grid pricing when cattle were priced individually (Table 2). The grid pricing method had the highest standard deviation and was always statistically different ($P<.05$). Typically, grid price variability was more than double that of the other methods with individual carcass pricing.

To help manage risk, producers have several options. They can breed for superior genetics so the cattle better match the grid specifications and receive premiums for high quality. They can feed cattle to desired market weights to avoid large weight discounts. They also can sort cattle according to grid specifications. Initially accounting for variability at the individual-head level may help to increase revenue at the individual-pen level, which is where many producers measure improvement. In general, the more knowledge producers have about the expected merit of their cattle and how these carcass qualities affect price variation, the better price risk can be managed.

**Table 1. Percentage Change in Standard Deviation of Price and Revenue with One Percent Changes in Selected Variables**

| | Dependent Variable: Standard Deviation of | |
|---|---|---|
| Independent Variable | Price, $/cwt. | Revenue, $/head |
| % Lightweight carcasses | 0.084 | 0.039 |
| % Heavyweight carcasses | 0.136 | -0.175 |
| Weight standard dev. | 0.052 | 0.771 |
| Quality grade standard dev. | 0.463 | 0.097 |
| Yield grade standard dev. | 0.205 | 0.071 |
| Choice-to-Select price spread | 0.773 | 0.234 |

**Table 2. Summary Statistics of Pricing Methods for 11,703 Individual Cattle or Carcasses**

| Pricing Method | Mean | Standard Dev. | Minimum | Maximum |
|---|---|---|---|---|
| | $/cwt (live basis) | | | |
| Live-weight | 65.60 | 1.78[a] | 61.89 | 69.96 |
| Dressed-weight | 67.19 | 1.90[a] | 63.07 | 71.22 |
| Grid | 66.90 | 3.91[b] | 44.46 | 80.69 |
| | $/head | | | |
| Live-weight | 823.00 | 82.38[a] | 478.73 | 1,200.33 |
| Dressed-weight | 842.60 | 84.92[b] | 486.19 | 1,247.19 |
| Grid | 839.07 | 91.60[c] | 357.49 | 1,251.85 |

[a,b,c] If superscripts are the same, numbers are not statistically different (P<.05).

*Cattlemen's Day 1999*

# AN EFFICIENCY ANALYSIS OF CATTLE BACKGROUNDING OPERATIONS IN KANSAS

*L. Gow[1] and M. Langemeier[1]*


## Summary

As the structure of the beef industry changes, understanding its efficiency, cost, and profitability relationships is important. This study evaluates the relative efficiency of a sample of Kansas farm backgrounding and backgrounding/finishing operations for 1995-1997. No commercial feeders were included. On average, backgrounding operations were 71% technically efficient, 68% allocatively efficient, 83% scale efficient, and 39% overall efficient. The results suggest that Kansas backgrounding operations could reduce their cost by 61%, if all farms were producing at the lowest possible cost. On average, backgrounding/finishing operations were 84% technically efficient, 79% allocatively efficient, 90% scale efficient, and 60% overall efficient, suggesting that those operations could reduce their cost by 40%, if all were producing at the lowest possible cost. Given the average levels of technical, allocative, and overall efficiencies, significant room for improvement exists in technology adoption, input usage, and size adjustment for both backgrounding and backgrounding/finishing operations.


(Key Words: Backgrounding, Finishing, Production Costs, Efficiency, Size.)

## Introduction

The livestock sector comprises about 40% of agriculture's contribution to Kansas' gross state product. Within the livestock sector, cattle account for over 80% of the value of all livestock production. Consequently, fluctuating livestock profitability has a large effect on total income in the state's agricultural sector, and profitability of the cattle industry has a far greater effect on aggregate returns for Kansas agriculture than any other livestock enterprise.

Recently, great importance has been placed on the economic efficiency of agricultural production because of its role in explaining profitability differences. We have seen dramatic structural change in the commercial feedlot sector. The question now is, what is going to happen to farm back-grounding/feeding operations in Kansas? Efficiency measures can be used to generate inferences about the future direction of the industry and determine the factors that may influence the structure of the firms in that industry.

## Experimental Procedures

A series of mathematical programs was used to measure technical and cost efficiency for a sample of backgrounding and backgrounding/finishing operations. Specifically, overall efficiency, technical efficiency, allocative efficiency, and scale efficiency were measured. Data were obtained from the Kansas Farm Management Association for 41 backgrounding operations that reported data for 1995, 1996, and 1997. Enterprise data were converted to 1997 dollars and separated into six input categories: labor, utilities and fuel, capital, feed, veterinary, and miscellaneous. Feed costs include all cash and opportunity costs (i.e., feed grown and used on the operation is

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charged a market value.). Capital costs included: interest expense, interest charge, depreciation, machine hire and repair, and vehicle expenses. The interest charge represents an opportunity cost of owned capital. Output was measured in pounds of beef produced. Farms then were divided into three relative sizes based on output. Average revenue, cost, and efficiency characteristics were determined for each group.

## Results and Discussion

Table 1 presents the overall statistical summary for gross revenues, profits, costs and other relevant characteristics for both backgrounding and backgrounding/finishing operations. On average, gross income was $55.80/cwt, and total costs were $81.50/cwt for backgrounding operations. Feed was the highest cost component, accounting for 53.1% of the total costs, followed by capital expenses at 24%. The average operation size was 381 head, with an average of 288 lbs of beef produced per head. Average operator age was 51 years.

For backgrounding/finishing operations, gross income and total costs averaged $59.75/cwt and $58.55/cwt, respectively. Feed was the most expensive cost component, accounting for 59% of the total cost, followed by capital expenses, which accounted for 22%. The average operation size was 520 head, with an average of 614 lbs of beef produced per head. Average operator age was 53 years.

Table 2 reports the average revenue, cost, and efficiency characteristics of Kansas backgrounding operations, based on size. Efficiency measures are relative and are based on a comparison to the most efficient operator in the sample. The average sizes were 120 head for a small operation, 272 for a medium operation, and 788 for a large operation. Average gross incomes per cwt were $55.40 for small operations, $54.74 for medium, and $57.17 for large. Average total costs were $95.51/cwt for small operations, $81.17/cwt for medium, and $67.83/cwt for large operations.

Technical efficiency measures whether or not a producer is using the most up-to-date technologies. Consequently, a technically inefficient farm cannot produce as much output with the same levels of input as a technically efficient farm. Overall, backgrounding operations were 71% technically efficient. This means that, on average, output could be increased 29% if the latest technology was being implemented. Large operations had the highest average technical efficiency of 79%. Small and medium operations had measures of 68% and 67%, respectively.

Allocative efficiency measures whether a farm is using the cost-minimizing input mix for a given level of output. Overall, the sample was 68% allocatively efficient. This means that costs could be reduced by 32% if the optimal input mix was used. Small operations had the highest level of allocative efficiency with 76%, followed by large at 68%, and medium at 61%.

Scale efficiency measures whether a farm is producing at the most efficient size. Overall scale efficiency was 83%; costs could be reduced 17% if farms were operating at the most efficient size. Medium-sized operations had the highest scale efficiency with 94%, followed by large and small with 84% and 72%, respectively.

Overall efficiency is a function of technical, allocative, and scale efficiencies and determines the minimum cost of producing a given output level under constant returns to scale technology. At constant returns to scale, there is no cost advantage to becoming larger or smaller. Average overall efficiency was 39%. This means that the same level of output could be produced at 61% less cost if the operation was technically, allocatively, and scale efficient. This would be the optimal point of production, where costs are minimized. Large-sized operations had the highest measure of overall efficiency with 45%, followed by medium and small with 38% and 35%, respectively. This trend is evident by decreasing costs of production in every cost category as size increases (Table 2).

Table 3 reports the average revenue, cost, and efficiency characteristics of Kansas backgrounding/finishing operations. The average sizes were 153 head for a small operation, 445 for a medium operation, and 962 for a large operation. Average gross incomes per cwt for small, medium, and large operations were $60.12, $61.30, and $57.84, respectively. Average costs for small, medium, and large operations were $67.33, $53.78, and $54.39, respectively.

Overall, backgrounding/finishing operations were 84% technically efficient. Large operations had the highest average technical efficiency of 92% followed by small and medium operations at 77% and 83%, respectively. The sample was also 79% allocatively efficient. Again large operations had the highest level of allocative efficiency with 82%, followed by medium at 80% and small at 76%. Medium-size operations had the highest scale efficiency with 94%, followed by small and large with 93% and 83%, respectively.

Average overall efficiency was 60%. Medium-sized operations had the highest measure of overall efficiency of 63%, followed by large and small with 54% and 62%, respectively.

Given the average levels of technical, allocative, and overall efficiencies, significant room exists for improvement in technology adoption, input usage, and size adjustment. As the structure of the beef industry continues to change, understanding the industry's efficiency, cost, and profitability relationships will become increasingly important.

**Table 1. Overall Average Statistics for Kansas Backgrounding and Backgrounding/ Finishing Operations (1995-1997)**

| Variables | Unit | Backgrounding | Backgrounding/ Finishing |
|---|---|---|---|
| Gross income/cwt | $ | 55.80 | 59.75 |
| Total cost/cwt | $ | 81.50 | 58.55 |
| Feed cost/cwt | $ | 43.28 | 34.52 |
| Capital cost/cwt | $ | 19.86 | 12.85 |
| Labor cost/cwt | $ | 8.22 | 4.76 |
| Utility cost/cwt | | 2.22 | 1.37 |
| Vet cost/cwt | $ | 4.59 | 1.77 |
| Other cost/cwt | $ | 3.35 | 3.21 |
| Age of operator | Years | 51 | 52 |
| Size of operation | Head | 381 | 520 |

Source: Kansas Farm Management Association.

**Table 2. Average Characteristics of Kansas Backgrounding Operations Based on Size**

| Variable | Small | Medium | Large |
|---|---|---|---|
| Revenue Items | | | |
| Avg. size (head) | 120 | 272 | 788 |
| Avg. gross income/cwt | 55.49 | 54.74 | 57.17 |
| Avg. gain per head (lbs) | 259.87 | 290.02 | 313.84 |
| Cost Items | | | |
| Avg. total cost/ cwt ($'s) | 95.51 | 81.17 | 67.83 |
| Avg. labor cost/cwt ($'s) | 11.10 | 7.80 | 5.79 |
| Avg. vet cost/cwt ($'s) | 5.57 | 4.47 | 3.63 |
| Avg. feed cost/cwt ($'s) | 46.98 | 45.93 | 36.93 |
| Avg. utility cost/cwt ($'s) | 2.85 | 2.06 | 1.76 |
| Avg. capital cost/cwt ($'s) | 24.86 | 17.74 | 17.00 |
| Avg. other cost/cwt ($'s) | 4.15 | 3.17 | 2.72 |
| Efficiency Index Measures | | | |
| Avg. technical efficiency | .68 | .67 | .79 |
| Avg. allocative efficiency | .76 | .61 | .68 |
| Avg. scale efficiency | .72 | .94 | .84 |
| Avg. overall efficiency | .35 | .38 | .45 |

Source: Kansas Farm Management Association.

**Table 3. Average Characteristics of Kansas Backgrounding/Finishing Operations Based on Size**

| Variable | Small | Medium | Large |
|---|---|---|---|
| Revenue Items | | | |
| Avg. size (head) | 153 | 445 | 962 |
| Avg. gross income/cwt | 60.12 | 61.30 | 57.84 |
| Avg. gain per head (lbs) | 575.75 | 623.00 | 643.06 |
| Cost Items | | | |
| Avg. total cost/ cwt ($'s) | 67.33 | 53.78 | 54.39 |
| Avg. labor cost/cwt ($'s) | 7.70 | 4.37 | 2.25 |
| Avg. vet cost/cwt ($'s) | 1.98 | 1.64 | 1.75 |
| Avg. feed cost/cwt ($'s) | 35.82 | 32.86 | 34.89 |
| Avg. utility cost/cwt ($'s) | 2.18 | 1.22 | 0.70 |
| Avg capital cost/cwt ($'s) | 16.99 | 11.13 | 10.45 |
| Avg. other cost/cwt ($'s) | 2.66 | 2.63 | 4.35 |
| Efficiency Index Measures | | | |
| Avg. technical efficiency | .77 | .83 | .92 |
| Avg. allocative efficiency | .76 | .80 | .82 |
| Avg. scale efficiency | .93 | .94 | .83 |
| Avg. overall efficiency | .54 | .63 | .62 |

Source: Kansas Farm Management Association.

# EVALUATION OF SPRINGTIME DEWORMING STRATEGIES FOR BEEF COW/CALF PAIRS[1]

***D. A. Blasi, G. E. Newdigger[2], M. L. Pfeifer[2], J. C. Baker[2], and J. T. Seeger[3]***

## Summary

A field study was conducted at three different locations in south central Kansas to determine the effects of Dectomax® (DECTO) or Ivomec PO® (IVO) compared to no treatment (CONT) on the liveweight gain and reproductive performance of beef cow/calf pairs. Across all three locations, no differences occurred among treatments in cow and calf live weight gain, cow body condition, pregnancy rate, or age of fetus (P>.05). Low egg counts suggest that the parasite load was too low for a response to parasite control.

(Key Words: Spring Deworming, Cow/Calf Pairs.)

## Introduction

Economic losses from internal parasites can be significant. Such losses usually are hidden, because minor changes in performance of infected animals are not detected easily. The degree of infestation will vary with age, degree of exposure, and environment and ultimately will determine the value of worming cattle under a given set of conditions. This study was conducted to determine the efficacy of springtime administration of Dectomax® or Ivomec PO® in beef cows and their calves compared to no treatment.

## Experimental Procedures

Spring calving beef cow/calf pairs grazing native grass (164 pairs near Isabel, KS and 165 pairs near Geneseo, KS) or bermudagrass pasture (150 pairs near Cedar Vale, KS) were allocated randomly to one of three treatment groups based on cow age. The trial started at each location during May, 1997 and ended in October. All cows and calves had individual eartags. On day 0, the cow/calf pairs allotted to DECTO were injected subcutaneously with 1 mL/110 lb body weight Dectomax® (200 Fg doramectin per kg body wt); those allotted to IVO were treated topically with 1 mL/22 lbs body weight Ivomec PO® (500 Fg ivermectin per kg body wt) down the midline of the back. The CONT group received no anthelmintic treatment. Treatment groups were commingled after treatment on Day 0. Individual fecal samples were collected from 20 randomly selected pairs (cow and calf) from each treatment group on Day 0. Fecal samples were collected again from the same calves on days 56 and 150. All fecal samples were examined quantitatively for parasite eggs by a parasitologist.

Individual weights and body condition scores were recorded for all cows at the start and end of the trial. Calves were weighed individually at all three locations on days 0,

[1]Sincere appreciation is expressed to Colin and Chad Cargill, Isabel, KS; Jack and Jeff Janssen, Geneseo, KS; and Jim Aikman and Lazy G Ranch, Inc., Cedar Vale, KS, for providing cattle, facilities, and assistance and to Pfizer Animal Health for financial support.

[2]County Extension Agricultural Agents in Barber, Ellsworth, and Cowley Counties, respectively.

[3]Senior Technical Services Veterinarian, Pfizer Animal Health.

56, and 112. On day 150, the cows were pregnancy-checked (rectal palpitation), and the estimated ages of the fetuses were recorded.

The cow/calf pair was the experimental unit for statistical analysis. Although commingling treated and control cow/calf pairs adds power to the statistical analysis, it penalizes the treated group and rewards the control group by controlling parasites in two-thirds of the herd. A repeated measures, mixed general linear model, which included pasture as block, was used to analyze cow body weight, cow body condition score, calf ADG, and calf nematode egg counts. A general linear mixed model, which included pasture as a block, was used to analyze fetal age in days and cow nematode egg counts. All nematode counts (eggs per gram) were transformed to the natural log before analysis, then they were back-transformed to geometric means for presentation. Fisher's Exact test was used to test for an association between pregnancy status at the end of the study and treatment.

## Results and Discussion

Treating of cow/calf pairs harboring natural gastrointestinal nematode infections and grazing either native or bermudagrass pastures in Kansas with a single dose of DECTO subcutaneously or IVO topically did not influence (P>.05) weight gain or change body condition score in the cows, percentage pregnant, or age of the fetus (Table 1). Moreover, no significant differences occurred among treatments in ADG of the calves (Table 2). However, DECTO- and IVO-treated calves exhibited lower counts (P<.05) of trichostrongylid-type eggs and all genera of nematode eggs at day 56 compared to the CONT calves (Table 3). However, those differences had disappeared by day 150. We conclude that the parasite loads were so low that their control did not influence performance.

**Table 1. Cow Weight and Body Condition Score Changes by Treatment**

| Location | Cow Weight | | BCS[1] | | Fetal |
|---|---|---|---|---|---|
| Treatment | Day 0 | Day 150 | Day 0 | Day 150 | Age (Days) |
| Combined herds | | | | | |
| CONT[2] | 1055 | 1185 | 5.2 | 5.4 | 127 |
| DECTO | 1051 | 1176 | 5.2 | 5.3 | 133 |
| IVO | 1059 | 1179 | 5.2 | 5.3 | 128 |
| Barber | | | | | |
| CONT | 998 | 1098 | 5.0 | 5.4 | 164 |
| DECTO | 991 | 1097 | 5.1 | 5.4 | 173 |
| IVO | 965 | 1111 | 5.0 | 5.3 | 160 |
| Cowley | | | | | |
| CONT | 971 | 1141 | 4.9 | 5.5 | 122 |
| DECTO | 975 | 1134 | 5.0 | 5.5 | 127 |
| IVO | 1018 | 1125 | 5.0 | 5.4 | 126 |
| Ellsworth | | | | | |
| CONT | 1187 | 1335 | 5.3 | 5.6 | 96 |
| DECTO | 1168 | 1317 | 5.2 | 5.5 | 101 |
| IVO | 1182 | 1328 | 5.3 | 5.6 | 98 |

[1]Body Condition Score; 1 = extremely emaciated; 9 = extremely obese.
[2]CONT= Nonmedicated control; DECTO = Dectomax®; IVO= Ivomec PO®.

**Table 2. Calf Gains (lbs/day) during Successive Weigh Periods**

| Location Treatment | Day of Study | | | |
|---|---|---|---|---|
| | 0 to 56 | 56 to 112 | 112 to 150 | 0 to 150 (overall) |
| Combined herds | | | | |
| CONT[1] | 2.81 | 2.31 | 1.91 | 2.41 |
| DECTO | 2.79 | 2.20 | 1.87 | 2.36 |
| IVO | 2.73 | 2.27 | 1.86 | 2.36 |
| Barber Co. | | | | |
| CONT | 2.34 | 1.96 | 1.89 | 2.09 |
| DECTO | 2.45 | 1.88 | 1.78 | 2.09 |
| IVO | 2.36 | 2.02 | 1.83 | 2.12 |
| Cowley Co. | | | | |
| CONT | 2.97 | 1.96 | 1.80 | 2.33 |
| DECTO | 2.92 | 1.88 | 1.85 | 2.29 |
| IVO | 2.84 | 1.92 | 1.65 | 2.23 |
| Ellsworth Co. | | | | |
| CONT | 3.05 | 2.89 | 2.50 | 2.87 |
| DECTO | 3.00 | 2.78 | 2.50 | 2.81 |
| IVO | 2.97 | 2.80 | 2.57 | 2.82 |

[1]CONT = Nonmedicated control; DECTO = Dectomax®; IVO = Ivomec PO®.

**Table 3. Combined-Treatment Geometric Means of Nematode Eggs per Gram of Feces from Cows and Calves**

| | Cow Pretreatment | | | Calf Day 0 | | | Calf Day 56 | | | Calf Day 150 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nematode Species | CONT | DECTO | IVO | CONT | DECTO | IVO | CONT | DECTO | IVO | CONT | DECTO | IVO |
| Trichostron-gylid | 4.1 | 5.7 | 3.3 | 1.5 | 1.0 | 0.9 | 3.3[a] | 1.4[b] | 1.8[b] | 4.7 | 4.9 | 6.2 |
| Total all genera | 4.4 | 5.8 | 3.3 | 1.8 | 1.4 | 1.0 | 4.7[a] | 2.2[b] | 2.7[b] | 5.7 | 3.0 | 7.5 |

[a,b] Values in rows not sharing a common superscript are different (P< .05).

# PREVALENCE OF OCULAR LESIONS IN CATTLE FROM A KANSAS SALE BARN

*H. J. Davidson[1], G. L. Stokka, T. B. Taul[2]*

## Summary

This cross-sectional evaluation of cattle from a sale barn was completed to identify the prevalence of ocular lesions. A total of 100 cattle (91 cows and 9 bulls) was examined as they were being processed through a Kansas sale barn. Ocular lesions were found in 47%. The most frequently identified lesions were corneal scars, found in 26%. Although the exact cause of the scars could not be determined, they were similar in appearance to scars caused by infectious bovine keratoconjunctivitis (IBK) or pinkeye. The second most common lesion was squamous cell carcinoma (SCC), identified in 14%. Cataracts were identified in 7%. A white, raised, proliferative, optic nerve mass was identified in 11%. This high prevalence of eye lesions suggests that cattle frequently suffer from ocular disease or trauma. These lesions can be missed easily if the eye is not evaluated specifically during physical examination.

(Key Words: Eye, Ocular, Squamous Cell Carcinoma, Infectious Keratoconjunctivitis, Cataract.)

## Introduction

Eye diseases frequently are overlooked when examining cattle, yet they can cause severe problems. Revenue loss from eye problems is difficult to measure. Ocular lesions can result in increased production costs from medical treatments and in additional animal handling. Income also is lost from reduced weight gain, reduced milk production, and a reduction in animal value because of eye disfigurement.

## Experimental Procedures

The cattle in our study were selected randomly from those being processed at a Kansas sale barn. Examinations were competed during two different seasons (spring and fall) over 4 different days. Cattle in this study were examined by the attending veterinarian and were judged to be in good health. The reason for sale of the individual animals was unknown to the ophthalmic examiner. Animals ranged in age from 1 to 6 years, and included 91 females and 9 males. The cattle breeds included: Charlois (1), Simmental and Simmental crossbreds (17), Hereford and Hereford crossbreds (23), Angus and Angus crossbreds (39), Saler (1), Aryshire (1), Shorthorn and Shorthorn crossbreds (4), Holstein (9), Gelbvieh and Gelbvieh crossbreds (2), Limousin crossbreds (1), Tarentaise (1), and Chianina (1).

Animals were restrained with a standard hydraulic chute, and nose tongs were used to manipulate the head. Eyes were examined using a penlight to evaluate the entire globe and pupillary light reflexes, a slit-lamp biomicroscope to look closely at the iris and lens, and indirect ophthalmoscopy to evaluate the retina. Vision was accessed by observing cattle in the processing area and by the menace response. The entire eye was examined to include the top, bottom, and

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third eyelids; conjunctiva; sclera; cornea; iris; lens; and retina.

## Results and Discussion

The average age of the cattle could not be determined; no age records were available, and some animals were simply assessed to be greater than 6 years of age. A total of 86 abnormalities were found in the 200 eyes examined. Fifty-three animals were normal, 27 had unilateral lesions, and 20 had bilateral lesions. Multiple problems were present in several eyes. Five animals were blind in one eye, but no animal was completely blind.

The most common eyelid abnormality was squamous cell carcinoma(SCC), with the most common location being the third eyelid. SCC of the eyelids was identified in 11 animals; 3 were bilateral and 8 were unilateral. The tumors were raised, white to pink, irregular, tissue masses. Other eyelid lesions included one wart on the top eyelid and one eyelid laceration.

The most common corneal lesion was a scar. Corneal scars were found in 32 eyes of 26 animals. Scars were not broken down into specific descriptive categories. The majority were located in the central cornea. They appeared as white, lacy opacities in the superficial stroma. Active or inactive superficial corneal blood vessels occurred in many scars. In one eye, the cornea was so scarred that further examination of the internal structures was not possible.

The second most common corneal lesion was SCC at the limbus (junction of the cornea and sclera). This was seen most frequently at the lateral limbus, or outside edge. The lesion appeared as a raised white plaque, which ranged in diameter from less than 0.5 cm to 1.5 cm. One cow had a corneal ulcer associated with a large eyelid SCC that was rubbing on the corneal surface. Three animals had concurrent corneal scars and SCC. In two of these animals, the scar appeared to be a healed ulcer that was most likely caused by the mass rubbing on the corneal surface. One cow had bilateral central corneal scars that were unassociated with the lateral limbal SCC. Another cow had bilateral corneal opacities that were caused by persistent pupillary membranes adhering to the inner surface of the cornea. The overall prevalence of SCC was 14%.

Eleven abnormalities involved the anterior portion of the inner structures of the eye. One cow had bilateral persistent pupillary membranes that extended from the iris to the inner corneal surface. One cow had a portion of the iris stuck to the lens, which had resulted in a cataract. A third cow had a unilateral iris cyst, and a fourth had a misshapen pupil that resulted in multiple pupillary openings. Unilateral cataracts (lens opacity) were identified in 7 eyes. Two of the cataracts were complete and resulted in blindness. In one case of cataracts, an associated shifting of the lens position was observed. One eye that had an incomplete cataract also had a detached retina.

Only a few retinal abnormalities were noted. A single cow had a unilateral retinal detachment. In 11 animals, a lesion was found on the optic nerve. In 7 animals, the lesion was unilateral, and in 4 it was bilateral. The lesion was a raised, white, proliferative appearing mass. The retinal blood vessels could be seen to travel over the top or through the mass. The vessels appeared to be normal, and no identifiable abnormalities of the surrounding fundus were seen. The affected cattle appeared to have normal vision.

Although the literature has numerous descriptions of specific lesions, only one report describes lesion prevalence. The study of Brown Swiss cattle conducted in 1931 reported a total incidence of ocular lesions of 18.8%. Cattle less than 6 years old had an incidence of 3%, and animals between 7 and 14 years of age had an incidence of 43%. No description of the type of ocular lesion could be found. In a retrospective study of ocular disease in llamas, data were collected using the medical diagnosis information from the Veterinary Medical Database. That database collects information from multiple academic institutions. In the llama study, the number of ocular lesions in

cattle was included for comparison. Ocular lesions were reported in 3% of all cattle presented for examination at veterinary teaching hospitals. The reported prevalence of ocular disease is extremely dependent on the method of data collection. In the retrospective study, only the medical diagnosis information was included. Neither the record nor the actual animal was examined. It is uncommon for cattle eyes to be examined during routine health inspections. If lesions are not large enough to be obvious, or the eyes are not specifically evaluated, lesions may be missed, which would give a falsely low estimation of their true prevalence.

In our study, 47% of the animals had eye lesions. That prevalence was based on the presence of any ocular lesion, regardless of whether the animal had unilateral or bilateral lesions or the number of lesions per eye. In cattle 6 years of age or older, the prevalence was 69%. In cattle 5 years of age or younger, the prevalence was 24%. Our data did not provide enough information on any one breed to report prevalence by breed alone, and too few males were examined to determine the prevalence in males versus females.

In Kansas, the two most common clinical ocular problems in cattle are infectious bovine keratoconjunctivitis(IBK) or pinkeye, and SCC. Our data reaffirm that these two conditions are widespread in our cattle population. Corneal lesions that are typical of either IBK or trauma were found at a prevalence of 26%. SCC, whether on the eyelids or globe, was found at a prevalence of 14%.

Cataracts were found at a prevalence of 7%, and they were all unilateral. Cataracts have been reported to be genetic in some of the breeds in this study. However, the appearance of the cataract and the fact that each was unilateral suggests that trauma or previous ocular inflammation caused them.

The optic nerve lesion seen in 11 cows could not be classified as to physical structure, because histopathology was not completed. This lesion has been noted previously in the veterinary literature but has never been histologically described or associated with any form of systemic disease. The white, raised, proliferative mass did not appear to be a clinical problem, because the animals had sight and did not appear to be in pain.

The high prevalence of ocular lesions, the majority involving the cornea, suggests that cattle suffer from ocular disease or trauma much more frequently than is diagnosed by veterinarians. Producers often estimate the incidence of ocular disease in their herds, but there is little hard evidence to support such estimations. The exact type of ocular disease that results in the lesions reported here needs to be evaluated during the active disease process. Our data suggest that ocular disease is an underdiagnosed and undertreated condition in cattle.

# FIXED-TIME INSEMINATION OF SUCKLED BEEF COWS. 1. SELECT SYNCH, COSYNCH, AND THEIR COMBINATION[1]

***J. S. Stevenson, K. E. Thompson, G. C. Lamb, and D. M. Grieger***

## Summary

As in our previous studies, the GnRH + $PGF_{2"}$ treatment was very effective in inducing a fertile estrus and(or) ovulation. Ovulations induced in response to the first GnRH injection averaged 48% in three herds and ranged from 44 to 56%. The proportion of 536 cows that were cycling at the beginning of the breeding season averaged 48% and ranged from 35 to 59%. Conception rate was greater in Select Synch cows (those inseminated after detected estrus) than in cows in other breeding treatments. Pregnancy rates tended to be greater in Select Synch cows than in cows of other treatments. A treatment × herd interaction indicated that alternate breeding treatments performed differently in each herd. These results also emphasize the importance of early cycling activity to reproductive outcomes.

(Key Words: AI, Estrus-Ovulation Synchronization, GnRH, $PGF_{2"}$, Cows.)

## Introduction

Estrus-synchronization programs are designed to improve reproductive efficiency by reducing the duration of the breeding and calving season and to group together cows or heifers so artificial insemination (AI) can be used more efficiently. The major limitation of estrus-synchronization programs is their inability to induce a potentially fertile estrus and ovulation in noncycling cattle (i.e., prepubertal heifers and anestrous suckled cows). Because current estrus-synchronization programs were not designed for successful treatment of noncycling cattle, their use in cow-calf operations generally has not produced results that would encourage greater AI use. Currently, less than 5% of beef cows and an estimated 8 to 10% of beef heifers are AI-bred in the US. The potential for increasing AI in beef cattle is great if a system can successfully resolve the problem of the noncycling female at the beginning of the breeding season.

Our results using GnRH, norgestomet, and $PGF_{2"}$ have demonstrated a new method of inducing fertile ovulations in both cycling and noncycling cows (1996 Cattlemen's Day Report, pp 25-28; 1997 Cattlemen's Day Report, pp 91-93 and 94-96). Further, treatments involving a single injection of gonadotropin-releasing hormone (GnRH; Cystorelin®, Factrel®, or Fertagyl®) given 7 days before $PGF_{2"}$ (Lutalyse®) are successful in initiating a fertile estrus and(or) ovulation before insemination. GnRH induces secretion of LH and FSH and causes ovulation of mature follicles. The resulting corpus luteum is then responsive to the $PGF_{2"}$ given 7 days later. Our objective was to assess the best timing of insemination after GnRH + $PGF_{2"}$.

## Experimental Procedures

Three herds of suckled beef cows were used in this experiment: 1) 153 crossbred Angus×Hereford cows; 2) 225 crossbred Angus×Hereford×Simmental cows; and 3)

[1]We acknowledge the cooperation and participation of Joe Thielen, Dorrance, KS; Gary Johnson, Dwight, KS; and Troy Marple and student workers at the KSU Purebred Beef Unit.

158 purebred Angus, Hereford, and Simmental cows. Estrus and ovulation in all cows were programmed for AI using one system consisting of 100 µg of Cystorelin (day -7) and 25 mg of Lutalyse (day 0) given prior to the onset of the spring breeding season (day 0).

Cows were assigned randomly to three insemination treatments in which inseminations occurred (Figure 1): 1) 8 to 14 h after detected estrus during a 144-h period after $PGF_{2"}$ (Select Synch); 2) 54 h after Lutalyse ($PGF_{2"}$), when a second 100-µg injection of Cystorelin was given immediately after the insemination (Cosynch); or 3) up to 54 h after Lutalyse, based on heat detection, then all remaining cows were inseminated and given Cystorelin at 54 h (Select Synch + Cosynch). Cows were observed for estrus at least twice daily.

Blood samples were collected on days -17, -7 (first Cystorelin injection), and 0 for subsequent analysis of progesterone by radioimmunoassay. Cows were classified as cycling or anestrus based on concentrations of progesterone in the first two blood serum samples. Body condition score (BCS; 1 = thin and 9 = fat) was assessed at the time of Lutalyse injection. Pregnancy rates were determined by a single ultrasonograph 30 to 43 days after AI.

## Results and Discussion

Characteristics of the cows assigned to three breeding treatments are summarized in Table 1. Overall, only 48% of the cows had elevated blood progesterone concentrations before the beginning of the breeding season, thus, less than half of the cows were cycling before the hormonal protocol was initiated. Percentages of cows cycling varied from 35 to 59% among herds. Of those noncycling females, hormone treatment induced postpartum ovulation in 43 to 56% (average, 48%). Body condition ranged from 3.5 to 8.0 in one herd and 3.5 to 6.5 in the other two herds, with an overall average of 4.9. Days after calving at the onset of the breeding season varied from 11 to 118 days, with the three herd averages ranging from 64 to 74 days.

In the Select Synch treatment, only 70% of the cows were detected in heat during the 144 hours after Lutalyse. Only 20% of those heats occurred before 54 hours (Select Synch + Cosynch). Cows were not observed for heat in the Cosynch treatment. Conception rates (number of cows that became pregnant/number of cows inseminated) of cows inseminated after detected estrus in the Select Synch treatment were normal; 58 to 83%, with an average of 67%.

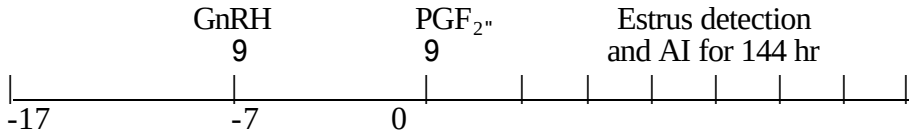
Conception and pregnancy rates (number of cows that became pregnant/number of cows treated) of all cows are summarized based on their cycling status at the beginning of the breeding season (Table 2). Overall conception rates were greater ($P<.01$) for Select Synch than the other two treatments.

For every one unit increase in BCS at the beginning of the breeding season, conception rate increased ($P=.06$) by 8.8 ± 0.05%, which emphasizes the importance of keeping cows in good body condition. To achieve early cycling activity and maximal conception rates, cows should have a BCS of at least 5 at calving time.

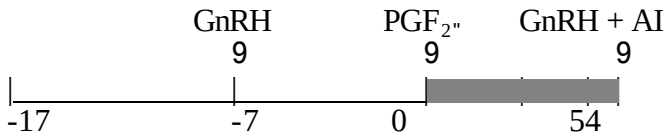
No significant differences in pregnancy rates occurred among treatments despite a large number of cows tested. However, pregnancy rates tended to follow the same trend as conception rates. For every one unit increase in BCS, pregnancy rate increased ($P=.07$) by 8.2 ± 0.04%. For every 10-day increase in days postpartum at the beginning of the breeding season (day 0), pregnancy rate increased ($P=.06$) by 2.5 ± 0.01%.

These results again emphasize the importance of early cycling activity to reproductive performance. Further, the benefit of the GnRH + $PGF_{2"}$ treatment to induce a fertile estrus and(or) ovulation cannot be overemphasized. The results also indicated that differences between herds affected the success of the insemination treatments.

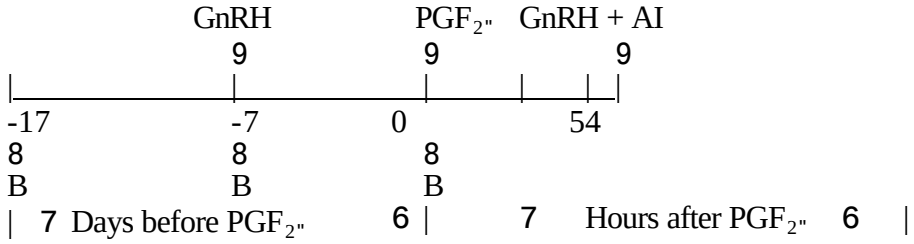
**Select Synch** (AI follows GnRH + $PGF_{2"}$)




**Cosynch** (AI follows GnRH + $PGF_{2"}$ but occurs at the same time as second GnRH injection)




**Select Synch + Cosynch**




Days of blood (B) collection for progesterone
Period of heat detection + AI =

**Figure 1. Experimental Protocol Used to Synchronize Estrus and(or) Ovulation in Suckled Beef Cows.**

**Table 1. Characteristics of Cows in Three Herds Assigned to Treatments**

| Herd | Assessed at the Beginning of the Breeding Season | | | |
|---|---|---|---|---|
| | Cycling[a] (%) | Induced Ovulation[b] (%) | Body Condition | Days Postpartum |
| 1 | 69/155 (43.8) | 48/86 (55.8) | 4.8 ± .4[c] (3.5-6.0)[d] | 64.5 ± 12.3[c] (34-88)[d] |
| 2 | 104/251 (35.1) | 66/147 (44.8) | 5.1 ± .4 (3.5-8.0) | 74.1 ± 17.6 (43-111) |
| 3 | 102/166 (59.4) | 28/64 (43.7) | 4.6 ± .6 (3.0-6.5) | 74.1 ± 20.3 (11-118) |
| 3 | 275/572 (48.1) | 142/297 (47.8) | 4.9 ± .5 (3.0-8.0) | 71.3 ± 17.6 (11-118) |

[a]At least one serum progesterone sample on either days -17, -7, or 0 was high (>1 ng/mL).
[b]Proportion of cows with two low (<1 ng/mL) concentrations of progesterone on days -17 and -7, followed by high progesterone on day 0 (evidence of GnRH-induced ovulation).
[c]Mean ± SD.
[d]Range in days.

**Table 2. Conception and Pregnancy Rates of Suckled Cows by Cycling Status**

| Item | Treatment | | |
|---|---|---|---|
| | Select Synch | Cosynch | Select Synch + Co-synch |
| | ---------- % (no.) ---------- | | |
| Conception rate[a], % | 69.6[x] (115) | 33.7[y] (175) | 32.8[y] (177) |
| Anestrus | 62.8 ( 43) | 26.9 (104) | 25.8 ( 97) |
| Cycling | 73.6 ( 72) | 43.7 ( 71) | 41.2 ( 80) |
| Pregnancy rate[b], % | 43.5 (184) | 33.7 (175) | 32.8 (177) |
| Anestrus | 28.4 ( 95) | 26.9 (104) | 25.8 ( 97) |
| Cycling | 59.6 ( 89) | 43.7 ( 71) | 41.2 ( 80) |

[a]Cycling effect (P<.01); sire within herd (P<.05); and body condition score (BCS; P=.06).
[b]Cycling effect (P<.001); treatment × herd (P=.06); body condition score (BCS; P=.07); and days postpartum (P=.06).
[x,y]Different (P<.01).

# FIXED-TIME INSEMINATON OF SUCKLED BEEF COWS. 2. COSYNCH AND PROGESTERONE[1]

***J.S. Stevenson, G.C. Lamb, J.A. Cartmill, B.A. Hensley, and T.J. Marple***

## Summary

The Cosynch protocol (GnRH 7 days before and again 48 h after $PGF_{2"}$ with AI at the second GnRH injection) produced pregnancy rates in suckled beef cows that exceeded 50% without heat detection and with only three handlings of all cows. The addition of an intravaginal progesterone insert to the Cosynch protocol improved pregnancy rates in two of the three breeds of cows studied.

(Key Words: Cows, AI, Estrus-Ovulation Synchronization, GnRH, $PGF_{2"}$.)

## Introduction

Recent studies have identified the effectiveness of using GnRH + $PGF_{2"}$ to synchronize estrus and ovulation in beef cattle (1998 Cattlemen's Day Report; pp 34-36). This protocol (known as Select Synch) requires an injection of GnRH 7 days before $PGF_{2"}$, which is given on the first day of the breeding season. Cows then are observed for estrus and inseminated. This protocol requires three separate handlings through the working chute (two for hormone injections and one for AI). The handling depends on when heat occurs. Pregnancy rates (number of pregnant cows/number of cows treated) have exceeded 50% using this protocol in other studies.

This protocol was refined further to allow for one fixed-time breeding, still with only three trips through the working chute. In this protocol, referred to as Cosynch, AI at 48 h after $PGF_{2"}$ is combined with a second injection of GnRH to induce ovulation. Work in Colorado consistently produced good pregnancy rates (approximately 50%) with the Cosynch protocol, whereas our pregnancy rates in Kansas field trials using Cosynch were lower (see page 61). We believe part of the reason for greater success in the Colorado studies is better body condition of their cows. In addition, about 10% of the cows treated with GnRH + $PGF_{2"}$ are observed in heat 1 or 2 days before the $PGF_{2"}$ is administered or 6 to 7 days after the first GnRH injection. To prevent these cows from showing heat prematurely, we applied an intravaginal progesterone insert during the 7-day interim between injections.

Our objective was to determine if progesterone would enhance pregnancy rates in the Cosynch protocol compared to using Cosynch alone.

## Experimental Procedures

Purebred Simmental, Angus, and Hereford cows were assigned randomly to each of two treatments (Figure 1): 1) 92 cows received (i.m.) 100 µg of GnRH (Fertagyl®), followed in 7 days with 25 mg of $PGF_{2"}$ (Lutalyse®), followed by a second injection of Fertagyl and one fixed time insemination at 48 h after Lutalyse (Cosynch); or 2) 95 cows were treated with the Cosynch protocol plus they received one intravaginal progesterone insert (IPI; CIDR-B, InterAg, Hamilton, NZ). The insert contained 1.9 g of progesterone and was in place during the 7

[1]We acknowledge the assistance of student workers at the KSU Purebred Beef Unit.

days between the first injection of GnRH and the injection of $PGF_{2\alpha}$ (Cosynch + IPI).

Days postpartum at the fixed-time insemination averaged 73 days (31 to 110 days). Blood samples were collected 10 days before the first GnRH injection and prior to each hormonal injection, for later determination of progesterone by radioimmunoassay. Pregnancy was diagnosed by transrectal ultrasound 35 days after the fixed-time insemination.

## Results and Discussion

Blood progesterone concentrations revealed that over 77% of these cows were cycling at the beginning of the 1998 breeding season. This rate is much greater than we have observed in previous yearly studies since 1994, where approximately 50% of the cows were cycling at the beginning of the breeding season. The rate of cyclicity in the Herefords (78%) was slightly (but not significantly) greater than that of the Angus (70%) and Simmental (66%) cows.

Because all cows that were treated also were inseminated (no heat detection), conception rates and pregnancy rates were synonymous. Summarized in Table 1 is the effect of treatments on pregnancy rates in the 2-year-old and mature cows. In both age groups, the progesterone insert tended (P=.12) to increase pregnancy rates by 26%.

However, the increase in pregnancy rate was different among the three breeds (Table 2). In the Hereford and Simmental cows, the progesterone insert increased (P=.06) pregnancy rates, whereas in the Angus cows, pregnancy rates were not different. Because the rates of cyclicity among breeds were nearly identical, there is no simple explanation for the differing pregnancy rates. Nevertheless, pregnancy rates exceeded 50% in both treatments without any heat detection, and cows were handled only three times to achieve a 100% AI submission rate. We plan
further replication of this work in 1999.

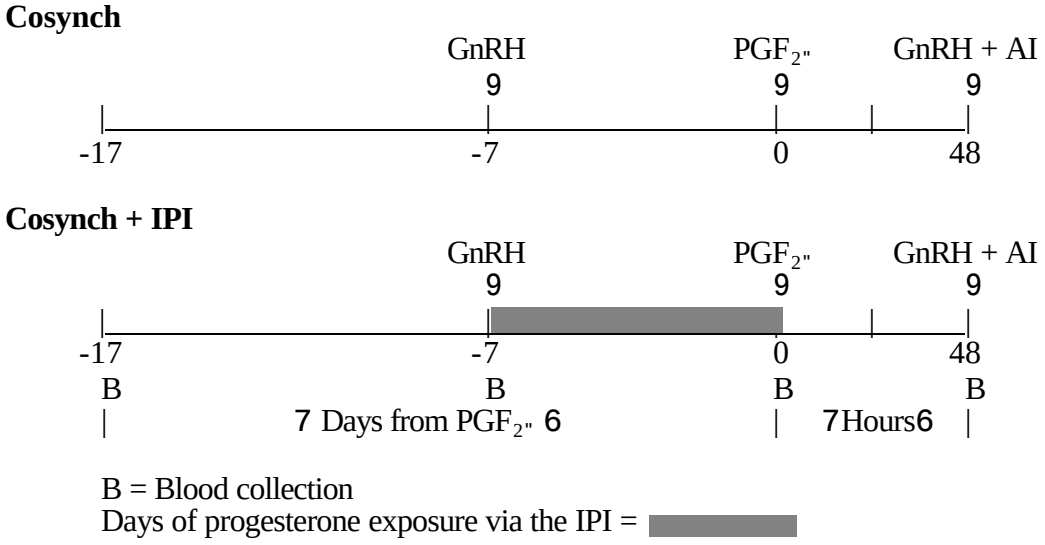



**Figure 1. Experimental Protocol Used to Synchronize Ovulation in Suckled Beef Cows.**

**Table 1. Pregnancy Rate of Suckled Beef Cows after Cosynch or Cosynch + Progesterone: Parity Effects**

| | Treatment[1] | |
|---|---|---|
| Parity | Cosynch | Cosynch + IPI |
| | ---------- % (no.) ---------- | |
| 1 | 43.5 (28) | 67.0 (29) |
| 2+ | 58.3 (64) | 67.8 (66) |
| 3 | 53.2 (92) | 67.4 (95) |

[1]Treatment effect (P =.12).

**Table 2. Pregnancy Rate of Suckled Beef Cows after Cosynch or Cosynch + Progesterone: Breed Effects**

| | Treatment[1] | |
|---|---|---|
| Breed | Cosynch | Cosynch + IPI |
| | ---------- % (no.) ---------- | |
| Angus | 65.1 (51) | 58.5 (53) |
| Hereford | 44.8 (23) | 75.4 (24) |
| Simmental | 49.7 (18) | 68.4 (18) |

[1]Treatment × breed interaction (P=.06).

# SYNCHRONIZING ESTRUS IN REPLACEMENT BEEF HEIFERS USING SELECT SYNCH, MGA, AND $PGF_{2\alpha}$ [1]

***J. S. Stevenson, G. C. Lamb, J. A. Cartmill, B. A. Hensley, S. El-Zarkouny, J. S. Heldt, and T. J. Marple***

## Summary

The Select Synch protocol (GnRH at day -7, $PGF_{2\alpha}$ at day 0, AI at detected heat) was compared to protocols using either MGA + prostaglandin (Colorado system) or two injections of prostaglandin to synchronize estrus in replacement heifers at three locations. Percentage of heifers detected in heat before, during, or after the target breeding week was not different among treatments but varied in percentages among locations. Overall conception rates ranged from 64 to 69%. Pregnancy rates varied from 46 to 56% and tended to be greatest in the MGA + $PGF_{2\alpha}$ treatment. Costs of these treatments ranged from $3.50 to $8 and were lowest for the MGA + $PGF_{2\alpha}$ protocol.

(Key Words: Heifers, Estrus-Synchronization, GnRH, $PGF_{2\alpha}$, AI.)

## Introduction

Replacement heifers are often fed in dry lots, making them more easily accessible for feeding, handling, and AI breeding. Unfortunately, only 8 to 10% of all replacement heifers are inseminated artificially. Use of Select Synch (a $PGF_{2\alpha}$ injection is preceded 7 days earlier by an injection of GnRH) has increased in cow herds because of its relative ease of administration and short duration of treatment (7 days).

The traditional MGA + $PGF_{2\alpha}$ system for heifers starts 31 days before the beginning of the breeding season. Even the two-injection $PGF_{2\alpha}$ protocol (given 11 to 14 days apart) is shorter than the MGA + $PGF_{2\alpha}$ protocol. Our objective was to determine if the Select Synch protocol would equal MGA + $PGF_{2\alpha}$ or two $PGF_{2\alpha}$ injections for inducing a fertile estrus during the first week of the breeding season (target breeding week).

## Experimental Procedures

Replacement beef heifers at three locations (Hereford × Angus Cow-Calf Unit heifers, Manhattan; Hereford, Angus, and Simmental Purebred Unit heifers, Manhattan; and Hereford × Angus heifers, Agra) were assigned to each of three treatments illustrated in Figure 1: 1) two $PGF_{2\alpha}$ injections (25 mg of Lutalyse®) given 14 days apart (2×$PGF_{2\alpha}$); 2) MGA (0.5 mg per head per day for 14 days) + $PGF_{2\alpha}$ 17 days later (MGA+$PGF_{2\alpha}$); or 3) 100 µg of GnRH (Fertagyl®) followed in 7 days by 25 mg of Lutalyse® (GnRH+$PGF_{2\alpha}$ or Select Synch). Heifers were observed for estrus beginning 5 days before the second or only $PGF_{2\alpha}$ injection and continuing for various durations thereafter.

Blood samples were collected from all Manhattan heifers on days -41, -31 -7, and 0 for determination of progesterone by radioimmunoassay. Heifers were observed for estrus at least twice daily and were inseminated 10 to 14 hours after first detected estrus according to the AM-PM rule. Pregnancy was diagnosed by transrectal ultrasonography

[1]We acknowledge the cooperation and participation of the Losey Bros., Agra, KS, in this study. We also thank Gary Ritter, Wayne Adolph, and students workers at the Cow-Calf and Purebred Units for their assistance.

between 33 and 37 days after insemination.

## Results and Discussion

Occurrence of estrus before, during, and after the target breeding week is summarized in Table 1. In the Agra herd, the MGA + $PGF_{2\alpha}$ treatment had the smallest percentage of heifers in heat during 5 days before the beginning of the breeding season (day 0), whereas in the Manhattan heifers, the smallest percentage of heats during that period was in the Select Synch treatment followed in order by the 2×$PGF_{2\alpha}$ and MGA+$PGF_{2\alpha}$.

Irrespective of treatment, over 72% of the heifers were detected in heat during the target breeding week (days 0 to 7), with the MGA+$PGF_{2\alpha}$ treatment having the greatest percentage of heifers in heat. This also was true in the Agra herd, but in the two groups of Manhattan heifers, either 2×$PGF_{2\alpha}$ or Select Synch induced the greatest percentage of heifers in heat. A similar percentage (about 8%) of heifers in any treatment was first detected in heat at more than 7 days or not at all (4 to 8%).

Conception rates (number of heifers pregnant/number of heifers inseminated) were similar among treatments, varying from 64 to 69%. In one location, conception rates were highest after the Select Synch protocol, whereas at the other two locations, conception rates were highest after the 2×$PGF_{2\alpha}$ protocol. Likewise, pregnancy rates (number of heifers pregnant/number of heifers treated) were not different but tended to be greater in the MGA+$PGF_{2\alpha}$ treatment. In the two Manhattan locations, pregnancy rates were lowest in the MGA+$PGF_{2\alpha}$ treatment, whereas the reverse was true at Agra.

The advantage of Select Synch is its shorter duration of administration (7 days) compared to the 2×$PGF_{2\alpha}$ (14 days) or MGA+$PGF_{2\alpha}$ (31 days). Neither conception nor pregnancy rates were significantly reduced by the two shorter duration treatments, although the best overall performance occurred with MGA+$PGF_{2\alpha}$. Treatment costs per head [Select Synch ($6-8); 2×$PGF_{2\alpha}$ ($6) or MGA+$PGF_{2\alpha}$ ($3.50)] were not too different. Work in dairy cattle has shown that 50 µg GnRH (as Cystorelin) works as well as the full (100 µg) dose. If that holds true in beef cattle, the cost of Select Sync could be reduced by using only half as much GnRH (we used Fertagyl).

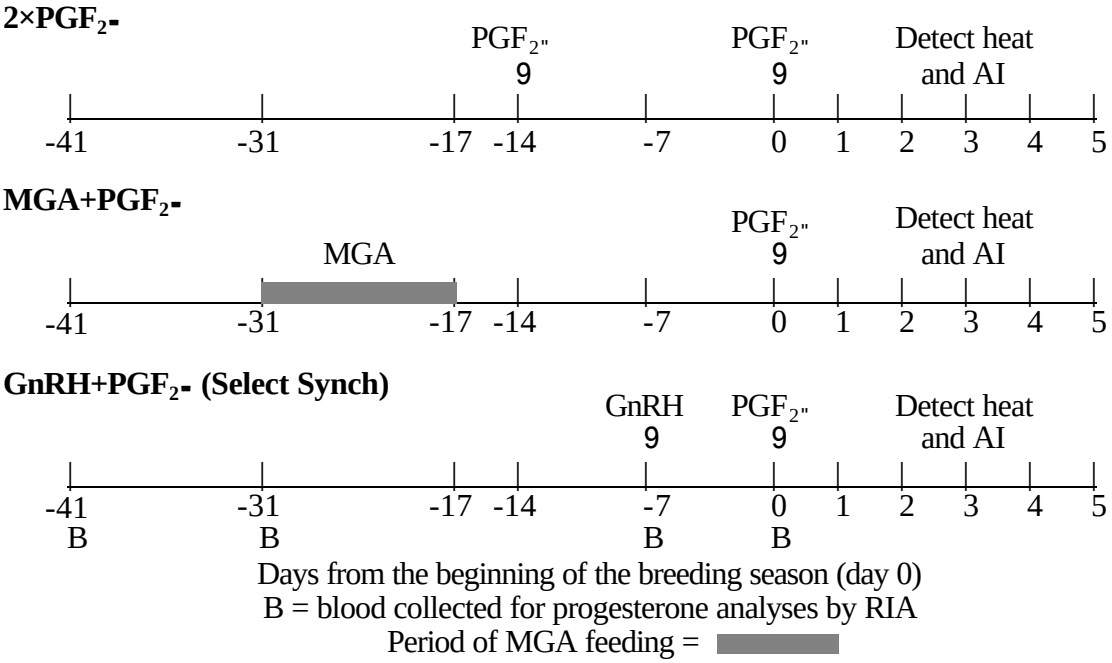



**Figure 1. Experimental Protocol Used to Synchronize Estrus in Replacement Heifers.**

**Table 1. Occurrence of Estrus before, during, and after the Target Breeding Week (days 0 to 7; day 0 = $PGF_{2\alpha}$)**

| | Treatment[1] | | |
|---|---|---|---|
| Item | 2×$PGF_{2\alpha}$ | MGA+$PGF_{2\alpha}$ | Select Synch |
| No. of heifers | 139 | 289 | 160 |
| | ---------- % (no.) ---------- | | |
| Before: days -5 to -1 | 8.6 ( 12) | 5.9 ( 17) | 12.5 ( 20) |
| During: days 0 to 7 | 74.8 (104) | 82.0 (237) | 72.5 (116) |
| (Average days to estrus) | (3.0 ± .1) | (3.2 ± .1) | (2.3 ± .1[x]) |
| After: >day 7 | 8.6 ( 12) | 8.3 ( 24) | 8.7 ( 14) |
| No estrus | 7.9 ( 11) | 3.8 ( 11) | 6.2 ( 10) |

[1]Treatment (P<.001) and treatment × location interactions (P<.001).
[X]Different ( P<.001) from other treatments.

**Table 2. Rates of Estrus, Conception, and Pregnancy for Heifers Detected during the Target Breeding Week (days 0 to 7; day 0 = $PGF_{2\alpha}$)**

| | Treatment[1] | | |
|---|---|---|---|
| Item | 2×$PGF_{2\alpha}$ | MGA+$PGF_{2\alpha}$ | Select Synch |
| No. of heifers | 139 | 289 | 160 |
| Estrus detection[2], % | 74.8 | 82.0 | 72.5 |
| Conception rate[3], % | 69.2 | 68.2 | 63.8 |
| Pregnancy rate[4], % | 51.8 | 56.0 | 46.2 |

[1]Models included treatment, location, and all two-way interactions.
[2]Treatment × location (P<.01).
[3]Treatment × location (P<.05).
[4]Treatment × location (P=.07).

# GENETIC ASSOCIATIONS OF GROWTH AND LACTATION CURVE COMPONENTS IN POLLED HEREFORD CATTLE

***J. B. Glaze, Jr.[1] and R. R. Schalles***


## Summary

Weight and milk production records of Polled Hereford cows born from 1967 to 1979 were used to fit growth and lactation curves. A multiple-trait, derivative-free, restricted maximum likelihood (MTDFREML) procedure, utilizing a full animal model, was used to estimate variances and covariances for the components of the growth and lactation curves. For the growth curve,

$$W=A+B(1-e^{-kt})$$

components A, B, and k each had moderate to high heritabilities ranging from .35 to .72. The genetic correlation between growth curve components A and B was positive (.42), whereas the genetic correlations between A and K (-.34) and between B and K (-.74) were negative. In the lactation curve,

$$Yn=n/(ae^{km})$$

heritabilities of components k and a were .15 and .40, respectively. The genetic correlation between these lactation curve components was -.78.


(Key Words: Growth Curve, Lactation Curve, Heritability, Genetic Correlation, Polled Hereford.)

## Introduction

Growth improvement is an emphasis of most breeding programs. Mathematical components of growth curves provide a means to evaluate various aspects of animal growth. Milk production has a major influence on calf weaning weights. The ability to predict milk production can be useful in improving calf weaning weight and matching cows to various environments. Total milk production per lactation can be predicted by inputting daily milk records into lactation curves. The purpose of this study was to estimate the heritabilities and genetic correlations of growth curve and lactation curve components.

## Experimental Procedures

Beginning in 1967, a study was initiated to examine the effects of selection for improved feed conversion. At the start of the 1971 breeding season, cows were assigned randomly to either the selection or control herd. Lifetime records (monthly weights and heights) were recorded on females born in both herds. Cows that attained the age of 10 years while in the herds and had complete monthly weight and height records from ages 5 to 10 were used to estimate mature weight and mature height. Average weight and average height over the 5-year period were considered to be mature weight and mature height. Monthly cow weights were used to fit a growth curve. The three parameter function,

$$W_t = A + B(1 - e^{-kt}),$$

where $W_t$ = weight at time t, A = weight at time zero, B = gain from time zero to infinity, e = base of natural logarithms, k = function of the rate of growth, and t = time, pro-

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vided a means to describe the growth and development of the cattle in this study.

During the final 3 years of the study, 205-day milk production was measured on a number of the cows. Twenty-four hour milk yields were estimated once each month, from April through August, using the weigh-suckle-weigh technique. This provided measures of milk production for each cow in each year. Data for each cow were used to fit the lactation curve

$$Y_n = n/(ae^{kn}),$$

where $Y_n$ = 24 hour milk yield in the $n^{th}$ week of lactation, e = base of natural logarithms, and a and k = parameters that define the shape of the curve.

A multiple-trait, derivative-free, restricted maximum likelihood (MTDFREML) procedure was used to analyze the data generated in this study. A full animal model was used to calculate the genetic and phenotypic (co)variances. Age of cow was the only fixed effect included in the model during the analyses of maximum height and maximum weight. Year of milking and age at milking were the fixed effects used during the analyses of milk production.

## Results and Discussion

The heritabilities ($h^2$) and genetic correlations ($r_g$) for the growth curve and lactation curve components are presented in Table 1. The heritabilities of the lactation curve components k and a were found to be .15 and .40, respectively. The genetic correlation between these lactation curve components was -.78.

Reported heritabilities of growth curve components are generally moderate to high. In this study, growth curve components A, B, and k had heritabilities of .35, .72, and .46, respectively. These heritabilities suggest that selection for weight, gain, and rate of maturity can be effective. The genetic correlation between growth curve components A and B ($r_g$ = .42) was positive, which is similar to reported genetic correlations between birth weight and mature weight. The genetic correlations between growth curve parameters A and k ($r_g$ = -.34) and B and k ($r_g$ = -.74) were negative. The negative association between B and k suggest that animals maturing fastest weigh less at maturity.

**Table 1. Heritabilities and Genetic Correlations of Growth[a] and Lactation[b] Curve Components[c]**

| Traits[d] | GCVA | GCVB | GCVk | MLKk | MLKa |
|---|---|---|---|---|---|
| GCVA | **.35** | | | | |
| GCVB | .42 | **.72** | | | |
| GCVk | -.34 | -.74 | **.46** | | |
| MLKk | n/a | n/a | n/a | **.15** | |
| MLKa | n/a | n/a | n/a | -.78 | **.40** |

[a]Growth curve: $W_t = A + B(1 - e^{-kt})$, where $W_t$ = weight at time t, A = weight at time zero, B = gain from time zero to infinity, e = base of natural logarithms, k = function of rate of growth, and t = time.
[b]Lactation curve: $Y_n = n/(ae^{kn})$, $Y_n$ = the 24-hour milk yield in the $n^{th}$ week, e = base of natural logarithms, and a and k = parameters that define the shape of the curve.
[c]Heritabilities (bold, underlined) lie on the diagonal; Genetic correlations lie below the diagonal.
[d]GCVA = growth curve component "A"; GCVB = growth curve component "B"; GCVk = growth curve component "k"; MLKk = lactation curve component "k"; MLKa = lactation curve component "a".

# ESTIMATES OF HERITABILITIES AND GENETIC CORRELATIONS IN POLLED HEREFORD CATTLE SELECTED FOR FEED CONVERSION

*J. B. Glaze, Jr.[1] and R. R. Schalles*

## Summary

Performance records of 1459 Polled Hereford cattle were analyzed to estimate heritabilities and genetic correlations of beef cattle traits from birth to maturity. Estimates of heritability ($h^2$) for birth weight (BWT), weaning weight (WWT), yearling weight (YWT), scrotal circumference (SC), yearling height (YHT), mature height (MHT), and mature weight (MWT) were moderate to high, with the exception of WWT ($h^2$ = .14), and ranged from .38 to .72. The traits associated with feed conversion, daily feed intake (INT), average daily gain (ADG), and feed conversion (CONV) had heritabilities of .24, .25, and .14, respectively. Genetic correlations ($r_g$) between the growth traits (BWT, WWT, YWT, YHT, MHT, MWT, and SC) were positive and ranged from .20 to .88. The $r_g$=.99 between milk production (MILK) and maternal weaning weight (MWW) indicates that the traits are essentially the same and supports the method in which many breed associations calculate and report expected progeny differences (EPDs) for milk production. The $r_g$ = .42 between ADG and INT, $r_g$ = .27 between INT and CONV, and the $r_g$ = -.82 between ADG and CONV suggest that faster gaining cattle have greater feed intakes and are more efficient.

(Key Words: Selection, Feed Conversion, Growth Traits, Heritability, Genetic Correlation, Polled Hereford.)

## Introduction

Feed costs represent a significant economic input to beef producers. To attain greater efficiency in production systems, beef producers should consider including feed conversion in selection programs. Reported heritabilities suggest that selection for more efficient cattle can be effective. However, one of the major stumbling blocks in selecting feed for conversion is the difficulty with which it is measured. It requires measurement of individual animal feed intakes and weight gains, a process that is expensive and not feasible for most beef producers. Therefore, beef producers need to identify traits that have favorable genetic associations with feed conversion, are easily and cost effectively measured, and can be incorporated readily into a selection program. Our purpose was to estimate the heritabilities and genetic correlations of beef cattle traits from birth to maturity and provide producers with an indirect means for improving feed conversion.

## Experimental Procedures

The data set examined in this study contained the performance records of 1459 Polled Hereford cattle born from the spring of 1967 through the spring of 1979. These data were the result of a project conducted at Kansas State University in which animals were selected on the basis of improved feed conversion. This herd was assembled in 1967 using animals donated by breeders from several states. The original animals (42 females and 5 males) represented 34 herds

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from Colorado, Illinois, Kansas, Missouri, Oklahoma, and Pennsylvania. From 1967 to 1971, animals in the herd were mated randomly to increase the size of the herd and to provide a foundation herd from which the selection and control herds would be established. Beginning with the 1971 breeding season, cows were assigned randomly to either the selection or control herds. Once these herds were established, they were closed, and no other genetic material was introduced. Each year in the selection herd, the two bulls exhibiting the best feed conversion (feed/gain) were selected as herd sires and used for 2 consecutive years. In the control herd, the first bull born to the oldest herd sire was selected to replace his sire. These bulls were used in the control herd for approximately 6 years.

Cows in both the selection and control herds were maintained on native Kansas tallgrass prairie throughout the year and were supplemented in the winter. Cows were bred to calve in March and April. Breeding was primarily by natural service during a 60 to 70 day breeding season. Progeny were weaned in the fall at approximately 200 days of age. Following a 3 to 4 week weaning period, bull calves were placed on an individual 140-day postweaning performance test, which allowed for the selection for feed conversion. The ration consisted of 25% prairie hay, 15% dehydrated alfalfa, 43% corn, 12.5% soybean meal, 4% molasses, and .5% salt. Heifers were group fed and not selected on the basis of improved feed conversion. In both the selection and control herds, cows were culled if they: (1) were not pregnant at the end of the breeding season, (2) had severe structural problems, or (3) were horned. Birth weight (BWT), weaning weight (WWT), yearling weight (YWT), yearling height (YHT), daily feed intake (INT), average daily gain (ADG), feed conversion (CONV), scrotal circumference (SC), scanned ribeye area (REA), scanned backfat thickness (FAT), mature height (MHT), mature weight (MWT), and milk production (MILK) records were available for analysis. The number of observations, means, and standard deviations are presented in Table 1.

A multiple-trait, derivative-free, restricted maximum likelihood procedure (MTDFREML) was used to analyze the data generated in this study. A full animal model was used to calculate the genetic and phenotypic (co)variances. The fixed effects used in the model included age of dam (2, 3, 4, 5-10, and >10 years) and contemporary group (sex and year of birth). For the analyses of MHT and MWT, age of cow was the only fixed effect included in the model. Year of milking and age at milking were the fixed effects used in the analyses of milk production. Ages at which various measurements were recorded were used as covariates for the respective trait. Average weight maintained over the 140-day test period was used as a covariate in the analyses of INT and CONV. Maternal and permanent environmental effects were included as random effects in the analyses of BWT and WWT.

## Results and Discussion

Heritabilities ($h^2$) provide an indication of the amount of genetic change that can be made through selection. The heritabilities that were estimated for the traits in this study generally would be considerate moderate to high (Table 2). The traits associated with weight, BWT, WWT, YWT, and MWT, had heritabilities of .38, .14, .39, and .47, respectively; generally within the range of reported estimates. The maternal heritabilities for BWT and WWT were .14 and .18, respectively. Traits related to structure usually have high heritabilities. The same held true for our study. Yearling height had a heritability of .52, and MHT had a heritability of .72. In this study, the traits associated with feed conversion (feed/gain) included ADG, INT, and CONV, which had heritabilities of .25, .24, and .14, respectively. Ultrasound technology allows for the measurement of various beef cattle traits without slaughter. Scanned backfat thickness ($h^2$ = .25) and REA ($h^2$ = .19) were moderately heritable. Scrotal circumference was found to be highly heritable, with an estimate of .48. The heritability estimate for MILK in this study was .19.

Genetic correlations ($r_g$) measure the strength of the relationship between the breeding values of two traits. They provide an estimate of how traits will react in a selection program. The genetic correlations estimated for the traits in this study are presented in Table 2. The genetic correlations between growth traits (BWT, WWT, YWT, MWT, YHT, and MHT) were found to be strong and positive, ranging from .33 to .88. The strength of these correlations was expected, because many of the same genes are involved in the expression of the growth traits and also because of the part-whole relationship that many of the traits share. The genetic correlations between traits associated with feed conversion (INT, ADG and CONV) and other traits in the study were of various magnitudes and signs. The $r_g$ = .42 between ADG and INT, $r_g$ = .27 between INT and CONV, and the $r_g$ = -.82 between ADG and CONV suggest that faster gaining cattle have greater feed intakes and are more efficient. Average daily gain on test had negative associations with BWT ($r_g$ = -.01) and WWT ($r_g$ = -.22) and positive associations with YWT ($r_g$ = .49) and MWT ($r_g$=.72). This indicates that animals with poor preweaning performance had greater average daily gains during the postweaning test period. Animals with greater postweaning gains were heavier when yearling and mature weights were measured. Larger framed animals had greater postweaning average daily gains, as evidenced by the genetic associations between ADG and YHT ($r_g$=.65) and between ADG and MHT ($r_g$=.97). Negative genetic correlations were found between INT and BWT ($r_g$ = -.35) and between INT and WWT ($r_g$ = -.61), suggesting that animals with poor preweaning performance had greater feed intakes during the postweaning performance test period. The positive genetic association between INT and YWT ($r_g$ = .59) indicates that those animals with greater feed intakes during the post-weaning period had heavier weights at the end of the test. The genetic associations between SC and many of the growth traits (BWT, WWT, YWT, YHT, and ADG) were positive. Scrotal circumference had a positive association ($r_g$ = .25) with MHT and a negative ($r_g$ = -.11) association with MWT. This suggests that animals with larger scrotal circumferences reached maturity sooner and had lighter mature weights. The genetic correlations between REA and other growth traits (BWT, WWT, YWT, YHT, ADG, and SC) ranged from .18 to .70. These correlations suggest that faster growing cattle have the propensity to have larger REA. The genetic association between MILK and maternal WWT was found to be very strong ($r_g$ = .99). This suggests that these traits are essentially the same. Milk expected progeny differences (EPDs), published by many breed associations, are calculated as maternal weaning weight. The strong correlation between MILK and MWW lends support for this method of estimating an animal's genotype for milk production.

**Table 1. Summary of Traits Analyzed**

| Traits[a] | N | Mean | SD | Minimum | Maximum |
|---|---|---|---|---|---|
| BWT (lb) | 1369 | 73.24 | 9.63 | 36.99 | 99.01 |
| WWT (lb) | 1284 | 383.80 | 68.23 | 150.00 | 590.00 |
| YWT (lb) | 1045 | 715.07 | 145.42 | 325.01 | 1047.99 |
| YHT (in) | 774 | 41.43 | 1.97 | 31.00 | 49.00 |
| INT (lb) | 486 | 16.67 | 2.36 | 9.11 | 24.29 |
| ADG (lb) | 534 | 2.80 | .42 | .68 | 3.77 |
| CONV (lb) | 486 | 5.93 | .82 | 3.95 | 13.40 |
| SC (cm) | 259 | 32.57 | 2.62 | 25.90 | 41.00 |
| REA ($in^2$) | 806 | 8.56 | 1.94 | 4.50 | 14.38 |
| FAT (in) | 806 | .20 | .10 | .01 | .76 |
| MHT (in) | 136 | 46.86 | 1.77 | 42.22 | 51.67 |
| MWT (lb) | 156 | 1025.22 | 107.06 | 757.00 | 1350.00 |
| MILK (lb) | 115 | 2498.63 | 859.94 | 964.46 | 8641.46 |

[a]BWT = birth weight; WWT = weaning weight; YWT = yearling weight; YHT = yearling height; INT = daily feed intake; ADG = average daily gain; CONV = feed/gain; SC = scrotal circumference; REA = scanned ribeye area; FAT = scanned backfat thickness; MHT = mature height; MWT = mature weight; MILK = 205-day milk production.

**Table 2. Heritabilities and Genetic Correlations of Traits Analyzed[a]**

| Traits[b] | BWT | MBW | WWT | MWW | YWT | YHT | INT | ADG | CONV | SC | REA | FAT | MHT | MW | MILK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BWT | **.38** | | | | | | | | | | | | | | |
| MBW | -.35 | **.14** | | | | | | | | | | | | | |
| WWT | .69 | .36 | **.14** | | | | | | | | | | | | |
| MW | -.39 | .73 | -.10 | **.18** | | | | | | | | | | | |
| YWT | .33 | .83 | .70 | .89 | **.39** | | | | | | | | | | |
| YHT | .44 | .39 | .60 | .51 | .68 | **.52** | | | | | | | | | |
| INT | -.35 | -.03 | -.61 | -.60 | .59 | .05 | **.24** | | | | | | | | |
| ADG | -.01 | .88 | -.22 | .58 | .49 | .65 | .42 | **.25** | | | | | | | |
| CONV | .08 | -.95 | .53 | .46 | -.73 | -.40 | .27 | -.82 | **.14** | | | | | | |
| SC | .35 | .20 | .49 | .53 | .32 | .40 | -.25 | .01 | .06 | **.48** | | | | | |
| REA | .55 | .48 | .41 | .75 | .70 | .35 | -.02 | .18 | .24 | .18 | **.19** | | | | |
| FAT | .70 | .26 | .01 | .64 | .37 | .15 | -.02 | -.06 | .37 | .48 | .30 | **.25** | | | |
| MHT | .58 | .40 | .69 | .51 | .79 | 1.0 | .12 | .97 | .64 | .25 | .82 | .02 | **.72** | | |
| MWT | .47 | .61 | .67 | .18 | .69 | .73 | -.36 | .72 | -.95 | -.11 | .73 | -.47 | .88 | **.47** | |
| MILK | .38 | -.57 | .01 | .99 | .45 | .16 | -1.0 | -.27 | -.46 | .15 | .31 | .43 | -.15 | -.16 | **.19** |

[a]Heritabilities (bold, underlined) lie on the diagonal; Genetic correlations lie below the diagonal.
[b]BWT = birth weight; MBW = maternal birth weight; WWT = weaning weight; MWW = maternal weaning weight; YWT = yearling weight; YHT = yearling height; INT = daily feed intake; ADG = average daily gain; CONV = feed/gain; SC = scrotal circumference; REA = scanned ribeye area; FAT = scanned backfat thickness; MHT = mature height; MWT = mature weight; MILK = milk production.

# SELECTION RESPONSE FOR FEED CONVERSION AND GROWTH TRAITS IN POLLED HEREFORD CATTLE

*J. B. Glaze, Jr.*[1] *and R. R. Schalles*

## Summary

Direct and correlated responses to selection for improved feed conversion were estimated from performance records of 1459 Polled Hereford cattle born from the spring of 1967 through the spring of 1979. Data were analyzed using a multiple-trait, derivative-free, restricted maximum likelihood (MTDFREML) procedure. A full animal model was used to calculate genetic and phenotypic (co)variances. The within-herd breeding values that resulted from the solution of the mixed model equations were regressed on year to create selection response curves. Feed conversion was shown to respond favorably to direct selection, with feed/gain changing -.005 per year.

(Key Words: Selection, Response, Feed Conversion, Polled Hereford.)

## Introduction

In beef cattle production, growth rates and the animal's ability to efficiently convert feed into body weight are economically important traits. Improvements in feed conversion can lead to greater efficiencies in overall production systems. Even though beef producers traditionally have placed emphasis on improving growth traits, many are unaware of the relationships between feed conversion and growth traits, as well as how these traits respond in selection programs. Our purposes were to estimate the direct and correlated responses to selection for improved feed conversion and to provide basic information that can be included in selection programs.

## Experimental Procedures

Performance data were collected on 1459 Polled Hereford cattle that were born from the spring of 1967 through the spring of 1979. These data were the result of a project conducted at Kansas State University in which animals were selected on the basis of improved feed conversion. Beginning with the 1971 breeding season, cows were assigned randomly to either a selection or control herd. Once these herds were established, they were closed, and no other genetic material was introduced. Each year in the selection herd, the two bulls exhibiting the best feed conversion (feed/gain) were selected as herd sires and used for 2 consecutive years. In the control herd, the first bull born to the oldest herd sire was selected to replace his sire. These bulls were used in the control herd for approximately 6 years.

Cows representing the selection and control herds were maintained on native pasture throughout the year and were supplemented in the winter. Cows were bred to calve in March and April, with progeny being weaned in the fall at approximately 200 days of age. Following a 3- to 4-week weaning period, bull calves were placed on an individual 140-day postweaning performance test, which allowed for the selection for feed conversion. Heifers were group fed and not selected on the basis of improved feed conversion. In both the selection and control herds, cows were culled if they: (1)

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were not pregnant at the end of the breeding season, (2) had severe structural problems, or (3) were horned. Birth weight (BWT), weaning weight (WWT), yearling weight (YWT), yearling height (YHT), daily feed intake (INT), average daily gain (ADG), feed conversion (CONV), mature height (MHT), and mature weight (MWT) records were available for analysis.

A multiple-trait, derivative-free, restricted maximum likelihood (MTDFREML) procedure was used to analyze the data. A full animal model was used to calculate the genetic and phenotypic (co)variances. The fixed effects used in the model included age of dam (2, 3, 4, 5-10, and >10 years) and contemporary group (sex and year of birth). For the analyses of MHT and MWT, age of cow was the only fixed effect included in the model. Ages at which various measurements were recorded were used as covariates for the respective trait. Average weight maintained over the 140-day test period was used as a covariate in the analyses of INT and CONV. Maternal and permanent environmental effects were included as random effects in the analyses of BWT and WWT. The breeding values that resulted from the solution of the mixed model equations were used in a regression analysis to estimate the amount of change that resulted in each trait from selection for improved feed conversion. Breeding values were used to estimate the amount of direct selection response for CONV and the correlated selection responses for all other traits. Direct and correlated responses were estimated by regressing each trait's selection herd breeding values on year.

## Results and Discussion

The within-herd time trend figures (response curves) are presented in Figures 1 - 9. In many of the response curves, pronounced changes in the selection herd can be seen between the years of 1973 and 1974. This was due to the fact that beginning in 1974, female offspring of selection herd sires began calving, which resulted in greater selection intensities. Because of selection for improved feed conversion (feed/gain), feed conversion (Figure 1) in this study changed by -.005 units per year. Although the sign may seem unfavorable, it in fact suggests that selection for improved feed conversion (feed/gain) has resulted in less feed being required per unit of gain.

As a result of the selection for improved feed conversion, the preweaning traits BWT (Figure 2) and WWT (Figure 3) decreased from 1974 until the end of the study. Yearling weight (Figure 4) and YHT (Figure 5) increased throughout the study. The increase in YWT was due to the increased ADG exhibited during the postweaning period. Both traits relating to mature size, MHT (Figure 6) and MWT (Figure 7), increased in response to selection for improved feed conversion. The increase in these traits was expected as a result of the genetic correlations between MHT and MWT ($r_g$ = .88) and between MWT and CONV ($r_g$ = -.95).

The response curve for INT (Figure 8) shows that the trait was somewhat variable but increased from beginning to end. As cattle on the postweaning test ate more, they in turn gained more, as shown in the response curve for ADG (Figure 9). This is consistent with the $r_g$ = .42 between INT and ADG. Selection for improved feed conversion (feed/gain) was successful, as shown in the response curve for CONV (Figure 1). The response curves for ADG (Figure 9) and CONV (Figure 1) show that faster gaining cattle are more efficient in their ability to convert feed into weight gain, which is consistent with the $r_g$ = -.82 between ADG and CONV. For a complete presentation of the heritabilities ($h^2$) and genetic correlations ($r_g$) for these traits, see the preceding paper by Glaze and Schalles.

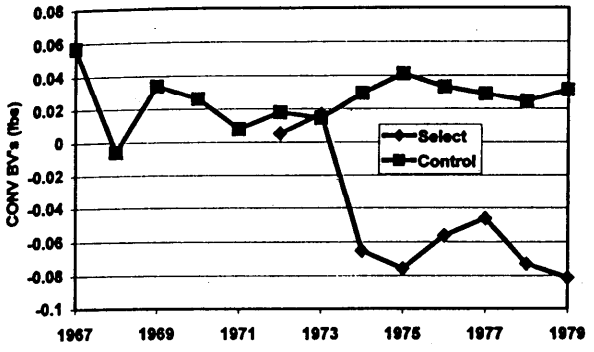


**Figure 1. Within-Herd Time Trend of Feed Conversion (CONV) Breeding Values.**

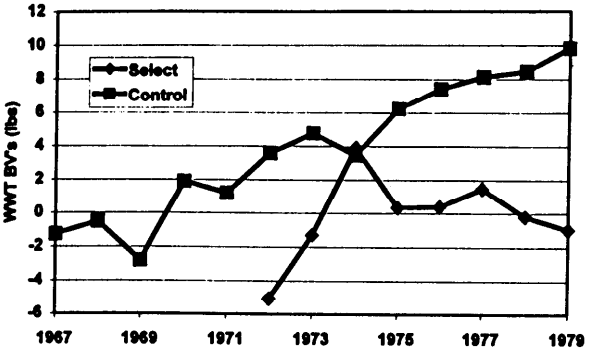


**Figure 3. Within-Herd Time Trend of Weaning Weight (WWT) Breeding Values.**

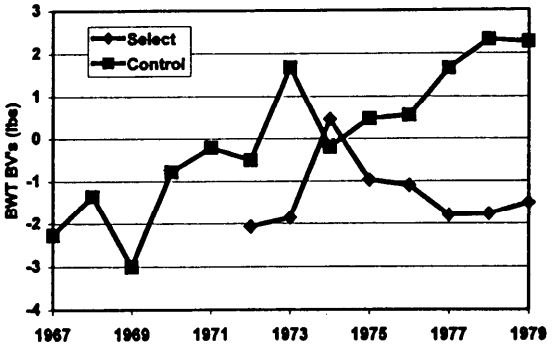


**Figure 2. Within-Herd Time Trend of Birth Weight (BWT) Breeding Values.**

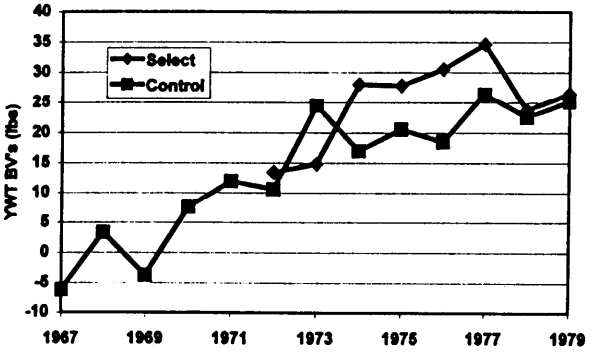


**Figure 4. Within-Herd Time Trend of Yearling Weight (YWT) Breeding Values.**

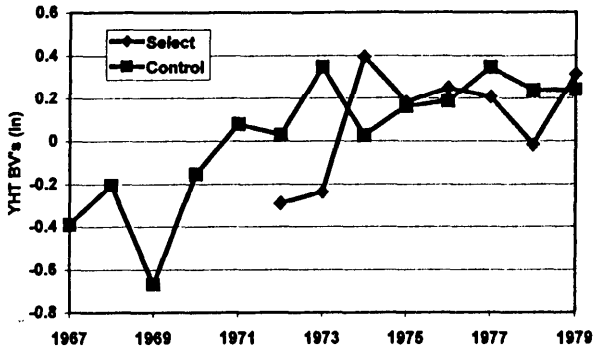


**Figure 5. Within-Herd Time Trend of Yearling Height (YHT) Breeding Values.**

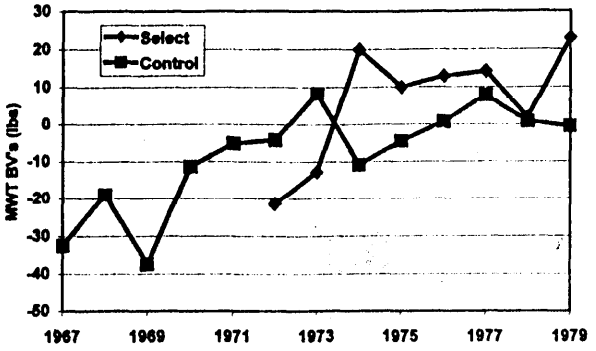


**Figure 7. Within-Herd Time Trend of Mature Weight (MWT) Breeding Values.**

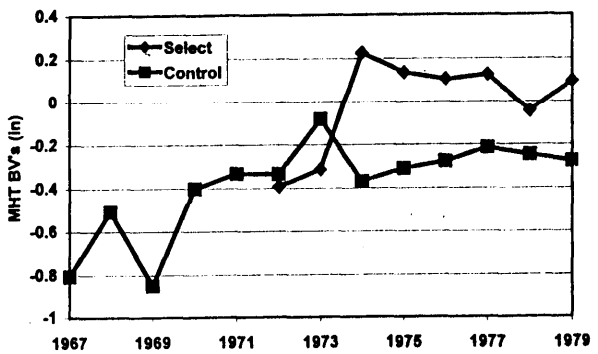


**Figure 6. Within-Herd Time Trend of Mature Height (MHT) Breeding Values.**

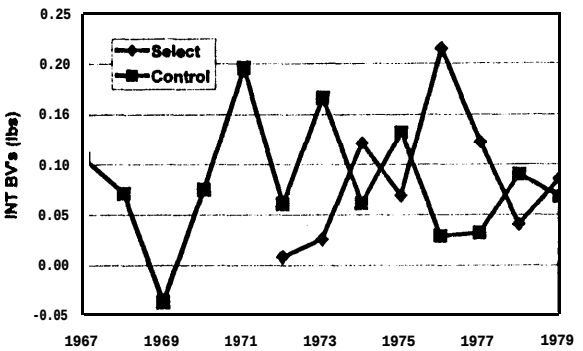


**Figure 8. Within-Herd Time Trend of Daily Feed Intake (INT) Breeding Values.**

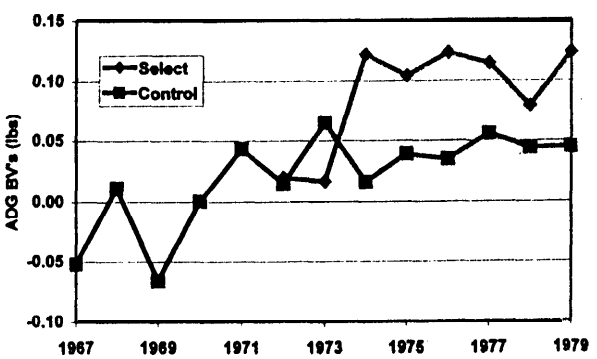


**Figure 9. Within-Herd Time Trend of Average Daily Gain (ADG) Breeding Values.**

# COMPARATIVE VALUE OF DRY-ROLLED CORN, DISTILLER'S DRIED GRAINS, AND WHEAT MIDDLINGS FOR RECEIVING DIETS

*J. S. Drouillard, S. E. Ives, D. W. Anderson, and R. H. Wessels*

## Summary

Two 28-day receiving experiments were conducted using 620 exotic × British cross steers to evaluate differences in growth performance, morbidity, and mortality when fed diets containing dry-rolled corn, distiller's dried grains with solubles, or wheat middlings. All diets contained approximately 60% concentrate and 40% roughage (alfalfa hay). Gain and efficiency tended to be poorer for cattle fed the wheat middling-based diet than for those fed corn. No notable differences were evident in terms of the percentage of cattle treated for respiratory disease. Feed intake and daily gain were improved slightly when corn was replaced by distiller's dried grains, but efficiency was not changed. However, the incidence of respiratory disease also was higher for cattle fed the distiller's grains diet in comparison to corn.

(Key Words: Distiller's Grains, Wheat Middlings, Receiving Cattle, Health.)

## Introduction

Typically, feed intake of stressed feeder calves is low and extremely variable following transportation and introduction into the feedlot. Adequate energy intake may be key to mounting an effective immune response. However, when intake is excessive, cattle may experience digestive disturbances that further challenge their ability to cope with the stresses of weaning, comingling and transportation. Diets with a high proportion of rapidly fermentable grains may predispose animals to digestive disturbances. By-product feeds such as wheat middlings and distiller's dried grains with solubles are good sources of energy but are higher in fiber than feed grains. These by-products are digested more slowly than feed grains such as corn or grain sorghum and theoretically would be less likely to cause digestive disturbances when eaten too rapidly or in excess quantity. Consequently, we designed these studies to compare performance of stressed feeders fed receiving diets based on rolled corn, wheat middlings, or distiller's dried grains with solubles.

## Experimental Procedures

Six hundred twenty weaned steer calves were used in two receiving experiments to evaluate growth performance, morbidity, and mortality when fed either a standard corn-based diet or diets based on distiller's dried grains or wheat middlings. Calves were purchased from sale barns in Ohio and Indiana and transported to the KSU Beef Cattle Research Center in Manhattan. Calves were placed into a large pen on arrival, given free access to long-stem prairie hay and water, and processed within 24 hours of arrival. Weight and temperature were recorded, and steers were administered Bovishield®-IV, Fortess®-7, injectable Ivomec®, and a Synovex®-S implant. Additionally, steers were given a metaphylactic dose of Micotil® at 1.5 ml per 100 lb body weight. Calves were allotted randomly to their respective treatments in each study and placed into pens ranging from 22 to 32 head each. A second dose of Bovishield®-IV was given 12 to 14 days after initial processing. Diets are shown in Table 1. Steers were fed their respective diets once daily.

Animals that exhibited clinical signs of respiratory disease were identified each morning

as candidates for treatment. They were treated for respiratory disease if clinical signs were accompanied by a rectal temperature of $103.5EF, or if they exhibited clinical signs for 2 consecutive days. The initial respiratory disease treatment was a subcutaneous injection of Micotil® at 1.5 ml per 100 lb body weight. Steers were returned to their original pen following treatment. Where necessary, calves were retreated after 48 hours, regardless of rectal temperature. The third-time treatment was a combination of 6 ml/cwt Biomycin® 200 and 5 ml/cwt Tylan® 200, administered intramuscularly.

Calves were weighed at the end of the 28-day receiving trials. Average daily gains and efficiencies were computed using the initial weight at processing and the final weight, both of which were measured approximately 24 hours after feeding.

## Results and Discussion

Performance during the 28-day receiving experiments is summarized in Table 2. Feed intake, treatment rate, and retreatment rate were not different for calves fed the corn-based diet in comparison to those fed the middling-based diet in trial 1. Cattle fed the corn tended (P=.20) to gain more rapidly and were more efficient (P=.09).

In trial 2, feed intake was greater (P=.05) for cattle fed the distiller's grains diet than for those fed corn. Gain also was marginally higher for cattle fed the distiller's grains diet, but efficiency was not different for cattle fed the two diets. Contrary to our expectations, both treatment and retreatment rates were higher (P=.09) for cattle fed the distiller's grains diet.

These studies indicate that grain by-products are reasonable substitutes for grain in receiving cattle diets. However, the incidence of respiratory disease apparently is not reduced when grain is replaced by low-starch by-products.

**Table 1. Compositions of Receiving Diets (100% Dry Basis)**

| Ingredient, % | Dry-Rolled Corn | Distiller's Dried Grains with Solubles | Wheat Middlings |
|---|---|---|---|
| Dry-rolled corn | 51.62 | | |
| Distiller's dried grains with solubles | | 53.36 | |
| Wheat middlings | | | 52.73 |
| Ground alfalfa hay | 40.15 | 40 | 40 |
| Cane molasses | 5 | 5 | 5 |
| Dehulled soybean meal | 1.43 | | |
| Limestone | .51 | .74 | 1.67 |
| Urea | .37 | | |
| Potassium chloride | .32 | .30 | |
| Mineral-vitamin premix[1] | .60 | .60 | .60 |
| Crude protein, actual % | 13.48 | 16.83 | 20.47 |
| Calculated NEg, Mcal/100 lb | 49 | 51 | 39 |

[1]Formulated to provide .35% salt, 2:1 Ca:P; 1.5 IU/lb vitamin A, 20 IU/lb vitamin E, .04 ppm cobalt, 8 ppm copper, .5 ppm iodine, 50 ppm manganese, .3 ppm selenium, 50 ppm zinc, and 25 grams per ton Rumensin® on a dry matter basis.

**Table 2. Performance of Feeder Steers Fed Receiving Diets Containing Corn, Distiller's Dried Grains with Solubles, or Wheat Middlings**

| Item | Dry-Rolled Corn | Distiller's Dried Grains with Solubles | Wheat Middlings | SEM | P= |
|---|---|---|---|---|---|
| Trial 1 | | | | | |
| No. pens (head) | 6 (155) | | 6 (136) | | |
| Dry matter intake, lb/day | 11.4 | | 11.5 | .3 | .86 |
| Daily gain, lb | 2.64 | | 2.33 | .16 | .20 |
| Feed:Gain | 4.38 | | 5.00 | .23 | .09 |
| Pulls, % | 13.8 | | 18.1 | 4.1 | .48 |
| Repulls, % | 3.6 | | 2.2 | 1.7 | .56 |
| Trial 2 | | | | | |
| No. pens (head) | 7 (186) | 7 (187) | | | |
| Dry matter intake, lb/day | 11.0 | 11.9 | | .3 | .05 |
| Daily gain, lb | 2.36 | 2.72 | | .15 | .11 |
| Feed:Gain | 4.73 | 4.48 | | | .55 |
| Pulls, % | 14.8 | 26.7 | | 4.5 | .09 |
| Repulls, % | 3.1 | 8.7 | | 2.1 | .09 |

# EFFECTS OF SUPPLEMENTING LIMIT-FED, WHEAT MIDDLING-BASED DIETS WITH EITHER SOYBEAN MEAL OR NON-ENZYMATICALLY BROWNED SOYBEAN MEAL ON GROWING STEER PERFORMANCE

*C. M. Coetzer, J. S. Drouillard, E. Coetzer, and R. H. Wessels*

## Summary

Seventy two individually fed Angus × Hereford steers (660 lb) were limit-fed, 16.7% CP wheat middling-based diets with 1.9 or 3.8 percentage units of additional CP from either soybean meal (SBM) or non-enzymatically browned soybean meal (NEBSBM). A limit-fed, rolled corn-based diet (16.7% CP) also was included. Steers were fed once daily for 70 days at 2.25% of BW. The SBM provided 30% bypass protein, and NEBSBM provided 68%. Average daily gain and efficiency improved linearly with increasing level of NEBSBM (P<.05; ADG=2.482 + .106 (increase in % CP); feed to gain=6.26 - .22(increase in % CP)), but not with increasing levels of SBM. Steers fed the wheat middling diets had lower ADG and efficiency than those fed the corn control diet. These data suggest that bypass protein may be first limiting in high-concentrate, limit-fed growing diets composed predominantly of wheat middlings.

(Key Words: Wheat Middlings, Growing Cattle, Undegraded Intake Protein.)

## Introduction

Previous KSU research has shown wheat middlings to have feed values of 95% relative to corn and soybean meal when used in full-fed sorghum silage-based rations but of only 83% when used in limit-fed diets. One likely reason for this lower feed value is the low bypass protein value. Non-enzymatically browned soybean meal (Soypass®) is a better source of bypass protein compared to commercial soybean meal. Our objective was to compare the effects of supplementing limit-fed, wheat middling-based diets with either soybean meal (SBM; 30% bypass) or non-enzymatically browned soybean meal (NEBSBM; 68% bypass) on growing steer performance.

## Experimental Procedures

Seventy two individually fed Angus × Hereford steers (660 lb) were used in a randomized complete block design to evaluate the effects of supplementing limit-fed, wheat middling-based diets with either SBM or NEBSBM on growing steer performance. Steers were stratified by weight and randomly allotted within strata to one of six treatments. The CP content of a wheat middling-based control diet (16.7%) was increased by 1.9 or 3.8 percentage units using SBM or NEBSBM (Table 1). A limit-fed, rolled corn-based diet (16.7% CP) also was included. Steers were fed once daily for 70 days at 2.25% of BW. Data were analyzed by regression using supplementation level as a continuous variable nested within supplement source (SBM or NEBSBM).

## Results and Discussion

Average daily gain (Figure 1) and efficiency (Figure 2) improved linearly with increasing level of NEBSBM (P<.05) but not with increasing level of SBM. With NEBSBM, ADG = 2.48 + .106 (increase in % CP) and feed-to-gain = 6.26 - .22 (increase in % CP). Steers fed the wheat middling diets had lower ADG and efficiency compared to those fed the corn control diet (data not shown). The improved performance with supplemental NEBSBM, but not SBM, indicates that bypass protein may be first limiting in high-concentrate, limit-fed growing diets based on wheat middlings.

**Table 1. Compositions of Experimental Diets (% of DM)**

| | Diet[a] | | | | | |
|---|---|---|---|---|---|---|
| Item | MID-CNTRL | SBM-18.6 | SBM-20.5 | NEBSBM-18.6 | NEBSBM-20.5 | CORN-CNTRL |
| Rolled corn | 0 | 0 | 0 | 0 | 0 | 68 |
| Alfalfa hay | 15 | 15 | 15 | 15 | 15 | 15 |
| Molasses (cane) | 4 | 4 | 4 | 4 | 4 | 4 |
| Wheat middlings | 77.3 | 71.7 | 66.2 | 69.8 | 62.4 | 0 |
| Vitamin/mineral mix[b] | 3.7 | 3.7 | 3.7 | 3.7 | 3.7 | 0 |
| Vitamin/mineral mix[c] | 0 | 0 | 0 | 0 | 0 | 3 |
| Soybean meal | 0 | 5.5 | 11 | 0 | 0 | 10 |
| NEBSBM[d] | 0 | 0 | 0 | 7.4 | 14.8 | 0 |

[a]MIDCNTRL=wheat middling control diet (16.7% CP); SBM-18.6, SBM-20.5=soybean meal was used to increase the CP content of the MIDCNTRL diet to 18.6 and 20.5%, respectively; NEBSBM-18.6, NEBSBM-20.5=non-enzymatically browned soybean meal was used to increase the CP content of the MIDCNTRL diet to 18.6 and 20.5%, respectively; CORNCNTRL=rolled corn control diet (16.7% CP).

[b]Formulated for the complete diet to contain 1.6% Ca, .8% P, 1.3% K, 1330 IU/lb added vitamin A, 30 g/ton Rumensin® and 10 g/ton Tylan®.

[c]Formulated for the complete diet to contain .78% Ca, .39% P, .88% K, 1330 IU/lb added vitamin A, 30 g/ton Rumensin®, and 10 g/ton Tylan®.

[d]Non-enzymatically browned soybean meal.

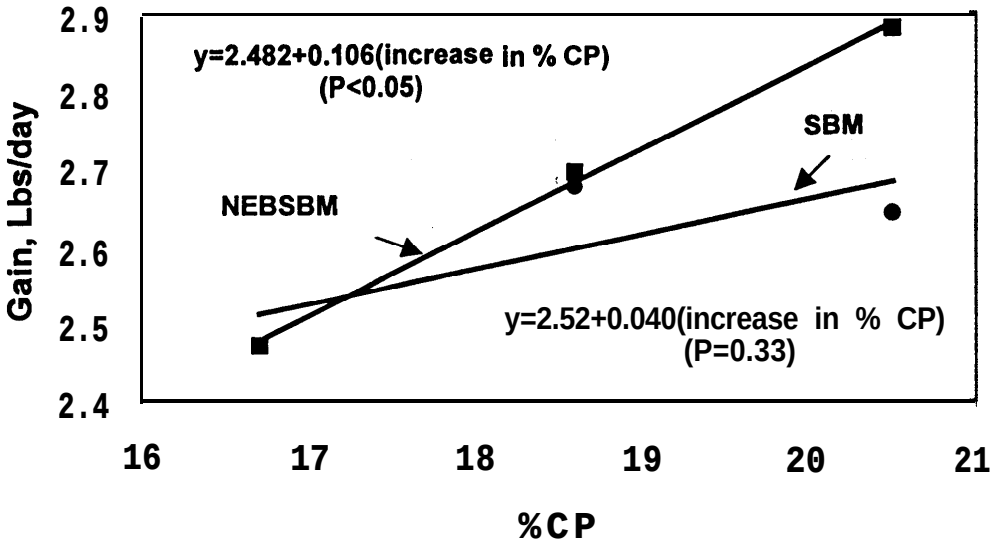


**Figure 1. Effect on Daily Gain of Increasing Crude Protein Level of a Limit-Fed, Wheat Middling-Based Diet by Using either Soybean Meal (SBM) or Non-Enzymatically Browned Soybean Meal (NEBSBM).**

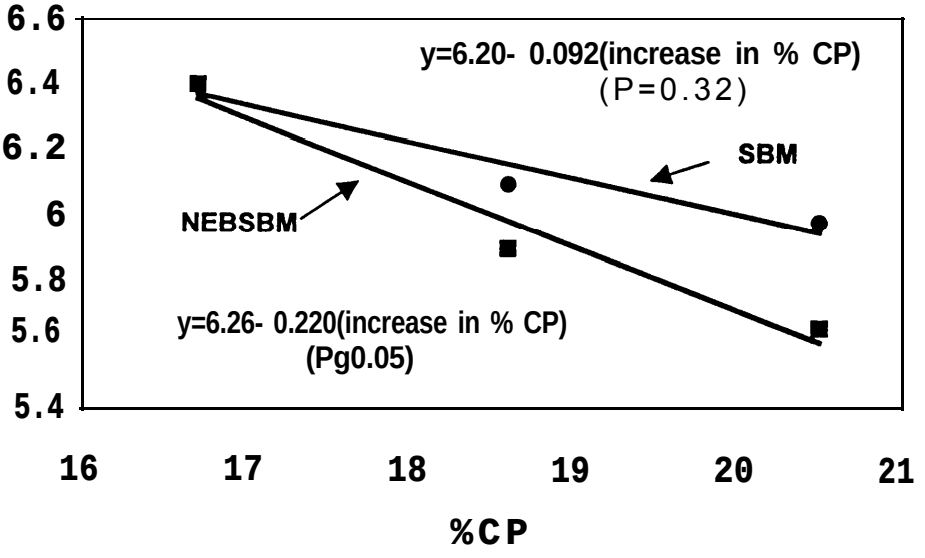


**Figure 2. Effect on Feed Efficiency of Increasing Crude Protein Level of a Limit-Fed, Wheat Middling-Based Diet by Using either Soybean Meal (SBM) or Non-Enzymatically Browned Soybean Meal (SBM).**

# EFFECT OF LEVEL OF NON-ENZYMATICALLY BROWNED SOYBEAN MEAL IN LIMIT-FED, GRAIN SORGHUM DIETS FOR GROWING HEIFERS

*R. D. Hunter, J. S. Drouillard, and E. C. Titgemeyer*

## Summary

Grain sorghum-based diets were fed in a limit-feeding trial involving 72 heifers for 100 days. Heifers were fed one of four diets designed to provide 12.5%, 14.9%, 17.3%, and 19.6% crude protein. Protein levels in the diets were altered by providing up to 20% of the diet as non-enzymatically browned soybean meal (Soypass®) at the expense of dry-rolled grain sorghum. Performance of heifers (gain and feed efficiency) tended (P=.15) to improve linearly as protein concentration of the diets was increased. The greatest improvements were observed at concentrations up to 17.3%.

(Key Words: Bypass Protein, Limit Feeding.)

## Introduction

Restricted feeding is gaining popularity among cattle feeders; traditional roughage-based growing diets fed ad libitum are replaced by high grain diets fed at restricted intake. Restricting intake of high concentrate rations has several advantages. Concentrates are usually less expensive sources of energy than roughages, and digestibility of grains is high in comparison to roughages, thereby reducing manure production.

Given the lower levels of intake with limit-fed diets, concentrations of protein, vitamins, and minerals in the diet must all be increased in order to satisfy daily nutrient requirements. Utilization of protein may be less than optimal if fed in excess of requirements or when provided by sources that are highly fermentable. This occurs because rumen microbes may not be able to utilize the nitrogen as rapidly as it becomes available. Degradable protein that the bacteria cannot utilize for formation of microbial protein is lost as ammonia. This represents an important economic loss for cattle producers and may contribute to contamination of watersheds. Recent work at Kansas State University with limit-fed corn diets indicated a linear increase in average daily gain as protein level increased from 14 to 20% of the diet. This experiment was designed to measure performance of cattle fed grain sorghum-based diets containing from 12.5 to 19.6% crude protein.

## Experimental Procedures

Seventy-two crossbred heifers of southern origin weighing approximately 660 lb were used in a randomized block design experiment. The heifers were stratified into three weight blocks and assigned to 12 pens of six head each. Diets were formulated to provide energy for weight gains of approximately 2 lb/day. The heifers were weighed every 14 days. The feed offerings were adjusted at that time to 2.2% (dry matter basis) of body weight. The limit-fed grain sorghum diets contained 12.5, 14.9, 17.3, or 19.6% crude protein. The protein levels were achieved by adding increasing amounts of Soypass, which is a non-enzymatically browned soybean meal containing a high proportion of bypass protein (Table 1). Cattle were fed once daily for a total of 100 days.

## Results and Discussion

Increasing the level of Soypass in limit-fed grain sorghum diets did not affect weight gain or feed efficiency significantly. However, there were linear trends for feed intake (P=.15) and daily gain (P=.15) to increase and for gain efficiency (P=.15) to improve with addition of Soypass to the diet (Table 2). The greatest improvements were observed up to a dietary crude protein concentration of 17.3%.

In this experiment, protein level was confounded with the substitution of Soypass for grain sorghum. In using this approach to assess protein requirements, we made the assumption that grain sorghum and Soypass are energetically equal. If Soypass contains more energy than the grain sorghum, the responses could have been due to changes of dietary energy rather than of dietary protein.

**Table 1. Experimental Diets (% of Dry Matter)**

| | Protein Level | | | |
|---|---|---|---|---|
| Ingredient | 12.5% | 14.9% | 17.3% | 19.6% |
| Dry-rolled grain sorghum | 79.3 | 72.7 | 66.2 | 59.6 |
| Chopped alfalfa hay | 12.0 | 12.0 | 12.0 | 12.0 |
| Soypass[1] | | 6.7 | 13.3 | 20.0 |
| Cane molasses | 4.0 | 4.0 | 4.0 | 4.0 |
| Soybean meal | 1.4 | 1.4 | 1.4 | 1.4 |
| Urea | 0.9 | 0.9 | 0.9 | 0.9 |
| Limestone | 1.0 | 1.0 | 1.0 | 1.0 |
| Calcium phosphate | 0.6 | 0.5 | 0.4 | 0.3 |
| Salt | 0.3 | 0.3 | 0.3 | 0.3 |
| Ammonium sulfate | 0.2 | 0.2 | 0.2 | 0.2 |
| Magnesium oxide | 0.1 | 0.1 | 0.1 | 0.1 |
| Potassium chloride | 0.1 | 0.1 | 0.1 | 0.1 |
| Vitamins/minerals[2] | 0.1 | 0.1 | 0.1 | 0.1 |

[1]Soypass® is a registered trade name for non-enzymatically browned soybean meal (Lignotech USA).
[2]Formulated to add to the diets (dry basis): 1220 IU/lb vitamin A, 600 IU/lb vitamin D, 0.05 ppm Co, 10 ppm Cu, 0.6 ppm I, 0.8 ppm Fe, 60 ppm Mn, 0.25 ppm Se, 60 ppm Zn, 30 g/ton monensin, and 10 g/ton tylosin.

**Table 2. Effect of Protein Level on Performance of Heifers Fed Diets Based on Dry-Rolled Grain Sorghum**

| | Protein Level | | | | |
|---|---|---|---|---|---|
| Item | 12.5% | 14.9% | 17.3% | 19.6% | SEM |
| Daily gain, lb[a] | 1.59 | 1.68 | 1.87 | 1.89 | 0.15 |
| Dry matter intake, lb/day[a] | 15.2 | 15.4 | 15.4 | 15.4 | 0.11 |
| Feed/gain[a] | 9.52 | 9.09 | 8.33 | 8.13 | 0.70 |

[a]Linear trend (P=.15).

# SOY MOLASSES AS A FEED INGREDIENT FOR FINISHING CATTLE

***J. S. Drouillard, C. K. Schoenholz, R. D. Hunter, and T. A. Nutsch***

## Summary

Eighty Angus × Hereford cross steers were used in an individual feeding study to compare soybean molasses (a by-product of soybean meal manufacture) and soybean meal as ingredients in finishing diets containing flaked corn or a combination of high-moisture corn and dry-rolled corn. Supplementation with soy molasses resulted in higher (P<.05) feed intakes in the cattle fed the high-moisture corn diet but had no effect on intakes of cattle fed the flaked diets. No such changes were noted for supplementation with soybean meal. In general, carcass traits were not influenced by level or type of supplement. Soy molasses appears to have feed value equal to or greater than that of soybean meal when compared on a protein basis. Its value as a source of supplemental nutrients appears to be greater in steam-flaked diets than in high-moisture diets.

(Key Words: Soy Molasses, Degradable Intake Protein, Finishing Cattle.)

## Introduction

Isolation of protein from defatted soy flakes results in the production of soy molasses, which is a waste stream composed largely of mono-, di- and trisaccharides, as well as protein and potentially valuable mineral nutrients. Disposal of this waste stream is costly and represents a lost opportunity because of its potential value as a feed ingredient for livestock.

Cereal grains typically are deficient in rumen degradable intake protein (DIP), thus requiring the addition of large amounts of urea and(or) natural proteins as sources of nitrogen and pre-formed protein in order to maximize performance of finishing cattle. Soybean meal is a common source of protein in finishing cattle diets because of its high rumen degradability and relatively low cost. Numerous studies have evaluated responses to soybean meal in finishing diets, and the responses naturally are attributed to its protein. Unfortunately, this disregards the possibility that other components constituting about half of the soybean meal may be stimulating digestion and/or animal growth. We feel that the carbohydrate fraction of soybean meal may stimulate ruminal digestion.

## Experimental Procedures

**Grain Processing**. Early harvest corn (26% moisture) was processed through a roller mill and subsequently packed into plastic AgBags® for ensiling. Dry rolled corn was processed to a mean geometric particle size of approximately 3,800 microns. Whole shelled corn was processed daily into flakes by steam conditioning for approximately 40 to 45 minutes and then flaking through corrugated rolls to a density of approximately 26 lb/bushel.

**Cattle Performance Trial**. Eighty Hereford-Angus steers (850 lb) were adapted to a common dry rolled corn (85% concentrate) diet prior to initiating the experiment, in order to equalize gastrointestinal fill. Animals were stratified by initial weight and allotted randomly within strata to 10 experimental treatments, with a total of eight animals per treatment combination. Cattle were implanted with Revalor®-S and treated for internal and external parasites. Steers were stepped up to final finishing diets containing 10% sorghum silage (dry basis) over a period of 10 days.

Compositions and actual protein content of the experimental rations are shown in Table 1. Cattle were fed diets containing either steam-flaked corn or a 70:30 mixture of high-moisture corn and dry-rolled corn. Additionally, diets were supplemented with 2 or 4% (dry basis) soybean meal (49.1% protein) or soybean molasses (20.9% protein; 62.1% carbohydrate). Cattle were placed into individual feeding pens (110 $ft^2$) and fed their respective diets once daily ad libitum. Unconsumed feed was collected, weighed, and analyzed weekly for dry matter content.

Final weights were determined as shrunk weights taken on the day of slaughter (gross weight less 4%) and as carcass weight divided by a common dressing percentage (63.85%). Ribeye area, fat thickness, percentage KPH fat, marbling score, incidence of dark cutters, and USDA quality and yield grades were evaluated 24 hours after slaughter. The experiment was conducted as a randomized complete-block design with eight replicates of 10 treatments. Individual animal was the experimental unit.

## Results and Discussion

Performance for the 107-day finishing experiment is summarized in Tables 2 and 3. Carcass-adjusted daily gains and feed efficiencies were similar for cattle fed steam-flaked corn and the high-moisture/dry-rolled corn combination (P>.2). Cattle fed the high-moisture diet tended (P=.07) to have greater dry matter intakes. The percentage of carcasses grading USDA Choice or better was similar for cattle fed flaked-corn diets and high-moisture/dry-rolled corn combinations, but most carcasses graded Choice, so there was little room for improvement.

Interactions between grain type and supplement type were not apparent (Table 2). The soy molasses yielded improvements in gain and efficiency (carcass adjusted) that were comparable to those with soybean meal. Coefficients obtained through regression analyses (Table 3) suggest that the growth responses observed may have been consistent with the level of degradable protein provided by each supplement. The response to supplemental protein was approximately 2½ times greater for cattle fed flaked corn than for those fed the high-moisture/dry-rolled combination. This may have been the result of lower ruminal degradability of protein in steam-flaked grain compared to high-moisture grain, thus providing for a greater response to supplemental degradable protein. Based on results of our study, nonprotein components of soybean meal and soy molasses may contribute to efficiency improvements. However, regression estimates (Table 3) could be interpreted to suggest that supplemental protein in the form of soy molasses is more readily available than that of soybean meal. This was confirmed by laboratory *in vitro* measurements in which soy molasses supported 55% greater microbial growth under nitrogen-limiting conditions than soybean meal.

Supplementation with soy molasses resulted in higher (P<.05) feed intakes in the cattle fed the high-moisture corn diet, but had no effect on intakes of cattle fed the flaked diets. No such changes were noted when the supplement was soybean meal. Dressing percentages were improved (P<.01) in cattle fed the steam-flaked diet as the level of soy molasses was increased. Other carcass traits were not influenced by level or type of supplement. Given the high percentage of carcasses grading USDA Choice or Prime, there obviously was little room for improvement of carcass quality.

In summary, soy molasses appears to have feed value equal to or greater than that of soybean meal when compared on a protein basis. Its value as a source of supplemental nutrients appears to be greater in steam-flaked than in high-moisture corn diets.

**Table 1. Compositions of Diets (Dry Matter Basis)[1]**

| | Steam-Flaked Corn | | | | | High-Moisture:Dry-Rolled Corn[3] | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ingredients | Control | SM2 | SM4 | SBM2 | SBM4 | Control | SM2 | SM4 | SBM2 | SBM |
| Corn | 84.18 | 82.50 | 80.81 | 82.29 | 80.41 | 84.17 | 82.50 | 80.81 | 82.29 | 80.40 |
| Sorghum silage | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 | 10.00 |
| Tallow | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Soy molasses | - | 2.00 | 4.00 | - | - | - | 2.00 | 4.00 | - | - |
| Soybean meal | - | - | - | 2.00 | 4.00 | - | - | - | 2.00 | 4.00 |
| Urea | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |
| Limestone | 1.60 | 1.52 | 1.45 | 1.61 | 1.61 | 1.60 | 1.52 | 1.45 | 1.61 | 1.61 |
| Sodium chloride | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 | 0.30 |
| Potassium chloride | 0.40 | 0.21 | 0.02 | 0.32 | 0.24 | 0.40 | 0.21 | 0.02 | 0.32 | 0.24 |
| Ammonium sulfate | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 | 0.20 |
| Calcium phosphate | 0.16 | 0.11 | 0.06 | 0.12 | 0.08 | 0.16 | 0.11 | 0.06 | 0.12 | 0.08 |
| Vit./TM premix[2] | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 | 0.16 |
| Actual crude protein, | 10.94 | 11.27 | 11.59 | 11.84 | 12.73 | 11.08 | 11.41 | 11.73 | 11.99 | 12.89 |

[1]SM2: 2% soybean molasses, SM4:4% soybean molasses, SBM2: 2% soybean meal, and SBM4: 4% soybean meal.

[2]Vit./ TM premix formulated to provide (total diet dry matter): 1.2 KIU/lb vitamin A, 15 IU/lb vitamin E, 0.05 ppm cobalt, 10 ppm copper, 0.60 ppm iodine, 60 ppm manganese, 0.25 ppm selenium, 60 ppm zinc, 30 g/ton Rumensin®, and 10 g/ton Tylan®.

[3]High-moisture corn (70%), dry-rolled corn (30%) mixture.

**Table 2. Least-Squares Means for Performance of Finishing Cattle**

| | Steam-Flaked Corn | | | | | High-Moisture:Dry-Rolled Corn | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Control | SM2 | SM4 | SBM2 | SBM4 | Control | SM2 | SM4 | SBM2 | SBM4 | SEM |
| DMI, lb/d[a] | 21.8 | 21.1 | 21.3 | 20.9 | 21.1 | 20.5 | 22.8 | 23.0 | 22.4 | 21.8 | .72 |
| ADG, lb/d | 2.86 | 2.81 | 2.81 | 2.77 | 3.24 | 2.44 | 2.78 | 3.11 | 2.79 | 2.83 | .22 |
| F:G lb/lb[b,c] | 7.56 | 7.50 | 7.54 | 7.43 | 6.47 | 8.33 | 8.14 | 7.34 | 7.96 | 7.61 | .28 |
| Carcass adjusted[2] ADG, lb/day | 2.58 | 2.99 | 2.91 | 2.64 | 3.21 | 2.52 | 2.84 | 3.04 | 2.87 | 2.94 | .22 |
| Carcass adjusted[2] | 8.48 | 7.08 | 7.33 | 7.83 | 6.53 | 8.07 | 7.98 | 7.51 | 7.72 | 7.37 | .48 |

[1]SM2: 2% soybean molasses, SM4:4% soybean molasses, SBM2: 2% soybean meal, and SBM4: 4% soybean meal.

[2]Calculated by estimating final live weight as carcass weight divided by a common dressing percentage of 63.85%.

[a]Grain processing effect (P<.10).

[b]Grain processing effect (P<.05).

[c]Supplement effect (P=.11).

**Table 3. Regression Coefficients for Performance of Finishing Cattle**

| | Soybean Meal | | | | Soy Molasses | | | |
|---|---|---|---|---|---|---|---|---|
| | Flaked Corn | | High-Moisture Corn/ Dry-Rolled Corn (70:30) | | Flaked Corn | | High-Moisture Corn/ Dry-Rolled Corn (70:30) | |
| Item | Intercept | Change per 1% Added Soybean Meal | Intercept | Change per 1% Added Soybean Meal | Intercept | Change per 1% Added Soy Molasses | Intercept | Change per 1% Added Soy Molasses |
| G:F[a] | .1154 | .0088[b] | .1239 | .0030 | .1221 | .0046 | .1229 | .0023 |
| DMI, lb | 21.58 | -.1629 | 20.89 | .3542 | 21.63 | .6191[b] | 20.83 | -.104 |
| ADG, lb[a] | 2.49 | .157[b] | 2.56 | .111 | 2.65 | .083 | 2.54 | .132 |

[1]SM2: 2% soybean molasses, SM4:4% soybean molasses, SBM2: 2% soybean meal, and SBM4: 4% soybean meal.

[a]Based on carcass weights and adjusted to a common dressing percentage of 63.85%.

[b]Slope is different from zero (P<.05).

**Table 4. Carcass Characteristics**

| | Steam-Flaked Corn | | | | | High-Moisture:Dry-Rolled Corn | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | Control | SM2 | SM4 | SBM2 | SBM4 | Control | SM2 | SM4 | SBM2 | SBM4 | SEM |
| Dressing percent[a] | 62.1 | 64.8 | 64.4 | 63.1 | 63.7 | 64.3 | 64.2 | 63.4 | 64.3 | 64.4 | .59 |
| HCW, lbs | 744 | 776 | 771 | 754 | 783 | 737 | 770 | 778 | 770 | 767 | 17.09 |
| Ribeye area, sq. in. | 12.51 | 12.65 | 12.65 | 12.89 | 13.37 | 12.30 | 13.43 | 13.13 | 13.64 | 12.45 | .05 |
| Kidney, pelvic heart fat, %[b] | 2.56 | 2.24 | 2.50 | 2.50 | 2.63 | 2.69 | 2.50 | 2.69 | 2.63 | 2.72 | .42 |
| Backfat, in | .63 | .67 | .62 | .54 | .58 | .59 | .56 | .54 | .57 | .67 | .05 |
| USDA yield grade | 3.13 | 3.02 | 3.13 | 2.88 | 3.00 | 3.00 | 3.00 | 3.00 | 3.25 | 3.01 | .13 |
| USDA quality grade[2] | 3.88 | 3.87 | 4.00 | 4.00 | 4.00 | 3.88 | 3.88 | 4.00 | 3.88 | 3.70 | .12 |
| Liver abscess, % | 12.5 | 15.3 | 0 | 0 | 0 | 12.5 | 0 | 0 | 0 | .1 | 6.9 |
| Percent choice | 87.5 | 86.8 | 100.0 | 100.0 | 100.0 | 87.5 | 87.5 | 100.0 | 87.5 | 85.3 | 9.8 |

[1]SM2: 2%soybean molasses, SM4:4% soybean molasses, SBM2: 2% soybean meal, and SBM4: 4% soybean meal.

[2]USDA quality grade 3 = select, 4 = choice.

[a]Grain processing x supplement interaction (P<.10).

[b]Effect of grain processing (P<.10).

# USING ARSOY™ AS A PROTEIN SUPPLEMENT IN GROWING CATTLE DIETS [1]

*T. T. Marston, K. K. Kreikemeier [2], L. E. Wankel, G. L. Huck, and T. J. Wistuba*

## Summary

Arsoy™ Soybean Feed is a by-product from the manufacture of soy protein isolate. It contains nearly 30% crude protein, but there is little documentation about its feeding value. Therefore, we fed basal growing diets of corn silage and stover to 196 crossbred heifers and supplemented those diets with soybean meal, Arsoy, or a combination of soybean meal and high moisture corn to determine the feeding value of Arsoy. Our results suggest that Arsoy can be substituted for soybean meal in growing cattle diets, without any negative impact on animal performance, dry matter intake, or feed efficiency.

(Key Words: Protein Supplementation, Soybean By-Products, Arsoy, Heifers.)

## Introduction

Cattle producers constantly are offered by- and co-products from grain and oil seed processors. The economic value of these feeds depends on animal performance; feed efficiency; palatability; and transportation, handling, and storage costs.

Arsoy Soybean Feed is the main by-product from processing dehulled, defatted soybeans to make soy protein isolate. Typical analyses show about 27% crude protein (35% UIP), very little fat, .4% calcium, .5% phosphorus, and 1.35% potassium. No energy values or nonprotein nitrogen values have been reported. These analyses indicate that Arsoy should be an excellent protein supplement for growing cattle, especially when diets contain a high percentage of low- and medium-quality forages. Our objective was to determine the feeding value of Arsoy as a protein supplement for growing cattle.

## Experimental Procedures

One hundred ninety-six crossbred heifers (491 lb average starting weight) were used in a completely randomized experiment. Heifers were allotted randomly into 21 pens, and pens were allotted randomly to one of three treatments. Basal diets of corn silage and corn stover (Table 1) were supplemented with 1) control (CON), soybean meal at 6.8% of the diet dry matter; 2) Arsoy (ARSOY) at 13% of the diet dry matter; or 3) soybean meal and high moisture corn (HMC) at 6.8% and 6.2% of the diet dry matter, respectively. Diets were formulated to contain similar concentrations of crude protein. Comparing CON and ARSOY allowed for evaluating ARSOY as a protein source, and comparing ARSOY and HMC allowed us to evaluate ARSOY as an energy source. The heifers started treatments on February 3, 1998 and were fed for 98 days. Weights were recorded on consecutive days and averaged for the starting and ending weights. Body weight also was measured on day 49. Daily feed deliveries and refusals were recorded, so that daily feed intakes and feed efficiency could be calculated.

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[1]The authors express their appreciation to ADM Specialties Division, Archer Daniels Midland Company for providing support for this research.

[2]Formerly at Southwest Research-Extension Center, Garden City.

## Results and Discussion

Table 2 shows the results of this trial. Only small differences occurred between treatments in daily gain, feed intake, and feed efficiency.

No difference in average daily gain was noted between CON- and ARSOY-fed heifers (P>.20). Heifers fed the HMC diets tended (P<.12) to gain more weight than the CON-fed heifers during the first half of the experiment, which gave them a slight overall advantage in weight gain for the total 98 days.

Heifers eating CON and ARSOY diets consumed less feed than did the HMC-fed heifers (P<.02). All groups consumed more than 2.5% of their body weights daily. Therefore, ARSOY's palatability does not appear to be a concern.

Feed efficiencies for the entire 98 days were similar (P<.19) for all treatments. However, feed:gain was higher for days 49-98 than for 0-49. Maintenance requirements may have increased and gut filling may have been higher at the mid-experiment weighing.

Using the net energy values shown in Table 1 and actual dry matter intakes, we predicted the average daily gains to be 2.0 to 2.5 lb/day. Thus, the assumed energy values for ARSOY shown in Table 1 are good approximations.

These growing diets were formulated to minimal recommended levels of crude protein. Our intent was to determine if the protein in ARSOY was readily available. Animal performance confirmed that it was. We conclude that Arsoy can be used to replace traditional sources of protein in growing cattle diets.

**Table 1. Diet Composition (Dry Matter Basis)**

| | Treatments | | |
|---|---|---|---|
| Item | Soybean Meal (CON) | Arsoy (ARSOY) | Soybean Meal + High Moisture Corn (HMC) |
| Ingredient, % | | | |
| Corn stalks | 33 | 33 | 33 |
| Corn silage | 58.2 | 52.1 | 52.1 |
| Mineral supplement | 2 | 2 | 2 |
| Soybean meal | 6.78 | -- | 6.7 |
| Arsoy | -- | 12.9 | -- |
| High moisture corn | -- | -- | 6.2 |
| Nutrient[a] | | | |
| Crude protein, % | 10.42 | 10.39 | 10.4 |
| NEm, Mcal/cwt | 61.5 | 64.3 | 60.6 |
| NEg, Mcal/cwt | 35.7 | 37.7 | 34.9 |

[a]NRC protein and energy values used on all ingredients except Arsoy. Assumed Arsoy nutrient values were 30% crude protein, 74 Mcal/cwt NEm, and 47 Mcal/cwt Neg.

**Table 2. Effects of Supplementing Growing Heifer Diets with Soybean Meal (CON), Arsoy (ARSOY), and Soybean Meal & High Moisture Corn (HMC)**

| | Treatments | | | |
|---|---|---|---|---|
| Item | CON | ARSOY | HMC | SEM |
| Body weight, lb | | | | |
| Initial wt | 499 | 480 | 491 | 7.3 |
| Mid wt | 616 | 604 | 625 | 8.9 |
| Ending wt | 734 | 714 | 727 | 8.6 |
| Average daily gain, lb | | | | |
| Day 0 - 49 | 2.37 | 2.51 | 2.73 | .12 |
| Day 49 - 98 | 2.27 | 2.25 | 2.23 | .10 |
| Day 0 - 98 | 2.33 | 2.39 | 2.48 | .07 |
| Daily dry matter intake, lb | | | | |
| Day 0 - 49 | 15.2 | 14.5 | 15.6 | .39 |
| Day 49 - 98 | 18.7 | 18.3 | 20.3 | .49 |
| Day 0 - 98 | 17.0 | 16.4 | 18.0 | .38 |
| Daily dry matter intake, %body weight | | | | |
| Day 0 - 49 | 2.73 | 2.67 | 2.81 | .06 |
| Day 49 - 98 | 2.79 | 2.78 | 2.99 | .05 |
| Day 0 - 98 | 2.77 | 2.75 | 2.93 | .05 |
| Feed:gain | | | | |
| Day 0 - 49 | 6.4 | 5.8 | 5.8 | .22 |
| Day 49 - 98 | 8.3 | 8.2 | 9.2 | .40 |
| Day 0 - 98 | 7.3 | 6.9 | 7.3 | .19 |

# FEEDING RAW SOYBEANS TO FINISHING CATTLE

***T. T. Marston, K. K. Kreikemeier[1], J. F. Gleghorn, G. L. Huck, and T. J. Wistuba***

## Summary

Two finishing trials were performed to determine if raw soybeans could be incorporated into diets to partially replace soybean meal and beef tallow. Our data indicated that no sacrifices in animal performance, feed efficiency, and carcass quality will occur if cattle feeders replace soybean meal and tallow with raw dry-rolled soybeans. The feeding value of raw soybeans is equal to .8 times the value of 44% CP soybean meal plus .2 times the value of fancy bleachable tallow. Raw soybeans contain the enzyme, urease, which converts urea to ammonia. Therefore, caution should be used in mixing raw soybeans with urea-containing diets.

(Key Words: Soybean, Protein, Fat, Finishing Cattle.)

## Introduction

Studies have indicated that up to 10% raw soybeans can be included in diets for growing cattle and sheep without sacrificing animal performance. Raw soybeans contain about 40% crude protein and 20% oil, two of the more expensive nutrients in finishing cattle diets. Additional costs of feeding soybean-based products are transportation, storage, handling, and processing. If raw soybeans can be added to finishing cattle diets, part of those costs can be redistributed to soybean growers and cattle feeders, thereby increasing their profits. Our objectives were to determine if raw soybeans could be included successfully in finishing cattle diets and to derive the economic feeding value of raw soybeans in the diet.

## Experimental Procedures

Two feeding trials were performed at the Southwest Research-Extension Center, Garden City, Kansas. Both had similar treatments but differed in basal diet composition and sex of animal fed. Diets were formulated to be equal in nitrogen and fat and included a minimum of 1.0% urea and 2% beef tallow (Table 1).

In trial 1, 220 crossbred steers (average starting weight 820 lb) were assigned to 22 pens, and pens were assigned randomly to treatments in a completely randomized experiment. The three treatments consisted of: negative control (NEG), 4% beef tallow and 1.6% urea; positive control (SBM), 6% soybean meal and 4% beef tallow; and raw soybeans (DRB), 7.5% dry-rolled soybeans and 2.5% beef tallow. The dry-rolled beans had a bulk density of 43 lb/bushel. Steers were stepped up to the final diets in 14 days. The steers were fed for 139 days starting on July 11, 1997. Traits measured were weight gains, feed intake, and carcass parameters that influence USDA quality and yield grades.

In trial 2, 242 crossbred heifers (average starting weight 692 lb) were fed for 164 days. Pen assignments and treatments were consistent with Trial 1. Heifers were placed on feed on December 20, 1997. Major differences between the trials were the sources

[1]Formerly at Southwest Research-Extension Center, Garden City.

of dietary roughage and grain. Diet compositions are listed in Table 1.

## Results and Discussion

Table 2 lists the overall results of trial 1 with steers. Throughout the entire feeding period, average daily gains were similar between treatments (P<.23). For the type of steers in this trial, gains were disappointing, partially because of extreme weather conditions during the feeding period. Daily dry matter intakes were quite robust. Only small differences occurred between treatments. The NEG-fed cattle consumed less dry matter daily than the SBM- and DRB-fed cattle. No differences were noted in feed efficiency. Differences did occur between the treatments in those traits used to calculate USDA quality and yield grades.

Table 3 lists the results of trial 2 with heifers. SBM- and DRB-fed heifers tended to gain faster than their NEG contemporaries (P<.11). The NEG heifers typically gained .1 to .2 lb/day slower than the rest of the cattle, probably because of lower consumption (P<.06). Throughout the entire feeding period, NEG-fed heifers ate about .7 lb/day less than the others. Because NEG-fed heifers ate proportionally less feed and had slightly lower gains, no difference was observed in feed efficiency among the treatments. Carcass traits used to determine USDA yield grades were similar among all treatments. However, SBM- and DRB-fed heifers had significantly greater marbling scores than NEG-fed heifers. This translated into a greater percentage (4.7% more for the SBM and 13.8% more for the DRB heifers), grading USDA Choice or higher.

Raw soybeans managed properly and not exceeding 7.5% of the diet can be fed without losing animal performance. Interpreting our data in economic terms, the value ($/lb) of raw soybeans as a feed ingredient is equal to .8 times the cost of 44% soybean meal ($/lb) plus .2 times the cost of fancy bleachable tallow ($/lb).

**Table 1. Final Diets for Trial 1, Steers, and Trial 2, Heifers[a]**

| | Treatments | | |
|---|---|---|---|
| Ingredient | NEG | SBM | DRB |
| *Trial 1, Steers* | - - - - - - - - - - - - - - - % of DM - - - - - - - - - - - - - - - | | |
| Steamed-flaked corn | 86 | 81 | 81 |
| Alfalfa hay | 5 | 5 | 5 |
| Soybean meal | 0 | 6 | 0 |
| Dry-rolled soybeans | 0 | 0 | 7.5 |
| Urea | 2 | 1 | 1 |
| Beef tallow | 4 | 4 | 2.5 |
| Supplement | 3 | 3 | 3 |
| *Trial 2, Heifers* | | | |
| High-moisture corn | 41.65 | 40 | 10 |
| Steamed-flaked milo | 41.65 | 40 | 40 |
| Corn silage | 10 | 10 | 40 |
| Soybean meal | 0 | 4 | 0 |
| Dry-rolled soybeans | 0 | 0 | 5 |
| Urea | 1.7 | 0.7 | 0.7 |
| Beef tallow | 3 | 3 | 2 |
| Supplement | 2 | 2.3 | 2.3 |

[a]Balanced to contain 14% CP, .7% K, .6% Ca, .4% P, and .2% Mg. Vitamins A, D, and E were included at 2,000, 200, and 20 IU/lb of diet DM. Monensin and tylosin were fed at 30 and 10 g/ton of diet DM. Supplements provided 1% urea to all diets.

**Table 2. Treatment Effects of Finishing Trial 1, Steers**

| | Treatments | | | |
|---|---|---|---|---|
| Item | NEG | SBM | DRB | P value |
| *Feeding traits* | | | | |
| Average daily gain, lb | 3.10 | 3.23 | 3.13 | .23 |
| Daily dry matter intake, lb | 23.2 | 24.1 | 23.6 | .10 |
| Feed:gain | 7.48 | 7.45 | 7.56 | .84 |
| *Carcass traits* | | | | |
| Hot carcass weight, lb | 774 | 788 | 779 | .22 |
| Back fat, in | .45 | .46 | .45 | .77 |
| KPH fat, % | 2.1 | 2.2 | 2.2 | .45 |
| Marbling score[a] | 4.5 | 4.5 | 4.6 | .66 |

[a]Marbling score scaled 4.0 = slight0, 5.0 = small0, 6.0 = modest0, etc.

**Table 3. Treatment Effects of Finishing Trial 2, Heifers**

| | Treatments | | | |
|---|---|---|---|---|
| Item | NEG | SBM | DRB | P value |
| *Feeding traits* | | | | |
| Average daily gain, lb | 2.84 | 3.07 | 3.01 | .11 |
| Daily dry matter intake, lb | 17.0 | 17.7 | 17.8 | .06 |
| Feed:gain | 6.00 | 5.78 | 5.94 | .46 |
| *Carcass traits* | | | | |
| Hot carcass weight, lb | 722 | 746 | 742 | .12 |
| Back fat, in | .53 | .55 | .54 | .87 |
| KPH fat, % | 1.9 | 2.0 | 2.0 | .07 |
| Marbling score[a] | 5.4 [b] | 5.7 [c] | 5.9 [c] | .01 |

[a]Marbling score scaled 4.0 = slight0, 5.0 = small0, 6.0 = modest0, etc.

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

# DEHYDRATED PAUNCH AND VEGETABLE BY-PRODUCTS FOR GROWING BEEF CATTLE

*J. S. Drouillard, T. A. Nutsch and R. D. Hunter*

## Summary

Crossbred beef heifers (avg wt 653 lb) were used in a feeding experiment to determine the relative feed value of dried paunch content, two separate vegetable processing by-products, and combinations of by-products with dry-rolled corn. Consumption of the vegetable by-product diets, both of which contained a high percentage of fat, was less than expected. Performance of cattle fed the by-product diets was less than that of cattle fed high-energy diets comprised of corn. However, when combined with corn, the vegetable by-product yielded performance similar to that of corn alone.

(Key Words: Paunch, Vegetable By-Product, Growing Cattle.)

## Introduction

Paunch content derived from beef cattle slaughter represents a significant waste disposal issue for commercial packers in the High Plains. Large volumes of material with high moisture content, high biological oxygen demand, and objectionable odor are produced. Disposal of these and other byproducts, including vegetable processing wastes, is costly. High moisture content makes transportation over long distances impractical. Dehydration lowers transportation costs and improved storage characteristics but is energy intensive and costly. To justify that added cost, we need to identify feeding applications that recognize optimum nutritive value. In this study, we evaluated dried paunch contents and vegetable wastes as ingredients in limit-fed, high-energy rations for growing beef cattle.

## Experimental Procedures

Two hundred sixteen crossbred heifers (653 lb) were vaccinated against common viral and bacterial diseases, treated for internal and external parasites, implanted with zeranol, and fed a common receiving diet (ad libitum) for 4 to 6 weeks prior to starting the experiment. On day 1, heifers were weighed individually to obtain weights for allocation to treatments. On day 2, animals were stratified by weight and randomly allotted, within strata, to six diets fed at 2.0% of body weight (dry matter basis).

Pressed paunch contents were dehydrated in a gas-fired rotary drum dryer, then pelleted through a 5/16-in. die. Two different vegetable by-product blends were used. The first (High-fat Veg), which included cull vegetables, vegetable peels, breading wastes, and filter sludge, was dehydrated in a rotary dryer and pelleted. The second differed from the first only in that it included approximately 20% soybean hulls (Veg/Soyhull).

Compositions of the experimental diets are summarized in Table 1. Rations were formulated to contain approximately 16% crude protein, 0.8% calcium, 0.4% phosphorus, 0.7% potassium, 30 g/ton Rumensin®, and 10 g/ton Tylan® on a dry matter basis. All diets were fed once daily.

Cattle were placed into pens of six head each, with six pens per treatment. Cattle were acclimated to their respective diets for the first 13 days and then reweighed to obtain a starting weight. The preliminary adjustment period made it feasible to substantially reduce confounding from gastrointestinal tract fill. Interim weights were taken

at approximately 2-week intervals, and amounts of feed offered to each pen were adjusted to reflect changes in body weight. Differences in average daily gain, feed consumption, and feed efficiency were compared for the period between days 13 and 84.

## Results and Discussion

Performance of growing heifers is shown in Table 2. Calves in all treatments lost weight during the initial 13-day acclimation period, which is consistent with changes in gut fill after being placed on limited intakes. Consequently, performance during the final 71 days provides for a more accurate assessment of tissue deposition and performance differences.

Cattle fed diets containing a high percentage of either of the vegetable by-products failed to consume their entire daily ration, particularly those fed High-fat Veg. We also observed a high incidence of bloating (including one death) among cattle fed the vegetable by-products. Bloating was most prevalent, and most severe, on High-fat Veg.

Daily gains for cattle fed the Veg/Soyhull by-product were only 60% of those for cattle fed the corn diet, and as expected, efficiency also was poorer. Cattle fed the High-fat Veg by-product gained less but also consumed far less feed than cattle on the corn treatment; consequently, efficiencies of those groups were not different.

The mixture of corn and Veg/Soyhull by-product yielded the most rapid gain and greatest feed efficiency. The 50:50 mixture of the corn diet and the Veg/Soyhull diet exhibited a classic positive associative effect. Gain was 30% faster and 35% more efficient than the average of the two separate diets. Feed intake was not depressed in the mixed diet, which may explain the improved performance relative to the Veg/Soyhull diet.

Cattle fed the dehydrated paunch content diet had the lowest gains and poorest feed efficiencies, but we observed no problems with its consumption. Combining corn with paunch content improved gain and efficiency relative to paunch content alone, but we saw no evidence of a positive associative effect.

**Table 1. Compositions of Experimental Diets**

| Item | Corn | Veg/ Soyhull | High-Fat Veg | Paunch Content | Veg/ Soyhull +Corn | Paunch +Corn |
|---|---|---|---|---|---|---|
| Dry-rolled corn | 67.98 | | | | 33.99 | 33.99 |
| Ground alfalfa hay | 15.00 | | | | 7.50 | 7.50 |
| Dehydrated vegetable by-product | | 79.39 | | | 39.70 | |
| Dehy, high-fat vegetable by-product | | | 79.93 | | | |
| Dehydrated paunch content | | | | 82.98 | | 41.49 |
| Soybean meal | 10.42 | 13.78 | 13.31 | 10.42 | 12.10 | 10.42 |
| Urea | .66 | .66 | .66 | .66 | .66 | .66 |
| Cane molasses | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 | 4.00 |
| Limestone | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 | 1.13 |
| Calcium phosphate | .38 | .61 | .54 | .38 | .49 | .38 |
| Salt | .33 | .33 | .33 | .33 | .33 | .33 |
| Mineral/vitamin premix | .10 | .10 | .10 | .10 | .10 | .10 |

**Table 2. Performance of Growing Cattle Limit-Fed Packing House and Vegetable Processing By-Products**

| Item | Corn | Veg/ Soyhull | High-Fat Veg | Paunch Content | Veg/Soyhull +Corn | Paunch +Corn | SEM |
|---|---|---|---|---|---|---|---|
| Days 1-13 | | | | | | | |
| Daily gain, lb | -.69[a] | -.61[a] | -3.63[b] | -2.60[b] | -1.3[a] | -2.45[b] | .37 |
| Dry matter intake, lb | 12.07[a] | 11.19[a] | 10.05[b] | 12.03[a] | 12.09[a] | 12.13[a] | .34 |
| Days 13-84 | | | | | | | |
| Daily gain, lb | 2.82[a] | 1.70[b,c] | 2.02[b] | 1.40[c] | 2.93[a] | 1.93[b] | .11 |
| Dry matter intake, lb | 14.48[a] | 12.86[b] | 10.97[c] | 13.24[b] | 14.51[a] | 13.80[a,b] | .40 |
| Feed efficiency | 5.12[a] | 7.60[b] | 5.44[a] | 9.50[c] | 4.95[a] | 7.10[b] | .31 |

[a,b,c]Means in the same row with like superscripts are not different (P>.05).

# EVALUATING CORN AND CORN GLUTEN FEED IN GROWING CATTLE DIETS AS A REPLACEMENT FOR ROUGHAGE[1]

*N. G. Whitham, J. S. Drouillard, D. A. Blasi, E.C. Titgemeyer, C. M. Coetzer, and R. D. Hunter*

## Summary

A 99-day study was conducted to evaluate growth performance of 216 beef heifers (average 524 lb) fed traditional roughage-based diets at 2.75% of body weight or limit-fed high-concentrate diets containing corn or corn gluten feed fed at 2.0% of body weight. Dietary treatments included roughage plus corn, roughage plus corn gluten feed, limit-fed corn, limit-fed corn with added Smartamine®-ML (providing 10 g/day ruminally protected lysine), limit-fed corn gluten feed, and limit-fed corn gluten feed with added Smartamine. Adding Smartamine-ML to the diet did not improve performance significantly compared to unsupplemented groups (P>.30). Limit-fed diets containing corn and corn gluten feed resulted in more efficient growth than the respective roughage-based treatments (P<.01). Limit-fed gluten feed diets resulted in gains that were approximately 88% of that with the corn-based diets. Performance was not different for corn and corn gluten feed when added to roughage-based diets.

(Key Words: Corn Gluten Feed, Smartamine-ML, Growing Cattle, Growth.)

## Introduction

Corn gluten feed (CGF) is the major by-product remaining after extraction of starch, gluten, and germ by the corn wet-milling process. CGF is used commonly as a source of protein for growing and finishing beef cattle. Its protein is roughly 70-75% degraded in the rumen, giving it a by-pass protein value similar to soybean meal. Additionally, CGF is a valuable energy source and often is used to displace grains in finishing and in roughage-based growing diets.

Minimizing the roughage level in growing diets can be advantageous in terms of reducing manure production. Additionally, feeding restricted quantities of high-concentrate diets also can be cost competitive relative to roughage-based growing diets that are full fed. These factors have led us to compare performance of growing calves fed roughage-based or high-concentrate diets containing corn or CGF.

Both CGF and corn are believed to be deficient in the essential amino acid lysine. Therefore, in addition to our initial comparison of roughage vs. energy-dense diets containing CGF or corn, we also compared the energy-dense diets with and without supplementation of Smartamine-ML, which is a ruminally protected form of lysine and methionine.

Our objectives were to evaluate growth performance of heifers fed roughage or energy-dense diets and to determine the effects of supplementation of Smartamine-ML in CGF- or corn-based diets.

## Experimental Procedures

Two hundred sixteen crossbred beef heifers (average wt. 524 lb) were placed on experiment on August 4, 1998 at the KSU Beef Cattle Research Center. Six heifers were allotted randomly to each of 36 pens

[1]This project was funded, in part, by the Kansas Corn Commission.

based on initial body weight, resulting in six pens per treatment. Treatments (Table 1) consisted of alfalfa hay plus corn, alfalfa hay plus CGF, limit-fed corn-based diet, limit-fed corn with added Smartamine-ML (to provide 10 grams/day ruminally protected lysine), limit-fed CGF-based diet, and a limit-fed CGF-based diet with added Smartamine-ML. Roughage diets were fed at 2.75% of BW, and all other diets were fed at 2.0% of BW. Intakes were increased weekly, assuming gains of 2.0 lb per day. Prior to initiation of the experiment, all heifers were fed a common diet (50% concentrate) at 2.5% of body weight. Treatments were fed for a 13-day adaptation period followed by a 71-day trial period. At the end of the study, heifers were fed a common series of step-up rations over a period of 15 days in order to minimize treatment effects on differences in gut fill. Heifers were weighed on days 13, 84, and 99 to determine growth performance during each phase.

## Results and Discussion

Table 2 summarizes growth performance of the heifers throughout the experiment. Performance between days 0 and 13 illustrates the dramatic effect of diet on differences in body weight. Cattle fed the rough- age-based diets gained faster and were more efficient than cattle receiving the limit-fed diets ($P<.05$). This appears to be a transient effect resulting from large differences in gut fill among the different dietary treatments. Gains during the period between 14 and 84 days are presumed to reflect actual changes in body weight more accurately, because differences in gut fill are accounted for. Performance between 0 and 99 days also provides a valid comparison, because cattle were fed common diets at the beginning and end of the experiment, thus minimizing differences in gut fill among treatments.

Gain and efficiency throughout the 99-day growing trail were very similar ($P>.5$) when heifers were fed roughage-based diets containing corn or CGF. Heifers fed energy-dense corn diets at 2.0% of BW had similar average daily gains compared to cattle fed the roughage-based diets but gained faster and were more efficient than cattle consuming the limit-fed CGF diets ($P<.05$). Limit-fed corn diets yielded the greatest efficiency of gain, followed by the limit-fed CGF diets. Cattle fed the roughage-based diets were the least efficient. Corn gluten feed was essentially equal to corn when included in roughage-based diets ($P>.5$), but produced lower gains and poorer feed efficiencies when used to replace corn in high-concentrate diets ($P<.05$).

Average daily gain and feed efficiency were not affected by the addition of Smartamine (a source of ruminally protected lysine) to energy-dense corn or CGF diets. Wet corn gluten fed can effectively replace corn in growing cattle diets, though its value is somewhat greater in high-roughage as compared to high-concentrate diets.

**Table 1. Compositions of Experimental Diets (% of Dry Matter)**

| | Diet | | | |
|---|---|---|---|---|
| Item | Limit-Fed Corn[ab] | Limit-Fed Corn Gluten Feed[ab] | Roughage plus Corn[c] | Roughage plus Corn Gluten Feed[c] |
| Alfalfa hay | 15.12 | 14.37 | 59.12 | 57.43 |
| Dry-rolled corn | 67.74 | - | 36.12 | - |
| Corn gluten feed | - | 82.59 | - | 42.14 |
| Dehulled soybean meal | 10.78 | - | - | - |
| Cane molasses | 4.03 | - | 4.16 | - |
| Limestone | 1.00 | 2.53 | - | - |
| Urea, 46% N | .69 | - | - | - |
| Salt | .35 | .35 | .30 | .30 |
| Calcium phosphate | .20 | - | .23 | - |
| Vitamin/mineral premix | .09 | .16 | .07 | .13 |
| Dry matter | 88.06 | 65.55 | 85.48 | 73.56 |
| Crude protein | 16.33 | 21.67 | 13.54 | 19.71 |
| Calcium | .72 | 1.13 | .93 | .83 |
| Phosphorus | .35 | .91 | .30 | .59 |
| Thiamin, ppm | - | 15.11 | - | 12.97 |

[a]Supplemented with or without 10 g per head daily of ruminally protected lysine.

[b]Limit-fed diets formulated to provide 1.4 IU/lb added vitamin A, .12 ppm added Co, 10 ppm added Cu, .6 ppm added I, 60 ppm added Mn, .25 ppm added Se, 60 ppm added Zn, and 30 g/ton Rumensin®.

[c]Full-fed diets formulated to provide 1.2 IU/lb added vitamin A, .10 ppm added Co, 8 ppm added Cu, .5 ppm added I, 50 ppm added Mn, .2 ppm added Se, 50 ppm added Zn, and 25 g/ton Rumensin®.

**Table 2. Performance of Heifers Fed Roughage-Based or High-Concentrate Diets with Corn or Corn Gluten Feed**

| Treatment | Dry Matter Intake, lb/day | Daily Gain, lb/day | Feed:Gain |
|---|---|---|---|
| Days 0 - 13 | | | |
| Roughage + Corn | 16.23[a] | 4.37[a] | 3.74[a] |
| Roughage + CGF | 16.90[a] | 5.72[b] | 2.96[b] |
| Limit-fed Corn | 11.33[b] | 2.43[c] | 4.65[c] |
| Limit-fed Corn + Smartamine-ML | 11.48[b] | 2.41[c] | 4.76[c] |
| Limit-fed CGF | 12.04[b] | 2.93[c] | 4.13[ac] |
| Limit-fed CGF + Smartamine-ML | 12.11[b] | 2.65[c] | 4.56[c] |
| SEM | .33 | .23 | .29 |
| Days 14 - 84 | | | |
| Roughage + Corn | 18.86[a] | 2.28[a] | 8.26[a] |
| Roughage + CGF | 20.09[b] | 2.32[a] | 8.64[a] |
| Limit-fed Corn | 12.93[c] | 2.47[b] | 5.22[b] |
| Limit-fed Corn + Smartamine-ML | 12.81[c] | 2.55[b] | 5.02[b] |
| Limit-fed CGF | 12.86[c] | 1.99[c] | 6.44[c] |
| Limit-fed CGF + Smartamine-ML | 12.91[c] | 1.95[c] | 6.60[c] |
| SEM | .17 | .07 | .19 |
| Days 0 -99[d] | | | |
| Roughage + Corn | 18.96[a] | 2.52[a] | 7.52[a] |
| Roughage + CGF | 19.81[b] | 2.57[a] | 7.72[a] |
| Limit-fed Corn | 13.73[c] | 2.54[a] | 5.42[b] |
| Limit-fed Corn + Smartamine-ML | 13.64[c] | 2.57[a] | 5.30[b] |
| Limit-fed CGF | 13.69[c] | 2.27[b] | 6.02[c] |
| Limit-fed CGF + Smartamine-ML | 13.76[c] | 2.20[b] | 6.25[c] |
| SEM | .18 | .08 | .60 |

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

[d]Heifers were fed a common series of step-up rations; includes a 15-days post trial period on common diets.

# EFFECTS OF VIRGINIAMYCIN OR MONENSIN PLUS TYLOSIN ON RUMINAL FERMENTATION CHARACTERISTICS IN STEERS FED DRY-ROLLED CORN WITH OR WITHOUT WET CORN GLUTEN FEED

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## Summary

A study was conducted to evaluate effects of virginiamycin and monensin plus tylosin on ruminal fermentation characteristics in steers fed dry rolled corn-based finishing diets with or without wet corn gluten feed. Ruminal pH was higher, concentrations of volatile fatty acids were lower, and ciliated protozoal numbers were higher in steers fed diets with wet corn gluten feed. Including virginiamycin or monensin plus tylosin had few effects on the ruminal fermentation characteristics we measured. Including wet corn gluten feed appeared to stabilize the ruminal fermentation.

(Key Words: Steers, Rumen Fermentation, Virginiamycin, Monensin, Corn Gluten Feed.)

## Introduction

Feed-grade antibiotics are commonly used in feedlot diets to increase performance and reduce morbidity. Virginiamycin (V-Max®) is labeled to increase average daily gain, improve feed efficiency, and reduce liver abscess incidence in feedlot cattle. Monensin (Rumensin®) and tylosin (Tylan®) are cross-cleared for feedlot diets to improve feed efficiency and reduce the incidence of liver abscesses, respectively. Wet corn gluten feed, a fibrous by-product of the corn wet milling process, is used commonly in feedlot diets in areas where this milling industry exists. Our objectives were to compare ruminal fermentation products and protozoal counts in cattle fed dry-rolled corn-based finishing diets with or without wet corn gluten feed, virginiamycin, and monensin plus tylosin.

## Experimental Procedures

Six ruminally cannulated Holstein steers with an initial body weight of 760 lb were used in a 6 × 6 Latin square design to evaluate a 2 × 3 factorial arrangement of treatments. Treatments consisted of two diets: 1) CORN+SBM diet containing (% of dry matter) dry rolled corn (72), soybean meal (12), alfalfa hay (10), and molasses (4) and 2) CORN + WCGF diet containing dry rolled corn (63), wet corn gluten feed (30), and alfalfa hay (5). The remaining 2% of the diets were minerals and vitamins. Antibiotic treatments included: 1) control (no antibiotic), 2) virginiamycin at 175 mg daily, and 3) monensin plus tylosin at 250 and 100 mg daily, respectively. Steers were fed approximately 2.4% of their empty body weight daily in two equal portions. Each period consisted of 18 days of adaptation to the diet and antibiotics followed by 2 days of ruminal fluid collections at the morning feeding and 2, 4, 6, 8, and 10 hours after. Ruminal fluid samples were analyzed for pH, volatile fatty acids, ammonia, lactic acid, and ciliated protozoa counts.

## Results and Discussion

Inclusion of virginiamycin or monensin plus tylosin had no significant effects on the remen metabolites measures or protozoa numbers (data not shown).

Including wet corn gluten feed had significant effects on ruminal fermentation (Table 1). Ruminal pH was higher; total VFA, propionate, and butyrate were lower; and the acetate to propionate ratio and molar percent acetate were higher for steers fed diets containing wet corn gluten feed.

Ruminal protozoal counts were higher in steers fed the wet corn gluten feed diet (Table 2), primarily because of increased numbers of *Entodinium* sp., but numbers of *Isotricha* sp. and *Polyplastron* sp. were lower. Wet corn gluten feed had no effect on ruminal ammonia, lactate, and acetate concentrations or molar percentages of propionate and butyrate.

The increased ruminal pH could have been due to lower ruminal VFA concentrations or to the increased ruminal protozoal counts. Ruminal protozoa are thought to stabilize rumen fermentation by sequestering starch, the primary substrate for fermentation in high grain diets, from the rumen bacteria and by reducing the rumen bacterial numbers through predation. The increases in acetate: propionate ratio and molar percent acetate were expected, because wet corn gluten feed is fibrous. Fiber is known to increase the proportion of acetate in rumen fermentation end products when compared to the fermentation of starch.

Our study indicates that dietary inclusion of wet corn gluten feed has a stabilizing effect on ruminal fermentation. This is supported by the observed increases in ruminal pH, reductions in volatile fatty acid concentrations, and increases in protozoal populations.

**Table 1. Effects of Wet Corn Gluten Feed on Rumen pH and Metabolites**

| Metabolite | Corn + Soybean Meal | Corn + Wet Corn Gluten Feed | SEM |
|---|---|---|---|
| pH[a] | 5.77 | 5.99 | .047 |
| Ammonia, mM | 7.8 | 8.1 | .74 |
| Lactate, mM | .19 | .20 | .009 |
| Total VFA[a], mM | 111.2 | 96.3 | 2.6 |
| Acetate, mM | 54.2 | 51.6 | 1.8 |
| Propionate[a], mM | 33.4 | 26.0 | 2.4 |
| Butyrate[b], mM | 18.0 | 13.8 | 1.7 |
| Acetate:propionate ratio[a] | 1.78 | 2.16 | .11 |
| Molar % acetate[a] | 49.4 | 54.0 | 1.2 |
| Molar % propionate | 29.5 | 26.4 | 1.6 |
| Molar % butyrate | 16.2 | 14.4 | 1.6 |

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

**Table 2. Effects of Wet Corn Gluten Feed on Rumen Protozoal Counts (× $10^3$/g Ruminal Content)**

| Item | Corn+ Soybean Meal | Corn+Wet Corn Gluten Feed | SEM |
|---|---|---|---|
| *Dasytricha* sp. | 1.8 | 2.1 | .68 |
| *Isotricha* sp.[a] | 2.9 | 1.8 | .39 |
| *Entodinium* sp.[a] | 337 | 1063 | 129 |
| *Polyplastron* sp.[a] | 1.2 | .30 | .32 |
| Total Protozoa[a] | 343 | 1068 | 129 |

[a]Diet effect (P<.05).

# EFFECTS OF GRAIN TYPE ON GROWTH AND PERFORMANCE OF STEERS LIMIT-FED GRAIN-BASED DIETS [1]

***R. D. Hunter, E. C. Titgemeyer, J. S. Drouillard, and T. Nutsch***

## Summary

Five hundred fifty two steers were used in a growth experiment designed to evaluate the use of grain sorghum in a limit-feeding program. Dry-rolled corn, dry-rolled grain sorghum, steam-flaked grain sorghum, or combinations of grains totaled 70% (dry matter basis) of the diet. Daily intakes were restricted to 2% of body weight (dry matter basis). Cattle were fed their assigned diet for 95 days followed by a 5-day period on a common diet to compensate for differences in gut fill. Steam-flaked grain sorghum and dry-rolled corn yielded similar gain efficiencies and average daily gains. Dry-rolled grain sorghum, however, had 71% the value of dry-rolled corn and 72% the value of steam-flaked grain sorghum. These values became 80% and 83% when the 5 days on a common diet were considered. No significant associative effects were observed for the combinations of grains. The data clearly indicate that grains that are slowly fermented (i.e. dry-rolled grain sorghum) are less desirable in a limit-feeding program. Differences among grains observed in full-fed, finishing diets will likely be as great or greater with high-grain, limit-fed diets. Consequently, extensive processing of grain sorghum would be as beneficial in a limit-fed ration for growing cattle as it is perceived to be in a full-fed, finishing diet.

(Key Words: Grain Sorghum, Limit Feeding, Grain Processing.)

## Introduction

Feeding growing cattle high grain diets at restricted intakes is becoming increasingly popular among commercial cattle feeders. This method offers several advantages. First, feeding diets at restricted dry matter intakes increases the digestibility of the feed. Second, concentrates are generally less expensive per unit of energy than roughages. Third, animals fed grain-based diets produce less manure.

The value of grain sorghum as an energy source in full-fed, finishing diets has been well defined in numerous feeding trials in the past 30 years. It is generally accepted that steam flaking improves the value of grain sorghum more than any other grain type for finishing diets. However, the feeding value of grain sorghum in limit-fed growing diets has not been well defined. Under conditions of limit feeding, the rate of passage of digesta from the rumen may be slower, thus allowing for more time for microbial digestion of the feed. Grain sorghum has a starch-protein matrix that renders it more resistant to breakdown by the microbes than grains like wheat, barley, or corn. Slower passage rates presumably would be better suited to slowly fermented grains like grain sorghum. In addition, combinations of grains with different fermentation rates may be more beneficial than single grains. Because cattle on limit-fed diets consume their feed quickly, they may be predisposed to digestive disturbances. Thus, feeding diets containing combinations of rapidly fermented steam-flaked

[1]Financial support from the Kansas Grain Sorghum Commission is greatly appreciated.

grains and slowly fermented dry-rolled grains may offer advantages.

## Experimental Procedures

Five hundred fifty two steers were used in a growth study to compare performance when they were fed diets containing steam-flaked and(or) dry-rolled grain sorghum relative to dry-rolled corn. The steers' average initial weight was 640 lb. Steers were allotted to 24 pens (23 head per pen) on the basis of weight, breed type, and previous diet in order to create pens that were as uniform as possible. The steers were assigned to one of six diets (Table 1).

Diets were fed at 2% of body weight on a dry matter basis. Feed intakes were calculated at the beginning of the study and adjusted once each week assuming that cattle would gain 2 lb/day. The experimental diets were fed for 95 days. A common diet was fed for 5 days at the end of the study in an attempt to equalize gut fill.

The grain sorghum was steam processed at the Kansas State University Beef Cattle Research Center mill using 18 in. × 24 in. rolls corrugated with 16 corrugations/inch and with a 96 cubic foot steam chest. The grain sorghum was conditioned for 90 minutes and flaked to a density of 23 lb/bu.

## Results and Discussion

No significant associative effects were observed for the grain combinations, indicating that the grain mixes performed similarly to the average of the two grains fed individually. Consequently, only differences among the three grain types are discussed.

Feed intakes for cattle fed the steam-flaked grain sorghum were about 2% higher than for the other grains because of slight variations in dry matter from the predicted levels. This was true both at the end of the treatments and after feeding the common diet.

Daily gains of cattle fed dry-rolled corn and steam-flaked grain sorghum were similar. However, steers fed dry-rolled grain sorghum grew slower than steers fed dry-rolled corn or steam-flaked grain sorghum. Steers on dry-rolled grain sorghum gained only 72% as fast as cattle fed dry-rolled corn and 71% as fast as cattle fed steam-flaked grain sorghum. The trend remained after the 5-day gut fill equalization period, with dry-rolled grain sorghum leading to gains of 80% of those from dry-rolled corn and 83% of those from steam-flaked grain sorghum. Similarly, efficiency of gain was poorest for cattle fed the dry-rolled grain sorghum.

Differences between dry-rolled sorghum and other grains were much larger than expected, based on data from finishing trials. Possibly the rate of passage is not slowed in limit feeding and, in fact, may be increased because limit-fed animals consume their daily allotments of feed in a few hours. This could explain the wider margin between the grains in this study.

Feeding management becomes very critical with steam-flaked grain sorghum diets. Consistent feeding is also more critical with limit-fed rations. When these two are combined, severe problems can occur if feeding time or ration changes. We experienced more pen deaths with the diets containing steam-flaked grain sorghum, although most were explained by poor weather and pen conditions inducing pneumonia. At least one animal fed steam-flaked grain sorghum died from a digestive problem. Whether diet impacted the occurrence of pneumonia is unknown.

We also expected to see benefits from combining slowly fermented dry-rolled grain with processed grain. However, no associative effects were observed, which indicates that some of our ideas of ruminal conditions with limit-fed high grain diets may be incorrect. If passage rate is actually faster for limit-fed than for full-fed cattle, we may not see benefits from grain combinations.

**Table 1. Experimental Diets (% of Dry Matter)**

| | Grain type | | | | | |
|---|---|---|---|---|---|---|
| Ingredient | DRC | DRM | SFM | ½DRM ½DRC | ½SFM ½DRC | ½SFM ½DRM |
| Alfalfa | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 | 15.0 |
| Dry-rolled corn (DRC) | 70.2 | — | — | 35.1 | 35.1 | — |
| Dry-rolled grain sorghum (DRM) | — | 70.2 | | 35.1 | — | 35.1 |
| Steam-flaked grain sorghum (SFM) | — | — | 70.2 | — | 35.1 | 35.1 |
| Soybean meal | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 | 8.0 |
| Molasses | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 | 4.0 |
| Urea | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Ammonium sulfate | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Limestone | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| Calcium phosphate | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Vitamins/minerals[a] | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |

[a] Formulated to add to the diet (dry basis): 1200 IU/lb vitamin A, 10 IU vitamin E, 0.35% salt, 0.05 ppm Co, 10 ppm Cu, 0.6 ppm I, 0.2 ppm Fe, 60 ppm Mn, 0.25 ppm Se, 60 ppm Zn, 30 g/ton monensin, and 10 g/ton tylosin.

**Table 2. Effect of Grain Type on Performance of Steers Limit-Fed Grain-Based Diets**

| | Grain Type | | | | | | |
|---|---|---|---|---|---|---|---|
| Item | DRC | DRM | SFM | ½DRM ½DRC | ½SFM ½DRC | ½SFM ½DRM | SEM |
| Daily gain, lb/day | | | | | | | |
| 0-95 days | 2.13[b] | 1.53[a] | 2.17[b] | 1.78 | 2.23 | 1.99 | 0.091 |
| 0-100 days | 2.36[b] | 1.89[a] | 2.28[b] | 2.01 | 2.41 | 2.18 | 0.097 |
| Feed intake, lb/day | | | | | | | |
| 0-95 days | 14.27[a] | 14.30[a] | 14.60[b] | 14.16 | 14.27 | 14.42 | 0.09 |
| 0-100 days | 14.43[a] | 14.43[a] | 14.78[b] | 14.31 | 14.42 | 14.56 | 0.091 |
| Feed:gain[c] | | | | | | | |
| 0-95 days | 6.71[b] | 9.35[a] | 6.71[b] | 7.94 | 6.37 | 7.25 | |
| 0-100 days | 6.10[b] | 7.63[a] | 6.49[b] | 7.14 | 5.99 | 6.67 | |

DRC=dry-rolled corn, DRM=dry-rolled grain sorghum, SFM=steam-flaked grain sorghum. All performance characteristics were calculated with dead animals removed from the analysis. Cattle were fed treatments for 95 days and then switched to a common diet for 5 days to equalize gut fill.
[a,b]Single grain types with different superscripts differ ($P<.05$). For the characteristics in this table, none of the grain combinations differed significantly from the average of the two grains fed singly.
[c]Statistically analyzed as gain:feed, but the inverse is reported here.

*Cattlemen's Day 1999*

# LIMITING AMINO ACIDS FOR GROWING CATTLE FED DIETS BASED ON SOYBEAN HULLS

*H. Greenwood, E. C. Titgemeyer, and C. A. Löest*

## Summary

Ruminally cannulated Holstein steers were used in three nitrogen balance experiments to determine the sequence of limiting amino acids for growing steers fed soybean hull-based diets. The steers in all experiments were fed the same basal diet (73% soybean hulls, 19% alfalfa, DM basis; formulated to minimize rumen undegradable intake protein and thus maximize microbial protein postruminally) and were given the same intraruminal infusions (400 grams per day acetate; to increase energy supply without increasing microbial protein supply). In experiment 1, treatments consisted of abomasal infusions of: water (control, no amino acids); L-methionine; and a mixture of 10 essential amino acids. Nitrogen retention (a measure of protein deposition) was greatest for steers receiving the mixture, and steers receiving methionine alone had greater nitrogen retention than control steers. In experiment 2, treatments consisted of abomasal infusions of the mixture of 10 essential amino acids or the same mixture without lysine. Nitrogen retention tended to be greater for the 10 amino acid mixture than for the mixture without lysine. In experiment 3, threonine, rather than lysine, was removed from the amino acid mixture. Nitrogen retention was not affected by removal of threonine. We conclude that methionine was the first limiting amino acid, threonine was not limiting, lysine appeared to be a limiting amino acid, and one or more untested amino acids in the mixture appeared to be second most limiting. Therefore, our data do not support the generally accepted concept that the sequence of limiting amino acids for steers is methionine, lysine, and threonine when microbial protein is the primary contributor to metabolizable (postruminal) protein.

(Key Words: Steers, Requirements, Amino Acids, Nitrogen Balance, Soybean Hulls.)

## Introduction

The use of soybean hulls in growing cattle diets has become popular for economical and nutritional reasons. They are relatively inexpensive and have been shown to provide slightly less energy than corn in certain grower diets. Additionally, the protein fraction of soybean hulls is considered to be highly ruminally degradable, such that they should supply growing cattle with metabolizable (postruminal) protein predominantly of bacterial origin.

Quantifying the limiting amino acid sequence of bacterial crude protein is important, because protein accretion may be limited by postruminal amino acid supply. Knowing the limiting amino acid sequence for steers fed soybean hull-based diets would allow nutritionists to supplement such diets to meet the animals' requirements and maximize protein accretion. Our objective was to determine the limiting amino acid sequence for growing cattle fed soybean hull-based diets.

## Experimental Procedures

Experiment 1 used five steers (440 lb) in a replicated 3 × 3 Latin square with one missing steer. Periods were 7 days with 3 days for adaptation and 4 days for collection of feces and urine. Steers were housed in individual metabolism crates and received 7.5 lb/day (as fed) of the basal diet (Table 1)

in two equal portions. The diet was formulated to minimize ruminally undegradable intake protein supply, thus maximizing microbial protein postruminally. Intraruminal infusion of 400 grams/day of acetate was provided to each steer to increase the energy supply without increasing microbial protein supply. Treatments consisted of abomasal infusions of (grams/day): a) water (control, no amino acids); b) L-methionine (10); and c) a mixture of 10 amino acids that included L-methionine (10), L-lysine (15.8), L- histidine (7.4), L-phenylalanine (10), L-tryptophan (4.9), L-leucine (20), L-isoleucine (10), L-valine (10), L-arginine (10), and L-threonine (10).

**Table 1. Composition of the Basal Diet**

| Ingredient | % of DM |
|---|---|
| Soyhulls | 72.6 |
| Alfalfa | 19.4 |
| Molasses | 4.8 |
| Dicalcium phosphate (16.5% Ca, 21% P) | 1.6 |
| Sodium bicarbonate | .8 |
| Magnesium oxide | .3 |
| Trace mineralized salt | .17 |
| Vitamin mixture | .17 |
| Elemental sulfur | .16 |

Experiment 2 used five steers in a 2-period crossover design. Diets, intraruminal infusions, and experimental conditions were similar to those in experiment 1. Treatments included the same amino acid mixture and the mixture with lysine deleted (9 amino acids).

Experiment 3 used six steers (427 lbs) in a 2-period crossover design with procedures similar to those experiments 1 and 2 except steers were fed 7.7 lb/day (as fed) of the basal diet. Treatments included the 10 amino acid mixture, with lysine increased from 15.8 to 19.7 grams/day, or the mixture with threonine deleted (9 amino acids).

## Results and Discussion

**Experiment 1**. Nitrogen retention (Table 2) was greatest (P<.05) for steers that received all 10 of the amino acids (13.7 grams/day). Steers that received only methionine had greater (P<.05) nitrogen retention (7.9 grams/day) than control steers (5.4 grams/day). The increase in nitrogen retention when methionine alone was provided illustrates that methionine was the first limiting amino acid. The additional increase in nitrogen retention when all 10 amino acids were provided indicates that one or more of the other amino acids in the mixture besides methionine also was limiting.

**Table 2. Nitrogen Balance of Steers Supplemented with Amino Acids (Exp. 1)**

| Nitrogen | No AA[1] | Methionine | 10 AA[1] | SEM |
|---|---|---|---|---|
| | -------- (grams/day) ------- | | | |
| Intake | 57.3[c] | 58.2[b] | 73.6[a] | .02 |
| Fecal | 26.5 | 25.9 | 27.8 | .75 |
| Urinary | 25.4[b] | 24.4[c] | 32.1[a] | .27 |
| Retention | 5.4[c] | 7.9[b] | 13.7[a] | .66 |

[1]AA= amino acids.

[a, b, c]Means within rows without common superscript differ (P<.05).

**Experiment 2**. Steers receiving all 10 amino acids (Table 3) tended (P<.09) to have greater nitrogen retention (19.0 grams/day) than those receiving the mixture without lysine (16.3 grams/day). This illustrates that the basal lysine supply limited protein deposition. However, the decrease in nitrogen retention when lysine was removed from the mixture (2.7 grams/day) was less then that observed when the remaining nine amino acids were removed in experiment 1 (5.8 grams/day), indicating that lysine was not the second most limiting amino acid, but rather that one or more of the other amino acids in the mixture was more limiting than lysine.

**Experiment 3**. Nitrogen retention (Table 4) was not different between steers receiving all 10 amino acids (17.8 grams per day) or those receiving the mixture without threonine (17.3 grams per day), illustrating that protein deposition was not limited by threonine supply.

**Table 3. Nitrogen Balance of Steers Supplemented with Amino Acids (Exp. 2)**

| Nitrogen | Without Lysine | With Lysine | SEM |
|---|---|---|---|
| | --- (grams/day) ---- | | |
| Intake | 73.2[b] | 76.0[a] | .13 |
| Fecal | 28.5 | 29.3 | .33 |
| Urinary | 28.4 | 27.7 | .43 |
| Retention | 16.3[d] | 19.0[c] | .74 |

[a,b]Means within rows without common superscript differ (P<.05).
[c,d]Means within rows without common superscript differ (P<.09).

We conclude that methionine was the first limiting amino acid and that threonine was not limiting for steers fed soybean hull-based diets. Lysine appeared to be a limiting amino acid, but one or more of the untested amino acids in the mixture appeared to be second most limiting. Our data do not support the generally accepted concept that the sequence of limiting amino acids for steers is methionine, lysine, and threonine when microbial protein is the primary source of metabolizable protein.

**Table 4. Nitrogen Balance of Steers Supplemented with Amino Acids (Exp. 3)**

| Nitrogen | Without Threonine | With Threonine | SEM |
|---|---|---|---|
| | ----- (grams/day) ------- | | |
| Intake | 78.2 | 79.4 | |
| Fecal | 31.8 | 32.7 | .53 |
| Urinary | 29.0 | 28.8 | .55 |
| Retention | 17.3 | 17.8 | .26 |

*Cattlemen's Day 1999*

# ROLE OF METHIONINE AS A METHYL GROUP DONOR IN CATTLE

*C. A. Löest, E. C. Titgemeyer, and R. H. Greenwood*

## Summary

Holstein steers were used in two 5 × 5 Latin square experiments to evaluate the sparing of methionine by alternative sources of methyl groups (betaine or choline). Steers were housed in metabolism crates and limit fed a diet high in rumen degradable protein. To increase energy supply, volatile fatty acids were infused into the rumens, and glucose was infused into the abomasum. An amino acid mixture, limiting in methionine, was infused abomasally to ensure that non-sulfur amino acids did not limit protein synthesis. Treatments for Exp. 1 were abomasal infusion of 1) water (control), 2) 2 g/day additional L-methionine, 3) 1.7 g/day L-cysteine, 4) 1.6 g/day betaine, and 5) 1.7 g/day L-cysteine + 1.6 g/day betaine. Treatments for Exp. 2 were abomasal infusion of 1) water (control), 2) 2 g/day additional L-methionine, 3) 8 g/day betaine, 4) 16 g/day betaine, and 5) 8 g/day choline. In both experiments, nitrogen retention increased ($P<.05$) in response to methionine, demonstrating a deficiency of sulfur amino acids. Responses to cysteine, betaine and choline were small. The low response to cysteine indicates that either the response to methionine is not due to transsulfuration to cysteine, or that cysteine supply does not alter the flux of methionine through transsulfuration. The small responses to betaine and choline suggest that they do not substitute for methionine. Thus, under our experimental conditions, responses to methionine likely were due to a correction of a deficiency of methionine per se rather than of methyl group donors.

(Key Words: Methionine, Cysteine, Betaine, Choline, Steers.)

## Introduction

Methionine is an essential amino acid often identified as limiting for growing ruminants. Methionine functions as a precursor for protein synthesis, and a deficiency of this amino acid can cause inefficient use of dietary protein for lean muscle (protein) deposition. However, methionine has many other functions in the body, including methyl group donation and use for cysteine and polyamine biosynthesis.

More than half the methionine requirement of rats can be replaced by cysteine. However, recent research with cattle has indicated that cysteine does not effectively spare methionine. The lack of response to cysteine may have been due to methyl groups being limiting, such that methionine was needed as a methyl group donor. Therefore, our objective was to evaluate the sparing of methionine by alternative sources of methyl groups (betaine or choline).

## Experimental Procedures

**Experiment 1.** Five ruminally cannulated Holstein steers (343 lb initial BW) were maintained in metabolism crates to facilitate total collection of feces and urine. Steers were limit fed (5.3 lb/day, dry basis) a diet based on soybean hulls (84% soybean hulls, 7% wheat straw, 3% molasses, 5% minerals/vitamins, and 0.5% urea). This diet was formulated to contain a low amount of undegradable intake protein so that only limited amounts of dietary amino acids were available postruminally. To increase energy supply without increasing ruminal microbial growth, steers received a continuous infusion of volatile fatty acids (180 g acetate, 180 g

propionate, and 45 g butyrate/day) into the rumen and a continuous infusion of glucose (300 g/day) into the abomasum. Also, an amino acid mixture containing 150 g L-glutamate; 50 g glycine; 20 g L-valine; 30 g L-leucine; 20 g L-isoleucine; 40 g L-lysine-HCl (feed grade, 79.8%); 10 g L-histidine-HCl-$H_2O$ (74%); 20 g L-arginine; 20 g L-threonine (feed grade, 98%); 35 g L-phenylalanine; 7 g L-tryptophan (feed grade, 98%); and 2 g L-methionine per day was infused continuously into the abomasum to ensure that nonsulfur amino acids did not limit tissue protein synthesis. The abomasal infusions were made by placing flexible tubing (inside diameter: 1/16 in.) through the rumen cannula and the reticulo-omasal orifice.

A 5 × 5 Latin square design was used with periods of 7 days. This allowed for a 2-day adaptation to the abomasal infusions and 5 days for total collection of feces and urine. Treatments were abomasal supplementation with 1) water (control), 2) 2 g/day additional L-methionine, 3) 1.7 g/day L-cysteine, 4) 1.6 g/day betaine, and 5) 1.7 g/day L-cysteine + 1.6 g/day betaine. The L-cysteine and betaine were provided in amounts that were equimolar to the L-methionine supplement. Only four observations were obtained for the 1.7 g/day L-cysteine + 1.6 g/day betaine treatment because of an infusion problem in the last period.

**Experiment 2.** Five ruminally cannulated Holstein steers (348 lb initial BW) were used in a design similar to Exp. 1 and were housed in similar conditions. They were limit-fed 5.5 lb/day, dry basis.

Treatments were abomasal supplementation with 1) water (control), 2) 2 g/day additional L-methionine, 3) 8 g/day betaine, 4) 16 g/day betaine, and 5) 8 g/day choline. The betaine was provided in amounts that were 5 and 10 times the amount in Exp. 1 in order to test the efficiency of betaine as a methyl group donor. Choline was infused to examine its role as an alternative methyl group donor.

## Results and Discussion

**Experiment 1.** Increases in retained nitrogen were due to decreases in urinary nitrogen excretion (Table 1). Nitrogen retention increased in response to supplementation with 2 g/day methionine ($P<.05$), but responses to equimolar amounts of cysteine and betaine alone or in combination were less dramatic. The response to methionine verifies the sulfur amino acid-deficient conditions intentially created by our model, whereas the low response to cysteine supplementation may indicate that the response to additional methionine supplementation is not due to conversion of methionine to cysteine. However, both cysteine and betaine tended ($P<.16$) to increase nitrogen retention relative to the control treatment. Because of the insignificant response to methyl groups (betaine), the sparing of methionine by methyl donors could not be demonstrated. However, replacement of methionine by betaine appeared to be relatively inefficient (the response to betaine was 20% as large as that to methionine). Therefore, we hypothesized that more betaine may be required to yield responses similar to that observed for methionine.

**Experiment 2.** As in Exp. 1, observed increases in retained nitrogen resulted from decreases in urinary nitrogen excretion (Table 2). Also, large increases in retained nitrogen occurred for steers supplemented with 2 g/day methionine ($P<.05$). However, betaine infused at levels that were 5 and 10 times higher than that supplied in Exp. 1 only tended ($P<.22$) to increase nitrogen retention. Nitrogen balance responses were only 23% (for 8 g/day betaine) and 20% (for 16 g/day betaine) as large as that observed for methionine. These responses were similar to that for the lower level of betaine in Exp. 1. Choline also failed to improve nitrogen balance.

Under our experimental conditions, responses to methionine likely were due to a correction of a deficiency of methionine per se rather than its role as a methyl group donor.

**Table 1. Nitrogen Balance of Steers Supplemented with Methionine, Cysteine, and/or Betaine**

| | Treatments[a] | | | | | |
|---|---|---|---|---|---|---|
| **Item** | Control | MET-2 | CYS-1.7 | BET-1.6 | BET-1.6 + CYS-1.7 | SEM |
| No. observations | 5 | 5 | 5 | 5 | 4 | |
| Nitrogen | ---------- g of N/day ---------- | | | | | |
| Intake | 101.1 | 101.4 | 101.5 | 101.5 | 101.6 | .12 |
| Fecal | 22.4 | 22.9 | 24.0 | 23.7 | 24.1 | .54 |
| Urinary | 59.0[b] | 51.9[c] | 56.6[b] | 56.8[b] | 56.1[b] | 1.01 |
| Retained | 19.7[c] | 26.6[b] | 21.0[c] | 21.0[c] | 21.4[c] | .64 |

[a]MET-2 = 2 g/day methionine, CYS-1.7 = 1.7 g/day cysteine, and BET-1.6 = 1.6 g/day betaine.
[b,c]Means not bearing common letter differ (P<.05).

**Table 2. Nitrogen Balance of Steers Supplemented with Methionine, Betaine, or Choline**

| | Treatments[a] | | | | | |
|---|---|---|---|---|---|---|
| Item | Control | MET-2 | BET-8 | BET-16 | CHO-8 | SEM |
| No. observations | 5 | 5 | 5 | 5 | 5 | |
| Nitrogen | ---------- g of N/day ---------- | | | | | |
| Intake | 97.3[f] | 97.5[e] | 98.3[c] | 99.3[b] | 98.0[d] | .06 |
| Fecal | 22.8 | 22.0 | 23.8 | 23.1 | 22.9 | .64 |
| Urinary | 54.5[b] | 46.2[c] | 52.4[b] | 54.3[b] | 54.8[b] | 1.03 |
| Retained | 20.0[c] | 29.3[b] | 22.2[c] | 21.9[c] | 20.4[c] | 1.02 |

[a]MET-2 = 2 g/day methionine, BET-8 = 8 g/day betaine, BET-16 = 16 g/day betaine, and CHO-8 = 8 g/day choline.
[b,c,d,e,f]Means not bearing common letter differ (P<.05).

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# EFFECTS OF SUPPLEMENTAL CARNITINE ON NITROGEN BALANCE AND BLOOD METABOLITES OF GROWING BEEF STEERS FED A HIGH-PROTEIN, CORN-BASED DIET

*R. H. Greenwood, E. C. Titgemeyer, and G. L. Stokka*

## Summary

Seven Angus-cross steers (475 lbs initial body weight) were used in a 7 × 4 incomplete Latin square experiment to evaluate the effects of supplemental L-carnitine on nitrogen balance and blood metabolites. Steers were fed the same high-protein, corn-based diet near ad libitum intake. Treatments were control and .25, .5, 1.0, 1.5, 2.0, and 3.0 grams/day of supplemental carnitine. Experimental periods were 18 days with 13 days for adaptation and 5 days for collection of feces and urine. Blood was collected at feeding and 3 and 6 hours after feeding on day 18 of each period. Supplementing steers with carnitine increased urinary carnitine excretion and plasma carnitine concentration. Nitrogen retention (a measure of protein deposition) was not affected by carnitine supplementation and averaged 29.3 g/d. Plasma insulin and glucagon, indicative of energy status, and cholesterol and triglyceride, representative of energy storage metabolites, were not affected by carnitine supplementation. Plasma glycerol and beta-hydroxybutyrate, reflective of fat catabolism, increased with intermediate levels of supplemental carnitine. In conclusion, carnitine supplementation did not alter N balance in our experiment, but it did alter some of the plasma metabolites of steers fed high-protein, corn-based diets.

(Key Words: Growing Steers, Carnitine, Nitrogen Balance, Plasma Metabolites.)

## Introduction

Newly weaned calves generally are limit-fed high-energy (corn-based) diets or fed low-energy (forage-based) diets ad libitum to restrict growth before they enter the finishing phase. These dietary regimens are implemented to increase the proportion of gain that is lean and decrease the proportion that is fat. Although this restricted growth optimizes finishing performance, it lengthens the time cattle must be fed to achieve market weight.

Carnitine is a vitamin-like compound required to metabolize fat for energy. It can either be produced by the body (de novo) or absorbed from the diet. However, negligible amounts of carnitine are found in common feedstuffs. Supplemental carnitine potentially could serve as a repartitioning agent by increasing fat utilization for energy, thereby increasing lean gain at the expense of fat deposition. This would allow growing cattle to be given ad libitum access to high-energy diets without causing excessive fat deposition, which would reduce the days required for cattle to achieve market weights. Our objectives were to evaluate the effects of supplemental L-carnitine on nitrogen balance and key blood metabolites.

## Experimental Procedures

Seven Angus-cross steers (475 lbs initial body weight) were used in a 7 × 4 incomplete Latin square design with seven treatments and four periods. Experimental periods were 18 days with 13 days for adaptation and 5 days for collection of feces and urine. Steers were housed in metabolism crates and fed a high-protein, corn-based diet at 2.5% of BW daily (Table 1).

Treatments were control and .25, .5, 1.0, 1.5, 2.0, and 3.0 grams/ day of supplemental carnitine provided as Carniking® (Lonza). Blood was collected at feeding and 3 and 6

hours after feeding on day 18 of each period. Only three observations were obtained for .25 grams carnitine/ day.

**Table 1. Composition of the Basal Diet[ab]**

| Ingredient | % of Dry Matter |
|---|---|
| Rolled corn | 71.9 |
| Alfalfa | 10.0 |
| Blood meal | 4.0 |
| Corn gluten meal | 4.0 |
| Molasses | 4.0 |
| Soybean meal | 2.1 |
| Tallow | 1.6 |
| Urea | .4 |
| Minerals/vitamins | 2.0 |

[a]Diet contained (dry matter basis): Ca .75%, P .35%, Mg .20%, K .70%, Na .17%, S .20%, Cl .45%, vitamin A 1.16 KIU/lb, monensin 29 g/ton, tylosin 9.7 g/ton.

[b]Added to diet (dry matter basis): Co .03 ppm, Cu 8.1 ppm, I .41 ppm, Fe 132 ppm, Mn 40 ppm, Se .23 ppm,
Zn 41 ppm.

## Results and Discussion

Supplementing steers with carnitine increased (P<.01) urinary carnitine excretions (Table 2) and tended to increase (P<.07) plasma carnitine concentrations (Table 3), illustrating that at least a portion of the dietary carnitine was absorbed. Urinary carnitine excretion was increased notably when 2.0 and 3.0 grams/day of carnitine were fed.

Nitrogen retention, a measure of protein deposition, averaged 29.3 grams/day and was not affected by carnitine supplementation. This indicates that de novo and basal dietary carnitine supplies were adequate to meet the animals' requirements for maximal protein gain. Additionally, plasma urea nitrogen, reflective of protein catabolism, and alpha-amino nitrogen, reflective of circulating amino acids, were not affected by carnitine supplementation (Table 3).

Concentrations of plasma metabolites representative of energy status generally were not affected by carnitine supplementation. Insulin averaged 1.72 ng/ml; glucagon, 199.9 pg/ml; insulin-like growth factor-1, 264.3 ng/ml; cholesterol, 141.9 mg/dl; and triglycerides, 16.0 mg/dl. A significant cubic increase (P<.02) in glucose concentrations occurred, but this did not correspond to changes in insulin, which generally responds to glucose levels. Metabolites reflective of lipid metabolism increased with intermediate levels of carnitine. Plasma glycerol (P<.04) and beta-hydroxybutyrate (P<.14) increased when 1.0 to 2.0 grams/day of carnitine were fed. Plasma nonesterified fatty acids measured before feeding decreased linearly (108.7 to 92.7 μeq/L) with increasing carnitine supplementation, but they increased linearly (95.4 to 109.3 μeq/L) at 6 hours postfeeding (data not shown). This may indicate that as steers were provided more carnitine, less adipose was catabolized prefeeding, whereas more circulating lipids were metabolized postfeeding.

In conclusion, carnitine supplementation did not increase nitrogen retention but did alter some blood and plasma metabolites. Although supplementation might affect lipid metabolism, the inability of carnitine to alter hormone concentrations or protein deposition raises questions about the importance of alterations in these factors.

**Table 2. Effects of Carnitine Supplementation on Nitrogen Balance and Urinary Carnitine Excretion**

| | Carnitine (grams/day) | | | | | | | | Contrast (P=)[a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | 0 | .25 | .50 | 1.0 | 1.5 | 2.0 | 3.0 | SEM[b] | L | Q | C |
| n[c] | 4 | 3 | 4 | 4 | 4 | 4 | 4 | | | | |
| Nitrogen | | | | | | | | | | | |
| Intake, g/day | 165.4 | 167.3 | 153.7 | 167.9 | 174.3 | 170.2 | 158.0 | 5.5 | .96 | .12 | .14 |
| Feces, g/day | 36.4 | 34.3 | 33.4 | 35.7 | 37.7 | 36.9 | 35.5 | 1.1 | .32 | .31 | .07 |
| Urine, g/day | 96.5 | 108.8 | 94.6 | 99.9 | 103.2 | 102.4 | 96.5 | 5.1 | .78 | .47 | .70 |
| Retention, g/day | 32.4 | 24.1 | 25.7 | 32.3 | 33.5 | 31.0 | 26.1 | 3.4 | .99 | .21 | .22 |
| Digestibility, % | 77.9 | 79.5 | 78.4 | 79.0 | 78.4 | 78.1 | 77.6 | .76 | .31 | .47 | .49 |
| Urine carnitine, mg/d | 46 | 62 | 30 | 90 | 119 | 180 | 428 | 31.8 | .001 | .003 | .66 |

[a]L= linear, Q= quadratic, C= cubic.

[b]For n= 4.

[c]n= number of observations per treatment.

**Table 3. Effects of Carnitine Supplementation on Plasma and Blood Metabolites**

| | Carnitine (grams/day) | | | | | | | | Contrast (P=)[a] | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Item | 0 | .25 | .50 | 1.0 | 1.5 | 2.0 | 3.0 | SEM[b] | L | Q | C |
| n[c] | 4 | 3 | 4 | 4 | 4 | 4 | 4 | | | | |
| Plasma | | | | | | | | | | | |
| Carnitine, nmol/ml | 58 | 54 | 75 | 65 | 74 | 82 | 79 | 9.8 | .07 | .46 | .92 |
| Insulin, ng/ml | 1.59 | 1.94 | 1.49 | 1.70 | 1.83 | 1.70 | 1.77 | .26 | .75 | .97 | .98 |
| Glucagon, pg/ml | 195 | 204 | 184 | 198 | 192 | 217 | 209 | 17 | .38 | .86 | .50 |
| IGF-1[d], ng/ml | 271 | 252 | 251 | 243 | 267 | 274 | 292 | 34 | .42 | .57 | .61 |
| Glucose, m*M* | 5.06 | 5.21 | 5.28 | 5.22 | 5.26 | 5.06 | 5.34 | .08 | .28 | .83 | .02 |
| Cholesterol, mg/dl | 141 | 127 | 130 | 151 | 157 | 145 | 142 | 10 | .31 | .22 | .58 |
| Triglyceride, mg/dl | 15.1 | 16.5 | 15.5 | 17.1 | 14.9 | 17.1 | 16.1 | .88 | .56 | .56 | .82 |
| Glycerol, mg/dl | .97 | .31 | 1.24 | 1.01 | 1.57 | 1.73 | .48 | .40 | .74 | .04 | .19 |
| NEFA[d], μeq/L | 101.9 | 97.3 | 105.1 | 107.6 | 103.2 | 97.4 | 101.4 | 3.7 | .76 | .53 | .19 |
| Urea, m*M* | 5.20 | 5.34 | 5.07 | 5.51 | 5.48 | 5.40 | 5.07 | .20 | .90 | .12 | .66 |
| ∝-amino N, m*M* | 2.84 | 2.67 | 2.66 | 2.84 | 2.85 | 2.95 | 2.81 | .15 | .43 | .63 | .30 |
| Blood | | | | | | | | | | | |
| BHBA[d], m*M* | .181 | .192 | .161 | .196 | .237 | .210 | .182 | .023 | .48 | .14 | .33 |

These values represent the means across the three sampling times (at feeding and 3 and 6 hours after feeding). Except for NEFA, no significant treatment × time interactions were observed.

[a]L= linear, Q= quadratic, C= cubic.

[b]For n= 4.

[c]n= number of observations per treatment.

[d]IGF-1= insulin-like growth factor-1; NEFA= non-esterified fatty acid; BHBA= beta-hydroxbutyrate.

# THE EFFECT OF DECREASING SORGHUM AMYLOSE CONTENT ON STEAM-FLAKING PRODUCTION CHARACTERISTICS

***J. R. Froetschner[1], K. C. Behnke[2], J. D. Hancock, and L. J. McKinney[2]***

## Summary

This experiment demonstrated no advantage in using a waxy sorghum over a conventional sorghum for steam flaking. Even though the waxy variety had a slight increase in in-vitro gas production after flaking, the benefit was outweighed by the significant increase in energy requirement and significant decrease in production rate during processing.

(Key Words: Waxy Sorghum, Steam Flaking.)

## Introduction

Sorghum is considered to have a lower feeding value than corn. That difference can be largely equalized by steam flaking. In an attempt to improve the feeding value of sorghum, varieties with altered starch compositions have been developed. Conventional sorghum starch is about 25% amylose. Waxy varieties have an amylose content near 0% and a concomitant increase in amylopectin.

In-vitro gas production is a test that mimics rumen fermentation and is used commonly to measure the extent of improvement from processes such as steam flaking or grinding. Previous data showed dramatically higher in-vitro gas production for a waxy sorghum variety compared to a conventional sorghum variety. In addition to waxy varieties, new varieties have been developed with an amylose content lower than that of conventional varieties but higher than that of waxy varieties. These varieties are known as heterowaxy.

The purpose of this experiment was to determine the steam-flaking production characteristics and in-vitro gas production potential of heterowaxy and waxy sorghum grains in comparison to conventional sorghum grain.

## Experimental Procedures

Four sorghum hybrids were obtained from NC+ Hybrids, Colwich, KS. The hybrids varied in amylose content, and the starch composition was verified by an endosperm iodine staining test. NC-262 was classified as conventional, and XFG-739 was classified as waxy. Varieties X-602 and XFG-665 were classified as heterowaxy.

The sorghum grains were cleaned prior to addition to a steam chamber located directly above a Roskamp Model K flaking mill equipped with a 25 hp drive motor. The 16.5 in. diameter × 11.7 in. wide rolls were driven at a differential of 1:1. They had a spiral of 1.5 in./foot of run and a pitch of 16.0 corrugations/in. The gap (.003 inches) was set to achieve an apparent density of 28.0 lbs./ft$^3$ using mill run sorghum prior to the start of the experiment. Prior to flaking, the sorghum was held in the steam chamber for approximately 45 minutes and exposed to steam until the temperature of the grain was approximately 185EF. Feed rate was set using mill run sorghum and was held con-

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stant for all treatments to allow for the collection of production data. Each variety was flaked independently in lots of approximately 1,500 lbs. Voltage and amperage were recorded to allow calculation of energy consumption. Samples were collected prior to cooling for the determination of apparent bulk density and in-vitro gas production. Data were analyzed with a one-way analysis of variance. Treatments were separated by the least significant difference test. Level of significance was established prior to the analysis at the 5% level.

## Results and Discussion

The results of the experiment are reported in Table 1. As the amount of amylose in the endosperm decreased, production rate decreased. The waxy variety (XFG-739) had the lowest production rate and tended to stick to the rolls. This "sticking" may have contributed to the dramatically reduced production rate. The lower production rate also contributed to the increased energy requirement per ton processed in comparison to the conventional or heterowaxy varieties.

Although gas production from raw grain was slightly higher for the waxy variety, differences were not statistically significant. For flaked grain, one of the heterowaxy varieties (XFG-665) had a significantly higher gas production value than all others tested. When gas production was expressed on a percentage increase basis (raw grain vs. flaked grain), the waxy variety had the lowest increase. The variety with the highest increase was the heterowaxy, XFG-665. However, the dramatic increase in gas production potential probably was offset by the increased energy required.

The heterowaxy variety, XFG-665 produced a significantly more dense flake than the waxy variety. No differences occurred in dry matter contents of the four varieties after flaking.

Overall, the waxy sorghum grain required significantly more energy to process and had a dramatically lower production rate than the conventional variety. Both heterowaxy varieties supported greater production rates than the waxy variety, and the heterowaxy variety XFG-665 benefitted the most from flaking as assessed by in-vitro gas production.

**Table 1. Steam Flaking Production Characteristics for Four Sorghum Varieties that Vary in Endosperm Amylose Content**

| | Variety | | | | |
|---|---|---|---|---|---|
| Item | NC-262 | X-602 | XFG-665 | XFG-739 | SE |
| Iodine staining test classification | Normal | Heterowaxy | Heterowaxy | Waxy | |
| Amylose content[c], % | 25.0 | 12.5 | 12.5 | 0.0 | - |
| Production rate, lbs/hr | 1,995[a] | 1,786[a] | 1,685[a] | 1,203[b] | 64.20 |
| Energy consumption, kWh/ton | 13.3[a] | 15.3[a] | 16.3[a] | 21.0[b] | .48 |
| Hot flake density, lbs/ft$^3$ | 27.8[a,b] | 27.7[a,b] | 29.0[a] | 27.2[b] | .25 |
| In-vitro gas production, ml gas/g DM | | | | | |
| Raw grain | 5.48 | 6.22 | 5.15 | 6.52 | - |
| Flaked grain | 9.79[a] | 10.49[a] | 11.48[b] | 9.91[a] | .14 |
| Gas production increase, % | 44.0 | 40.7 | 55.1 | 34.2 | - |
| Dry matter, % | 85.1 | 85.8 | 84.2 | 84.2 | - |

[a,b]Means within the same row with differing superscripts vary significantly (P<.05).
[c]Approximate percentage; based on information supplied by NC+ Hybrids.

# COMPARISON OF REVALOR®-S AND SYNOVEX® PLUS™ IMPLANTS FOR HEAVYWEIGHT, SHORT-FED, YEARLING STEERS

*J. S. Drouillard, G. L. Kuhl, and A. S. Flake*

## Summary

One hundred four Hereford × Angus steers averaging 897 lb were implanted with Revalor®-S or Synovex® Plus™ and fed a high concentrate diet for 82 days. Feed efficiencies and daily gains were not different between the two implant groups. Although most carcass characteristics were similar, Revalor-S tended (P<.09) to yield a higher percentage of carcasses that graded USDA Choice or better.

(Key Words: Steers, Finishing, Revalor-S, Synovex Plus.)

## Introduction

Combination implants containing estrogens and trenbolone acetate have become the industry standard because of their substantial effects on cattle growth and efficiency. Though extremely effective in producing rapid, efficient growth by feedlot cattle, these potent implants may degrade marbling and the resulting USDA quality grade. Our objective was to compare two commercially available implants, Revalor-S and Synovex Plus, when administered to heavy, short-fed, yearling steers.

## Experimental Procedures

One hundred four Hereford × Angus steers averaging 897 lb were weighed, then divided into eight groups of 13 head each. Steers received either a Revalor-S or Synovex Plus implant. Cattle were placed into eight feedlot pens and stepped up from 50% concentrate to their final finishing diet (Table 1) over 2 weeks. Cattle were fed once daily for 82 days and then slaughtered at a commercial abattoir.

Average daily gains and feed efficiencies were computed by applying a 4% pencil shrink to the final live weight, which was determined immediately before shipment, approximately 24 hours after the last feeding. Carcass data were obtained following a 24-hour chill.

**Table 1. Composition of Final Finishing Diet (Dry Basis)**

| Ingredient | Percent |
|---|---|
| Dry rolled corn | 84.84 |
| Ground alfalfa hay | 8.92 |
| Molasses-fat blend | 3.22 |
| Urea | .54 |
| Dehulled soybean meal | .13 |
| Limestone | 1.61 |
| Salt | .30 |
| Potassium chloride | .35 |
| Trace mineral/ vitamin premix[1] | .09 |

[1]Provided 1 IU/lb vitamin A, .04 ppm cobalt, 10 ppm copper, .5 ppm iodine, 50 ppm manganese, .2 ppm selenium, 50 ppm zinc, 28 grams/ton Rumensin®, and 8 grams/ton Tylan®.

## Results and Discussion

Performance and carcass traits for steers implanted with Revalor-S and Synovex Plus are shown in Table 2. Feed intakes and daily gains and, consequently, feed efficiencies were similar for steers implanted with Revalor-S vs. Synovex Plus. Most carcass characteristics were unchanged as a result of type of implant used. However, the Revalor-S groups tended (P<.09) to have a higher percent of carcasses graded USDA Choice or better than those implanted with Synovex Plus.

These results suggest that Revalor-S and Synovex Plus yield comparable growth performance in heavy, short-fed, yearling steers. However, under those circumstances, Revalor-S may improve carcass grade.

**Table 2. Performance and Carcass Characteristics of Finishing Steers**

| Item | Revalor-S | Synovex Plus | SEM |
|---|---|---|---|
| No. head (pens) | 52 (4) | 52 (4) | |
| Initial weight, lbs | 896 | 898 | 42 |
| Dry matter intake, lb | 23.4 | 22.8 | .98 |
| Average daily gain, lb | 3.47 | 3.48 | .11 |
| Feed:gain | 6.71 | 6.52 | .25 |
| Hot carcass weight, lb | 723.4 | 728.2 | 4.8 |
| Carcass-adjusted average daily gain, lb[1] | 3.42 | 3.49 | .13 |
| USDA yield grade | 2.35 | 2.23 | .09 |
| USDA Choice or better, %[2] | 73.1 | 46.2 | 6.4 |
| Dark cutter, % | 0 | 0 | 0 |
| Fat over 12$^{th}$ rib, in. | .42 | .40 | .02 |
| Rib-eye area, square in. | 12.5 | 12.6 | .2 |
| Kidney, pelvic & heart fat, % | 2.40 | 2.36 | .05 |
| Marbling score | Small[13] | Slight[96] | 11 |

[1]Computed using hot carcass weight divided by a common dressing percentage (61.5%) as the final live weight.
[2]Revalor-S greater than Synovex Plus (P<.09).

# IMPLANT QUALITY ASSURANCE: DETECTION OF ABSCESSED IMPLANTS AND THEIR EFFECT ON FEEDLOT PERFORMANCE OF BEEF HEIFERS[1]

*M. F. Spire[2], D. A. Blasi, J. S. Drouillard, and J. M. Sargeant[2]*

## Summary

Infrared thermography (IRT) can be used successfully to differentiate abscessed implanted ears from nonimplanted ears 8 days postimplanting. Abscessed ears averaged 5.7EF warmer than nonimplanted ears when ambient temperature was 60 to 63EF. Average daily gain and feed efficiency were reduced 8.9% and 8.3%, respectively, over the 91-day feeding period for cattle with abscessed implants compared to cattle with normal implants. Dry matter intake was not affected by an abscessed implant and averaged nearly 18.0 lb/head/day for both treatment groups. Abscessed implants reduced economic return by $17.70 per head.

(Key Words: Infrared Thermography, Abscessed Implants, Feedlot Performance.)

## Introduction

Growth-promoting implants that combine strong estrogen and an androgen are reported to improve average daily gain by 14.8% and feed efficiency by 7.5% for feeder heifers. They are intended to be placed aseptically as a series of pellets in the subcutaneous tissue of the middle one-third of the back of the ear. Feedlot implant audits by Fort Dodge Animal Health for 1996 and 1997 found 6.0% (range by state = 2.2 to 33.3%) of 109,388 implants to be classified as problem implants: abscessed following placement; missing at audit; or improperly placed in the ear, such as bunching or crushing of pellets or pellets placed in the cartilage. Abscess formation and its sequelae accounted for over 60% of the observed problem implants. The effect of abscessed implants on performance has not been well documented. This trial evaluated the thermographic appearance of ears following the placement of aseptic or septic implants in the ears of feedlot heifers and the performance of those cattle during a 91-day growing period.

## Experimental Procedures

A total of 72 British crossbred heifers (400 to 550 lb) were assigned to one of two treatment groups in May,1997. Group A (normal implant) received a Synovex®-H (200 mg testosterone + 20 mg estradiol benzoate, Fort Dodge Animal Health, Overland Park, KS) implant in an ear washed with a brush saturated with Nolvasan® solution (Fort Dodge Animal Health) at 6 oz. per gallon of water. Group B (abscessed implant) received a Synovex-H implant in an ear to which a slurry of water and cattle feces had been applied immediately prior to and after implanting. The nonimplanted ear served as the control for thermographic evaluation. The heifers were stratified by weight and fed in pens of six head each with a total of six replicates per treatment. The heifers were fed once per day a sorghum silage plus dry rolled corn ration (Table 1) for a 91-day growing period. Feed consumption, weight gain, and gain efficiency were recorded for each pen. Thermal

[1]The authors express their appreciation to Fort Dodge Animal Health for providing grant support and survey data for this research.

[2]Food Animal Health and Management Center, College of Veterinary Medicine.

imaging was done on unrestrained cattle in their pens 8 days after implantation. The front of each ear was imaged from a distance of 6 to 24 feet. A high resolution, short wave (3 to 5 $u$m), infrared thermal imaging camera (Radiance PM®, Amber Engineering, Goleta, CA) was used. An analysis of a rectangular area on the front of each ear was made to determine minimum, maximum, and mean temperatures. Analysis of variance was used to determine the relationship between mean ear temperature (response variable) and treatment. Least square mean temperatures of ears having normal and abscessed implants were compared to those of nonimplanted control ears using Tukey's correction for multiple comparisons. Analysis of variance was used to evaluate average daily gain (ADG), feed intake, and gain efficiency over the 91-day feeding period.

## Results and Discussion

Ambient temperature during the thermal observation period was 60 to 63EF. Abscessed ears were warmer (P<0.001) than nonimplanted ears. Mean ear temperatures were 79.0±0.5EF for nonimplanted; 81.0±0.6EF for implanted, non-abscessed; and 84.7±0.6EF for abscessed ears. No difference (P=0.15) was found between nonabscessed and nonimplanted ears. Abscessed implants reduced (P<.05) average daily gain over the 91-day feeding period (2.92 vs. 3.18 lb/day) (Table 2). Total weight gains were 291 vs. 267 lb/head for normal vs. abscessed implants. Dry matter intakes of 18.01 lb for normal and 17.97 lb for abscessed implant groups were not affected (P=0.97) by treatment. Though not significant (P=0.11), efficiency (gain/feed) tended to be higher for nonabscessed heifers (0.178 vs. 0.163) corresponding to feed/ gains of 5.62 vs. 6.13.

For the 91-day growing period, cattle with abscessed growth implants showed $17.70 lower return per head compared to their counterparts with nonabscessed implants. That number is based on a 650 lb heifer price of $74/cwt and a ration cost of $120 per ton.

Infrared thermography (IRT) can be used as part of an implant quality assurance program when cattle are screened in the pen within 8 days of implanting. The use of IRT as a screening tool would eliminate multiple handling of cattle, would provide a rapid assessment of implanting technique as compared to conventional quality assessment programs, and would decrease reliance on quality audits at slaughter.

**Table 1. Composition of Diet Fed to Heifers**

| Ingredient | % of DM |
|---|---|
| Dry rolled corn | 45.60 |
| Sorghum silage | 40.00 |
| Soybean meal | 10.80 |
| Dicalcium phosphate | 1.33 |
| Limestone | 1.22 |
| Urea | .67 |
| Premix[a] | .38 |

[a]As formulated premix provided .30% salt, 1200 IU Vit A/lb., 48 ppm Mn, 48 ppm Zn, .23 ppm Se, 8.0 ppm Cu, .50 ppm I, .04 ppm Co, and 25 g/ton monensin.

**Table 2. Effects of Abscessed Growth Promotant Implants on Feedlot Performance of Beef Heifers [a]**

| | Abscessed | | Non-Abscessed | | |
|---|---|---|---|---|---|
| Item | Mean | SEM | Mean | SEM | P-value |
| ADG | 2.92 | .65 | 3.18 | .77 | .02 |
| DMI | 17.97 | .75 | 18.01 | .80 | .97 |
| Gain:Feed | .163 | .006 | .178 | .005 | .11 |

[a]Average initial weight of both treatment groups was 446 lb.

*Cattlemen's Day 1999*

# COMPARISON OF MORBIDITY AND PERFORMANCE AMONG STRESSED FEEDER CALVES FOLLOWING VACCINATION WITH PYRAMID™ MLV 4 OR PYRAMID™ 4+PRESPONSE® SQ

*S. Ives, J. Drouillard, D. Anderson, G. Stokka, and G. Kuhl*

## Summary

A study was conducted to compare performance, morbidity, retreatment percent, and mortality in stressed heifer calves during the receiving and growing phases after receiving either Pyramid™ MLV 4 or Pyramid™ 4+Presponse® SQ on arrival at a feedlot research facility. Vaccination with Pyramid 4+Presponse SQ (a 4-way viral modified live vaccine with a *Pasteurella haemolytica* bacterin-toxoid) tended to reduce the incidence of bovine respiratory disease (P=.2) and reduced retreatment rate (P<.06).

## Introduction

Respiratory disease has major economic significance for the beef industry, with estimated losses approaching $600 million annually. Efforts to reduce the incidence of respiratory disease have not resulted in major declines in losses from this disease complex. The production and marketing systems employed in the beef industry can have a significant influence on susceptibility to disease in confinement feeding operations. Viral vaccines are essential to reducing the morbidity that occurs in calves soon after arrival in feedlots. Protecting against this viral challenge should result in fewer pulls, less mortality, and improved performance in the first 28 days.

*Pasteurella haemolytica* serotype A1 is the most commonly identified bacterial pathogen involved in bovine respiratory disease early in the receiving period. Vaccination might abate this challenge, thereby improving feed intake, rate of gain and feed efficiency, while decreasing the risk of death loss.

The present study was conducted to evaluate feed intake, weight gain, feed efficiency, morbidity, retreatment percentage, and mortality of heifers vaccinated using each of two modified live vaccines, one of which contained the *Pasteurella haemolytica* bacterin-toxoid. Performance during the postreceiving period also was evaluated.

## Experimental Procedures

This study was conducted at the KSU Beef Cattle Research Center in Manhattan, Kansas, and was initiated on September 4, 1997. The receiving period was 28 days and was followed by a growing period of 102 days.

Three hundred twenty four weaned heifer calves (avg wt 500 lb) were purchased from sale barns in Arkansas and trucked to Manhattan. Upon arrival at the feedlot, each load was placed into a large pen and offered ad libitum access to clean water and long-stem prairie hay. Approximately 24 hours after arrival, weight and rectal temperature were recorded for each heifer. Heifers were worked through the processing facility at random and uniquely identified with numbered ear tags during initial processing. Each heifer was implanted with Synovex®-H and treated for internal and external parasites using Synanthic® oral drench and CyLence® pour-on. Additionally, heifers were vaccinated against common clostridial diseases using a subcutaneous injection of Fortress®-7. Experimental treatments consisted of subcutaneous injections of Pyramid MLV 4 (4-way viral vaccine) or Pyramid 4+Presponse SQ (4-way viral plus *Pasteurella* toxoid). During processing, heifers were sorted by their respective treatments into groups of six head,

with a total of 27 pens per vaccination treatment. Groups were placed into partially covered, concrete surface pens (14' × 28') where they were fed throughout the 28-day receiving period and subsequent growing period.

Heifers were fed a common starter ration during the receiving period. Bunks were read at approximately 6:00 a.m., at which time the amount of feed to be offered at the next feeding was determined. Heifers were fed once daily.

Heifers that exhibited clinical signs of respiratory disease, including depression, lethargy, anorexia, coughing, rapid breathing, and nasal and (or) ocular discharge, were identified each morning. Morbid heifers received a subcutaneous injection of tilmicosin (Micotil®) at a dosage of 1.5 ml/cwt and were returned to their original pen. When necessary, this treatment was repeated after 48 hours. Therapy for third-time treatments was a combination of Biomycin™ 200 and Tylosin™ 200, administered intramuscularly at 6 and 5 ml/cwt, respectively.

Upon completion of the 28-day receiving period, chronically ill and (or) lame animals were removed from the experiment. The remaining calves were allotted, on a pen basis, to each of nine dietary treatments in the subsequent growing period. Nutritional regimens were applied uniformly across vaccination treatments, thus making it possible to monitor growing performance of the two vaccination treatments.

## Results and Discussion

Performance and health data of the heifers during the receiving and growing periods are summarized in Table 1. Average dry matter intake was similar (P=.28) for calves vaccinated with Pyramid and Pyramid+Presponse. Likewise, feed efficiency and daily gain were similar (P>.8) for the two groups. The percentage pulled and treated for respiratory disease tended (P=.2) to be less when heifers were vaccinated with Pyramid+Presponse compared to Pyramid alone. Fewer animals required retreatment if vaccinated with Pyramid+Presponse (P=.06). The percentage of animals classified as chronically ill (i.e., three or more therapeutic treatments) was not significantly different for the two vaccine treatments (P=.22). Mortality rate (<2%) was not different for the two vaccine treatments. Vaccine treatment also had no carryover effects on gain during the subsequent growing period.

Figure 1 illustrates the epidemic curve for respiratory disease in heifers during the 28-day receiving period. The peak prevalence occurred approximately 3 to 6 days after arrival in the feedlot and followed a similar pattern for Pyramid and Pyramid+Presponse groups. Figure 2 shows the cumulative respiratory morbidity percentage over the 28-day receiving period. The Pyramid+ Presponse heifers had fewer pulls, especially earlier in the receiving period (P<.1), but the responses converged until day 23, at which time no statistical difference was found for the two treatments (P=.2). Figure 3 illustrates the cumulative retreatments for the two vaccine regimens. By day 13 of the study, a significant divergence of the two treatments had occurred, with the Pyramid+Presponse heifers needing fewer retreatments.

Although the Pyramid+Presponse treatment tended to reduce morbidity and to statistically improve retreatment percentage, performance was not altered (Table 1). We speculate that performance and health responses to the two vaccines might be different, if they were used in stressed heifers that do not break with disease until later in the receiving period.

**Table 1. Performance of Stressed Heifer Calves during the Receiving and Growing Periods as Affected by Vaccine [a]**

| Item | Pyramid @ MLV-4 | Pyramid@-4 + Presponse | SEM |
|---|---|---|---|
| Pens (head/pen) | 27 (6) | 27 (6) | |
| Initial weight, lb | 496.3 | 495.2 | 2.8 |
| Dry matter intake, lb/day | 9.2 | 9.5 | .2 |
| Feed efficiency | 6.15 | 5.84 | .94 |
| Gain, lb/day | 1.60 | 1.66 | .24 |
| Gain, lb/day (deads out) | 2.07 | 2.03 | .12 |
| Pulls, % | 46.3 | 37.0 | 4.7 |
| Retreats, %[b] | 10.5 | 4.3 | 2.3 |
| Chronics, % | 4.3 | 1.85 | 1.4 |
| Deads, % | 1.85 | 1.85 | 1.1 |
| Growing gain, lb/day (deads & chronics removed) | 1.60 | 1.57 | .04 |

[a] Least-squares means.
[b] Pyramid different than Pyramid +Presponse, P<.06.

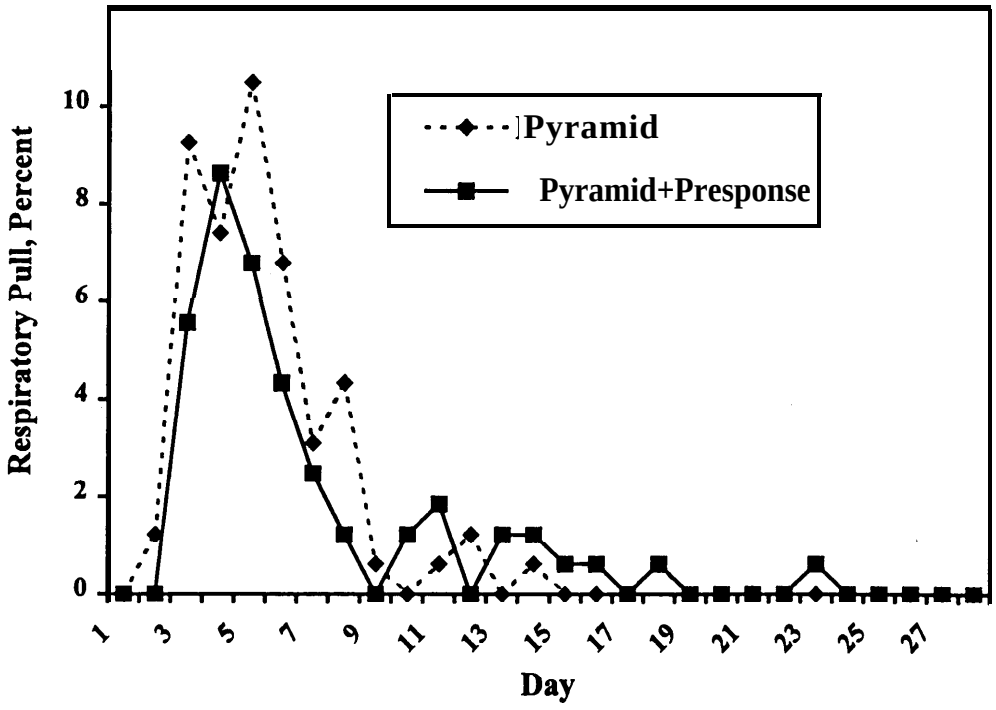


**Figure 1. Animals Pulled for Respiratory Disease vs. Days after Arrival.**

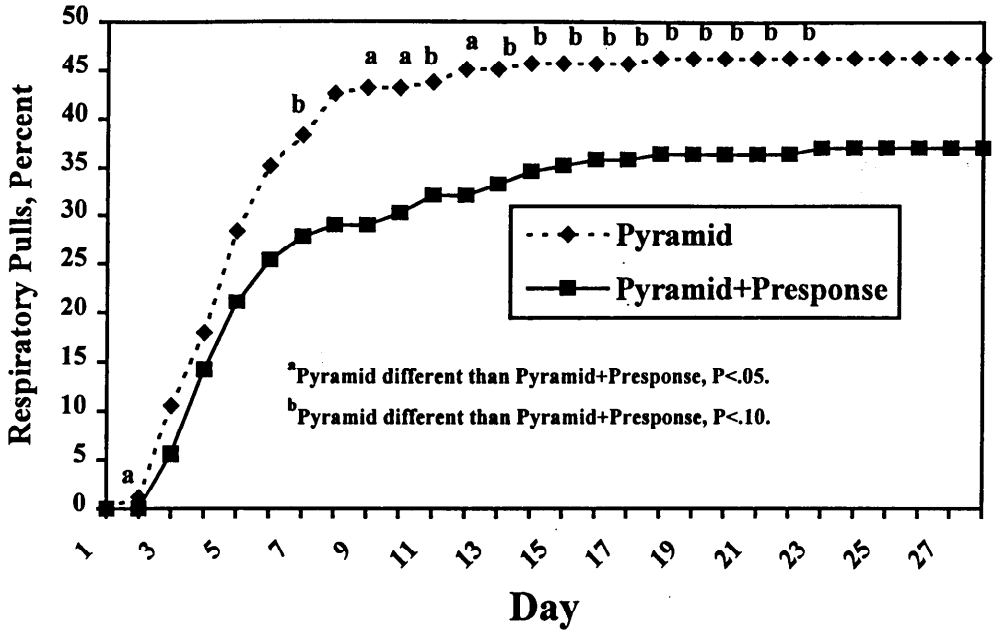


**Figure 2. Cumulative Percent of Animals Pulled for Respiratory Disease vs. Days after Arrival.**

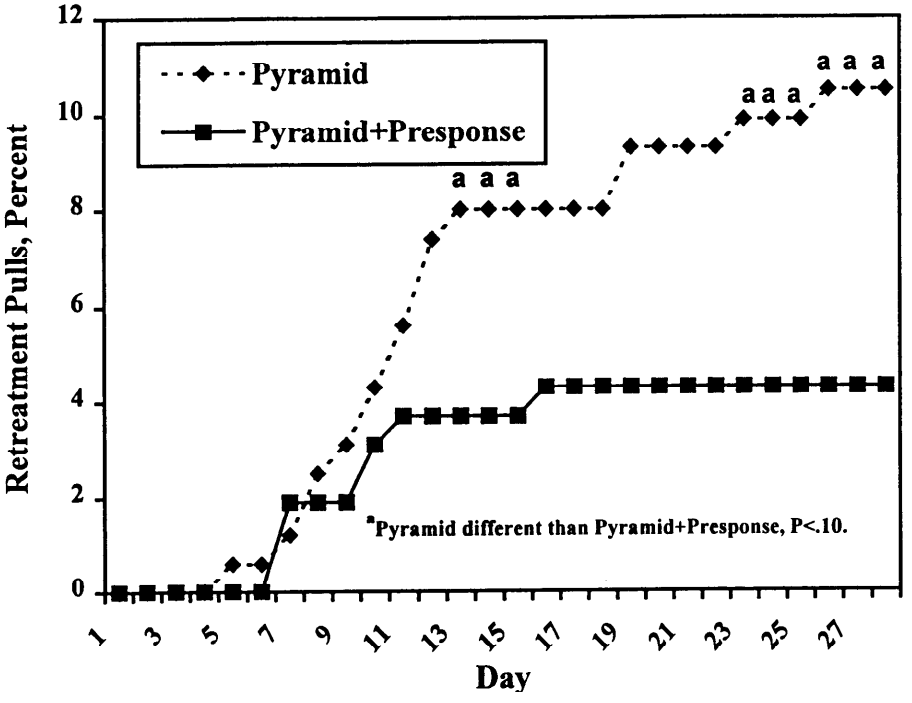


**Figure 3. Cumulative Retreatment Percentage.**

*Cattlemen's Day 1999*

# *SARCINA VENTRICULI* AS THE POTENTIAL CAUSE OF ABOMASAL BLOAT

*T. J. Schemm, T. G. Nagaraja, and B. M. DeBey*

## Summary

*Sarcina*-like bacteria, possibly *Sarcina ventriculi*, have been seen upon histopathologic examination of the abomasums of calves that died of abomasal bloat. The ability of the organism to grow at a low pH and produce large amounts of gas suggests that it may be the cause of abomasal bloat.

(Key Words: Abomasal Bloat, Calves, *Sarcina ventriculi*.)

## Introduction

Abomasal bloat affects newborn calves, sheep, and goats, usually at less than 2 months of age. It has been observed in calves and lambs fed milk replacer diets ad libitum and in nursing calves. It is life threatening because of the extreme abdominal distension. The syndrome may be associated with proliferation of gas-producing bacteria in the abomasum.

A previous report described abomasal bloat with high mortality in kids up to 10 weeks of age at a goat dairy. The kids were found dead within 2 hours of the initial clinical signs of lethargy, reluctancy to stand, distended abdomen, and a hollow sound upon ballottement. Histopathological examination of the abomasum revealed large, spherical cells in packets of 4 to 20, similar to *Sarcina ventriculi*. Those authors postulated that *S. ventriculi* may have a role in the development and pathogenesis of abomasal bloat in goat kids. Similar association of *Sarcina*-like bacteria with abomasal bloat in calves has been reported.

## Experimental Procedures

At the Kansas State University Veterinary Diagnostic Laboratory, 20 to 30 cases of abomasal bloat in calves have been examined during the past 2 years. Calves were necropsied, and abomasal tissue was collected for histopathological examination. The abomasal contents of three calves were collected for bacteriological examination. The contents were inoculated into a preenrichment medium at pH 3.0 in an attempt to isolate *S. ventriculi*.

## Results and Discussion

Necropsy revealed abomasal distension with free gas and occasionally abomasal rupture with perforated ulcers. Histopathological examination of the abomasal wall showed spherical bacteria (Figure 1) in packets of 4 to over 20 in 80-90% of the cases. In calves with ruptured abomasums, bacteria were observed on the peritoneal surface. One of the abomasal content samples for which isolation was attempted exhibited *Sarcina*-type cells in the preenrichment medium. However, attempts to isolate the cells in pure culture have not succeeded.

*Sarcina ventriculi* is a gram-positive, nonmotile bacterium, generally occurring as spherical shaped cells, 1.8 to 3.0 μm in diameter, in packets of 4 to 20. The organism is anaerobic, somewhat aerotolerant, and capable of growth at a wide range of pH (1.0 to 9.8). It ferments sugars and produces ethanol, acetate, $CO_2$, and $H_2$. It has been isolated from soil, mud, cases of human gastritis, rabbit and guinea pig stomach

contents, elephant dung, human feces, and cereal seeds.

We propose that this *Sarcina*-like organism may be a cause of abomasal bloat in calves because, it can survive and grow at acidic pH (2 to 3) and it produces large amounts of gas from the fermentation of sugars. However, conclusive evidence to declare that *S. ventriculi* is the causitive agent of abomasal bloat is lacking.

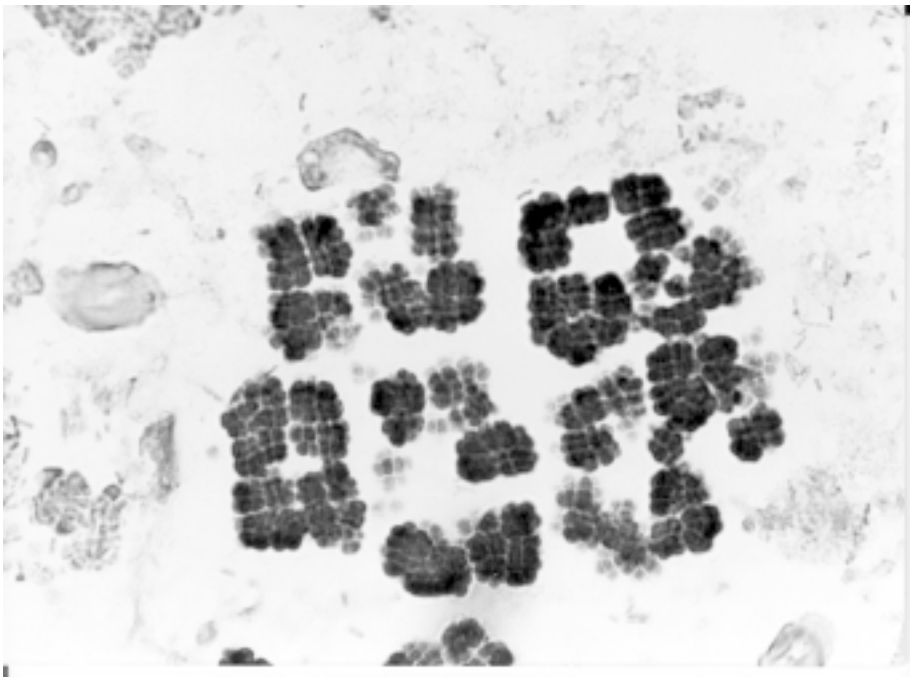

**Figure 1. Photomicrograph Showing Spherical Cells on the Mucus Layer Adherent to the Surface of the Abomasum from a Calf that Died of Abomasal Bloat.**

# EFFECT OF RUMINAL VERSUS POSTRUMINAL ADMINISTRATION OF DEGRADABLE PROTEIN ON UTILIZATION OF LOW-QUALITY FORAGE BY BEEF STEERS

*C. A. Bandyk, R. C. Cochran, T. A. Wickersham, E. C. Titgemeyer, and C. G. Farmer*

## Summary

Twelve ruminally fistulated steers were used to evaluate the effects of supplying a highly degradable protein source (casein) both ruminally and postruminally on intake and digestibility of low-quality native hay. Both protein supplementations substantially increased voluntary intake, organic matter digestion, rate of passage, ruminal ammonia, and blood urea concentrations, but intakes were considerably greater when protein was given ruminally as opposed to postruminally.

(Key Words: Intake, Degradable Protein, Low-Quality Forage.)

## Introduction

Protein supplementation stimulates forage intake, digestion, and performance in animals fed low-quality roughage. Because an inadequate nitrogen supply in the rumen limits microbial growth and, therefore, limits ruminal fermentation and outflow, responses to supplemental protein often are attributed to its ability to satisfy microbial nitrogen requirements. Degradable intake protein (DIP) (protein that is broken down in the rumen) can meet these requirements directly. Because the resulting increase in microbial growth leads to more microbial protein passing to the small intestine, increased DIP intake is associated with increased postruminal protein supply to the host animal.

By-pass, or undegradable intake protein (UIP), provides a direct postruminal supply of protein. UIP also can contribute to meeting the rumen microbial nitrogen need by recycling nitrogen back to the rumen as urea. Although recycling is often very important in maintaining adequate N status in ruminants, it seems unlikely that using UIP to correct a ruminal nitrogen deficiency (via recycling) will be as effective as using DIP per se to directly correct the deficiency. To evaluate that concept, we designed an experiment in which supplemental DIP or UIP was simulated by placing protein directly into different segments of the digestive tract and the effects of these treatments on intake, digestion, and ruminal fermentation were monitored.

## Experimental Procedures

Twelve ruminally fistulated steers (average weight, 1239 lbs) were assigned randomly to one of three treatments: control (hay only) or hay plus ruminal or postruminal infusion of 400 g of casein/day. Casein is a high-quality protein source that is degraded readily in the rumen. The experiment had five time periods: 1) 10-day adaptation to the hay diet; 2) 7-day measurement of voluntary intake (hay only); 3) 10-day adaptation to protein treatments (intake measurements continued); 4) 7-day measurement of hay intake and digestibility; 5) 3-day ruminal sampling period. The animals were housed in individual tie stalls and given continuous access to a low-quality, tallgrass-prairie hay (3.4% CP and 76.6% NDF). Orts were removed and measured daily, and fresh hay was offered at 130% of the previous 5-day average intake. Beginning in period 3, casein was administered just prior to feeding, either directly into the rumen or solubilized and infused through lines anchored in the abomasum. Fecal grab samples were collected daily during period 4 and analyzed for acid detergent insoluble ash, which served as an internal marker to determine total fecal

output. Feed offered, feed refused, and fecal output were used to calculate voluntary intake, organic matter digestion (OMD), and neutral detergent fiber digestion (NDFD). During period 5, various fill, passage, and fermentation characteristics were measured.

## Results and Discussion

Protein supplementation by either route increased hay and total organic matter (OM) intake (P#.01) and OM digestion (P=.04) relative to controls (Table 1). Placing supplemental protein directly into the rumen (P=.04) increased hay intake more than postruminal supplementation (P=.04). In addition, the steers took longer (P=.02) to increase their intake when given their supplement postruminally. These steers also stopped responding sooner after their initial response, but their rate of increase during the period of positive response was similar to that seen with ruminal supplementation (P=.32). The larger intake response for ruminal than postruminal supplementation was accompanied by higher ruminal ammonia levels and an increased passage rate (P<.01). In conclusion, when cattle are consuming low-quality, nitrogen-deficient forages, providing a source of ruminally degradable protein is more effective in stimulating forage utilization than providing ruminally undegradable (by-pass) protein.

**Table 1. Effect of Ruminal or Postruminal Casein Infusion on Voluntary Intake and Digestion in Steers Fed Low-Quality, Tallgrass-Prairie Hay**

| | Treatment | | | | Contrasts[1] | |
|---|---|---|---|---|---|---|
| Item | Control | Post-ruminal | Ruminal | SEM | S vs. None | P vs. R |
| Hay intake, g/kg MBW[2] | 47.8 | 61.0 | 77.4 | 4.85 | < .01 | .04 |
| Total intake, g/kg MBW[3] | 47.8 | 64.4 | 80.7 | 4.89 | .01 | .05 |
| Intake change, g/kg MBW[4] | -6.8 | 10.1 | 24.6 | 1.97 | < .01 | .03 |
| Days to intake increase[5] | NA | 4.3 | 1.0 | .53 | NA | .02 |
| Rate of intake increase[6] | NA | 2.3 | 2.7 | .24 | NA | .32 |
| OM digestion, % | 39.5 | 47.0 | 44.7 | 2.10 | .04 | .42 |
| NDF digestion, % | 39.8 | 44.9 | 42.1 | 3.69 | .18 | .35 |

[1]S vs. None = supplemented vs. control, P vs. R = postruminal vs. ruminal infusion.

[2]Hay organic matter intake expressed as grams per kilogram of metabolic body weight (MBW).

[3]Total organic matter intake (hay + supplement) expressed as grams per kilogram of metabolic body weight (MBW).

[4]Change in hay intake from period 2 (period without supplementation) to period 4 (period when supplements were being given). Units are in grams per kilogram of metabolic body weight (MBW).

[5]Number of days after infusions began before a positive increase in hay intake. NA=not applicable.

[6]Rate at which intake increased (g of total organic matter/kg metabolic body weight/day) once a positive change in intake was observed.

**Table 2. Effect of Ruminal or Postruminal Casein Infusion on Ruminal pH, Ammonia, Total Volatile Fatty Acid Concentration, Fill, Passage, and Plasma Urea Nitrogen in Steers Fed Low-Quality, Tallgrass-Prairie Hay**

| | Treatment | | | | Contrasts[1] | |
|---|---|---|---|---|---|---|
| Item | Control | Post-ruminal | Ruminal | SEM | S vs. None | P vs. R |
| pH | 6.67 | 6.60 | 6.50 | .13 | .42 | .54 |
| Ammonia, mM | .55 | 1.35 | 4.16 | .32 | < .01 | < .01 |
| Total VFA, mM | 70 | 78 | 82 | 6.7 | .21 | .64 |
| Plasma urea N, mM | .83 | 2.59 | 2.05 | .49 | .05 | .48 |
| Dry matter contents, g/kg MBW[2] | 114.7 | 127.4 | 114.8 | 6.8 | .46 | .22 |
| Liquid contents, g/kg MBW[2] | 712.4 | 858.9 | 762.4 | 40.3 | .08 | .12 |
| Liquid dilution rate, %/hr | 4.61 | 4.79 | 5.34 | .71 | .62 | .60 |
| ADIA[3] passage, %/hr | 2.06 | 2.26 | 3.36 | .13 | < .01 | < .01 |

[1]S vs. None = supplemented vs.control, P vs. R = postruminal vs. ruminal infusion.

[2]Units are in grams per kilograms of metabolic body weight (MBW).

[3]ADIA=acid detergent insoluble ash.

# PERFORMANCE OF GROWING HEIFERS FED PRAIRIE HAY AND SUPPLEMENTED WITH ALFALFA AND(OR) COOKED MOLASSES BLOCKS OF DIFFERENT PROTEIN CONCENTRATIONS

*E. C. Titgemeyer, J. S. Drouillard, D. J. Bindel, R. D. Hunter, and T. Nutsch*

## Summary

Crossbred heifers (683 lb; n = 175; 30 pens) were used to evaluate alfalfa and cooked molasses block supplementation to prairie hay. Treatments were arranged in a 2×3 factorial with the factors being 0 or 5 lbs of alfalfa supplementation, and supplementation with no block or with low or high protein blocks (analyzed to contain 14.4 and 27.5% crude protein, respectively). Heifers had ad libitum access to prairie hay and salt. The experiment was 89 days, with heifers fed blocks for 84 days. During days 5 to 19, heifers had ad libitum access to blocks. Thereafter, access was restricted to 4 hours daily. No significant interactions occurred between alfalfa and blocks for intake or gain. Supplementation with alfalfa increased total forage intake by 49% (18.4 vs. 12.3 lb/day), and gains from –.39 lb/day to +.95 lb/day. Intake of the blocks was lower when alfalfa was supplemented (.76 vs. .98 lb/day). Heifers fed the high-protein block gained more weight (.46 lb/day) than those fed the low-protein block (.25 lb/day) or no block (.12 lb/day). Heifers fed the high-protein block ate more forage (16.1 lb/day) than those fed the low-protein block (14.8 lb/day), with heifers fed no block (15.3 lb/day) being intermediate. Intake of block was greater for the high-protein (.93 lb/day) than for the low-protein block (.81 lb/day). Differences in forage intake accounted for much of the differences in performance among treatments.

(Key Words: Heifers, Forage, Supplementation.)

## Introduction

Performance of cattle grazing dormant range usually is limited by the supply of protein. This is a result of nutrients (primarily N) limiting ruminal fermentation of forage fiber, which in turn reduces feed intake and further depresses performance.

The use of cooked molasses blocks is a common feeding strategy in the cattle industry. Much of the response to these blocks can be attributed to the protein they contain stimulating ruminal fermentation. This project evaluated responses to cooked molasses blocks under conditions that mimicked unsupplemented range and range supplemented with alfalfa hay. We evaluated cooked molasses blocks containing two levels of protein to determine how much of the response is attributable to the protein supplied by the blocks.

## Experimental Procedures

**Performance Trial**. One hundred seventy-five crossbred beef heifers averaging 683 lb were used in a randomized block design experiment where forage intake and growth rate were measured. A total of 30 pens was used, with each pen containing 5 or 6 heifers. The six treatments, which were randomly allotted within each of five replications, were arranged in a 2 × 3 factorial with the factors being the basal forage offered to the heifers and block supplementation. The forage fed was either 1) prairie hay fed ad libitum or 2) prairie hay ad libitum plus 5 lb (as fed) alfalfa daily. These treatments represent a poor-quality and an intermediate-quality forage diet for cattle. The block

supplementation treatments were 1) a negative control, 2) a low-protein (14.4% crude protein, dry basis) cooked molasses block, and 3) a high-protein (27.5% crude protein dry basis) cooked molasses block. Blocks (approximately 40 lb) were manufactured in 4 gallon tubs and were placed in the feedbunks, one per pen. All heifers had ad libitum access to white salt blocks and water.

The entire experiment lasted 89 days, with heifers being fed blocks for 84 days. Beginning on day 6, heifers were provided ad libitum access to the appropriate cooked molasses block. After 14 days of block consumption, we noticed that block intake was much greater than that typical of free ranging cattle. Therefore, for the remainder of the experiment, heifers were allowed access to the blocks for only 4 hours of each day.

**Digestion Study**. Digestibilities for complete diets were measured during days 80 to 83 by cleaning pens and subsequently collecting total fecal output by scraping pens daily for 3 days. Digestibilities were measured for three of the five replicates; one observation (alfalfa plus the high-protein block) was lost because heifers escaped from their pen.

## Results and Discussion

The prairie hay contained 5.2% crude protein and 73% NDF on a dry basis. The alfalfa hay contained 18.6% crude protein and 60% NDF on a dry basis.

**Performance Trial**. Effects of treatments on intake and performance are shown in Table 1. No significant interactions occurred between forage and block supplementation for any of the intake or performance criteria. Supplementing heifers with 5 lb/day of alfalfa increased average daily gain, gain efficiency, and forage and total intakes. On average, forage intake was increased 49% (6.1 lb dry matter/day) when alfalfa was supplemented to the heifers. Part of this increase can be accounted for by the alfalfa itself (4.4 lb dry matter/day). The remainder (1.7 lb dry matter/day) came from prairie hay. Gains were increased from an average loss of .39 lb/day to a gain of .95 lb/day when alfalfa was supplemented. Gain efficiencies were increased accordingly.

Although the largest responses were to alfalfa, responses to block supplementation also were significant. Heifers fed the high-protein block gained weight faster than those fed the low-protein block; those fed the low-protein block did not gain significantly faster than those receiving no block. Efficiencies followed the same pattern.

Heifers fed the high-protein blocks ate more ($P<.05$) forage than those fed the low-protein blocks, with the control heifers being intermediate but not statistically different than either block treatment. These trends follow the expected pattern when low and high protein supplements are fed to cattle consuming poor-quality (low protein) forages. Although the statistics did not indicate an alfalfa by block interaction, effects of block supplementation on forage intakes were numerically greater when heifers were not supplemented with alfalfa. Because protein would be less limiting when alfalfa was supplemented, less response to protein level in the molasses blocks would be expected.

**Digestion Study**. A significant interaction between alfalfa and block was observed for DM digestion. For heifers not receiving alfalfa, supplementation with either block increased DM digestibility. However, when alfalfa was supplemented, blocks numerically decreased DM digestibility. Supplementation with alfalfa led to remarkable increases in DM digestibility. Digestible DM intake were increased markedly by alfalfa supplementation; both intake and digestion increased.

Digestibility for heifers fed the low-protein block was nearly as high as that for heifers fed the high-protein block. Thus, differences in forage intake may account for much of the performance difference between the two blocks.

**Table 1. Effect of Supplemental Alfalfa and Cooked Molasses Blocks on Total Feed Intake and Performance of Heifers**

| | No Alfalfa | | | 5 lb/Day Alfalfa | | | |
|---|---|---|---|---|---|---|---|
| Item | No Block | 14.4% Block | 27.5% Block | No Block | 14.4% Block | 27.5% Block | SEM |
| In weight, lb | 683 | 683 | 685 | 682 | 682 | 684 | 9.8 |
| Out weight, lb[1,2] | 632 | 649 | 665 | 754 | 761 | 786 | 9.2 |
| ADG[a], lb[1,2] | -.57 | -.39 | -.22 | .81 | .89 | 1.14 | .073 |
| Gain:feed[1,2] | -.047 | -.030 | -.016 | .044 | .048 | .058 | .0052 |
| Forage intake[b], lb/d[1,3] | 12.10 | 11.52 | 13.42 | 18.41 | 17.99 | 18.83 | .44 |
| Block intake, lb/d[c,1,3] | 0 | .90 | 1.05 | 0 | .72 | .80 | .038 |
| Total intake, lb/d[1,2] | 12.10 | 12.42 | 14.47 | 18.41 | 18.71 | 19.63 | .45 |

[a]ADG = average daily gain.
[b]For heifers fed alfalfa, roughly 4.4 lb/day of forage dry matter intake would be alfalfa, and the remainder would be prairie hay.
[c]Calculated as block intake from days 6 through 89 divided by 89.
[1]Effect of alfalfa (P<.05).
[2]Effect of block, 27.5%>14.4%=none (P<.05).
[3]Effect of block, 27.5%>14.4% (P<.05).

**Table 2. Effect of Supplemental Alfalfa and Cooked Molasses Blocks on Total Diet Digestion by Heifers**

| | No Alfalfa | | | 5 lb/Day Alfalfa | | | |
|---|---|---|---|---|---|---|---|
| Item | No Block | 14.4% Block | 27.5% Block | No Block | 14.4% Block | 27.5% Block | SEM |
| DM[a] intake, lb/day | | | | | | | |
| Forage[b,1] | 13.01 | 13.81 | 14.61 | 20.94 | 21.28 | 20.80 | .95 |
| Block[1] | - | 1.05 | 1.24 | - | .67 | .79 | .06 |
| Total[1] | 13.01 | 14.85 | 15.85 | 20.94 | 21.94 | 21.59 | .95 |
| DM[a] digestion, %[1,2] | 38.1[a] | 42.5[b] | 43.5[b] | 51.7[c] | 50.5[c] | 48.6[c] | .91 |
| DDM[a] intake, lb/d[1] | 4.96 | 6.31 | 6.87 | 10.85 | 11.10 | 10.50 | .50 |

[a]DM = dry matter. DDM = Digestible dry matter.
[b]For heifers fed alfalfa, roughly 4.4 lb/day of forage dry matter intake would be alfalfa, and the remainder would be prairie hay.
[1]Effect of alfalfa (P<.05).
[2]Alfalfa × block interaction (P<.05); means not bearing common superscript differ.

# EFFECTS OF COOKED MOLASSES BLOCKS ON INTAKE AND DIGESTION BY STEERS FED BROME HAY WITH OR WITHOUT ALFALFA

*E. C. Titgemeyer, J. S. Drouillard, J. W. Ringler, and R. H. Greenwood*

## Summary

This study was conducted to determine how cattle fed medium to high quality forages respond to supplementation with cooked molasses blocks. Responses to blocks were measured for steers fed each of three different hays ad libitum: 1) brome containing 8.4% CP and 72% NDF, 2) alfalfa containing 19.2% CP and 52% NDF, and 3) brome fed ad lib and supplemented daily with 5 lb/day of the alfalfa (MIX). Eighteen steers (622 lb) were used for two periods. Six steers received each of the forages, and each steer was supplemented with the block in only one of the two periods. Blocks were fed once daily and removed after the appropriate amount had been consumed. Block intakes averaged .66 lb of dry matter daily (.55 lb OM) and were similar among forages. Forage organic matter (OM) intake was not affected by the block when brome (9.8 lb/day) or MIX (11.6 lb/day) was fed, but it decreased from 15.4 to 14.4 lb/day when the block was supplemented to alfalfa. Digestibility of OM was greater (P<.05) for alfalfa (61.0%) than brome (55.7%) or MIX (57.5%) and was not impacted by block supplementation. Digestible OM intake was greater (P<.05) for alfalfa (9.3 lb/day) than brome (5.6 lb/day) or MIX (6.8 lb/day) and was not greatly impacted by block supplementation. Thus, supplementation with a cooked molasses-urea block had only small effects on intake and digestion of medium to high quality forages.

(Key Words: Steers, Forage, Supplementation.)

## Introduction

Previous studies conducted at Kansas State University have demonstrated clearly that cattle fed low quality forages (prairie hay containing 5 to 6% crude protein) respond to supplementation with cooked molasses-urea blocks with increased forage intake and digestion. Much of this response is attributable to the supply of protein, which has been demonstrated to be the most limiting nutrient under those conditions.

However, it is unclear how cattle fed higher quality forages may respond to block supplementation. Higher quality forages typically contain reasonable quantities of protein, so response to protein supplementation per se may be limited. In addition, substitution effects (reductions in forage intake in response to supplement consumption) are usually greater with high-quality forages than with poor-quality forages, suggesting that increases in forage intake are less likely to occur.

## Experimental Procedures

Eighteen steers (622 lb) were used in an intake/digestion trial to evaluate supplementation with cooked molasses blocks at a level of 0.10% of body weight. The blocks were obtained from a commercial company and were analyzed to contain 33.2% crude protein on a dry basis (not more than 12% crude protein from urea). Responses to block supplementation were measured for steers fed each of three different forage treatments: 1) brome hay containing (dry basis) approximately 8.4% crude protein and 72% NDF, 2) alfalfa hay containing approximately 19.2% crude protein and 52% NDF, and 3) the brome hay supplemented daily with 5 pounds of the alfalfa hay. All forages were coarsely chopped.

Six steers received each of the forages, and each steer was supplemented with the block in only one of the two periods; consequently, six observations were made for each treatment,

except for one missing observation on the MIX without block.

Steers were provided access to the blocks once daily, and the blocks were removed after the intended amount had been consumed. Plain salt (20 g/day) was provided to each steer. Each period was 18 days long, with 12 days for adaptation and 6 days for total collection of feces with the use of fecal collection bags.

## Results and Discussion

Block intakes averaged .66 lb/day of dry matter (.55 lb/day OM, Table 1) and were similar among forages. These were slightly higher than projected, because steers occasionally consumed the block faster than anticipated.

Forage quality was reflected clearly by differences in intake and digestion. Digestible OM intake, a measure of energy available to the animal, was 65% greater for alfalfa than for the brome hay (9.3 vs 5.6 lb/day). Providing 5 lb/day of alfalfa to the brome-fed steers increased digestible OM intake by 22% (6.8 vs 5.6 lb/day). OM digestibility was greater ($P<.05$) for alfalfa (61.0%) than brome (55.7%) or MIX (57.5%).

Block supplementation had little effect on intake or digestion of these medium- to high-quality forages. Although the interaction between forage and block was not statistically significant, forage OM intake was barely changed by the block when brome (9.8 lb/day) or MIX (11.6 lb/day) was fed, but it decreased from 15.4 lb/day to 14.4 lb/day when the block was supplemented to alfalfa-fed steers. Organic matter digestibility was not impacted by supplementation with the block.

In conclusion, supplementation with a 30% crude protein cooked molasses block had very little impact on forage intake or digestion when alfalfa (19% crude protein, dry basis), brome (8% crude protein, dry basis), or a mixture of these two forages was fed to growing steers.

**Table 1. Effect of Treatment on Intake and Digestion of Organic Matter**

| | No Block | | | Block Supplementation | | | |
|---|---|---|---|---|---|---|---|
| Organic matter | Alfalfa | Brome | MIX[1] | Alfalfa | Brome | MIX[1] | SEM |
| Forage OM intake, lb/d[a] | 15.4 | 9.9 | 11.6 | 14.4 | 9.8 | 11.7 | .52 |
| Block OM intake, lb/d | - | - | - | .60 | .52 | .53 | .019 |
| Total OM intake, lb/d[a] | 15.4 | 9.9 | 11.6 | 15.0 | 10.3 | 12.2 | .52 |
| Dig. OM intake, lb/d[a] | 9.4 | 5.5 | 6.6 | 9.1 | 5.7 | 7.1 | .40 |
| OM digestibility, %[b] | 60.9 | 56.1 | 56.9 | 61.0 | 55.4 | 58.0 | 1.0 |

[1]MIX = Ad libitum brome supplemented with 5 lb/d alfalfa.
[a]Effect of forage: Alfalfa >MIX>Brome ($P<.05$).
[b]Effect of forage: Alfalfa >MIX=Brome ($P<.05$).

# WHEAT BRAN AND SECOND CLEARS AS SUPPLEMENTAL ENERGY SOURCES FOR BEEF COWS GRAZING WINTER PASTURE

*C. G. Farmer, R. C. Cochran, D. D. Simms[1], J. S. Heldt, and C. P. Mathis*

## Summary

Ninety spring-calving Hereford × Angus cows grazing low-quality, tallgrass-prairie forage during the winter were fed 5 lb/day of a supplement containing combinations of wheat bran (high in digestible fiber) and second clears (high in starch). The by-product combinations accounted for 47 to 49% of each supplement, as follows: 1) 100% wheat bran; 2) 67% wheat bran, 33% second clears; and 3) 33% wheat bran, 67% second clears. Cow performance was measured by changes in body weight and body condition score. The combinations of wheat bran and second clears had no significant effects on cow performance, calf birth weights, calf performance, or cow pregnancy rates.

(Key Words: Cows, Forage, Wheat, By-Product.)

## Introduction

Supplemental protein is imperative for efficient utilization of low quality range forage. Recent research at Kansas State University also implies that the type of supplemental protein is important. Degradable intake protein (DIP) is that portion of crude protein degraded by ruminal microorganisms and is essential for efficient utilization of low-quality forage. However, even when DIP needs are met, additional energy may be required to achieve desired levels of performance. Our objective was to evaluate the ability of two wheat-milling by-products to provide additional supplemental energy to range beef cows.

## Experimental Procedures

Wheat bran is high in digestible fiber, and second clears is a low grade flour that is high (>75%) in starch. A cow performance study was conducted during the winter of 1997-98 on the impact of feeding supplements with various combinations of wheat bran and second clears. Supplements were fed to spring-calving cows grazing low-quality, tallgrass prairie. Ninety Hereford × Angus cows were weighed and body condition scored on December 2, 1997. Their initial body weight averaged 1218 lbs, and initial average body condition score was 5.3. Cows then were sorted by weight and body condition and assigned randomly to one of three pastures. Within pasture, cows were assigned randomly to one of three treatments with different supplements, each fed at 5 lbs/ day. Wheat-milling by-products accounted for 47 to 49% of each supplement, as follows: 1) 100% wheat bran; 2) 67% wheat bran, 33% second clears; and 3) 33% wheat bran, 67% second clears. Each supplement contained about 40% soybean meal as a source of supplemental DIP. The cows were gathered and sorted into their respective treatments daily and were group-fed their supplements. Group was the experimental unit. Cows were weighed and body condition-scored again on January 6, on February 6, and within 48 hours after calving. Calf birth weights also were taken within 48 hours after calving.

[1]Consolidated Nutrition, Omaha, NE.

## Results and Discussion

Using high fiber (bran) versus high starch (second clears) wheat by-products as supplemental energy sources had little effect on cow performance. Losses in body weight (Table 1) and body condition (Table 2) through calving were similar across the wheat by-product combinations. Similarly, calf birth weight and performance and cow pregnancy rate (Table 3) were not affected by treatments. Results of previous work indicate that the supplemental soybean meal provided adequate DIP to maximize intake and digestion of low-quality, tallgrass prairie forage. Apparently once DIP needs are met, the carbohydrate source does not greatly affect cow performance.

**Table 1. Influence of Wheat-Milling By-Product in Supplements on Beef Cow Weight**

| | Treatment[a] | | | | Contrasts[b] | |
|---|---|---|---|---|---|---|
| Item | BRAN | BRSC | SCBR | SEM | L | Q |
| No. of cows | 30 | 30 | 30 | | | |
| Initial wt., lb | 1230 | 1217 | 1217 | 13.79 | .55 | .71 |
| Period weight changes, lb | | | | | | |
| 6 Dec - 6 Jan | -.37 | -2.17 | -8.50 | 4.47 | .27 | .70 |
| 6 Jan - 6 Feb | 16.83 | 12.83 | 12.93 | 5.23 | .63 | .76 |
| 6 Feb - calving | -173.46 | -170.43 | -169.23 | 9.33 | .76 | .94 |
| Cumulative weight changes, lb | | | | | | |
| 6 Dec - 6 Feb | 16.47 | 10.67 | 4.43 | 7.68 | .33 | .98 |
| 6 Dec - calving | -157.03 | -159.77 | -164.80 | 14.29 | .72 | .95 |
| Ending wt., lb | 1077 | 1057 | 1053 | 19.18 | .42 | .76 |

[a]The by-product portions of the supplements were: BRAN=100% Bran; BRSC=67% Bran, 33% Second clears; SCBR=33% Bran, 67% Second clears.
[b]L=Linear; Q=Quadratic.

**Table 2. Influence of Wheat-Milling By-Product in Supplements on Beef Cow Body Condition**

| | Treatment[a] | | | | Contrasts[b] | |
|---|---|---|---|---|---|---|
| Item | BRAN | BRSC | SCBR | SEM | L | Q |
| No. of cows | 30 | 30 | 30 | | | |
| Initial BC score | 5.30 | 5.29 | 5.30 | .03 | 1.0 | .84 |
| Period BC changes | | | | | | |
| 6 Dec - 6 Jan | .23 | .14 | .13 | .07 | .37 | .72 |
| 6 Jan - 6 Feb | -.19 | -.16 | -.22 | .06 | .78 | .55 |
| 6 Feb - calving | -.36 | -.38 | -.29 | .07 | .52 | .58 |
| Cumulative BC changes | | | | | | |
| 6 Dec - 6 Feb | .03 | -.02 | -.09 | .08 | .32 | .90 |
| 6 Dec - calving | -.33 | -.39 | -.38 | .04 | .34 | .46 |
| Ending BC score | 4.98 | 4.90 | 4.92 | .05 | .40 | .47 |

[a]The by-product portions of the supplements were: BRAN=100% Bran; BRSC=67% Bran, 33% Second clears; SCBR=33% Bran, 67% Second clears.
[b]Contrasts: L=Linear; Q=Quadratic.

**Table 3. Influence of Wheat-Milling By-Product in Supplements on Pregnancy Rate and Performance of Calves**

| | Treatment[b] | | | | Contrasts[c] | |
|---|---|---|---|---|---|---|
| Item | BRAN | BRSC | SCBR | SEM | L | Q |
| Pregnancy rate, % | 97 | 97 | 97 | | | |
| Birth wt, lb | 91.6 | 91.2 | 92.8 | 2.67 | .76 | .78 |
| Calf ADG[a], lb/d | 2.3 | 2.3 | 2.3 | .03 | .54 | .19 |

[a]ADG=Average daily gain.
[b]The by-product portions of the supplements were: BRAN=100% Bran; BRSC=67% Bran, 33% Second clears; SCBR=33% Bran, 67% Second clears.
[c]L=Linear; Q=Quadratic.

# IMPACTS OF WHEAT MILLING BY-PRODUCTS IN SUPPLEMENTS ON THE INTAKE AND DIGESTION OF STEERS CONSUMING LOW-QUALITY FORAGE

*C. G. Farmer, R. C. Cochran, D. D. Simms[1], J. S. Heldt, and C. P. Mathis*

## Summary

Sixteen ruminally fistulated steers were used to evaluate the effects of feeding supplements containing combinations of two wheat-milling by-products on forage intake, digestibility, and ruminal characteristics. The by-products accounted for 47 to 49% of each supplement and were as follows: 1) 100% wheat bran; 2) 67% wheat bran, 33% second clears; and 3) 33% wheat bran, 67% second clears. All supplements contained about 30% CP. Compared with unsupplemented controls, forage intake and digestibility were significantly higher for supplemented steers. However, no differences occurred among by-product treatments. In conclusion, if the protein content is adequate, the choice of bran (high digestible fiber) vs. second clears (high starch) has little impact on forage use.

(Keyword: Steers, Forage, Intake, Digestion, Wheat By-Products.)

## Introduction

When beef cows graze low-quality forage, supplemental protein is imperative to stimulate intake. Recent research at Kansas State University also implies that the type of protein is important. Degradable intake protein (DIP) is that portion of the crude protein that is degraded by ruminal microorganisms. It is required for efficient utilization of low-quality forage and, consequently, for desirable cow performance. Even so, when DIP needs are met, additional energy may be required to achieve desired levels of performance. Our objective was to evaluate the effect of two wheat-milling by-products used as supplemental energy sources on forage intake, digestion, and selected ruminal fermentation characteristics of steers.

## Experimental Procedures

Sixteen ruminally fistulated beef steers (avg. BW 1064 lb)were blocked by weight and assigned to one of four treatments. Each steer was offered tallgrass prairie hay (3.1% CP, 76.4% NDF) at 130% of average voluntary intake for the preceding 5-day period. The treatments included a negative control (no supplement) and three different supplements fed at a rate (.378% BW per day, dry basis) similar to that provided to cows in a companion trial. The wheat-milling by-products accounted for 47 to 49% of each supplement and were as follows: 1) 100% wheat bran, 2) 67% wheat bran, 33% second clears; and 3) 33% wheat bran, 67% second clears. Wheat bran is high in digestible fiber, and second clears is a low-grade flour that is high in starch (> 75%). Soybean meal (approximately 40% of the supplements) provided sufficient DIP to maximize forage intake and digestion (based on previous K-State research). Supplements were formulated to contain about 30% CP. Based on National Research Council values, about 70% of each supplement's CP was in the form of DIP. The forage contained about 50% of its CP as DIP. A 7-day intake and fecal collection period was followed by a 14-day adaption period. Fecal grab samples were analyzed for acid detergent insoluble ash, which served as an internal marker to

[1]Consolidated Nutrition, Omaha, NE.

determine total fecal output. Feed offered, feed refused, and total fecal output were used to calculate intake and digestibility coefficients. Immediately following the collection period, ruminal pH and ammonia concentrations were measured at feeding and 3, 6, 9, and 12 hours after feeding.

## Results and Discussion

Forage organic matter (OM) intakes and total OM intakes were lower (P<.01) for the negative control compared with supplemented steers but were not different (P≥.23) among the supplemented steers (Table 1). Digestion of OM was lower (P=.03) for control than for supplemented steers, with no difference (P≥.46) among supplemented groups. Digestion of NDF was not affected (P≥.47) by treatment. Total digestible OM intake was also lower (P<.01) for control than supplemented steers, with no difference (P≥.21) among supplements. Ruminal pH was slightly higher (P<.01) for the control than supplemented steers, and the 67% wheat bran/33% second clears treatment resulted in slightly higher ruminal pH than the other supplements. Ammonia concentrations were lower (P<.01) for the control vs. the supplemented steers, but no differences (P≥.44) were evident among supplemented treatments.

Improved forage intake and digestion for the supplemented steers probably were due to the provision of ruminally available protein (i.e., DIP). Ruminal nitrogen concentrations are extremely deficient when cattle consume low-quality forage. The DIP provided in the supplement alleviated some or all of this deficiency (as seen in the ruminal ammonia concentrations) and increased microbial growth and forage breakdown. The lack of differences between the two wheat-milling by-products suggests that formulating supplements based on starch versus digestible fiber will have little impact on forage use if ruminally available protein is adequate.

**Table 1. Influence of Wheat-Milling By-Product in Supplements on Intake and Digestion by Steers**

| | Treatment[a] | | | | | Contrasts[b] | | |
|---|---|---|---|---|---|---|---|---|
| Item | NC | BRAN | BRSC | SCBR | SEM[c] | NC | L | Q |
| Forage OM[d] intake | | | | | | | | |
| g/kg $BW^{.75}$ | 40.0 | 62.4 | 70.3 | 68.2 | 3.65 | <.01 | .29 | .29 |
| % BW | .86 | 1.32 | 1.50 | 1.46 | 0.08 | <.01 | .26 | .27 |
| Total OM intake | | | | | | | | |
| g/kg $BW^{.75}$ | 40.0 | 77.8 | 85.9 | 84.1 | 3.65 | <.01 | .26 | .29 |
| % BW | .86 | 1.66 | 1.83 | 1.80 | 0.08 | <.01 | .23 | .30 |
| Digestible intake | | | | | | | | |
| g/kg $BW^{.75}$ | 20.0 | 42.8 | 46.0 | 46.3 | 1.90 | <.01 | .23 | .53 |
| % BW | .43 | 0.91 | 0.98 | 0.99 | 0.04 | <.01 | .21 | .54 |
| OM Digestion, % | 50.1 | 55.1 | 53.7 | 55.1 | 1.53 | .03 | 1.00 | .46 |
| NDF Digestion, % | 50.1 | 49.7 | 47.8 | 48.8 | 1.61 | .49 | .71 | .47 |
| Ruminal pH | 6.74 | 6.56 | 6.62 | 6.54 | 0.02 | <.01 | .45 | .44 |
| Ammonia N, m*M* | .42 | 1.16 | 1.07 | 1.09 | 0.06 | <.01 | .57 | .03 |

[a]NC=negative control. The by-product portion of the supplements were: BRAN=100% Bran; BRSC=67% Bran, 33% Second clears; SCBR=33% Bran, 67% Second clears.
[b]Contrasts: NC=Negative control vs. supplement, L=Linear within supplement; Q=Quadratic within supplement.
[c]SEM=standard error of the mean (n=16).
[d]OM=organic matter.

# EFFECT OF INTERSEEDING LEGUMES INTO ENDOPHYTE-INFECTED TALL FESCUE PASTURES ON FORAGE PRODUCTION AND STEER PERFORMANCE

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## Summary

A total of 135 steers grazed high-endophyte tall fescue pasture interseeded with either lespedeza, red clover, or ladino clover during 1995, 1996, and 1997. Legume cover, forage dry matter production, grazing steer performance, and subsequent feedlot performance were measured. Legume treatment caused no differences in forage availability. Grazing gains corresponded to the amount of legume coverage present. Results of this study indicate that interseeding high endophyte fescue pastures with ladino clover produced higher stocker gains during the grazing phase than interseeding with lespedeza or red clover. Legume treatment had no effect on subsequent finishing gains.

(Key Words: Grazing, Tall Fescue, Endophyte, Legumes, Interseeding, Finishing.)

## Introduction

Cattlemen with high-endophyte tall fescue pastures can either tolerate low gains, seek to improve performance by replacing existing fescue stands with endophyte-free fescue or other forages, or interseed legumes into existing pastures to reduce the adverse effects. Previous research at the Southeast Agricultural Research Center has shown that performance of stocker steers grazing high-endophyte tall fescue improved significantly when 'Regal' ladino clover was broadcast on the pastures in late winter. Lespedeza and red clover also are grown widely in southeastern Kansas. Information comparing grazing performance on these legumes with ladino clover interseeded in high-endophyte tall fescue is limited. This study was conducted to compare legume establishment, forage production, grazing performance, and subsequent feedlot performance of stocker steers grazing high-endophyte tall fescue pastures interseeded with ladino clover, lespedeza, or red clover.

## Experimental Procedures

**Pastures**. Nine 5-acre pastures located at the Parsons Unit of the Kansas State University - Southeast Agricultural Research Center on a Parsons silt loam soil (fine, mixed thermic Mollic Albaqualf) were used in an experiment with a randomized complete block design containing three replications. The pastures of established (>5-yr) `Kentucky 31N tall fescue were more than 65% infected with the endophyte *Neotyphodium coenophialum* Glen, Bacon, Price, and Hanlin (formerly *Acremonium coenophialum*). Pastures were fertilized in September 1994 with 40-40-40 and in September 1995, 1996, and 1997 with 16-40-40 lb/acre of N-$P_2O_5$-$K_2O$. Pastures were treated in early spring of 1994 with 3 tons/acre of ag lime (62% ECC). The three legumes were seeded in late February 1995 with a no-till drill. Three pastures each received 4 lb/acre of Regal ladino clover, 12 lb/acre of `KenlandN red clover, or 15 lb/acre of 'Marion' striate lespedeza. Pastures were seeded again in mid-March of 1996 and early March of 1997 with the same legumes planted in 1995, except that Korean rather

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than Marion lespedeza was planted. Seeding rates in 1996 were 6 lb/acre of Regal ladino clover, 13 lb/acre of Kenland red clover, or 17 lb/acre of Korean lespedeza. Seeding rates in 1997 were 4 lb/acre of Regal ladino clover, 12 lb/acre of Kenland red clover, or 14 lb/acre of Korean lespedeza.

Available forage was determined at the initiation of grazing and during the season with a disk meter calibrated for tall fescue. Three exclosures (15-20 $ft^2$) were placed in each pasture; total production was estimated from three readings per exclosure, and available forage was determined from three readings near each cage. Legume canopy coverage was estimated from the percentage of the disk circumference that contacted a portion of the canopy.

**Grazing Steers**. In 1995, 1996, and 1997, 45 mixed-breed steers were weighed on consecutive days, stratified by weight, and allotted randomly to the nine pastures. Grazing was initiated on March 31, 1995; April 24, 1996; and April 1, 1997. Initial weights were 690 lb in 1995, 524 lb in 1996, and 516 lb in 1997. Cattle were treated for internal and external parasites prior to being turned out to pasture and later were vaccinated for protection from pinkeye. Steers grazed for 200 days in 1995, 168 days in 1996, and 220 days in 1997. Steers were fed 2 lb of ground grain sorghum per head daily and had free access to commercial mineral blocks that contained 12% calcium, 12% phosphorus, and 12% salt. Grazing was terminated and steers were weighed on October 16 and 17 in 1995, October 8 and 9 in 1996, and November 6 and 7 in 1997.

Following the grazing period, cattle were shipped to a finishing facility and fed a diet containing 80% ground grain sorghum, 15% corn silage, and 5% supplement on a dry matter basis. Steers were implanted with Synovex S® on days 0 and 84 of the finishing period. Cattle grazed during 1995, 1996, and 1997 were fed finishing diets for 164, 139, and 154 days, respectively, and were slaughtered in a commercial facility. Carcass data were collected.

## Results and Discussion

**Pastures**. Available, total, forage dry matter and legume coverage of the pastures for 1995, 1996, and 1997 are presented in Figures 1, 2, and 3, respectively. Legume treatment caused no differences in forage availability during any year. However, total forage availability was less in 1996 than in 1995 and 1997, perhaps because of a reduction in the density of the fescue stand caused by the extremely cold and dry winter of 1995-96. In 1997, total forage dry matter production and legume coverage were both higher than in previous years because of the favorable rainfall pattern.

In 1995, canopy coverages of legumes were generally less than 10%. Stands of legumes likely were diminished by extremes of spring drought followed by wet soils in early summer and drought again in late summer. Coverage was higher ($P<.05$) in red clover-seeded pastures than in other legume pastures in March and April, but coverage was greatest in the lespedeza pastures by the end of June. Lespedeza coverage in cages appeared higher than for the other legumes at the end of summer, but this was not significant ($P>.20$). In 1996, cover was higher for lespedeza than for red or ladino clover. Cover was highest for lespedeza and lowest for red clover during July and August. In 1997, cover for most of the season was higher for ladino clover than for red clover or lespedeza, particularly during July and August.

## Cattle Performance

Grazing and subsequent finishing performances of steers grazing fescue pastures interseeded with the various legumes in 1995, 1996, and 1997 are presented in Table 1. Results are listed by year for each legume treatment, because a significant ($P < .05$) treatment x year interaction occurred. Differences in grazing performance due to legume treatment increased each year during the duration of the study. Steers grazing pastures interseeded with lespedeza or ladino clover had identical ($P = .82$ and $P = .93$) gains in 1995 and 1996, respectively. In 1995, steers grazing red clover gained 11.3% less ($P = .13$) and 10.4% less ($P = .19$) than those grazing lespedeza and ladino clover, respectively. In 1996, steers grazing red clover gained 12.1% less ($P = .08$ and $P = .07$) than those grazing lespedeza and ladino clover, respectively. In 1997, steers grazing pastures interseeded with ladino clover gained 35.6% more ($P = .0001$) and 28.1% more ($P = .0001$) than those grazing pastures interseeded with lespedeza and red clover, respectively. Gains of steers grazing pastures interseeded with red clover or lespedeza were similar ($P = .26$).

Subsequent finishing gains and feed efficiencies were similar among legume treatments during all 3 years. Few differences in carcass measurements were observed for cattle grazing in 1995 and 1996. However, steers that grazed ladino clover during 1997 had heavier ($P = .0002$ and $P = .0004$) hot carcass wt., greater ($P = .01$ and $P = .03$) fat thickness, and higher ($P = .01$ and $P = .02$) numerical yield grade than steers that had grazed pastures interseeded with lespedeza and red clover, respectively. Steers that grazed lespedeza in 1997 had lower ($P = .02$ and $P = .004$) marbling scores and fewer ($P = .03$ and $P = .01$) percent choice carcasses than those that grazed red clover and ladino, respectively.

Overall gains (grazing plus finishing phase) were similar among legume treatments during 1995 and 1996. However, steers that grazed ladino during 1997 had higher ($P = .008$ and $P = .01$) overall gains than those that grazed red clover and lespedeza, respectively.

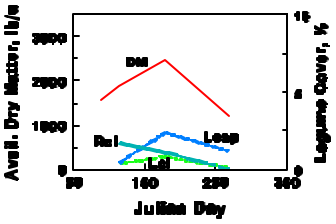


**Figure 1. Available Forage and Legume Canopy Cover in Tall Fescue Pastures, 1995, Southeast Agricultural Research Center.**

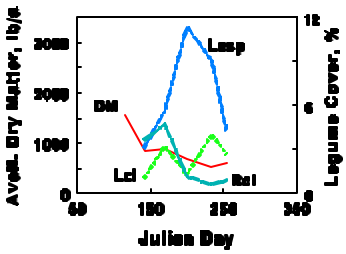


**Figure 2. Available Forage and Legume Canopy Cover in Tall Fescue Pastures, 1996, Southeast Agricultural Research Center.**

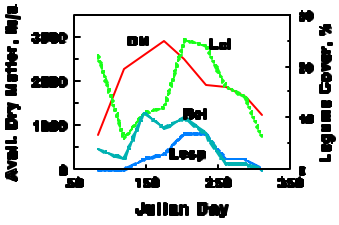


**Figure 3. Available Forage and Legume Canopy Cover in Tall Fescue Pastures, 1997, Southeast Agricultural Research Center.**

**Table 1. Effects of Interseeding Legumes into Endophyte-Infected Fescue Pastures on Performance of Steers**

| | 1995 | | | 1996 | | | 1997 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Legume | | | Legume | | | Legume | | |
| Item | Lespedeza | Red Clover | Ladino Clover | Lespedeza | Red Clover | Ladino Clover | Lespedeza | Red Clover | Ladino Clover |
| Grazing Phase | | | | | | | | | |
| No. of days | 200 | 200 | 200 | 168 | 168 | 168 | 220 | 220 | 220 |
| No. of head | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 |
| Initial wt., lb | 690 | 694 | 691 | 524 | 524 | 524 | 512 | 517 | 519 |
| Ending wt., lb | 926 | 906 | 924 | 757 | 733 | 758 | 813[a] | 838[a] | 930[b] |
| Gain, lb | 236 | 212 | 233 | 233 | 209 | 234 | 301[a] | 321[a] | 411[b] |
| Daily gain, lb | 1.18 | 1.06 | 1.17 | 1.39 | 1.24 | 1.39 | 1.37[a] | 1.46[a] | 1.87[b] |
| Finishing Phase | | | | | | | | | |
| No. of days | 164 | 164 | 164 | 139 | 139 | 139 | 154 | 154 | 154 |
| No. of head | 15 | 15 | 15 | 14 | 15 | 14 | 15 | 15 | 15 |
| Starting wt., lb | 926 | 906 | 924 | 762[a,b] | 733[a] | 763[b] | 813[a] | 838[a] | 930[b] |
| Final wt., lb | 1404 | 1386 | 1367 | 1223 | 12071227 | 1318[a] | | 1313[a] | 1408[b] |
| Gain, lb | 478 | 480 | 443 | 461 | 474 | 464 | 505 | 475 | 478 |
| Daily gain, lb | 2.91 | 2.93 | 2.70 | 3.31 | 3.41 | 3.34 | 3.28 | 3.08 | 3.10 |
| Daily DM intake, lb | 25.7 | 25.0 | 25.2 | 23.5 | 23.5 | 23.6 | 25.5 | 25.7 | 26.1 |
| Feed/gain | 8.9 | 8.6 | 9.4 | 7.1 | 6.9 | 7.1 | 7.8 | 8.3 | 8.4 |
| Hot carcass wt., lb | 867 | 862 | 844 | 756 | 735 | 761 | 781[a] | 789[a] | 858[b] |
| Dressing % | 61.8 | 62.1 | 61.7 | 61.8[a] | 60.9[b] | 62.1[a] | 59.2[a] | 60.1[a,b] | 60.9[b] |
| Backfat, in | .44 | .46 | .49 | .29 | .30 | .24 | .41[a] | .45[a] | .56[b] |
| Ribeye area, $in^2$ | 14.5 | 14.1 | 14.0 | 14.9[a] | 14.0[a] | 16.2[b] | 12.4 | 12.3 | 13.0 |
| Yield grade | 2.3[a,b] | 2.1[a] | 2.5[b] | 1.7 | 1.6 | 1.3 | 2.9[a] | 3.0[a] | 3.5[b] |
| Marbling score | SM[63] | SM63 | SM[89] | SM[21a] | SM[03a,b] | SL[59b] | SM[21a] | SM[97b] | MT[22b] |
| % Choice | 87 | 80 | 87 | 57 | 40 | 43 | 67[a] | 93[b] | 100[b] |
| Overall Performance (Grazing + Finishing Phase) | | | | | | | | | |
| No. of days | 364 | 364 | 364 | 307 | 307 | 307 | 374 | 374 | 374 |
| Gain, lb | 714 | 692 | 677 | 698 | 683 | 702 | 806[a] | 796[a] | 889[b] |
| Daily gain, lb | 1.96 | 1.90 | 1.86 | 2.27 | 2.22 | 2.29 | 2.15[a] | 2.13[a] | 2.38[b] |

[a,b]Means within a row within the same year with the same letter are not significantly different (P<.05).

# NUTRITIONAL EVALUATION OF CORN AND SORGHUM CROP RESIDUES [1,2,3]

*D. A. Blasi, R. K. Taylor[4], G. L. Kilgore[5], S. R. Duncan[5], and J. J. Higgins[6]*

## Summary

Crop residue samples from 22 grazed and nongrazed corn and sorghum residue fields across Kansas were collected every 2 weeks during the 1997/98 winter feeding season to evaluate quality and yield. Corn residue averaged about 2 ½ tons of total dry matter (DM)/acre, with the leaf fraction (attached and unattached) constituting about 60% of that residue. Unattached leaves represented 85% of the total leaf DM. Yield estimates for sorghum residue averaged over 2 tons/ acre. The stem component represented 55 to 60% of the total DM collected, and about 58% of the leaves remained attached to the stem.

(Key Words: Crop Residues, Forage Quality.)

## Introduction

Tillage and fertilization practices and crop varieties have changed dramatically since the 1970's when the vast majority of crop residue research was conducted by Midwest universities. Moreover, today's harvesting equipment is much more efficient, so less grain is left in the field. The objective of this demonstration project was to obtain yield and quality estimates of corn and sorghum residue from across Kansas.

## Experimental Procedures

Twenty-one County Extension Agents from across the state each identified a progressive livestock producer willing to participate in the study. At the onset of the grazing season, approximately ½ acre at each location was excluded from active grazing to evaluate the effects of weathering on residue nutrient content.

Residue was collected at 2-week intervals throughout the grazing season. For each sampling period, the residue in the grazed and nongrazed areas was collected from four different areas of the residue field in 8-foot

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[1]A project sponsored by the K-State Research and Extension Forage Task Force.

[2]Appreciation is expressed to the following County Extension Agents for their active involvement in this study: Cynthia Dixson, Rawlins; Lyle Hammer, Logan; John Stannard, Russell; Sandra Wick, Smith; Frank Swan, Stanton; Darl Henson, Grant; Gary Gold, Stevens; Dean Whitehill, Finney; Bob Frisbie, Pawnee; Paul Rickabaugh, Comanche; Todd Whitney, Rice; Greg McCormack, Reno; Ron Graber, Harvey; Steve Tonn, Marion; Ron Seyfert, Ottawa; Michael Vogt, Marshall; Jody Holthaus, Jackson; Ray Ladd, Atchison; Bill Wood, Doniphan; Jeff Davidson, Greenwood; and Dean Stites, Crawford.

[3]Peterson Laboratories, Inc., Hutchinson, KS.

[4]Extension Specialist, Farm Power and Machinery, Biological and Agricultural Engineering.

[5]Extension Specialists, Crop and Soils, Southeast and South Central Area, respectively.

[6]Department of Statistics.

row lengths and separated into attached leaves (manually removed from stem), unattached leaves, and stems (harvested above the brace root). After each sampling period, the collected samples were allowed air dry. All subsamples from each plant part and sampling period were weighed individually to estimate lbs DM/ acre and ground through a lawn chipper. The replicated samples were composited and sent to a commercial forage testing laboratory for analysis of DM and crude protein (CP) content. In addition, neutral detergent fiber (NDF) and acid detergent fiber (ADF) levels were determined, and the ADF concentrations were used to estimate TDN (see footnote in tables). To arrive at district averages, data from individual counties were composited by crop. Only counties with multiple sampling periods were included in this compilation. Means and standard deviations are presented for each residue type by plant part, as well as by grazed versus nongrazed.

## Results and Discussion

Statewide averages for DM yield/acre and nutrient content of corn and sorghum residues are shown in Tables 1 and 4, respectively. Corn residue in the west averaged over 4 tons total DM/acre (Table 2). This value was almost double that from the central area and considerably higher than that from northeast Kansas. Corn leaves (attached and unattached) constituted 50 to 60% of residue DM. Unattached leaves represented almost 85% of the total leaf DM weight and 50% of the total plant DM collected. These observations are consistent with earlier reports citing the vulnerability of corn residue to wastage from trampling and snow. Total CP content of corn residue averaged about 5% and ranged from 4.60 to 5.60% across the state (Table 5). CP contents averaged about 5% in the leaf fraction and close to 4% in the stem fraction. The TDN content of the leaf fractions (unattached and attached) ranged from 48 to 51% throughout the state, whereas that of stems was close to 44%.

The DM yields of sorghum residue for central Kansas averaged about 2.0 tons per acre and is consistent with previous research reporting lower residue production per acre for sorghum than corn (Table 3). The stem component represented 55 to 60% of the total DM collected from the grazed and ungrazed locations. Stem percentage (as a percent of total DM) increased and leaf fractions declined as residue grazing progressed. In contrast to corn, about 58% of the sorghum leaves were attached.

Total CP contents of sorghum residue in the central area averaged 5.6% for grazed and 6.8% for the ungrazed areas (Table 6). CP contents in the leaf fractions averaged 8.0% in the nongrazed and about 7% in the grazed fields. The TDN for both sorghum stem and leaf fractions was near 50%. CP and TDN values obtained from the collected samples are comparable to values from other published reports.

**Table 1. Statewide Dry Matter Yield (lbs DM/acre) of Crop Residue by Crop Type and Plant Part**

| | Corn | | Sorghum | |
|---|---|---|---|---|
| Plant Part | Grazed | Nongrazed | Grazed | Nongrazed |
| Leaves | | | | |
| Unattached | 2655 ± 1084 | 2787 ± 1148 | 636 ± 754 | 778 ± 711 |
| Attached | 486 ± 329 | 581±326 | 867 ± 551 | 1100 ± 541 |
| Stem | 2388 ± 1181 | 2544 ± 1309 | 2507 ± 1026 | 2412 ± 1064 |

**Table 2. Corn Dry Matter Yield (lbs DM/acre) by Crop Reporting District and Plant Part**

| | Central | | West | | East | |
|---|---|---|---|---|---|---|
| Plant Part | Grazed | Nongrazed | Grazed | Nongrazed | Grazed | Nongrazed |
| Leaves | | | | | | |
| Unattached | 2434 ± 688 | 2415 ± 753 | 4204 ± 579 | 4516 ± | 1928 ± 448 | 2047 ± |
| Attached | 499 ± 425 | 431 ± 421 | 640 ± 253 | 880 ± 126 | 389 ± 169 | 522 ± 242 |
| Stem | 2707 ± 589 | 2952 ± 782 | 3943 ± 345 | 4146 ± | 1272 ± 207 | 1256 ± |

**Table 3. Sorghum Dry Matter Yield by Cropping District and Plant Part**

| | Central | | East | |
|---|---|---|---|---|
| Plant Part | Grazed | Nongrazed | Grazed | Nongrazed |
| Leaves | | | | |
| Unattached | 660 ± 550 | 868 ± 798 | 556 ± 294 | 506 ± 210 |
| Attached | 898 ± 580 | 1170 ± 545 | 715 ± 385 | 791 ± 443 |
| Stem | 2513 ± 1006 | 2447 ± 1117 | 2482 ± 1207 | 2258 ± 875 |

**Table 4. Statewide Nutrient Contents of Corn and Sorghum Crop Residues by Plant Part**

| | Corn | | Sorghum | |
|---|---|---|---|---|
| Plant Part | Grazed | Nongrazed | Grazed | Nongraze |
| Leaves | | | | |
| Unattached | | | | |
| DM[1] | 88.6 ± 3.4 | 86.9 ± 5.2 | 87.1 ± 4.8 | 87.5 ±3.9 |
| CP | 5.18 ± .55 | 5.15 ± .68 | 6.54 ± 2.4 | 7.4 ± 2.6 |
| ADF | 49.9 ± 1.9 | 50.6 ± 2.9 | 48.4 ± 4.2 | 47.6 ± 4.7 |
| NDF | 76.2 ± 1.9 | 74.9 ± 4.4 | 66.1 ± 8.1 | 67.0 ± 8.6 |
| TDN[2] | 49.5 ± 2.3 | 49.0 ± 2.3 | 50.7 ± 3.3 | 51.3 ± 3.7 |
| Attached | | | | |
| DM | 87.4 ± 7.7 | 87.5 ± 6.1 | 86.6 ±5.3 | 87.3 ±3.1 |
| CP | 5.17 ± .74 | 5.13 ± .98 | 6.96 ± 2.7 | 8.17± 2.7 |
| ADF | 50.25 ± 3.5 | 49.7 ± 2.1 | 47.2 ± 4.1 | 45.1 ± 4.2 |
| NDF | 77.1 ± 2.9 | 77.0 ± 2.2 | 66.0 ± 4.2 | 64.4 ± 4.7 |
| TDN | 49.5 ± 2.8 | 49.0 ± 1.7 | 51.6 ± 3.2 | 53.3 ± 3.3 |
| Stem | | | | |
| DM | 89.1 ± 3.5 | 88.9 ± 3.7 | 70.0 ± 18.4 | 68.3 ±18.4 |
| CP | 4.05 ± .76 | 4.14 ± .47 | 4.20 ±1.6 | 4.43± 1.6 |
| ADF | 57.2 ± 3.5 | 56.7 ± 2.4 | 50.7 ± 3.2 | 50.3 ± 3.7 |
| NDF | 79.3 ± 4.0 | 79.1 ± 2.2 | 72.8 ± 4.1 | 72.1 ± 4.6 |
| TDN | 43.7 ± 2.8 | 44.1 ± 1.9 | 50.2 ± 7.1 | 49.1 ± 2.9 |

[1]DM= % dry matter; CP= % crude protein; ADF = % acid detergent fiber; NDF = % neutral detergent fiber; TDN = % total digestible nutrients.
[2]% TDN = 88.9 - (.79 × % ADF).

**Table 5. Corn Residue Nutrient Content by Crop Reporting District and Plant Part**

| | Central | | West | | East | |
|---|---|---|---|---|---|---|
| Plant Part | Grazed | Nongrazed | Grazed | Nongrazed | Grazed | Nongrazed |
| Leaves | | | | | | |
| Unattached | | | | | | |
| DM[1] | 92.6 ± 1.4 | 92.4 ± 1.4 | 88.4 ± .58 | 84.8 ± 4.8 | 85.8 ± 2.2 | 84.0 ± 4.0 |
| CP | 5.27 ± .77 | 4.58 ± 5.4 | 5.1 ± .36 | 5.23 ± 2.8 | 5.18 ± .53 | 5.56 ± .69 |
| ADF | 51.3 ± 3.5 | 51.8 ± 3.8 | 50.6 ± 1.4 | 52.1 ±1.55 | 48.5 ± 2.7 | 48.6 ± 1.7 |
| NDF | 77.2 ± 2 | 77.9 ± 2.0 | 76.4 ± 1.3 | 75.4 ± 2.9 | 75.4 ± 2.1 | 72.3 ± 5.1 |
| TDN[2] | 48.4 ± 2.8 | 48.0 ± 3.0 | 48.9 ± 1.1 | 47.7 ±1.2 | 50.6 ± 2.1 | 50.5 ± 1.31 |
| Attached | | | | | | |
| DM | 92.4 ± 1.2 | 91.5 ± .88 | 88.9 ± 1.3 | 88.1 ±.98 | 83.1 ±10.2 | 84.0 ± 8.2 |
| CP | 5.76 ± .67 | 5.78 ± 4.2 | 4.61± .28 | 5.75 ± .79 | 5.07 ± .72 | 4.24 ± .72 |
| ADF | 51.3 ± 3.0 | 51.0 ± 2.9 | 47.9 ± 8.4 | 49.2 ± .32 | 50.9 ± 4.39 | 49 ± 1.84 |
| NDF | 75.5 ± 2.9 | 75.9 ±1.4 | 79.3 ± 1.39 | 75.7 ± 1.9 | 76.9 ± 2.9 | 78.7 ± 1.9 |
| TDN | 48.4 ± 2.3 | 48.6 ± 2.3 | 51.1 ± .67 | 50 ±.25 | 48.7 ± 3.47 | 50.2 ± 1.5 |
| Stem | | | | | | |
| DM | 93.3 ± 1.4 | 92.6 ± .82 | 88.3 ± 3.2 | 89.6 ± .71 | 86.5 ±1.4 | 85.5 ± 2.8 |
| CP | 3.4 ± .73 | 3.87 ± .56 | 4.16± .44 | 4.12 ± .13 | 4.45 ± .67 | 4.36 ± .48 |
| ADF | 58.8 ±4.5 | 57.9 ± 2.5 | 55.5 ± 3.7 | 55 ± 1.49 | 57.0 ± 2.7 | 56.6 ± 2.4 |
| NDF | 78.7 ± 4.7 | 78.8 ±1.14 | 77.9 ± 5.4 | 77.1 ± 3.23 | 80.6 ± 2.8 | 80.5 ± 1.3 |
| TDN | 42.4 ± 3.5 | 43.2 ± 2.00 | 45.0 ± 2.9 | 45.4 ±.1.18 | 43.9 ± 2.1 | 44.2 ± 1.9 |

[1]DM= % dry matter; CP= % crude protein; ADF = % acid detergent fiber; NDF = % neutral detergent fiber; TDN = % total digestible nutrients.
[2]% TDN = 88.9 - (.79 × % ADF).

**Table 6. Sorghum Residue Content by Crop Reporting District and Plant Part**

| | Central | | East | |
|---|---|---|---|---|
| Plant Part | Grazed | Nongrazed | Grazed | Nongrazed |
| Leaves | | | | |
| Unattached | | | | |
| DM[1] | 86.4 ± 5.2 | 86.8 ± 4.2 | 89.8 ± 1.1 | 89.7 ±1.12 |
| CP | 6.92 ± 2.6 | 8.0 ± 2.6 | 5.04 ± .31 | 5.26± .63 |
| ADF | 47.1 ± 3.4 | 46.02 ±4 | 53.6 ± 2.4 | 53.4 ± 1.5 |
| NDF | 64.1 ± 8.0 | 64.3 ±7.6 | 73.9 ± 1.2 | 77 ± 1.9 |
| TDN[2] | 51.7 ± 2.7 | 52.5 ± 3.2 | 46.5 ±1.9 | 46.7 ±1.21 |
| Attached | | | | |
| DM | 86.1 ± 5.6 | 86.7 ± 3.1 | 89.7 ±1.6 | 89.9 ±1.43 |
| CP | 6.9 ± 2.8 | 8.2 ± 2.9 | 7.32 ± 1.7 | 7.91± 1.71 |
| ADF | 46.9 ± 4.2 | 44.4 ±4.3 | 49.2 ± 2.9 | 48.1 ± 1.6 |
| NDF | 65.7 ± 4.5 | 63.5 ±4.7 | 68 ± .77 | 68.4 ± 1.8 |
| TDN | 51.9 ± 3.3 | 53.9 ± 3.4 | 50 ±2.32 | 50.9 ± 1.3 |
| Stem | | | | |
| DM | 68.5 ± 19.8 | 65.6 ±18.7 | 79.7 ± 14.2 | 80 ±12.6 |
| CP | 4.21 ± 1.6 | 4.5 ± 1.6 | 4.16 ±1.21 | 4.01± 1.14 |
| ADF | 50.2 ± 3.2 | 49.9 ± 3.7 | 53.3 ±1.74 | 52.3 ± 3.26 |
| NDF | 72.7 ± 4.4 | 71.9 ± 4.8 | 73.7 ± 2.2 | 73.1 ± 3.62 |
| TDN | 50.7 ± 7.5 | 49.5 ± 2.9 | 46.8 ± 1.4 | 47.6 ± 2.58 |

[1]DM= % dry matter; CP= % crude protein; ADF = % acid detergent fiber; NDF = % neutral detergent fiber; TDN = % total digestible nutrients.
[2]% TDN = 88.9 - (.79 × % ADF).

# EFFECT OF DATE OF HARVEST ON THE YIELD AND NUTRITIONAL QUALITY OF NATIVE GRASS HAY

***J. C. Baker, D. E. Kehler, S. R. Tonn, S. I. Paisley, and D. A. Blasi***

## Summary

Native grass hay meadows in three Kansas Flint Hills counties were sampled at 2-week intervals during the 1997 and 1998 growing seasons to determine the effect of harvest date on forage quality and dry matter (DM) yield. Each sample was weighed and analyzed for crude protein (CP), acid detergent fiber (ADF), and phosphorus (PHOS). The CP and PHOS contents declined, whereas ADF and DM yield increased as harvest date progressed. Although CP, ADF and DM yield were related highly to harvest date, the association for PHOS content was only moderate. Because harvest date of native grass hay can significantly influence supplemental protein needs for beef cows, mid-July harvesting appears to be the best compromise between yield and forage quality.

(Key Words: Native Grass, Hay, Forage Quality, Cows.)

## Introduction

Native grass hay is an important roughage source for wintering beef cattle in Kansas. Harvest date is the most important management factor for native grass hay meadows, because it has a major impact on DM yield, forage quality, and subsequent plant vigor. Native hay harvest in the Flint Hills region normally occurs in mid-July, although it can take place from late June through September.

Because forage quality decreases and DM yield per acre increases with advancing plant maturity, the optimum harvest date for native grass hay involves a compromise between DM yield (tons/acre) and forage quality. Additionally, sufficient time must be permitted for perennial, warm-season grasses to replenish their root carbohydrate reserves prior to winter dormancy.

Our objective was to document and develop prediction equations for changes in yield and nutritive value of native-grass hay harvested at progressively later dates throughout the growing season.

## Experimental Procedures

Native-grass hay meadows in Butler, Cowley and Marion counties were used. Meadows consisted of mixed species of perennial, warm-season grasses and forbs that are dominant in the Kansas Flint Hills. Growing conditions were near normal in 1997 at all three locations. In 1998, however, both the Butler and Cowley locations experienced drought conditions during much of the growing season (June to mid-August).

A 35 ft. long by 3 ft. wide plot was established at each county location. Within each plot, 12 blocks corresponding to harvest dates were established. A 30-in. x 30-in. sample was hand clipped from the center of each block leaving a 4-in. stubble height. Samples were harvested at 2-week intervals from June 3 to November 4, 1997, and June 2 to November 3, 1998.

Immediately after clipping, forage samples were sealed in an airtight bag and submitted to a commercial forage testing laboratory for chemical analysis. Samples for each harvest date were analyzed for dry matter (DM), crude protein (CP), acid detergent fiber (ADF), and phosphorus (PHOS). In

1998, samples were weighed prior to shipping, and DM yields (lb/acre) determined. Regression equations were developed to describe the relationships between harvest date and CP, ADF, PHOS, and DM yield. Julian calendar date (JCD) was included as the independent variable (June 1=day 153, November 3=day 308). Feed costs were estimated for lactating beef cows consuming native grass hay of various CP content.

## Results and Discussion

Individual county data for both years (1997 and 1998) were combined and pooled into one overall regression equation for CP and PHOS. Only combined county data from 1998 were available to pool and develop an overall regression equation for DM. Because of a significant year effect, regression equations for ADF were developed for each year. Harvest date accounted for the majority of the variation in CP ($R^2$=.84). As anticipated, CP content declined with advancing maturity (Figure 1), where %CP= 25.75-(.1461 x JCD) + (.00025 x $JCD^2$). Average CP contents ranged from 10.46% on June 3 to 3.58% on November 4 in 1997 and from 8.48 % on June 2 to 4.64% in 1998. CP content tended to be higher in 1997 than 1998, particularly early in the growing season.

The ADF content increased by 1 percentage unit every 12 days (%ADF=21.75 + [.0836 x JCD]) in 1997 and by 1 percentage unit every 18 days (%ADF=29.84 + [.0557 x JCD]) in 1998, within the window of the sampling period (Figure 2). Drought stress at two of the four locations in 1998 reduced early season plant growth and development. This resulted in greater variation in ADF values and a stronger relationship between harvest date and ADF in 1997 ($R^2$=.81) than in 1998 ($R^2$=.62).

Harvest date was less effective in predicting PHOS content ($R^2$=.40) for the 2-year period (Figure 3). However, PHOS content tended to decline with advancing maturity and ranged from .18% to .04% (%PHOS= .1783 - [.00034 x JCD]). In 1998, average dry matter yield ranged from 783 lb/acre on June 2 to 2138 lb/acre on November 3 (Figure 4). Drought conditions at two of the four locations influenced DM yield. During the sampling period, DM increased by 500 lb/acre every 55 days (DM = -563.5 + [9.14 x JCD]), ($R^2$=.61).

Because the CP content of the base forage influences the amount of supplemental protein needed, beef cows or stockers fed forages harvested beyond the optimum date will require more supplemental protein. Table 1 illustrates the influence of harvest date and CP content of native hay on the supplemental protein requirements for a 1,100 lb lactating beef cow.

In this example, cows consuming 4.0% CP native grass hay would require an additional .88 lb of protein supplement at an added cost of $.24/day, compared to cows consuming 8.0% CP hay. Represented another way, an approximate cost savings of $3.54 per cow occurs for each percentage unit improvement in CP between 4.0 and 8.0%. Based on the results of this study, native hay meadows harvested by mid-July would be an acceptable compromise between forage quality and dry matter yield, while allowing adequate time for range grasses to replenish root carbohydrate reserves prior to fall dormancy.

**Table 1. Influence of Harvest Date and Crude Protein Content of Native Grass Hay on Supplemental Protein Cost[1]**

| Date | % CP Content of Native Grass Hay | Pounds of Supplemental CP Required[2] | Cost/Day of Supplemental CP Source[3] | Total Supplement Cost[4] |
|---|---|---|---|---|
| 7/1 | 8.0 | .84 | $.23 | $13.57 |
| 7/15 | 7.0 | 1.06 | $.29 | $17.28 |
| 7/29 | 6.0 | 1.28 | $.35 | $20.81 |
| 8/26 | 5.0 | 1.50 | $.41 | $24.19 |
| 9/23 | 4.0 | 1.72 | $.47 | $27.73 |

[1]CP requirements for 1,100 lb mature, lactating beef cow of superior milk production (20 lb/day), 3-4 months postpartum=2.6 lb CP/day.
[2]After accounting for CP content in native grass hay; assuming dry matter intake=22 lb/day.
[3]38% commercial protein cube ($210/ton).
[4]For the postcalving period February 15 to April 15 (59 days).

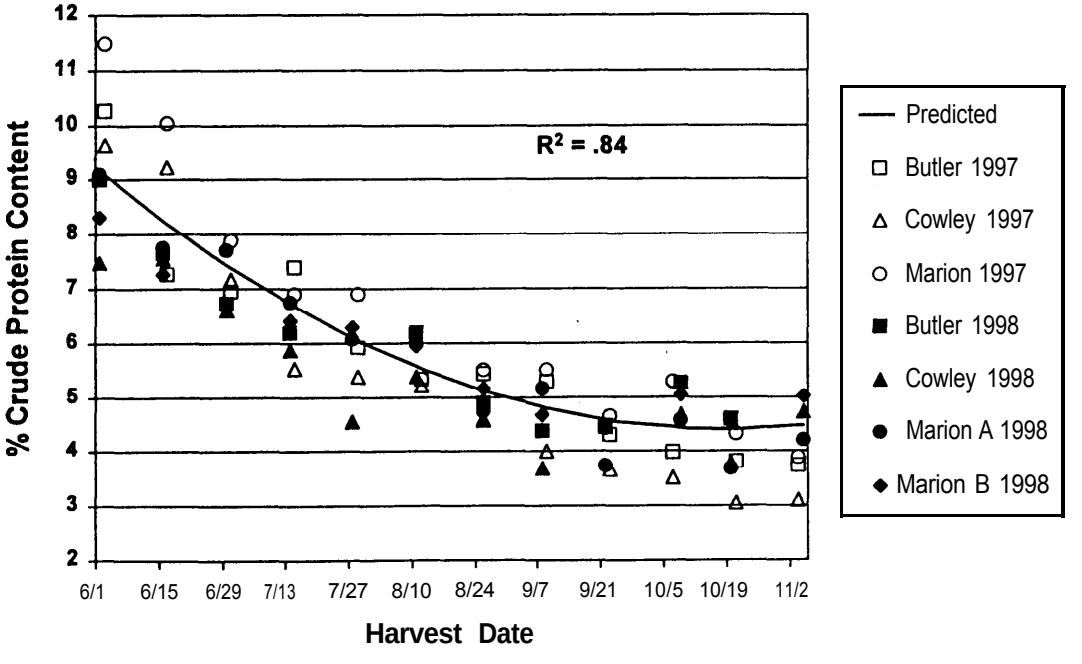
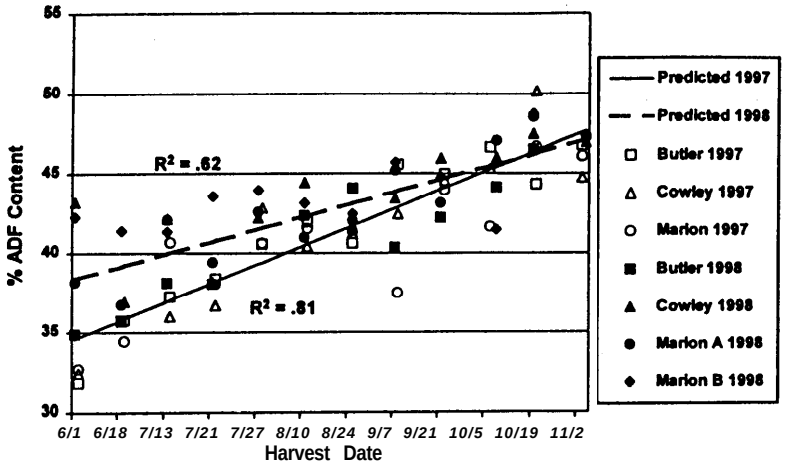
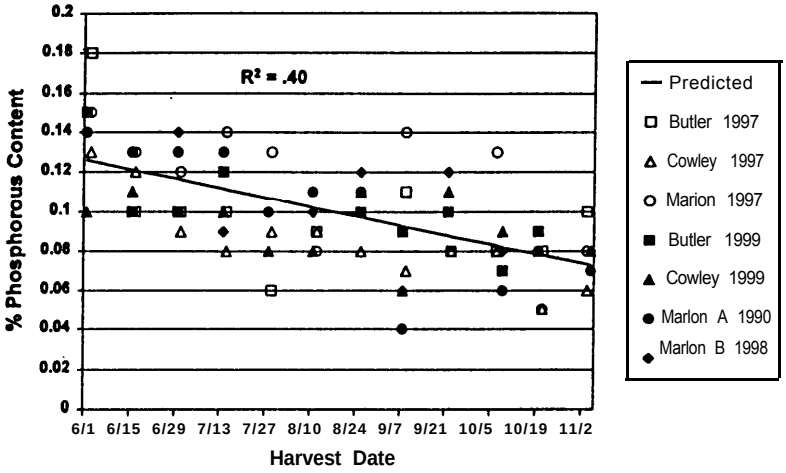



**Figure 1. Crude Protein Content of Native Grass Hay.**



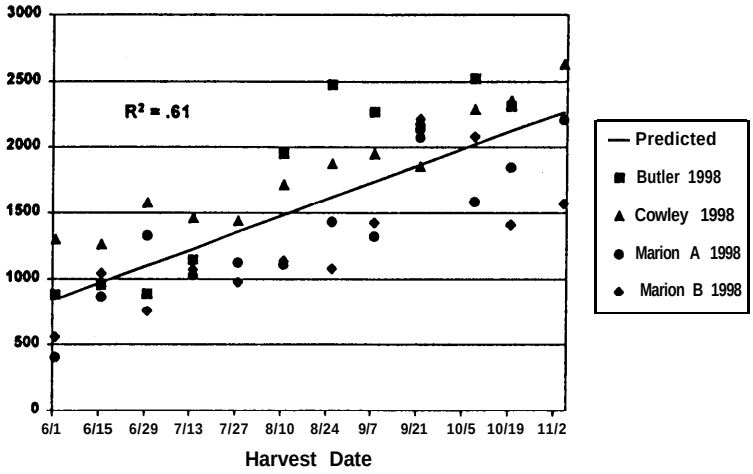

ADF (1997) = 21.75 + (.0836*Julian Date). ADF (1998) = 29.84 + (.0557* Jullan Date)

**Figure 2. Acid Detergent Fiber Content of Native Grass Hay.**




Phosphorous - .1783 - (00034*Jullian Date)

**Figure 3. Phosphorous Content of Native Grass Hay.**




Dry Matter = -563.5 + (9.14*Julian Date)

**Figure 4. Dry Matter Yield of Native Grass Hay.**

# EFFECTS OF STARTING WEIGHT, BODY CONDITION, AND AGE ON GAIN OF CATTLE GRAZING NATIVE GRASS

*F. K. Brazle[1] and J. Higgins[2]*

## Summary

In 29 trials over 10 years, 6,614 head of cattle (heifers - 11 trials, 2,862 hd; steers - 18 trials, 3,752 hd) were used to determine the effect of starting weight on gain while grazing burned, native-grass pastures. The heifers grazed for an average of 81 days (70 to 93) and steers for an average of 86 days (75 to 99) from April to July. Stocking rate was one animal per 2 acres. The cattle were sorted by starting weight into groups as follows: below 399 lb, 400 to 499 lb, 500 to 599 lb, 600 to 699 lb, and above 700 lb. In three other trials, 613 yearling heifers were sorted by starting weight, as shown above, and assigned a body condition score from 1 (thinnest to 5 (fattest). A separate grazing trial was conducted in which 158 yearling steers were compared to 103 steer calves. The yearlings were spring born and wintered on wheat pasture; the calves were fall born. Lightweight heifers had the greatest daily gain. Heifers between 400 and 499 lb gained considerably more ($P<.08$) than heifers that weighed more than 600 lb. The steers with starting weights between 400 to 499 lb and 500 to 599 lb gained substantially more ($P<.01$) than other weight groups. Steers gained faster than heifers (2.29 lb vs 1.90 lb/day, $P<.01$). As heifers became fleshier, gain declined in all weight groups. Fall-born steer calves (444 lb) gained slower (2.45 vs 2.68 lb per day, $P<.01$) than spring-born yearling steers (587 lb). Based on these data, the optimum starting weight for stocker cattle is between 400 and 499 lb for heifers and between 400 and 599 lb for steers. Yearling steers gained better than calves. In conclusion, sex, age, and starting weight of cattle affect their gains while grazing burned, native grass pastures. The optimum weight for best pasture gain may vary by forage type and quality, but clearly there is an ideal weight range for stocker cattle used for grazing.

(Key Words: Stocker, Starting Weight, Grass.)

## Introduction

Historically, considerable variability has occurred in the weight, sex, and kind of grazing cattle. However, there is little documentation on how starting weight, age and sex affect gain. Therefore, we compiled the records from many studies where cattle grazed native pasture to determine the effects of weight and sex on performance while grazing. Other studies were conducted to evaluate the effects of age and body condition on performance while grazing.

## Experimental Procedures

To evaluate the effect of age on performance, 158 spring-born steer calves that had been wintered on wheat pasture and 103 fall-born calves out of the same cow herd (Limousin × Angus) grazed the same pastures for 93 days. Both groups were subject to a standard health and implant program.

To evaluate the effect of body condition and starting weight on performance, three

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studies were conducted using 602 yearling heifers that had been wintered together. They were condition scored (1 = thin, 3 = average, 5 = fleshy) and allotted to starting weights of 300 to 399 lb, 400 to 499 lb, 500 to 599 lb, and 600 to 699 lb.

To evaluate the effect of starting weight, 11 studies used 2862 heifers sorted into the following starting weight groups: 399 lb and down, 400 to 499 lb, 500 to 599 lb, 600 to 699 lb, and 700 lb and up. The heifers grazed burned native grass pastures for an average of 81 days.

To evaluate the effect of starting weight of steers, 18 studies were compiled in which 3752 steers were sorted into starting weights of: 399 lb and less, 400 to 499 lb, 500 to 599 lb, 600 to 699 lb, and 700 lb and up. The steers grazed for an average of 86 days.

In all studies, the health and implant programs were those typically followed with grazing cattle in the Flint Hills. The data were analyzed by SAS using weighted analysis of variance, where weight groups per study were weighted by reciprocal standard errors, and number of animals per weight group were used for calf vs yearling and condition studies.

## Results and Discussion

Yearling steers grazing native grass pastures gained faster (2.68 vs 2.45 lb/day, P<.004) than calves (Table 1). Heifers that were average in body condition or a little thin gained faster than heifers with higher body condition (Table 2). Heifers that had both heavy starting weights and high body condition had poor weight gains on grass.

Pooling data from the 29 steer and heifer studies (Table 3) showed that steers typically gained faster than heifers (2.3 vs 1.9 lb/day, P<.01) while grazing native grass pastures. The best steer gains were in the groups that weighed 400 to 499 lb and 500 to 599 lb (P<.01; Table 2). Lighter and heavier cattle exhibited the poorest gains. However, body condition was not accounted for in this analysis. In general, the most desirable weight range for steers grazing native grass pasture for less than 100 days was between 500 and 599 lb. The most desirable starting weight for heifers grazing native grass was between 400 and 499 lb (Table 5). When heifers were heavier, we saw a decline in gain, particularly when starting weights were over 700 lb. Based on these results, it is clear that weight, age, and condition of cattle can significantly affect their performance when grazing native grass.

**Table 1. Grass Gains of Calves vs Yearling Steers**

| Item | Calves | Yearlings |
|---|---|---|
| No. head | 103 | 158 |
| Starting wt, lb | 444 | 587 |
| ADG, lb | 2.45[a] | 2.68[b] |
| Days | 93 | 93 |

[a,b]Means in the same row with unlike superscripts are different (P<.004).

**Table 2. Effect of Weight and Condition on Heifers' Gains**

| Starting Wt, lb | Condition Score 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| 300 to 399 ADG, lb | 2.01 | 2.10 | 1.56 | — |
| 400 to 499 ADG, lb | 2.12[a] | 2.18[a] | 1.96[ab] | 1.66[b] |
| 500 to 599 ADG, lb | 2.15[a] | 2.01[a] | 1.89[a] | 1.11[b] |
| 600 to 699 ADG, lb | 2.06[ab] | 2.08[a] | 1.68[b] | .98[c] |

[a,b,c]Means in the same row with unlike superscripts are different (P<.08).

**Table 3. Pooled Gain Data by Sex**

| Sex | ADG, lbs |
|---|---|
| Steers/lb/day | 2.3[a] |
| Heifers/lb/day | 1.9[b] |

[a,b]Means in the same column with unlike superscripts are different (P<.0007).

**Table 4. Effect of Steers Starting Weight on Gains on Native Grass (18 studies, 3,752 head, 86 days)**

| Starting Wt, lb | ADG, lb |
|---|---|
| 399 9 | 1.77[c] |
| 400 to 499 | 2.77[a] |
| 500 to 599 | 2.62[a] |
| 600 to 699 | 2.39[b] |
| 700 8 | 1.95[c] |

[a,b,c]Means in the same column with unlike superscripts are different (P<.01).

**Table 5. Effect of Heifer Starting Weight on Gains on Native Grass (11 studies, 2,862 head, 81 days)**

| Starting Wt, lb | ADG, lb |
|---|---|
| 399 9 | 2.09[ab] |
| 400 to 499 | 2.10[a] |
| 500 to 599 | 1.96[ab] |
| 600 to 699 | 1.82[b] |
| 700 lb 8 1 | .53[b] |

[a,b]Means in the same column with unlike superscripts are different (P<.08).

*Cattlemen's Day 1999*

# EFFECTS OF HALF- VS THREE-QUARTER-SEASON GRAZING OF NATIVE GRASS PASTURES

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## Summary

Mixed-breed steers (563 lbs) grazed burned, native-grass pastures (1990 to 1998). Steers were allotted randomly to graze native grass pastures for either 1/2 season (1/2) from April to July 15 (81 days, at 1 steer to 2 acres) or for 3/4 season (3/4) from April to August 15 (112 days, at 1 steer per 3 acres). The grass composition was measured in the first, fourth, and eighth years of the study. The economics of steers grazing the two systems were determined by calf and feeder cattle prices at Dodge City adjusted to southeast Kansas. The steers grazing 1/2 gained more per day (2.78 lb vs 2.48 lb, $P<.01$) but gained less ($P<.01$) per season (225 lb vs 278 lb). No changes in percentage composition occurred between systems for big bluestem, little bluestem, switchgrass, total perennial grass, or total perennial forbs. However, Indiangrass increased more ($P<.05$) while managed under 1/2 than 3/4 grazing. The 1/2 system had a higher return per acre, but the 3/4 system had a higher return per head. Grazing system did not appear to have a negative effect on grass composition during the 9-year period.

(Key Words: Native Grass, Stocker Cattle, Grazing Systems.)

## Introduction

The cost of renting native grass and the economics of the stocker cattle business have dictated consideration of different grazing times and stocking rates. In addition, flexibility in marketing times also is needed to reduce risks associated with the volitality of the cattle market. Our purpose was to compare two grazing systems (1/2 season and 3/4 season) in terms of steer gains, steer economics, and the effect of grazing on grass compositions.

## Experimental Procedures

Mixed breed steers (average starting weight = 563 lb) grazing native grass pastures were allotted each year (1990 to 1998) to either 1/2-season or 3/4-season grazing systems. The 1/2-season system entailed grazing from late April to July 15 (1 steer/2 acres, 81 days), and the 3/4-season system entailed grazing from late April to August 15 (1 steer to 3 acres, 112 days). The pastures were burned every year except 1996, when only the east four pastures were burned because of dry weather. Four pastures were used per treatment per year. The steers were weighed individually at the start and end of the grazing periods.

To evaluate the economic returns, the various costs associated with each grazing system were compared. Direct costs per animal included start-up costs (drugs, veterinary, starter feed, trucking, processing labor), death loss, mineral, salt, and interest. Pasture costs included labor of looking after cattle on grass and cost of renting grass (*Bluestem Pasture Report* by Kansas Department of Agriculture). The monthly average prices for the weight range at Dodge City were adjusted to southeast Kansas prices.

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The step point method (300 to 400 points per pasture) was used to take actual plant inventories (1990, 1994, 1998). The pastures were sampled each year after animals were removed and again in November by clipping small areas to determine how much dry matter remained compared to caged areas that excluded animals.

## Results and Discussion

We observed a greater increase in Indiangrass (P<.05, Table 1) and a greater increase in percentage basal cover of perennial grass (P<.05) for 1/2-season grazing compared with 3/4-season grazing. Change in percent of total perennial grasses was the same for both systems after 9 years of grazing. Little bluestem declined (percentage of composition) in both grazing systems but was not different by system. Neither of the grazing systems had a negative effect on the grass composition. In the 3/4-season pastures, only 350 lb of dry matter per acre were produced after cattle were removed; in 1/2-season grazing pastures, 1,100 lb of dry matter were produced per acre.

The steers that grazed the 1/2-season pastures for 81 days gained faster (2.78 vs. 2.48 lb per day, P<.01) than the steers that grazed the 3/4-season pastures for 112 days. However, allowing the steers to graze until August 15 resulted in more total pounds gained per animal (278 lb vs 225 lb; Table 2).

Average costs during the 0-year period were: pasture/acre, $16.43; labor/hd, $10.00; mineral $0.05/hd/day; interest/hd, $10.70; veterinary charges/hd, $10; handling/hd, $4.00; and processing/hd, $1.00. Death loss averaged 1.25%.

The 1/2-season grazing system had the highest return per acre ($33.31/acre vs $29.98/acre). The 3/4-season grazing had the highest return/animal ($30.61 vs $23.75, Table 3). The economic desirability of a particular system will depend on the perspective of the individual producer. For example, producers who own both land and cattle likely will prefer the 1/2-season grazing. However, the producers who own cattle but rent pasture and hire labor likely will favor the 3/4-season grazing system because of cattle costs and the additional total gain. However, this analysis considers only selling cattle at the end of the grazing period. If cattle are owned and graze on other forages prior to native grass or owned during the feedlot phase, this could change the overall view of the economic desirability of a particular system.

**Table 1. Effect of Grazing System on Plant Composition, 1990 to 1998**

| | Change in Percentage Composition, 1990 to 1998 | |
|---|---|---|
| | ½ Season | 3/4 Season |
| Big bluestem | + 7 | + 6 |
| Little bluestem | ! 5 | ! 3 |
| Indiangrass | + 9[a] | + 4[b] |
| Switchgrass | 0 | + 2 |
| Total perennial grass | 0 | + 1.3 |
| Perennial grass % basal cover | + 14.7[a] | + 11.5[b] |

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

**Table 2. Effect of Grazing System on Animal Performance (9-Yr Summary)**

| Item | ½ Season | 3/4 Season |
|---|---|---|
| No. steers | 1,354 | 915 |
| Pastures/9 yr | 36 | 36 |
| Starting wt, lb | 562.3 | 562.1 |
| Average days | 81 | 112 |
| ADG, lb | 2.78[a] | 2.48[b] |
| Gain/animal, lb | 225[a] | 278[b] |

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

**Table 3. Effect of Grazing System on Economics (Dollars per Steer)**

| Item | ½ Season | 3/4 Season |
|---|---|---|
| Direct costs | $38.38 | $44.97 |
| Pasture/labor costs | 42.86 | 59.29 |
| Return to land, labor, management | 66.61 | 89.91 |
| Return to management | 23.75 | 30.61 |

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Pfizer Animal Health, Exton, Pennsylvania
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Protein Plus, LLC, St. Paul, Nebraska
Protein Technologies International, St. Louis, Missouri
Roche Vitamins, Nutley, New Jersey
Rhone Poulenc Animal Nutrition, Atlanta, Georgia
Schering-Plough Animal Health, Kenilworth, New Jersey
Select Sires, Plain City, Ohio
Taylor Implement, Hoxie, Kansas
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## BIOLOGICAL VARIABILITY AND STATISTICAL EVALUATION OF DATA

The variability among individual animals in an experiment leads to problems in interpreting the results. Animals on treatment X may have a higher average daily gain than those on treatment Y, but variability within the groups may indicate that the difference between X and Y is not the result of the treatment alone. You can never be totally sure that the difference you observe is due to the treatment, but statistical analysis lets researchers calculate the probability that such differences are from chance rather than from the treatment.

In some articles, you will see the notation "$P < .05$." That means the probability that the observed difference was due to chance is less than 5%. If two averages are said to be "significantly different," the probability is less than 5% that the difference is due to change— the probability exceeds 95% that the difference is true and was caused by the treatment.

Some papers report correlations — measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one gets larger, the other gets smaller). A perfect correlation is either +1 or –1. If there is no relationship at all, the correlation is zero.

You may see an average given as $2.5 \pm .1$. The 2.5 is the average; .1 is the "standard error." That means there is a 68% probability that the "true" mean (based on an unlimited number of animals) will be between 2.4 and 2.6. "Standard deviation" is a measure of variability in a set of data. One standard deviation on each side of the mean is expected to contain 68% of the observations.

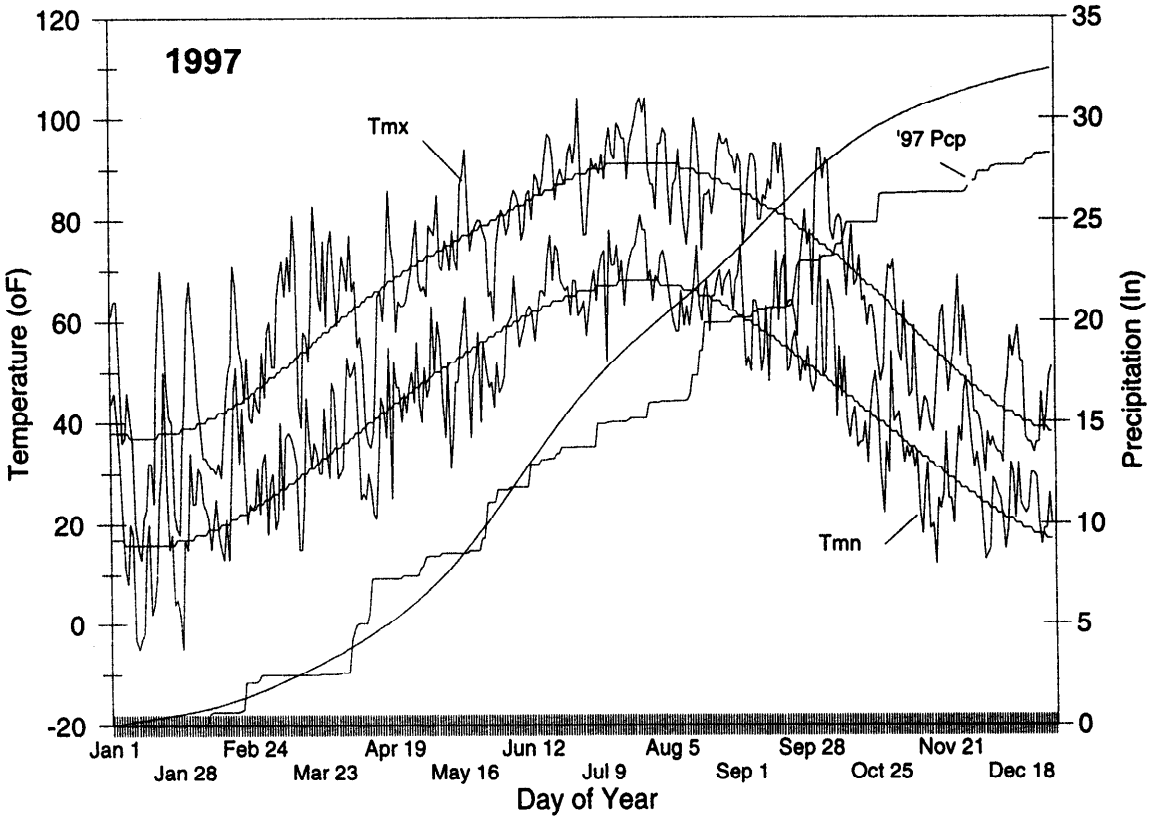
Many animals per treatment, replicating treatments several times, and using uniform animals all increase the probability of finding real differences when they actually exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals in an experiment. In the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

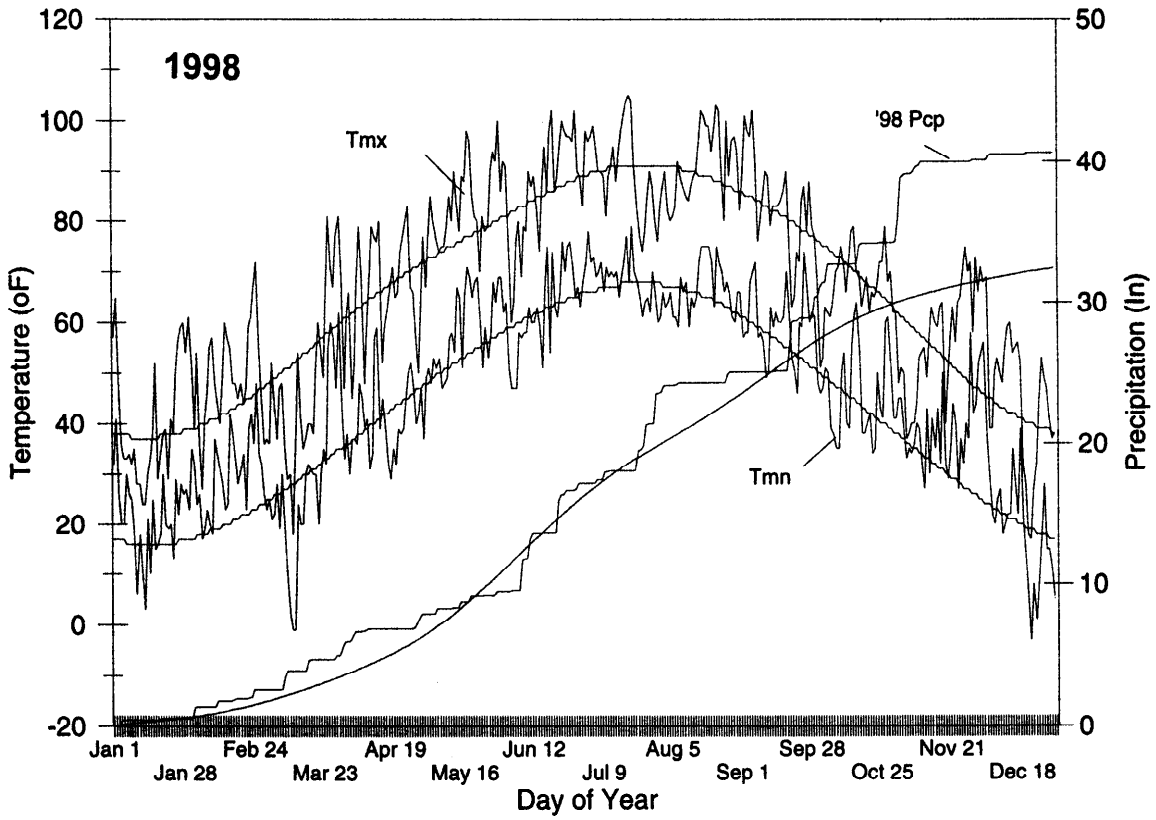
In most experiments, the statistical analysis is too complex to present in the space available. Contact the authors if you need further statistical information.

## WEATHER DATA, 1997-1998

On the following page are graphs of the 1997 and 1998 Manhattan weather. They were produced by the Kansas State University Weather Data Library. The smooth line that starts in the lower left corner of each graph is the normal accumulated precipitation since January 1. The rough line starting in the lower left corner represents actual accumulated precipitation. A long horizontal section of that line represents time during which no precipitation fell. A vertical section represents precipitation. The other two smooth lines represent average daily high and low temperatures, and the rough lines represent actual highs and lows.

These graphs are included because much of the data in this publication, especially data on animal maintenance requirements and forage yields, can be influenced by weather. Weather graphs have been included in Cattlemen's Day publications since 1985.

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