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MEATS AND FOOD SAFETY

MANAGEMENT

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HIGH CARBON DIOXIDE, MODIFIED-ATMOSPHERE PACKAGING (MAP) FOR BEEF STEAKS

S. E. Luchsinger, M. C. Hunt, and D. H. Kropf

Summary

To determine the effects of storage in a high-carbon dioxide, modified-atmosphere package (MAP) on shelf life, beef strip steaks were packaged under 30% CO_2-70% N_2 and stored for up to 42 days at 30 or 38 °F. Aerobic plate counts (APC) and lactic acid bacteria (LAB) counts in these ExtendPak™ packages were well below the threshold of spoilage even after 42 days of MAP storage. After 28 days of storage, steaks stored in vacuum packages had APC counts 1.0 $\log_{10}$ greater than steaks in MAP. APCs increased during a 5-day display period in steaks stored in vacuum packages, but no increases occurred with MAP. Repackaged steaks from vacuum packages bloomed to a brighter red color than steaks stored in MAP, but MAP steaks were more color stable through display. Microbial data indicated that steaks can be stored for up to 42 days using this promising MAP system. The long storage life of MAP steaks allows packers and retailers more flexibility to respond to variable consumer demand, without the threat of product spoilage.

(Key Words: Packaging, Beef Steaks, Shelf Life.)

Introduction

Annually in the United States, over 25 billion lb of fresh beef and other meats are vacuum-packaged, gas packed, or master packaged (several retail portions in a single gas package). Increasingly, packers/processors are using modified-atmosphere packaging (MAP) for case-ready retail cuts. MAP allows for packer or centralized retail cutting, thereby reducing labor costs and facilitating improved meat quality, decreased contamination, and an immediate response to consumer demands. A high carbon dioxide (CO_2) atmosphere (>20-25%) with minimal to no oxygen reduces microbial growth during storage, allowing extended shelf life for both wholesale and retail cuts. This study determined the effects of MAP storage time (up to 42 days) and storage temperature (30 or 38 °F) on the shelf life of beef strip steaks packaged in the ExtendPak MAP system and then displayed for 5 days.

Experimental Procedures

Eight paired, vacuum-packaged, boneless strip loins (NAMP #180A) were obtained from a commercial processor. Twenty steaks per loin pair were cut 1 in. thick, trimmed to $\leq$.25 in. of fat, and assigned randomly to all combinations of two storage temperatures (30 and 38 °F); four MAP storage periods (21, 28, 35, and 42 days); two package types (ExtendPak MAP and vacuum packaging); and two display times (0 or 5 days). The ExtendPak system consists of two compartments: a tray holding the individual steak, which is covered by oxygen-permeable PVC film, and a dome that covers the tray. During packaging, the tray and dome areas are evacuated, flushed, and filled with a 30% CO_2/70% N_2 gas mixture, and the tray, PVC film, and dome are sealed into an integral MAP package. Four steaks per loin pair were vacuum-packaged.

Oxygen and CO_2 levels within the ExtendPak dome and tray were determined after storage. Aerobic plate counts (APCs), *Escherichia coli*/coliform counts, and lactic acid bacteria (LAB) counts were determined after steak cutting, after storage, and after display, using standard procedures. After MAP and ExtendPak storage, packages were opened and blooming ability was evaluated instrumentally. Vacuum-stored steaks were rewrapped onto an

ExtendPak tray covered with identical PVC film. Steaks then were displayed at 38 °F for 5 days under 150 foot candles of Deluxe Warm White fluorescent lighting. Steak color was analyzed instrumentally and by a trained panel at 0, 1, 2, 3, and 5 days of display. Visual color was scored as 1=very bright cherry red, 2=bright cherry red, 3=slightly dark red to brown, 4=moderate dark red to brown, and 5=dark red to brown, in .5 intervals. A score of $\geq$3.5 was considered unacceptable color. Steaks were scored for off-odor after storage and after display. The scale (.5 intervals) was 1=none, 2=slight off-odor, 3=small off-odor, 4=moderate off-odor, and 5=extreme off-odor.

Data were analyzed as two-way (gas composition), three-way (blooming ability and display color), or four-way (off-odor and microbial analysis) treatment structures. Animal served as a blocking factor. Least square means were determined, and the statistical significance level was set at $P<.05$.

Results and Discussion

Carbon dioxide levels in ExtendPak packages were maintained above 25% throughout 42 days of storage, and oxygen levels remained between .01 and .18%. Oxygen levels were greater after storage at 30 than at 38 °F. At 38 °F, oxygen-utilizing meat enzymes are more active and, thus, may have lowered the oxygen level.

The APCs were 2.0 $\log_{10}$ and LAB counts were 1.9 $\log_{10}$ cfu/cm^2 after steak cutting, well below the threshold for bacteria spoilage (APC $\geq$ 7.0 $\log_{10}$). (cfu is "colony forming unit". 2.0 $\log_{10}$ = 100, 3.0 $\log_{10}$ = 1000.) *E. coli* and coliforms were not detected (<1.9 $\log_{10}$ cfu/cm^2). These results indicate that the product was essentially free of microbial contamination at the initiation of storage.

Within ExtendPak MAP storage, APCs or LAB counts did not increase during storage (Table 1). *E. coli* was not detected and coliform levels were maintained <1.9 $\log_{10}$ throughout storage, regardless of storage temperature, package type, or display time. The APCs and LAB counts were greater at 38 than at 30 °F and after display than after MAP (Table 1) but were maintained below the spoil age threshold. These results were expected, because microbial growth is faster at 38 °F and in the presence of oxygen. The APCs (Table 2) were greater in vacuum-packaged controls after 28 d of storage and after display than in ExtendPak samples. In addition, APCs increased by 2.4 $\log_{10}$ in steaks stored in vacuum packages during display, whereas counts did not change during display for ExtendPak samples. Thus, residual antimicrobial effects of CO_2 carried over into the display of ExtendPak samples.

Off-odors were none to slight on steaks from ExtendPaks after MAP storage for 42 days, and odors increased only slightly during retail display. Steaks stored in vacuum packages had more off-odors after display than those in ExtendPaks.

Steaks stored for up to 35 days in ExtendPaks at 38 °F were more red, more vivid, and less discolored than steaks stored at 30 °F. This temperature effect was unexpected, because beef has been reported to tolerate residual oxygen levels of 400 ppm (.04%) or more without discoloration when stored at 30 °F but to discolor at temperatures greater than 35 °F. Visual color for steaks in ExtendPaks from both temperatures was described as slightly to moderately dark red or brown. Steaks stored under vacuum for 28 days were more red and less discolored after 2 days of display than ExtendPak samples. However, by 3 days display, ExtendPak steaks had color equal to or better than that of steaks from vacuum storage. ExtendPak samples were more color stable than vacuum-packaged controls throughout display.

Although microbial results indicate that the shelf life of steaks in this MAP system is at least 42 days, bloom and display color of beef steaks from MAP need improvement. Research continues on this problem. The long storage life of MAP steaks should allow packers and retailers more flexibility to respond to variable consumer demand, without product spoilage.

Table 1. Microbial Analyses [1] as Affected by Evaluation Time and Days in MAP Storage for ExtendPak™ Containing Beef Strip Steaks

	Evaluation Time			MAP Storage, Days				
Attribute	After MAP	After Display	SE	21	28	35	42	SE
APC	2.5[b]	3.4[a]	.2	2.5[a]	3.2[a]	3.1[a]	3.0[a]	.2
LAB	2.1[b]	2.5[a]	.1	2.1[a]	2.4[a]	2.4[a]	2.2[a]	.2
E. coli	<1.9	<1.9	---	<1.9	<1.9	<1.9	<1.9	---
Coliform	<1.9[a]	<1.9[a]	.02	<1.9[a]	<1.9[a]	<1.9[a]	<1.9[a]	.04

[1]APC=aerobic plate counts, LAB=lactic acid bacteria counts; Expressed as $\log_{10}$ cfu/cm^2.
[a,b]Means within a row within a variable with a different superscript letter are different (P<.05).

Table 2. Microbial Analyses [1] as Affected by Evaluation Time, Storage Temperature, and Package Type for ExtendPak™ and Vacuum Packages Containing Beef Strip Steaks and Stored for 28 days

	Evaluation Time/	Package Type		
Attribute	Temperature, °F	ExtendPak	Vacuum	SE
APC	After MAP	2.8[bx]	3.8[ay]	.2
	After display	3.4[bx]	6.2[ax]	
LAB	After MAP	2.2[ax]	2.8[ay]	.2
	After display	2.6[bx]	4.4[ax]	
	30	<1.9[ay]	2.3[ay]	.2
	38	3.0[bx]	4.9[ax]	

[1]APC = aerobic plate counts, LAB = lactic acid bacteria counts; Expressed as $\log_{10}$ cfu/cm^2.
[a,b]Means within a row within a variable with a different superscript letter are different (P<.05).
[x,y]Means within an attribute within a column with a different superscript letter are different (P<.05).

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STEAM PASTEURIZATION TO REDUCE BACTERIAL POPULATIONS ON COMMERCIALLY SLAUGHTERED BEEF CARCASSES

R. K. Phebus, A. L. Nutsch, D. E. Schafer, and C. L. Kastner

Summary

A steam pasteurization system (SPS) has been shown in laboratory and commercial evaluations to effectively reduce bacterial populations on freshly slaughtered beef. Our study evaluated the bactericidal uniformity of SPS. Samples were collected from the five anatomical locations, one per carcass, 40 samples per location, so that 200 carcasses were evaluated before and 200 after pasteurization. Each carcass was sampled by wiping a 300 cm^2 area of the specified location with a moist, sterile sponge. For all locations, the total aerobic plate count (APC) after pasteurization was lower ($P \leq .01$). Before pasteurization, the midline was contaminated most heavily (2.5 $\log_{10}$ cfu/cm^2). After pasteurization, the neck and midline had the highest residual APCs (1.3 and 1.1 $\log_{10}$ cfu/cm^2, respectively). For all anatomical locations, the enteric bacteria (*E. coli*, total coliform, and *Enterobacteriaceae*) were lower ($P \leq .01$) after than before pasteurization. Only two of 200 pasteurized carcasses had *E. coli* populations greater than 1 cfu/cm^2. During pasteurization, steam blankets the carcasses, theoretically providing uniform bacterial destruction. This study demonstrated the effectiveness of SPS for reducing total aerobic and enteric bacterial populations uniformly over five anatomical locations on commercially processed carcasses.

(Key Words: Beef Carcasses, Antimicrobial Treatment, Steam Pasteurization.)

Introduction

The microbiological safety of meat products has received increased attention in recent years. The potential for bacteria in meat products to cause illness and death has pushed this issue to the forefront for consumers, regulators, researchers, and the industry.

In July 1996, the USDA-FSIS issued a final rule on "Pathogen Reduction; Hazard Analysis and Critical Control Point (HACCP) Systems". The regulations require changes in the way industry produces meat and meat products. Foremost is the requirement that all slaughter facilities develop HACCP systems. In addition, facilities will be required to implement sanitation standard operating procedures and microbiological testing of carcasses, with standards for generic *E. coli* and *Salmonella* being defined. Antimicrobial treatments during slaughter will likely be necessary to consistently meet these USDA microbial standards. In previous studies, steam pasteurization (Frigoscandia Food Process Systems, Bellevue, WA) effectively reduced both pathogen (laboratory evaluations) and naturally occurring bacterial populations (evaluations on commercial beef carcasses). The current study was designed to verify, in a commercial slaughter facility, the uniformity of bacterial destruction over the entire carcass surface.

Experimental Procedures

A commercial-scale SPS was used after the final carcass wash in a beef slaughter facility. Samples were collected during 2 processing days from randomly selected carcasses immediately before and immediately after pasteurization. Samples were collected from inside round, loin, midline, brisket, and neck. One location was sampled per carcass and 40 carcasses were sampled per location before and after pasteurization (200 carcasses before and 200 others after pasteurization). Samples were collected using the sponge technique required under the new USDA-FSIS regulations for

carcass microbial sampling. Both sides of a single sterile sponge are passed over a 300 cm^2 area. The sponge is premoistened in a sterile stomacher bag containing 30 ml of diluent (.1% peptone diluent with .1% Tween 20) and, after sampling the specified area, is returned to the same diluent. Dilutions were plated on Petrifilm™ plates to enumerate APCs, enteric bacteria *E. coli* (generic), total coliforms, and *Enterobacteriaceae*. Counts were made according to manufacturer's instructions. The minimum detectable count for Petrifilm™ plates was .1 cfu/cm^2. All data were converted to $\log_{10}$ cfu/cm^2. The significance level was set at $P \leq .01$.

Results and Discussion

For all carcass sites, the APC was lower ($P \leq .01$) after than before pasteurization (Table 1). Before pasteurization, the midline had the highest APCs; the loin had the lowest; and the inside round, brisket, and neck were intermediate. After pasteurization, the neck and midline had the highest APCs, approximately 1.2 $\log_{10}$ cfu/cm^2. The inside round, loin, and brisket had similar APCs, approximately .6 $\log_{10}$ cfu/cm^2. Pasteurization reduced bacteria by 65% for inside round, 84% for loin, 96% for midline, 92% for brisket, and 60% for neck.

E. coli was present at low levels before pasteurization and was decreased ($P \leq .01$) at all sites after pasteurization. *E. coli* populations on 189 of 200 carcasses fell within the range <.1 to 1.0 cfu/cm^2 before pasteurization. Some sample counts were as high as 5 cfu/cm^2. After pasteurization, 198 of 200 carcasses fell within the <.1 to 1.0 cfu/cm^2 range, with only two carcasses having *E. coli* populations greater than 1 cfu/cm^2. Very similar results were found for coliform and *Enterobacteriaceae* populations.

In previous steam pasteurization evaluations, samples were collected from one carcass location. Those evaluations demonstrated effective bacterial destruction, but questions remained about the uniformity of bacterial destruction over the entire carcass surface. Our study demonstrated that steam pasteurization reduces bacterial populations uniformly. A large surface area was sampled at each location, and the locations represented the entire carcass. Steam pasteurization can reduce the risk of pathogenic bacterial contamination in beef, but is not a replacement for good sanitation standards, clean and careful slaughter operations, or Good Manufacturing Practices. Steam pasteurization can serve as a critical control point for pathogens during slaughter. Current technology allows automatic tracking of individual carcasses. Additionally, SPS provides assurance to processors that USDA-FSIS microbiological standards will be met continuously.

Table 1. Aerobic Bacterial Populations on Five Beef Carcass Sites before and after Steam Pasteurization

	Before[1]		After	
Carcass Site	Mean ($\log_{10}$ cfu/cm^2)[2]	SEM	Mean ($\log_{10}$ cfu/cm^2)	SEM
Inside round	1.8[c]	.1	.5[a]	.1
Loin	1.4[b]	.1	.6[a]	.1
Midline	2.5[d]	.1	1.1[b]	.1
Brisket	1.8[c]	.1	.7[a]	.1
Neck	1.7[c]	.1	1.3[b]	.1

[1]Before = population immediately before steam pasteurization treatment; After = population immediately after steam pasteurization treatment.
[2]Mean bacterial populations are averages of 40 replicates. SEM=standard error of mean.
[a,b,c,d]Means with different superscripts are different ($P \leq .01$).

LIQUID SMOKE EFFECTS ON *ESCHERICHIA COLI* O157:H7 IN BEEF TRIMMINGS AND GROUND BEEF PATTIES

R. Estrada-Muñoz, E.A.E. Boyle, and J.L. Marsden

Summary

Liquid smoke (LS) reduced *Escherichia coli* O157:H7 counts in inoculated beef trimmings and ground beef patties. The counts were reduced ($P<.05$) by .5 $\log_{10}$ cfu/g immediately after beef trimmings were treated with 8% LS and by 1.2, 2.0, 1.6, and 2.3 $\log_{10}$ cfu/g after the trimmings were formed into patties and tested or stored under refrigeration for 1, 2, and 3 days, respectively (2 $\log_{10}$ reduction represents 99%) Thus, LS could make beef-containing products safer with respect to foodborne pathogens.

(Key Words: Liquid Smoke, *Escherichia coli* O157:H7, Ground Beef.)

Introduction

Recently, outbreaks of foodborne illness and deaths associated with ground beef containing *E. coli* O157:H7 have occurred in the United States. *E. coli* O157:H7 is the third or fourth most common pathogen recovered from human stool samples and was first recognized as a foodborne pathogen in 1982. Since that time, undercooked ground beef has been implicated in outbreaks of *E. coli* O157:H7 infections.

Smoking of food provides a desirable flavor and color, but also contributes substantially as an antimicrobial agent. As a food additive, it has the advantage of being labeled as a natural product.

Preliminary experiments evaluated the antibacterial properties of liquid smoke (LS) in a model system. The LS inhibited *E. coli* O157:H7 growth at all levels (6-12%) evaluated in preliminary studies (data not shown). Its bactericidal activity increased with concentration.

Based on those preliminary findings, our objective was to evaluate the bactericidal effects of adding 8% LS to beef trimmings inoculated with *E. coli* O157:H7, which were then used in production of experimental ground beef patties.

Experimental Procedures

A low-flavor-profile LS provided by Hickory Specialties was used. Fresh beef trimmings (4 days postmortem) were inoculated with a strain of *E. coli* O157:H7 resistant to the antibiotic Rifampicin to give a target of 1×10^7 cfu/g and mixed for 4 min using a Hobart mixer. The LS or sterile water (control) was added at 8% to the inoculated trim, and each mixed for 4 min. A second uninoculated control was mixed for 4 min and used for psychrotrophic counts. Then all treatments were coarsely ground (1.27 cm), followed by a fine grind (.32 cm), using a sterile grinder. Patties (70-90 g) were made using a manual patty maker, bagged aerobically in heat-sealed bags, and stored in the dark at 4°C for up to 3 days. Three replications were performed.

Immediately after inoculation, duplicate 25 g surface samples were taken from inoculated beef trimmings, from treated (LS and water) beef trimmings, and from noninoculated beef trimmings to check initial *E. coli* O157:H7 population, antibacterial effects of treatment of trimmings, and psychrotrophic counts. The surface samples (approx. .7 cm deep) were taken using a sterile scalpel and tongs. Duplicate 25 g samples were taken from the LS-treated patties, inoculated control patties, and noninoculated control patties at days 0, 1, 2 and 3. Each sample was placed in a filter stomacher bag, 225 ml of .1% of peptone water was

added, and the mixture was stomached for 2 min. Serial dilutions were prepared in peptone water (.l%) and spiral plated on MacConkey sorbitol agar containing Rifampicin (inoculated samples) or on plate count agar (noninoculated control samples). The plates for inoculated samples were incubated at 37°C for 24 hr, and the plates for noninoculated samples were incubated at 7°C for 10 days for psychrotrophic counts. A Laser Spiral System Bacterial Colony Counter was used to count colonies growing on or in the culture medium and reported as $\log_{10}$ cfu/g of sample.

The statistical design was a split-plot design, with meat block was the whole plot and the meat sample each day from the meat block as the subplot. Significance level was set at P<.05. Analysis of variance and least significant difference procedures were used.

Results and Discussion

Adding 8% LS to beef trimmings inoculated with *E. coli* O157:H7 and later ground inhibited *E. coli* O157:H7 growth (Figure 1). The *E. coli* O157:H7 counts were lower in treated inoculated beef patties than controls (P<.05) from day 1 to day 3. In untreated inoculated beef patties (control), *E. coli* O157:H7 counts did not change (P>.05).

E. coli O157:H7 counts were reduced (P<.05) by .5 $\log_{10}$ cfu/g, after beef trimmings were treated with 8% LS and by 1 .2, 2.0, 1.6, and 2.3 $\log_{10}$ cfu/g in patties made from the trimmings before (0 day) and after 1, 2 and 3 days of refrigerated storage, respectively. The psychrotrophic counts in beef trimmings and ground beef remained constant from day 0 to day 1, but increased rapidly from day 1 to day 3. Psychrotrophic bacterial growth did not impact *E. coli* O157:H7 growth. *E. coli* O157:H7 growth was not affected by meat fat content in treated or untreated beef patties (data not shown). Thus, 8% LS was effective in reducing *E. coli* O157:H7 counts in ground beef patties.

The level of LS we used was higher than normally recommended (1.5-2.0%) for meat products. However, adding 8% LS to beef trimmings could be feasible as a food safety tool for sausage production if the trimmings are only one component of the product formulation. For instance, if beef trimmings were treated with 8% LS, and the sausage contained 25% beef, the LS level would be reduced to a level normal for a meat product. Liquid smoke is used in meat mainly to provide flavor and color. However, because of its antimicrobial characteristics, LS could be added to meat products to make them safer and at the same time to extend product shelf-life. Further research should examine the antimicrobial properties of LS in meat systems.

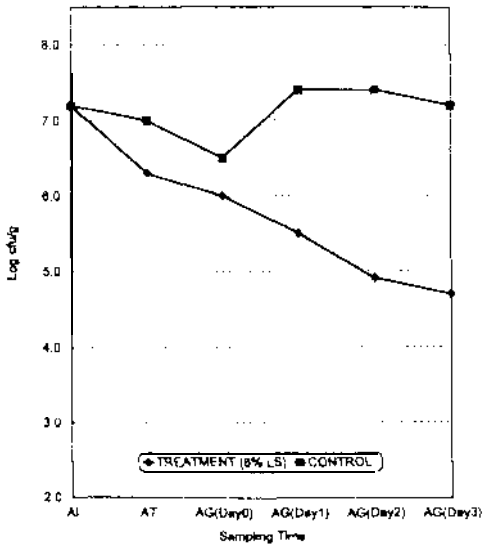

Figure 1. Growth of E. *coli* O157:H7 in Beef Trimmings Inoculated, Ground, Treated with 8% Liquid Smoke, and Stored at 4°C. (AI = after inoculation, AT = after treatment, AG = after grinding). S.E. = .15. ab = Means with same letter are not different (P >.05).

ANTIOXIDANT PROPERTIES OF LIQUID SMOKE IN PRECOOKED BEEF PATTIES

R. Estrada-Muñoz, E.A.E. Boyle, and J. L. Marsden

Summary

Liquid smoke (LS) effectiveness in controlling lipid oxidation and warmed-over flavor (WOF) in beef was investigated. Aroma scores, α-thiobarbituric acid (TBA) numbers, and pH values were lower (P<.05) in LS-treated beef patties than in patties without LS. LS has useful antioxidative properties in precooked ground beef patties at the normally recommended percentage of 1.5%. That should reduce undesirable flavor development and product loss.

(Key Words: Liquid Smoke, Warmed-Over Flavor, Precooked Beef Patties.)

Introduction

Ground beef, in addition to food safety concerns, is susceptible to developing warmed-over flavor (oxidative rancidity). Although WOF can develop in fresh meat, it most commonly occurs in meats that are cooked or in which the cellular membranes are broken by processes such as restructuring or grinding. Antioxidants can effectively control or retard lipid oxidation in meat products.

Smoking of food, an effective antioxidant process, contributes substantially to preservation. Like natural smoke, liquid smoke solutions act as antioxidants, primarily because of phenol compounds. They prevent fat oxidation by stabilizing free radicals and are effective in retarding or preventing the development of oxidative off-flavors. Our objective was to evaluate the antioxidative properties of liquid smoke (LS) when used at the normally recommended level in precooked beef patties.

Experimental Procedures

Nine kg of fresh beef gooseneck round (2 weeks old), ground successively through 1/2 in., 3/16 in., and 1/8 in. plates, was formulated to yield 20% fat. One half of the meat block was treated with 1.5% LS, and the other half was used as a control. The treatment and the control each were blended in a mixer for 2 min. The ground beef was made into 1/4 lb patties (1/2 in. thick), using a patty machine (Hollymatic Corp., Countryside, IL). The study was repeated three times.

Patties were cooked according to American Meat Science Association (AMSA) Cookery Guidelines on a preheated (325°F) electric skillet to 160°F internally. To obtain uniform heat distribution, patties were turned every 1.5 min. After 4.5 min of cooking, patties were turned every 30 sec. Individual patties were removed when they reached 155 to 160°F, monitored by a needle probe connected to a temperature recorder. Patties were packaged individually aerobically in heat-sealed plastic bags and immediately frozen at 5°F. Patties evaluated on day 0 were not frozen.

A five-member, sensory panel from the KSU Department of Animal Sciences and Industry evaluated WOF intensity of the beef patties. Frozen precooked beef patties were thawed at 40°F for 24 hr. Samples were reheated to an internal temperature of 160°F and kept warm in an oven. Taste panel evaluations were made on 1/4 patty portions that were reheated and placed in glass petri dishes. Panelists used a 5-point scale (1= no, 2 = slight, 3 = moderate, 4 = very, and 5= extreme WOF). Five sensory sessions (0, 30, 60, 75, and 90 days) were held in individual booths with combined red and green light and free from

outside noise and odor. Patties were evaluated immediately following presentation and again after 15 min of cooling. Twelve samples (4 samples/ replicate) were presented at each session. TBA was determined as a measure of fat rancidity.

Measurements of pH were taken from duplicate thawed cooked beef patties at each time of evaluation. Ten g of sample and 40 ml of deionized distilled water were combined in a stomacher bag and blended for 1 min before pH was measured.

Results and Discussion

Liquid smoke treated beef patties had lower ($P<.05$) aroma scores (less warmed over) compared to nontreated beef patties, both immediately after warming and after 15 min of cooling. The aroma of LS-treated beef patties evaluated immediately after presentation did not change ($P>.05$) from day 0 to day 90 (data not shown). Aroma scores for nontreated beef patties evaluated immediately after presentation increased after day 0 and again after day 60. Aroma scores for beef patties after a 15-min cooling period were similar to the scores obtained immediately after presentation. However, aroma scores for LS-treated beef patties after the 15 min cooling increased ($P<.05$) by day 90. Some panelists gave higher scores to cold samples.

The TBA numbers were lower ($P<.05$) from LS-treated beef patties than from controls on all sampling days (Figure 1) . The TBA numbers clearly demonstrated that 1.5% LS in precooked beef patties possessed antioxidative properties. The TBA values for untreated precooked beef patties increased during the initial 60 days of frozen storage, then decreased by 75 days, and increased again at 90 days. The TBA values for treated precooked beef patties decreased ($P<.05$) during the first 30 days, then increased, but decreased again after 60 days. The increase and/or decrease in TBA values at different storage times could be explained by the instability of the malonaldehyde produced and/or by the oxidation and further breakdown of different lipid populations at different times. The correlation coefficient between TBA numbers and WOF intensity scores was 0.84 ($P<.05$). Hence, TBA and aroma results were very similar.

The pHs of precooked beef patties before (0 day) and after days 30, 60, 75, and 90 are shown in Figure 2. The pH was higher ($P<.05$) in control than in LS-treated patties at all sampling days. These results were expected, because the pH of the LS was 2.0. Higher meat pH has the disadvantage of causing longer cooking time and/or higher final internal temperature required for complete protein denaturation. Thus, a high pH inhibits formation of brown cooked meat color. Also, muscle with higher pH is more susceptible to microbial problems. Conversely, oxidation of meat pigment is favored by lower pH.

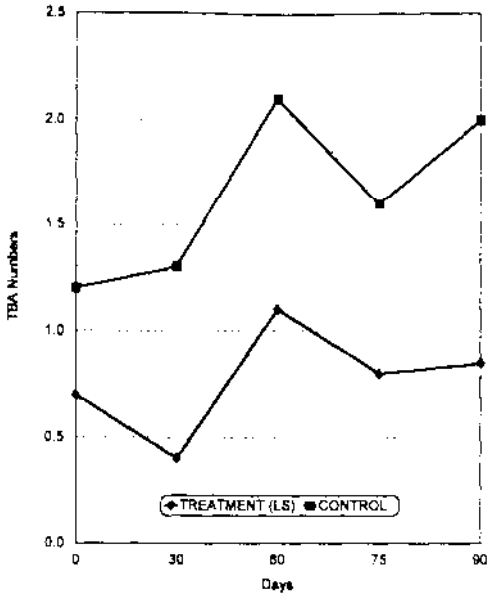

Figure 1. TBA Values for Precooked Beef Patties Treated with 1.5% Liquid Smoke (Treatment) or Not Treated (Control) at Day 0, 30, 60, 75, and 90 of Storage at -15°C. S.E. = .07. ab = Means with same letter are not different (P>.05).

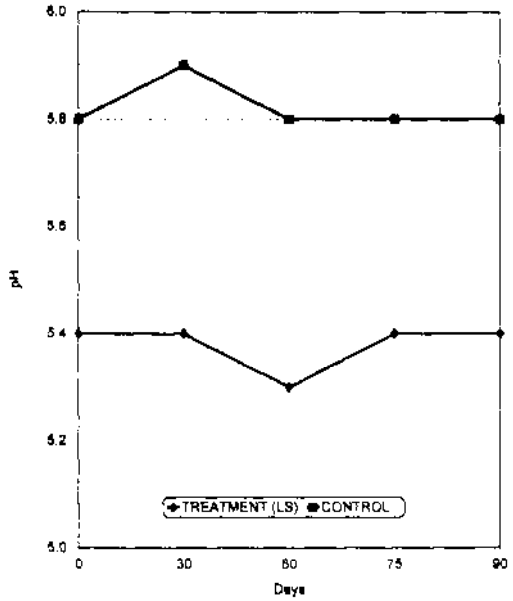

Figure 2. pH of Precooked Beef Patties Treated with 1.5% Liquid Smoke (Treatment) or Not Treated (Control) at Day 0, 30, 60, 75, and 90 of Storage at -15°C. S.E. -.22. ab = Means with same letter are not different (P > .05).

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ULTRASOUND VERSUS CONVECTION COOKING OF BEEF LONGISSIMUS AND PECTORALIS MUSCLES

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J. F. Zayas [2], and J.A. Unruh

Summary

Longissimus and pectoralis muscles were removed from 10 steer carcasses at 4 days postmortem, aged for 14 days at 4°F, then assigned to either ultrasound (ULS) or convection (Conv) cooking to either 144 or 158°F internal temperature. Ultrasound cooking was faster (P<.05), had greater (P<.05) moisture retention and less (P<.05) cooking loss, and used less energy (P<.05). It also produced muscle samples that required less (P<.05) peak force to shear than those from Conv cooking and resulted in superior (P<.05) myofibrillar tenderness. No significant interactions occurred among cooking method, muscle, or endpoint temperature. As expected, longissimus (ribeye) muscles cooked faster (P<.05) and required less (P<.05) energy and were superior (P<.05) in instrumentally measured texture and sensory tenderness than pectoralis muscles. Cooking to 158°F caused greater (P<.05) moisture and cooking losses, required more (P<.05) time and energy, and degraded (P<.05) instrumental textural and sensory characteristics. Ultrasound offers a new cooking mode that could increase cooking speed, improve energy efficiency and improve some textural characteristics, compared to conventional cooking.

(Key Words: Beef, Ultrasound Cooking, Endpoint Temperature, Tenderness.)

Introduction

Although numerous techniques have been used to cook meat, variability in cooking time, energy consumption, and palatability provide obstacles for universal use of any single technique. Microwave cooking provides fast heating and superior energy efficiency, but lower cooking yields and less tender and flavorful meat than conventional techniques. Ultrasound (ULS) also can heat muscle, and apparatuses have been developed for ULS cooking of foods and tenderizing meat. Our objective was to compare the effects of ULS and convection cooking to two endpoint temperatures on cooking characteristics and textural and sensory properties of a beef locomotion (pectoralis) and a support (longissimus) muscle.

Experimental Procedures

Deep pectoralis (brisket) and longissimus thoracic (rib cut) muscles were removed from the right sides of 10 Select and Choice steer carcasses at 4 days postmortem, vacuum packaged, and aged at 4°F for a total of 14 days. After aging, muscles were sliced into .4×3.0×3.0 in. sections and individually vacuum packaged; and muscles within each carcass were assigned randomly to treatments. Treatments were arranged in 2×2×2 factorial design with two cooking methods (high intensity ultrasound or Farberware® "Open Hearth" electric convection broiler), two muscle types (deep pectoralis and longissimus thoracic), and two internal endpoints (144 and 158°F) as main

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effects. The ULS cooking was accomplished by placing single, unpackaged, meat sections into a water-filled chamber and applying an ultrasonic field using a Tekmar® Sonic Disrupter, operating at 20 kHz and 1000 W. Convection (Conv) cooking was performed with a Farberware electric broiler. A utility watt meter was connected to both instruments to monitor energy use during cooking and preheating (Conv only). After cooking, muscles were evaluated for Lee-Kramer shear force using an Instron® Universal Testing Machine. Before shearing, cooked meat pieces were cooled to room temperature and weighed to determine cooking losses and to standardize shear force values to a per-gram-of-meat-sheared basis. Peak force (kg/kg sample) and peak force work were determined by shearing perpendicular to the muscle fiber orientation. Flavor and texture were evaluated by trained sensory panelists. Analysis of variance was used to determine treatment effects for this 2×2×2 factorial, randomized, complete block, experimental design. Because no interactions occurred, only main effect means are presented.

Results and Discussion

Because of greater (P<.05) moisture retention (Table 1), ULS cooking resulted in a 60% advantage (P<.05) in cooking yield. Cooking time was nearly double (P<.05) for Conv vs. ULS cooking and required nearly twice the energy (P<.05). Because Conv cooking also required preheating, it was even less efficient (P<.05) when total energy use was considered. Ultrasound cooks efficiently because energy is directed to the muscle being cooked, and less is lost to the environment. Also, ULS cooking is uniform because the intense agitation of the liquid medium by sound wave pressures results in an even distribution of heat.

Cooking loss percentage (Table 1), after adjustment for sample weight, did not vary (P>.05) between muscle types. Longissimus muscles required less (P<.05) cooking time on a cooked, weight-constant basis. Cooking to 144°F internal temperature resulted in less (P<.05) cooking loss, more (P<.05) retained moisture, less (P<.05) cooking time, and, thus, less total energy than cooking to 158°F. No difference (P>.05) was observed between ULS and Conv treatments for peak force to shear samples, when adjusted to per-gram-of-muscle basis (Table 2). However, peak force work was lower (P<.05) for the ULS-cooked samples, which may have been related to the higher (P<.05) postcooking moisture content. As expected, pectoralis muscle required more (P<.05) peak force and peak force work to shear than longissimus muscles (Table 2) because of the higher (P<.05) content of connective tissue (Table 1). Muscles cooked to 158°F required more (P<.05) peak force to shear than samples cooked to 144°F; however, no difference (P>.05) was observed in peak-force work to shear (Table 2).

Sensory panelists detected more charbroiled and beef flavor with Conv cooking (Table 2), probably because of the dry heat. Moist heat ULS cooking not only inhibited development of charbroiled flavor, but also may have extracted beef flavor components into the discarded liquid medium. Greater moisture retention (Table 1) also might have diluted the natural flavor compounds. Although ULS-cooked muscles contained more postcooking moisture, no difference (P>.05) occurred in sensory juiciness between cooking methods. However, sensory panelists indicated more tender (P<.05) myofibrils with ULS cooking. Connective tissue amount and overall tenderness scores were unaffected (P>.05) by cooking method.

Cooked pectoralis and longissimus muscles had similar (P>.05) charbroiled flavor intensity, beef flavor intensity, and juiciness (Table 2). However, sensory panelists found that pectoralis muscles had less (P<.05) myofibrillar tenderness (slightly tender), connective tissue amount (moderate), and overall tenderness (slightly tough) than longissimus muscles. Charbroiled flavor and beef flavor intensity did not differ (P>.05) between the 144 and 158°F treatments (Table 2). Sensory panelists rated the 144°F treatment more (P<.05) juicy and having more (P<.05) myofibrillar tenderness but found no difference (P>.05) in either connective tissue amount or overall tenderness.

Because sensory properties were not impacted severely, ULS may have advantages in speed and energy efficiency for commercial cooking or precooking. Possible uses of ULS

include moist heat precooking or cooking of meat cuts destined for prepared meals. Liquid media such as gravies, sauces, or soups would be ideal for coupling ULS energy with the meat. Liquid media also would enhance meat textural characteristics and cooked product yields, especially for lower quality cuts containing more connective tissue. Other possible ULS applications might be as in-home cooking devices. Ultrasound would allow convenient, rapid, meal preparation without detrimental effects on meat texture.

Table 1. Effects of Cooking Method, Muscle, and Endpoint Temperature on Beef Muscle Cooking Characteristics and Energy Consumption

	Cooking Method		Muscle		Endpoint Temperature	
Characteristic	Ultrasound	Convection	Pectoralis	Longissimus	144°F	158°F
Moisture, %	68.0[a]	62.1[b]	66.3[a]	63.8[b]	66.1[a]	64.0[b]
Cooking loss, %[c]	14.7[a]	23.9[b]	20.0	18.5	16.4[a]	22.1[b]
Cooking time, min	6.7[a]	12.3[b]	10.1	9.1	8.5[a]	10.7[b]
Preheat energy, watt[e]	.00[a]	2.01[b]	.89[a]	1.11[b]	.93[a]	1.08[b]
Cooking energy, watt[f]	3.8[a]	7.07[b]	5.72	5.16	4.85[a]	6.04[b]
Total energy, watt[f]	3.8[a]	9.07[b]	6.65	6.24	5.78[a]	7.11[b]

[a,b]Means within cooking method, muscle, or endpoint temperature bearing different superscript letters differ (P<.05).
[c]Calculated as [1–(cooked wt/fresh wt)] × 100.
[d]Energy consumed during preheating mode.
[e]Energy consumed during cooking mode.
[f]Energy consumed during cooking plus preheating modes.

Table 2. Effects of Cooking Method, Muscle, and Endpoint Temperature on Instrumental Textural Properties and Sensory Panel Evaluations

	Cooking Method		Muscle		Endpoint Temperature	
Characteristic	Ultrasound	Convection	Pectoralis	Longissimus	144°F	158°F
Peak force, kg/g sample	10.0	10.7	56.8[a]	28.4[b]	9.8[a]	10.8[b]
Peak force work[c]	40.0[a]	45.2[b]	130.7[a]	70.7[b]	41.8	43.3
Charbroiled flavor intensity[d]	1.2[a]	1.7[b]	1.5	1.3	1.4	1.4
Beef flavor intensity[d]	4.9[a]	5.9[b]	5.4	5.4	5.4	5.4
Juiciness[e]	6.0	6.1	6.1	6.0	6.2[a]	5.9[b]
Myofibrillar tenderness[f]	6.2[a]	5.8[b]	5.3[a]	6.7[b]	6.1[a]	5.9[b]
Connective tissue amount[g]	5.7	5.5	4.1[a]	7.1[b]	5.6	5.6
Overall tenderness[f]	5.7	5.4	4.3[a]	6.8[b]	5.6	5.4

[a,b]Means within cooking method, muscle, or endpoint temperature bearing different superscript letters differ (P<.05).
[c]Peak force work (energy) to shear samples in units of kg force/unit area under plotter curve.
[d]1 = extremely bland, 4 = slightly bland, 8 = extremely intense.
[e]1 = extremely dry, 4 = slightly dry, 8 = extremely juicy.
[f]1 = extremely tough, 4 = slight tough, 8 = extremely tender.
[g]1 = abundant, 4 = moderate, 8 = none.

USE OF VIDEO IMAGE ANALYSIS, RIBEYE GRIDS, AND LINEAR RIBEYE MEASUREMENTS TO PREDICT AND COMPARE RIBEYE AREAS FROM CARCASS LEFT AND RIGHT SIDES

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

Summary

Ribeye tracings from 265 beef carcasses were used to compare ribeye areas from right and left sides. When video image analysis (VIA) was used to determine ribeye area, no difference (P=.48) was observed between right and left sides. However, when ribeye area was determined by using USDA grids, those on the left side were slightly larger (P<.01) than those on right side. This difference is negligible considering the wide range in variation (SD=.68 in^2) between right and left side ribeye areas. Ribeye area correlations between VIA and grid results were high for both right (.96) and left (.95) sides. Linear measures (length, mid-width, and widest width) of ribeyes predicted ribeye area with reasonable accuracy (R^2=.90 and .91). These methods provide several options to determine ribeye area. However, data collectors need to realize that the difference between right and left side ribeye areas may be a greater variable than the sensitivity of the method used.

Introduction

Ribeye area is the muscling factor used in calculating yield grade. However, ribeye areas from the left and right sides of a carcass may differ. This study evaluated the difference in size of ribeyes between the left and right sides. Ribeye measurements are traditionally performed by using a USDA ribeye grid. However, at current chain speeds in most packing plants, the time needed to accurately "grid" a ribeye is too long. Many techniques have been used to accelerate collection of carcass data. Systems that measure images using current computer and video technology (video image analysis, VIA) offer faster and more accurate ribeye area measurements. In addition, simple linear measures of ribeye dimensions potentially could predict ribeye area very rapidly if less accuracy is acceptable. Therefore, our objective was to compare USDA ribeye grids, linear measures, and VIA for determining ribeye area.

Experimental Procedures

Ribeyes from the right and left sides of 265 beef carcasses were traced onto acetate tracing paper at a commercial packing facility. Members of the KSU Meats Judging Team measured the ribeye tracings using USDA grids. Two individuals measured each ribeye twice and averaged their two measurements. The measurements from the two individuals were averaged to determine the final ribeye area. If the difference between the two individuals' results was greater than 0.5 in^2, a third person measured the ribeye and the measurement furthest from the mean was deleted. In addition, ribeye length, center mid-width, and widest width were measured using a ruler calibrated to the nearest .05 in. Ribeye tracings also were measured by VIA. Correlations, paired t-tests, and regression analysis were conducted on data.

Results and Discussion

A plot of right vs. left side ribeye areas using VIA is displayed in Figure 1. The ribeye areas ranged from 7.6 to 19.9 in^2. When rounded to the nearest .1 in^2, right side ribeyes were larger in 124 carcasses (46.8%) and left side ribeyes were larger in 129 carcasses (48.7%). The mean difference (right-left) was $-.04 \pm .68$ in^2. When the right side was larger, the mean difference (right-left) was $.69 \pm .40$ in^2 (range .1 to 2.7 in^2) vs. $.74 \pm .42$ in^2 (range .1 to 3.4 in^2) when the left side was larger. A paired

t-test revealed no difference (P=.48) between right (12.92 in^2) and left (12.95 in^2) sides when measured by VIA. However, when USDA grids were used, ribeyes from the left sides (13.05 in^2) were slightly larger (P<.01) than ribeyes from the right sides (12.86 in^2).

Selected correlations of right and left side ribeye areas and measurements using USDA grids, a ruler, and VIA are presented in Table 1. Correlations between grid and VIA ribeye areas and between ruler and VIA-measured ribeye lengths were high for both the right (.96 and .97, respectively) and left (.95 and .97, respectively) carcass sides. For both right and left carcass sides, linear measures (length, mid-width, widest width, and VIA length) had moderately high correlations (.73 to .80) with ribeye area measures (Grid and VIA). However, length measures (Ruler and VIA) had lower correlations (.37 to .49) with width measures (mid-width and widest width).

For carcass right sides and pooled right and left sides (Table 2), ribeye areas measured with a grid or VIA were similar (P=.33). For the left sides, ribeyes measured with a USDA grid were slightly larger (P<.01) than VIA-measured ribeyes. However, the .1 in^2 difference is negligible when calculating yield grade. Measurement of ribeyes by either VIA or USDA grids can accurately determine ribeye area. Length of ribeyes measured by a ruler and VIA were similar (P=.51) for carcass left sides. For carcass right sides and combined right and left sides, ribeye lengths measured by VIA were slightly greater (P<.05) than those measured by ruler. Again the .05 and .02 in. differences are minimal and have little consequence compared to the wide range in ribeye lengths.

Regression equations (Table 3) were developed to predict VIA ribeye area from linear ruler measurements of ribeye length, mid-width, and widest width. Equations utilizing ribeye length and either mid-width or widest width had R^2 between .84 and .87 for right, left, and combined right and left side ribeyes. Equations combining ribeye length, mid-width, and widest width improved the R^2 to .90 and .91. Potentially, linear measurements could be collected at chain speeds of commercial plants by a data collection team. By incorporating these measures into regression equations, ribeye areas could be predicted with reasonable accuracy. This is especially true considering the differences that may exist between right and left side ribeyes.

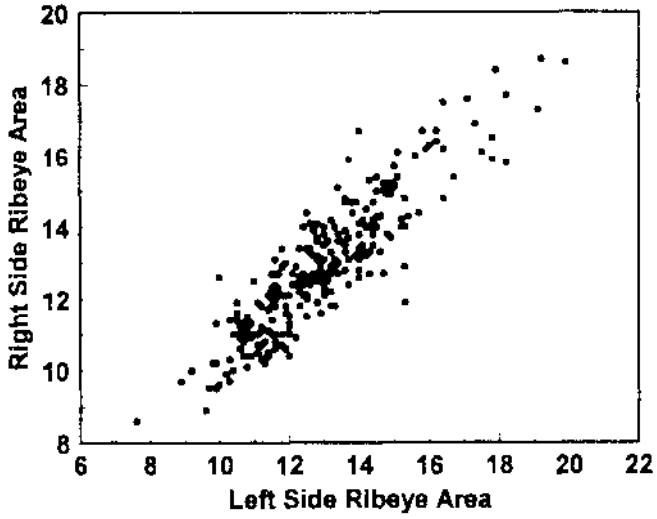

Figure 1. Plot of Right Side vs. Left Side Carcass Ribeye Areas Using Video Image Analysis.

Table 1. Selected Correlations of Right and Left Side Ribeye Areas and Measurements Using USDA Grids, a Calibrated Ruler, and Video Image Analysis (VIA)

	Right Side						Left Side					
		Ruler			VIA			Ruler			VIA	
Item	Grid Area	Length	Mid-Width	Widest Width	Area	Length	Grid Area	Length	Mid-Width	Widest Width	Area	Length
Right side												
Grid area	1											
Length	.75	1										
Mid-width	.78	.44	1									
Widest width	.73	.37	.72	1								
VIA area	.96	.77	.73	.77	1							
VIA length	.77	.97	.47	.41	.80	1						
Left side												
Grid area	.93	.74	.75	.73	.93	.77	1					
Length	.74	.79	.46	.46	.73	.80	.78	1				
Mid-width	.78	.48	.80	.66	.76	.52	.78	.44	1			
Widest width	.76	.47	.68	.68	.73	.49	.78	.46	.75	1		
VIA area	.93	.71	.73	.71	.90	.73	.95	.78	.79	.81	1	
VIA length	.76	.80	.48	.48	.75	.81	.80	.97	.48	.49	.82	1

Table 2. Means for Ribeye Area and Length Measured by a USDA Grid and Calibrated Ruler or Video Image Analysis (VIA)

Trait	Grid/Ruler	VIA	P value
Right side, n=265			
Ribeye area, in.^{2}	12.86	12.95	.33
Length, in.	5.59	5.64	< .01
Left side, n=265			
Ribeye area, in^2	13.05	12.95	< .01
Length, in.	5.63	5.63	.51
Combined, n=530			
Ribeye area, in^2	12.96	12.93	.33
Length, in.	5.61	5.63	< .01

Table 3. Regression Equations for Predicting Ribeye Area (VIA) from Linear Ribeye Measurements

	Parameter Estimates				
Equation for:	Intercept	Length	Mid-Width	Widest Width	R^2
Right side (n=265)					
Ribeye area, in ^{2}	-8.912	2.341	3.204		.84
Ribeye area, in ^{2}	-10.776	2.500		3.206	.86
Ribeye area, in ^{2}	-10.666	2.225	1.727	2.121	.90
Left Side (n=265)					
Ribeye area, in ^{2}	-10.338	2.470	3.439		.86
Ribeye area, in ^{2}	-11.083	2.380		3.510	.87
Ribeye area, in ^{2}	-11.396	2.211	1.955	2.167	.91
Combined (n=530)					
Ribeye area, in ^{2}	-9.604	2.404	3.317		.85
Ribeye area, in ^{2}	-10.911	2.443		3.347	.86
Ribeye area, in ^{2}	-11.011	2.216	1.837	2.145	.91

CHARACTERIZATION OF DIFFERENT BIOLOGICAL TYPES OF STEERS (CYCLE IV): RETAIL PRODUCT YIELDS [1]

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Summary

Retail product (RP) yields of 888 steers were obtained from mating Hereford (H) and Angus (A) dams to H or A (HA), Charolais (Ch), Gelbvieh (Gb), Pinzgauer (Pz), Shorthorn (Sh), Galloway (Gw), Longhorn (Lh), Nellore (Ne), Piedmontese (Pm), and Salers (Sa) sires. The yields were measured at two trim levels (.30 and .00 in.). Data were evaluated at constant age (426 d), carcass weight (714 lb), and marbling (Small[00]) endpoints. At a constant age of 426 d, RP% was greater in carcasses from steers sired by Continental European breeds (Gb, Ch, Sa, Pz; 63.3 to 65.5 % at .00 in. trim) than steers sired by British breeds (Sh, HA; 60.1 to 61.0%). Carcasses from Pm-sired steers had the highest RP% (69.7%) at the age-constant endpoint. Although carcasses were heavier ($P<.05$) for Ch-sired than for Pm-sired steers, lean growth rate measured by RP trimmed to .30 in. fat at 426 d, was similar for Ch- and Pm-sired steers. Lean growth rate was slowest for Lh-sired steers. Differences in RP% among sire breeds were minor at the Small[00] marbling endpoint. The ranking of sire breeds for weight of RP at a constant age of 426 d was: Ch, Pm, Gb, Sa, Ne, Pz, HA, Sh, Gw, and Lh. These sire-breed differences in RP yields allow for selection and crossing of breeds to optimize these traits. Of the breeds evaluated, Pm-sired steers produced the most muscular, trimmest, and highest cutability carcasses, and HA and Sh-sired steers produced the fattest, lowest cutability carcasses. Lh-sired steers had the slowest lean growth rate. Differences in RP% and(or) weight among sire breeds should be balanced with meat quality and other important production traits.

(Key Words: Breeds, Carcasses, Retail Product.)

Introduction

Breed differences in production traits are essential genetic resources for improving beef production efficiency and carcass RP yields, because no breed excels in all traits important to beef production. Diverse breeds are necessary to exploit heterosis and complementarity through crossbreeding and to match genetic potential with feed resources, environments, and market demands. Considerable variation in percentage and weights of retail product and fat trim was detected among 16 sire breeds characterized in the first three cycles of the GermPlasm Evaluation (GPE) research project at the Roman L. Hruska U.S. Meat Animal Research Center. The objective of Cycle IV research, which includes six new breeds and five breeds repeated from earlier cycles of GPE research, was to characterize a new sample of cattle breeds representing diverse biological

[1]This article was derived from a research paper submitted to the Journal of Animal Science. These data are from the GermPlasm Evaluation research program conducted under the leadership of Dr. Larry V. Cundiff at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE. Dr. Michael E. Dikeman was a collaborator on the carcass retail product data collection.

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types for carcass yields of RP, fat trim, and bone that affect quantity and value of production.

Experimental Procedures

Cycle IV of the GermPlasm Evaluation program began in 1985. Hereford and Angus dams were mated by AI to 30 Angus, 32 Hereford (both born 1982 to 1984), 29 Longhorn (Lh), 24 Piedmontese (Pm), 31 Charolais (Ch), 29 Salers (Sa), 31 Galloway (Gw), 22 Nellore (Ne), and 26 Shorthorn (Sh) bulls to produce progeny in five calf crops. Only data from Hereford × Angus and Angus × Hereford (HA) matings and not purebreds are presented to avoid confounding sire-breed effects with heterosis effects. After a 45-day AI period, one or two bulls each of Hereford, Angus, Ch, Gelbvieh (Gb), and Pinzgauer (Pz) breeds were used each year by natural service in single-sire breeding pastures. Data from cleanup (CU) sires were reported separately from AI sire data because of differences in selection intensity for those sires.

Calves were born from mid-March to late May and creep fed whole oats from mid July or early August until weaning in October at about 170 days of age. Following a postweaning adjustment of 25 to 40 days, steers were fed separately by sire breed in replicated pens for about 200 days. A growing diet containing 66% corn silage, 22% corn, and 12% supplement (dry matter basis) was fed until steers weighed about 706 lb. Then a finishing diet containing 25% corn silage, 70% corn, and 5% supplement was fed to slaughter. Steers were slaughtered serially each year, in three or four groups spanning 56 to 84 days. USDA yield and quality grade data were obtained by USDA-ARS personnel.

The right side of each carcass was fabricated into subprimal cuts trimmed to .30 in, lean trim (20% fat), fat trim, and bone. Retail product was the sum of subprimal cuts plus lean trim. Subprimal cuts then were trimmed free (.00 in.) of surface fat, and all components were reweighed.

Data were analyzed by least squares, mixed model procedures. In addition, linear regressions of traits on days fed provided a method of adjusting the age constant sire breed means to alternative endpoints. The regressions were used for estimating values that would have been obtained if all animals in a sire breed had been fed fewer or more days until the breed group average reached a given endpoint with regard to age, carcass weight, fat thickness, fat trim percentage, or marbling.

Results and Discussion

When data were adjusted to 426 days of age, AI Ch-sired steers produced the heaviest carcasses, whereas Lh-sired steers produced the lightest carcasses (Table 1). Carcasses produced by Gw-sired steers were lighter than all breeds except Lh. Carcasses from AI Ch- and Pm-sired steers produced greater weights of RP than most other sire breeds at both trim levels. Carcasses from Lh-sired steers produced the lowest weight of RP at both trim levels, followed by Gw- and CU HA-sired steers. AI HA- and Sh-sired steers produced similar weights of RP. Carcasses from Pm-sired steers produced the lowest weight of fat trim at both trim levels, whereas Sh- and AI HA-sired steers produced the most fat trim (Table 1). AI Ch-sired steers yielded the greatest weight of bone, whereas Lh-sired steers yielded the lowest weight of bone followed by Gw-sired steers. Differences in weights of carcass components, of course, were associated with sire-breed differences in carcass weights.

When RP, fat trim, and bone were expressed as percentages of carcass weights, Pm-sired steers showed greater advantages over other breeds in percentages of RP and fat trim than in weights of these components. Their RP% was 4.2 to 5.8% greater at .00 in. trim than the Ch- and Gb-sired groups. AI Ch-, CU Ch-, Sa-, and CU Gb-sired steers were intermediate in RP% (64.2 to 65.5% at .00 in. trim), whereas AI HA-, CU HA- and Sh-sired steers had the lowest RP% (60.1 to 61.0% at .00 in. trim). These differences in RP% among sire-breed groups largely were due to differences in percentages of fat trim, but also to differences in muscle to bone ratio rather than to differences in percentages of bone. For example, the difference between AI HA- and Pm-sired steers in percentage of fat trim (.00 in.) was 26.4 versus 16.9%, respectively, whereas no difference

occurred in percentage of bone (13.4 versus 13.4%). The range in percentage of bone among all sire-breed groups was from 13.4 to 14.5%.

When data were adjusted to a constant carcass weight of 714 lb, Pm-sired steers still produced the highest RP% and lowest percentage of fat trim. Shorthorn-, CU HA-, AI HA-, and Lh-sired steers produced carcasses with the lowest RP%. Longhorn-sired steers produced carcasses with a higher percentage of fat trim than all sire breeds except CU HA-, AI HA-, and Sh-sired steers. Carcasses from Pm-sired steers produced the lowest percentage of fat trim of all sire breed groups. In fact, Pm-sired steers produced less fat at .00 in. trim than AI HA-, CU HA-, Sh-, Gw- and Lh-sired steers when trimmed to only .30 in. The percentage of bone still ranged only from 13.0 to 15.0% among sire breed groups when data were adjusted to a constant weight of 714 lb. These differences among sire breeds at 714 lb endpoint reflect maximum variation in RP, fat trim, and bone percentages relative to age or marbling endpoints.

At a constant marbling endpoint (Small^{00}), CU Ch- and Ne-sired steers produced the heaviest carcasses, whereas Sh-, Lh and CU HA-sired steers produced the lightest. Carcasses from Pm-sired steers still had the highest RP%, whereas AI HA and Ne-sired steers had lower RP% than all sire breeds except for CU Ch-sired steers. Percentages of fat trim among AI HA-, CU HA, Lh-, and Sa-sired steers were not different ($P<.05$) at Small^{00} marbling. However, Sh-sired steers produced carcasses with a lower percentage of fat trim than AI HA- and CU Ch-sired steers at Small^{00} marbling. Percentage of fat trim was highest for Ne-sired steers at Small^{00} marbling. Percentages of bone changed only slightly when the data were adjusted to different endpoints.

On the average, RP% was reduced 5.6% by trimming all fat (.00 in.) compared to leaving .30 in. of fat on subprimal cuts. Trim level had little impact on sire breed differences in RP%, although relatively less fat was trimmed from Pm- and more from Sh- and HA-sired steers by trimming to .00 in. compared to trimming to .30 in.

Table 1. Sire Breed Least Squares Means for Product Yields at Two Fat Trim Levels Adjusted to 426 Days of Age

			Sire Breed[a]												
Trait	Trim Level	Mean	AI HA	CU HA	AI Ch	CU Ch	CU Gb	CU Pz	Sh	Gw	Lh	Ne	Pm	Sa	LSD[b]
Cold carcass wt, lb[c]		686	718	679	751	720	709	690	716	645	600	711	695	717	22.5
Product wt, lb															
Total retail product	.30 in.	468	473	452	524	503	498	473	468	444	411	487	515	498	16.3
	.00 in.	430	431	412	484	464	461	436	427	407	378	447	483	459	15.4
Fat trim	.30 in.	132	157	142	127	124	119	128	156	122	114	137	96	127	12.3
	.00 in.	162	191	174	157	154	148	157	188	151	139	169	120	157	13.7
Bone	.30 in.	86	88	85	100	93	91	89	92	80	75	87	85	92	3.1
	.00 in.	94	96	93	109	101	99	97	100	87	83	95	93	100	3.5
Product, %[d]															
Total retail product	.30 in.	68.5	66.1	66.8	70.0	70.2	70.6	68.8	65.7	69.0	68.7	68.7	74.3	69.6	1.3
	.00 in.	62.9	60.2	61.0	64.8	64.9	65.5	63.4	60.1	63.3	63.3	63.2	69.7	64.2	1.4
Fat trim	.30 in.	18.9	21.4	20.6	16.6	16.8	16.4	18.2	21.4	18.6	18.7	18.9	13.5	17.5	1.5
	.00 in.	23.3	26.4	25.3	20.7	20.0	20.4	22.5	25.9	23.1	22.9	23.4	16.9	21.7	1.6
Bone	.30 in.	12.6	12.3	12.6	13.4	13.0	13.0	13.0	12.9	12.5	12.6	12.3	12.2	12.9	.4
	.00 in.	13.8	13.4	13.7	14.5	14.2	14.1	14.1	14.1	13.6	13.8	13.5	13.4	14.0	.4

[a]The Hereford and Angus sires were considered new (born 1982-84) relative to the original Hereford and Angus sires (born 1963-70) used in Cycles I to III of the GermPlasm Evaluation project. Cleanup (CU) sires also represented "new" sires, but did not have as much selection intensity as the AI sires, and thus, results from their progeny were reported separately. HA = Hereford × Angus and Angus × Hereford crosses, Ch = Charolais, Gb = Gelbvieh, Pz = Pinzgauer, Sh = Shorthorn, Gw = Galloway, Lh = Longhorn, Ne = Nellore, Pm = Piedmontese, Sa = Salers.

[b]LSD is the least difference between means of breeds required for significance (P<.05).

[c]Calculated as the sum of all dissected parts from each side (x 2 to give carcass weight) to avoid confounding percentage yield differences with differences in side shrink caused by various lengths of time before sides were cut.

[d]Expressed as a percentage of carcass weight.

Table 2. Sire Breed Least Squares Means for Percentages of Product at Two Fat Trim Levels Adjusted to a Common Carcass Weight or Marbling Endpoint

		Sire Breed[a]												
Endpoint	Trim Level	AI HA	CU HA	AI Ch	CU Ch	CU Gb	CU Pz	Sh	Gw	Lh	Ne	Pm	Sa	LSD[b]
Carcass wt, 714 lb														
Total retail product, %	.30 in.	67.0	66.6	71.7	71.1	71.3	68.9	66.4	67.8	66.0	69.3	74.6	70.3	1.3
	.00 in.	61.2	60.8	66.5	65.8	66.1	63.5	60.8	62.1	60.5	63.8	70.0	65.0	1.4
Fat trim, %	.30 in.	20.3	20.9	14.8	15.8	15.7	18.1	20.3	20.1	22.1	18.2	13.3	16.7	1.5
	.00 in.	25.1	25.6	18.8	20.0	19.7	22.4	24.8	24.6	26.4	22.6	16.7	20.8	1.7
Bone	.30 in.	12.5	12.6	13.8	13.2	13.2	13.0	13.1	12.1	11.9	12.5	12.3	13.1	.4
	.00 in.	13.6	13.7	15.0	14.4	14.3	14.1	14.3	13.3	13.0	13.6	13.5	14.3	.4
Marbling, small[00]														
Carcass weight, lb		617	547	716	760	705	597	544	596	564	749	708	714	24.3
Total retail product, %	.30 in.	68.7	70.2	70.9	69.2	70.7	71.3	69.9	70.3	69.8	67.8	73.9	69.7	1.3
	.00 in.	62.8	64.4	65.7	63.9	65.6	65.9	64.3	64.7	64.4	62.2	69.3	64.3	1.5
Fat trim, %	.30 in.	17.9	15.7	15.7	17.9	16.3	15.2	15.1	16.9	17.3	20.2	13.8	17.4	1.6
	.00 in.	22.6	20.4	19.7	22.1	20.3	19.4	19.6	21.3	21.5	24.7	17.2	21.6	1.7
Bone	.30 in.	12.9	13.6	13.6	12.7	13.0	13.6	14.1	12.8	12.9	12.1	12.1	12.9	.4
	.00 in.	14.1	14.7	14.8	13.9	14.2	14.8	15.3	14.0	14.1	13.2	13.3	14.1	.4

[a]The Hereford and Angus sires were considered new (born 1982-84) relative to the original Hereford and Angus sires (born 1963-70) used in Cycles I to III of the GermPlasm Evaluation project. Cleanup (CU) sires also represented "new" sires, but did not have as much selection intensity as the AI sires, and thus, results from their progeny were reported separately. HA = Hereford × Angus and Angus × Hereford crosses, Ch = Charolais, Gb = Gelbvieh, Pz = Pinzgauer, Sh = Shorthorn, Gw = Galloway, Lh = Longhorn, Ne = Nellore, Pm = Piedmontese, Sa = Salers.

[b]LSD is the least difference between means of breeds required for significance ($P<.05$).

ECONOMIC IMPACT OF PREWEANING VACCINATIONS ON HEALTH AND PERFORMANCE OF WEANED FEEDER CATTLE [1]

J. M. Lynch [2], P. L. Houghton [2], L. R. Corah, and G. L. Stokka

Summary

In October, 1995, 3,565 head of freshly weaned, British-breed calves were received into a weaning facility in southwest Nebraska. Calves were determined to be preconditioned if they had received both viral and *Pasteurella* vaccines prior to weaning (PREWEAN; n = 2,315), and all other calves were considered to have no preconditioning (CRTL; n = 1,250). Cattle were processed within 24 hours of arrival, and booster vaccinations were given when appropriate. Average days on feed at the weaning facility were similar between PREWEAN and CTRL calves (52.4 and 50.3 days, respectively), but average daily gain (2.24 vs 1.87 kb) and cost per lb of gain ($.64 vs $.81) were improved (P<.01) for PREWEAN. Processing ($7.48 vs $9.10/hd) and medicine costs ($1.39 vs $5.27/hd) were lower (P<.01) for PREWEAN calves during the weaning phase. Only 10.6% of the PREWEAN calves were treated for sickness, whereas 34.7% of the CTRL calves were treated at least once (P<.01). Mortality tended to be lower for PREWEAN calves compared to CTRL calves, although it was low for both groups (.26% vs .48%, respectively). The average total cost per head was similar for PREWEAN and CTRL calves ($73.62 vs $72.79, respectively). Theoretical breakevens reflected lower costs and increased performance in PREWEAN cattle. These results suggest that producers should get a return on their money invested in preconditioning programs that include protection against IBR, BVD, PI3, BRSV, and *Pasteurella*.

(Key Words: Feeder Cattle, Weaning, Preconditioning, Economics.)

Introduction

Each year the feedlot industry faces huge economic losses from decreased performance, treatment costs, and mortality associated with respiratory diseases. These diseases are particularly prevalent in newly weaned feeder cattle that tend to be more susceptible because of stress, impaired immune function, and changes in nutritional management. Total losses have been estimated to be $250 million to $1 billion annually. Management practices including branding; viral and clostridial vaccinations (at 30 to 60 days of age); implanting; or processing (dehorning, castration) followed by booster vaccinations 14 to 21 days prior to weaning can help producers optimize weaning weights and minimize post-weaning disease problems.

The objective of this field trial was to demonstrate the economic impact of preconditioning feeder cattle on feedlot performance, morbidity, and mortality.

Experimental Procedures

In October, 1995, 3,565 head of freshly weaned, British-breed calves were received into a weaning facility in southwest Nebraska. Lot size ranged from 48 to 445 head, with an average of 149 head per lot. Calves originated from 24 sources; 14 of which vaccinated for both viral diseases and *Pasteurella* prior to

[1]The authors express sincere appreciation to the employees of Heartland Cattle Company for their assistance in the collection of this data set.

[2]Heartland Cattle Company, McCook, NE.

weaning (PREWEAN; n = 2,315) and 10 of which either didn't vaccinate preweaning or vaccinated for only the viral diseases or *Pasteurella* (CTRL; n = 1,250). Both CTRL and PREWEAN treatments included calves purchased from local sale barns, but CTRL had more. These calves were locally produced, ranch fresh, and of high quality. Additionally, the CTRL calves tended to be lighter at arrival, which may have influenced their performance. For the purpose of this data set, calves were considered to be preconditioned if they had received both viral and *Pasteurella* vaccines 14 to 21 days prior to weaning.

Upon arrival, calves were placed in a receiving pen and given ad libitum access to water and high quality prairie hay. All cattle were processed within 24 hours of arrival. Standard processing included a modified-live 4-way viral with leptospirosis, *Haemophilus*, external and internal parasite control, and an implant. If they had not received a 7-way clostridial prior to weaning, it was included at processing. Branding, tipping horns, and castration were performed when necessary. Booster vaccinations were given 10 to 15 days after arrival to ensure that all animals received two injections with *Haemophilus* and modified live viral vaccines. In addition, each animal was tagged and weighed.

All animals were observed daily, and individual treatment records were maintained throughout the feeding phase. At the conclusion of the backgrounding phase, cattle were transported to a common facility in north-central Kansas and fed for slaughter.

Results and Discussion

The results for PREWEAN and CTRL calves are summarized in Table 1. Average

Table 1. Effects of Preweaning Vaccinations on Growth Performance, Morbidity, Mortality, and Profitability of Freshly Weaned Feeder Calves

Item	PREWEAN[a]	CTRL	SE
No. of cattle	2,315	1,250	
Initial weight, lbs	602	565	14.7
Purchase price[b], $/cwt	63.50	64.00	
Days on feed, days	52.4	50.3	4.2
Daily gain[c], lb/head	2.24[x]	1.87[y]	.12
Feed efficiency[c],F:G	7.56	8.20	.48
Total gain[c], lb/head	116.0	97.0	10.8
Morbidity, %	10.6[x]	34.7[y]	
Mortality, %	.26	.48	
Processing cost,$/head	7.48[x]	9.10[y]	.48
Medicine cost, $/head	1.39[x]	5.27[y]	.64
Cost of Gain[c]	.64[x]	.81[y]	.05
Break even[d],$/cwt	63.50	65.60	

[a]PREWEAN cattle received at least viral and *Pasteurella* vaccinations prior to weaning.
[b]Purchase price was assigned to PREWEAN and CTRL cattle based on historical data for November 1, 1995; 600 and 550 lb feeder cattle, respectively.
[c]Figures include death loss.
[d]Calculated breakevens were derived from purchase price, total cost, and final weight.
[x,y]Columns with different superscripts differ (P<.01).

days on feed in the weaning facility were similar between PREWEAN and CTRL calves (52.4 and 50.3 days, respectively). However, daily gain (2.24 vs 1.87 lb/day), and cost per pound of gain ($.64 vs $.81 lb gain) were improved (P<.01) when cattle received viral and *Pasteurella* vaccinations 14 to 21 days prior to weaning. The lower cost per pound of gain resulted from a decrease (P<.01) in both processing ($ 7.48 vs $9.10) and medicine costs ($1.39 vs $5.27) for PREWEAN compared to CTRL calves. Only 10.6% of the PREWEAN calves were treated compared to 34.7% of the CTRL calves, which resulted in less labor and medicine costs for the PREWEAN calves. In addition, mortality tended to be lower for PREWEAN compared to CTRL calves, although it was low for both groups (.26% vs .48%, respectively).

The average total cost per head was similar for PREWEAN and CTRL calves ($73.62 vs $72.79, respectively). The PREWEAN calves gained an additional 19 pounds with virtually no additional inputs. Based on average initial weight, cattle were assigned purchase prices of $63.50 and $64.00/cwt for PREWEAN and CTRL, respectively, which corresponded to current cattle markets at the time of purchase. Theoretical breakevens were calculated using total cost and final weight. The breakevens were $63.50 and $65.60/cwt for PREWEAN and CTRL cattle, respectively, reflecting the lower costs and increased performance in PREWEAN cattle.

The economic impact of preconditioning may vary in years when price/cost relationships are different from those used in this study. Nevertheless, growth performance, treatment costs, and death loss reflect the impact of preweaning vaccinations.

Our data indicated that preconditioning with viral and *Pasteurella* vaccines prior to weaning decreased both morbidity and mortality, while improving growth performance and profitability. These results suggest that producers should get a return on money invested in preconditioning programs that include protection against IBR, BVD, PI3, BRSV and *Pasteurella*.

THE EFFECT OF VITAMIN E, SELENIUM, AND COPPER SUPPLEMENTATION PREWEANING ON THE PERFORMANCE AND IMMUNE RESPONSE OF BEEF CALVES

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Summary

Two experiments were conducted to determine the effect of vitamin E, selenium, and copper supplementation on the pre- and postweaning performance, immune responses, and serum metabolites of crossbred beef calves. In experiment 1, 71 calves were blocked by weight and allotted to one of four individually fed treatments: 1) control supplement (2 lb grain creep) (CS), 2) CS + .27 mg selenium + 500 IU vitamin E, 3) CS + 9.1 mg copper, and 4) combination of treatments 2 and 3. In experiment 2, 80 crossbred beef calves were blocked by weight and allotted to 5 individually fed treatments: 1) control supplement (2 lb grain creep) (CS), 2) CS + .27 mg selenium, 3) CS + .27 mg selenium + 500 IU vitamin E, 4) CS + .27 mg selenium + 1000 IU vitamin E, and 5) CS + .27mg selenium + 1500 IU vitamin E. Supplements were fed daily on an individual basis. In experiment 1, vitamin E supplementation reduced plasma haptoglobin levels by the end of the study and tended (P=.11) to improve postweaning gain. However, no other effect was noted on calf performance or immune parameters in either experiment.

(Key Words: Vitamin E, Selenium, Copper, Suckling Calves, Growth, Health, Immune System.)

Introduction

Environmental and management stresses have been shown to compromise the immune system and lower disease resistance of newly weaned beef calves. Because stress caused by weaning and transportation are nearly inevitable, any management practices that reduce immunosuppressive consequences of physical or pathological stress could be beneficial.

The effects of vitamin E, selenium, and copper supplementation on immune system function has received a great deal of research attention. Studies have shown that deficiencies in vitamin E and selenium can depress immune function and that, when supplemented postweaning, these nutrients can improve calf performance. Preweaning supplementation of vitamin E, selenium, and copper has not been studied previously and merits attention. Thus, our goal was to evaluate the effects of preweaning vitamin E, selenium and copper supplementation on performance and immune function in beef calves.

Experimental Procedures

Experiment 1. Seventy-one Hereford-Angus calves (mean age = 163 days) were blocked by weight and allotted to one of four treatment groups; 1) control supplement (2 lb grain creep) (CS), 2) CS + .27 mg selenium + 500 IU vitamin E, 3) CS + 9.1 mg copper, and 4) combination of treatments 2 and 3. CS was 60% dry rolled corn, 25% rolled oats, 10% soybean meal, and 5% wet molasses, fed at the rate of 2 lb/daily. Because additional copper was provided only in the creep supplements, the copper content of the total diet (supplement, forage, and milk) was below the recommended level of 8 to 10 ppm. For 49 days prior to weaning, calves were separated from their dams

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daily, sorted into treatment groups, and individually fed their respective diets.

At weaning, calves were separated from their dams; vaccinated (CattleMaster 4® and Ultrabac 7®, Pfizer Animal Health, Lincoln, NE); and shipped 150 miles where they were unloaded, bled, and provided water and grass hay. On the following day, calves were returned to the Kansas State University Beef Cattle Research Center, where they were re-vaccinated; dewormed (Safe Guard®, Hoechst Roussel, Somerville, NJ); and fed a standard feedlot receiving ration for 28 days.

Blood samples were collected at the start of the trial, at weaning, postshipping, and after the growing period. These samples were analyzed for erythrocytes and total leukocyte counts, whole blood hematocrit, hemoglobin, haptoglobin, lymphocyte blastogenic response, and IBR/BVD antibody titers. Haptoglobin, which is an acute phase protein, is gaining acceptance as an indicator of health problems in cattle. Elevated levels serve as an early warning of infection or inflammation.

Experiment 2. Eighty Hereford-Angus calves (mean age = 167 days) were blocked by weight and allotted to one of five treatment groups; 1) control supplement (2 lb grain creep) (CS), 2) CS + .27 mg selenium, 3) CS + .27 mg selenium + 500 IU vitamin E, 4) CS + .27 mg selenium + 1000 IU vitamin E, and 5) CS + .27 mg selenium + 1500 IU vitamin E. The control supplement was the same as in experiment 1. For the last 53 days prior to weaning, calves were separated from their dams daily, sorted into treatment groups, and individually fed 2 lbs of their respective diet.

At weaning, calves were separated from their dams and shipped 250 miles to a commercial feedlot, where they were unloaded, weighed, and bled. All calves were revaccinated (CattleMaster 4 and Ultrabac 7, Lincoln, NE) and dewormed (Safe Guard, Hoechst Roussel, Somerville, NJ). Cattle were fed a series of step-up diets for the first 5 days then placed on a growing diet. Calf weights were taken at the start of the trial; at weaning; and 7, 18, and 45 days postweaning. All weights were taken full except on day 53 (postshipping) and day 98 (postshipping) when cattle were shrunk following transportation. As in experiment 1, blood samples were collected for immune parameter analysis.

Results and Discussion

Pre- and postweaning calf performances are shown in Tables 1 and 2. In experiment 1, feeding supplemental vitamin E and selenium tended to improve (P=.11) the postweaning gain of the calves. In both experiments, dietary treatment had no other effect on calf performance or immune response, and in experiment 2, postweaning performance was not influenced by experimental dietary treatment.

Table 1. Effect of Copper and Vitamin E Supplementation on Calf Performance in Experiment 1

Treatment	Preweaning ADG [a]	SE	Postweaning ADG [b]	SE
	lb		lb	
Control supplement	2.31	.043	1.87	.075
Vitamin E, 500 IU/day	2.29	.042	2.16	.073
Copper 9.1 mg/day	2.22	.042	2.09	.073
Vitamin E and copper added	2.33	.042	2.35	.073
Contrast analyses:				
Vitamin E	2.31	.03	2.24	.05
No vitamin E	2.24	.03	1.98	.05
Probability	.39		.11	
Copper	2.29	.03	2.20	.05
No Copper	2.27	.03	2.02	.05
Probability	.90		.26	

[a]Measured days 0 to 49 (preship).
[b]Measured days 49 to 78.

Table 2. Effect of Vitamin E and Selenium on Pre- and Postweaning Calf Performance in Experiment 2 [a]

	Treatment					
Item	Control	Selenium [c]	Low E [d] Selenium	Med E [d] Selenium	High E [d] Selenium	S E
Preweaning ADG (lb) [a]	2.02	2.11	1.94	2.09	2.02	.10
Postweaning ADG (lb) [b]	2.18	2.13	1.99	2.38	1.66	.28

[a]Measured from the initiation of the feeding period until weaning.
[b]Measured for 45 day post-weaning growing period.
[c].27 mg added selenium daily.
[d]Low, medium, an dhigh levels of added vitamin E are 500, 1000, and 1500 IU daily, respectively.

DELINEATION OF GEOGRAPHIC MARKETS FOR FED CATTLE

T. C. Schroeder[1]

Summary

Determining the extent of geographic markets for fed cattle is important for monitoring performance of the industry. The ability of packing plants to influence prices is determined in part by their ability to segment the market for fed cattle and isolate themselves from plants in other regions. This study analyzed transaction data from 43 U.S. steer and heifer slaughter plants collected by the Grain Inspection Packers and Stockyards Program for approximately a 1-year period during 1992-93. Beef packers procured an average of 64% of their cattle within 75 miles of packing plants, 82 % within 150 miles, and 92% within 250 miles. However, these average distances varied by region of the U.S. Prices were linked strongly across plants, suggesting a national market for fed cattle. This indicates that local measures of packing plant concentration overstate the degree of concentration among potential cattle buyers in the region.

(Key Words: Geographic Markets for Cattle, Beef Packers, Packer Concentration.)

Introduction

Determining relevant geographic procurement markets for fed cattle is essential in monitoring market behavior and assessing the industry's structure and performance. Market boundaries identify separate economic markets within which firms or plants operate independent of firms or plants located in other regions. Beef packing is highly concentrated; the top four firms accounted for 81.1% of 1995 commercial steer and heifer slaughter. In many states, beef packing by these four firms exceeds 90%. Therefore, determining the extent to which plants in a region compete for cattle purchases with plants located in other regions is an important determinant of whether plants in local areas can unduly influence fed cattle price. The purpose of this study was to determine the relevant geographic procurement markets for fed cattle in the U.S.

Experimental Procedures

Data were collected by the Grain Inspection Packers and Stockyards Administration (GIPSA) on individual transactions for all pens of cattle of 35 head or more slaughtered by 43 U.S. fed cattle slaughter plants from early April 1992 through early April 1993. Plants from the states of Kansas, Texas, Colorado, Nebraska, Iowa, Minnesota, Arizona, California, Utah, Washington, Idaho, Illinois, Michigan, Pennsylvania, and Wisconsin were represented. The transaction price data were analyzed for several aspects including examination of geographic source of cattle purchased and regression analysis of how prices at each plant responded to price changes at other plants over time. As a result of numerous missing data and inconsistencies in data reporting, the data set analyzed by regression consisted of 103,442 pens of cattle slaughtered in 28 of the 43 plants. Prior to making comparisons across plants, all price data were adjusted for differences in sex, quality, and pen characteristics.

Results and Discussion

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Table 1 shows the percentages of cattle purchased within various distances from plants. Plants located in Kansas and Texas (MidSouth) bought 76% of their cattle within a 75-mile radius. This is the largest percentage of cattle purchased within that distance of any region and makes sense given the concentration of cattle feeding in this region. This contrasts with plants in Eastern states that purchased only 32% of their slaughter needs within 75 miles. Plants located in Kansas and Texas purchased 95% of their cattle within 250 miles. The maximum distance cattle were hauled by a plant was 1140 miles, and nine plants hauled at least some cattle in excess of 900 miles. Cattle procurement areas for many of the plants analyzed showed considerable overlap. Some plants had more than 15 other plants (of the 43 in the study) that purchased cattle from the same counties where they purchased 10% or more of their cattle. Significant procurement overlaps were most common for plants located in MidSouth and MidNorth states. Procurement overlaps help ensure that plants compete with each other for fed cattle.

Table 1. Regional Procurement Areas for Fed Cattle Slaughter Plant

	Avg Percent of Cattle Procured within Indicated Miles of Plants		
Region[a]	75 miles	150 miles	250 miles
West	72.05%	90.46%	93.20%
East	31.88%	52.24%	78.06%
MidNorth	64.94%	83.93%	94.65%
MidSouth	76.42%	90.84%	95.29%

[a]West includes plants in Arizona, California, Utah, Washington, and Idaho; East includes plants in Illinois, Wisconsin, Michigan, Pennsylvania, and Illinois; MidNorth includes plants in Nebraska, Colorado, Iowa, and Minnesota; MidSouth includes plants in Texas and Kansas. Source: Hayenga et al. in M.L. Hayenga, S.R. Koontz, and T.C. Schroeder. *Definition of Regional Cattle Procurement*

Prices across plants were related closely. During the time period studied, prices across plants did not diverge from each other, suggesting that these plants were competing for cattle in linked markets. Fed cattle prices at different plants are related, because producers sell cattle to the plant offering the highest price, forcing plants to compete with each other for cattle. Strength of price relationships declined as distance between plants increased because of increased costs and risks of shipping cattle. The larger the overlapping trade areas shared by plants, the more closely their prices related to each other and the more quickly they responded to each other. Plants in close proximity or with significant procurement overlap are forced to offer prices competitive with other plants, if they are going to purchase sufficient numbers of cattle.

Plants that purchased more of their cattle in the cash market tended to react more to price changes at other plants than those that procured cattle through contracts or that fed their own cattle. This suggests that plants that use means other than cash purchases to secure cattle may not be as responsive to price changes at other plants. Smaller plants tended to have prices that were linked more closely to other plants' prices. Finally, plants owned by the same firm tended to have stronger and quicker price responses to each other than to plants owned by different firms. This is because information flow and ability to coordinate cattle purchases across location are greater for plants owned by the same parent firm.

Overall, results suggested that fed-cattle prices across the U.S. are linked strongly. Prices at plants in the core cattle feeding regions are tied very closely to each other, because competition forces plants to change prices in accordance to other plants' prices in the area. Because no regions can isolate themselves from competition by plants in other regions and because information flows rapidly, cattle trading tends to be in a national market. This suggests that local measures of packer concentration overstate the level of actual concentration on a national basis.

DETERMINANTS OF PRICES FOR PUREBRED BEEF BULLS

K. C. Dhuyvetter, T. C. Schroeder[1], D. D. Simms, R. P. Bolze Jr., and J. Geske

Summary

Animal characteristics and sale price data for 1651 bulls sold at 26 Kansas purebred beef sales during 1993 were collected and analyzed to determine which factors affected price differentials for beef bulls. Bull sale price varied, from $650 to $20,000 per head. Regression analysis was used to determine the price differential associated with bull traits and marketing factors. Black bulls in the Simmental, Gelbvieh, and Limousin breeds brought premiums of 15% to 53% compared to their nonblack peers. Conformation, disposition, and muscling affected sell prices. Bulls with lower birth weights and birth weight expected progeny differences (EPD) brought higher prices. Bulls with higher adjusted weaning weights, weaning weight EPD, and milk EPD also brought higher prices, although these varied depending upon bull breed. Several marketing factors, including sale order, semen retention, and pictures in the sale catalogs, influenced bull prices. Bull buyers can use this information to make more informed bull buying decisions, and purebred producers can use results to target production and marketing.

(Key Words: Bull Prices, Bull EPD, Bull Marketing.)

Introduction

The value of a breeding bull is determined by its expected value in production. Bull sale prices vary considerably, and numerous physical and genetic characteristics contribute to that variation. Additionally, reputation of the seller impacts sale price. The large number of bull attributes that must be considered make it difficult for bull buyers and sellers to determine the market value of individual bulls. Our objective was to determine the relative impact of individual physical attributes on sale prices of breeding bulls. Buyers can use this information to make more informed purchase decisions, and producers can use these results to better target their production and marketing.

Experimental Procedures

Sale price, physical characteristics, genetic information, and marketing factors were collected on individual animals from 26 purebred beef bull sales in Kansas during spring, 1993. The data set included 1700 bulls representing seven breeds. Because of incomplete data, 1651 observations were retained for analysis. The data set included Angus (46.5%), Charolais (12.4%), Gelbvieh (14.4%), Hereford (7.5%), Limousin (3.6%), Red Angus (4.4%), and Simmental (11.2%).

Individual bulls were evaluated at the time of sale and assigned a rank of 1 (poor) to 5 (excellent) with respect to conformation, muscling, structural correctness, and disposition. Other information recorded at the time of sale were sale order, breed, lot, horned status, color, age, and price. Performance information was obtained from sale catalogs, although information printed in the catalogs varied among sales. Physical and genetic characteristics considered were actual birth weight, birth weight EPD, adjusted weaning weight, weaning weight EPD, and milk EPD. We also noted from sale catalogs whether

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semen was retained and whether the bull was pictured in the catalog.

Regression analysis was used to determine the relative value of each piece of information on a bull's sale price. This procedure enabled us to allocate the entire price paid for a bull into values of individual attributes.

Results and Discussion

Bull sale prices ranged from $650 to $20,000 and averaged $2308.70 per head. Average birth weight was 85 lb and average adjusted weaning weight was 652 lb. Bulls averaged 450 days of age with, a range of 298 to 1136 days. On average ,8% of the bulls were pictured in the catalog. Roughly 1% of bulls had at least some proportion of semen rights retained by the seller.

Numerous factors were statistically important in explaining bull price differentials. After adjusting for all other attributes, no significant differences were found in prices between breeds. However, bull color was a significant price determinant. Black Simmentals, Gelbvieh, and Limousins brought premiums ranging from 15% to 53% over their nonblack peers. This is consistent with previous K-State studies indicating that black feeder cattle brought market premiums. Polled bulls brought premiums of 10%. Bull conformation was more important than muscling, structural correctness, and disposition with price premiums of 7% associated with each unit increase in conformation score.

Historically, bulls often have been sold as 2-year-olds, but the beef industry has shifted to greater use of yearling bulls. This is confirmed by the fact that 79% of the bulls sold were less than 18 months old. Age had a nonlinear effect on bull prices, indicating that buyers paid a premium for older bulls but at a decreasing rate (Figure 1). Two-year-old and older bulls brought premiums compared to younger bulls, but it was generally not enough to offset the added expense.

Bull birth weight, adjusted weaning weight, and EPDs for birth weight, weaning weight, and milk were all important price determinants, but their importance varied among bull breeds. Table 1 reports the price impacts of these growth performance and EPD measures. For Angus and Charolais, the bull's actual birth weight was an important price determinant, with prices declining by 3.8% and 7.7%, respectively, for each pound increase in bull birth weight. For Simmental, Angus, and Gelbvieh, the birth weight EPD was a significant ($P<.05$) variable with price discounts of 4.4% to 4.6% for each unit increase in EPD. Adjusted weaning weight was significant for all breeds except Red Angus and Limousin. Lack of significance of some growth performance factors and/or EPD measures does not indicate that these are unimportant. The sample size for a breed may have been too small to detect a significant impact.

Several marketing factors also affected sale prices. After adjusting for all other factors, bull prices differed across sales. This was probably a reflection of seller reputation, level of competition among buyers at a particular sale, location, and/or other marketing factors not evaluated in this study. Sale order significantly affected price. The highest priced and highest quality bulls usually were sold early in the sale. The rate of price decline associated with sale order differed depending upon the total number of bulls in the sale; smaller sales experienced smaller total percentage price declines relative to larger sales. Bulls pictured in sale catalogs received premiums averaging 27% relative to those not pictured, after adjusting for all other differences.

One interesting feature of purebred beef bull sales is that some bulls brought considerably higher prices than their set of attributes predicted. Typically, the highest priced bulls were sold early in the sale. Althoughbuyer identity wasn't available, these bulls may have been purchased by purebred as opposed to commercial breeders. In these instances, the bulls sold for prices that were 20% or more greater than prices for other bulls.

Table 1. Effect of Growth Performance and Expected Progeny Differences on Bull Price

Breed	Birth Wt, lb	Adjusted Weaning Wt, lb	Birth Wt EPD	Weaning Wt EPD	Milk EPD
	------% price change for a one-unit change in each facto -+---				
Simmental	-[a]	.009	-.44	.14	.28
Angus	-.038	.012	-.44	.08	.08
Charolais	-.077	.012			
Hereford		.022		.12	
Red Angus					.24
Gelbvieh		0.14	-.46	.10	
Limousin				.33	

[a]Indicates not statistically different from zero (P<0.10).

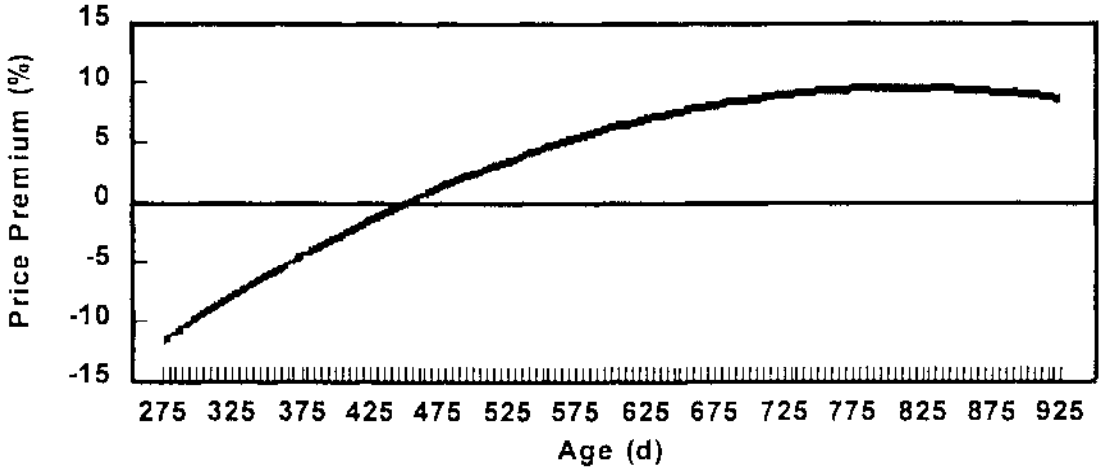

Figure 1. Effect of Age on Bull Price (Base Age is 450 Days).

SUMMARY OF GRAZING RESEARCH ON KANSAS CRP LAND [1]

M. R. Langemeier [2], P. D. Ohlenbusch [3], and R. D. Jones [2]

Summary

Animal performance and net return per acre were examined for four CRP research sites in Kansas in 1994, 1995, and 1996. Both mowing and prescribed burning increased animal performance in 1994. Mowing was economically feasible on one of the four sites. Prescribed burning was economically feasible on three of four sites. Mowing and burning treatments were not repeated in 1995 or 1996. Net returns per acre for the site that was grazed with cow-calf pairs ranged from -$8.55 to -$25.54. For the sites grazed with stockers, net returns per acre varied from -$18.67 to $31.39. Net returns per acre for stockers averaged $14.22 in western Kansas and $16.93 in central Kansas. Based on this research, grazing stockers on post-CRP land appears to have more potential than grazing cow-calf pairs.

(Key Words: Conservation Reserve Program, Cow/Calf Grazing, Stocker Grazing.)

Introduction

Congress established the Conservation Reserve Program (CRP) in 1985. Program goals included the reduction of erosion, protection of the long-term productivity of the land, water quality improvement, enhancement of wildlife, reduction of sedimentation, reduction of surplus commodities, and income support for farmers.

The first CRP contracts expired in 1995. Holders of 1995 and 1996 contracts were given the option to renew, and a vast majority exercised that option. These renewed contracts will expire along with 1997 contracts in the fall of 1997, accounting for approximately two-thirds of the CRP contracts in Kansas. Alternative uses of post-CRP land have been given little attention. In response to a need expressed by contract holders, a research project was initiated to determine the effect of spring mowing or burning on grazing potential of Kansas CRP land. This report summarizes the grazing results from the project.

Experimental Procedures

An exemption was obtained from the Kansas Consolidated Farm Services Agency to establish haying and grazing studies on CRP land. Five haying and four grazing sites were established in eight counties in 1994. The location of grazing sites and use were Edwards County (cow/calf grazing), Greeley County (early-intensive grazing of heifers), Kearny County (season-long grazing of stockers), and Reno County (season-long grazing of stockers).

Each CRP site was divided into: 1) no treatment, 2) spring mowing, and 3) spring burning plots. Mowing and burning treatments were applied in 1994 but not in subsequent years. All animals were weighed and identified before being placed onto the plots and also weighed at the end of the grazing period. Data collected included days on grass, gain per head,

[1]The authors acknowledge CRP contract holders, county extension agents, and other personnel who assisted with this research.

[2]Department of Agricultural Economics.

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average daily gain, gain per acre, and stocking rate (lb/acre). Marketing decisions and days on grass were at the discretion of the producer.

Weather and grass condition were used to determine the length of the grazing season and stocking rates. In Edwards County, cow-calf pairs grazed for 144 days in 1994, 168 days in 1995, and 130 days in 1996. In Greeley County, heifers grazed for 58 days in 1994, 74 days in 1995, and 79 days in 1996. The steers on the Kearny County plot grazed for 130 days in 1994, 103 days in 1995, and 94 days in 1996. In Reno County, steers grazed for 103 days in 1994, 141 days in 1995, and 112 days in 1996. Stocking rates ranged from 212 lb/acre to 267 lb/acre on the Edwards County site, from 175 lb/acre to 196 lb/acre on the Greeley County site, from 112 lb/acre to 156 lb/acre on the Kearny County site, and from 162 lb/acre to 169 lb/acre on the Reno County site. Stocking rates were adjusted on three sites to compensate for changes in forage production.

Budgets were used to estimate gross income, total cost, and net return per acre for each of the treatments. Monthly cattle price information was used along with month in, month out, weight in, and weight out to estimate gross income for each treatment and year. Per acre costs were estimated to be $7.60 for mowing and $2.00 for burning. Land ownership costs and the costs associated with fencing or developing a water source were not included. All other costs, including hired and operator labor, were taken into account. Thus, the net return per acre for each treatment and year represents the return to land and management.

Results and Discussion

Table 1 presents animal performance and net return per acre for each CRP research plot. Animal performance in 1994 was enhanced by either mowing or burning. Stocker performance in 1994 averaged .33 lb/day higher for the mowed than for the no-treatment plots and .72 lb/day higher for the burned treatment. Calf performance (Edwards Co.) was only slightly higher on the mowed and burned plots. Average performance on the mowed plots over the 3 years of the study was from 2% to 5% higher than performance on the no-treatment plots. Average performance on burned plots was similar to that on the no-treatment plot at the Edwards County site but was from 6% to 38% higher at the three stocker sites.

A comparison of net returns per acre in 1994 can be used to determine the economic feasibility of mowing or burning CRP before grazing. Although mowing increased grazing performance on each site, it was economically feasible only on the Reno County site. Prescribed burning, on the other hand, increased grazing performance and was economically feasible on the sites in Greeley, Kearny, and Reno counties. The increase in calf performance on the Edwards County site was not large enough to justify either mowing or burning.

Average net returns per acre on the burned plots can be used to assess potential profitability of grazing CRP land. Because of low calf prices, net return per acre for cow-calf grazing averaged -$16.81. The average net return for stocker grazing was $14.22 on the two western Kansas sites and $16.93 per acre on the central Kansas site. Based on this research, stocker grazing appears to have more potential than cow/calf grazing on post-CRP land.

Table 1. Animal Performance and Net Return per Acre from Grazing on CRP Research Plots in Kansas

	1994		1995		1996	
Research Site and Treatment	Average Daily Gain, lb	Net Return per Acre, $	Average Daily Gain, lb	Net Return per Acre, $	Average Daily Gain, lb	Net Return per Acre, $
Edwards County: Cow-calf grazing. Calf performance shown						
No treatment	2.36	-8.55	2.20	-13.41	2.36	-20.28
Spring mowed [a]	2.44	-15.91	2.22	-11.78	2.48	-19.97
Spring burned	2.48	-9.79	2.12	-15.10	2.32	-25.54
Greeley County: Early-intensive heifer grazing						
No treatment	2.73	10.14	2.49	17.12	1.31	16.60
Spring mowed	3.07	6.77	2.21	12.89	1.39	18.10
Spring burned	3.47	15.45	2.27	13.96	1.22	13.50
Kearny County: Season-long stocker grazing						
No treatment	1.16	-13.18	1.61	8.00	1.57	12.01
Spring mowed	1.27	-18.67	1.60	7.61	1.57	13.83
Spring burned	1.93	-.05	2.10	17.88	1.96	24.58
Reno County: Season-long stocker grazing						
No treatment	2.01	5.68	1.15	-3.39	1.79	31.39
Spring mowed	2.55	8.99	1.24	-.81	1.44	24.31
Spring burned	2.65	16.10	1.39	2.47	1.68	31.21

[a]Mowing and burning treatments were applied in 1994 but not in subsequent years.

Cattlemen's Day 1997

A SURVEY OF PURCHASERS OF WHEAT MIDDLINGS: STORAGE, FEEDING PRACTICES, AND PROBLEMS [1]

D. A. Blasi [2], G. W. Warmann [2], and K. C. Behnke [3]

Summary

We surveyed 290 purchasers of wheat middlings (WM) from a single flour mill located in central Kansas to characterize the incidence of transport and storage problems and to determine intended animal use and method of feeding. Over 30% of the 106 respondents had encountered storage problems with WM; mold, spoilage, and bridging in the storage structure were the most common. Over 75% of the respondents who reported no storage problems purchased WM during the winter months and avoided WM purchases at other times, especially during the summer.

(Key Words: Wheat Middlings, Storage, Survey.)

Introduction

Wheat middlings (WM) is a high volume, economically important byproduct of milling wheat for flour. Often, the price of WM is lowest in the spring and early summer then increases in the fall and winter. However, users making purchases during those low price periods have reported a variety of problems, especially during extended storage. Our objectives were to: 1) profile purchasers of WM from a flour mill located in central Kansas; 2) characterize the incidence of transport and storage problems as affected by manner of storage and length of storage; and 3) determine intended animal use and manner of feeding.

Experimental Procedures

Questionnaires were mailed to 290 livestock producers who had purchased WM directly from a flour mill in central Kansas. This mill has been pelleting and selling WM directly to producers since 1991. A self-addressed stamped envelope was enclosed with each questionnaire to improve the response rate. Respondents were allowed 3 weeks to return the questionnaire before the data was summarized. We received 123 responses (42%), of which 17 were removed because of incomplete answers.

Producer Profile

Users from 23 Kansas counties returned the questionnaires. Over 72% resided within 50 miles of the flour mill. The remaining 27% were split evenly between 51 to 75 and 76 to 100 miles. Respondents learned of the availability of WM from numerous sources; 15% became aware of WM through the Kansas Cooperative Extension Service. Private consultants and the news media each informed another 24%. Cost was the most important factor in the WM purchasing decision. Nutrient content and WM availability were identified only as minor factors. Only 44% of the respondents indicated that they routinely analyze feedstuffs.

The primary use of WM was in beef cow and stocker/feedlot operations. Respondents owned or managed 12,272 beef cows and 27,496 stockers/feeders. Collectively, the

[1]Appreciation is extended to Archer Daniels Midland Milling Company; Richard Nelson, General Manager of Western Star Mill Company in Salina, KS, for cooperation; and Martha Monihen, Dept. of Extension Planning, Reporting, and Evaluation, for analyzing survey results.

[2]South Central Area Extension Office, Hutchinson.

[3]Department of Grain Science and Industry.

respondents had purchased an average of 7,639 tons of WM annually during the past 3 years.

Transportation and Handling Considerations

Over 75% of the respondents transported 50% of the total WM tonnage by farm truck, whereas 14% transported over 35% of the total WM via semitrailer. Only 3% of the respondents related problems with unloading pelleted WM. According to several user comments, pellets unload easier than bulk WM, although pellet breakage can result in excessive concentrations of fines.

Storage Methods and Problems

Over 48% of respondents stored WM in bulk bins. Several (16.7%) reported storing WM on their farm trucks and other implements. Other means of storage included overhead bins (7.4%), wooden bins (6.5%), and hopper bins (5.6%). Approximately 2% reported flat storage and silos.

Thirty percent of the respondents encountered problems such as mold, spoilage, and bridging. They attributed the causes to direct moisture contact, to the ability of WM to draw moisture during periods of high humidity, and to high temperature of the WM when loaded at the mill.

Over 75% of the respondents reporting no storage problems purchased WM primarily during the winter months. In contrast, respondents who experienced storage problems purchased WM during the remainder of the year, especially during the summer. Respondents indicating no storage problems stored WM for 4 weeks or fewer.

Feeding Practices

Approximately 46% of respondents fed pelleted WM in bunks. Many commented that 3/16 in. pellets were not ideal for range or pasture use, especially in windy, wet, or muddy conditions, because of fines and wastage. Over 65% of the respondents were interested in buying 3/4 in. pellets.

Only 10.2% of the survey respondents experienced feeding problems with WM. Approximately 73% of stocker and 68% of cow operators fed between 2 and 6 lb per head daily. According to the summary of comments, WM has caused diarrhea when overfed (10 lb or more). Only one respondent indicated fed refusal of WM. A few respondents indicated poor feedlot performance with WM in finishing diets. Only 32% of the survey respondents indicated that they modified their mineral program to account for WM in the diet.

INFLUENCE OF IMPLANTING GRAZING STEERS WITH RALGRO® OR SYNOVEX-S® FOLLOWED BY SYNOVEX® PLUS™ OR A RALGRO®/SYNOVEX® PLUS™ REIMPLANT PROGRAM IN THE FEEDLOT ON PASTURE/FINISHING PERFORMANCE AND CARCASS MERIT [1]

T. R. Fankhauser, G. L. Kuhl, J. S. Drouillard
D. D. Simms, G. L. Stokka, and D. A. Blasi [2]

Summary

In an 84-day pasture/132-day finishing study using 480 crossbred steers (675 lb), Ralgro® increased (P<.05) pasture gains 9.3% compared to nonimplanted controls. Gains of Synovex-S®-implanted steers were intermediate. Pasture treatments were split into two finishing-phase implant treatments: Synovex® Plus™ or initial Ralgro with a Synovex Plus reimplant on day 56. No interactions occurred between pasture and finishing implants with respect to finishing performance or carcass traits. Steers on the Synovex Plus treatment gained 11.7% faster and 7.9% more efficiently (P<.01) during the first 56 days of the finishing phase than the Ralgro-implanted steers. However, when those steers were reimplanted with Synovex Plus, they gained 22.2% faster and 21.1% more efficiently (P<.01) during the last 76 days. Over the entire 132-day finishing phase, the feedlot reimplant program improved rate (4.0%; P<.06) and efficiency (7.5%; P<.01) of gain compared to Synovex Plus alone. Overall, gains and intakes during the finishing phase were similar for all pasture implant treatments. However, control pasture steers were 4.5% more efficient (P<.08) than Ralgro and Synovex steers during the finishing phase. Neither pasture or finishing implant treatment influenced carcass traits. This study indicates that implanting during grazing may reduce feed efficiency during the finishing phase, especially when a feedlot reimplant program is not used. However, this finding disagrees with several previous research studies where pasture implantation had no effect on feedlot performance.

(Key Words: Ralgro, Synovex, Synovex Plus, Pasture, Finishing, Carcass, Implants.)

Introduction

Estrogenic implants enhance performance and profitability of grazing cattle. However, many stocker producers still do not implant because of concerns about negative carryover effects on feedlot performance and/or carcass grade. These concerns have increased as a result of the recent, widespread use of androgenic implants containing trenbolone acetate (TBA) and estrogen. Although these androgenic products maximize feedlot performance, they have the potential to reduce USDA quality grades more than their estrogenic counterparts. This is especially evident in aggressive reimplant programs.

Synovex Plus (200 mg TBA and 28 mg estradiol benzoate) was approved recently by the FDA for feedlot cattle. This TBA/ estrogen combination contains 67% more TBA than Revalor-S® (120 mg TBA and 24 mg estradiol), suggesting a greater potential for reducing carcass quality, especially when used in a reimplant program. In theory, that problem could be minimized by using a mild estrogenic product initially in the pasture and/or feedlot. Our objective was to test the effects of Ralgro vs. Synovex-S on stocker performance and effects of subsequent Synovex Plus or Ralgro with a Synovex Plus reimplant on finishing performance and carcass attributes.

Experimental Procedures

[1]Appreciation is expressed to Mallinckrodt Veterinary, Inc. for financial support of this study.

[2]South Central Area Extension Office, Hutchinson.

Approximately 750 head of yearling steers (650 to 700 lb) were purchased from Oklahoma livestock auctions during late April and early May. Upon arrival at the KSU feedlot, all cattle were individually weighed, vaccinated against common viral and bacterial diseases, and treated for internal and external parasites. The ears of each steer were palpated and those with pre-existing implants were excluded from the study. The cattle were fed a nutritionally-balanced receiving ration containing Rumensin® during the short pre-trial stage. From this group, 480 head of more uniform, predominantly British and Continental crossbred steers with no more than one-fourth Brahman breeding were selected for the study.

At the beginning of the grazing trial (May 15), on-test weights were based on the average of two consecutive, early-morning, unshrunk weights. All 480 steers were stratified by weight and randomly allotted within strata to three grazing implant treatments: Control (no implant), Ralgro, and Synovex-S. In addition, cattle were pre-assigned to one of two finishing implant treatments: a single Synovex Plus (Syn+) or an initial Ralgro implant with a Syn+ reimplant, using the same stratification/randomization technique based on pregrass weights. Cattle then were shipped to a single intensive-early stocked native Flint Hills pasture in eastern Kansas. The cattle were monitored weekly on grass, and a medicated complete mineral supplement was provided. On August 5, the cattle were returned back to the KSU Beef Cattle Research Center. Upon arrival, steers were fed a standardized amount of a high-roughage receiving diet for 3 days to equalize gut fill, then two consecutive morning unshrunk weights were used to determine final 84-day grazing-phase weights.

The finishing phase began immediately, using the average of the two final grazing body weights as the starting point. All steers were dewormed and treated for lice and grubs and received a booster viral vaccination. Cattle from each of the three pasture implant treatments were placed into randomly pre-assigned pens (eight pens of 15 head, and four pens of 10 head). Half of the pens from each grazing treatment were implanted with Syn+, and the remaining half were implanted initially with Ral, followed by Syn+ after 56 days on feed (Ral/Syn+). Cattle were located in 36 pens (24 dirt pens and 12 concrete pens) with six replications per treatment. Cattle were moved up on feed over 15 days using four step-up rations, with the final *ad-libitum* finishing ration (dry basis) consisting of 83% dry-rolled corn, 9% ground alfalfa hay, 4% Car-mil Glo® (a molasses-fat source), and 4% supplement. The final ration was formulated to contain 13.8% crude protein (1% urea), .75% calcium, .70% potassium, .35% phosphorus, .25% magnesium, and .30% salt, plus 30 g Rumensin® and 10 g Tylan® per ton on a dry matter basis. Trace minerals and vitamins A and E were supplemented to exceed 1996 NRC requirements.

Interim body weights (days 30, 56, 84, 112) and implant status (missing, abscess, etc.) were monitored during the finishing period. The 132-day finishing period ended on December 16, and an average of unshrunk weights on two consecutive mornings was determined. Eleven steers were removed because of health problems unrelated to the study. The remaining 469 were slaughtered at a commercial packing plant on the same day that the last weight was obtained, and complete carcass data were obtained.

Results and Discussion

No significant pasture × finishing phase treatment interactions occurred. Pasture gains were 9.3% higher ($P<.05$) for steers implanted with Ral vs. controls, and gains of steers implanted with Syn were intermediate (Table 1). Overall stocker gains (1.35 lb/day) were below normal as a result of the dry, late spring. Control pasture steers gained faster ($P<.06$) than Ral steers during the first 56 days in the finishing period, while gains of Syn steers were intermediate. Overall, 132-day finishing gains were similar for all pasture implant treatments. Intakes during the finishing phase were similar for all pasture implant treatments. However, control pasture steers tended to be more efficient ($P<.08$) than pasture implanted steers during the first 56 days and over the entire 132-day finishing phase.

In the finishing period, steers implanted with Synovex-S at the start of the finishing period gained 11.7% faster ($P<.01$) than the Ralgro/Synovex-S steers during the first 56 days; however, following reimplantation of the Ralgro steers with Synovex-S at 56 days, the reimplanted group gained 22.2% faster ($P<.01$), resulting in 4.0% better ($P<.06$) gain over the entire 132-day finishing period (Table 2). Correspondingly, steers on the Synovex-S treatment were 7.0% more efficient ($P<.01$) during the first 56 days, 21.1% less efficient ($P<.01$) during the last 76 days, and 7.5% less efficient ($P<.01$) over the entire 132-day finishing period than the Ralgro/Synovex-S treatment. These results indicate that the payout from Synovex-S may have declined after 56 days, resulting in reduced performance. Table 3 shows the finishing performance for each of the pasture/finishing implant combinations.

Table 4 shows the carcass characteristics for each of the pasture/finishing implant strategies. Treatment had no effects ($P>.10$) on dressing percentage, ribeye area, backfat, or yield grade. Additionally, carcass quality characteristics, such as marbling score, percentage Choice, and lean/bone maturity scores, were the same for all pasture/feedlot implant combinations.

Table 1. Effect of Pasture Implant on 84-Day Grazing Gains and Subsequent 132-Day Finishing Performance of Steers

	Pasture Treatment		
Item	Control	Ralgro	Synovex-S
Pasture phase:			
No. steers	160	160	160
Initial wt, lb	676	674	676
Final wt, lb	784	791	790
Daily gain,lb	1.29[a]	1.41[b]	1.35[ab]
Finishing phase:			
No. steers (pens)	156 (12)	155 (12)	158 (12)
Final wt, lb	1264	1250	1254
Period, days	---------- Daily gain, lb ----------		
1-56	4.45[d]	4.21[c]	4.36[cd]
57-132	3.04	2.93	2.89
1-132	3.64	3.47	3.51
	---------- Daily DM intake, lb ----------		
1-56	21.0	21.0	21.1
57-132	22.6	22.7	22.8
1-132	21.8	21.9	22.0
	---------- Feed/gain ----------		
1-56	4.72[e]	5.00[f]	4.83[ef]
57-132	7.42	7.72	7.89
1-132	5.98[e]	6.29[f]	6.23[f]

[ab]Means in a row not bearing a common superscript differ ($P<.05$).
[cd]Means in a row not bearing a common superscript differ ($P<.06$).
[ef]Means in a row not bearing a common superscript differ ($P<.08$).

Table 2. Effect of Finishing Phase Implant Program on Steer Performance (Initial Implant, Day 0; Secondary Implant, Day 56)

Item	Syn +	Ral/Syn +
No. steers (pens)	232 (18)	237 (18)
Initial wt, lb	789	788
Final wt, lb	1247	1264
Period, days	----------Daily gain, lb----------	
1-56	4.58[c]	4.10[d]
57-132	2.66[c]	3.25[d]
1-132	3.47[a]	3.61[b]
	---------- Daily DM intake, lb----------	
1-56	21.5	20.6
57-132	23.1	22.3
1-132	22.3	21.4
	---------- Feed/gain ----------	
1-56	4.68[c]	5.03[d]
57-132	8.69[c]	6.86[d]
1-132	6.41[c]	5.93[d]

[ab]Means in a row not bearing a common superscript differ (P<.06).
[cd]Means in a row not bearing a common superscript differ (P<.01).

Table 3. Effect of Pasture and Finishing Implant Combinations on Steer Feedlot Performance

Pasture Trt:	Control		Ralgro		Synovex-S	
Finishing Trt:	Syn+	Ral/Syn+	Syn+	Ral/Syn+	Syn+	Ral/Syn+
No. steers (pens)	78 (6)	78 (6)	76(6)	79(6)	78(6)	80(6)
Initial wt, lb	788	779	788	795	791	789
Final wt, lb	1276	1252	1234	1265	1241	1266
Period, days	---------- Daily gain, lb ----------					
1-56	4.77	4.13	4.44	3.97	4.60	4.13
57-132	2.90	3.19	2.60	3.26	2.53	3.24
1-132	3.69	3.59	3.38	3.56	3.41	3.62
	---------- Daily DM intake, lb ----------					
1-56	21.9	20.1	21.1	21.0	21.7	20.5
57-132	23.6	21.7	23.1	22.3	23.0	22.7
1-132	22.7	20.9	22.1	21.6	22.2	21.6
	---------- Feed/gain ----------					
1-56	4.58	4.87	4.74	5.29	4.69	4.98
57-132	8.14	6.81	8.85	6.83	9.05	6.99
1-132	6.14	5.82	6.54	6.07	6.52	5.97

Table 4. Effect of Pasture/Feedlot Implant Strategy on Carcass Traits

Pasture Trt:	Control		Ralgro		Synovex-S	
Finishing Trt:	Syn+	Ral/Syn+	Syn+	Ral/Syn+	Syn+	Ral/Syn+
HCW, lb	785	776	767	779	764	786
Dressing %	61.5	61.9	62.2	61.6	61.6	62.1
Ribeye area, sq. in.	13.8	13.9	13.5	13.5	13.0	13.8
Backfat, in.	.41	.38	.43	.40	.39	.39
KPH, %	2.5	2.3	2.5	2.4	2.4	2.3
Yield grade	2.6	2.4	2.7	2.6	2.7	2.5
Maturity score						
Lean	A^{80}	A^{79}	A^{81}	A^{77}	A^{79}	A^{80}
Skeletal	A^{82}	A^{81}	A^{83}	A^{82}	A^{84}	A^{88}
Marbling score	Sl^{64}	Sl^{85}	Sl^{81}	Sl^{57}	Sl^{71}	Sl^{69}
Choice, %						
Initial [a]	30.6	44.3	40.9	23.8	36.3	34.1
Final [b]	40.6	57.8	52.0	34.4	45.5	41.6
Abs. livers, n	3	3	7	5	3	2

[a]Initial % Choice determined by USDA grader approximately 20 minutes after carcasses were ribbed.
[b]Final % Choice reflects percentage following additional chill time and regrading by USDA grader.

EFFECT OF REVALOR-G ON THE PERFORMANCE OF STOCKER HEIFERS GRAZING IRRIGATED, SMOOTH BROMEGRASS PASTURE FOR A FULL SEASON [1]

D. A. Blasi [2], G. L. Kuhl, M. D. Reynolds [3], and R. T. Brandt, Jr. [4]

Summary

A 150-day field study was conducted to evaluate single vs. reimplant strategies for stocker heifers grazing irrigated smooth bromegrass. Three hundred forty-three previously nonimplanted British crossbred heifers averaging 494 lb were assigned to one of seven treatments:

1) no implant-control (NC),
2) Revalor-G® (REVG),
3) Ralgro® (RAL),
4) Synovex-H® (SYNH),
5) REVG/REVG,
6) RAL/RAL, and
7) SYNH/SYNH.

Reimplanting (Treatments 5, 6, and 7) was done on day 75 of the trial. In the first 75 days, all implants increased (P<.05) average daily gain (ADG) compared to NC. For the last 75 days (days 75 through 150), heifers implanted with REVG, REVG/REVG, RAL/RAL, and SYNH gained faster (P<.05) than NC or those implanted with RAL, and SYNH/SYNH. No significant differences occurred among the latter three treatments. Over the entire trial, there was no advantage to reimplanting heifers with REVG or RAL. SYNH/SYNH heifers gained less (P<.05) than their single-implanted counterparts.

(Key Words: Growth Implant, Revalor-G, Ralgro, Synovex, Heifers, Pasture.)

Introduction

Growth-promoting implants have been adopted widely by cattle producers to enhance the performance of grazing stockers. Revalor-G is a newly approved anabolic agent for grazing cattle. However, no published research is available comparing REVG to traditional estrogenic implants for grazing heifers.

The objectives of this 150-day field study were to document the comparative effectiveness of REVG (40 mg trenbolone acetate and 8 mg estradiol), RAL (36 mg zeranol), and SYNH (20 mg estradiol benzoate and 200 mg testosterone propionate) as growth promotants for yearling heifers grazing irrigated smooth bromegrass pasture, using either single-dose or reimplant strategies.

Experimental Procedures

Three hundred forty-three heifers purchased in Mississippi were assembled 4 weeks prior to trial initiation. Upon arrival, they were vaccinated against common viral and bacterial diseases. At trial initiation, all heifers were weighed individually (unshrunk) on 2 consecutive days, identified with a tag in each ear, dewormed, checked for evidence of prior implants, allotted to the seven treatments randomly within weight blocks, implanted according to manufacturers' recommendations, and dewormed. At the onset of the study, the smooth Bromegrass pasture (115 acres with

[1]Sincere appreciation is expressed to Great Plains Alfalfa, Pratt, KS, for providing cattle, facilities, and assistance and to Hoechst-Roussel Vet for financial support.

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center pivot irrigation) was separated into four equal paddocks. All calves were rotated to a different paddock every week through the midtest period. The stocking rate up to the midtest period was 1800 lb liveweight per acre. Because of hot weather, the stocking rate was reduced to 900 lb liveweight per acre during the last 75 days of the trial. This was accomplished by sorting each treatment into two groups and placing them on two adjacent irrigated pastures.

On day 75, heifers were gathered and individually weighed, and appropriate treatment groups were reimplanted. Approximately 10 weeks prior to the end of the study, all heifers received 7 lb weekly of a wheat middlings-based cube containing GAINPRO® fed three times per week in prorated amounts. At the end of the study, all heifers were weighed offtest on 2 consecutive days. Two heifers were removed because of health problems unrelated to implant treatment. The individual animal was the experimental unit for statistical analysis of weight gain data.

Results and Discussion

All implant treatments improved (P<.05) gain compared to NC heifers during the first 75 day of the trial (Table 2), and no significant differences (P>.05) occurred among implant treatments. For the last 75 days (days 75 through 150), heifers implanted with REVG, REVG/REVG, RAL/RAL, and SYNH gained faster (P<.05) than NC or those implanted with RAL, and SYNH/ SYNH. The REVG/REVG treatment resulted in only slightly greater gain (.09 lb/day) than it's single-implant counterpart (REVG). During the last half of the study, reimplanted RAL/RAL heifers gained faster (P<.05) than RAL heifers. Those receiving SYNH/SYNH during the last 75 days gained slower (P>.05) than single-implant counterparts (SYNH). Although buller activity was not seen in any treatment, SYNH/SYNH heifers exhibited above normal udder development and elevated tailheads.

Table 1. Nutritional Composition of Experimental Supplement [a]

Item	Percent, Dry Matter Basis
Dry matter	88.29
Crude protein	24.00
Crude fiber	14.60
Ether extract	2.05
Calcium	2.46
Phosphorus	.84

Table 2. Effect of Implant Treatment on Stocker Heifer Average Daily Gain

Treatment	Days 1 - 75	Days 75 - 150	Days 1 - 150
	---------- lb/day ----------		
Control	1.94[a]	1.22[a]	1.58[a]
Revalor-G	2.22[b]	1.39[b]	1.81[b]
Revalor-G/Revalor-G	2.19[b]	1.48[b]	1.83[b]
Ralgro	2.13[b]	1.25[a]	1.69[c]
Ralgro/Ralgro	2.14[b]	1.38[b]	1.76[b,c]
Synovex-H	2.22[b]	1.41[b]	1.82[b]
Synovex-H/Synovex-H	2.17[b]	1.19[a]	1.68[c]

[a,b,c]Values in columns with different superscripts are significantly different (P<.05).

EFFECT OF GRAIN SORGHUM PARTICLE SIZE AND DIGEST "M" ENZYME TREATMENT ON PERFORMANCE OF GROWING STEERS [1]

T. J. Kessen, D. D. Simms, G. L. Kuhl, and J. S. Drouillard

Summary

A 73-day growing study utilizing 203 crossbred steers (681 lb) and a digestion trial examined the effect of sorghum grain particle size on rumen fermentation, ration digestibility, and performance of growing steers fed 37% grain and 63% ground alfalfa. Dry-rolled grain sorghum particle sizes in both trials were about 2000, 1500, and 1000 microns, for the coarse- (CR), medium- (MR), and fine-rolled (FR) treatments, respectively. Coarsely rolled corn (2000 microns) was included as a positive control. In the growing study, half of sorghum was treated at feeding time with an enzyme product, Digest "M". The rations were 35 to 37% dry grain plus ground alfalfa hay and supplement.

Total ration dry matter, neutral detergent fiber, and starch digestibilities increased linearly (P<.02) with decreasing sorghum grain particle size. Rumen pH, ammonia and total volatile fatty acid concentrations, and acetate-to-propionate ratio were unaffected by grain type or particle size. Dry matter intake was not influenced by grain types or particle size. Steers fed FR sorghum gained 9% faster (P<.03) during the first 28 days and tended to gain faster (5%, P<.14) over the entire trial than those fed CR sorghum, with gains on MR sorghum being intermediate. FR sorghum produced 6% more efficient gains (P<.07) than CR, and MR grain was intermediate. Digest "M" enzyme treatment of the sorghum grain had no influence. Feed conversions of CR, MR, and FR sorghum were 93, 94, and 99% of corn. This research indicates that grain sorghum in high roughage backgrounding programs should have a maximum average particle size of 1000 microns.

(Key Words: Grain Sorghum, Particle Size, Processing, Digestibility, Enzyme, Growing Cattle.)

Introduction

Grain sorghum is used widely for growing cattle and normally is dry-processed by either roller or hammer mill. Samples collected across Kansas indicate that particle size is often coarse. Although the effect of sorghum particle size has been studied in finishing rations, it has not been studied in higher roughage, growing rations. We investigated the influence of grain particle size on growing cattle performance and ration digestibility and also evaluated the effect of Digest "M", an enzyme product that has shown potential to improve sorghum digestibility.

Experimental Procedures

Digestion Trial. Sixteen ruminally fistulated steers (944 lb) were assigned randomly to four treatments: 1) dry-rolled corn (CO) with an average particle size of 2172 microns as a positive control, and 2) fine-rolled (FR, 1040 microns), 3) medium-rolled (MR, 1371 microns), and 4) coarse-rolled (CR, 2008 microns) grain sorghum. These particle sizes were selected to cover the spectrum of grain particle sizes typically observed in cattle rations. Feedstuff composition is shown in Table 1. Diets consisted of 37% of the respective grain and

[1]Appreciation is expressed to the Kansas Grain Sorghum Commission for partial funding of this research and to Loveland Industries, Loveland, CO for the Digest "M" used in this study.

63% ground alfalfa. Steers were housed in an individual tie stall barn, with free access to water and a trace mineral salt block. Steers were fed once daily at 7 AM with dry matter intake limited to 2.25% of body weight. They were adapted to rations for 11 days. On day 12, ruminal fluid samples were taken at feeding and at 3, 6, 9, and 12 hours postfeeding. Beginning on day 13, feed samples were taken daily. Any feed refused was weighed back and sampled. On day 14, steers were fitted with fecal bags for total fecal collection to measure digestibility. Fecal samples were taken twice daily for 7 consecutive days.

Table 1. Composition of Diets and Feedstuffs Used in the Digestion and Steer Growing Trials

	Percent in		Dry Matter Basis			
Feedstuff	Ration	% DM	% Starch	% CP	% ADF	% NDF
Digestion trial:						
Dry rolled grain	37.0					
Sorghum, coarse		86.6	72.2	9.0	3.9	8.5
Sorghum, medium		86.9	73.6	9.4	3.4	9.0
Sorghum, fine		86.8	72.7	9.4	3.2	9.4
Corn, coarse		86.7	67.5	9.6	2.2	10.7
Alfalfa hay, ground	63.0	94.0	2.1	14.2	43.8	55.6
Steer growing trial:						
Dry rolled grain	35.0					
Sorghum, coarse		88.4	75.4	8.9	3.0	9.6
Sorghum, medium		88.4	77.1	8.6	2.9	9.1
Sorghum, fine		88.6	75.2	8.8	2.9	9.2
Corn, coarse		88.0	71.2	8.6	2.3	10.5
Alfalfa hay, ground	57.0	88.1	---	18.2	37.7	52.4
Supplement [1]	5.0	89.6	---	40.5	3.8	12.1
Molasses [2]	3.0	---	---	---	---	---

[1]Soybean meal-based supplement fortified with minerals and vitamins to meet 1996 NRC requirements, plus Rumensin®.
[2]Cane molasses was not analyzed.

Growing Steer Trial. Two hundred and three thin, short yearling, crossbred steers (681 lb) were weighed unshrunk on 2 consecutive days, blocked by breed type, and assigned randomly by weight to the same grain treatments described for the digestion trial, except that one-half of each sorghum particle size treatment was treated with Digest "M". This design resulted in seven treatments with five pens per treatment and five to six head

per pen. Pens were roofed partially and had concrete floors. Digest "M" application followed manufacturer's recommendations, including the addition of 5% water to the grain. Steers were fed a totally mixed ration (Table 1) once daily. The experiment started on February 27, 1996, and steers were weighed every 28 days. On days 73 and 74, the steers were weighed off-test, with the average serving as the final unshrunk weight.

Results and Discussion

Sorghum particle size did not influence rumen fermentation (Table 2). Corn produced a rumen fermentation profile similar to that with grain sorghum, except for a higher (P<.10) concentration of valerate than the FR and MR sorghum treatments. Ration starch and NDF digestibilities (Table 2) increased linearly (P<.02) with decreasing sorghum particle size, and dry matter digestibility increased linearly (P<.01) as a direct result of the increased digestibility of starch and fiber.

Because no interactions occurred between effects of grain particle size and enzyme treatment on steer performance, both were pooled (Table 3). Feed intake was not affected by grain type or particle size. Steers on FR sorghum gained (9%) faster (P<.03) than those on CR sorghum during the first 28 days; with gains on MR sorghum being intermediate. Feed conversions were 10 and 4% better for FR and MR than CR sorghum (P<.01 and P<.06, respectively) during the first 28 days, and the FR treatment was 6% more efficient (P<.07) than CR sorghum during the entire 73-day trial. Steers carried considerable mud and fecal matter during the middle of the trial, which affected the apparent gains toward the end. Digest "M" had no effect on intake or performance (Table 4).

Decreasing grain sorghum particle size in high roughage, growing rations increased total ration starch, NDF, and dry matter digestibility, which improved feed conversion. In fact, the fine-rolled grain sorghum produced feed efficiencies equal to those with dry-rolled corn. These results indicate that producers should strive to process grain sorghum to a maximum, average, particle size of about 1000 microns.

Table 2. Influence of Dry Rolled Grain Type and Particle Size on Apparent Digestibility and Ruminal Fermentation Characteristics in Beef Steers

	Corn	Grain Sorghum			Contrasts[2]	
Item	Coarse[1]	Fine	Medium	Coarse	L	Q
Digestion study:						
DM intake, lb/day	21.5	21.5	21.3	21.6	.99	.92
Apparent digestibility:						
Dry matter, %	71.2	70.9	68.2	65.0	<.01	.29
NDF, %	59.4	58.1	56.6	53.0	.02	.52
Starch, %	95.0	94.4	88.3	82.3	<.01	.14
Ruminal fermentation profile:					P-value[2]	
pH	6.01	5.90	6.17	6.21	.34	
VFA conc., mM	61.97	62.39	53.00	56.79	.47	
NH_3N, mM	2.48	1.57	1.49	1.78	.38	
VFA, mol/100 mol:						
Acetate	60.56	63.08	63.49	62.57	.27	
Propionate	17.99	17.46	17.40	17.76	.88	
A:P[3]	3.45	3.66	2.76	3.59	.67	
Butyrate	15.65	14.45	13.81	13.93	.28	
Isobutyrate	1.33	1.20	1.35	1.41	.14	
Valerate	2.23[a]	1.84[b]	1.86[b]	1.99[ab]	.09	
Isovalerate	2.23	1.98	2.10	2.34	.52	

[1]Grain mean particle sizes were: corn, coarse = 2172 microns; sorghum, coarse = 2008 microns, medium = 1371 microns, fine = 1040 microns.
[2]Probability of observing a significant F or P-value: L = linear response, Q = quadratic response to reducing sorghum particle size.
[3]Acetate:propionate ratio.
[ab]Means in same row not sharing the same superscript differ (P<.10).

Table 3. Effect of Grain Sorghum Particle Size on Dry Matter Intake, Average Daily Gain, and Feed Efficiency of Growing Steers

	Corn	Grain Sorghum		
Item	Coarse[1]	Fine	Medium	Coarse
Dry matter intake, lb/day				
0-28 days	22.6	23.4	23.4	23.6
0-56 days	24.6	25.8	25.8	26.0
0-73 days	25.6	26.5	26.8	26.9
Average daily gain, lb				
0-28 days	4.67	4.72[a]	4.54[ab]	4.32[b]
0-56 days	4.37	4.17	4.12	3.99
0-73 days	3.62	3.68	3.57	3.51
Feed/gain				
0-28 days	4.85	4.95[c]	5.15[c]	5.46[d]
0-56 days	5.62	6.21	6.25	6.45
0-73 days	7.14	7.25[c]	7.58[cd]	7.69[d]

[1]Grain particle sizes were: corn ,coarse = 2235 microns; sorghum, coarse = 1956 microns, medium = 1514 microns, and fine = 1077 microns.
[ab]Means in same row not sharing the same superscript differ (P<.03).
[cd]Means in same row not sharing the same superscript differ (P<.07).

Table 4. Effect of Digest "M" Treatment of Sorghum Grain on 73-Day Performance of Growing Steers

Item	Control	Digest "M"
Daily gain, lb		
0-28 days	4.48	4.55
0-56 days	4.09	4.09
0-73 days	3.57	3.60
Dry matter intake, lb/day		
0-28 days	23.4	23.6
0-56 days	25.9	25.8
0-73 days	26.8	26.7
Feed/gain		
0-28 days	5.21	5.18
0-56 days	6.29	6.29
0-73 days	7.46	7.41

PROTEIN REQUIREMENTS OF GROWING STEERS LIMIT-FED CORN-BASED DIETS

R. H. Wessels and E. C. Titgemeyer

Summary

Seven steers (513 lb) were used in an experiment to investigate optimal levels and sources of protein in diets limit-fed to allow gain of 2.2 lb/day. Treatments were: a negative-control diet (urea; supplemented, 11.7% crude protein) and six diets containing either 13.5, 15.4, or 17.2% crude protein with either solvent-extracted (SSBM) or expeller-processed (ESBM) soybean meal, in which the soybean meal replaced corn in the control diet. Diets provided 75, 87.5, 100, or 112.5% of estimated crude protein requirement for a gain of 2.2 lb/day. The basal diet contained 83% rolled corn, 15% alfalfa, and .2% urea. Nitrogen (N) retention was increased linearly ($P<.01$) by SBM addition with no differences between sources. Because N retention increased to the highest level offered, the steers apparently required more protein than estimated by the 1984 National Research Council's *Nutrient Requirements of Beef Cattle*.

(Key Words: Protein Requirements, Restricted Feeding, Steers.)

Introduction

Calves can be grown efficiently on high-concentrate diets fed at restricted intakes. Benefits of restrictedly feeding high-grain diets relative to ad libitum feeding of high-roughage diets include more stable intake patterns, more predictable performance, and reductions in cost of gain. Growing programs aim to restrict energy-allowable gain without restricting other nutrients required to support that gain. Thus, compared to a low-energy diet fed at ad libitum intake, a limit-fed high-energy diet requires higher concentrations of dietary protein. However, restricted feeding alters ruminal function, which may influence optimal levels and sources of protein.

Our objectives were to 1) investigate optimum levels of dietary protein, and 2) compare solvent-extracted soybean meal (SSBM) and expeller-processed soybean meal (ESBM) as sources of supplemental protein for limit-fed steers.

Experimental Procedures

Seven Angus-cross steers (513 lb) were used in a nitrogen balance experiment to determine optimal levels of dietary protein and source of supplemental protein in a high-concentrate diet fed at restricted intakes designed to allow gain of 2.2 lb/day. The experiment was a 7 × 4 incomplete Latin square. Treatments consisted of six diets in a 3 × 2 factorial arrangement plus a negative-control diet containing only urea as supplemental crude protein. The two main factors were source of supplemental protein and level of protein in the diet. Protein sources were SSBM and ESBM (Super Soy®, Delavan Processing). These protein sources replaced corn in the basal diet (negative control) at levels of approximately 5, 10, and 15% (as-fed basis). Diets (Table 1) were formulated to provide 75, 87.5, 100, and 112.5% of the recommendation for protein required by a 513 lb steer gaining 2.2 lb/day, according to the 1984 National Research Council's *Nutrient Requirements of Beef Cattle*.

Steers were implanted with Compudose® 200 and housed in metabolism crates. Each period contained a 9-day adaptation and a 5-day collection phase. Feed allocated to each steer was fed in equal portions twice daily (7 a.m. and 7 p.m.). Feed allocations were adjusted at

the start of each new period for projected changes in body weight.

Feed samples, urine, and feces were collected and analyzed for N in order to calculate the amount of N retained by the steers. Nitrogen retention was used as an indicator of protein accretion (lean growth) in the steers. A jugular blood sample was taken 5 hiyrs after the morning feeding on the last day of each period to measure plasma urea and amino acid concentrations.

Estimates of the undegraded intake protein (escape protein) in SSBM and ESBM were obtained by incubating samples with protease enzymes and measuring the protein resistant to degradation.

Results and Discussion

On average, steers consumed 9.9 lb of dietary dry matter per day. Nitrogen balance data are presented in Table 2. No significant interactions occurred between level and source of protein, and effects on N balance were similar for SSBM and ESBM. Urinary N excretion increased linearly ($P<.01$), whereas fecal N excretion remained constant with increasing levels of protein. Nitrogen retention was increased linearly ($P<.01$) by increasing levels of protein up to the highest level of supplementation (112.5% of the 1984 NRC recommendation). This suggests that, under the conditions of our study, the protein requirement of steers was underestimated by the 1984 NRC.

Concentrations of total amino acids (α-amino nitrogen) and urea in plasma increased as protein intake increased (Table 2). The increases in urea concentrations are reflective of the higher dietary protein concentration, whereas the increases in amino acid concentrations are reflective of increased supply of absorbable amino acids to the small intestine.

Enzymatic digestion of SBM samples in vitro estimated undegraded intake protein to be 32% of SSBM-protein and 48% of ESBM-protein. The relatively small difference in ruminal escape between the two protein sources resulted in relatively small differences between sources in the supply of protein to the intestine; this could explain the similarity in N balance responses for SSBM and ESBM. Also, when ESBM with its higher escape value was used instead of SSBM, degradable protein supply may have become marginal for ruminal microbes; this could decrease microbial protein synthesis, thereby eliminating any advantage gained by using a protein source with a higher escape value. The conclusion that total supply of protein to the intestine was not affected markedly by source of protein also is supported by the similar increases in plasma α-amino N (amino acid) concentrations between the SBM sources.

Previous studies that investigated supplemental protein for limit-fed growing cattle have yielded equivocal results. In our study, N retention of limit-fed growing steers was improved when corn-urea diets were supplemented with SBM, and N retention increased up to the highest level of protein supplementation (112.5% of estimated crude protein requirement). This suggests that requirements of limit-fed steers for dietary protein are higher than predicted by the 1984 NRC.

Table 1. Ingredient and Nutrient Composition of Diets

		SSBM[a]			ESBM[b]		
Item	Control	5%	10%	15%	5%	10%	15%
Ingredient:				% of the dry matter			
Rolled corn	82.76	78.37	73.99	69.61	77.74	72.72	67.71
Alfalfa	14.68	14.67	14.66	14.65	14.66	14.63	14.61
SSBM[a]	0	4.40	8.80	13.19	0	0	0
ESBM[b]	0	0	0	0	5.06	10.11	15.14
Urea	.22	.22	.22	.22	.22	.22	.22
Minerals and vitamins [c]	2.31	2.31	2.31	2.31	2.30	2.30	2.30
Rumensin/Tylan [d]	.03	.03	.03	.03	.03	.03	.03
Nutrient:							
Crude protein [e]	11.7	13.5	15.3	17.1	13.5	15.4	17.2

[a]SSBM = solvent-extracted soybean meal.
[b]ESBM = expeller-processed soybean meal.
[c]Contained trace-mineralized salt; vitamins A, D, and E; sulfur; limestone; and dicalcium phosphate.
[d]Provided 30 ppm monensin and 11 ppm tylosin to diets.
[e]Analyzed crude protein content.

Table 2. Nitrogen Balance and Plasma Metabolites of Steers Fed Different Levels of Solvent-Extracted (SSBM) or Expeller-Processed Soybean Meal (ESBM)

		SSBM			ESBM			
Item	Control	5%	10%	15%	5%	10%	15%	SEM
Nitrogen				grams of N/day				
Intake[ab]	85.7	98.3	110.8	124.5	98.9	112.0	125.6	.7
Feces	24.7	26.4	28.4	27.7	26.9	25.6	26.5	1.5
Urine[ab]	30.2	40.7	47.9	59.5	38.4	50.0	60.6	2.1
Retained[ab]	30.8	31.2	34.5	37.3	33.6	36.4	38.6	1.5
Plasma				mmol/liter				
α-amino nitrogen[ac]	2.10	2.16	2.29	2.28	2.46	2.27	2.33	.06
Urea nitrogen	1.69	3.29	3.17	4.41	2.64	3.15	4.11	.24

[a]Linear effect of level of solvent soybean meal ($P<.05$).
[b]Linear effect of level of expeller soybean meal ($P<.05$).
[c]A measure of total amino acids in plasma.

EFFECTS OF VARIOUS SUPPLEMENTAL STARCH AND PROTEIN LEVELS ON RUMINAL FERMENTATION AND LIQUID PASSAGE OF BEEF STEERS FED TALLGRASS-PRAIRIE HAY

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Summary

The effect of supplements containing various proportions of degradable intake protein (DIP) and starch on ruminal digestion characteristics of forage-fed beef steers was evaluated. Fluid passage rates, ruminal ammonia (NH_3), and total volatile fatty acid (VFA) concentrations increased as the amount of supplemental DIP increased. Starch infused at .3% of BW increased molar proportions of propionate and butyrate and decreased acetate, compared to feeding DIP alone. However, proportions of branched-chain VFA increased with DIP at all levels of starch infusion. Total digestible organic matter intake (TDOMI) was increased with each addition of DIP; however, infusing starch within a DIP level decreased TDOMI. Providing supplemental DIP is more important for improving the use of low-quality, tallgrass-prairie hay than is ruminally available starch.

(Key Words: Beef Steers, Protein, Starch, Supplements, Ruminal Fermentation.)

Introduction

Intake and digestion of low-protein forages by beef cattle are known to increase when supplemental degradable intake protein (DIP) is fed. Precise feeding recommendations for DIP need to be established, because protein-based feedstuffs are expensive. Furthermore, it is unclear how other supplement components, like starch, affect animal response to DIP supplementation. Studies investigating the effect of supplements containing various proportions of DIP and starch on ruminal digestion characteristics are needed to define desirable supplement compositions. This study was designed to examine the interactive effects of supplemental DIP and starch on ruminal fermentation and liquid passage rate of steers consuming low-quality hay.

Experimental Procedures

Thirteen beef steers (average initial body weight = 570 lb) were used in a 13-treatment, four-period, Latin square. Treatments were arranged as a 3 x 4 factorial plus an unsupplemented control and consisted of four DIP levels (casein infused at .03, .06, .09, and .12% of BW) superimposed on three starch levels (none or corn starch grits infused at .15 and .3% of BW). All steers had ad libitum access to tallgrass-prairie hay (5% CP). Forage refusals were measured, and new forage was offered once daily. Supplements were infused intraruminally immediately before forage was fed. Following an adequate adaptation period, digestibility was determined via total fecal collection. Subsequently, ruminal VFA, NH_3, and fluid passage rates were evaluated by collecting multiple samples of ruminal fluid throughout a given day.

Results and Discussion

Production responses by beef cattle are driven, to a large degree, by the total amount of digestible organic matter (digestible forage organic matter + digestible supplement organic matter; TDOMI) that is consumed. Supplementation programs that increase TDOMI can be said to augment total energy supply to the animal. Steers receiving no supplement in our study had lower TDOMI than supplemented

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steers (Table 1). In general, TDOMI was increased when DIP was provided but was decreased when starch was added within a given level of DIP supplementation. We interpret this result to mean that DIP is more critical to achieving optimal use of low-protein forages than is ruminally degradable starch.

Effects of starch and DIP supplements on ruminal fermentation and rate of fluid passage were consistent with changes in TDOMI. Average levels of ruminal NH_3 were low for all treatments (range = trace to 1.5 mM), likely because of the low protein level in the basal forage and efficient use by ruminal microbes. Ruminal NH_3 increased as supplemental DIP increased, regardless of starch level. Steers receiving only DIP had greater ruminal NH_3 than steers receiving starch at .15 or .3% of BW, probably because of the greater capability of starch-digesting bacteria to compete for NH_3 compared with fiber-digesting bacteria.

Total volatile fatty acid (VFA) concentrations are correlated with ruminal diet digestibility. Unsupplemented steers had lower total VFA than supplemented steers. Total VFA concentration increased with supplemental DIP but was not affected by starch infusion.

Proportions of individual ruminal VFA are useful indicators of the type of fermentation predominating. Supplemented steers had greater proportions of isobutyrate, valerate, and isovalerate than unsupplemented steers, which likely was due to the provision of precursors for these VFA in the supplemental DIP. Steers receiving only DIP had higher acetate and lower propionate and butyrate than steers fed DIP plus starch at .3% BW. Greater proportions of acetate in steers given only DIP indicated increased fermentation of structural carbohydrates from the forage. Conversely, increased propionate and butyrate in steers fed the highest level of starch suggested that ruminal microbes were less reliant on forage fiber as an energy source.

Frequently, increased rate of nutrient passage from the rumen is associated with higher feed intake. Ruminal liquid passage rate in our study became more rapid as the amount of supplemental DIP increased but was not altered by starch supplementation.

This study supports the contention that DIP is the primary factor limiting the effective use of low-quality, tallgrass-prairie forage by beef cattle. In general, total VFA concentration, rate of ruminal liquid passage, and TDOMI were greatest when DIP fell between 10 and 12.5 % of TDOMI. Infusion of ruminally degradable starch altered patterns in VFA and NH_3 concentration and decreased TDOMI.

Table 1. Effect of Supplemental Degradable Intake P rotein and Starch Levels on Total Digestible Organic Matter Intake, Ruminal Fermentation, and Liquid Passage Rate

Starch Level (% BW)	Protein Level (% BW)	TDOMI (% BW)	DIP Intake (% of TDOMI)	NH_3 (mM)	Passage Rate (%/h)	Total VFA (mM)	Acetate (%)	Propionate (%)	Butyrate (%)	Isobutyrate (%)	Valerate (%)	Isovalerate (%)
0	0	.9	4.9	0	5.7	55.0	77.1	14.4	7.1	.5	.4	.5
0	.03	1.1	7.4	.3	7.7	70.4	79.2	12.0	7.1	.6	.5	.6
0	.06	1.3	9.0	.4	9.3	65.9	78.3	12.4	7.1	.7	.7	.8
0	.09	1.4	10.3	.6	7.6	74.5	74.1	16.5	6.8	.8	.9	.9
0	.12	1.6	11.2	1.5	10.6	75.2	78.0	11.6	7.2	1.0	1.0	1.2
.15	.03	1.0	7.2	.1	7.7	69.7	77.1	13.6	7.4	.7	.5	.7
.15	.06	1.2	9.0	.3	7.4	71.8	76.4	14.1	7.2	.7	.8	.8
.15	.09	1.5	9.4	.6	9.7	77.6	76.3	13.7	7.3	.8	.9	.9
.15	.12	1.4	12.6	1.1	10.2	77.9	76.0	12.5	8.1	1.0	1.1	1.3
.30	.03	1.0	7.7	.1	7.4	65.2	70.6	19.7	7.4	.7	.8	.8
.30	.06	1.1	9.4	.2	8.3	69.1	75.0	14.5	8.0	.7	.7	1.1
.30	.09	1.3	10.3	.5	7.5	68.4	71.5	17.0	8.5	.8	1.1	1.0
.30	.12	1.4	11.8	.9	9.6	76.2	72.6	15.8	8.2	.9	1.2	1.2
	SE	.1	.4	.1	1.4	5.4	1.9	1.8	.4	.1	.1	.1
Contrast [1,2,3]												
1	-	.001	.001	.001	.027	.002	.338	.976	.228	.001	.002	.001
2	L	.001	.001	.001	.015	.006	.543	.802	.933	.001	.001	.001
	Q	.285	.013	.024	.754	.344	.959	.816	.711	.544	.913	.413
3	L	.001	.001	.001	.006	.001	.552	.460	.096	.001	.001	.001
	Q	.095	.678	.096	.929	.156	.979	.780	.321	.387	.989	.481
4	L	.001	.001	.001	.040	.005	.130	.973	.003	.001	.001	.001
	Q	.615	.023	.294	.859	.623	.272	.395	.350	.881	.672	.159
5	-	.032	.808	.046	.955	.406	.421	.728	.082	.440	.510	.514
6	-	.001	.264	.008	.485	.612	.001	.003	.001	.948	.066	.097

[1]Probability of a greater F-test

[2]L = linear effect, Q = quadratic effect

[3]1 = No supplement vs. s upplement, 2 = DIP only, 3 = DIP + .15% BW starch, 4 = DIP + .3% BW starch, 5 = DIP only vs. DIP + .15% BW starch, 6 = DIP only vs. DIP + .3% BW starch

EFFECT OF SUPPLEMENT STRATEGY ON INTAKE AND DIGESTION OF PRAIRIE HAY BY BEEF STEERS

R. H. Greenwood, E. C. Titgemeyer, C. A. Löest, and J. S. Drouillard

Summary

The effects of supplemental corn (4 lb/day), rumen-protected methionine (4.25 grams DL-methionine per day), or a cooked molasses block (1 lb/day) on intake and digestion of prairie hay were measured in beef steers. Steers that consumed the cooked molasses block ate more forage than control steers, whereas forage intake was decreased by supplemental corn. Total tract organic matter digestion, expressed as a percent of intake, was numerically greatest for steers consuming the cooked molasses block. Digestible organic matter intake, a rough estimate of energy available to the steers, was unaffected by methionine but was increased by supplementation of either corn or the cooked molasses block. Digestible organic matter intake tended to be greater for the block than for corn. Providing protein in a more concentrated form (block) tended to be more beneficial, because the negative effects of starch (corn) on forage intake were avoided.

(Key Words: Steers, Forage, Intake, Digestibility.)

Introduction

Intake of dormant forage often is limited by nutrient deficiencies. Degradable intake protein often is the most limiting nutrient. Deficiencies of degradable intake protein can reduce forage digestion and intake, thereby reducing the energy available for maintenance and growth of cattle grazing dormant forages. To increase available energy, supplements based on grains or on more concentrated sources of protein often are fed. Differences have been noted in the ability of these supplements to increase available energy to cattle.

Methionine is thought to be the first limiting amino acid in microbial protein. Supplying that amino acid to cattle may improve performance with low levels of total supplement.

Another aspect of supplementing cattle grazing dormant forages is the time and cost associated with supplementation. Blocks can be used to supplement cattle with less time expenditure than hand-feeding supplements. With these points in mind, our objective was to investigate the effects of supplementation strategy on forage intake and digestion.

Experimental Procedures

Twelve British and British cross steers (average BW = 820 lb) were used in three, 4 × 3 incomplete Latin squares to evaluate the effect of supplement strategy on forage intake and digestion. Steers were penned individually in an open-front barn and provided ad libitum access to water and prairie hay (5.7% crude protein, 67.6% NDF (dry basis).

Treatments were: 1) control, no supplement, 2) 4 lb/day (as fed) of supplemental corn (.31 lb crude protein per day), 3) 5 grams/day of Smartamine-M®, a rumen-protected methionine product that provided 4.25 grams/day of DL-methionine, and 4) 1 lb/day of a cooked molasses block (.31 lb crude protein per day). All steers received 20 grams of salt daily. Smartamine-M was mixed with the salt.

The experimental periods were 21 days with a 14-day adaptation period followed by a 7-day intake and total fecal collection period. Orts

and fecal samples were collected daily in the morning, after which supplements and forage were offered.

Results and Discussion

One animal assigned to the cooked molasses block refused to consume his daily supplement; data from this steer were deleted from our analyses. Forage organic matter (OM) intake increased (P<.05) with cooked molasses block supplementation, but decreased with corn supplementation; rumen-protected methionine did not improve intake or digestion of forage (Table 1). Because animals assigned to the corn treatment received more supplemental OM than steers assigned to the other treatments, total OM intakes were similar between steers receiving corn and those receiving the cooked molasses block. This illustrates the substitution effect on intake of corn for forage. Organic matter digestibility was numerically highest for steers consuming the cooked molasses block. Corn did not affect digestion of the total diet, probably indicating that forage digestion was decreased when the highly digestible corn was included. Digestible OM intake, an indicator of energy available for maintenance and(or) growth, was increased by supplementation with either block or corn but tended to be higher for the block than for corn (P=.06).

In conclusion, supplemental corn increased digestible OM intake because the highly digestible starch more than offset its negative effect on forage intake. Digestible OM intake increased when animals received the cooked molasses block, because the additional protein (without extra starch) increased forage digestion, which subsequently increased forage and energy intake. Rumen-protected methionine was ineffective in stimulating forage intake or digestion by steers fed prairie hay.

Table 1. Intake and Digestion of Prairie Hay by Steers Fed Different Supplements

		Supplement			
Item	Control	Corn	Methionine	Block	SEM
Forage OM intake, lb/day	13.7[a]	12.1[b]	13.0[a]	15.3[c]	.24
Supplement OM intake, lb/day	.0	3.4	.0	.7	
Total OM intake, lb/day	13.6[a]	15.5[b]	13.1[a]	16.0[b]	.25
Digestible OM intake, lb/day	6.8[a]	7.9[b]	6.4[a]	8.6[b]	.25
OM digestibility, % of intake	49.6	50.3	49.6	53.5	1.2

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

EVALUATION OF THE PROTEIN CHARACTERISTICS OF FOUR DIVERSE GRASSES

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Summary

Forage protein characteristics in four grasses were evaluated by the nylon bag method. All of the forages used (Bermudagrass hay, brome hay, forage sorghum hay, and prairie hay) were of relatively low quality, except the Bermudagrass, which was of average quality. The forages differed in the size of different protein fractions and in the rate and extent of protein degradation. Predicted extent of ruminal protein degradation (i.e., ruminal protein availability) was lowest for prairie hay, intermediate for Bermudagrass and forage sorghum hay, and highest for the brome hay.

(Key Words: Forage, In Situ Analysis, Protein, Degradable Intake Protein.)

Introduction

Forages are the primary sources of nutrients for beef cattle in the United States and throughout the world. However, meeting the nutritional requirements of beef cattle grazing low-quality forage often requires protein supplementation. The amount of supplemental protein needed is related directly to the amount and availability of forage protein as well as the amount of forage consumed and its digestibility. Therefore, it is important to have precise information on protein characteristics of different forages. Currently, information of this type exists for relatively few forages, and this limits the ability of newer feed formulation systems to predict nutrient requirements and animal performance. The objective of this study was to characterize the proteins of Bermudagrass hay, brome hay, forage sorghum hay, and prairie hay.

Experimental Procedures

Four ruminally fistulated beef steers (avg BW = 1142 lb) were used in a Latin square design to determine the rate and extent of protein degradation in Bermudagrass, brome, forage sorghum, and prairie hays using a nylon bag (i.e., *in situ*) procedure. Steers were fed hay twice daily (1.5% of BW daily). During each period, forage samples were weighed into nylon bags and incubated in the rumen of a steer consuming the same forage type for 2, 4, 8, 16, 24, 36, 48, 72, and 96 hours. Following incubation, the residue in the nylon bag was analyzed for protein remaining at each time-point. The washout at 0 hours (that removed by rinsing) was assumed to be fraction A (i.e., the soluble, rapidly degradable protein). The protein remaining after incubation for 96 hours was assumed to be fraction C (i.e., the ruminally unavailable protein). Size of fraction B (i.e., the insoluble, potentially ruminally degradable protein) was determined by difference (B = 100% – A – C). The ruminally undegradable fraction was subtracted from the protein remaining at each time point, and the natural logarithm of the resulting value was regressed against time to estimate the degradation rate (K_d) of the B fraction of each forage. Degradable intake protein (DIP) was calculated (Table 1) based on the fraction sizes, the K_d, and an assumed rate of passage for the forage (.03/hour).

[1]KSU Agricultural Research Center - Hays.

Results and Discussion

Sizes of the soluble, rapidly degradable fraction (fraction A) and the ruminally undegradable fraction (fraction C) were similar among Bermudagrass, brome, and forage sorghum hays, whereas prairie hay had a smaller (P<.01) fraction A and a larger (P<.01) fraction C. Forage sorghum hay had a larger (P<.03) insoluble, potentially ruminally degradable fraction (fraction B) than prairie hay, and the B fractions of bermuda and brome hays fell between these two extremes. In contrast, the K_d was similar among Bermudagrass, forage sorghum, and prairie hays but fastest (P<.01) for brome hay. The rapid degradability of the insoluble, potentially ruminally degradable fraction of brome hay resulted in the greatest (P<.02) extent of ruminal protein degradation (i.e., larger DIP content). Bermudagrass and forage sorghum hays had higher (P<.01) concentrations of DIP than prairie hay. Relative to the other forages, the large ruminally undegradable and small soluble, rapidly degradable protein fractions in prairie hay were the primary contributing factors leading to the low DIP content of this forage.

Identification of the size of each protein fraction, as well as the rate and extent of degradation of the insoluble, potentially ruminally degradable fraction, provides valuable information for nutritionists and producers. This is especially true for those interested in using the 1996 Beef Cattle NRC guidelines for evaluating diets and predicting performance of forage-fed beef cattle.

Table 1. Fractions, Degradation Rates, and Extent of Protein Degradation in Bermudagrass, Brome, Forage Sorghum, and Prairie Hays

Item	Bermuda	Brome	Forage Sorghum	Prairie	SEM[a]
DM[b]	92.7	94.5	88.9	93.0	
CP[c], % of total DM	7.8	5.3	4.5	4.8	
NDF[d], % of total DM	72.2	70.6	62.3	67.5	
Nitrogen fractions, % of total CP[e]					
A	32.0[k]	32.8[k]	29.9[k]	22.3[l]	1.14
B	39.1[kl]	39.9[kl]	45.8[k]	34.8	2.26
C	28.9[k]	27.3[k]	24.3[k]	42.9[l]	2.52
K_d[f], per hour	.027[l]	.046[k]	.028[l]	.025[l]	.003
DIP[g], % of total protein[h]	50.5[k]	57.2[l]	52.0[k]	36.4[m]	1.07

[a]Standard error of the mean for treatments without missing values.
[b]Dry matter.
[c]Crude protein.
[d]Neutral detergent fiber.
[e]A is the soluble, rapidly degradable fraction assumed to be removed by rinsing alone (zero hour); C is the 96-hour residue, assumed to be the ruminally undegradable fraction; B is the insoluble, potentially degradable fraction, determined by difference (i.e., B = 100% – A – C).
[f]K_d = degradation rate of fraction B.
[g]Degradable intake protein.
[h]Degradability was calculated using the equation:
$DIP = A + B\{ K_d/(K_d + K_p)\}$, where K_p = rate of passage = .03 per hour.
[klm]Means within a row without common superscripts differ (P<.03).

EVALUATION OF THE EFFECTS OF CARBOHYDRATE SOURCE AND LEVEL OF DEGRADABLE INTAKE PROTEIN ON THE INTAKE AND DIGESTION OF TALLGRASS-PRAIRIE HAY BY BEEF STEERS

J. S. Heldt, R. C. Cochran, C. P. Mathis, B. C. Woods, K. C. Olson, E. C. Titgemeyer, G. L. Stokka, and T. G. Nagaraja

Summary

Thirteen ruminally fistulated steers were used to determine the effect of carbohydrate (CHO) source and degradable intake protein (DIP) on intake and digestion of tallgrass-prairie hay. In general, DIP supplementation had positive effects on intake and digestion, although response varied somewhat with CHO source. Increasing the amount of supplemental CHO generally decreased hay intake, but effects on digestion were dependent on CHO source.

(Key Words: Steers, Intake, Digestion, Carbohydrate, Protein.)

Introduction

Feeding supplements with a high concentration of protein has been shown to increase intake and digestion of low-quality forages. In contrast, feeding supplemental carbohydrate (CHO) in the form of starch has been shown to decrease intake and digestion of low-quality forages . The use of byproduct feedstuffs in supplementation programs has increased the use of nonstarch CHO sources, which may have different effects on low-quality forage utilization compared to starch. Recent research at KSU demonstrated that the main dietary constituent limiting the use of low-quality tallgrass prairie is degradable intake protein (DIP) and subsequently defined the amount of DIP required to maximize intake and digestion of such forage. However, it is unclear how different amounts and types of supplemental CHO might affect DIP use and (or) "requirement". Therefore, this study was designed to evaluate the effects of various CHO sources and DIP level on intake and digestion of tallgrass-prairie hay.

Experimental Procedures

Thirteen ruminally fistulated Angus x Hereford steers (average BW = 580 lb) were used in a 4-period, 13-treatment, incomplete Latin square. The treatments were arranged in a 2x3x2 factorial plus negative control (no supplement). Supplement treatments consisted of two levels of DIP (sodium caseinate; .031 and .122% BW) and three CHO sources (starch, sugar, and digestible fiber) at two levels (.15 and .30% BW). Supplements were placed directly into the rumen once daily prior to feeding prairie hay (5.7% CP, 74.9% NDF) at 130% of the previous 5-day average intake. The sugar fed was a monosaccharide (dextrose), and the fiber was a commercially prepared oat fiber (treated with alkaline hydrogen peroxide) that was highly digestible. The experimental period consisted of an 11-day adaptation followed by a 7-day intake and total fecal collection period. Feed offered, feed refused, and fecal output measured during that period were used to calculate organic matter (OM) and neutral detergent fiber (NDF) digestibilities.

Results and Discussion

Results are shown in Table 1. In general, DIP supplementation increased forage and total diet intakes and digestion, although response varied somewhat with CHO source. Forage and total diet OM intakes were not affected by increasing level of DIP when starch was the CHO source. However, OM and NDF digestion and total digestible OM intake (TDOMI; a measure of overall energy intake) were enhanced by increasing level of DIP for steers fed supplemental starch. Increasing DIP when dextrose or fiber was

Table 1. Influence of Supplemental Carbohydrate and Degradable Intake Protein on Intake and Digestion

		Low DIP (.031% BW)						High DIP (> 122% BW)							
		Starch (% BW)		Dextrose (% BW)		Fiber (% BW)		Starch (% BW)		Dextrose (% BW)		Fiber (% BW)			
Item	NC	.15	.30	.15	.30	.15	.30	.15	.30	.15	.30	.15	.30	SEM	Contrasts[b]
Forage OMI[c] g/kg $BW^{.75}$	57.72	66.11	57.86	57.25	53.58	62.94	55.43	66.26	55.89	71.73	64.52	68.65	66.43	3.10	1,3,4,5,6,7,8
Forage OMI kg/d	3.77	4.30	3.76	3.75	3.49	4.10	3.58	4.31	3.65	4.66	4.20	4.46	4.31	.20	1,3,4,5,6,7,8
Forage OMI % BW	1.43	1.64	1.44	1.42	1.33	1.57	1.38	1.65	1.39	1.79	1.60	1.71	1.65	.08	1,3,4,5,6,7,8
Total OMI g/kg $BW^{.75}$	57.74	74.13	72.69	65.15	68.19	70.31	68.82	78.06	74.48	83.52	82.89	77.70	83.47	3.09	1,3,4
Total OMI kg/d	3.77	4.82	4.73	4.26	4.44	4.58	4.46	5.08	4.87	5.43	5.41	5.17	5.43	.20	1,3,4
Total OMI % BW	1.43	1.84	1.81	1.62	1.70	1.75	1.71	1.94	1.85	2.07	2.06	1.99	2.08	.08	1,3,4
TDOMI[d] g/kg $BW^{.75}$	28.47	42.29	39.78	35.87	39.64	38.18	35.51	48.93	43.93	51.48	52.68	45.03	51.84	2.10	1,2,3,4,6
TDOMI kg/d	1.87	2.75	2.59	2.35	2.58	2.49	2.29	3.19	2.87	3.35	3.44	2.92	3.38	.14	1,2,3,4,6
TDOMI % BW	.71	1.05	.99	.89	.99	.95	.88	1.21	1.09	1.28	1.31	1.12	1.29	.05	1,2,3,4,6
OMD[e] %	50.00	57.44	54.31	55.37	59.20	54.30	51.38	62.61	59.23	62.03	63.46	56.74	62.19	1.94	1,2,3,4,6
NDFD[f] %	48.65	52.61	41.60	49.44	47.22	56.05	53.31	58.82	50.11	58.65	56.21	56.48	63.18	2.31	1,2,3,4,5,6

[a]NC = negative control (no supplement).

[b]Statistically significant ($P \leq .12$) contrasts were 1= low vs high DIP, 2 = low vs high DIP for starch treatments, 3 = low vs high DIP for dextrose treatments, 4 = low vs high DIP for fiber treatments, 5 = low vs high CHO, 6 = low vs high CHO for starch treatments, 7 = low vs high CHO for dextrose treatments, 8= low vs high CHO for fiber treatments.

[c]OMI = organic matter intake.

[d]TDOMI = total digestible organic matter intake.

[e]OMD = organic matter digestion.

[f]NDFD = neutral detergent fiber digestion.

infused increased hay and total diet OM intakes, as well as OM and NDF digestion and TDOMI. The highest level of DIP supplementation was designed to provide sufficient total dietary DIP to maximize forage intake and digestion in the absence of supplemental CHO . Our results indicated that increasing the amount of supplemental DIP up to this approximate "requirement" (about 11% of TDOMI) resulted in increased TDOMI regardless of the type of supplemental CHO fed. However, TDOMI differed among CHO sources at the highest level of DIP supplementation, suggesting that the amount and type of supplemental CHO are important factors to consider when planning an approach for delivering supplemental DIP.

Increasing the amount of supplemental starch within both DIP levels decreased forage intake , as well as OM and NDF digestion. Increasing the amount of a highly digestible CHO like starch typically results in conditions in the rumen that are unfavorable for forage digestion. This decrease in digestion coupled with decreased forage intake resulted in less TDOMI (i.e., less energy intake). Increasing the amount of supplemental dextrose or fiber within a DIP level decreased forage intake, but neither OM and NDF digestion nor TDOMI were greatly affected. Increasing the amount of supplemental digestible fiber had minimal effects on digestion, possibly because this CHO source is similar to the forage and, therefore, is unlikely to result in ruminal conditions adverse to forage digestion. Similarly, the fundamental source of microbial energy from digested forage (glucose) is the same as that provided by the dextrose (d-glucose). This may have circumvented some of the negative effects of starch on fiber digestion by avoiding use of a substrate that is preferentially used by amylolytic (starch-digesting) bacteria. Amylolytic bacteria are highly competitive with fibrolytic (fiber-digesting) bacteria and, with adequate starch availability, can reduce ruminal ammonia available for fiber digestion.

Our results suggest that supplemental DIP will improve low-quality forage utilization. All three sources of supplemental CHO decreased forage intake; however, the effects on OM and NDF digestion were dependent on the CHO source and the amount of supplemental DIP provided.

EFFECTS OF SUPPLEMENTAL DEGRADABLE INTAKE PROTEIN ON INTAKE AND DIGESTIBILITY OF FORAGE SORGHUM HAY

C. P. Mathis, R. C. Cochran, B. C. Woods, J. S. Heldt, K. C. Olson, G. L. Stokka, E. C. Titgemeyer, and E. S. Vanzant [1]

Summary

Sixteen ruminally fistulated beef steers with ad libitum access to forage sorghum hay were used to evaluate the effect of increasing level of degradable intake protein (DIP) on forage intake and digestion. Forage OM intake and total OM intake were enhanced with increasing level of DIP supplementation. Similarly, increases in total OM digestibility and total digestible OM intake (TDOMI) were evident. Compared with the negative control, TDOMI was approximately doubled at the highest level of DIP supplementation.

(Key Words: Steers, Forage, Intake, Digestion, Degradable Intake Protein.)

Introduction

Over the last decade, the approach to protein nutrition in ruminants has shifted from a crude protein (CP) system described in the 1984 NRC to a metabolizable protein (MP) system described in the 1996 NRC. Metabolizable protein is defined as the true protein absorbed by the small intestine, which is supplied by microorganisms passing out of the rumen and by undegradable intake protein (UIP, i.e., escape protein). The MP system accounts for the degradation of protein in the rumen and separates protein requirements into the needs of ruminal microorganisms and the animal. Crude protein includes some that is ruminally degraded (degradable intake protein = DIP) and some that is not (UIP).

Beef cattle in the midwestern and plains states commonly are fed forage sorghum hay as a roughage source. Frequently, this forage is of relatively low quality. Previous research on low-quality, tallgrass-prairie forage has demonstrated that DIP supplementation dramatically improved forage intake and utilization. In addition, the amount of DIP needed to maximize total digestible forage intake has been defined for this forage. However, information pertaining to the effects of DIP supplementation on forage sorghum hay is limited. This study was conducted to determine the impact of DIP supplementation on forage sorghum intake and digestion and to determine the amount of DIP needed to maximize intake of digestible material for this forage.

Experimental Procedures

Sixteen ruminally fistulated beef steers (avg BW = 639 lb) were blocked by weight and assigned to one of four treatments to evaluate the effect of increasing level of DIP on forage intake and digestion. Each steer was offered forage sorghum hay at 130% of average voluntary intake for the preceding 5-day period. Supplemental DIP (sodium caseinate; 91.6% CP, 100% DIP) was ruminally infused at 7 a.m., immediately prior to feeding forage, at levels of .041, .082, and .123% BW/day (.045, .090, and .134% BW of casein as DM/day). The control treatment had no supplemental DIP. The forage contained 55.8% NDF, 4.3% CP, and 51% DIP. Forage DIP (% of CP) was estimated using a single-point enzyme assay.

[1]KSU Agricultural Research Center - Hays.

Following a 10-day adaptation, feed offered, feed refused, and total fecal output were measured for 7 days and used to calculate digestibility coefficients.

Results and Discussion

Forage OM and total OM intakes increased (P<.01) in direct proportion to increasing level of DIP supplementation, although they tended to plateau (P=.13 and P=.15, respectively) at the higher levels. Similarly, a linear increase (P<.01) with a trend toward diminishing returns (P=.17 and P=.14, respectively) was evident for both total OM digestion (TOMD) and TDOMI. Total NDF intake and total NDF digestibility responded similarly.

Compared with the negative control, TDOMI was approximately doubled at the highest level of DIP supplementation. This was due to concomitant increases in both forage OM intake and digestibility. Although some decline in relative response was evident with increasing DIP supplementation, a clear plateau was not achieved with the levels of supplement provided. However, we suspect that neither forage OM intake nor OM digestion would increase much beyond that achieved at the highest level of supplementation. Therefore, we believe that the amount of DIP needed to maximize TDOMI is close to that provided at this level of supplementation. Using the estimate of forage DIP (51% of total CP), the total DIP consumed by steers on the .123% treatment was 12.2% of TDOMI.

Table 1. Effect of Increasing Amount of Degradable Intake Protein on DM and OM Intakes and Digestibility in Beef Steers Fed Forage Sorghum Hay

	DIP (% BW)					Contrasts[a]		
Item	0	.041	.082	.123	SEM[b]	L	Q	C
DM[c] intake	---------- % BW ----------							
Forage	1.72	2.11	2.32	2.40	.11	<.01	.20	.93
Total	1.72	2.15	2.41	2.54	.11	<.01	.20	.93
DM intake	---------- g/kg $BW^{.75}$ ----------							
Forage	70.49	87.42	96.13	97.79	4.56	<.01	.13	.96
Total	70.49	89.28	99.84	103.27	4.57	<.01	.13	.96
OM[d] intake	---------- % BW ----------							
Forage	1.54	1.90	2.09	2.16	.10	<.01	.20	.93
Total	1.55	1.94	2.18	2.31	.10	<.01	.22	.95
OM intake	---------- g/kg $BW^{.75}$ ----------							
Forage	63.42	78.65	86.49	87.99	4.10	<.01	.13	.96
Total	63.57	80.45	90.39	94.07	4.10	<.01	.15	.97
Total DOMI[e]								
% BW	.71	1.05	1.28	1.43	.08	<.01	.23	.99
g/kg $BW^{.75}$	29.39	43.59	53.17	58.14	3.21	<.01	.18	>.99
Total OM D[f], %	46.34	54.13	59.00	61.70	1.70	<.01	.17	.92
Total NDF D[g], %	34.38	43.18	51.12	53.73	2.13	<.01	.18	.65

[a]L = linear, Q = quadratic, C = cubic.
[b]Standard error of the mean (n = 16).
[c]DM = dry matter.
[d]OM = organic matter.
[e]DOMI = digestible organic matter intake.
[f]OMD = organic matter digestion.
[g]NDFD = neutral detergent fiber digestion.

THE EFFECTS OF SUPPLEMENTATION FREQUENCY AND AMOUNT OF UREA IN DRY SUPPLEMENTS ON INTAKE AND DIGESTIBILITY OF LOW-QUALITY TALLGRASS-PRAIRIE FORAGE BY BEEF STEERS [1]

B. C. Woods, R. C. Cochran, C. P. Mathis, J. S. Heldt, K. C. Olson, E. C. Titgemeyer, and G. L. Stokka

Summary

Sixteen ruminally fistulated steers were used to evaluate the effects of altering supplementation frequency and including urea in dry supplements on forage intake and digestion. Intake of low-quality tallgrass-prairie hay was not affected by supplementation frequency or by the inclusion of urea. Supplementing cattle less frequently resulted in a decrease in diet digestion. However, we observed a slight trend for reduced supplementation frequency to exert a greater impact when cattle were fed supplements that contained urea.

(Key Words: Steers, Forage, Urea, Supplementation Frequency, Intake, Digestibility.)

Introduction

Because of the higher costs associated with true protein use in winter supplements, producers have been interested in the use of urea as a substitute for a portion of the degradable intake protein (DIP) present in supplements. Also large-scale supplementation of cattle may entail the feeding of supplements on a less than daily schedule. Previous research at Kansas State University indicates that urea can replace up to 30% of the supplemental DIP in dry supplements with little effect on forage intake and digestion or livestock performance. Similarly, research conducted on supplementation frequency indicated that dry supplements that do not contain urea can be fed on a less than daily schedule without adverse effects on performance. The objective of our study was to evaluate whether urea inclusion in winter range supplements would alter the response to changing supplementation frequency.

Experimental Procedures

Sixteen Hereford x Angus steers (average BW = 555 lb) with ruminal fistulas were housed in individual tie stalls and had ad libitum access to low-quality tallgrass-prairie hay (5.6% CP, 68.4% NDF). Steers were assigned to treatments consisting of two supplementation frequencies (daily and alternate day) and inclusion of urea at 30% of the DIP or no urea. Supplements were formulated to contain 30% CP (approximately 70% of the CP was DIP) and were composed of rolled sorghum grain, soybean meal, urea (30% treatment only), dry molasses, and minerals. The amount of supplement fed (as-fed basis) was .46% of BW/daily or .92% of BW every other day. Based on previous research, the amount of supplement fed should have provided sufficient DIP to maximize forage intake. Supplements were fed in the early morning, and complete supplement consumption generally occurred within 45 minutes. Animals were adapted to the diets for 14 days followed by a 6-day fecal collection period during which feed offered, feed refused, and fecal output were recorded.

Results and Discussion

Forage organic matter (OM) intake and total OM intake were not affected ($P>.57$) by frequency of supplement feeding or urea inclusion in the supplement (Table 1). Similarly, including urea in the supplement, when

[1]The authors express their appreciation to Gary Ritter and Wayne Adolph for their assistance in conducting this experiment.

considered on its own, did not significantly affect OM or neutral detergent fiber (NDF) digestion. Digestion of OM and NDF was depressed ($P \leq .06$) by supplementing less frequently. However, there was a slight tendency ($P=.13$ for OM and $P=.19$ for NDF digestion) for supplementation frequency to interact with urea inclusion in the supplement. In general, cattle fed the supplement that contained 30% of the DIP from urea responded more dramatically to changes in supplementation frequency than did those fed supplements without urea.

Supplement refusal can be a problem with dry supplements, if urea is included at a high level. With feeding every other day, some steers in this trial were given as much as 5.8 lb (as fed) to consume in a single feeding (.92% of BW). In general, supplement consumption was not a problem, but we observed a trend, over time, for steers fed the largest amount of supplement on alternate days to refuse some of the supplement, although the amount was seldom more than .25 lb. In these cases, the supplement was placed directly into the rumen to ensure a legitimate comparison of supplement effects on intake and digestion. In conclusion, intake of low-quality tallgrass-prairie hay was not affected by supplementation frequency or by low-level inclusion of urea in a dry supplement. However, digestion may be somewhat lower for cattle supplemented less frequently. This may be particularly true when a dry supplement contains part of its DIP in the form of urea.

Table 1. Effect of Supplementation Frequency and Inclusion of Urea as a Portion of the Supplement DIP on Intake and Digestion

	With Urea		Without Urea			Contrasts[a]		
	Alternate		Alternate					
Item	Day	Daily	Day	Daily	SE	U	F	U×F
Forage OM[b] intake, g/kg BW $^{.75}$	69.0	66.7	67.4	70.8	5.2	.81	.91	.60
Forage OM intake, % BW	1.73	1.67	1.70	1.78	.13	.78	.94	.61
Supplement OMI, g/kg BW $^{.75}$	15.1	15.1	15.1	15.1	.05	.72	.39	.91
Supplement OM intake, % BW	.38	.38	.38	.38				
Total OM intake, g/kg BW $^{.75}$	83.3	81.9	81.5	86.2	5.1	.81	.76	.57
Total OM intake, % BW	2.09	2.05	2.06	2.17	.13	.77	.79	.57
OM digestibility, %	58.9	66.1	60.9	62.6	1.7	.66	.03	.13
NDF[b] digestibility, %	53.7	62.3	55.2	57.0	2.4	.47	.06	.19
Digestible OM intake, g/kg BW $^{.75}$	48.9	54.1	49.7	53.8	3.4	.96	.21	.88
Digestible OM intake, % BW	1.23	1.36	1.25	1.35	.09	.92	.21	.88

[a]Probability of a greater F value. U = urea, F = frequency, U×F = urea by frequency interaction.
[b]OM = organic matter; NDF = neutral detergent fiber.

EFFECT OF UREA LEVEL IN PROTEIN SUPPLEMENTS ON PERFORMANCE BY BEEF COWS CONSUMING LOW-QUALITY, TALLGRASS-PRAIRIE FORAGE [1]

B. C. Woods, R. C. Cochran, C. P. Mathis, J. S. Heldt, K. C. Olson, E. C. Titgemeyer, and D. M. Grieger

Summary

One hundred thirty two Hereford × Angus cows grazing tallgrass-prairie range during winter were used to evaluate the effects of varying the amount of supplemental degradable intake protein (DIP) derived from urea on cow and calf performance. Treatment groups were: 0, 15, 30, and 45% of the supplemental DIP from urea. Supplements were formulated to contain 30% crude protein (CP), with approximately 70% of the CP being DIP. Palatability was not a significant problem within the range of urea inclusion tested. In general, prepartum weight and condition losses were greater with increasing levels of urea, although the magnitude of condition loss was greater when urea comprised more than 30% of the DIP. Calf performance was not affected by treatment.

(Key Words: Cows, Forage, Urea, Performance.)

Introduction

Supplementing cattle consuming low-quality, tallgrass-prairie forage with DIP has been shown to increase forage intake and digestion and subsequently enhance animal performance. True proteins from feedstuffs such as the oilseed meals are rich in DIP and have been used frequently in formulating protein supplements. However, such feedstuffs are typically quite expensive. Previous research at Kansas State University has suggested that urea can replace at least 30% of the DIP in a natural-protein, dry supplement without adversely affecting forage intake and digestion. In contrast, trends have been evident in previous research for a decline in performance when urea exceeded that level. This study was conducted to evaluate supplement palatability and animal performance when urea accounted for up to 45% of the supplemental DIP in dry supplements fed to beef cows consuming low-quality, tallgrass-prairie forage.

Experimental Procedures

Our study was conducted to evaluate the influence of increasing the portion of DIP from urea in dry supplements on cow body weight and body condition changes, pregnancy rate, and calf performance when cows grazed dormant, tallgrass-prairie range. The experiment consisted of four supplement treatments furnishing 1) no urea, 0% of the supplemental DIP (0% of the supplemental CP) or the following amounts of urea 2) 15% of the supplemental DIP (11% of the supplemental CP), 3) 30% of the supplemental DIP (22% of the supplemental CP), and 4) 45% of the supplemental DIP (34% of the supplemental CP).

One hundred thirty two Hereford × Angus cows (BW = 1175 lb, final 3 to 5 months of pregnancy) were assigned randomly to supplement treatments and pastures. Three pastures were used, and all supplements were represented within each pasture. Cows received approximately 4.95 lb per day of supplemental dry matter (DM). Supplements were formulated with rolled sorghum grain, soybean meal; urea (15, 30, 45% treatments only);

[1]The authors express their appreciation to Gary Ritter and Wayne Adolph for their assistance in conducting this experiment.

molasses; and minerals to contain 30% CP and a nitrogen to sulfur ratio of 10:1. Based on previous KSU research, the DIP supplied by this amount of supplement should have been sufficient to maximize the digestible forage intake.

Body weight and condition measurements were taken at approximately 5-wk intervals beginning on November 30 and continuing through calving, with additional measurements taken 48 hours after calving, before breeding (April 26), and at weaning (October 1). After calving, all cows were handled as a group and received 10 lb per day of alfalfa hay (as-fed basis), (89.3% DM, 18.0% CP and 45.7% neutral detergent fiber (NDF) on DM basis) until adequate new grass growth had occurred (end of April).

Calf birth weights were recorded within 48 hours. Calf average daily gain was calculated as weaning weight minus birth weight divided by the number of days from birth. Cows were bred by natural service after a single shot of PGF2$_\alpha$ was administered at the beginning of the breeding season.

Table 1. Effect of Different Proportions of DIP from Urea on Body Weight (BW) and Body Condition (BC)[a] Changes in Beef Cows Grazing Dormant, Tallgrass-Prairie Forage

	% Supplemental DIP from Urea[b]					Contrasts		
Item	0	15	30	45	SEM[d]	L	Q	C
No. of cows	33	33	33	33				
Initial BW, lb	1178	1170	1175	1177	9.35	.97	.61	.71
Period BW change, lb								
30 November - 4 January	38.7	23.2	21.8	-4.1	3.20	<.01	.15	<.04
5 January - 9 February	30.0	24.0	13.5	26.1	6.36	.46	.19	.37
10 February - 8 March (calving)	-172.5	-169.8	-159.8	-162.8	8.80	.36	.76	.62
calving - 26 April (breeding)	-86.3	-77.8	-76.9	-80.3	8.66	.64	.52	.94
26 April - 1 October (weaning)	192.8	209.7	210.0	229.1	8.63	.03	.88	.41
Cumulative BW change, lb								
30 November - 9 February	68.8	47.2	35.3	22.0	8.18	<.01	.63	.77
30 November - 8 March (calving)	-103.7	-122.6	-124.5	-140.9	6.44	<.01	.85	.32
30 November - 26 April (breeding)	-190.0	-200.5	-201.4	-221.2	9.25	.06	.63	.52
30 November - 1 October (weaning)	15.0	20.1	8.6	11.0	8.44	.55	.88	.45
Initial BC	5.33	5.33	5.33	5.34	.01	.21	.37	.66
Period BC change								
30 November - 4 January	-.06	-.06	-.15	-.11	.05	.35	.69	.37
5 January - 9 February	.08	-.03	-.01	-.13	.05	.03	.90	.24
10 February - 8 March (calving)	-.32	-.20	-.19	-.37	.07	.68	.08	.82
calving - 26 April (breeding)	-.23	-.35	-.36	-.23	.07	.96	.13	.89
26 April - 1 October (weaning)	.50	.58	.64	.74	.06	.02	.91	.82
Cumulative BC change								
30 November - 9 February	.02	-.09	-.16	-.24	.05	<.01	.76	.81
30 November - 8 March (calving)	-.30	-.29	-.35	-.62	.05	<.01	.04	.60
30 November - 26 April (breeding)	-.53	-.64	-.71	-.84	.04	<.01	.78	.67
30 November -1 October (weaning)	.02	-.02	-.07	-.06	.07	.41	.71	.83

[a]Body condition scale: 1 = extremely emaciated; 9 = extremely obese.

[b]Percent of the total supplemental N from urea is 0, 11, 22, and 34, respectively.

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

[d]Standard error of the mean.

Results and Discussion

All supplements were consumed readily, which agrees with previous work at K-State suggesting that palatability was not affected by providing up to 45% of the DIP in a dry supplement from urea. Cumulative body weight loss before calving increased (linear; P=.06) with increasing level of urea inclusion. This was primarily due to differences in response noted during the first 5-week period (cubic; P<.04). In contrast, body condition loss during the same time frame was greatest for those cattle receiving 45% of the supplemental DIP from urea (quadratic; P=.04). By weaning, changes in body weight and condition were similar among treatments. Calf birth weight, ADG, and weaning weights were not affected (P≥.40) by the level of urea fed to their dams prior to calving (Table 2). Similarly, pregnancy rate was not affected (P=.44) by treatment in this study and averaged 92%.

Table 2. Effect of Different Proportions of DIP from Urea on Calf Birth Weight and Gain and Pregnancy Rate in Beef Cows Grazing Dormant, Tallgrass-Prairie Forage

	% Supplemental DIP from Urea [a]					Contrasts [b]		
Item	0	15	30	45	SEM [c]	L	Q	C
No. of cows	33	33	33	33				
Calf birth weight, lb	92.5	91.6	91.5	93.0	1.84	.88	.53	.92
Calf ADG, birth-weaning, lb	2.20	2.18	2.21	2.19	.03	.93	.93	.45
Calf weaning weight, lb	543	542	553	552	8.8	.40	.98	.57

[a]Percent of the total supplemental N from urea is 0, 11, 22, and 34, respectively.
[b]L = linear, Q = quadratic, C = cubic.
[c]Standard error of the mean.

FEATHERMEAL/BLOODMEAL LIQUID SUSPENSIONS FOR CALVES GRAZING WINTER WHEAT PASTURE [1]

D. A. Blasi [2], J. S. Drouillard, G. L. Kuhl, G. E. Newdigger, G. E. LeValley, Jr., and G. D. McCormack

Summary

A field study was conducted over 2 years at four different locations in south central Kansas to compare a feathermeal/bloodmeal (ESCAPE) liquid suspension to a molasses-based liquid supplement (ENERGY) and a dry mineral supplement (CONTROL) on the liveweight gain of 768 calves grazing wheat pasture. No significant differences occurred in supplement intake between ESCAPE and ENERGY across years (P=.88). Offering a liquid supplement containing either ESCAPE or ENERGY did not improve (P=.91) growth performance relative to CONTROL calves.

(Key Words: Wheat Pasture, Feathermeal, Liquid Suspensions.)

Introduction

Wheat pasture plays an important role in beef production systems in Kansas and other southern plains states. Despite the fact that it is a source of high quality forage, wheat forage has potential problems. Its crude protein has been calculated to be 58 to 70% degradable in the rumen. Consequently, only 30 to 42% of the crude protein is undegraded intake protein (UIP). Because of the extensive degradability, supplemental UIP may be needed to meet the metabolizable protein requirements of rapidly growing cattle. To determine the need for such supplementation, a study was conducted to evaluate the use of a liquid suspension that delivered supplemental UIP.

Experimental Procedures

This field study was conducted with four cooperating producers in south central Kansas, with each stocker operation representing a trial replicate. The study was conducted during the fall/winters of 1990-91 and 1994-95. The second year was delayed because of poor growing conditions for wheat pasture. For each year, replicate trials were conducted at three separate producer locations with 81 to 165 head of crossbred stocker calves at each location. The average initial weights were 430 lb for the first year and 450 lb for the second. The grazing period ranged from 78 to 119 days, depending upon prevailing environmental conditions.

All stocker calves were assembled 3 to 4 weeks prior to trial initiation and were vaccinated against common viral and bacterial diseases, treated for internal and external parasites, and implanted with an estrogenic growth implant at the onset of the trial. All 768 calves were weighed individually, identified with numbered ear tags and randomly allotted to one of three treatments. We used color-coded ear tags to ensure that calves remained pastured with their specific treatment group. At

[1]Appreciation is expressed to the following individuals and companies for their assistance with this project: (1) U.S. Poultry and Egg Association for financial support. (2) Bob and Mike Cather, Anthony; John Farney, Kiowa; Rod Lungren, Caldwell; and David Govert and Tom Theis, Kingman, for providing cattle, equipment and assistance. (3) Fort Dodge Animal Health for donation of Synovex-S and Synovex-H implants. (4) Pfizer Animal Health for donation of Bloat-Guard. (5) Sunglo Feeds for liquid supplement mixing and delivery.

[2]South Central Area Extension Office, Hutchinson.

the conclusion of the study, calves were gathered and individually weighed. For each year, either heifer or steer calves were used exclusively at each location.

Each trial location was uniform in terms of cereal cultivar, fertility, topography and cultural management to ensure that any differences detected would be due to supplement. Each pasture was cross-fenced and stocked to ensure that forage availability was similar across treatment. During periods of snow cover or inclement weather, equivalent amounts of harvested forage were provided to all treatments.

The supplements were formulated and delivered to each location by a commercial feed company. For the ENERGY and ESCAPE treatments, the supplement was provided free-choice to calves in 1000-lb tubs equipped with grooved lick wheels. Supplement intake was projected to be 1.5 to 2 lb/head/day. At the onset of the trial, the tubs were calibrated so that supplement consumption could be measured. The ingredient composition and actual nutrient analysis of the ESCAPE and ENERGY liquid supplements are shown in Table 1. A typical dry mix containing Bloat Guard (48 grams poloxalene/lb) and accepted mineral levels for wheat pasture was provided free-choice to all groups. Controls received the mineral mix alone.

The data were analyzed by analysis of variance with year and supplement type as the sources of variation. Supplement intake and average daily gain were the response criteria.

Results and Discussion

During the 2 years when this study was conducted, wheat forage was abundant. No significant interactions occurred between year and treatment; therefore, only main effects are shown. Average daily gains across all treatments were 2.48 and 2.58 lb/head/day in year 1 and year 2, respectively, suggesting that plane of nutrition provided by the wheat forage was exceptionally high. Average daily gain and supplement intake for each treatment are presented in Table 2. Calves receiving ENERGY and ESCAPE liquid supplements had slightly higher weight gains relative to the CONTROL treatment, but these differences were not significant (P=.91). Differences in consumption rate of the ESCAPE and ENERGY supplements were statistically similar as well (P=.88). Previous research evaluating high UIP protein supplementation for growing stocker cattle grazing wheat pasture has yielded variable results.

Assuming that wheat forage protein is 58 to 70% DIP and using the gain performance from our study, the NRC 1996 software determined that metabolizable protein requirements were exceeded by 20% with consumption of wheat forage alone. The availability of high quality, abundant wheat forage was sufficient over the two years this study to meet metabolizable protein requirements without feeding a liquid supplement containing UIP.

Table 1. Composition of Supplements (% as fed)

Supplement	Energy Control	Feathermeal/Bloodmeal
Ingredient		
Cane molasses	81.50	53.75
Feathermeal/bloodmeal		26.75
Water	12.50	13.50
Urea liquor	4.60	3.00
Ammonium sulfate	1.00	2.50
Propylene glycol	.40	.40
Xanthan gum	.10	.10
Calculated analysis (actual)		
Dry matter, %	57.5	67.3
Crude protein, %	9	30
Crude fat, %	.70	3.25
Crude fiber, %	1.00	1.00
Phosphorus, %	.10	.18
Calcium, %	.61	.72
Potassium, %	3.29	2.46
Calories/lb	903	1,165

Table 2. Performance and Liquid Supplement Intakes of Calves Grazing Wheat Pasture (pooled across year)

	Treatment		
Item	CONTROL[a]	ENERGY[b]	ESCAPE[c]
Daily gain, lb/day[d]	2.47	2.54	2.58
Supplement intake, lb/day[e]	--	1.47	1.40

[a]Control=mineral mix containing Bloat Guard.
[b]Energy=molasses-based liquid supplement.
[c]Escape=feathermeal/bloodmeal.
[d]P=.91.
[e]P=.88.

ESTIMATING THE UNDEGRADABLE INTAKE PROTEIN CONTENT OF TWO FORAGES BY DIFFERENT COMMERCIAL PROTEASES

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Summary

We evaluated the potential of several commercially available proteases for use in predicting the undegradable intake protein (UIP) concentrations of alfalfa and prairie hay. Proteases differed in their estimates of the rate of forage protein breakdown and the amounts of different forage protein fractions. At least one protease appeared to yield acceptable predictions of UIP via a short-term, single time-point assay. Assays of this type deserve further consideration for commercial application.

(Key Words: Protein Degradability, Proteases, Forages.)

Introduction

Current feeding systems for ruminants require knowledge of the proportion of forage protein degraded in the rumen (degradable intake protein = DIP) versus that escaping the rumen (undegradable intake protein = UIP). Measuring the DIP or UIP content using animals (i.e., via *in vivo* or *in situ* techniques) requires maintenance of intestinally or ruminally fistulated animals, which are expensive, require special care, and are frequently unavailable in commercial laboratory settings.

In vitro procedures using semipurified proteolytic enzymes have shown promise as routine laboratory techniques for estimating UIP, but in most cases, only concentrates and protein supplements have been tested extensively. Information about how these proteases work with forages is needed. Therefore, our objectives were to evaluate the potential of several commercial proteases for determining protein degradability, size of protein fractions, and the UIP content of forages. Values obtained using the proteases were compared with those obtained by *in situ* and *in vivo* methods in a previous experiment.

Experimental Procedures

Experiment 1. Four commercially available proteases were used to measure protein degradability in alfalfa and prairie hay. The proteases were from *Streptomyces griseus* (SGP), *Aspergillus oryzae* (AOP), *Ficus glabrata* (ficin), or bromelain from pineapple stem (BR).

For the SGP procedure, hay samples containing 14 mg N (.52 g of alfalfa or 1.64 g of prairie hay, air-dry basis) were incubated for 1 hour at 39°C in 40 ml of borate-phosphate buffer (pH 8.0). For the AOP, BR, and ficin procedures, .5 ml of triton X-100 and 20 ml of 1:1 mixture of *in vitro* rumen buffer (pH 6.8) and macromineral solution were added to hay samples. One ml of sodium azide (1% w/v) was added to all flasks as an antimicrobial agent. Following the 1-hour buffer incubation, 10 ml of SGP at .33 units/ml, AOP at 3.5 units/ml, BR at 5.0 units/ml, or ficin at 2.15 units/ml were added, and samples were incubated for .25, .5, 1, 2, 4, 8, 12, 24, and 48 hours. The 0-hour incubations were those subjected only to the 1-hour buffer incubation.

[1]KSU Agricultural Research Center - Hays.

Following exposure to the proteases, samples were filtered, residues were washed with 400 ml of deionized water, and nitrogen (N) contents of the residues were measured. Fractions and rates obtained were used to calculate the UIP contents of the forages using passage rates measured in a previous *in vivo* trial (average for both forages was approximately 2.9%/hour).

Experiment 2. Alfalfa and prairie hay samples were incubated at 39°C for 1 hour in an appropriate buffer solution, followed by addition of 10 ml of SGP solution containing .33, 3.3, or 33 units/ml; BR solution containing .5, 5.0, or 50 units/ml; or ficin solution containing .215, 2.15, or 215 units/ml. Based on results observed in Exp. 1, the AOP enzyme was not used in Exp. 2. Samples were incubated for 2, 4, or 48 hours. Residual N was considered to represent the UIP content and was expressed as a percentage of total protein.

Results and Discussion

Experiment 1. The size of forage protein fractions and degradation rates (Table 1) estimated with different proteases were similar in some instances to those obtained by a standard *in situ* procedure. However, none replicated *in situ* methods consistently. These results agreed with other reports indicating lack of consistency between *in situ* methods and those based on protease enzymes. In contrast, combining degradation rates and fractions to estimate the UIP content yielded UIP estimates that, for the SGP, BR, and ficin proteases, were similar to those determined in animals (*in vivo*).

The UIP estimates from the AOP enzyme were significantly larger than those from the other enzymes, as well as those from the *in situ* and *in vivo* methods. We also observed that in several cases, the amount of N remaining after incubation in SGP, ficin, or BR for a defined length of time closely approximated *in vivo* UIP. As a result, we felt that further exploration of simple, single time-point assays was justified (see Exp. 2).

Experiment 2. The main focus of this experiment was to develop a rapid, commercially viable, UIP assay. We used a range of enzyme concentrations and incubation times to see if assay length could be reduced by using higher enzyme concentrations. The highest concentrations of ficin (21.5 units/ml) and BR (50 units/ml) resulted in viscous solutions, causing filtration problems that prevented adequate washing of the residue from solubilized N. Consequently, results obtained at these high enzyme concentrations, particularly at short incubation times, were unreliable.

The two combinations of enzyme concentration and incubation time that compared best to *in vivo* values were the 4-hour incubation in SGP at 33 units/ml and the 48-hour incubation in SGP at .33 units/ml (Table 2). Results with the long incubation, low concentration study concur with research from Cornell University. Although short-term incubations in ficin did not yield particularly good predictions of UIP across both forages, the 48-hour incubation at 2.15 units/ml yielded values reasonably close to *in vivo* values. The BR method yielded reasonable values in some cases for alfalfa but not for prairie hay.

In conclusion, single time-point estimates of UIP using SGP and possibly ficin appear to have potential for estimating forage UIP content in a commercial setting. The potential for short-term, single time-point assays of forage UIP across a wide array of forages and different stages of maturity deserves further evaluation.

Table 1. Nitrogen Pool Sizes and Degradability of Alfalfa and Prairie Hay Estimated by Commercial Proteases [a] (Experiment 1)

Item	*In situ*	SGP	AOP	Ficin	BR	SEM[b]
Alfalfa hay						
N fractions, % of total N [c]						
A	44.8	31.6	30.9	30.2	33.1	.23
B	50.4	45.1	24.6	52.7	51.5	1.08
C	4.8	23.3	44.5	17.1	15.4	1.09
UIP[d], % of crude protein	12.8	30.6	53.2	17.7	16.7	.23
Kd, hour^{-1}	.16	.16	.05	2.57	1.12	.24
Prairie hay						
N fractions, % of total N						
A	32.7	24.4	21.1	22.7	20.6	.43
B	45.9	25.4	26.1	24.7	24.1	.38
C	21.4	50.2	52.8	52.6	55.3	.17
UIP[e], % of crude protein	42.8	54.8	63.7	53.4	56.3	.15
Kd, hour^{-1}	.04	.15	.04	.74	.65	.04

[a]SGP = *Streptomyces griseus* protease; AOP = *Aspergillus oryzae* protease; BR = bromelain.
[b]SEM for protease treatments.
[c]B and C fractions estimated using a single-pool kinetic model where B = insoluble potentially degradable protein fraction and C = undegradable protein fraction; A = (100% - C - B); undegradable intake protein(UIP) = $B \times [K_p/(K_d + K_p)] + C$ where K_p = rate of passage (.029 hour^{-1}) and K_d = degradation rate of the B fraction.
[d]*In vivo* UIP = 16.6 ± 4.3, % of total protein.
[e]*In vivo* UIP = 44.5 ± 3.5, % of total protein.

Table 2. Effect of Protease Type, Concentration (unite/ml), and Incubation Time on UIP[a] Estimates for Alfalfa and Prairie Hay (Experiment 2)

	Streptomyces griseus								
Item	.33	3.3	33	.215	2.15	21.5[b]	.5	5	50[b]
	---------- UIP[a] estimate, % of total crude protein ----------								
Alfalfa hay[c]									
Incubation time, hour									
2	64.0	41.7	26.6	42.4	23.8	26.6	44.9	27.78	23.6
4	57.1	32.4	18.6	34.9	20.4	30.2	34.9	22.1	21.7
48	23.2	12.8	10.4	18.4	13.9	26.8	18.5	11.9	17.8
Prairie hay[d]									
Incubation time, hour									
2	70.9	55.9	51.6	68.6	60.8	81.5	76.0	66.7	79.1
4	67.6	53.4	47.7	66.5	58.9	81.3	72.0	63.5	73.2
48	50.6	38.9	30.7	53.8	44.8	57.9	63.0	55.0	59.1

[a]UIP = undegradable intake protein.
[b]Higher enzyme concentrations caused filtration difficulties resulting in unreliable estimates.
[c]*In vivo* UIP, % of total protein = 16.6 ± 4.3. SEM for protease UIP estimates = .81, LSD (P = .05) = 2.28. Within assay CV = 3.42% for first run and 4.04% for second; between assay CV = 6.87%.
[d]*In vivo* UIP, % of total protein= 44.5 ± 3.5. SEM for protease UIP estimates = .93, LSD (P = .05) = 2.627. Within assay CV = 1.48% for first run and 1.77% for second run; between assay CV = 2.82%.

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AGRONOMIC AND SILAGE QUALITY TRAITS OF FORAGE SORGHUM CULTIVARS IN 1995

M. K. Siefers, J. E. Turner, G. L. Huck, M. A. Young, S. A. Anderson, R. V. Pope, and K. K. Bolsen

Summary

Agronomic and silage quality traits were measured for 37 forage sorghum cultivars and three grain sorghum hybrids. The 1995 growing season was characterized by above average rainfall in the spring and early summer, and a hard freeze on September 22. At the time of the freeze, 20 cultivars had reached the early-milk to early-dough stage, 12 were in the bloom stage, and the remaining eight were still in the early- to late-boot stage. The late planting date and low plant populations resulted in below-normal whole-plant DM and grain yields. Plant heights for the grain sorghums were near normal, but the forage sorghums were well below expected plant heights. The preensiled, whole-plant DM contents of the 37 forage sorghums ranged from 23.0 to 39.9%. As expected, the silage nutritive value traits of CP, NDF, and ADF were most favorable for the three grain sorghum hybrids and least favorable for the eight forage sorghum hybrids that were still in the boot stage when the freeze occurred.

(Key Words: Sorghum, Grain, Forage, Silage, Quality Traits.)

Introduction

Forage sorghum is an important silage crop for beef and dairy cattle producers in the High Plains region of the United States. Sorghums have greater drought tolerance, better ability to recover from drought, and lower production costs than corn. Kansas livestock producers harvested about 80,000 acres of sorghum for silage in 1995, which yielded approximately 800,000 tons.

Results from earlier studies indicated that cultivar and growing season have a tremendous effect on agronomic and silage quality traits of forage sorghums (KAES Report of Progress 678, page 13; and KAES Report of Progress 727, page 68). Our objective was to continue documenting agronomic performance and silage quality traits over a wide range of forage sorghum cultivars currently available in Kansas.

Experimental Procedures

Thirty seven forage sorghum cultivars and three grain sorghum hybrids were selected to represent a wide range of phenotypic characteristics and season lengths. All were grown under dryland conditions in 1995 near the Kansas State University campus. The forage and grain sorghum plots were planted on July 3, and each cultivar was assigned randomly to each of three replications. The six-row plots were in a Reading silt loam soil with anhydrous ammonia applied at 80 lb of nitrogen per acre. Rows were 27 ft long with a 30-inch spacing, and plots were thinned to a uniform stand of 26,000 to 28,000 plants per acre.

The three grain sorghums and 11 of the 17 forage sorghums that had reached the early-milk to early-dough stage before a hard freeze on September 22 were harvested between September 26 and October 6. The remaining 26 forage sorghums were harvested on October 19, which is near the average annual first-freeze date for the Riley County location of the plots.

The two outside rows in each plot were protective borders. All heads in two inside rows were hand clipped, and the heads were dried in a forced air oven for 2 weeks. The dried heads were threshed with a stationary machine, and the grain yield was adjusted to a 14.5% moisture basis. Whole-plant DM yield was measured by harvesting the two remaining

inside rows with a FieldQueen precision forage harvester. The chopped material from each plot was sampled for whole-plant DM determination and ensiled in 4 × 14 inch PVC laboratory-scale silos. All silos were packed to similar densities using a specially designed hydraulic press. The PVC silos were opened after approximately 90 days of storage. All silages were analyzed for pH and DM, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and ash contents.

Results and Discussion

Agronomic performance of the 40 sorghum cultivars is shown in Tables 1 and 2. Days to half bloom for the 16 grain-producing forage sorghum cultivars that reached the early-milk to early-dough stage before September 22 ranged from 56 to 67 days. Plant heights for all 37 forage sorghums were below normal. As expected, the three grain sorghums were the shortest overall. Two of the late-season hybrids (Mycogen Red Top Kandy and Casterline Supersile) were the tallest forage sorghums; Pioneer 841F, DeKalb X585, and Golden Harvest H-45 were the shortest.

The preensiled whole-plant DM contents of the 37 forage sorghums ranged from 23.0 to 39.9%. The three grain sorghum hybrids averaged 37.5% DM, whereas the eight late-season forage sorghum hybrids that were harvested in the boot stage averaged only 24.1% DM. The average pH of 3.9 indicated an extensive fermentation phase, which was primarily a function of the low DM content of most cultivars. Forages ensiled with less than 30% DM can produce large amounts of effluent during initial storage. Whole-plant DM yield was highest for two late-season hybrids (Century II Hygrachop and Casterline Supersile) and the middle-season DeKalb FS-5, whereas Pioneer 8771 grain sorghum and Early Sumac forage sorghum had the lowest whole-plant DM yields. Grain yields were below normal for the three grain sorghums and the 16 forage sorghums that produced grain. Pioneer 8771 grain sorghum and DeKalb X489 forage sorghum had the highest grain yields, and Early Sumac variety had the lowest grain yield. Surprisingly, none of the 40 sorghum cultivars lodged before harvest.

Silage quality traits of the 40 sorghums are shown in Tables 1 and 3. As expected, the three grain sorghum silages had a higher average CP content (10.4%) and lower average contents of NDF (46.8%) and ADF (27.9%) than the 37 forage sorghum silages. Among the forage sorghums, CP values ranged from 7.2% (Mycogen Red Top Kandy) to 10.1% (Northrup King 300). The NDF values ranged from 45.1% (NC+ Nutri-Cane II) to 58.0% (Cargill 455). The ADF values ranged from 27.3% (NC+Nutri-Cane II) to 36.5% (Pioneer 923).

The early freeze on September 22 coupled with the late planting date and low plant populations resulted in below-normal whole-plant DM and grain yields for all 40 cultivars. The silages of the 16 grain producing forage sorghums that reached the early-milk to early-dough stage before the freeze had an average DM content of 28.3%, whereas the silages of the 20 forage sorghums with little or no grain fill had an average DM content of 23.1%. In addition to a suitable DM content, the early- and middle-season cultivars that produced grain also had higher silage quality traits than the 20 late-season cultivars, as evidenced by a higher average CP content (8.6% vs. 8.3%) and lower average contents of NDF (48.9% vs. 54.4%) and ADF (29.6% vs. 33.8%).

These data indicate that in the 1995 growing season, the late-season forage sorghum cultivars generally produced more whole-plant DM yield than the grain sorghums or early- and middle-season forage sorghums. However, the late-season cultivars had the lowest nutritive values and would be prone to produce excessive effluent and undergo an unfavorable fermentation because of their low DM content.

Table 1. Mean Agronomic Performance and Silage Quality Traits of the Grain Sorghums, Forage Sorghums that Produced Grain (w/grain), and Forage Sorghums that Did Not Produce Grain (w/o grain)

Cultivar [1]	Plant Ht.	Whole-Plant DM Content	Whole-Plant DM Yield	Grain Yield	Whole-Plant Silage DM	CP	NDF	ADF	Ash	pH
	inches	%	tons/acre	bu/acre		%	- % of the silage DM -			
Grain sorghum (3)	43.8	37.5	3.5	52.4	3.9	36.0	10.4	46.8	27.9	7.7
Forage sorghum (w/grain) (17) [2]	73.4	30.8	4.4	44.4	3.8	28.0	8.6	48.9	29.6	6.6
Forage sorghum (w/o grain) (20)	81.4	25.0	4.8	0	3.8	23.1	8.3	54.4	33.8	7.1

[1]Number of cultivars is shown in parenthesis.
[2]Mycogen Greenleaf Sterile was not included in the calculation of the mean grain yield.

Table 2. Agronomic Performance of the 40 Sorghum Cultivars

Cultivar[1]	Days to 1/2 Bloom[2]	Harvest Date	Plant Ht.	Whole-Plant DM Content	Whole-Plant DM Yield	Grain Yield[3]
Grain sorghum			inches	%	tons/acre	bu/acre
Pioneer 8771	52	Sept. 26	39	40.2	3.1	59
Pioneer 8500	56	Oct. 3	46	38.2	3.5	55
Pioneer 8310	57	3	46	34.0	3.8	43
Forage sorghum						
Buffalo Canex	56	Oct. 3	79	30.7	3.6	30
Mycogen Greenleaf AP	57	3	67	36.5	4.5	56
NC+ Nutri-Choice	58	3	65	39.9	4.8	57
DeKalb FS-5	59	6	83	35.0	5.5	53
Casterline Sucane	59	3	80	28.5	4.0	37
Cargill 200F	59	3	73	37.2	4.2	49
Rox Orange	59	3	70	23.5	3.2	30
NC + 305F	60	6	83	27.5	4.5	44
Early Sumac	60	3	75	24.5	3.0	18
DeKalb FS-2	60	6	66	31.7	5.2	49
Mycogen Greenleaf Sterile	---	6	84	27.1	4.4	---
DeKalb X585	61	19	60	29.7	4.2	51
Pioneer 849F	62	19	82	32.2	5.1	52
NC+ Nutri-Cane II	62	19	76	30.5	4.7	43
Pioneer 841F	62	19	60	30.5	4.6	49
DeKalb X489	63	19	66	27.4	5.1	58
Atlas	67	19	80	28.4	3.5	33
NK 300	33% bl	19	61	25.8	4.2	---
NC + 965	25% bl	19	101	24.7	4.8	---
Mycogen Greenleaf	25% bl	19	73	26.8	4.3	---
Mycogen Milk-A-Lot	25% bl	19	62	30.9	5.4	---
Century II Hygrachop	20% bl	19	104	25.3	5.6	---
Golden Harvest H-45	20% bl	19	58	26.4	4.7	---
NK XF429	15% bl	19	103	25.1	5.4	---
Pioneer XSF-35	15% bl	19	73	26.4	5.1	---
Golden Harvest H-46	40% hd	19	71	26.7	4.6	---
Mycogen Silomaker	30% hd	19	71	25.5	4.9	---
Pioneer XSF-36	20% hd	19	71	23.7	5.2	---
Pioneer 838F	20% hd	19	65	24.5	4.1	---
Mycogen Red Top Kandy	Late-bt	19	112	23.0	4.9	---
Casterline Supersile	Late-bt	19	108	23.7	5.5	---
ICI 333	Late-bt	19	78	25.3	4.2	---
Pioneer 923	Early-bt	19	99	25.7	4.9	---
Pioneer XSF-45	Early-bt	19	94	23.4	5.3	---
DeKalb FS-25E	Early-bt	19	87	22.9	4.9	---
NK X920	Early-bt	19	73	23.7	5.0	---
Cargill 455	Early-bt	19	62	25.0	4.2	---
LSD (P < .05)[4]			4.7	2.9	.7	---

[1]NK is Northrup King, and an X in a hybrid's number indicates that it is experimental.
[2]bl = bloom stage, hd = heading stage, and bt = boot stage.
[3]Adjusted to a 14.5% moisture basis.
[4]The LSD (least significant difference) is valid only within a column.

Table 3. Silage Quality Traits of the 40 Sorghum Cultivars

	Whole-Plant Silage					
Cultivar	pH	DM	CP	NDF	ADF	Ash
Grain sorghum		%	% of the silage DM			
Pioneer 8771	4.0	40.8	10.8	42.5	26.0	7.0
Pioneer 8500	3.9	36.6	10.3	48.6	28.5	8.0
Pioneer 8310	3.8	30.6	10.1	49.4	29.3	8.0
Forage sorghum						
Buffalo Canex	3.7	28.8	8.0	47.3	28.4	7.2
Mycogen Greenleaf AP	3.9	34.1	9.2	47.7	28.3	6.6
NC + Nutri-Choice	3.9	34.0	9.6	51.4	30.0	7.4
DeKalb FS-5	3.8	29.5	8.2	49.5	30.2	6.5
Casterline Sucane	3.8	25.1	7.7	52.3	29.3	6.2
Cargill 200F	3.9	35.0	9.2	49.2	29.7	6.8
Rox Orange	3.7	23.3	8.1	51.1	30.7	6.5
NC + 305F	3.7	25.2	8.0	48.0	29.4	6.5
Early Sumac	3.7	20.7	8.1	51.8	31.6	7.1
DeKalb FS-2	3.8	27.8	9.4	47.0	28.2	7.9
Mycogen Greenleaf Sterile	3.6	24.1	8.5	49.5	31.0	6.5
DeKalb X585	3.9	28.3	9.5	45.9	28.9	5.8
Pioneer 849F	3.8	30.2	8.3	48.0	28.9	6.4
NC + Nutri-Cane II	3.8	28.5	7.9	45.1	27.3	5.6
Pioneer 841F	3.8	28.1	9.4	50.4	31.3	6.9
DeKalb X489	3.8	27.2	9.0	46.2	28.3	6.5
Atlas	3.8	26.6	8.1	50.9	31.9	5.8
NK 300	3.9	27.0	10.1	56.5	34.0	8.6
NC + 965	3.8	22.6	7.6	51.8	32.1	7.0
Mycogen Greenleaf	3.9	24.5	9.0	53.1	33.2	7.3
Mycogen Milk-A-Lot	3.9	25.5	9.4	56.0	34.4	7.0
Century II Hygrachop	3.9	22.8	7.4	52.9	32.6	6.7
Golden Harvest H-45	3.9	23.2	8.9	55.2	33.5	7.0
NK XF429	3.8	23.0	7.3	52.3	33.3	6.2
Pioneer XSF-35	3.9	24.1	8.7	54.4	32.7	7.0
Golden Harvest H-46	3.9	24.2	9.4	53.0	32.2	7.6
Mycogen Silomaker	3.9	22.7	8.1	54.6	33.6	7.2
Pioneer XSF-36	3.8	23.1	8.3	56.3	34.9	7.4
Pioneer 838F	3.9	22.3	9.4	54.4	33.9	8.1
Mycogen Red Top Kandy	3.8	19.9	7.2	50.9	33.1	5.9
Casterline Supersile	3.8	21.7	7.4	53.7	33.7	6.1
ICI 333	3.9	23.0	8.0	55.2	34.0	6.6
Pioneer 923	3.9	24.2	8.1	57.0	36.5	7.0
Pioneer XSF-45	3.9	20.9	7.7	54.4	34.6	6.8
DeKalb FS-25E	3.8	21.1	8.1	53.3	33.2	6.7
NK X920	3.9	22.4	8.0	54.8	34.7	8.2
Cargill 455	3.9	23.8	8.8	58.0	36.2	7.7
LSD (P < .05) [1]	.1	4.1	1.0	3.8	3.0	1.1

[1]The LSD (least significant difference) is valid only within a column.

EFFECT OF BACTERIAL INOCULANTS ON THE FERMENTATION AND PRESERVATION EFFICIENCIES AND NUTRITIVE VALUE OF ALFALFA SILAGE FOR GROWING STEERS [1]

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Summary

Two silage bacterial inoculants from Pioneer Hi-Bred International, Inc. were evaluated using second-cutting alfalfa. The Pioneer brand 1174® inoculant and a Pioneer experimental inoculant each increased the rate and efficiency of the ensiling process in both farm-scale and laboratory-scale silos. The two inoculants increased the DM recovery in the farm-scale silos compared to the untreated silage. Steers fed the experimental inoculant-treated silage gained faster (P<.10) (2.56 vs. 2.37 lb per day), had a 4.0% higher DM intake, and were 4.3% more efficient than steers fed the untreated silage. The 1174-treated silage supported a numerically but not statistically better steer performance than the control silage. When the DM recovery results were combined with the feed per gain results, the silages with 1174 and experimental inoculant produced 5.3 and 10.5 lb more steer gain per ton of crop ensiled, respectively, than the control silage.

(Key Words: Alfalfa, Silage, Inoculant, Preservation, Nutritive Value.)

Introduction

Adding selected strains of lactic acid bacteria (LAB) has become common practice in silage-making. Bacterial inoculants have improved silage fermentation quality, reduced DM losses in the silo, and increased rate and efficiency of gain in over 30 growing/backgrounding trials with corn and sorghum silages at Kansas State University (KAES Report of Progress 651, page 101). The LAB are intended to dominate the fermentation phase of the ensiling process. Alfalfa and other legumes can be difficult to ensile because of their low sugar content and high buffering capacity. However, we have shown in numerous trials over the past 15 years that inoculants help ensure that as much of the fermentable carbohydrates as possible are converted to lactic acid, which removes some of the risk of having a poorly preserved, low-quality silage.

The objective of this study was to determine the effect of two LAB inoculants on the fermentation, preservation, and nutritive value of alfalfa silage.

Experimental Procedures

On June 22 and 28 of 1995, second-cutting alfalfa was swathed with a mower-conditioner; field-wilted for 24 hours; and ensiled in six, 10 × 50 ft, concrete stave silos by the alternate windrow and load method. The three treatments were: 1) no additive (control), 2) Pioneer brand 1174® inoculant, and 3) a Pioneer experimental inoculant. The inoculants were applied in water solutions at the silage blowers and supplied approximately 150,000 colony-forming units (cfu) of LAB per gram of ensiled alfalfa. The control received only water and the carrier ingredients contained in the inoculants without the LAB. Nine thermocouple wires were spaced evenly in the forage mass in each silo to measure ensiling temperatures during the first 8 weeks of storage. On each of the 2 silo-filling days, chopped alfalfa was removed from a

[1]Financial assistance, technical support, and bacterial inoculants were provided by Pioneer Hi-Bred International, Inc., Johnston, IA.

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randomly selected load, and control and inoculated forages were ensiled in 18 PVC laboratory-scale silos per treatment. Triplicate PVC silos were opened at 1, 2, 4, 7, 21, and 90 days postfilling.

One farm-scale silo for each treatment was opened on September 13 and December 3 and emptied at uniform rates during a 12- to 16-week period. Samples were taken twice weekly for DM recovery calculations and chemical analyses. Each silage was fed to 20 steer calves in a 75-day growing trial (November 8, 1995 to January 22, 1996). The calves were housed in individual pens, and ration DM intake was measured daily. The complete mixed rations were fed to appetite and contained 76% silage and 24% concentrate (cracked corn-based) on a DM basis. The concentrate was formulated to provide each steer with 200 mg of Rumensin; 50 mg of Tylan; 20,000 IU of vitamin A; 3,000 IU of vitamin D; and 150 IU of vitamin E daily.

For 5 days before the start of the growing trial, all steers were limit-fed a forage sorghum silage-based ration to provide a DM intake of 2.0% of body weight. Steers then were weighed individually on 2 consecutive days. For 2 days before the final weighing, the steers were fed their respective silage rations at a restricted DM intake of 2.0% of bodyweight. Then individual weights were taken on 2 consecutive days.

The alfalfa silages in the six farm-scale silos in this study also were fed to 60 early-lactation Holstein cows over a 7-month period (KAES Report of Progress 771, page 26).

Results and Discussion

A summary of the preservation and composition results for the three alfalfa silages is shown in Table 1. The average DM, CP, NDF, and ADF contents for the three silages were nearly identical, and these values reflect the uniformity of the wilted, preensiled alfalfa during the two silo-filling days. Further evidence of the uniformity of the preensiled alfalfa were results for the numbers of epiphytic (natural occurring) LAB per gram of forage -- alfalfa ensiled on June 23 had 1.0×10^5 cfu per gram and alfalfa ensiled on June 29 had 1.6×10^5 cfu per gram. Yeast and mold counts for the alfalfa on the two filling days were approximately 1.0×10^5 cfu per gram of preensiled alfalfa.

Ensiling temperature results showed that silages treated with both 1174 and experimental inoculant averaged 1 to 3°F cooler than the untreated silage throughout the first 8 weeks of storage (data not shown). These cooler temperatures for the inoculated silages are consistent with several other inoculant studies using whole-plant corn and sorghum silages in the KSU farm-scale silos.

The fermentation profiles showed that the inoculated silages underwent a more efficient ensiling process in both the farm- and laboratory-scale silos than the untreated silages. The silages treated with 1174 and experimental inoculant were characterized by having higher lactic acid contents and lactic to acetic acid ratios; lower pH values; and lower contents of acetic acid, ethanol, and ammonia-nitrogen contents than the untreated silages. Both inoculants also increased the rate of the ensiling process, as evidenced by lower pH values and higher lactic acid contents at days 2, 4, 7, and 21 postfilling for inoculated silages compared to the untreated silages (data not shown). Both inoculants increased the DM recovery in the farm-scale silos compared to the control silage -- 1174 by 1.95 percentage units and the experimental inoculant by 3.6 percentage units.

Performance by the steers fed the three alfalfa silage rations is presented in Table 2. Steers fed the experimental inoculant-treated silage gained significantly faster (2.56 vs. 2.37 lb per day), had a 4.0% higher DM intake, and were 4.3% more efficient than steers fed the untreated silage. The 1174-treated silage supported a numerically but not statistically better steer performance than the control silage. When the DM recovery results in Table 2 are combined with the feed per gain results (Table 2), the 1174 and experimental inoculant silages produced 5.3 and 10.5 lb more steer gain per ton of crop ensiled, respectively, than the control silage.

Table 1. Fermentation and Preservation Efficiencies and Chemical Composition of the Three Alfalfa Silages in the Farm-Scale and Laboratory-Scale Silos

	Control		1174		Experimental	
Item	Farm[1]	Lab[2]	Farm[1]	Lab[2]	Farm[1]	Lab[2]
Dry matter, %	41.8	40.8	42.8	41.0	42.1	41.6
DM recovery[3]	81.20	---	83.15	---	84.80	---
pH	4.65	4.55	4.48	4.41	4.50	4.41
	——————% of the silage DM ——————					
Lactic acid	7.42	7.62	8.24	8.28	8.37	8.30
Acetic acid	2.08	3.85	1.76	3.26	1.78	3.44
Lactic:acetic	3.6	2.0	4.8	2.5	4.8	2.4
Ethanol	.392	.515	.276	.465	.291	.490
Ammonia-nitrogen	.232	.230	.193	.190	.195	.218
Crude protein	18.5	---	18.6	---	18.7	---
NDF[4]	41.6	---	41.6	---	41.6	---
ADF[4]	34.6	---	34.5	---	34.5	---

[1]Each value is the mean of 20 samples taken from the silos during the growing trial.
[2]Each value is the mean of 6 silos opened at 90 days postfilling.
[3]Expressed as a percen tof the crop DM ensiled. Data are only for the three silos filled on June 23, 1995.
[4]NDF = neutral detergent fiber and ADF = acid detergent fiber.

Table 2. Performance by Calves Fed the Three Alfalfa Silage Rations

Item	Control	1174	Experimental
No. of steers[1]	19	19	19
Initial wt, lb	588.6	594.7	597.4
Final wt, lb	766.3	779.1	789.6
Avg daily gain, lb	2.37[b]	2.46[a,b]	2.56[a]
Daily DM intake, lb	17.4	17.9	18.1
Feed/lb of gain, lb[2]	7.47	7.34	7.15
Silage fed, lb/ton of crop ensiled[3]	1624	1663	1696
Silage/lb of gain, lb[3]	14.2	13.9	13.6
Cattle gain/ton of crop ensiled, lb[3]	114.3	119.6	124.7

[a,b]Means on the same line with different superscripts differ (P<.10).
[1]One steer was removed from each of the three treatments because of extremely low DM intake during the first 28 days of the trial.
[2]100% DM basis.
[3]Adjusted to 40% dry matter.

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ECONOMICS OF SEALING HORIZONTAL SILOS

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Summary

Determining the value of silage saved by effectively sealing a horizontal silo requires only a few simple calculations, but it is still a concept that is often overlooked by many livestock producers who store large amounts of silage in that manner. Kansas produces about 3.0 million tons of silage annually, primarily from corn and sorghum. A majority of this silage is made and stored in either bunker, trench, or "drive-over" pile silos. Only 20 to 30% of these silos are sealed after filling. Producers who do not seal need to take a second look at the economics of this highly troublesome "technology" before they reject it as unnecessary and uneconomical. The loss from a 100 × 250 ft silo filled with corn silage can exceed $10,000.

(Key Words: Silage, Top Spoilage, Silo, Bunker Silo, Trench Silo, Pile Silo.)

Introduction

Three economically attractive methods in Kansas for storing large amounts of ensiled forage are the horizontal silos (i.e., bunker, trench, or pile), but because so much of the surface of the ensiled material is exposed, dry matter (DM) and nutrient losses can be extensive. If left unprotected, losses in the top 2 to 4 ft can exceed 50%. This is particularly disturbing when one considers that in the typical horizontal silo, over 20% of the silage might be within the top 4 feet.

These losses can be minimized by sealing (covering) the ensiled mass with polyethylene sheets, which usually are weighted with tires or soil. Although this method minimizes losses, it is so awkward, cumbersome, and labor intensive that many producers feel the silage saved is not worth their time and effort.

Top-spoilage research has been conducted at Kansas State University since 1989, and the results document the magnitude of the DM and nutrient losses in the original top 3 ft of the ensiled crop. However, these losses can not be seen until the silo is opened. Even then, the spoilage might be apparent only in the top 6 to 12 inches of silage, obscuring the fact that this area of spoiled silage represents substantially more silage as originally stored.

We provide here a few simple equations, that can be hand-calculated or incorporated into a computer spreadsheet. They allow producers to estimate the value of silage saved by sealing, based on their crop value, silo dimensions, cost of the sealing material, and labor to cover their silage.

Calculations and Examples

Calculating the value of silage saved by sealing is based on four economic inputs and two silo/silage inputs. The four economic inputs are:

1) Value of the silage ($/ton)
2) Cost of the polyethylene sheet (cents/ft^2 × number of ft^2)
3) Cost of the weighting material (zero was used in the examples)
4) labor cost ($/hr × number of hrs).

Ten hours per 4,000 ft^2 of polyethylene sheet were used to calculate the labor cost.

In order to account for overlapping from sheet to sheet and along the side walls or base, we assumed a covering efficiency of 80%.

The first of the two silo/silage inputs determines the amount of silage within the original top 3 ft of the silo after filling is complete. It is determined by multiplying the silo width(ft) by length(ft) by depth of interest (3 ft) by the silage density (lb/ft^3) and dividing the product by 2,000 (lb/ton).

The second silo/silage input estimates the amount of silage within the original top 3 ft of the silo that is lost as spoilage. These values (50% of sealed, 20% if unsealed) are based on research conducted at Kansas State University and published in KAES Reports of Progress 623, p. 70; 651, p. 127; and 727, p. 59 and 63.

The following example estimates the net return from sealing a horizontal silo 40 ft wide by 100 ft long (4,000 ft^2).

Economic assumptions:

1) Corn silage price: $25/ton
2) Polyethylene film: $.055 per ft^2 of surface covered. $.055 × 4,000 ft^2 = $220
3) Weighting material: zero cost assumed
4) Labor cost: 10 hr/4,000 ft^2 sheet × $20/hr = $200
   Sealing cost = $220 + $200 = $420

Silo/silage assumptions:

1) Assuming a silage density of 45 lb/ft^3 (4000 ft^2 surface × 3 ft deep × 45 lb/ft^3)/2000
   = 270 tons of silage within the original top 3 ft

(total capacity of the silo is about 1,080 tons)

2) Assume 20% loss in the top 3 feet if sealed, 50% loss if unsealed.

Loss, unsealed:
270 tons × $25/ton × 50% = $3,375

Loss, sealed:
270 tons × $25/ton × 20% = $1,350
Cost of sealing = $ 420
Net, sealed = $1,770

Net return to sealing:
$3,375 – $1,770 = $1,605

The concepts shown above are presented in a user-friendly spreadsheet format in Table 1. The first nine lines are economic inputs determined by the producer, and the next six lines are results that are based on formulas utilizing the producer's inputs. They can be programmed easily into the spreadsheet using the row letters as guides.

The most important single factor influencing preservation efficiency of ensiled forages is the degree of anaerobic fermentation achieved during ensiling. When silage is not sealed or when the seal is inadequate, air and moisture enter the mass and affect both the ensiling process and silage quality during the storage and feedout phases. Based on the examples in Table 1, sealing a 40 ft × 100 ft silo could save approximately $1,600 worth of silage. Using the same concept, covering a 100 ft × 400 ft silo could save the producer over $16,000.

Although future technology might introduce a more environmentally and user-friendly product, polyethylene (6 mm) is the most effective sealing material available today. The most common sealing method is to place the polyethylene sheet over the ensiled forage and weight it down with rubber tires (20 to 25 tires per 100 sq ft).

Research-based calculations confirm that the financial loss incurred by not sealing silage is substantial and reinforces our recommendation that sealing the exposed surface of a horizontal silo is one of the most important management decisions in any silage program.

Table 1. Value of Silage Saved by Sealing Three Horizontal Silos Differing in Size

Economic inputs					
Silage crop	Corn	Corn	Corn		Spreadsheet Formulas
Silage value, $/ton	25	25	25	A	
Silage density, lb/ft ^{3}	45	45	45	B	
Silo width, ft	40	100	100	C	
Silo length, ft	100	250	400	D	
Cost of 40 ft × 100 ft poly sheet, $	175	175	175	E	
Efficiency of sheet, %	80	80	80	F	
Silage lost if unsealed, %	50	50	50	G	
Silage lost if sealed, %	20	20	20	H	
Labor cost, $/hr	20	20	20	I	
Results					
Silage in the top 3 ft, tons	270	1,688	2,700	J	(C×D×3×B)/2000
Silage value lost if unsealed, $	3,375	21,094	33,750	K	J×(G/100)×A
Silage value lost if sealed, $	1,350	8,438	13,500	L	J×(H/100)×A
Cost per ft ^{2} of poly sheet, ¢	5.5	5.5	5.5	M	([E/(F/100)]/4000)×100
Sealing cost, $	419	2,617	4,188	N	[(C×D×M/100)]+ [(I×C×D×10)/4000]
Value of silage saved, $	1,606	10,039	16,063	P	K–(L+N)

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THE EFFECT OF STAGE OF MATURITY ON THE NUTRITIVE VALUE OF SMOOTH BROMEGRASS AND EASTERN GAMAGRASS SILAGES

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Summary

Early- and late-harvested smooth bromegrass and eastern gamagrass silages and fourth-cutting alfalfa silage were compared in two, 20-day voluntary intake and digestion trials. Visual appraisal and pH values indicated that all five forages were well preserved as silage. Voluntary intake tended to be higher for sheep fed bromegrass and alfalfa silages compared to those fed gamagrass silages. The late-harvested gamagrass silage had the lowest DM intake in both periods. Dry matter, crude protein, and neutral detergent fiber digestibilities were generally similar for the two grasses within the early- and late-harvested silages. Chemical analyses indicated that the two bromegrass silages were of nearly equal nutritive value; however, digestion trial results showed that the early-harvested silage was higher in quality than the late-harvested silage. Results of both chemical analyses and digestion trials showed that the early-harvested gamagrass silage was higher in quality than the late-harvested silage.

(Key Words: Grass, Smooth Brome, Eastern Gama, Silage.)

Introduction

Smooth bromegrass is a cool-season perennial found throughout most of the northern United States. It is used primarily as a pasture or hay crop in northern and eastern Kansas. Eastern gamagrass is a warm-season perennial bunch grass found from Texas to Kansas and east to New England. Because of difficulties in establishment, gamagrass has received little commercial attention or on-farm use until recently. Virtually no controlled experiments have looked at the ensiling traits of these two grasses.

Our objective was to determine the ensileability and nutritive value of smooth bromegrass and eastern gamagrass when ensiled at two stages of maturity. Alfalfa silage was used for comparison.

Experimental Procedures

In the summer of 1995, smooth bromegrass and eastern gamagrass were swathed with a New Holland mower-conditioner; wilted for approximately 24 hours; chopped using a FieldQueen forage harvester; and ensiled in 55 gallon, polyethylene-lined, pilot-scale silos. Both grasses were harvested at approximately the heading and flowering stages of maturity—June 12 and July 11 for the bromegrass and June 21 and July 12 for the gamagrass. The smooth bromegrass plot was located at the Kansas State University Sheep Teaching and Research Unit in Manhattan, and the eastern gamagrass plot was located at the Kansas State University Department of Agronomy Research Farm in Manhattan. The bromegrass and gamagrass plots received 100 lb of nitrogen per acre as ammonium nitrate on May 2. The fourth cutting alfalfa was in the bud stage of maturity and provided by Bert and Wetta of Abilene, Kansas. It was harvested similarly to the two grasses and ensiled after a 24-hour wilting period on September 17. All preensiled forages were treated with Pioneer® brand 1174 inoculant to supply 150,000 cfu of lactic acid bacteria per gram of fresh material.

Because of a limited supply of forage, sheep were used as model animals. Each silage was fed to four Ramboillet crossbred wether lambs (avg wt. of 69.5 lb) in two, 20-day voluntary intake and digestion trials. Rations contained 90% silage and 10% supplement (DM basis). After a 7-day ration adaption, voluntary DM intake was measured for 7 days. The lambs then were fed 85% of their average voluntary DM intake during the subsequent 6-day digestion trial.

Results and Discussion

Results are presented in Table 1. Weather conditions were excellent (warm temperatures and low humidities) for each of the five 24-hour, field-wilting periods. As expected, the standing, preswathed, early-harvested grasses had a lower DM content than the standing, late-harvested grasses. Visual appraisal and pH values indicated that all five forages were well preserved as silage.

Voluntary DM intake tended to be higher for sheep fed bromegrass and alfalfa silages compared to those fed gamagrass silages. The late-harvested gamagrass silage had the lowest (P<.05) DM intake in both periods, which was likely due to the high NDF content of the silage (71.7%). The late-harvested bromegrass silage had an unexpectedly high DM intake in the second period, which resulted in a silage × period interaction for DM intake. Alfalfa silage had the highest (P<.05) DM and CP digestibilities in both periods, and the late-harvested bromegrass silage had the lowest (P<.05) ADF digestibility in both periods. This high DM intake of the late-harvested bromegrass silage was likely responsible for its very low NDF and ADF digestibilities. Grass silage × period interactions also were observed for DM, CP, and NDF digestibilities.

Chemical analyses indicated that the two bromegrass silages were of nearly equal nutritive value; however, digestion trial results clearly showed that the early-harvested silage was higher in quality than the late-harvested silage. Results of both chemical analyses and digestion trial results showed that the early-harvested gamagrass silage was higher in quality than the late-harvested silage.

Table 1. pH and Chemical Composition of the Five Silages and Nutritive Value of the Five Silage Rations in Periods 1 and 2

	Early-Harvested		Late-Harvested		Fourth-Cutting
Item	Brome	Gama	Brome	Gama	Alfalfa
Silage composition					
Dry matter[1], %	44.0	42.7	53.8	51.9	46.8 (24.5)
pH	4.18	4.27	4.40	4.68	4.64
	% of the silage DM				
CP	8.8	10.8	9.0	7.9	21.9
NDF	60.9	66.4	61.2	71.7	30.7
ADF	34.5	34.9	35.1	38.4	22.5
Voluntary intake,	Period 1				
g/metabolic body wt. ($k\ g^{.75}$)	40.6^{b}	38.9^{b}	39.2^{b}	33.2^{c}	45.7^{a}
	Digestibility, % of the ration				
DM	54.5^{b}	54.5^{b}	50.0^{c}	48.0^{c}	69.1^{a}
CP	48.1^{c}	55.3^{b}	43.3^{d}	45.7^{cd}	75.0^{a}
NDF	54.7^{a}	55.7^{a}	47.6^{c}	48.4^{bc}	$51.5^{a,b}$
ADF	$48.8^{a,b}$	50.7^{a}	41.8^{c}	46.2^{b}	50.7^{a}
Voluntary intake,	Period 2				
g/metabolic body wt. ($k\ g^{.75}$)	38.9^{b}	36.1^{b}	45.2^{a}	30.8^{c}	47.4^{a}
	Digestibility, % of the ration				
DM	55.7^{b}	54.0^{c}	43.1^{d}	50.0^{c}	73.2^{a}
CP	40.1^{c}	50.4^{b}	37.6^{d}	34.4^{d}	70.1^{a}
NDF	53.1^{a}	53.3^{a}	37.2^{b}	51.3^{a}	54.5^{a}
ADF	46.8^{b}	$49.5^{a,b}$	32.1^{c}	$49.8^{a,b}$	56.1^{a}

[1]The DM content of the standing, preswathed forage is shown in parenthesis.
[a,b,c]Means on the same line with different superscripts differ (P<.05).

RAPID NUTRIENT EVALUATION OF SORGHUM SILAGES USING TWO TYPES OF NEAR-INFRARED REFLECTANCE SPECTROSCOPY

K. J. Budiongo, L. H. Harbers, B. W. Seabourn [1], K. K. Bolsen, and B. E. Brent

Summary

This research was designed to develop a set of prediction equations to measure nutrient composition of Kansas sorghum silages using both a portable and a research type near-infrared spectrometer (NIRS). A robust set of equations for dry matter, crude protein, neutral detergent fiber, and acid detergent fiber was developed for a wide range of sorghum phenotypes. NIRS analysis of sorghum silages is feasible with both a tilting filter (portable) and research instrument with a grating monochrometer.

(Key Words: Sorghum Silage, Nutrient Content, Near-Infrared Reflectance Spectroscopy.)

Introduction

Near-infrared spectrometers, originally designed to test grains, are used widely in the feed and food industries for rapid nutrient analysis. Various models are available. Simple portable systems are based on tilting filters. More sophisticated, expensive models have a grating monochrometer capable of producing a continuous wavelength scan. We developed equations for use with two popular models; one that is suitable for field use and another designed for use in a testing laboratory or research facility.

Experimental Procedures

Two hundred and eighty-eight sorghum silage samples were dried using a forced air-oven (55°C), then ground to 1 mm using a UDY impact mill. Samples were scanned using an NIRS Systems scanning monochrometer unit and immediately placed in a vacuum oven to obtain total dry matter data. A computer program selected 106 scans that differed enough to be useful in developing equations. Those samples were analyzed in duplicate for crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF).

Sixty-eight samples were selected by the instrument's computer to be used to develop calibration equations for the monochrometer instrument using the full spectrum. The remaining 38 samples were used for validation. Then, the process was repeated, limiting the software to the wavelengths available to the tilting filter instrument (1900 to 2320 nm).

Results and Discussion

Of the original 68 samples selected for calibration, several were rejected by the instrument's software because the chemical analysis values were outside the expected norm relative to the respective spectra. Neutral detergent fiber had the highest standard error of calibration (SEC) because of variation in samples, whereas the SEC of ADF was slightly lower and also had higher R^2 values. Crude protein appeared to be the most consistent among nutrient values tested and is the only nutrient derived directly from a chemical analysis. The others (moisture, NDF, and ADF) are derived by weights

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both before and after a physical treatment and are highly impirical compared to the direct nitrogen determination used for CP.

Regression equations (Table 2) show that from two to four wavelengths were needed for prediction. Linear equations were formed where B_0 is the intercept, and $B_1...B_n$ are coefficients for the value log 1/R (R is reflectance) at the designated wavelength.

A wide range of sorghum cultivars was used, ranging from high grain-yield grain sorghums to headless, nongrain-producing forage sorghums, and this could account for the lower R^2 values than would be expected from more uniform forage species, such as corn silage or alfalfa hays.

In summary, these data indicate that the development of robust equations for all sorghum silages is feasible and NIRS analysis would be useful for practical determinations of nutritional value.

Table 1. Selected Means, Standard Errors, and Coefficients for Nutrient Components of Sorghum Silage Using Two Types of Near-Infrared Reflectance Spectrometers

Variable	N	Mean	SEC[a]	R^2	SEV[b]	R^2
		Tilting Filter Instrument (1900-2320 nm)				
Dry matter	65	93.46	.91	.65	.94	.62
Crude protein	66	8.31	.56	.86	.58	.85
Neutral detergent fiber	66	51.33	1.83	.87	1.91	.86
Acid detergent fiber	68	32.53	1.30	.90	1.36	.89
		Full Spectrum Instrument				
Dry matter	65	93.46	.79	.73	.83	.70
Crude protein	66	8.28	.52	.88	.54	.87
Neutral detergent fiber	66	51.32	1.70	.89	1.74	.88
Acid detergent fiber	65	32.61	1.13	.93	1.16	.92

[a]SEC = standard error of calibration.
[b]SEV = standard error of validation.

Table 2. NIRS Equation Constants for Nutrient Analysis of Sorghum Silages

		Tilting Filter		Full Spectrum	
Variable	Component	Coefficien t	Wavelength	Coefficient	Wavelength
Dry matter	B_0	90.25		75.98	
	B_1	-68.41	2220	-143.00	1812
	B_2	-116.59	2300	-14.86	1908
	B_3			-66.48	1740
	B_4			6.81	624
Crude protein	B_0	20.64		33.46	
	B_1	-21.84	2148	110.17	872
	B_2	-42.55	2196	53.13	1748
	B_3	-30.15	2316	151.69	1228
	B_4	-28.67	2252	-46.91	2028
Neutral detergent fiber	B_0	45.09		90.20	
	B_1	186.40	1948	-121.31	848
	B_2	-202.61	2300	117.05	1740
	B_3	486.44	2276	-103.86	2348
	B_4	-892.82	2108	35.11	2116
Acid detergent fiber	B_0	-2.09		2.40	
	B_1	910.61	2212	214.18	1616
	B_2	-156.37	2308	-500.07	2476
	B_3	-1089.24	2220	-507.69	1652
	B_4			106.28	472

FERTILITY AFTER TIMED BREEDING USING GnRH, PG$F_{2\alpha}$, AND NORGESTOMET [1]

K. E. Thompson, J. S. Stevenson, D. M. Grieger, G. C. Lamb, T. J. Marple, L. R. Corah, D. A. Nichols, and R. M. McKee

Summary

At the KSU Purebred Unit, 164 purebred Angus, Hereford, and Simmental cows were used to test a new estrus-synchronization program using GnRH, PG$F_{2\alpha}$, and norgestomet. Cows were inseminated after detected estrus, or in the absence of estrus, inseminations were made at one fixed time after a second injection of GnRH. The treatment consisted of a 100 μg injection of GnRH plus a 6-mg ear implant of norgestomet. Seven days later, the ear implant was removed, and 25-mg of PG$F_{2\alpha}$ was injected. In the absence of estrus, the time-bred group received a second injection of GnRH 48 h after PG$F_{2\alpha}$ and was inseminated 16 h later. The treatment induced 10 of 36 anestrous cows to ovulate. Conception rates tended (P<.09) to be greater in Angus (72.2%) than Hereford cows (52.8%), with conception rates in Simmental cows (51.5%) being similar to those in Hereford. Overall, pregnancy rates were similar between the time-bred group (59.3%) and the estrus-bred group (53.8%). We conclude that using GnRH, PG$F_{2\alpha}$, and norgestomet in a timed breeding program can eliminate the necessity of heat detection. In addition, the treatment induced estrus in 28% of the noncycling cows.

(Key Words: GnRH, PG$F_{2\alpha}$, Norgestomet, Timed Breeding, Anestrous Suckled Cows, Induced Ovulation.)

Introduction

The goals of estrus-synchronization programs are to shorten the breeding season, produce a more uniform calf crop, and allow the production of more calves from artificial insemination (AI) sires with superior genetic potential for growth and carcass traits. Limitations of AI in the beef industry are the additional cost and expertise associated with AI breeding and the poor response of late-calving (anestrus) cows to current estrus-synchronization programs when applied at the onset of the breeding season. In attempt to resolve these problems, we tested a new estrus-synchronization program using GnRH, PG$F_{2\alpha}$, and norgestomet. An advantage of this program is its ability to induce estrus in anestrous suckled cows without increasing the incidences of persistent follicles and short cycles that typically occur after breeding at the first postcalving estrus.

Experimental Procedures

Fifty two primiparous and 112 multiparous purebred Angus, Hereford, and Simmental cows located at the KSU Purebred Unit were assigned randomly to two groups. All cows received a 100-μg injection of GnRH (Cystorelin®) and a 6-mg norgestomet ear implant (SyncroMate® implant only) 7 days before an injection of PG$F_{2\alpha}$ and implant removal on day 0 (Figure 1). Cows assigned to the estrus-bred group were inseminated 12 to 16 hr after detected estrus. Cows assigned to the estrus + time bred

[1]Partial funding of this study was provided by Select Sires, Plain City, OH.

group were inseminated after detected estrus until 48 hr after PGF $_{2\alpha}$; noninseminated cows then were given a second l00- µg GnRH injection and inseminated 16 hr later. Three blood samples were collected: 11 days before GnRH (day -18), on the day when GnRH was given (day -7), and just before the injection of PGF $_{2\alpha}$ (day 0). Concentration of progesterone in the first two blood samples were used to determine the cycling status of cows, and the third was used to determine the number of cows induced to ovulate after the first GnRH injection. Between days 33 and 43 after AI, pregnancy was detected using transrectal ultrasonography.

Results and Discussion

At the beginning of the breeding season, 83.3% of Angus, 68.4% of Hereford, and 75% of Simmental cows were cycling. Of the 36 animals not cycling, 10 were induced to ovulate after the first GnRH injection. Because the primiparous cows calved 22 to 31 days before the multiparous cows, the percentage cycling was similar between the younger and older cows. Body conditions at the beginning of the breeding season were similar among treatment, breed, and parity groups, and averaged 5 on a scale of 1 to 9 (Table 1).

Conception rate tended (P = .09) to be greater in Angus (72.2%) than Hereford (52.8%) cows. Conception rate in Simmental cows (51.5%) was similar to the Hereford cows, but less than that for the Angus cows. Conception rate (the proportion of cows detected in estrus and inseminated during the first 144 hours after the injection of PGF $_{2\alpha}$ that become pregnant) was greater (P = .06) for the estrus-bred group (67.7%) than in the estrus + time bred group (59.3%) (Table 2). In contrast, pregnancy rates (the proportion of cows assigned to treatment that became pregnant) were similar between treatments. Therefore, use of timed breeding allowed us to impregnate cows that might have been missed when breeding was based solely on heat detection.

Combining heat detection and timed breeding after GnRH, PGF $_{2\alpha}$, and norgestomet can eliminate the extra labor devoted to heat detection before first inseminations .Our results with this method of heat synchronization indicate no difference between breeding after detected estrus or combining estrus detection with timed AI. This treatment protocol induced ovulation in suckled anestrous cows. By synchronizing ovulation prior to timed breeding, the number of pregnant cows can be increased by eliminating the possibilities of missed heats or silent heats.

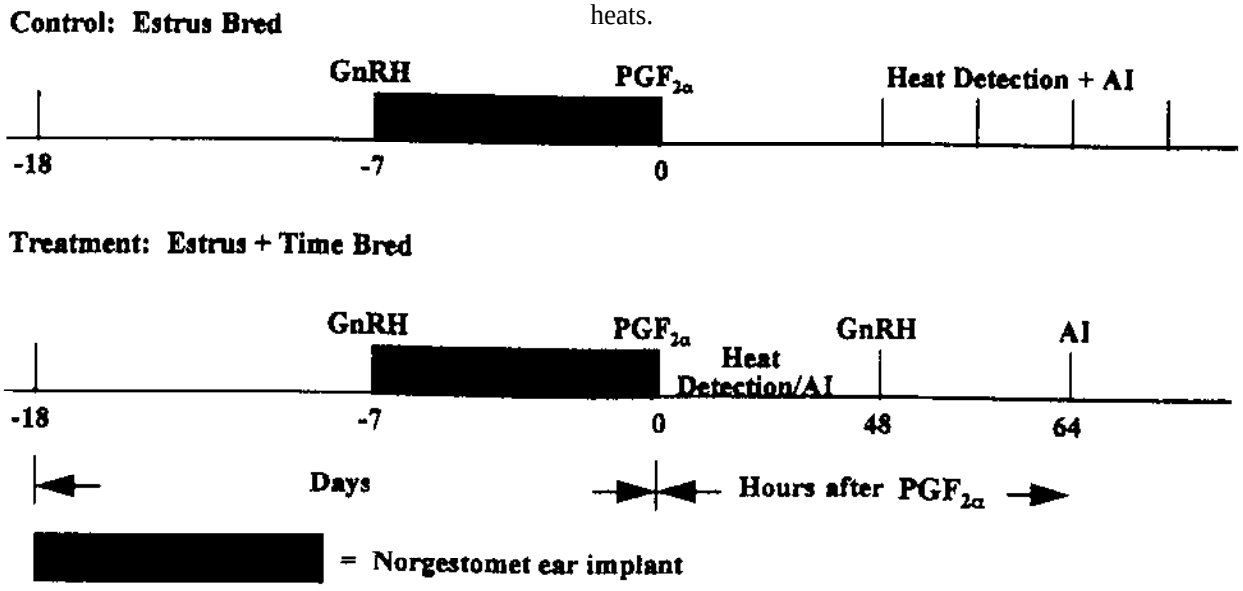

Figure 1. Experimental Protocol for Estrus Synchronization Using GnRH, PGF $_{2\alpha}$, and Norgestomet.

Table 1. Percentage of Cows Cycling, Body Condition, and Days Postpartum at Onset of Treatments in Angus, Hereford, and Simmental Cattle

Breed	No.	% Cycling [a]	Body condition	Days Postpartum
Angus				
Primiparous	25	84.0	4.9	91
Multiparous	65	83.1	4.7	69
Hereford				
Primiparous	13	76.9	4.9	88
Multiparous	25	64.0	5.0	64
Simmental				
Primiparous	14	85.7	5.0	90
Multiparous	22	68.2	5.0	59

[a]Percentage of cows with elevated serum progesterone before the beginning of the breeding season.

Table 2. Effect of using GnRH, PGF $_{2\alpha}$, and Norgestomet on Estrus, Conception Rate, and Pregnancy Rate

		Heat Detection + Time Bred		
Item	Estrus Bred	Estrus Bred	Time Bred	Total
% in Heat	79.5 (78) [c]	100 (16)	14.3 (70)	30.2 (86)
% Conception [a]	67.7 (62)	68.8 (16)	57.1 (70)	59.3[x] (86)
% Pregnant [b]	53.8 (78)	68.8 (16)	57.1 (70)	59.3 (86)

[a]% Conception = no. of pregnant cows/no. of cows inseminated during 144 hours after PG $F_{2\alpha}$.
[b]% Pregnant = no. of pregnant cows/no. of cows synchronized.
[c]Number of cows.
[x]Different (P=.06) from estrus bred.

A NOVEL ESTRUS-SYNCHRONIZATION PROGRAM FOR ANESTROUS AND CYCLING, SUCKLED, BEEF COWS [1]

W. L. Forbes, L. R. Corah, D. M. Grieger, K. E. Thompson, G. C. Lamb, and J. S. Stevenson

Summary

We used four herds at three Kansas ranches to evaluate the potential of two new estrus synchronization strategies to increase estrus expression and fertility of 911 crossbred suckled beef cows. The treatments included: 1) 100 µg of GnRH and a 6-mg norgestomet ear implant on day -7 and 25 mg of PG $F_{2\alpha}$ and implant removal on day 0 (GnRH+NORG+PG $F_{2\alpha}$); 2) 100 µg of GnRH on day -7 and 25 mg of $PGF_{2\alpha}$ on day 0 (GnRH+PG $F_{2\alpha}$); and 3) (control) 25-mg injections of PG $F_{2\alpha}$ on days -14 and 0; (2×$PGF_{2\alpha}$ control). The GnRH+NORG+ $PGF_{2\alpha}$ and GnRH+$PGF_{2\alpha}$ treatments increased (P<.01) the overall percentages of cows detected in estrus by 49% and 27% and pregnancy rates by 46% and 37%, respectively, over the control group, without altering conception rate. Both treatments increased the estrus, conception, and pregnancy rates of noncycling cows, compared to controls.

(Key Words: Estrus Synchronization, AI, GnRH, PG $F_{2\alpha}$, Norgestomet.)

Introduction

Estrus-synchronization programs are popular and profitable tools for improving the reproductive performance of cow herds. Synchronization combined with artificial insemination (AI) improves overall reproductive efficiency by reducing the duration of the breeding and calving seasons and allowing increased use of AI sires with superior genetic potential. Current synchronization programs are designed to synchronize estrus in cows that are already cycling at the beginning of the breeding season. They are not intended to induce estrus in noncycling cows. Therefore, our objective was to test the effect of two new treatments to induce estrus and increase conception and pregnancy rates in anestrous suckled beef cows, as well as to synchronize estrus in cycling cows.

Experimental Procedures

Four herds of predominantly crossbred cows (n= 911) at three locations were allotted randomly to two treatments and one control (Figure 1): 1) 100 µg of GnRH and a 6-mg norgestomet ear implant on day -7 and 25 mg of $PGF_{2\alpha}$ and implant removal on day 0 (GnRH+NORG + $PGF_{2\alpha}$); 2) 100 µg of GnRH on day -7 and 25 mg of $PGF_{2\alpha}$ on day 0 (GnRH+$PGF_{2\alpha}$); and 3) 25-mg injections of

[1]We acknowledge partial financial support by Select Sires Inc., Plain City, OH; Pharmacia & Upjohn, Kalamazoo, MI, for $PGF_{2\alpha}$ (Lutalyse®); Fort Dodge Laboratories Inc., Fort Dodge, IA, for GnRH (Factrel®); Rhone-Merieux, Inc., Athens, GA, for GnRH (Cystorelin®) and SyncroMate B® implants (norgestomet); and the assistance of Jon Ferguson, Joe Thielen, and Dean Perkins, cattle producers who most willing cooperated in this study. Special thanks go to all who assisted in this project: Chris Riedel, Brice Guttery, Mike Marshall, Dustin Covey, Jon Siefkes, Linc Lunsway, Becky Hansen, Abby Janssen, Juliana Coalson, Brian Miller, Betty Hensley, and Cody Wright.

$PGF_{2\alpha}$ on days -14 and 0; (2×PG $F_{2\alpha}$) (control). Three blood samples were collected (days -14, -7, and 0) before the last $PGF_{2\alpha}$ injection to determine estrus-cycling status. If any one of the three samples containe d ≥1 ng/ml serum progesterone, then the cows wer eassumed to be cycling. Cows were observed for estrus twice daily (4 hours each) for 144 hours after PG $F_{2\alpha}$. All cows wer einseminated 12 to 14 hours after first detected standing estrus. Body condition score was assessed at the time of $PGF_{2\alpha}$ injection, and pregnancy was diagnosed by transrectal ultrasonography between 32 and 51 days after AI. Conception rate was defined as the proportion of cows detected in estrus and inseminate d during 144 hours afte r$PGF_{2\alpha}$ that becam e pregnant. Pregnancy rat ewas defined as the proportion of treated cows that became pregnant.

Results and Discussion

Body condition scores ranged from 1 (thinnest) to 6.5, with an average o f4.5 on a 1 to 9 scale. In addition, days postpartum at the onset of the breeding season ranged from 21 to 108, with an overall average of 72 across all herds. The combination of somewhat lower body condition scores, fewer days postpartum, and the lack of spring pasture may have reduced estrus, conception, and pregnancy rates in herds 3 and 4.

The percentages of cows that exhibited standing estrus were greater (P<.05) in the two treatments than in controls. The GnRH +NORG+$PGF_{2\alpha}$ treatment had 51% and the GnRH+$PGF_{2\alpha}$ treatment had 27% more cows showing heat than the control. Although the treatment s had no statistically significant effect on conception rate (Table 1), pregnancy rates were greate r(P<.05) in the two treatments than in the control.

Based on the three blood s amples, 54.8% of the females were cycling at the time of the $PGF_{2\alpha}$ injection. Within the cycling cows, conception and pregnancy rates were not different between treatments and control (Table 2). The major advantage of the treatments was the positive reproductive response in the anestrous cows. Both GnRH+NORG +$PGF_{2\alpha}$ and GnRH+$PGF_{2\alpha}$ treatments resulted in a greater proportion of cows detected in estrus with higher fertility, resulting in greater pregnancy rates compared to controls (Table 2). The GnRH+NORG+$PGF_{2\alpha}$ treatmen t induced both the earliest and tightest synchrony of estrus (Figure 2). In that treatment, 50.5% of the cows showed detectable estrus between 24 and 48 hours after the $PGF_{2\alpha}$ injection, compared to 32.4% in the GnRH+ $PGF_{2\alpha}$ and 16.1% in the 2×$PGF_{2\alpha}$ (control) group.

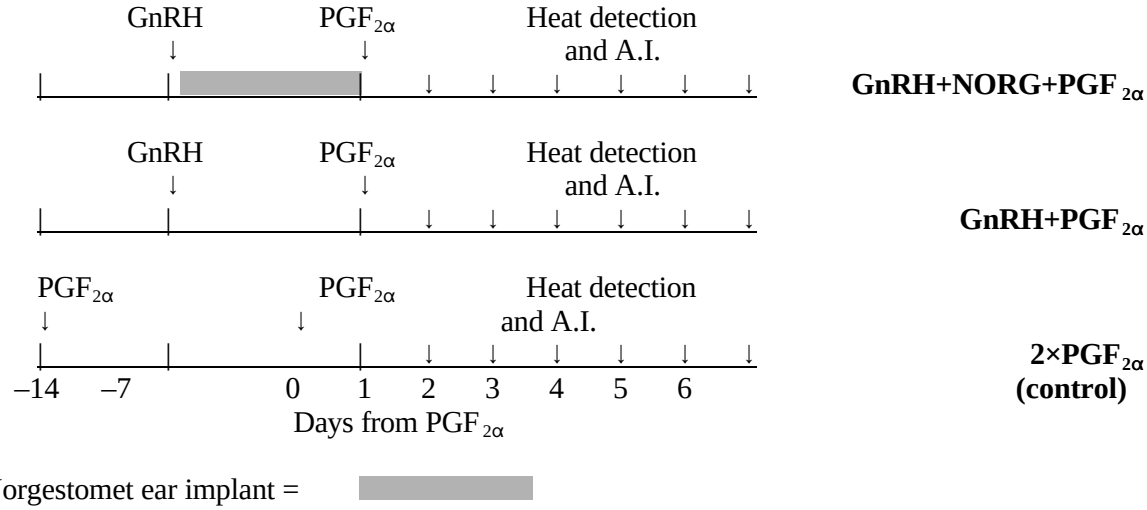

Figure 1. Experimental Protocol for Two New Estrus-Synchronization Treatments.

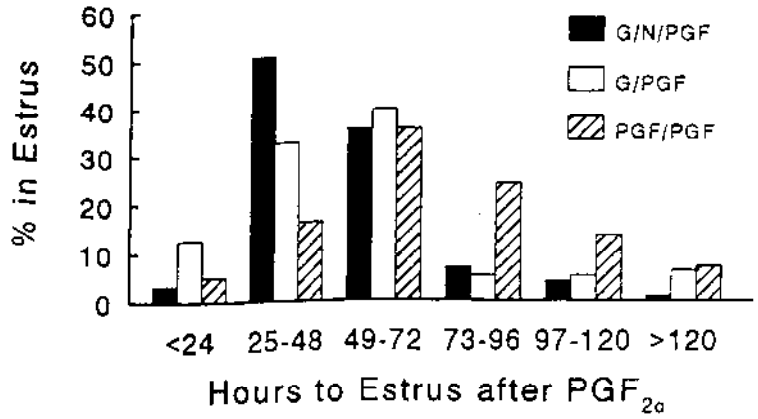

Figure 2. Distribution of Estrus in Cows that Were Detected in Estrus after PGF $_{2\alpha}$.

Table 1. Expression of Estrus, Conception, and Pregnancy Rates[a]

		Estrus, %			Conception, %			Pregnancy, %				
Herd	No.	A	B	C	A	B	C	A	B	C	BCS[b]	Days[b]
1	206	92.1	76.5	60.9	67.2	75.5	52.4	61.9	57.8	31.9	4.7	81
2	266	89.5	79.8	71.6	57.1	69.0	68.2	51.2	55.1	48.9	4.6	73
3	329	54.6	44.4	25.7	53.4	55.3	57.1	28.7	24.1	14.7	4.5	68
4	110	38.9	23.5	25.0	57.1	37.5	55.6	22.2	8.8	13.9	3.8	64
All	911	71.0[x]	59.7[y]	47.0[z]	58.9	65.7	60.6	41.6[x]	39.0[x]	28.5[y]	4.5	72

[a]A = GnRH+NORG+PGF $_{2\alpha}$; B = GnRH+PGF $_{2\alpha}$; and C = 2xPGF $_{2\alpha}$.
[b]BCS = body condition score and days postpartum at beginning of the breeding season (time of PGF $_{2\alpha}$ injection).
[x,y,z](P < .05).

Table 2. Reproductive Traits of All Cows Based on Concentrations of Progesterone

	Treatment		
Cycling Status [a]	GnRH+NORG+PGF $_{2\alpha}$	GnRH+PGF $_{2\alpha}$	2xPGF $_{2\alpha}$ (control)
Anestrus, %	51.2	38.3	45.6
No. of cows	153	116	140
Estrus, %	51.0	30.2	15.7
Conception rate, %	58.4	68.6	27.3
Pregnancy rate, %	29.4	20.7	4.2
Cycling, %	48.8[b]	61.7[c]	54.4[b,c]
No. of cows	146	187	166
Estrus, %	91.8	79.1	74.1
Conception rate, %	59.0	64.6	66.7
Pregnancy rate, %	54.1	50.8	49.4

[a]If any one of three blood serum samples contained high (1 ng/ml) progesterone, then the cows were assumed to be estrus-cycling before PGF $_{2\alpha}$ injection.
[b,c](P < .0l).

ESTRUS DETECTION, FIRST SERVICE CONCEPTION, AND EMBRYONIC DEATH IN BEEF HEIFERS SYNCHRONIZED WITH MGA AND PROSTAGLANDIN [1]

G.C. Lamb, B.L. Miller [2], V. Traffas [3], and L.R. Corah

Summary

In April, 1996, 1501 yearling crossbred heifers located on seven different ranches were estrus-synchronized and artificially inseminated (AI) 12 hours after they were detected in estrus. Herd size ranged from 82 to 439 head. Of the 1501 heifers, 86.1% were detected in estrus. First service conception rates of those 1292 heifers averaged 58.4% (40.3 to 68.8%). In three herds, ultrasonography was used to diagnose 525 heifers as pregnant at 30 days after AI. At 60 to 90 days after the breeding season, palpation of the uterus confirmed that embryonic death had occurred in 4.2% (4.0 to 4.8%). First service conception rates varied widely among ranches. The variation might have been due to factors such as climate, average daily gain, body condition, AI technician, and AI sire. A small percentage of embryos died after the 30-day ultrasound exam regardless of the ranch or management system.

(Key Words: Artificial Insemination, Synchronization, Ultrasound, Conception, Embryonic Death.)

Introduction

Proper management of replacement heifers is critical to their future production and longevity. Many producers utilize estrus-synchronization systems and AI to increase the proportion of replacement heifers that conceive earlier in the breeding season. Consequently, these females produce their first calf early in the calving season and tend to continue to calve earlier throughout their productive life.

Fetal aging by rectal palpation, subsequent estrus activity, or calving dates are used to determine whether the calf was sired by an AI or cleanup bull. Although these methods are useful, they very often produce inaccurate conception or pregnancy rates.

Ultrasonography can be used to determine the presence of a viable embryo as early as 28 days of pregnancy. In addition, ultrasonography can be used for ovarian and uterine scans and fetal sexing. This technology also can be used to accurately determine conception and pregnancy rates and evaluate the viability of estrus synchronization and AI protocols. Our objectives were to determine the difference in first service conception rates among ranches using a common estrus-synchronization protocol and to estimate the incidence of embryonic death after a viable embryo had been detected at 30 days of pregnancy.

Experimental Procedures

In April, 1996, 1501 yearling crossbred heifers from seven ranches in Kansas and Missouri were synchronized using a common estrus synchronization and AI program. Herd size ranged from 82 to 439 and averaged 214 head. Estrus was synchronized by feeding MGA (.5 mg per head per day for 14 days) and then

[1]The authors express their appreciation to Jack Grothuson, Otto Levin, Roger and Mark Losey, Steve Peterson, Mike Peterson, and Sam Rice for providing the heifers used in this experiment.

[2]RR1, Box 30, Mt. Solon, VA.

[3]Traffas Veterinary Service, Smith Center, KS.

giving a prostaglandin $F_{2\alpha}$ injection 17 days after MGA withdrawal. Heifers were observed for signs of estrus and inseminated artificially by an experienced technician 12 to 16 hours after the first detected standing heat. At 29 to 33 days after AI, ultrasonography was used to establish the presence of a viable embryo and to determine first service conception rates. Incidence of subsequent embryonic death was monitored in three herds. At 60 to 90 days after the end of the breeding season, pregnancy was reconfirmed by uterine palpation in the 525 heifers that were earlier diagnosed pregnant to AI by ultrasonography.

Results and Discussion

Table 1 shows the variability in detection of estrus and first service conception rates among ranches. Of the 1501 heifers initially synchronized, 1292 (86.1%) were detected in estrus within 72 hours and had first service conception rates of 40.3 to 68.8%, with an average of 58.4%. The remaining 209 heifers received a fixed-time AI and(or) were exposed to cleanup bulls. A primary goal of an estrus-synchronization system is to maximize the number of replacement heifers bred to proven AI sires within the first few days of the breeding season. Thus, calves are born earlier and have the potential for greater growth and heavier weaning weights.

The variability in first service conception rate among ranches could have been a result of such factors as average daily gain, body condition score, climate, AI technician, and AI sire.

Embryonic death was measured in three herds (A, D, G; Table 1). Of the 525 heifers diagnosed pregnant at 29 to 33 days after insemination, 4.2% (4.0 to 4.8%) of the heifers did not have viable embryos at palpation. Most reports suggest a 5 to 25% embryonic loss between 30 and 60 days after insemination. Therefore, our observations support the notion that, regardless of the management system, a small percentage of embryos die. Ultrasonography can monitor the success of a breeding program and can accurately determine first service conception rates and embryonic death. This technology can enhance the ability of cow-calf producers to make decisions that impact profitability and efficiency of their operation.

Table 1. Estrus Detection, First-Service Conception, and Embryonic Death of Beef Heifers Synchronized with MGA and Prostaglandin

	Ranch						
Item	A	B	C	D	E	F	G
No. of heifers	414	175	121	439	82	101	169
No. detected in estrus (%)	339 (81.9)	151 (86.3)	85 (70.2)	404 (92.0)	62 (75.6)	93 (92.1)	158 (93.5)
% first service conception	44.0	60.9	57.6	67.1	40.3	68.8	66.5
No. of embryo deaths[a] (%)	6 (4.0)	-	-	11 (4.1)	-	-	5 (4.8)

[a]Viable embryos at 30 days of pregnancy that died thereafter.

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MILKING TWICE DAILY IN THE PRESENCE OF A COW'S OWN CALF FAILS TO PROLONG POSTPARTUM ANESTRUS

G. C. Lamb, J. M. Lynch, B. L. Miller, D. M. Grieger, and J. S. Stevenson

Summary

Six treatments were initiated approximately 15 days after calving: 1) calf was weaned permanently from its dam (calf weaned; CW); 2) calf was present continuously with its dam but contact with the udder was prohibited (calf restricted; CR); 3) calf was present continuously with its dam (calf present; CP); 4) CR dam was suckled twice daily by her own calf (CR+S2×); 5) CW dam was milked twice daily (CW+M2×); 6) CR dam was milked twice daily (CR+ M2×). During the 4-week treatment period, cows in the CR+M2× treatment had twofold greater yield milk and milk components than CW+M2× cows. After completing treatments, calves were returned to their dams and allowed to suckle ad libitum. At the time when suckling was reestablished, milk yield was greatest in CP cows, followed by CR+S2×, CR+M2×, and CW+M2× cows, respectively. Although, lactation in CW and CR cows ceased, it was reinitiated after 1 week of renewed suckling, and increased further by 5 weeks. Cows milked twice daily (CR+M2× and CW+M2×) had their first postpartum ovulation about 2 weeks after weaning, similar to cows not milked or suckled (CW and CR). In contrast, cows suckled by their calves either twice daily (CR+S2×) or ad libitum (CP) first ovulated about 5 weeks after initiation of treatments. We concluded that milk removal by suckling, but not mechanically by milking 2× daily, is essential to prolong postpartum anestrus. Furthermore, suckling limited to 2× daily prolonged postpartum anestrus as much as ad libitum suckling.

(Key Words: Milking, Suckling, Calf Presence, Anestrus.)

Introduction

Because duration of gestation in cows limits them to one calf crop per year, loss in potential calf gains is attributed to the failure of cows to conceive during the normal breeding season. That loss can be reduced by shortening the interval to first postpartum estrus.

The cow-calf suckling interaction is a critical component in maintaining anestrus. Previous KSU research showed that cows suckled continuously had longer intervals to first estrus than cows whose calves were weaned. Maintaining cows continuously with their muzzled or nose-plated nonsuckling calves prolonged anestrus as long as when calves were allowed to suckle, because continued calf presence maintained the perception of suckling or milk removal.

Cows nursing foster calves continuously or nursing alien calves continuously in the presence of their own nonsuckling calves (their own calves were present continuously but contact with the udder was prohibited) had intervals to first ovulation similar to those of cows nursing their own calves and longer than those of weaned cows. These observations suggest that a cow must first recognize the suckling calf to be her own (bonding to her natural born calf or reforming a bond with an alien "foster" calf) before subsequent suckling will prolong anestrus. The present experiment was designed to confirm our earlier report (1996 Cattlemen's Day; KAES Report of Progress 756:22) that milking a cow 2× daily in the presence of her own udder-restricted calf would prolong the postpartum interval to first ovulation. An additional objective was to determine to what extent lactation could be reestablished after cows were neither suckled

nor milked for 4 weeks, followed by renewed ad libitum suckling by their own calf.

Experimental Procedures

Crossbred (Angus × Hereford) cow-calf pairs were used in two replicates following calvings during the spring of 1995 and 1996. Cows were assigned randomly to six treatments, 15 days after calving: 1) calf was weaned permanently from its dam (calf weaned; CW; n=9); 2) calf was present continuously with its dam but contact with the udder was prohibited (calf restricted; CR; n=9); 3) calf was present continuously with its dam (calf present; CP; n=9); 4) CR plus dam was suckled twice daily by her own calf (calf restricted + suckled; CR+S2×; n=8); 5) CW plus dam was milked twice daily (calf weaned + milked; CW+M2×; n=9); 6) CR plus dam was milked twice daily (calf restricted + milked; CR+M2×; n=9). Cows remained on treatments for 4 weeks and then were reintroduced to their calves and allowed to nurse them continuously. Daily blood samples were collected from cows to determine their first increase in serum progesterone after the initiation of treatments. Ovulation occurred 1 to 2 days before serum progesterone exceeded .5 ng/ml for at least 2 days.

Cows were fed individually to meet or exceed NRC recommendations, and intakes were adjusted weekly according to individual body weight and condition. The CW and CR cows were fed as dry second-trimester, pregnant, beef cows and the CP, CR+S2×, CW+M2×, and CR+M2× cows were fed as superior milk producers. Restricted calves in the CR and CR+M2× treatment were fed a whole-milk replacer twice daily.

Milk production was recorded daily and milk samples were collected weekly to assess contents of fat, protein, lactose, and solids-not-fat (SNF) and somatic cell counts (SCC) in the CW+M2× and CR+M2× treatments. Before and 1 and 5 weeks after reintroducing cows to their calves and suckling ad libitum, 24-hour milk production (two milkings during 24 hours after receiving 40 IU of oxytocin) and fat, protein, lactose, SNF, and SCC in milk were measured.

Results and Discussion

Average daily milk production characteristics of CW+M2× and CR+M2× cows during the 4-week treatment period are shown in Table 1. Percentage of milk components was similar between treatments, but daily yields of fat, protein, lactose, and SNF in milk were greater ($P<.05$) in CR+M2× cows than in CW+M2× cows. In addition, average daily milk production throughout the 4-week treatment period was 15.8 lb for CR+M2× compared to 8.4 lb for CW+ M2× cows. Therefore, the nonsuckling presence of a cow's calf is a critical component in maintaining milk production in milked beef cows.

Milk yield and SNF for all cows at the initial reestablishment of suckling (0 weeks) and 1 and 5 weeks later are shown in Figure 1. At the time that suckling was reestablished, CP cows had the greatest milk yield, followed by CR+S2×, CR+M2×, and CW+M2×, respectively.

Because CW and CR cows were not suckled during the 4-week treatment period, they were no longer lactating. However, after 1 week of renewed suckling, lactation in both groups was reinitiated. After 5 weeks of suckling, milk production had increased further, but not to the extent of those cows whose lactation was not interrupted.

Percentages of milk fat, milk protein, milk lactose, and milk SNF before renewed suckling were less in CW and CR cows than in the other four treatments, but after 1 week of suckling, milk composition was restored to normal percentages. Therefore, although those cows were neither suckled nor milked for 4 weeks, when suckling was reestablished, they reinitiated sufficient lactation to support a growing calf.

The postpartum interval to first increase in progesterone (first ovulation) was shorter ($P<.05$) in the CW (14.1 ± 3.1 d), CR (14.2 ± 3.1 d), CW+M2× (13.0 ± 31 d), and CR+M2× (17.2 ± 3.1 d) treatments than in the CP (34.7 ± 3.1 d) and CR+S2× (33.9 ± 3.3 d) treatments. These results contradict our earlier report (1996 Cattleman's Day; KAES Report of Progress

756:22), which indicated that anestrus was no t prolonged when a cow is milked (by machine) twice daily. In the present study, anestrus was prolonged when a cow was suckled only twice daily by her own calf.

Maintaining anestrus involves two critical components: 1) a cow must first recognize and remain bonded to her own calf and 2) milk must be removed by suckling (at least 2× daily) but not by machine milking . We conclude that milk removal by suckling is essential to prolong postpartum anestrus. Furthermore, suckling limited to twice daily prolonged postpartum anestrus as much as ad libitum suckling.

Table 1. Average Daily Milk Production Characteristics of Cows during a Four-Week Treatment Period Initiated on Day 15 Postpartum

Treatment[a]	No. of cows	Milk (lb)	Fat (lb)	Protein (lb)	Lactose (lb)	SNF[b] (lb)	SCC[c] (×1000)
CR+M2x	9	15.8[x]	.69[x]	.53[x]	.81[x]	1.43[x]	140
CW+M2x	9	8.4	.34	.28	.39	.74	104

[a]CW+M2x = calf weaned + milked and CR+M2× = calf restricted + milked.
[b]SNF = solids-not-fat.
[c]SCC = somatic cell count.
[x]Different (P < .05) from CW+M2×.

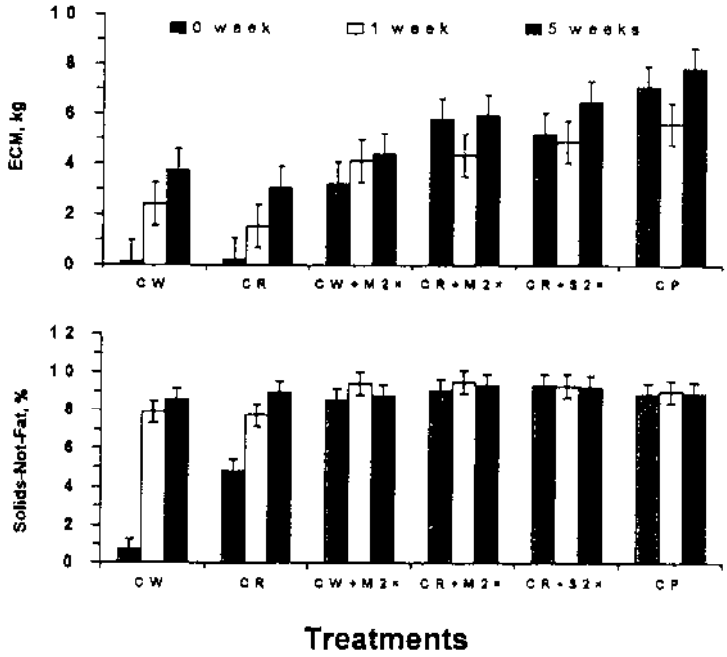

Figure 1. Energy-Corrected Milk (ECM; upper panel) and SNF (lower panel) at 0, 1, and 5 weeks in Cows after Ad Libitum Suckling was Reestablished Following the End of Treatments. Cows were suckled ad libitum until 15 days postpartum and then treatments imposed were: calves were weaned (CW); calves were udder restricted (CR); CW + milked twice daily (C W+M2×); CR + milked twice daily (CR+M2×); CR + suckled twice daily (CR+S2×); cows were suckled ad libitum (CP). Treatments continued for 4 weeks and then calves were reunited with their dams (0 week) and allowed to suckle ad libitum thereafter.

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REPRODUCTIVE PERFORMANCE OF REPLACEMENT HEIFERS IMPLANTED AS YOUNG CALVES OR AT WEANING [1]

D. M. Grieger, L. R. Corah, A. R. Spell, D. L. Cook [2], M. D. Butine [3], and K. Anderson

Summary

This study evaluated the effect of implanting potential replacement heifers (n=548) with Component E-C®[4,5] (10 mg of estradiol and 100 mg of progesterone) between 45 and 120 days of age or at weaning (200 days of age) on future reproductive performance. Trials were conducted at five ranches in Kansas and one in Nebraska. At each location, heifers were allotted to three treatments: no implant (Control), one implant at 45 to 120 days of age (Early-IMP), or one implant at 200 days of age (Wean-IMP). No differences were detected among treatments for first service conception rate (55%), overall pregnancy rate (85%), or calving rate (80%). In addition, no differences were observed among treatments for pelvic area, reproductive tract score, or calving difficulty or for birth or weaning weights of their calves. We conclude that implanting replacement heifers with Component E-C early in life or at weaning had no effect on their subsequent reproductive performance.

(Key Words: Implant, Calves, Replacement Heifers, Conception Rate.)

Introduction

Although implanting weaned heifers and steers destined for the feedlot enhances their rate of growth, growth benefits also are observed when calves are implanted at younger ages, before their selection as future replacements. Conflicting reports exist concerning the effects of early implanting of heifers on their subsequent reproductive performance. Therefore, our objective was to determine the effect of early implantation with Component E-C on future reproductive performance of replacement heifers.

Experimental Procedures

This study involved 548 calves located at five ranches in Kansas and one in Nebraska. Heifer calves at each location were assigned to three treatments at 45 to 120 days of age. Controls received no implant. Early implanted (Early-Imp) calves received one Component E-C implant between 45 and 120 days of age. Weanling-implanted (Wean-IMP) calves received one Component E-C implant between 192 and 205 days of age. A single Component E-C implant contains 10 mg of estradiol and 100 mg of progesterone. Heifers were weighed at the onset of the study, weaning, 1 year of age, and precalving. All heifers remained with their dams until 6 to 8 months of age. A single technician made pelvic measurements at approximately 12 months of age. Reproductive

[1]Sincere appreciation is expressed to Ivy Laboratories, Overland Park, KS for financial support.

[2]Ivy Laboratories, Inc., Overland Park, KS.

[3]Department of Statistics.

[4]Marketed by VetLife, Overaland Park, KS. Previously known as Implus-C® and Calfoid®.

[5]Now cleared for use in replacement heifers.

tract scores were assessed at 12 months of age by palpation per rectum. Tracts were scored from 1 to 5; with 1 being an infantile tract (prepubertal) and 5 indicating good uterine tone, at least one large ovarian follicle, and a corpus luteum (cycling). All heifers were inseminated artificially during at least a 21-day period and pregnancy was diagnosed by ultrasonography after a 45- to 60-day breeding season. Subsequent calving difficulty was scored from 1 to 5 (1=no assistance and 5=cesarean section. Birth and weaning weights of their calves were recorded.

Results and Discussion

Implanting heifers at 45 to 120 days improved weaning and yearling weights (Table 1), but had no effect on first service conception rate, overall pregnancy rate or calving rate among the three treatments (Table 2). Similarly, no differences were detected for pelvic area, reproductive tract score, or calving difficulty of implanted heifers. Birth and weaning weights of calves born to implanted heifers were unaffected by treatments (Table 3). We concluded that implanting heifer calves as early as 45 days of age with Component E-C had no effect on their subsequent reproductive performance.

Table 1. Effect of Treatment on Weight Change of Implanted and Control Heifers

Treatment	Beginning[a]	Weaning	Prebreeding
Control, lb	254.3	561.7[x]	775.1[x]
Early-implant, lb	251.7	578.4[y]	790.5[y]
Wean-implant, lb	258.6	564.3[x]	785.2[xy]

[a]Heifers were 45 to 120 days of age at the beginning of the study.
[xy]Averages within columns lacking a common superscript letter differ (P<.05).

Table 2. Conception and Calving Rate for Control, Early-IMP, and Wean-IMP Heifers

Treatment	First Service Conception Rate %	Overall Pregnancy Rate %	Calving Rate %
Control	55.6	84.5	78.3
Early-IMP	56.2	85.6	81.0
Wean-IMP	52.1	84.6	80.7

Table 3. Reproductive Traits for Control, Early-IMP and Wean-IMP Heifers and Weights of Their Calves

	Heifers			Calves	
Treatment	Pelvic Area,[a] cm^2	Reproductive Tract Score[a]	Calving Difficulty	Birth Weight, lb	Weaning Weight, lb
Control	165	3.7	1.5	72	493
Early-IMP	176	3.8	1.4	71	489
Wean-IMP	171	3.8	1.4	74	487

[a]Measured at 12 months of age.

EFFECT OF HEIFER SOURCE ON REPRODUCTIVE PERFORMANCE, CULLING, MARKETING AND PROFITABILITY FOR A COMMERCIAL HEIFER DEVELOPMENT PROGRAM [1]

J. M. Lynch [2], G. C. Lamb, D. M. Grieger, and L. R. Corah

Summary

A commercial heifer development operation purchased 483 weanling Angus × Hereford heifers from 11 sources. Heifers were fed a common silage-based diet through an initial developmental period and retained or culled based on average daily gain, pelvic area, and disposition. The percentage of heifers culled from each source ranged from 18.1% to 94.7% and were either sold directly through a local sale barn or sent to a feedlot with retained ownership. Estrus was synchronized, and heifers were artificially inseminated (AI) for 30 days followed by 15 days of natural mating. First service conception rates for each source ranged from 0% to 92.3%, whereas overall pregnancy rates for the 45-day breeding season ranged from 81.3% to 100%. When expressed as a percentage of the original heifers purchased from each source, overall pregnancy rates ranged from 5.3% to 80%. Heifers that lost their fetuses were sold for a net loss of $213 per head. Heifers sold as first service AI bred, second service AI bred, and naturally mated netted $160, $129, and $89 per head, respectively. With accurate records, stringent culling practices, and evaluation of cost and performance, producers can optimize profit potential of replacement heifers. Early culling and pregnancy diagnosis also will decrease costs while increasing opportunities to minimize the financial risks.

(Key Words: Replacement Heifers, Culling, Artificial Insemination, Economics.)

Introduction

Beef producers commonly replace 10 to 20% of mature cows each year with heifers. Those heifers represent the future genetics and profit potential of the operation. Many producers utilize artificial insemination (AI) to hasten genetic progress. Likewise, commercial heifer development programs have grown in popularity in recent years. Our purpose was to evaluate the influence of the source of heifer calves on subsequent reproductive rates, and on the economic performance of both nonpregnant and pregnant heifers.

Experimental Procedures

In October, 1994, a commercial heifer development facility in North-Central Kansas purchased 483 weanling Angus × Hereford heifers (mean body weight = 506 lb) from 11 sources. Heifers per source ranged from 19 to 84, with an average of 44. Heifers were fed a common silage-based diet through the initial developmental period. In March, 1995, a prebreeding exam was done. Some heifers were culled, based on low average daily gain (minimum of 1.4 lb per day), small pelvic area (minimum of 140 cm^2), poor reproductive tract scores, poor disposition, or visually appraised structural unsoundness. Culled heifers were either sold directly through a local sale barn or sent to a feedlot where the producer retained ownership until they were sold for slaughter in September, 1995.

Estrus in the remaining heifers was synchronized by feeding MGA (.5 mg per head per day) for 14 days, then injecting prostaglandin $F_{2\alpha}$ (PGF) 17 days after MGA

[1]Appreciation is expressed to Losey Bros., Agra, KS for providing data for the study.
[2]Current address: Heartland Cattle Co., RR3, Box 134, McCook, NE.

withdrawal. Heifers were observed for signs of estrus beginning 24 hours after PGF and artificially inseminated (AI) 12 hours after the onset of standing heat using semen from one sire. Artificial insemination continued for 30 days followed by 15 days of natural mating to complete the 45-day breeding season. Ultrasonic pregnancy diagnosis was performed approximately 30 days after AI to determine date of conception. Pregnancy rates after first service AI, second service AI, and natural mating were determined.

In August, 1995, all nonpregnant heifers were sold directly through a local sale barn. After the breeding season, all pregnant heifers were moved to native prairie grass pasture until early November, at which time they grazed cornstalk residue for 60 days. Heifers were supplemented with prairie hay when weather limited grazing. Pregnant heifers were returned to drylot facilities for 2 weeks in January, 1996, and prepared for a special replacement heifer sale in south-central Nebraska. Pregnancy was reconfirmed via uterine palpation to determine the percentage of heifers that had aborted since conception. Heifers that lost their fetuses were sold locally. The remaining animals were sorted into groups according to their date of conception and sold at the special sale.

We calculated net profit or loss for each group using actual feed costs throughout the 15-month developmental period and actual market prices at the time animals were sold. In addition, performance and reproductive data were analyzed as a percentage of the heifers originally purchased from each source as well as the percentage of heifers retained from each source for the breeding season.

Results and Discussions

Heifers in this study were sold at various times throughout the 15-month developmental period. The net profit or loss varied for each group (Figure 1). Heifers culled at the time of the prebreeding exams and sold directly had a net loss of $45 per head, whereas those retained in the feedlot had a net profit of $8 per head. Heifers diagnosed as nonpregnant shortly after the breeding season were sold for a net loss of $33 per head; the loss for nonpregnant heifers that were wintered and sold in the following spring was $213/head. These results emphasize the importance of early culling and pregnancy detection to provide alternative sale routes. The remaining pregnant heifers were sold as first service AI bred, second service AI bred, or naturally mated for net profits of $160, $129, and $89 per head, respectively.

Another objective was to evaluate the influence of heifer source on reproductive efficiency. Following prebreeding exams, 194 heifers were culled primarily on the basis of low average daily gain and small pelvic area. The percentage of heifers culled from each source ranged from 18.1% to 94.7% (mean = 41.7%; Figure 2). Of the heifers retained for breeding, the average daily gain was 1.63 lb per day, and the mean pelvic area was 167 cm^2. First service conception rates for each source ranged from 0% to 92.3% (mean = 66.8%). Following the 45-day breeding season, overall pregnancy rates for each source ranged from 81.3% to 100% (mean = 93.8%). When expressed as a percentage of the original heifers purchased from each source, pregnancy rates ranged from 5.3% to 80% (mean = 51.8%). These results indicate that source is a major factor in predicting heifer performance. Initial culling prior to the breeding season can reduce feed costs and provide opportunities for alternative sale routes. Initial culling also reduces breeding costs and saves time and labor associated with low-fertility heifers.

Replacements for the second year were purchased from the same source only if at least 75% of heifers purchased in the year before had become pregnant during the 45-day breeding season. This resulted in repeat purchases from only 3 of the 11 original ranches and provided 33% of the heifer crop for the second year. As a result, the culling rate for the second year decreased from 41.7% to 8.6%. For producers who opt to purchase replacement heifers each year, accurate records and evaluation of heifer source, development costs, and marketing options are essential to optimize performance and improve overall management of the operation.

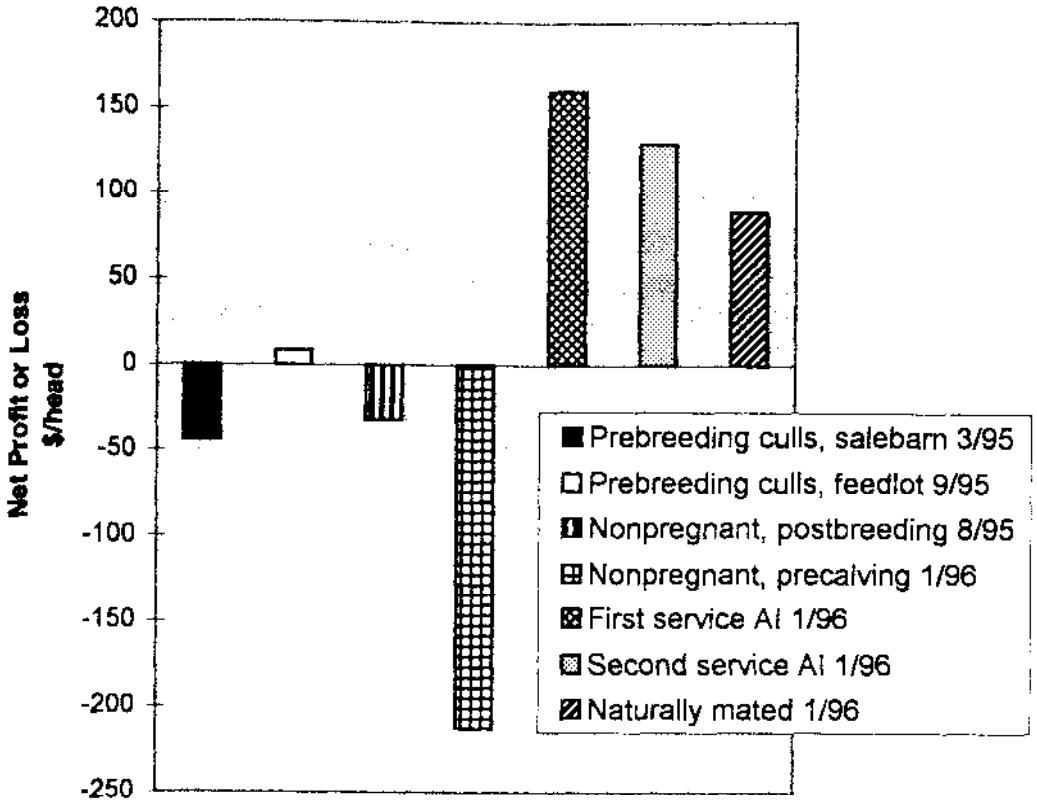

Figure 1. **Net Profit or Loss Associated with the Sale of Heifers of Various Physiological Status during a 15-Month Developmental Period.**

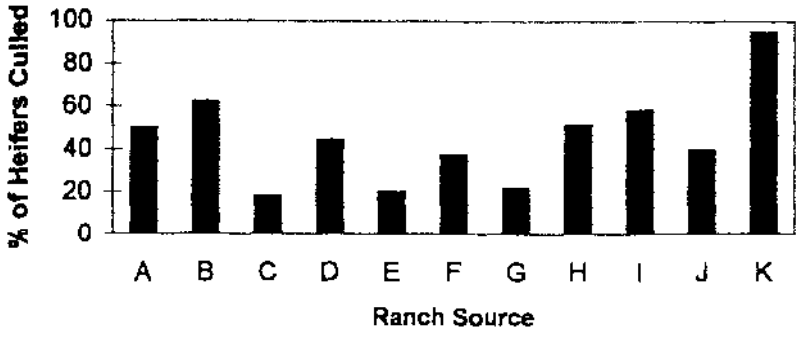

Figure 2. **Percentage of Heifers Culled from Each Source Prior to the Breeding Season.**

Cattlemen's Day 1997

FAILURE OF PRECALVING SUPPLEMENTATION OF VITAMIN E AND DIETARY FAT TO ALTER REPRODUCTIVE PERFORMANCE OF FIRST LACTATION COWS OR THE HEALTH OF THEIR CALVES

J. L. Coalson, L. R. Corah, G. L. Stokka, and F. Blecha [1]

Summary

A study was conducted to determine the effect of precalving supplementation with vitamin E and fat on the reproductive performance of first lactation cows and the health of their calves. Approximately 50 days before the first expected calving, 48 crossbred heifers were allotted to four treatments: 1) basal diet that consisted of 13 lb of prairie hay, 7.3 lb of milo, and 1 lb of supplement per heifer per day; 2) basal diet+supplement bringing the diet to 4% fat; 3) basal diet+supplement providing 1000 IU supplemental vitamin E/day; and 4) basal diet plus both fat and vitamin E. Supplementation of vitamin E and(or) fat had no effect on any reproductive trait in the cows or any immunological measurement in the calves.

(Key Words: Vitamin E, Fat, Reproduction, Calf Health.)

Introduction

Previous research has shown vitamin E supplementation (500 to 1000 IU per cow per day) before calving to improve the reproductive performance of dairy cows and reduce the incidence of conditions such as mastitis and udder edema. This benefit is apparently related to vitamin E's function as an antioxidant and its ability to prevent lipid peroxidation of membranes. Information is limited on the precalving use of vitamin E supplementation in beef cattle. An Alberta researcher reported a significant reduction in the incidence of calf scours in heifers receiving 1000 IU of vitamin E per day for 60 to 100 days prior to calving.

The objective of our experiment was to examine the effect of precalving supplementation of vitamin E with or without 4% total dietary fat on reproductive traits of first-lactation beef cows and immunological measurements on their calves.

Experimental Procedures

Approximately 50 days before the first expected calving, 48 crossbred beef heifers were allotted randomly to four treatments: 1) a basal diet consisting of 13 lb of prairie hay and 7.3 lb of grain sorghum, plus 1 lb of a basic supplement per day (control); 2) basal diet+1 lb of a supplement to bring the diet to 4% fat; 3) basal diet+ 1 lb of a supplement providing 1000 IU of supplemental vitamin E; and 4) basal diet+both fat and vitamin E. The basic supplement (control) consisted of 72% soybean meal, 27% grain sorghum, and 1% trace mineral premix. In the supplement containing the fat, grain sorghum was reduced to accommodate 24% added fat. In the supplement containing vitamin E, the grain sorghum was reduced to accommodate 3.6% of a vitamin E supplement. The fat was Fat Plus® (100% dry animal fat product; Farmland Industries, Inc.).

Within each treatment, pregnant heifers were allotted to replicates based on weight and expected calving date, resulting in heavy, average, and light weight replicates (n=4). Heifers were maintained as replicates until approximately 14 to 16 days before their expected calving date, when they were transferred to a calving unit and continuously maintained on their respective dietary regimen until 48 h after calving. Heifers were weighed at the onset of

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dietary treatments, precalving, and 36 to 40 hours after calving. Body condition scores were assessed at the beginning of the trial and just before calving.

To determine plasma concentrations of vitamin E and selenium in the dams and their calves, blood was collected at the beginning of the trial, precalving, and 36 to 40 hours after calving. Colostrum samples were collected from each dam at 36 to 40 hours postcalving, and colostral concentration of immunoglobulin (IgG) was determined by the use of single radial immunodiffusion plates containing monospecific antisera in buffered agarose. To determine the calf IgG status, blood was collected from the calves at calving, before suckling, and 36 to 40 hours later.

Beginning 44 days after the first calving, weekly blood samples were collected from the cows and later analyzed for progesterone to determine first occurrence of postpartum ovulation and luteal function. When serum progesterone exceeded 1 ng/ml in two consecutive samples, onset of estrous was presumed. Cows were exposed to a bull for natural mating during a 60-d breeding season.

Results and Discussion

Supplemental vitamin E and(or) fat had no effect on body weights, body condition score, rate of fetal membrane expulsion, interval to first ovulation, or pregnancy rates at the end of the breeding season (Table 2).

Neither fat nor vitamin E supplementation had any impact on the immunoglobulin concentration in calves, calf vigor, or their weaning weight (Table 2).

Table 1. Nutrient Content of Basal Diet [a]

Item	Prairie[b] Hay	Sorghum[c]	Soybean Meal[d,e,f]	Total Diet
Dry matter, %	90.2	86.7	88.6	88.5
Crude protein, %	6.2	10.4	47.8	9.6
Selenium, mg/kg	.10	.14	.72	.3
Vit. E[g], IU/kg	112	10.0	3.0	125
Fat[h], %	1.9	3.2	.73	3.1

[a]Results are expressed on a dry matter basis.
[b]Prairie hay and sorghum fed at the rate of 13 lb and 7.3 lb per heifer per day, respectively.
[c]Soybean meal fed as part of supplement, supplement fed at the rate of 1 lb per heifer per day. Basic supplement (control) consisted of: 72% SBM; 27% sorghum; 1.0% Z 10 mineral mix; and .004% Se premix.
[d]Vitamin E treatment received the basic supplement with the following changes: sorghum was reduced to accommodate vitamin E premix providing 1000 IU daily
[e]Fat treatment received the basic supplement with the following changes: sorghum was reduced to accommodate 24% fat.
[f]Vitamin E+fat received the basic supplement modified to contain 24% fat and 1000 IU/day vitamin E by removing sorghum.
[g]dl-∝-tocopheryl acetate.
[h]Fat Plus™ 100 (100% dry animal fat product).

Table 2. Effect of Maternal Treatment on Dam and Calf Weigh ts, Reproductive Traits, Colostral Vitamin E, and Immune Status of the Neonatal Calves

Item	n	Control	Fat	Vit E	Vit E+Fat	P	SE
Dam weight, lb							
Day 0	48	997	988	983	983	.94	19.6
Precalving	48	1032	1063	1038	1067	.57	20.9
Postcalving	46	1001	983	1001	1012	.77	20.9
Dam BCS [a]							
Day 0	48	5.0	5.2	5.1	5.0	.32	.10
Precalving	48	5.1	5.3	5.4	5.4	.10	.09
Fetal membrane expulsion, h	48	4.8	4.1	4.7	3.4	.43	.69
Days to 1st luteal function	46	52.2	69.6	64.1	73.4	.08	6.0
Pregnancy rate, %	46	100	91	91	100	.59	
Colostral vitamin E, µg/ml	46	3.1	4.9	5.1	4.2	.53	1.1
Calf IgG [b]							
Pre-suckle, mg/100 ml	47	132	282	140	132	.19	62.0
Post-suckle, mg/100/ml	47	1684	1725	1347	1589	.65	247.0
IgG <800 mg/100 ml, no.	47	1	2	3	2	.82	
Calf vigor							
1st nurse, min	47	103	145	178	115	.32	33.0
1st stand, min	47	38	63	95	73	.52	28.0

[a]Body condition score reported on a 1-8 scale (1=extremely thin; 5=moderate; 8=obese).

[b]Passive transfer: poor/low <800 mg/100 ml; moderate 800-1600 mg/100 ml; excellent >1600 mg/100 ml.

INDEX OF KEY WORDS

Indexer's note: The numbers refer to the first pages of each article that uses the listed key word.

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 ± .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.

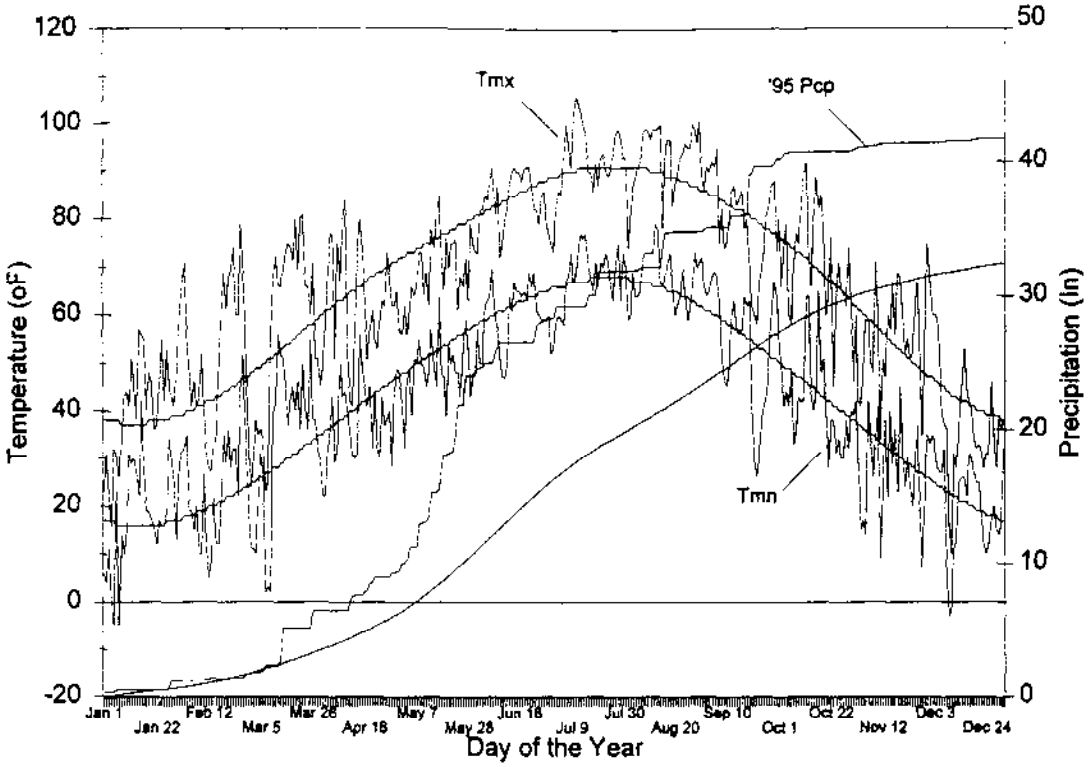
In most experiments, the statistical analysis is too complex to present in the space available. Contact the authors if you need further statistical information.

WEATHER DATA, 1995-1996

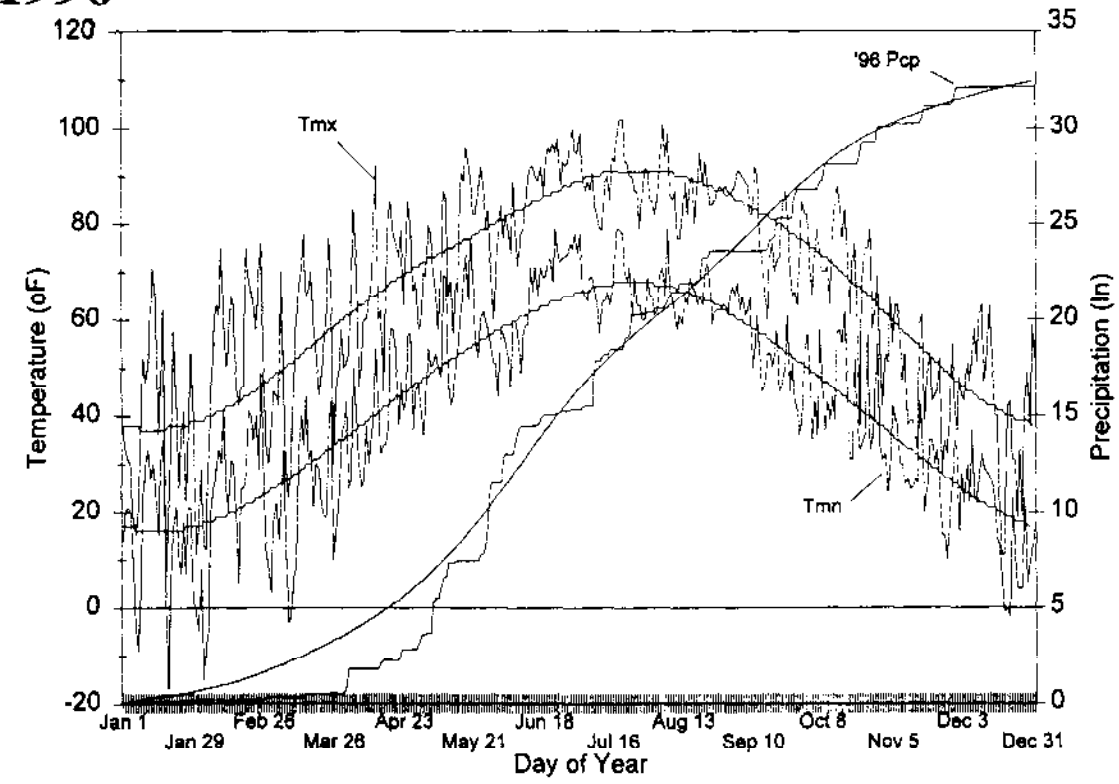
On the following page are graphs of the 1995 and 1996 Manhattan weather. They were produced by the Kansas State University Weather Data Library. The smooth line that starts in the lower left corner of each graph is the normal accumulated precipitation since January 1. The rough line starting in the lower 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.

1995



1996



Summaries of Weather in Manhattan, KS, 1995 and 1996

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Listed below are individuals, organizations, and firms that have contributed to this year's beef research program through financial support, product donations, or services. We appreciate your help!

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BASF Animal Nutrition, Mount Olive, New Jersey
Bayer Corporation, Shawnee Mission, Kansas
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BRC Bearing Co., Inc., Salina, Kansas
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Brill Corporation, Norcross, Georgia
Browning Manufacturing, Maysville, Kentucky
Bunge Corporation, Emporia, Kansas
Cargill Meat Sector, Minneapolis, Minnesota
Cargill Molasses Liquid Products, Minneapolis, Minnesota
Central City Scale, Central City, Nebraska
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Elanco Animal Health, Indianapolis, Indiana
Excel Corporation, Wichita, Kansas
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Kansas Beef Council, Topeka, Kansas
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Losey Bros., Agra, Kansas
Loveland Industries, Greeley, Colorado
M&W Distributing, Adel, Iowa
Mallinckrodt Veterinary, Inc., Mundelein, Illinois
Merck AgVet, Inc., Rahway, New Jersey
Ore-Ida Foods Inc., Boise, Idaho
Peterson Farms, Wamego, Kansas
Pfizer Animal Health, Exton, Pennsylvania
Pharmacia and Upjohn, Kalamazoo, Michigan
Pioneer Hi-Bred International, Inc., Johnson, Iowa
Poly Tank Corporation, Litchfield, Minnesota
Richard Porter, Porter Farms, Reading, Kansas
Rhone-Merieux, Inc., Athens, Georgia
Rhone-Poulenc Animal Nutrition, Atlanta, Georgia
Roche Animal Health, Nutley, New Jersey
Schering-Plough Animal Health, Kenilworth, New Jersey
Select Sires, Plain City, Ohio
Stanion Wholesale, Salina, Kansas
Sunglo Feeds, Inc., Hesston, Kansas
Superior Boiler Works, Hutchinson, Kansas
Snyder Industries, Lincoln, Nebraska
Tenneco Packaging, Canandaigua, New York
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