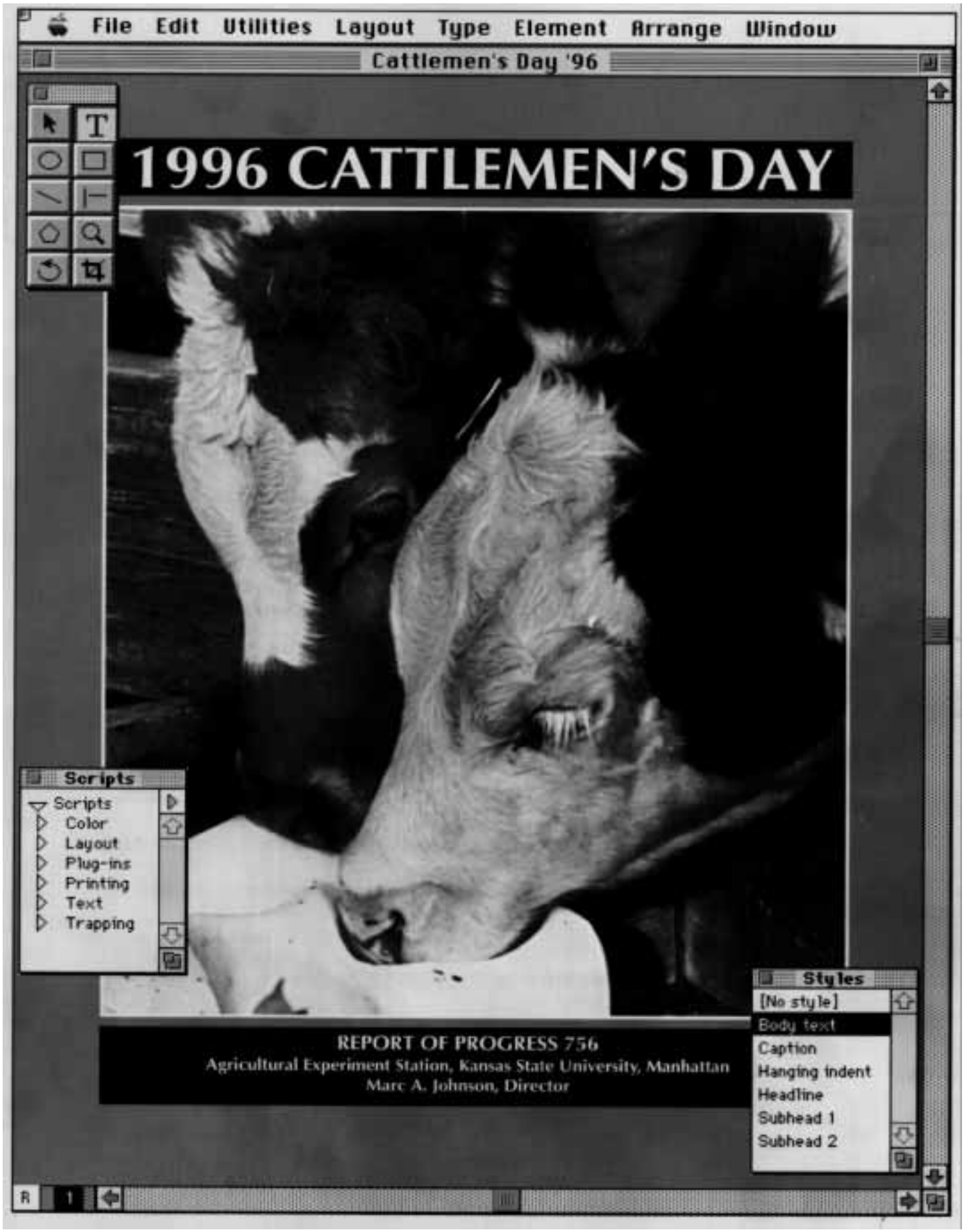

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Contribution No. 96-334-S from the Kansas Agricultural Experiment Station.

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STEAM PASTEURIZATION OF BEEF CARCASSES

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Summary

This research evaluated the effectiveness of a newly patented steam-pasteurization process for reducing bacterial populations on the surfaces of freshly slaughtered beef carcasses. The process was developed jointly by Frigoscandia Food Processing Systems (Bellevue, WA) and Excel Corp. (Wichita, KS), a division of Cargill (Minneapolis, MN). In laboratory studies, portions of prerigor beef carcasses inoculated with very high levels of three pathogens, *Salmonella*, *Escherichia coli* O157:H7, and *Listeria*, were treated in a prototype steam-pasteurization chamber, which effectively eliminated at least 99.9% of all three pathogens and was most effective when used in combination with other standard commercial decontamination methods. The effectiveness of a full-scale, automated, steam-pasteurization system was evaluated in a commercial beef slaughter facility. The commercial system was very effective, reducing the naturally occurring overall bacterial population by over 90% and reducing the population of *E. coli* (nonpathogenic) and related organisms to undetectable levels. Steam pasteurization is very effective at reducing bacterial contamination on unchilled beef carcasses and should be viewed as one step in an overall process of reducing the risk of pathogenic bacteria in beef and beef products.

(Key Words: Steam Pasteurization, Slaughter, Beef Safety, *E. coli* O157:H7.)

Introduction

During slaughter, bacterial contamination of beef carcass surfaces is unavoidable. The surface of dressed carcasses may become contaminated with bacteria via many sources including processing equipment and slaughterhouse workers. However the predominant source of bacteria is the animal itself. Materials associated with cattle, such as hide, hooves, intestinal contents, and milk, may harbor large numbers of bacteria, including pathogens. For this reason, current USDA-FSIS regulations require that all visible feces, hair, ingesta, or milk be removed from the surface of beef carcasses. According to USDA-FSIS, the investigation of processing procedures that effectively eliminate physical and microbial contamination is of prime importance.

Our research was conducted in two phases; the first in a laboratory and the second in a commercial setting. The objective of the laboratory phase was to determine the effectiveness of steam pasteurization and four other decontamination treatments, when used in combination and individually, for reducing high levels of three pathogens that had been inoculated onto the surfaces of prerigor beef. The objective of the commercial phase was to determine the effectiveness of a full-scale steam-pasteurization process for eliminating naturally occurring bacteria on freshly slaughtered beef carcasses.

Experimental Procedures

Laboratory Phase. Unchilled prerigor sections of *Cutaneous truncii* (rose meat) muscles from freshly slaughtered fed steers were smeared with bovine feces with added pathogens to inoculate the surface with high levels (5.0 $\log_{10}$ CFU/cm^2) of *Salmonella typhimurium*, *Escherichia coli* O157:H7, and *Listeria monocytogenes* (5.0 log equals 100,000 microorganisms). Meat portions then were treated with either a single decontamination treatment or a combination of two or more treatments. The treatments included steam pasteurization (S) for 15 seconds, knife trimming

(T) of visible contamination, washing (W) with warm (95 F) water, applying a 2% lactic acid (L) solution, and removing visible contamination with a commercial, spot-cleaning, hot water/steam, vacuum system (V). Samples removed from the inoculated meat surface area before and after treatment were analyzed for pathogenic bacteria. All experiments were repeated four times.

Commercial Phase. After passing final inspection and immediately prior to entering coolers, carcass sides were treated in a commercial-size, automated, steam-pasteurization system capable of treating four carcass sides per cycle. Sides were exposed to steam for 8 seconds (meat surface temp of 195 F or higher) and then immediately cooled with a cold (34 F) water shower. Samples were taken from 140 carcass sides (70 cows and 70 fed cattle) before, immediately after, and 24 hours after steam treatment to determine the number of bacteria killed. Samples collected before and immediately after treatment also were analyzed for the presence of naturally occurring *Salmonella*.

Results and Discussion

Laboratory Phase. The mean reduction in populations of each pathogen by various decontamination treatments (Table 1) was analyzed statistically in two separate parts. All treatments in both experimental parts reduced ($P<.05$) the initial populations of all three pathogens. In part 1, all combinations of treatments were equally effective at reducing populations of *E. coli* O157:H7. For both *S. typhimurium* and *L. monocytogenes*, TW, TWLS, and VWLS were slightly more effective, and VW and VWS were least effective. In part 2, regardless of pathogen type, the least effective treatment was warm water wash alone. For *E. coli* O157:H7, all treatments except wash alone were equally effective. Vacuum spot-cleaning and steam pasteurization were very similar to combination treatments in part 1 in their ability to reduce populations of *S. typhimurium* and *L. monocytogenes* and were slightly more effective than trimming alone.

Although several methods were effective at reducing high levels of pathogenic bacteria on the surface of prerigor beef, they are not equally practical in a commercial setting. It is impossible to use knife trimming and vacuum spot-cleaning to decontaminate an entire carcass; warm water washing used alone may simply redistribute contamination; and lactic acid is corrosive to processing equipment and unpleasant for employees. Steam pasteurization does not have these drawbacks.

Commercial Phase. The average bacterial populations on the surface of carcasses before, immediately after, and 24 hours after steam pasteurization are shown in Table 2. The total aerobic bacterial population (which is equivalent to the overall population of bacteria) for both cows and fed cattle was reduced immediately by approximately 1.1 $\log_{10}$ CFU/cm^2, or over 90% (1 log is equivalent to 90%). Although the average *E. coli* (nonpathogenic) population was very low initially, it was reduced to undetectable levels immediately after steam pasteurization. The bacterial populations after 24 h were very similar to those seen immediately after pasteurization, which indicates that the system is not just injuring bacteria but actually killing them.

Commercial steam pasteurization effectively reduced the number of bacteria on the surfaces of carcasses, but did not remove gross physical contamination such as fecal material, ingesta, or hair. Those contaminants should be removed by knife trimming, washing, or other methods prior to steam pasteurization.

Steam pasteurization effectively reduces the overall risk associated with pathogens in meat products.

Table 1. Reductions in Pathogen Populations on Freshly Slaughtered Beef *Cutaneous truncii* Muscles by Laboratory Decontamination Treatments

Experimental Part	Treatment[b]	Mean Reduction (Log_{10} CFU/cm^2)[a]		
		E. coli O157:H7	*L. monocytogenes*	*S. typhimurium*
Part 1	TW	4.7[c]	5.0[c]	4.9[cd]
	TWS	4.4[c]	4.6[cd]	4.4[cde]
	WS	4.2[c]	4.4[cde]	4.8[cd]
	VW	3.5[c]	3.5[e]	3.6[e]
	VWS	3.8[c]	3.8[de]	4.2[de]
	TWLS	4.1[c]	5.1[c]	5.3[c]
	VWLS	4.7[c]	5.0[c]	5.1[cd]
Part 2	T	3.1[c]	2.5[e]	2.7[d]
	W	.7[d]	1.3[f]	1.2[e]
	V	3.1[c]	3.3[def]	3.4[cd]
	S	3.5[c]	3.4[de]	3.7[cd]
	VWLS*5	3.4[c]	4.5[c]	4.5[c]
	VWLS*10	3.6[c]	4.2[cd]	3.9[cd]

[a]Initial level ca. 5.0. [b]Abbreviations are T=knife trimming, W=warm water washing, V=vacuum spot-cleaning, S=steam pasteurization (15 second exposure time unless otherwise noted: *5=5 second exposure, *10=10 second exposure), L=2% v/v lactic acid spray, all listed in order of application. [c-f]Means having the same superscript within columns and experimental part are not different (P>.05).

Table 2. Naturally Occurring Bacterial Populations on Beef Carcasses Treated with a Commercial Steam-Pasteurization System

Carcass Type	Sampling Time	Mean Population (Log_{10} CFU/cm^2)	
		Total Aerobic Bacteria	*E. coli* (nonpathogenic)[a]
Cows n = 70	Before	2.19[b]	.10[b]
	After	.84[c]	ND[c]
	24 h After	.94[c]	ND[c]
Fed Cattle n = 70	Before	2.14[b]	.07[b]
	After	1.03[c]	ND[c]
	24 h After	1.09[c]	ND[c]

[a]ND=none detectable. [b-c]Means having the same superscripts within columns and carcass type are not different (P>.01).

SENSORY TRAITS, COLOR, AND SHELF LIFE OF LOW-DOSE IRRADIATED BEEF STEAKS

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Summary

Irradiation had minimal effects on flavor and texture of frozen or chilled vacuum-packaged boneless beef steaks. A dose level of 3.5 kilograys (kGy) reduced beef aroma in chilled steaks. Irradiation did not influence internal or external cooked color, most raw color traits, cooking loss, pH, oxidative rancidity, or Warner-Bratzler shear force in chilled or frozen boneless steaks. PVC-wrapped controls were less red than irradiated steaks after 5 days of display. Exposure to oxygen by repackaging into oxygen-permeable film increased oxidative rancidity after display. Vacuum-packaging, in combination with irradiation, enables boneless beef steaks to be stored and/or displayed up to 28 days with minimal effects on color, oxidative rancidity, and bacterial counts.

(Key Words: Irradiation, Beef Steaks, Sensory, Color.)

Introduction

Consumers are concerned about food-borne infections, and irradiation of meat produced under a program of good manufacturing processes can reduce this problem. Although consumers previously have rejected irradiation, they are increasingly recognizing its benefits. Our objective was to determine flavor, aroma, color, and shelf life of boneless beef steaks in one of two packaging systems (vacuum and/or PVC film) and exposed to two dose levels (2 and 3.5 kGy) of nonradioactive irradiation or not irradiated.

Experimental Procedures

Twelve steaks per treatment were cut 1.0 in. thick from boneless beef strip loins (NAMP #180A) for each of three replications. Steaks were vacuum packaged in oxygen-barrier bags and either stored frozen at 4 °F or chilled at 36 °F. Steaks were stored for about 60 hr, then removed, boxed, and shipped either under dry ice or chilled to arrive within 6 hr at Iowa State University's irradiation facility. After stabilizing product temperature to either 4 °F or 36 °F overnight, steaks were treated with either 2.0 or 3.5 kilograys (kGy) of nonradioactive X-rays or not irradiated, then shipped back to KSU. The frozen steaks were thawed at 36 °F overnight (frozen/thawed treatment). Chilled steaks were stored at 30 °F for 14 days. After 14 days, one-half of the chilled steaks were placed onto styrofoam trays, covered with oxygen-permeable PVC film, and allowed to bloom overnight at 30 °F.

Eight steaks per treatment per replication were broiled to 158 °F internally. Eighteen texture/flavor attributes (animal hair-fat, animal hair-lean, beef identity, bitter, bloody, browned/roasted, burnt, chemical-fat, chemical-lean, fat-like, juiciness, liver-like, metallic, rancid-fat, rancid-lean, sour, sweet, and toughness) were assessed by five professional flavor-profile panelists using a 15-point structured scale (0 = none to 15 = very intense; 0.5 intervals). Each panelist received one steak per treatment. Off-odors in the package (frozen/thawed steaks) and beef aroma and off-odors after broiling (frozen/thawed and chilled steaks) were evaluated. Cooking loss percentage, Warner-Bratzler shear force, and cooked

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internal and external color traits also were evaluated.

Two steaks were displayed at 36 °F under 150 foot candles of Deluxe Warm White fluorescent lighting and instrumentally evaluated for reflectance color at days 0, 7, and 14 for frozen/thawed steaks. For chilled steaks, PVC-packaged (PVC) steaks were evaluated at 0, 2 and 5 days only, and vacuum-packaged (VP) steaks were evaluated at 0, 2, 5, 7, and 14 days. Two additional steaks (chilled or frozen/thawed) per treatment per replication were tested before display for purge and pH and before and after display for total microbial plate count (TPC) using standard procedures. Rancidity was measured with a modified 2-thiobarbituric acid (TBA) analysis, before and after display.

Data were analyzed as a split plot design using the maximum likelihood mixed model analysis of the Statistical Analysis System. Least square means were determined, and the statistical significance level was set at $P<.05$.

Results and Discussion

Frozen/Thawed Steaks. Irradiation had minimal effects on the sensory quality of frozen, vacuum-packaged, boneless, beef steaks. Dose level did not affect beef identity, bitter, bloody, browned/roasted, fat-like, juiciness, liver-like, metallic, sour, sweet, and toughness flavor/textural attributes, or beef aroma (Table 1). Animal hair-fat, animal hair-lean, burnt, chemical-fat, chemical-lean, and rancid-fat flavor intensities were inconsistent, but less than 1 on the sensory scale, too low to be detected by most consumers. No rancid- lean or cooked off-odors were detected. In the package, off-odors were greater for irradiated steaks than for controls (Table 1). However, most of those aromatics came from the packaging film, because when samples were removed from the bag and exposed to air for 2 to 3 min, those aromas diminished or were not perceptible.

Color lightness and yellowness values were stable throughout display. Redness increased as irradiation increased from 2.0 to 3.5 kGy and as display time increased from 7 to 14 days.

Irradiation dose level did not influence any instrumental internal or external cooked color values. Cooking loss percentage, shear force, pH, and TBA values were not influenced by dose. Purge percentage was not consistent across dose level. Total microbial plate counts were not different across dose at day 0 (data not shown). At day 14, 3.1 $\log_{10}$ and 5.0 $\log_{10}$ TPC reductions (approximately 99.9 and 99.999%) from nonirradiated controls were observed for 2.0 and 3.5 kGy irradiated steaks, respectively (data not shown). Nonirradiated control and 2.0 kGy TPC values increased from day 0 to day 14, but TPC for 3.5 kGy did not increase.

Aged Chilled Steaks. Neither irradiation dose level nor package type affected bitter, fat-like, juiciness, metallic, or sweet flavor/textural attributes (Table 2). Animal hair-fat, animal hair-lean, burnt, chemical-fat, chemical-lean, rancid-fat, and rancid-lean flavor attributes and cooked off-odors results were inconsistent, but below 1 on the sensory scale.

The introduction of oxygen when steaks were repackaged in PVC increased some undesirable characteristics, such as toughness, sour and liver-like flavors, and decreased desirable flavors, such as beef aroma, browned/roasted, and beef identity. Intensity levels for undesirable attributes, such as bloody, liver-like, and sour, were at the lower end of the sensory scale and would not be detected by most consumers.

VP steaks were stable during display for most color traits. PVC-wrapped steaks (oxygen-permeable film) were lighter colored and yellower at 0, 2, and 5 days compared to VP. In addition, PVC steaks had lower red intensity. Redness decreased with longer display for PVC steaks for all dose levels. At day 5 of display, control steaks were less red and more yellow than irradiated steaks. Rewrapping steaks into PVC degraded color and shortened display life when compared to steaks left in vacuum packaging. However, within PVC-wrapped steaks, irradiation slowed the decreasing redness and increasing yellowness, thus allowing a slightly longer retail display.

Irradiation dose level did not affect any instrumental internal or external cooked color values. Cooking loss percentage, pH, and Warner-Bratzler shear force were not affected by dose level or package type (Table 2). Greater purge percentage was observed for VP than for PVC steaks. Within PVC and VP steaks, TPC were higher for controls than irradiated samples at 0 and 5 days and 0 and 14 days, respectively. TPC at day 14 for 3.5 kGy VP were not different than day 0 counts, but TPC increased for controls and 2 .0 kGy samples during display.

Day 0 TBA values were slightly higher for PVC steaks than for VP counterparts. Day 5 TBA values for PVC were higher than day 0 counterparts and above the taste detection threshold level of 1.0. No increase in TBA values was observed in VP steaks during display. Exposing steaks to oxygen by repackaging in PVC film resulted in increased TBA values. Vacuum-packaging, in combination with irradiation, enables boneless beef steaks to be stored and(or) displayed up to 28 days with minimal effects on sensory attributes, color, oxidative rancidity and bacterial counts.

Table 1. Effect of Irradiation on Flavor/Aroma Sensory Attributes [a] for Cooked Frozen Boneless Beef Steaks

	Dose, kGy			
Attribute	0	2.0	3.5	SE
Beef identity	12.1	12.0	11.8	.3
Bitterness	1.5	1.8	1.8	.3
Bloody	4.8	6.2	6.1	.6
Browned/Roasted	8.6	8.0	8.1	.2
Fat-like	2.1	2.3	2.3	.3
Juiciness	9.9	9.3	9.4	.3
Liver-like	1.8	2.1	1.2	.5
Metallic	3.1	4.0	3.8	.3
Sour	1.7	1.9	1.8	.2
Sweet	.7	.5	.5	.2
Toughness	6.1	6.7	7.0	.7
Beef aroma	11.7	11.0	11.2	.4
Off-odor - In package	.5[c]	3.5[b]	3.5[b]	.6
- Cooked	.0	.0	.0	.0

[a]15-point scale: 0 = none to 15 = very intense.
[bc]Mean values within the same row with different superscripts are different (P<.05).

Table 2. Flavor/Aroma Sensory Attributes [a] and Warner-Bratzler Shear Force (WBS) as Affected by Irradiation Dose and Package Type

	Dose, kGy				Package Type		
Attribute	0	2.0	3.5	SE	PVC	VAC	SE
After cooking							
Bitterness	1.5	1.7	1.8	.3	1.7	1.6	.3
Fat-like	2.5	2.5	2.6	.2	2.5	2.6	.2
Juiciness	8.8	8.6	8.5	.3	8.6	8.7	.3
Metallic	3.3	3.7	3.7	.4	3.5	3.6	.4
Sweet	1.0	.9	.8	.2	.9	.8	.2
Beef aroma	11.3[c]	11.5[c]	10.6[d]	.2	10.8[d]	11.5[c]	.1
Off-odors	.3	.0	.5	.4	.6	.0	.3
WBS, kg[b]	3.20	3.25	3.23	.31	3.29	3.16	.25
Cooking loss, %	22.6	22.1	23.7	1.1	22.8	22.8	1.0
Purge, %	.30	.42	.49	.18	.0[d]	.8[c]	.16
pH	5.59	5.64	5.61	.04	5.63	5.59	.03

[a]15-point scale: 0 = none to 15 = very intense.
[b]Six 1/2 in.-cores per steak.
[cd]Mean values within the same row within a variable with differe nt superscripts are different (P<.05).

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SENSORY TRAITS, COLOR, AND SHELF LIFE OF LOW-DOSE IRRADIATED, RAW, GROUND BEEF PATTIES

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Summary

Irradiation of raw ground beef patties had minimal effects on flavor and aroma of patties after cooking. Oxidative rancidity increased when patties were irradiated in aerobic but not in vacuum packages. Irradiation of vacuum-packaged ground beef patties produced a more stable color. In both packaging types, irradiation significantly reduced microbial growth during storage.

(Key Words: Irradiation, Ground Beef, Sensory, Color.)

Introduction

Outbreaks of foodborne infecti ons involving meat products have increased consumer awareness of food pathogens, especially *Escherichia coli* O157:H7. In addition to good manufacturing practices, irradia tion is a possible way to help assure meat safety. A dose of 2.5 kilograys (kGy) reduces f ive major pathogens in ground beef by 4 to 10 l og$_{10}$ (a 4 log$_{10}$ reduction kills 99.99%). The World Health Organization states that no toxicolog ical hazard resulted from consuming food irradiated with up to 10 kGy. Historically, consumers have rejected irradiation, but recent studies indicate that consumer acceptance is increasing. Our objective was to determine how irradiation, package type, and fat level influence flavor, aroma, and shelf life of raw ground beef patties. Raw ground beef patties of two fat levels (10 and 22%) and with two packaging systems (aerobic and vacuum) were exposed to two dose levels (2.0 and 3.5 kGy) of nonradioactive irradiation or not irradiated.

Experimental Procedures

Closely trimmed beef knuckles and beef fat trim were coarsely ground separately through a 3/8 in. plate, mixed to obtain fat levels of 10 and 22%, then ground twice through a 1/8 in. plate. Twelve 1/4 lb patties per treatment, made using a hand press, were stacked individually, crust frozen at 40 °F for 20 min, then were either vacuum packaged in oxygen barrier bags (VP) or sealed in oxygen-permeable bags (AP) and frozen at 4 °F. Patties were freezer stored for about 60 hr, then removed, boxed, and shipped under dry ice to arrive within 6 hr at Iowa State University's irradiation facility. After stabilizing the product temperature (17 °F) overnight, patties were treated with either 2.0 or 3.5 kilograys (kGy) of non-radioactive X-rays. One set of patties was not irradiated. After irradiation, the product was shipped back to KSU and stored at 2 °F overnight.

Eight frozen patties per treatment per replication were broiled to 165 °F internally. Fifteen flavor/texture attributes (animal hair, bitter, bloody, browned/roasted, burnt, chemical, fat-like, juiciness, liver-like, beef identity, metallic, rancid, sour, sweet, and toughness) were assessed by five professional flavor-profile panelists using a 15-point scale (0=none to 15=very intense; 0.5 intervals). Each panelist received one patty per treatment. Beefy aroma and off-odor were evaluated on broiled patties, as well as cooking loss per-centage, Warner-Bratzler shear force, and cooked internal color traits.

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Two raw patties were displayed at 2 °F under 150 foot candles intensity from fluorescent Deluxe Warm White lighting and evaluated instrumentally for color reflectance at days 0, 7, 14, and 21. Two additional thawed raw patties per treatment per replication were tested before display for purge (drip loss), pH, and total microbial plate count (TPC) using standard procedures. Rancidity was measured with a modified 2-thiobarbituric acid (TBA) analysis, before and after display.

Data were analyzed as a strip-split plot design using the maximum likelihood mixed model analysis of the Statistical Analysis System. Least square means were determined, and the statistical significance level was set at $P<.05$.

Results and Discussion

Irradiation dose level, package type (Table 1), and fat percentage (data not shown) did not affect burnt, chemical, juiciness, liver-like, sour, sweet, and toughness flavor/textural attributes of cooked beef patties or beefy aroma. Stronger metallic notes were observed for vacuum-packaged (VP) patties than for their aerobically packaged (AP) counterparts, which may have been a result of the packaging materials. Intensity levels for animal hair, burnt, chemical, rancid, and sweet were <1 in the sensory scale for all treatments, except that animal hair was greater for 10% fat, 3.5 kGy VP (mean=1.5) than for control or 2.0 kGy samples (data not shown). No off-odors were detected.

Determining optimum packaging conditions and controlling packaging permeability can control sensory changes in raw ground beef patties. Low-dose irradiation treatment, even up to 3.5 kGy, had limited or no effect on flavor, texture, or aroma attributes of raw ground beef patties. Package type had a greater impact on flavor than either irradiation or fat level.

Vacuum-packaged patties were darker than aerobically packaged counterparts at all display days. Nonirradiated patties were lighter colored than irradiated patties at day 0, but not different at 7, 14, and 21 days. All VP patties were redder than AP at days 7, 14, and 21 of display, except for day 7 nonirradiated controls. At day 0, nonirradiated VP patties were redder than AP patties, but no difference occurred between packaging types at 0 day for irradiated samples. Darker and less red AP patties may have been caused by moisture condensation and formation of ice crystals, which may have destabilized or masked the color. Reduced redness of irradiated beef may be detrimental to its consumer acceptance. Color degraded faster with aerobic than with vacuum packaging. The general trend toward yellowing in both nonirradiated and irradiated patties may limit the use of that packaging, especially at the retail level.

Fat and irradiation dose levels did not affect instrumental cooked internal-color values (data not shown), but VP samples were redder.

Shear force and pH were not affected by irradiation dose level, package type (Table 1), or fat level. Neither fat nor irradiation dose level influenced cooking loss percentage. Cooking loss was less in VP than AP patties. Total microbial plate count reductions of 1.6 $\log_{10}$ and 2.0 $\log_{10}$ (1 log=90% reduction, 2 logs=99% reduction) from non-irradiated was observed for 2.0 and 3.5 kGy irradiated patties, respectively. Fat level and packaging type did not affect TPC. Percent purge was higher for VP patties than AP patties within a fat level.

Higher TBA values (more oxidative rancidity) were observed at both display days for AP than VP patties (data not shown). TBA values were higher for 2.0 and 3.5 kGy AP patties at day 21 than for nonirradiated controls. In addition, TBA values increased in AP irradiated samples from 0 to 21 days. No increase in rancidity occurred in VP samples. Reduction of oxygen through vacuum-packaging minimized autoxidation and thus helped extend the shelf life of raw ground beef patties.

Table 1. Flavor/Aroma Sensory Attribute s[a], Warner-Bratzler Shear Force (WBS), Cooking Loss, Raw Total Microbial Plate Counts (TPC), and pH Prior to Display as Affected by Irradiation Dose Level and Package Type

	Dose, kGy				Package Type		
Attribute	0	2.0	3.5	SE	Aerobic	Vacuum	SE
Sensory (cooked)							
Browned/roasted	8.1	8.1	8.1	.3	8.1	8.1	.3
Burnt	.2	.4	.4	.2	.3	.3	.1
Chemical	.1	.4	.5	.2	.3	.3	.1
Juiciness	6.2	5.7	6.2	.4	6.0	6.1	.3
Liver-like	1.8	1.3	1.1	.3	1.5	1.3	.2
Metallic	2.9	2.9	2.9	.5	2.6[e]	3.2[d]	.5
Sour	1.5	1.5	1.5	.2	1.5	1.5	.2
Sweet	.7	.6	.7	.2	.7	.7	.2
Toughness	6.2	6.2	6.2	.3	6.1	6.3	.3
Beef aroma	10.0	10.3	10.0	.4	10.1	10.1	.3
WBS, kg[b]	3.0	2.9	2.9	.1	3.0	2.9	.1
Cooking loss, %	34.7	36.7	35.0	1.0	36.1[d]	34.9[e]	.8
TPC[c]	4.4[d]	2.8[e]	2.4[f]	.4	3.1	3.3	.4
pH	5.8	5.8	5.8	.1	5.8	5.8	.1

[a]15-point scale: 0 = none to 15 = very intense.
[b]Two 1.2 in.-wide strips per patty.
[c]Expressed as $\log_{10}$ CFU/g.
[def]Mean values within same row within a variable with different superscripts are different (P<.05).

Cattlemen's Day 1996

SENSORY TRAITS, COLOR, AND SHELF LIFE OF LOW-DOSE IRRADIATED, PRECOOKED, GROUND BEEF PATTIES

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Summary

Irradiation did not influence bitter, bloody, burnt, chemical, fat-like, juiciness, liver-like, beef identity, metallic, rancid, sour, sweet, and toughness flavor/textur al attributes, beef aroma, or off-odor in precooked ground beef patties. Irradiation slightly increased the animal hair flavor note, but intensity levels were <1 on the 15-point sensory scale. Except for 10% fat non-irradiated controls, reheated precooked patties had a slight sour, ammonia-like, top note. Irradiation at 3.5 kilograys (kGy) increased external redness in vacuum-packaged patties, but not in aerobic packages. Aerobic packaging with or without irradiation decreased external precooked redness. Oxidative rancidity increased when patties were irradiated in aerobic but not in vacuum pa ckages. Reduction of oxygen in vacuum bags extended the shelf life of the precooked ground beef patties, at least in terms of oxidative ran cidity. Precooking ground beef patties, irrespective of irradiation or packaging type, posed senso ry disadvantages, and improvements to the precooking process are needed bef ore irradiating at low-dose levels is appropriate.

(Key Words: Irradiation, Ground Beef, Precooked, Sensory, Color.)

Introduction

Consumer concerns regarding foodborne pathogens, especially *Escherichia coli* O157:H7, are well documented. Low level X-ray irradiation is effective in reducing these pathogens. However, consumers have historically been skeptical of irradiation. Precooked, packaged, ground beef patties are an important item in the food service industry. Our objective was to determine flavor, aroma, color, and product life of precooked ground beef patties of two raw fat levels (10 and 22%) and with two packaging systems (aerobic and vacuum), exposed to t wo dose levels (2 and 3.5 kGy) of nonradioactive irradiation or not irradiated.

Experimental Procedures

Closely trimmed beef knuckles and beef fat trim were coarsely ground separately through a 3/8 in. plate, mixed to obtain fat levels of 10 and 22%, then ground twice through a 1/8 in. plate. Twelve 1/4 lb patties per treatment, made with a Hollymatic patty maker, were stacked individually on metal broiler pans and precooked to 160°F internally in a forced air oven set at 350°F, then crust frozen (40 °F). After precooking, patties were either vacuum packaged in oxygen-barrier bags or sealed in oxygen-permeable bags, frozen (4 °F), and freezer stored for about 60 hr. Then they were removed, boxed, and shipped under dry ice to arrive within 6 hr at Iowa State University's irradiation facility. After stabilizing the product temperature (17 °F) overnight, patties were treated with either 2.0 or 3.5 kGy of nonradioactive X-rays. One set of patties was not irradiated. After irradiation, the product was shipped back to KSU and stored at 2 °F overnight.

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Eight frozen precooked patties per treatment per replication were reheated with a combination broil (1.5 min)/bake (4.1 to 4.3 min per side) to 165 °F internally. Fifteen flavor/texture attributes (animal hair, bitter, bloody, browned/roasted, burnt, chemical, fat-like, juiciness, liver-like, beef identity, metallic, rancid, sour, sweet, and toughness) were assessed by five professional flavor-profile panelists using a 15-point scale (0 = none to 15 = very intense; 0.5 intervals). Each panelist received one patty per treatment. Beefy aroma and off-odors were evaluated at 2 and 6 min during reheating and after removal from the reheating oven. Cooking loss percentage, Warner-Bratzler shear force, and cooked internal color traits also were evaluated on reheated patties.

Two patties were displayed at 2 °F under 150 foot candles intensity from Deluxe Warm White fluorescent lighting and evaluated instrumentally for color reflectance at days 0, 7, 14, and 21. Two additional thawed precooked patties per treatment per replication were tested (no display) for purge (drip loss), pH, and total microbial plate count (TPC) using standard procedures. Rancidity was measured with a modified 2-thiobarbituric acid (TBA) analysis, before and after display.

Data were analyzed as a strip-split plot design using the maximum likelihood mixed model analysis of the Statistical Analysis System. Least square means were determined, and the statistical significance level was set at $P \leq .05$.

Results and Discussion

Irradiation dose level, package type (Table 1), and fat percentage (data not shown) did not affect bloody, burnt, chemical, beef identity, metallic, rancid, sour, and sweet flavor or beef aroma attributes in reheated patties. Intensity levels for animal hair, burnt, chemical, rancid, and sweet were <1 on the sensory scale for all treatments. Irradiation at 2.0 kGy increased the browned/roasted notes for AP patties.

Irradiation dose level, package type (Table 1), and fat percentage (data not shown) did not affect the intensities of cooking and cooked off-odors. However, nonirradiated patties had a sweet-dough-like aroma during reheating, whereas irradiated samples were described as having heated oil aromatics. After reheating, all treatments, except 10% fat nonirradiated controls, had a slight sour, ammonia-like, top note aroma with an underlying slight impression of animal habitat odor. Precooking ground beef patties, with or without irradiation treatment, caused sensory problems, which were not affected positively or negatively by irradiation.

Vacuum-packaged (VP) precooked patties were redder on the surface at all display days and dose levels than AP patties. Redness decreased from 7 to 14 days in AP patties and from 0 through 14 days in VP samples, but increased from 2.0 to 3.5 kGy in VP samples. Packaging, in combination with irradiation treatment, had more effect on precooked external color than did fat level, especially for 3.5 kGy AP patties, which were redder than either 0 or 2.0 kGy samples. The retail marketing of irradiated, vacuum-packaged, precooked, ground beef may be hindered by the formation of the persistent red pigment, and the marketing of aerobic-packaged patties may be hampered by the trend toward yellowness.

Irradiation dose level, package type, and fat level did not affect instrumental internal cooked-color values.

Shear force was not affected by irradiation dose level, package type (Table 1), or fat level (data not shown). Neither fat nor irradiation dose level influenced cooking loss or purge percentages. Cooking loss was greater for AP than VP patties (Table 1), but the reverse was true for purge values. Doses of 2.0 or 3.5 kGy decreased total microbial plate counts, as expected. However, plate counts were low even in nonirradiated precooked patties.

Higher TBA values were observed for AP than for VP patties at all display days, fat levels, and irradiation dose levels (data not shown). No difference was observed between display days, fat levels, or dose level for VP patties, but longer display, higher fat levels, or irradiation dose increased TBA of AP patties.

Table 1. Flavor/Aroma Sensory Attributes[a], Warner-Bratzler Shear Force (WBS), Cooking Loss, Precooked Total Microbial Plate Counts (TPC), and Purge Prior to Display as Affected by Irradiation Dose Level and Package Type[b]

	Dose, kGy				Package Type		
Attribute	0	2.0	3.5	SE	Aerobic	Vacuum	SE
Sensory (reheated)							
Bloody	1.3	1.1	1.2	.2	1.1	1.3	.2
Burnt	.2	.4	.3	.2	.3	.3	.2
Chemical	.2	.3	.3	.1	.3	.3	.1
Beef identity	10.8	10.9	10.7	.2	10.8	10.8	.1
Metallic	1.5	1.5	1.3	.2	1.4	1.4	.2
Rancid	.0	.0	.1	.0	.1	.0	.0
Sour	1.5	1.5	1.5	.3	1.5	1.5	.3
Sweet	.6	.6	.6	.2	.6	.6	.2
Beef aroma	9.4	8.7	7.8	.6	8.5	8.8	.6
Off odor - 2 min	7.7	8.1	7.8	.6	8.0	7.8	.5
- 6 min	7.9	8.0	7.9	.4	8.0	7.8	.4
- Final	2.0	4.1	5.2	1.5	4.4	3.1	1.4
WBS, kg[c]	2.8	2.9	2.7	.1	2.8	2.8	.1
Cooking loss, %	17.3	17.3	17.9	.8	18.7[e]	16.3[f]	.7
TPC[d]	1.9[e]	1.2[f]	<1.0[f]	.2	1.3	1.4	.1
Purge, %	.1	.1	.1	.1	.0[f]	.1[e]	.1

[a]15 point scale: 0 = none to 15 = very intense.
[b]Data for 10 and 22% fat are combined.
[c]Two 1.2 in.-wide strips per patty.
[d]Expressed as $\log_{10}$ CFU/g.
[ef]Mean values within the same row within a variable with different superscripts are different (P<.05).

FATE OF FUMONISINS IN CATTLE FED CONTAMINATED FEED

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Summary

Fumonisins are water-soluble carcinogenic mycotoxins produced by many species of *Fusarium* molds. Fumonisins occur widely in corn, making them a problem in corn-based feed. Their toxicity has been established in many species. However, their effects on cattle and the potential of carryover to the human diet through beef has not been studied extensively. A 30-day cattle feeding study was conducted by feeding fumonisin-contaminated corn grits dosed at 400 g/g fumonisin B_1 (FB_1) and 130 g/g fumonisin B_2 (FB_2) to 3 steers averaging 480 lb. Premortem analysis involved urinalysis; tests for liver functionality; and analysis of the blood, urine, and feces for the presence of fumonisins or their metabolites. Postmortem analysis involved necropsy, analysis of tissue for fumonisins, and histopathology. The test animals showed some slight liver abnormalities. The feces contained unmetabolized FB_1 and FB_2 ($\geq$80% of the fed dose), and trace amounts were detected in the urine. Tissue analysis resulted in detection of 2.1 g/g FB_1 in the liver, 0.1 g/g FB_1 in the muscle, and 0.02 g/g FB_1 in the kidney, indicating a high feed:tissue ratio, and consequently insignificant carryover into the human diet.

(Key Words: Fumonisins, Toxicity, Residues in Tissues.)

Introduction

The toxicological effects of fumonisins have been established in horses, swine, rats, and nonhuman primates. However, their effect(s) on ruminants remain undetermined. The unique physiology of the ruminant and its microbes may alter the fumonisin toxicology normally seen in nonruminant species. The evidence for such alteration in cattle is their tolerance to fumonisin exposure at levels fatal to horses and swine. The common occurrence of fumonisins in corn and the suspected tolerance of cattle to fumonisins potentially could result in chronic fumonisin exposure in cattle consuming corn-based diets, could lead to residues of fumonisins or their metabolites in cattle tissues, and could carry over to the human diet via consumption of fumonisin-contaminated beef. Our study was designed to test that hypothesis.

Experimental Procedures

Animal Feed and Dose

Six individually penned Holstein steers were acclimated for a period of 10 days before the start of the study and were weighed before, midway, and at the end of the feeding study. Three steers were used as test animals, and the remaining three served as controls. They were fed twice daily for 30 days on a diet consisting of a 85:15 (wt/wt) mix of dairy herd-mix and alfalfa hay. Daily consumption was 2% of body weight. The fumonisin-contaminated grits were prepared by inoculating previously sterilized corn grits with a high-fumonisin producing strain *(Fusarium moniliforme M1293*) and incubating them in a greenhouse for 25 days. Before feeding, the fumonisin-contaminated grits were mixed manually with the daily ration to obtain a daily dose of 400 g/g fumonisin B_1 (FB_1) and 130 g/g fumonisin B_2 (FB_2). On day 31, the animals were sacrificed, and necropsies were done to check for presence of gross lesions. The visceral organs, muscle, and fat were analyzed for the presence of fumonisins and their metabolites. Histopathology, involving tissue examination by both light and electron microscopy, was done on selected visceral organs.

Clinical Chemistry and Urinalysis

Premortem collection of blood, feces, and urine samples was done in the morning before the animals were fed on days 3, 0, 7, 14, 21, and 28 of the study. The steers were bled via jugular venipuncture, and the blood was analyzed for aspartate amino transferase (AST), gamma glutamyl transpeptidase (GGT), lactate dehydrogenase (LDH), bilirubin, a nd cholesterol to evaluate liver function. Urine was analyzed for creatinine, color, specific gravity, glucose, bilirubin, ketone, blood, pH, and protein and microscopically examined for erythrocytes, leukocytes, casts, epithelial cells, crystals, and bacteria.

Sample Preparation

Blood and urine. Blood (10 cc) was centrifuged for 15 min to separate the plasma layer. The plasma protei ns were precipitated by addition of methanol and separated by centrifuging for 15 min. The resulting super-natant was used for solid-phase extraction (SPE) cleanup prior to analysis.

Feces, visceral organs, and meat. Ten g of sample (feces, liver, spleen, kidneys, gall bladder, gastrohepatic lymph nodes, pancreas, tongue, sub-cutaneous fat, kidney-fat, longissimus dorsi, chuck, and round) were blended at high speed with 75 ml of acetoni-trile:water (1:1, v/v). The resulting supernatant was used for SPE cleanup.

Analysis of fumonisins. All chromato-graphic analyses were done using high per-formance liquid chromatography (HPCC), with a C-18 reversed phase c olumn and fluorescence detection. Samples were a nalyzed for FB_1, FB_2, and their metabolites resulting from full or partial hydrolysis.

Results and Discussion

Each of the test animals was exposed to an average of 25,830 mg of FB_1 and 8,430 mg of FB_2 during the 30-day feeding period. The test animals showed no sign of feed refusal and consumed all of their feed before the next feeding period. Body temperatures taken on days -5, -4, -3, -2, -1, 0, 1, 2, 3, 4, 7, 14, 21, and 28 were unaffected by fumonisin-contaminated feed. No significant body weight differences occurred.

Evidence of liver stress can be construed from changes in the liver function tests, namely serum AST, GGT, LDH, and cholesterol. These changes suggest some hepatotoxicity at the molecular level, an effect common to all species affected by fumonisins. The feces showed the highest levels o f FB_1 (127 g/g) and FB_2 (35 g/g). No evide nce of any metabolized fumonisins was found in the feces. Traces of the intact fumonisins were detected in the urine.

No significant gross lesions were noted in any of the tissues of the test an d control animals. The organ-to-body weight ratios for heart, brain, lungs, liver+ gall bladder, kidneys, spleen, and pancreas were normal. Fumonisin B_1 was found in muscle (0.1 g/g), liver (2.1 g/g), and kidneys (0.02 g/g). Fumonisins were not detected in the fat, tongue, gall bladder, spleen, pancreas, or the gastro-hepatic lymph node. Table 1 shows the amounts of FB_1 residue detected in the tissues and their corresponding feed:tissue ratios.

In conclusion, cattle exhibit a high feed:tissue ratio of fumonisin, and, therefore, can tolerate levels in feed that are normally fatal to horses or swine. The majority of the dose was excreted as the unmetabolized parent molecule in the feces. Fumonisins were not detected in the blood at 12 h or more after feeding, and only trace amounts were detected in the urine. Thus, carryover of FB_1 from cattle consuming fumonisin-contaminated feed to the human diet via consumption of beef does not seem to be a problem.

Table 1. Fumonisin Residues in Tissues from Cattle Fed Dietary FB_1 and FB_2

Steer No.	Levels of $FB_1 + FB_2$ in Feed[a]	Liver		Muscle[b]		Kidney[c]	
		FB_1	F/T[d]	FB_1	F/T	FB_1	F/T
	(g)	(g/g)		(g/g)		(g/g)	
T-1	27.2 + 8.9	4.6	1,600	.52	1,702	.03	1.0 10^6
T-2	24.5 + 8.0[b]	0.11	81,666	.15	61,250	.01	2.8 10^6
T-3	24.5 + 8.0	1.5	6,125	.64	2,227	.02	1.2 10^6

[a]Animals were fed the fumonisin contaminated diet for 30 days.
[b]Calculations based on 50% of total body weight being edible tissue.
[c]Calculations based on weight of both kidneys.
[d]Feed to tissue ratio (F/T) - overall level of fumonisins in feed divided by the level in the specified tissue.

VARIATION IN AND EFFECTS OF PREFABRICATION FAT TRIMMING ON YIELDS AND PREDICTION EQUATION ACCURACIES OF RETAIL PRODUCT AND FAT TRIM [1]

M. E. Dikeman, L. V. Cundiff [2], K. E. Gregory [2], K. E. Kemp [3], and R. M. Koch [4]

Summary

Carcass data from one side of 1,149 steers born from 1986 to 1990 were analyzed to develop means for carcass traits and retail product percentage by yield grades. Carcasses from 610 of these steers born from 1988 to 1990 were fabricated to two fat trim levels (.30 and .00 in.), with subcutaneous fat and intermuscular (internal) fat weighed separately. Subcutaneous fat from the primal round, loin, rib, chuck, brisket, and flank in excess of .30 in. plus the kidney knob were considered to constitute an industry 'hot-fat trim equivalent' (HFTE). Quadratic regression curves were plotted for percent retail product (RP) and percent fat trim (FT) vs. USDA yield grade. In addition, prediction equations were developed for weights and percentages of RP and FT that could be used in plants that do hot-fat trimming and quality grading of carcasses. Percentage of RP, trimmed to either .30 or .00 in. of fat, decreased an average of 4% for each full yield grade increase. Trimming to .00 in. of fat instead of .30 in. reduced RP about 5.5%. The average percentage of HFTE for a yield grade 3.0 carcass was 8.4%. The range in percentage of RP at both trim levels was reduced by trimming fat to an HFTE basis, but considerable range still existed. The range in percentage of internal (seam) fat across yield grades was greater than the range in percentage of HFTE. An equation to predict percentage RP in HFTE carcasses using percentage of hot fat trim, carcass weight, ribeye area, and marbling score had an R^2 of .75, which was considerably higher than that for an equation using USDA yield grade traits from untrimmed carcasses (R^2=.54). The high accuracy of our prediction equation suggests that the industry could use it to accurately predict closely trimmed RP percentage of hot-fat trimmed carcasses.

(Key Words: Carcass, Prefabrication Fat Trimming, Meat Yields.)

Introduction

The three major U.S. beef processors produce 'close-trimmed' (maximum of .25 in. of surface fat) boxed beef. The demand for that product has increased to about 43% of total boxed beef production. In 1989, the USDA/AMS uncoupled yield and quality grading to allow for innovative processing technologies, such as hot-fat trimming (trimming before carcasses are chilled). Although carcasses cannot be yield graded after hot-fat trimming, they can be quality graded. Until recently, one major beef processor was 'hot-fat trimming' much of their production to .25 in. or less. But now, the three major beef processors trim fat after carcass chilling during fabrication.

Several research studies have reported that, as expected, hot-fat trimming reduced the

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[1]This article was derived from data from the Germ Plasm Evaluation project that was conducted under the leadership of Dr. Larry Cundiff at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, NE. Michael E. Dikeman was a collaborator on the carcass retail product data collection.

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variation in cutability across different cattle types and yield grades, even though only subcutaneous fat is removed. Much of the variation that remains is due to differences in intermuscular fat and has not been well quantified.

Our objectives were to estimate the variability in cutability among carcasses that were trimmed to the equivalent of hot-fat trimmed carcasses; to determine the relative effects of subcutaneous and internal fat on cutability; to examine the regression of fabrication components on yield grade; and to develop prediction equations for carcass composition that use 'hot fat trim equivalent' and available cooler measurements.

Experimental Procedures

Carcasses from 1149 steers from Cycle IV of the Germ Plasm Evaluation research program at the U.S. Meat Animal Research Center were used. Eleven sire breeds were mated to Hereford and Angus dams to produce F_1 progeny in five calf crops (1986-1990). Calving occurred from late March through mid-May, and after a postweaning adjustment of about 35 days, steers were fed a growing diet until they reached about 700 lb live weight. Steers then were fed a high concentrate diet until slaughtered serially in four groups about 3 weeks apart in a commercial processing plant. After a 24-hr chill, USDA yield grade and quality grade data were obtained. Right sides from all five calf crops were fabricated into retail product (RP) (roast and steak meat trimmed to .30 in. of subcutaneous and internal fat at all surface locations, plus lean trim with 20% fat). After all components were weighed and recorded, all subcutaneous and accessible internal fat was removed (.00 in.) from roast and steak meat, then reweighed.

For the 610 sides from cattle born in 1988 to 1990, the round, loin, rib, chuck, brisket, and flank were trimmed to .30 in. of subcutaneous fat cover (includes cod fat from the flank). In our study, the weight of the side after trimming the primal cuts to .30 in. of subcutaneous fat, plus additional subcutaneous fat in excess of .30 in. trimmed during fabrication of the subprimals, plus the kidney and pelvic fat were considered to constitute an industry 'hot-fat trim equivalent' (HFTE).

Equations were developed to predict percentages of retail product (RP) and fat trim using traits obtainable in plants that do hot-fat trimming and quality grading of carcasses.

Results and Discussion

Table 1 presents the distribution of carcasses and means for carcass traits in the different yield grades for all 1,149 steers (1986-90) and for the 610 steers born in 1988-90. As expected, hot carcass weights, adjusted fat thicknesses and percentages of kidney and pelvic fat increased as yield grade number increased. Longissimus muscle area decreased as yield grade number increased to 3.2, then did not change consistently as yield grade increased to 5.5. Marbling score and percentage of carcasses grading Choice increased up to yield grade 3.7 and then did not increase further. Percentage of RP, when trimmed to either .30 in. (RP .30) or .00 in. (RP .00) of surface fat decreased by an average of 4% for each full yield-grade increase. Trimming to .00 in. vs. .30 in. resulted in about 5.5% less RP.

For the 610 carcasses from cattle born from 1988 to 1990, when carcasses were trimmed to an HFTE basis, the percentage of fat removed increased nearly linearly through the full range of yield grades (Figure 1). The average percentage of HFTE for yield grade 3.0 carcasses was about 8.4%.

Figure 2 illustrates how percentage of RP .00 changed as yield grade increased. Even though percentage of RP .00 decreased more rapidly on an untrimmed carcass basis than on an HFTE carcass basis, it still decreased about 12 percentage points across the range of yield grades. Figure 2 clearly shows that a considerable range occurs in percentage of RP among carcasses, even after HFTE, and suggests that some method is needed to predict yields of carcasses after hot fat trimming.

Figure 3 illustrates how subcutaneous fat trim (.00 in.) increased for untrimmed carcasses and carcasses after HFTE (.30 in.) as yield grade increased. The rate of increase in fat trim

was faster on a carcass basis after HFTE than on an untrimmed carcass basis. This suggests that an increasing proportion of subcutaneous fat may be left on carcasses during hot fat trimming as yield grade increases. The predicted percentage of subcutaneous fat trim (.00 in.) (excluding kidney knob) on an untrimmed carcass weight basis for yield grade 3.0 carcass was 7.2%.

Figure 4 illustrates how internal (seam) fat increased as yield grade increased. A wider range occurred in internal fat trim than in percentage of HFTE (Figure 1).

Use of HFTE clearly reduces the range in percentage yields of RP and FT; however, considerable difference still exists. Thus, methods are needed to predict yields of hot-fat trimmed carcasses, so we developed prediction equations using traits available in plants that do hot fat trimming and quality grading of carcasses.

Prediction equations that we developed for weights and percentages of carcass components and their R^2 values are shown in Table 2. Weight of RP was predicted with a high degree of accuracy (R^2=.93) using weight of HFTE, carcass weight after HFTE, ribeye area, and marbling score. Predicting the weight of FT remaining after HFTE was somewhat less accurate (R^2 = .80). Percentage of RP could be predicted with more accuracy than percentage of fat trim remaining after HFTE (R^2=.75 vs .62).

Comparing R^2 values in Tables 2 and 3 shows that equations using HFTE for predicting percentages of RP and FT were consistently more accurate than those using USDA yield-grade traits.

Table 1. Distribution of Carcasses and Means for Carcass Traits in Yield-Grade Categories for All Steers Born 1986-90 and Distribution and Mean Yield Grades for Steers Born 1988-90

	Yield Grade Category							
Variable	<2.0	2.0-2.49	2.5-2.99	3.0-3.49	3.5-3.99	4.0-4.49	4.5-4.99	≥5.0
1986-90								
No. carcasses	70	143	262	265	208	118	48	36
Hot carcass wt, lb	643.6[a]	661.7[ab]	672.7[b]	705.4[c]	751.5[d]	767.3[d]	801.7[e]	835.3[e]
Adj. fat thickness, in.	.21[a]	.27[b]	.34[c]	.43[d]	.54[e]	.67[f]	.85[g]	1.04[h]
Longissimus muscle area, in.^{2}	13.2[a]	12.3[b]	11.6[c]	11.3[de]	11.5[cd]	11.2[ef]	11.4[cde]	10.7[f]
Kidney and pelvic fat, %	2.3[a]	2.5[b]	2.7[c]	2.9[d]	3.1[e]	3.2[f]	3.5[g]	3.6[g]
Yield grade	1.7[a]	2.3[b]	2.7[c]	3.2[d]	3.7[e]	4.2[f]	4.7[g]	5.5[h]
Marbling score[i]	4.5[a]	4.8[b]	5.0[c]	5.2[d]	5.4[e]	5.5[e]	5.6[e]	5.5[e]
Percentage ≥ Choice	20.0[a]	39.0[b]	53.4[c]	66.3[d]	76.1[e]	83.5[e]	81.3[e]	80.6[e]
Retail product at .30 in.								
Retail product at .00 in.								
1988-90								
No. carcasses	23	57	139	141	121	66	33	30
Yield grade	1.8[a]	2.3[b]	2.8[c]	3.2[d]	3.7[e]	4.2[f]	4.8[g]	5.6[h]

[a,b,c,d,e,f,g,h] Means in the same row without a common superscript letter differ (P < .05).

[i] 4.00-4.90 = slight; 5.00-5.90 = small, etc.

Table 2. Regression Equations and Residual Standard Deviations (RSD) for Predicting Weights and Percentages of Retail Product and Fat Trim at .00 in. Fat Trim Using Data from Hot Fat Trimmed Equivalent Carcasses

		Parameter Estimates					
Equation for	Intercept	Carcass Wt., lb	Hot Fat Trim, lb	Ribeye Area, in.^{2}	Marbling Score[a]	R^2	RSD
lb Retail product	22.95	.72	-1.55	3.84	-8.20	.93	6.39
lb Fat trim	-44.61	.12	.77	-1.138	5.60	.80	5.15
% Retail product	78.95	-.005	-1.56	.516	-1.14	.75	1.95
% Fat trim[b]	-.085	.006	.98	-.129	.82	.62	1.68

[a]4.00 - 4.90 = slight; 5.00 - 5.90 = small, etc.
[b]Dependent variable is percentage of fat trim after hot-fat trim equivalent.

Table 3. Regression Equations and Residual Standard Deviations for Predicting Weights and Percentages of Retail Product and Fat Trim at .00 in. Fat Trim from Traits Used in Determining USDA Yield Grades

		Parameter Estimates					
Equation for	Intercept	Adjusted Fat Thickness, in.	Kidney and Pelvic Fat, %	Ribeye Area, in.^{2}	Hot Carcass Wt.,lb	R^2	RSD
lb Retail product	23.20	-72.97	-8.91	8.96	.52	.86	8.58
lb Fat trim	-63.46	83.95	10.12	-6.68	.33	.83	7.62
% Retail product	65.69	-9.93	-1.29	1.23	-.013	.54	2.66
% Fat trim	13.64	11.38	1.48	-.84	.014	.64	2.38

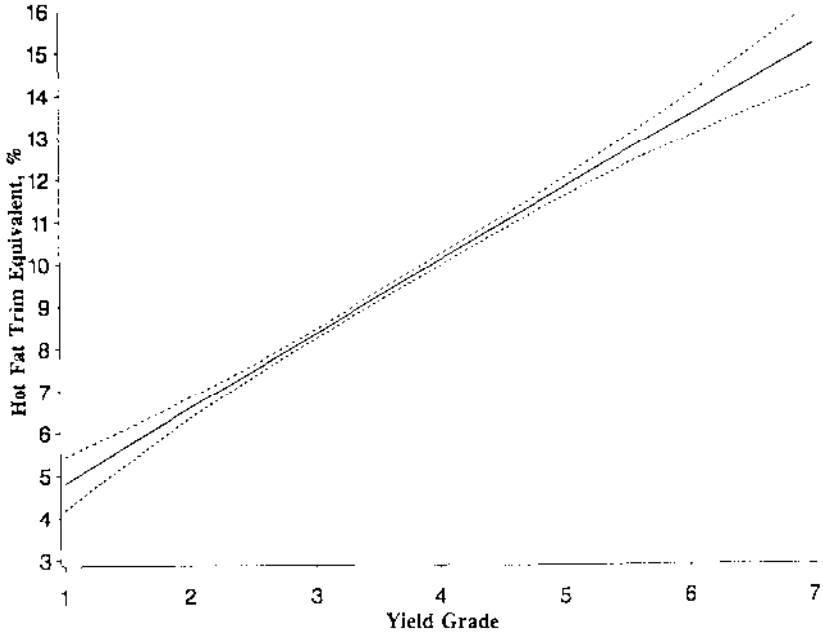


Figure 1. Hot-Fat Trim Equivalent as a Percentage of Carcass Weight as Yield Grade Increases

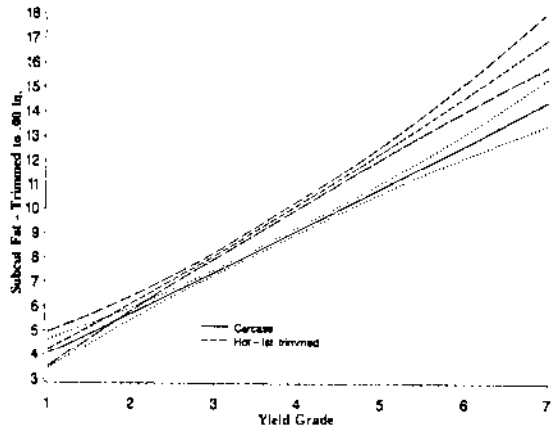


Figure 2. **Retail Product Trimmed to .00 in. Fat Cover as a Percentage of Carcass Weight and as a Percentage of Hot-Fat Trim Equivalent Carcass Weight Relative to Yield Grade Increases**

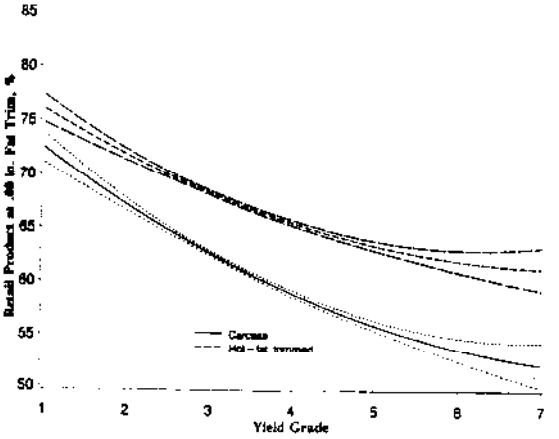


Figure 3. **Subcutaneous Fat Trimmed to .00 in. as a Percentage of Carcass Weight and as a Percentage of Hot-Fat Trim Equivalent Carcass Weight Relative to Yield Grade Increases**

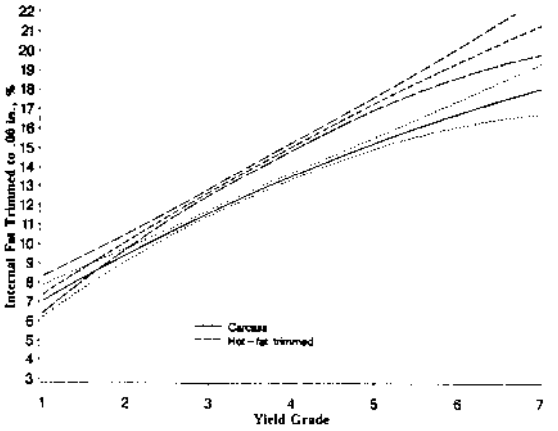


Figure 4. **Internal Fat Trimmed to .00 in. as a Percentage of Carcass Weight and as a Percentage of Hot-Fat Trim Equivalent Carcass Weight Relative to Yield Grade Increases**

Cattlemen's Day 1996

CALF PRESENCE AND MILKING TWICE DAILY PROLONGS POSTPARTUM ANESTRUS

G. C. Lamb, J. M. Lynch, and J. S. Stevenson

Summary

Four treatments were initiated approximately 15 days after calving: 1) calf was weaned permanently from its dam (CW; n=6); 2) calf was present continuously with its dam (CPO; n=5); 3) calf was weaned permanently from its dam + dam was milked twice daily (CWM; n=6); 4) calf was present continuously with its dam but contact with the udder was prohibited + dam was milked twice daily (CRM; n=5). During the 4-week treatment period, cows in the CRM treatment produced about twice as much milk, milk fat, milk protein, milk lactose, and milk solids-not-fat (SNF) than CWM cows. After completion of treatments, calves were returned to their dams and allowed to suckle ad libitum. After calves had been reunited with their dams for 1 week, cows in the CRM treatment produced similar amounts of milk, milk fat, milk protein, milk lactose, and milk SNF as CPO cows, but about twice as much as CWM cows. Cows weaned and milked twice daily had their first postpartum ovulation about 2 weeks after weaning, similar to cows weaned but not milked, whereas cows milked in the presence of their own restricted calf first ovulated in about 4 weeks and calf-present cows in about 5 weeks. We conclude that both milk removal (either mechanically or by a calf) and a cow-calf bond are essential to prolong postpartum anestrus.

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

Introduction

Reproduction is the major limiting factor in the efficiency of production in beef cattle enterprises. Gestation length limits producers to one calf crop per year. The largest loss in the potential calf crop is the failure of cows to conceive during the breeding season. This loss can be reduced by shortening the interval to first postpartum estrus.

The cow-calf suckling interaction is a critical component in maintaining anestrus. 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 the perception of suckling or milk removal was maintained with continued calf presence.

Cows that limit-nursed an alien calf (limited to four, 10-min, suckling bouts per day) had a shorter anestrus than cows nursing their own calves. However, cows nursing foster calves continuously or nursing alien calves continuously in the presence of their own restricted calves (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 but longer than those of weaned cows. This suggests that a cow must first recognize the suckling calf to be her own (natural born calf or reformed with a foster calf) before subsequent suckling will

prolong anestrus. The present experiment was designed to determine whether milking a cow twice daily in the presence or absence of her own udder-restricted calf would alter the post-partum interval to first ovulation.

Experimental Procedures

Twenty-two multiparous, crossbred (Angus Hereford) cow-calf pairs were assigned randomly to four treatments at 15 days after calving: 1) calf was weaned permanently from its dam (calf weaned; CW; n = 6); 2) calf was present continuously with its dam (own calf present; CPO; n = 5); 3) calf was weaned permanently from its dam, plus dam was milked twice daily (calf weaned + milked; CWM; n = 6); 4) calf was present continuously with its dam but contact with the udder was prohibited, plus dam was milked twice daily (calf restricted + milked; CRM; n = 5). Cows remained on treatment for 4 weeks, after which CWM and CRM cows were reintroduced to their calves and allowed to nurse their calves continuously. Daily blood samples were collected from cows to determine their first increase in 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 cows were fed as dry second-trimester, pregnant, beef cows and the CPO, CWM, and CRM cows were fed as superior milk producers. Restricted calves in the CRM treatment were fed 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 count (SCC) in the CWM and CRM treatments. One week after terminating treatments (after CRM and CWM cows had been reintroduced to their calves and suckled ad libitum for 1 week), 24-hour production of milk (two milkings during 24 hours after receiving 20 I.U. of oxytocin), and fat, protein, lactose, SNF, and SCC in milk were measured.

Results and Discussion

Daily milk production characteristics of calf weaned + milked and calf restricted + milked cows during the 4-week treatment period are shown in Table 1. Production of fat, protein, lactose, and SNF in milk was greater ($P<.05$) in calf restricted + milked cows than in calf weaned + milked cows. In addition, daily milk production (Figure 1) throughout the 4-week treatment period was greater ($P<.05$) for calf restricted + milked cows than for calf weaned + milked cows. Therefore, the presence of a cow's calf is a critical component in maintaining milk production in milked beef cows.

Milk yield for calf weaned + milked, calf restricted + milked, and calf-present cows 1 week following the conclusion of treatments is shown in Table 2. Cows in the calf restricted + milked and calf-present treatments produced similar amounts of milk, milk fat, milk protein, milk lactose, and milk SNF; and all milk traits were greater ($P<.05$) than those of calf weaned + milked cows. The presence of the cow's non-suckling calf in the CRM treatment during the 4-week treatment period maintained milk production. Thus, when calf restricted + milked cows were reunited with their calves and suckled for 1 week, their milk production was similar to that of calf-present cows. Because the calf was absent during the treatment period for calf weaned + milked cows, milk production declined, which probably accounts for the decrease in production 1 week after they were reunited.

The postpartum interval to first increase in progesterone was shorter ($P<.05$) in the CW (16.5 – 4.2 d) and CWM (14.2 – 4.2 d) treatments than in the CPO (35.6 – 4.5 d) and CRM (27.6 – 4.5 d) treatments. These results support our earlier report (1995 Cattleman's Day; KAES Report of Progress 704:105), indicating that anestrus is prolonged in cows maintained with their own restricted calf but suckled by another calf or maintained with their own restricted calf and milked. Maintaining anestrus involves two critical components: 1) a cow must recognize and remain bonded to her own calf and 2) a cow must be suckled by her calf or her

milk removed by another calf or by milking. We conclude that a cow-calf bond and milk removal (either mechanically or by a calf) are essential to prolong anestrus in beef cows.

Table 1. Daily Milk Production Characteristics of Cows during the 4-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] (x1000)
CWM	6	9.2[x]	.38[x]	.31[x]	.43[x]	.80[x]	95
CRM	5	18.3	.81	.62	.94	1.66	51

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

Table 2. Daily Milk Production Characteristics of Cows 1 Week after Termination of Treatments

Treatment [a]	No. of Cows	Milk (lb)	Fat (lb)	Protein (lb)	Lactose (lb)	SNF[b] (lb)	SCC[c] (x1000)
CWM	6	7.5[x]	.11[x]	.30[x]	.44[x]	.82[x]	57
CRM	5	14.8[y]	.39[y]	.49[y]	.74[y]	1.35[y]	113
CPO	5	14.8[y]	.36[y]	.46[y]	.73[y]	1.29[y]	122

[a]CWM = calf weaned + milked, CRM = calf restricted + milked, and CPO = own calf present.
[b]SNF = solids-not-fat.
[c]SCC = somatic cell count.
[x,y]Means within a column without common superscripts differ (P<.05).

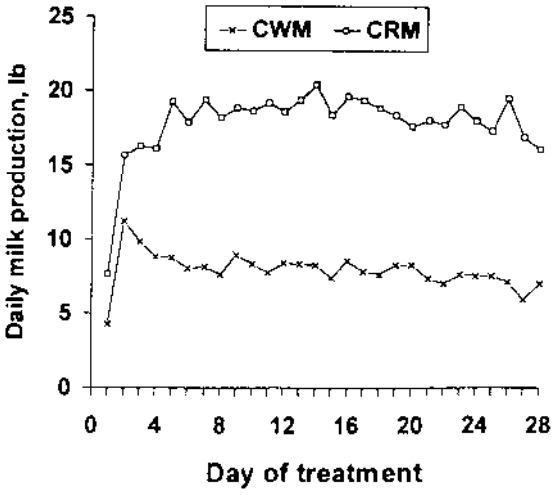


Figure 1. Daily Milk Production for Six CWM (Calf Weaned + Milked) and Five CRM (Calf Restricted + Milked) Cows during a 4-week Treatment Period Initiated on Day 15 Postpartum

PREGNANCY RATES IN HEIFERS AND SUCKLED BEEF COWS AFTER SYNCHRONIZED OVULATION USING $PGF_{2\alpha}$, GnRH, AND NORGESTOMET

D. P. Hoffman, J. S. Stevenson, C. L. Krehbiel, D. A. Nichols, and R. M. McKee

Summary

Suckled cows and virgin heifers received a novel treatment that included $PGF_{2\alpha}$, GnRH, and norgestomet, with the objective of inducing estrus in prepubertal heifers and anestrous suckled cows, as well as synchronizing ovulation in estrus-cycling females. The treatment consisted of two injections of $PGF_{2\alpha}$ (day 14 and 0) plus 100 μg of GnRH and a 6-mg norgestomet ear implant on day 7. The implant was removed 24 h after the second injection of $PGF_{2\alpha}$ (day 0), and a second injection of GnRH was given 30 hours after implant removal. The treated females were inseminated 18 hours after the second injection of GnRH or at estrus, if it was detected before the second GnRH injection. Pregnancy rate in the treated females was greater than in control females that had received two injections of $PGF_{2\alpha}$ 14 days apart and were inseminated at estrus or at one fixed time (60.2 vs. 48%). The treatment successfully induced a fertile ovulation in previously prepubertal heifers and anestrous cows, resulting in 63.5% pregnancies vs. 26.5% for controls. In addition, in females not showing estrus, the treatment increased pregnancy rate following a fixed-time insemination (treatment vs. control; 60.0 vs. 3.8%). We concluded that treatment with $PGF_{2\alpha}$, GnRH, and norgestomet induced estrus and increased pregnancy rates in prepubertal heifers, anestrous cows, and cycling females.

(Key Words: GnRH, Norgestomet, $PGF_{2\alpha}$, Heat Synchronization, Prepubertal Heifers, Anestrous Suckled Cows.)

Introduction

Estrus-synchronization programs improve reproductive efficiency by reducing the length of breeding and calving seasons, increasing calf weaning weights, and grouping cows and heifers so artificial insemination (AI) can be used more efficiently. They are not designed to induce estrus in prepubertal heifers or anestrous suckled beef cows. Treatments involving single or multiple injections of gonadotropin-releasing hormone (GnRH) given 10 to 12 days apart and(or) implants of norgestomet have been used to jump start (induce estrus) noncycling heifers and cows. The result of injecting GnRH is to induce secretion of LH and FSH and cause ovulation of mature follicles. Norgestomet primes the hypothalamic-pituitary axis for release of the endogenous GnRH, LH, and FSH necessary for follicle growth. In prepubertal heifers and anestrous suckled cows, the norgestomet implant also prevents the short luteal phase or short estrous cycle that normally follows the first pubertal or postpartum ovulation. That short cycle prevents the continuation of pregnancy, even when fertilization occurs. Therefore, our objective was to test the effect of this novel treatment using prostaglandin F2 α ($PGF_{2\alpha}$), GnRH, and norgestomet for its ability to induce estrus and increase conception in prepubertal heifers and anestrous suckled cows, as well to synchronize estrus in cycling females before one fixed-time insemination.

Experimental Procedures

In a 2-year study, purebred Angus, Hereford, and Simmental heifers and suckled cows were assigned to two treatments: 1) two injections of $PGF_{2\alpha}$ 14 days apart (control); or 2) two injections of $PGF_{2\alpha}$ (days 14 and 0) plus 100 μg of GnRH and a 6-mg norgestomet

implant on day 7 (ovulation synchronization; Figure 1). The norgestomet implant was removed 24 h after the second injection of $PGF_{2\alpha}$ (day 0). A second injection of 100 μg of GnRH was given 30 h after implant removal. Three blood samples were collected (24, 14, and 7 days) before the first GnRH injection to determine estrus-cycling status.

Control females were inseminated 12 to 16 h (AM-PM rule) after first detected estrus until 80 h after the second $PGF_{2\alpha}$ injection, when all remaining females were inseminated. The females in the ovulation synchronization treatment were inseminated either at estrus or at 18 h after the second injection of GnRH (48 h after implant removal or 72 h after the second $PGF_{2\alpha}$ injection). Pregnancy status was determined by intrarectal ultrasonography on days 34 or 35 after insemination.

Results and Discussion

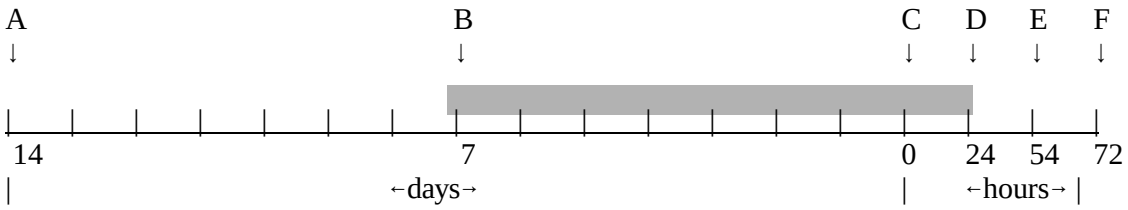
The majority of heifers (87%) and cows (66%) were cycling at the time the treatments were initiated, based on serum progesterone concentrations 24, 14, and 7 days before the time of the GnRH injection and implant (Figure 1). Similar proportions of noncycling control and ovulation-synchronized heifers showed estrus and were inseminated at estrus (46.9 vs. 34.6%). For noncycling cows, more ($P<.05$) control than ovulation- synchronized cows were inseminated at estrus (80 vs. 39.5%). The remaining heifers and cows were inseminated at a fixed time after $PGF_{2\alpha}$.

No differences in pregnancy rates were detected among breeds or parity groups (heifers and cows). Pregnancy rate was greater ($P<.01$) in the ovulation-synchronized females than in controls (60.2 vs. 48%). Control and treated females that were already cycling had similar pregnancy rates (56.2 vs. 58.8%). The experimental treatment increased pregnancy rates in noncycling females (26.5 vs. 63.5%; Table 1). Our results indicate that the ovulation synchronization treatment successfully induced a fertile ovulation in previously prepubertal heifers and anestrous suckled cows.

Pregnancy rates were similar in ovulation-synchronized females (66.1 vs. 60.6%), regardless of whether inseminated at estrus or at one fixed time (72 hours after $PGF_{2\alpha}$; Table 2). In contrast, controls inseminated at estrus had greater pregnancy rates than controls inseminated at one fixed time (80 hours after $PGF_{2\alpha}$), 60 vs. 3.8%.

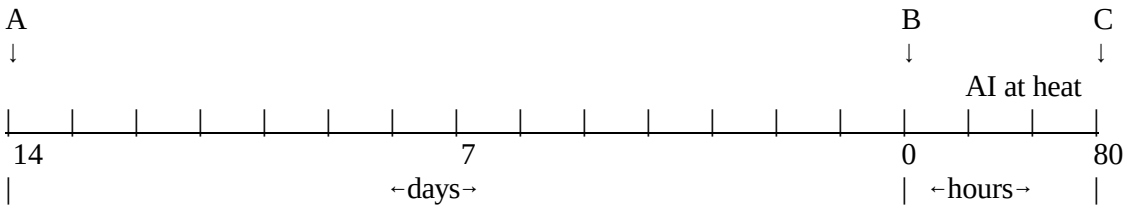
These results demonstrate that our novel ovulation synchronization treatment induced a fertile ovulation in both noncycling and cycling heifers and cows. Furthermore, conception rate by fixed timed insemination after the ovulation synchronization equalled that achieved when inseminations were made at estrus in controls. Therefore, our treatment synchronizes ovulation with estrus. We conclude that treatment with $PGF_{2\alpha}$, GnRH, and norgestomet induced estrus and increased pregnancy rates in prepubertal heifers, anestrus cows, and cycling females. In addition, the treatment increased pregnancy rates following one fixed-time insemination.

Ovulation Synchronization



A = 25 mg of Lutalysefi (PGF $_{2\alpha}$)
B = 100 g of Cystorelinfi (GnRH)+ 6-mg ear implant of norgestomet ( )
C = 25 mg of Lutalyse
D = Removal of implant
E = 100 g of Cystorelin
F = Insemination

Control



A = 25 mg of Lutalyse
B = 25 mg of Lutalyse
C = Insemination (in absence of detected estrus)

Figure 1. Treatment Protocols for Ovulation Synchronization Treatment and Control

Table 1. Pregnancy Rates in Previously Noncycling and Estrus-Cycling Heifers and Suckled Cows after Synchronized Ovulation using $PGF_{2\alpha}$, GnRH, and Norgestomet[a]

	Treatment[b]			
	Control		Ovulation Synchronized	
Parity	No.	% Pregnant	No.	% Pregnant
Noncycling	49	26.5[x]	52	63.5[y]
Heifers	4	0.0	5	100.0
Cows	45	28.9	47	59.6
Cycling	130	56.2[x]	119	58.8[x]
Heifers	32	56.3	32	59.4
Cows	98	56.1	87	58.6

[a]Heifers and suckled cows were classified as noncycling or estrus-cycling based on serum concentrations of progesterone measured in three samples (24, 14, and 7 days before the second injection of $PGF_{2\alpha}$).
[b]See Figure 1 for details.
[x,y]Interaction (P=.08) of treatment and estrus-cycling status.

Table 2. Effect of Fixed-Time Insemination on Pregnancy Rates in Heifers and Suckled Cows

	Treatment[a]			
	Control		Ovulation Synchronized	
AI Time[b]	No.	% Pregnant	No.	% Pregnant
Estrus	127	66.1[x]	66	60.6[x]
Fixed time	52	3.8[y]	91	60.0[x]
Total	179	48.0	171	60.2

[a]See Figure 1 for details.
[b]Controls were inseminated at one fixed time (80 hours after the second injection of $PGF_{2\alpha}$) in the absence of estrus. Ovulation synchronized females were inseminated 18 hours after the second GnRH injection (48 hours after the norgestomet implant was removed or 72 hours after the second injection of $PGF_{2\alpha}$) in the absence of estrus.
[x,y]Interaction (P<.01) of treatment and insemination time.

TIMING OF GAIN DOES NOT ALTER PUBERTY AND REPRODUCTIVE PERFORMANCE OF BEEF HEIFERS FED A HIGH-ROUGHAGE DIET

J. M. Lynch, G. C. Lamb, B. L. Miller, J. E. Minton, R. C. Cochran, and R. T. Brandt, Jr. [1]

Summary

Eighty crossbred heifers (549 lb initial body weight) were developed in drylot and limit-fed a forage sorghum silage diet predicted to produce gains of either 1 lb/day for the entire developmental period (EVENGAIN) or .25 lb/day for the first two-thirds of the period followed by 2 lb/day during the last third (LATEGAIN). Treatments began on November 7, 1994 and continued until April 24, 1995 (onset of the breeding season). Actual daily gains over the entire feeding period averaged 1.18 and 1.10 lb/day for EVENGAIN and LATEGAIN heifers, respectively. Age and weight at puberty were not affected by feeding treatment. Body condition score, frame score, and pelvic area were similar at the end of the experiment regardless of growth regimen. At the conclusion of the 168-day feeding period, estrus was synchronized using two injections of prostaglandin $F_{2\alpha}$, and heifers were inseminated artificially during a 45-day breeding season. Open heifers were mated naturally for an additional 15 days. First service and overall pregnancy rates were similar between treatments. In summary, timing of gain did not affect the onset of puberty or breeding performance. These data indicate that beef producers may be able to utilize low quality feedstuffs early in heifer development without adversely affecting reproductive performance. Because feed inputs are major costs for developing beef heifers, such a management alternative may decrease costs. (Key Words: Heifers, Puberty, Heifer Development, High-Roughage Diet.)

Introduction

Yearling beef heifers that conceive early in their first breeding season and calve early as 2-year olds will have greater lifetime productivity than heifers that calve older. In addition, heifers that produce their first calf early in the calving season tend to continue to calve early in subsequent calving seasons, resulting in increased lifetime production and efficiency. To ensure that heifers conceive early in the breeding season, they must attain sufficient weight to initiate their first estrous cycle before the onset of the breeding season. Current management practices target heifers to reach 60 to 65% of their estimated mature body weight by the start of the breeding season, but little is known regarding the importance of the timing of this weight gain. Previous research at Kansas State University (1995 Cattlemen's Day Report, KAES Report of Progress 727:107) indicated that, when the majority of weight gain is delayed until the last third of the developmental period, heifers may be raised in a more cost-efficient manner; a smaller heifer can be maintained on less feed for a longer period of time. On a relatively high concentrate diet, we saved about 12% on feed cost without sacrificing mature weight or reproductive performance.

The objective of this study was to evaluate the effect on forage-fed heifers of feed restriction early in the developmental period followed by rapid weight gain.

[1]Adjunct Faculty, Hoechst-Roussel Agric-Vet, Overland Park, KS.

Experimental Procedures

Eighty spring-born, Angus x Hereford heifers (549 lb initial body weight) were blocked by weight and assigned randomly within weight blocks to two treatments. Heifers were fed to gain 1 lb/day for the entire 168-day development period (EVENGAIN; n=40) or to gain .25 lb/day for the first two-thirds of development period followed by approximately 2 lb/day for the last third (LATEGAIN; n=40). Heifers were housed in drylot with eight head per pen and five pens per treatment. The feeding period began on November 7, 1994 and continued until April 24, 1995 (onset of the breeding season). LATEGAIN heifers were switched to the higher rate of gain on February 27, 1995. Diets were formulated according to NRC (1984) recommendations. Based on previous research with restricted gains, dry matter intake was adjusted to compensate for increased efficiency at the predi cted rate of gain. The diet (as fed) was 92.5% forage sorghum silage and 7.5% vitamin-mineral supplement, which included soybean meal and rolled milo to meet protein requirements for the desired gain. Heifers were weighed every 28 days, and intakes were adjusted as necessary.

Beginning in January, weekly bl ood samples were collected via tail venipuncture. Serum was harvested and stored at 20°C until progesterone analysis was completed. Two consecutive samples with progesterone >1 ng/ml indicated first ovulation and luteal function. The day of puberty was estimated by subtracting 3 days from the first day when progesterone was >1 ng/ml, followed by an estrous cycle of normal duration.

Body weight and body condition score (1=extremely thin, 9= extremely fat) were determined at day 0 (initial), day 112 (feed switch), and day 168 (onset of breeding season). In addition, pelvic area and frame score were determined at the conclusion of the experiment. Estrus was synchroniz ed using two injections of prostaglandin $F_{2\alpha}$ (Lutalysefi) given 14 days apart. Heifers were inseminated artificially at estrus according to the AM -PM rule for the first 45 days of the breeding season. Heifers then were exposed to a mature bull for 15 days to complete the 60-day breeding season. First-service and overall pregnancy rates were determined by transrectal ultrasonography approximately 30 days after breeding.

Results and Discussion

The results for EVENGAIN and LATEGAIN treatments are summarized in Table 1. Age and weight at puberty were similar between treatments. Treatment had no effect on body condition score, frame score, or pelvic area at the conclusion of the experiment. In addition, we found no differences in first-service or overall pregnancy rates in heifers.

Because LATEGAIN heifers did not reach the programmed .25 lb/d for the first two-thirds of development (actual gain = .12 lb/d), dry matter intake for the last third of development was adjusted to provide an adequate daily gain to reach a projected end weight similar to that of EVENGAIN heifers. Overall gains for the entire feeding period were 1.10 and 1.18 lb/d for LATEGAIN and EVENGAIN heifers, respectively. Dry matter intake was approximately 2.5% less for the LATEGAIN heifers, but this amount was not statistically significant.

Our data indicate that the timing of gain did not affect the onset of puberty or breeding performance in these beef replacement heifers. Also, utilizing a high-forage diet did not provide the feed savings that were observed previously with heifers on similar treatments and fed high-concentrate diets. Even so, collectively, the data indicate that considerable latitude exists relative to the timing of gain in beef replacement heifers. This may allow producers to winter replacements on low quality, lower-cost feeds such as dormant native range and crop residues. However, heifers should be switched to higher quality feedstuffs far enough in advance of the breedin g season to ensure reaching puberty and the appropriate body weight. This approach may reduce the cost of developing beef replacement heifers without degrading reproductive performance.

Table 1. Performance and Reproductive Characteristi cs of Heifers Developed at Different Rates and Times of Gain

	Dietary Treatment [a]		
Item	EVENGAIN	LATEGAIN	SE
No. of heifers	40	40	
Initial weight, lb	551	547	19.3
Prebreeding weight,lb	739.2	722.6	17.25
Daily gain, lb/head	1.18	.12; 3.45 [b]	.037
Age at puberty, days	386	405	8.75
Weight at puberty, lb	690	687	17.8
Body condition score [c,d]	5.40	5.38	.09
Pelvic area [d], cm^2	191.1	201.8	5.8
Frame score [d]	4.99	5.05	.16
First-service conception, %	56.4	71.0	
Overall pregnancy rate, %	87.5	87.5	
Daily feed intake, lb DM/hea d	12.1	11.8	.28

[a]EVENGAIN heifers were fed to gain 1 lb/day (November 7, 1994 to April 24, 1995) and LATEGAIN heifers were fed to gain .25 lb/day from November 7, 1994 until February 27, 1995, when predicted rate of gain was increas ed to reach the projected end weight of EVENGAIN heifers on April 24, 1995.
[b]Daily gain for LATEGAIN heifers represents the gains during the first two-thirds and last third of the feeding period.
[c]BCS: 1 = extremely thin, 9 = extremely fat.
[d]Determined at the onset of the breeding season (April 24, 1995).

EFFECTS OF POSTWEANING MANAGEMENT SYSTEM AND BREED ON GROWTH AND CARCASS TRAITS

K. M. Andries, R. R. Schalles, M. E. Dikeman, and D. E. Franke [1]

Summary

Data from 5 years of a long-term, rotational, crossbreeding project were used to calculate heritabilities and correlations and to make breed comparisons for growth rate and carcass traits in two different postweaning management systems. The traits studied were weight per day of age, hot carcass weight, ribeye area, marbling score, and days of age at slaughter. One group was placed on full feed after weaning. A second group underwent a backgrounding phase for 7 months at Louisiana State University before being placed on feed at KSU. The breeds involved were Angus, Brahman, Charolais, Hereford, Simmental, and Gelbvieh. Differences in heritabilities between management systems were generally small, indicating similar genetic expression across management systems. Genetic correlations also were high except for marbling score, which indicates some difference in genetic expression between management systems for this trait. Some changes in rank of breeds occurred between management systems, but they generally were not significant.

(Key Words: Breeds, Management, Carcass Traits, Genetics, Growth.)

Introduction

With the increased use of retained ownership of calves and increased growth potential of some biological types of calves, many producers are changing from a conventional management system that utilizes backgrounding on forage followed by feedlot finishing to one in which calves are placed directly on feed after weaning. Differences in some carcass traits have been related to increased days on feed and differences in age of calves. Also, increased efficiency of gain has been reported for calves placed directly in the feedlot at weaning. Various breeds also may perform differently under different management systems. Our objectives were to determine the heritabilities and genetic and phenotypic correlations between measurements of the same trait in two postweaning management systems and to compare breeds in the two management systems.

Experimental Procedures

Records from 488 crossbred steers were available for analysis of growth rate and carcass traits between two postweaning management systems. The traits studied were weight per day of age, hot carcass weight, ribeye area, marbling score, and slaughter age. This project was conducted in cooperation with Louisiana State University (LSU). All steers were produced at LSU in the fifth generation of a rotational crossbreeding project involving Angus, Brahman, Charolais, and Hereford. All possible F_1, two-, three-, and four-breed rotational crosses were produced with the restriction that Brahman be included in all crosses. All F_1 dams and half of each rotational dam line were mated to terminal sires. Gelbvieh was used for the first 3 years and Simmental for the last 2 years as the terminal sire breeds. Angus Hereford F_1 cross calves also were produced.

Calves were born between mid-January and mid-April. Bull calves were dehorned and

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castrated in July. Calves were weaned and vaccinated in the first week of September. Approximately 60% of the steers within each breed group were assigned randomly to the calf management group and shipped to KSU during the first week of October at an average age of 8 months. The remaining 40% of the steers made up the yearling management group and were backgrounded on ryegrass pasture at LSU before being shipped to KSU in early May at an average age of 15 months. In 1993, only a calf management group was available, because fewer steers were produced at LSU.

Upon arrival at KSU, steers were weighed, sorted into pens, and placed on feed. The ration consisted of sorghum silage and cracked corn plus a soybean meal, urea, and mineral supplement. Silage was reduced from 75 to 15 % of the diet dry matter over a 4-week starter period. Steers were slaughtered at IBP, Inc., Emporia, Kansas, when ultrasound-measured fat thickness was between .3 and .5 inches. Carcass data were collected by members of the KSU faculty. Marbling scores were converted to a numeric value for analysis.

The data were analyzed by considering each trait separately in the two management systems. A multiple-traits DFREML procedure in a full-animal model was used. Two- trait models were used, with the two management systems being analyzed together for each measured trait. The model included the fixed effect of year of birth. Heterosis was adjusted for by regression procedures. All traits were analyzed to a constant adjusted backfat end point (.42 in.). Breed differences were adjusted for by use of regression procedures in the calculation of heritabilities and correlations. The pedigree file contained information from all five generations of the breeding project. The breeds were included as genetic groups in the pedigree file for calculation of breed effects. Solutions for the breed effects were contrasted to determine differences between breeds for each trait within a management systems.

Results and Discussion

A total of 488 steers was shipped from LSU to KSU as part of this study. The calf management group totaled 289 (59.2%), and the yearling management group, 199 (40.8%). Because of missing data, only 261 steers from the calf group and 176 from the yearling group were available for analysis of all traits. The calf management group had an average weight per day of age of 2.75 lb/day and averaged 463 days of age at slaughter. The yearling management group averaged 2.18 lb/day and a slaughter age of 564 days. Both management systems produced acceptable average carcass weights; 693 lb for calves and 756 lb for yearlings. Ribeye area also were very acceptable, being 12.6 in^2 and 13.4 in^2 for calf and yearling groups, respectively. The calf management group had a higher average marbling score than the yearling management group (small ^{18} vs slight ^{92}, respectively). A marbling score of small ^{00} is necessary to be graded Choice.

Heritabilities and correlations are presented in Table 1. Differences in heritability between management systems were generally small, indicating that genetics were expressed equally. The greatest difference was for marbling, with .28 for calf vs .12 for yearling management. This may indicate greater expression of genetic potential for marbling in the calf management group.

All genetic correlations were extremely high, except for weight per day of age and marbling. High genetic correlations for a trait for both calves and yearlings indicates that the same genes affect traits at both ages. The lower correlations for weight per day of age may have been due to differences in rate of maturity. The base used is the average of the breeds. The earlier maturing breeds (Gelbvieh and Simmental) had the greatest weight per day of age as calves, whereas the later maturing breeds (Brahman and Charolais) had the greatest weight per day of age as yearlings (Table 2). Simmental was significantly higher than Angus, Brahman,

and Hereford in the calf management group for weight per day of age. The rankings of breeds for all traits, except weight per day of age, were very similar between the calf and yearling management groups.

These results indicate that steers in different management systems showed similar genetic expression of traits, except for weight per day of age and marbling score. For these two traits, the calf management group had higher heritabilities, indicating greater expression of genetic potential. The breed comparisons indicate that breeds perform similarly under different managements, except for weight per day of age.

Table 1. Heritabilities and Genetic and Phenotypic Correlations within Management System[a]

	Heritability		Correlations	
Traits	Calf	Yearling	Genetic	Phenotypic
Weight/day of age	.61	.54	.69	.82
Hot carcass weight	.24	.24	1.0	1.0
Ribeye area	.17	.23	1.0	.28
Marbling	.28	.12	.22	.84
Age at slaughter	.19	.22	1.0	1.0

[a]Calf is calf management and yearling is yearling management.

Table 2. Breed Comparisons for Growth Rate and Carcass Traits within Management System[a]

	Breeds					
Traits[b]	Angus	Brahman	Charolais	Hereford	Simmental	Gelbvieh
WDA, Calf (lb)	.097 ^{z}	.207 ^{z}	.035^{yz}	.066 ^{z}	.282^{y}	.053^{yz}
WDA, Year (lb)	.007^{yz}	.035^{yz}	.128^{z}	.097 ^{y}	.015 ^{yz}	.053 ^{yz}
HCW, Calf (lb)	16.89 ^{z}	16.89 ^{z}	66.13^{y}	102.64 ^{x}	38.17^{yz}	32.17^{yz}
HCW, Year (lb)	51.98 ^{xz}	51.98 ^{xz}	112.19^{y}	99.62 ^{x}	81.28^{yz}	10.10^{z}
REA, Calf (in^2)	.65 ^{z}	.58 ^{z}	.99^{z}	1.13 ^{z}	.78^{z}	.60^{z}
REA, Year (in^2)	1.23 ^{z}	.64 ^{yz}	.43^{xy}	1.93 ^{z}	2.48^{x}	.90^{xy}
MAR, Calf (%)	9.10^{yz}	53.50 ^{z}	14.66^{yz}	2.00^{yz}	75.60^{y}	47.87 ^{z}
MAR, Year (%)	37.82^{z}	128.94 ^{y}	68.29^{z}	30.07 ^{x}	82.04^{z}	29.10 ^{x}
DOA, Calf (d)	18.54 ^{z}	18.54 ^{z}	30.27^{y}	18.54 ^{z}	8.87^{yz}	16.48^{yz}
DOA, Year (d)	15.64 ^{z}	15.64 ^{z}	15.64 ^{z}	15.64 ^{z}	37.71^{y}	24.85^{y}

[a]The base is the average of the breed groups.
[b]Calf is calf management group, Year is yearling management group, WDA = weight per day of age (lb/day), HCW = hot carcass weight (lb), REA = ribeye area (in ^{2}), MAR = marbling score (% of score), DOA = days of age at slaughter (day).
[x,y,z]Values in the same row with different superscripts differ significantly.

COMPARISONS AMONG CROSSBRED BEEF CATTLE FOR GROWTH AND CARCASS TRAITS

K. M. Andries, R. R. Schalles, M. E. Dikeman, and D. E. Franke [1]

Summary

Data from 5 years of a long-term, rotational crossbreeding project were used to compare breeds for growth and carcass traits. The traits of interest were direct and maternal birth and weaning weights, gain on feed, hot carcass weight, ribeye area, marbling score, and slaughter age. Angus, Brahman, Hereford, Charolais, Simmental, and Gelbvieh breeds were involved. Simmental and Gelbvieh were used as terminal breeds, so maternal effects were not calculated for them.

Brahman breeding caused an increased direct birth weight of the calves, but the maternal influence of Brahman decreased birth weight. No difference occurred in maternal weaning weight among the Angus, Brahman, Charolais, and Hereford breeds. Charolais and Simmental breeding increased gain on feed. Charolais, Simmental, and Gelbvieh breeding resulted in the heaviest hot carcass weights and largest ribeye areas. Simmental, Charolais and Angus breeding resulted in the most marbling. Hereford and Angus breeding reduced age at slaughter compared to the other breeds. All six breeds have some advantages in the traits studied. Which breed will work best depends on the production environment and goals of the producer.

(Key Words: Breeds, Growth, Carcass Traits.)

Introduction

The advantages of crossbreeding have been reported many times. One of these advantages is the ability to choose breeds to fit the specific production goals and needs of a specific environment. To do this, one needs to know how the breeds compare. The objective of this study was to compare six breeds for growth and carcass traits using crossbred data.

Experimental Procedures

Records from 488 crossbred steer calves were available for analysis of growth and carcass traits. The traits of interest were direct and maternal birth and weaning weights, gain on feed, hot carcass weight, ribeye area, marbling score, and slaughter age. Steers were produced at Louisiana State University (LSU) in the fifth generation of a rotational crossbreeding project carried out in cooperation with KSU. Breeds were Angus, Brahman, Charolais, and Hereford. All F_1 and two-, three-, and four-breed rotational crosses were represented with the restriction that Brahman be included in each cross. Terminal cross sires were mated to all F_1 dams and half of each rotational-cross dam group. Gelbvieh was used as the terminal sire breed for the first 3 years and Simmental for the last 2 years. Angus Hereford F_1 were also produced.

Calves were born between mid January and mid April. Bull calves were dehorned and castrated in July. Calves were weaned and vaccinated in the first week of September. Approximately 60% of the steers were assigned randomly to a calf management group and shipped to KSU during the first week of October at an average age of 8 months. The remaining 40% made up a yearling management group and were backgrounded on ryegrass pasture at LSU before being shipped to KSU in early May at an average age of 15 months. In 1993, only

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a calf management group was available, because fewer steer calves were produced at LSU.

Upon arrival at KSU, steers were weighed, sorted into pens, and placed on feed. The ration consisted of sorghum silage and cracked corn plus a soybean meal, urea, and mineral supplement. Silage was reduced from 75 to 15 % of the diet dry matter over a 4-week starting period. Steers were slaughtered at IBP, Inc., Emporia, Kansas, when ultrasound-measured fat thickness was between .3 and .5 inches. Carcass data were collected by members of the KSU faculty. Marbling scores were converted to a numeric value for analysis.

Data were analyzed using a multiple trait DFREML procedure in a full-animal model. The model included pedigree information from all five generations of the project. Breeds were included as genetic groups in the pedigree file, and breeding values were calculated for each breed. These values then were contrasted to determine differences between breeds. The average of all the breeds was used as the base for the breeding values. The model also included fixed effects of year of birth and management group for postweaning traits and year of birth and age of dam for preweaning traits. Direct and maternal heteroses were accounted for by use of regression procedures. Birth date was a co-variant for birth weight and age at weaning for weaning weight. Gain on feed was adjusted for days on feed by regression procedures. All postweaning traits were adjusted by regression to a common adjusted backfat thickness end point.

Results and Discussion

Because of missing data, only 437 of the 488 steers were available for analysis of all growth and carcass traits. The steers averaged 83.2 lb at birth and 521.0 lb at weaning. The average hot carcass weight was 718.3 lb, with a 12.9 in^2 ribeye and small^{07} marbling at an average age of 504 days. Adjusted backfat averaged .42 in., and actual backfat was .37 in.

Brahman and Gelbvieh had the only positive breed effects on direct birth weight (Table 1). Brahman had an increasing effect on direct birth weight (+18) and decreasing effect on maternal birth weight (17), whereas Hereford had the greatest decreasing effect on direct birth weight (11) and next to the greatest increasing effects on maternal birth weight. Charolais had the greatest increasing effect (+9).

Brahman, Gelbvieh, and Simmental all had similar positive effects on direct weaning weight. The only significant difference was for Brahman, which was higher than Angus, Charolais, and Hereford. No differences were found between breeds for maternal weaning weight. Charolais and Simmental were similar for gain on feed and higher than Brahman, Hereford, and Gelbvieh. Angus was similar to Hereford and Gelbvieh, but higher than Brahman for gain on feed.

Charolais, Simmental, and Gelbvieh had the highest breed effects on hot carcass weight; Angus, Brahman, and Hereford had the lowest. Charolais, Simmental, and Gelbvieh breeding significantly increased ribeye area over that of Angus, Brahman, and Hereford.

Simmental, Charolais, and Angus had similar positive effects on marbling score at the same adjusted backfat end point. Charolais and Simmental had significantly higher effects on marbling than Brahman, Hereford, and Gelbvieh. Angus and Hereford were similar to Gelbvieh but higher than Brahman for marbling score. It is important to remember that a fat-constant end point was used in this study. Most earlier studies used weight or days on feed as their end points and found that Continental breeds did not develop marbling as well as British breeds. By allowing the Continental breeds time to put on the external fat, they also were able to develop marbling in our study.

Hereford and Angus breeding reduced the days on feed to reach the constant fat end point, with Hereford being significantly lower than all other breeds except Angus. Charolais, Simmental, and Gelbvieh breeding required significantly more days on feed than Angus and Hereford.

Table 1. Breed Effects on Growth and Carcass Traits [a]

	Breeds					
Traits[b]	Angus	Brahman	Charolais	Hereford	Simmental	Gelbvieh
BWT DA (lb)	5.49 ^{xz}	18.39^{y}	3.79 ^{xz}	10.82 ^{x}	1.85 ^{xz}	3.55^{yz}
BWT MA (lb)	.59^{z}	17.30 ^{y}	9.30^{x}	7.36^{x}	NA	NA
WWT DA (lb)	20.06 ^{z}	54.32^{x}	33.77 ^{z}	23.06 ^{z}	1.46^{xz}	21.19^{xz}
WWT MA (lb)	14.57 ^{z}	2.27^{z}	21.32^{z}	9.04^{z}	NA	NA
GOF (lb)	8.42^{yz}	98.08 ^{x}	51.98^{z}	16.45 ^{y}	76.87^{z}	22.75 ^{xy}
HCW (lb)	42.64 ^{z}	73.70 ^{z}	97.75^{y}	73.70 ^{z}	59.04^{y}	33.22^{y}
REA (in^2)	.92 ^{z}	.82 ^{z}	.93^{y}	1.41 ^{z}	1.43^{y}	.78^{y}
MAR[c]	15.39^{xz}	73.47 ^{y}	38.23^{z}	10.63 ^{xy}	66.12^{z}	35.66 ^{xy}
DOA (d)	30.62 ^{xz}	1.84^{xy}	34.46^{y}	38.12 ^{z}	15.37^{y}	17.05^{y}

[a]The base is the average of the breed groups.

[b]DA = direct, MA = maternal, BWT = birth weight, WWT = Weaning Weight, GOF = Gain on feed, HCW = hot carcass weight, REA = ribeye area, MAR = marbling, DOA = days of age at slaughter.

[c]Marbling score is a percent of a score, with average = small ^{07}.

^{x,y,z}Values in the same row with different superscripts differ significantly

NA Simmental and Gelbvieh were not represented in any dam line, so maternal effects were not calculated for these breeds.

GENETIC PARAMETERS FOR GROWTH AND CARCASS TRAITS FROM CROSSBREEDING

K. M. Andries, R. R. Schalles, M. E. Dikeman, and D. E. Franke [1]

Summary

Growth and carcass data from 5 years of a long-term, rotational, crossbreeding project were used to calculate heritabilities and genetic and phenotypic correlations for direct and maternal birth and weaning weight, gain on feed, hot carcass weight, ribeye area, marbling score, and age at slaughter. Angus, Brahman, Hereford, Charolais, Simmental, and Gelbvieh breeds were involved. Heritabilities of traits ranged from low (maternal weaning weight 0.04) to moderate (direct weaning weight 0.41). Direct birth weight, direct weaning weight, gain on feed, and hot carcass weight had moderate to high genetic correlations. Marbling had negative genetic correlations with birth and weaning weight but positive correlations with slaughter age and hot carcass weight.

(Key Words: Breeds, Heritability, Correlations, Carcass Traits, Growth.)

Introduction

With a movement toward more value-based marketing, both growth and carcass traits become more important to producers. Knowledge of the relationships between growth and carcass traits will help producers select cattle that perform in both areas. Our objectives were to determine the heritability of seven growth and carcass traits and to calculate genetic and phenotypic correlations among those traits.

Experimental Procedures

Records from 488 crossbred steer calves were available. Traits of interest were direct and maternal birth and weaning weights, gain on feed, hot carcass weight, ribeye area, marbling score, and age at slaughter. Steers were produced at Louisiana State University (LSU) in the fifth generation of a rotational crossbreeding project carried out in cooperation with KSU. Breeds were Angus, Brahman, Charolais, and Hereford. All F_1 and two-, three-, and four-breed rotational crosses were represented with the restriction that Brahman be included in each cross. Terminal cross sires were mated to F_1 dams and half of each rotational-cross dam group. Gelbvieh was used for the first 3 years and Simmental for the last 2 years as the terminal sire breeds. Angus Hereford F_1 calves also were produced.

Calves were born between mid-January and mid-April. Bull calves were dehorned and castrated in July. Calves were weaned and vaccinated in the first week of September. Approximately 60% of the steers were assigned randomly to a calf management group and shipped to KSU during the first week of October at an average age of 8 months. The remaining 40% made up a yearling management group and were backgrounded on ryegrass pasture at LSU before being shipped to KSU in early May at an average age of 15 months. In 1993, only a calf management group was available, because fewer steers were produced at LSU.

Upon arrival at KSU, steers were weighed, sorted into pens, and placed on feed. The ration consisted of sorghum silage and cracked corn

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plus a soybean meal, urea, and mineral supplement. Silage was reduced from 75 to 15 % of the diet dry matter over a 4-week starting period. Steers were slaughtered at IBP, Inc., Emporia, Kansas, when ultrasound-measured fat thickness was between .3 and .5 inches. Carcass data were collected by members of the KSU faculty. Marbling scores were converted to a numeric value for analysis.

Data were analyzed using a multiple trait DFREML procedure in a full-animal model. The model included pedigree information from all five generations of the project. The model also included fixed effects of year of birth and management group for postweaning traits and year of birth and age of dam for preweaning traits. Heterosis was accounted for by use of regression procedures. Birth date was included as a covariant for birth weight and age at weaning for weaning weight. Gain on feed was adjusted for days on feed by regression procedures. All postweaning traits were adjusted by regression to a common adjusted backfat thickness end point. Two-trait analyses were used to calculate the heritabilities and correlations. Breed differences were accoun ted for by regression procedures.

Results and Discussion

A total of 488 steers calves was shipped form LSU to KSU; however, because of missing data, only 437 steers were available for analysis of all growth and carcass traits. The steers average 83.2 lb at birth and 521.0 lb at weaning. They had an average hot carcass weight of 718.3 lb, with a 12.9 in ^{2} ribeye and small^{07} marbling at an average slaughter age of 504 days. Adjusted backfat averaged .42 in., and actual backfat was .37 in.

Heritabilities and genetic and phenotypic correlations for the seven traits are presented in Table 1. Maternal heritabilities were low in this study. Direct birth and weaning weight had heritabilities (.17 and .41, respectively) lower than most estimates reported earlier for these traits, as did gain on feed and ribeye area. Differences in the model used and the use of a fat-constant end point may have caused these differences. Hot carcass weight and marbling score had moderate heritabilities (.24 and.32, respectively). Days of age at a fat-constant end point had a heritability of .20 in this study.

Maternal birth and weaning weight generally had negative genetic correlations with other traits except ribeye area. No genetic correlations were found between maternal birth weight and gain on feed, hot carcass weight, or days of age. Direct birth weight had little genetic relationship with carcass traits. Direct weaning weight had high positive genetic correlations with gain on feed, hot carcass weight, and ribeye area. Negative correlations were found between direct weaning weight and marbling score and days of age.

Gain on feed had a small negative correlation with hot carcass weight and moderately positive correlations with ribeye area and marbling. The only other negative correlation between postweaning traits was between ribeye area and marbling score (.64).

Days of age had high negative genetic correlations with weaning weight (.56) and gain on feed (1.0) and a moderately negative correlation with ribeye area (.41). The relationship between days of age and hot carcass weight was very low (.07), but marbling score had a moderately positive genetic correlation with days of age (.58).

The results of this study indicate that desirable growth and carcass traits are compatible. Positive correlations between preweaning and postweaning growth indicates that selection for early growth will transfer to faster later growth. Age that an animal reaches an end point of set fat thickness should be reduced by selection for growth rate.

Table 1. Heritability and Genetic and Phenotypic Correlations [a]

Traits [b]	BWT DA	BWT MA	WWT DA	WWT MA	GOF	HCW	REA	MAR	DOA
BWT DA	**.17**	-.91	.79	-.01	.46	.50	0.0	-.07	0.0
BWT MA	NA	**.09**	-.37	-.53	0.0	0.0	.10	-.01	0.0
WWT DA	.49	NA	**.41**	-.56	.68	1.0	.88	-.20	-.56
WWT MA	NA	NA	NA	**.04**	-.04	-.58	.42	0.0	-.33
GOF	.29	NA	.25	NA	**.17**	-.04	.42	.37	-1.0
HCW	.42	NA	.47	NA	.73	**.24**	.40	.40	.07
REA	.17	NA	.20	NA	.42	.56	**.21**	-.64	-.41
MAR	-.04	NA	-.09	NA	.21	.19	-.01	**.32**	.58
DOA	-.04	NA	0.0	NA	.03	.54	.31	.19	**.20**

[a]Heritabilities are underlined and on the diagonal, genetic correlations are above the diagonal, and phenotypic correlations are below the diagonal.

[b]DA = direct, MA = maternal, BWT = Birth weight, WWT = Weaning weight, GOF = gain on feed, HCW = hot carcass weight, REA = ribeye area, MAR = marbling score, DOA = days of age at slaughter.

NA = not available

Heritabilities and Genetic Correlations

Direct heritabilities estimate the fraction of variation among animals caused by genes received from the parents and range from zero to 1. The dam also provides a maternal environment (uterine environment, milking ability, etc.), which is influenced by the dams own genetics, separate from the genes she passes on to the offspring. The heritability of this maternal environment is referred to a smaternal heritability. Direct heritabilities include a calf s own genetics for growth up to birth, expressed as birth weight heritability, or growth to weaning, expressed as weaning weight heritability, etc.

Correlations indicate the relationship between two traits and can range from -1 to +1. Genetic correlations indicate the relationship between two traits caused by the same genes. For example, some genes that cause rapid growth from birth to weaning also cause rapid growth from weaning to yearling. Some genetic correlations are less obvious. A correlation between maternal weaning weight and direct yearling weight would indicate that some of the genes that influence milk production also influence the individuals s own growth rate . Phenotypic correlations represent relationships between traits, regardless of their cause.

INHERITANCE OF THE "RAT-TAIL" SYNDROME [1]

R. R. Schalles

Summary

A form of congenital hypotrichosis, commonly known as rat-tail, is characterized by the colored hair anywhere on the body being short, curly, malformed, and sometimes sparse and an abnormal tail switch.

The "rat-tail" syndrome is controlled by interaction between two loci. Cattle that express this syndrome must have at least one gene for black color and be heterozygous at the other locus involved.

(Key Words: Rat-Tail Syndrome, Genetics, Breeds.)

Introduction

When black breeds of cattle (such as Angus and Holstein) are crossed with Continental European breeds, a small percentage of the calves will have a form of congenital hypotrichosis, which is commonly known as "rat-tail" syndrome. The condition is characterized by the colored hair anywhere on the body being short, curly, malformed, and sometimes sparse and an abnormal tail switch. The condition does not exist in red or white cattle. In an earlier study (1992 Cattlemen's Day Report), we reported that "rat-tail" calves had a lower rate of gain during the winter months, probably because of the poor insulation value of the hair. The objective of the current study was to determine the mode of inheritance of the "rat-tail" syndrome.

Experimental Procedures

Because purebred black Angus and red Simmental do not show the "rat-tail" condition, but approximately 13% of the offspring from crossing these two breeds do, we assumed that at least two loci were involved in the inheritance of this trait. The F_1 "rat-tail" cattle would be expected to be heterozygous at these loci, and segregation should be observed in the F_2 generation.

Six females and four males that were "rat-tails" produced from mating purebred black Angus cows to purebred dark red Simmental bulls were produced in 1991. In addition, two mature "rat-tail" cows from similar matings were transferred from a project at the Southeast Agricultural Research Center to be used in this study. Semen was collected from two of the bulls by KABSU[1] and used to breed the six females. Cross Country Genetics[2] superovulated, flushed, and froze embryos produced by the mating of F_1 bulls to F_1 females. The embryos were transferred by Cross Country Genetics into cows owned and cared for by ECCO Ranch at Buffalo, KS. A total of 64 F_2 calves was produced during 1993-94.

All calves were evaluated visually and designated as being a "rat-tail" or not. In addition, all calves were photographed by 2 months of age and reevaluated at weaning

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[1]Kansas Artificial Breeding Service Unit, Kansas State University.

[2]7101 Anderson Avenue, Manhattan, Kansas 66502.

(approximately 7 months). Minerals, especially copper, are involved in pigment formation, and some evidence indicates that Continental breeds are less efficient in either copper absorption or transport. Therefore, blood samples were obtained from all calves at weaning, and liver biopsies and hair samples were taken from 30 calves born in the fall of 1994. Liver and plasma levels of copper, iron, zinc, manganese, molybdenum, and cobalt as well as ceruloplasmin were determined for the 30 calves.

Results and Discussion

Results of the "rat-tail" classification and the expected number of individuals are given in Table 1. Two loci are involved in the inheritance of this syndrome. The alleles at one locus are the dominant gene for black (R^b) and the recessive allele for red (R) color. (Note: The allele for white, present in some Shorthorn cattle also can occupy this locus; however, we have no indications that it is involved in the "rat-tail" syndrome.) The other locus has incomplete dominance between the two alleles "C" and "c". An interaction occurs between the genes at the "R" locus and the genes at the "C" locus to produce the colors shown in Table 1.

The dominant dilution gene that can occupy another locus is not involved in the production of the "rat-tail" syndrome. The cattle used in this study were homozygous for the nondilution gene. We assumed that "rat-tail" cattle that have the dominant dilution gene would be lighter in color than the ones in this study.

No significant relationship was found between "rat-tail" syndrome and mineral contents of either serum or liver.

Table 1. Genotypes and Number of Calves Observed and Expected in Each Phenotype

		Number of Calves	
Genotypes	Phenotypes	Observed	Expected
R^bR^bCC R^bR CC	Light to medium gray with fine hair	15	12
R^bR^bCc R^bR Cc	Charcoal colored with rat-tail syndrome	21	24
R^bR^bcc R^bR cc	Normal black hair	12	12
R R CC R R Cc R R cc	Normal red color	16	16

EFFECT OF INCREASING UREA LEVEL IN PROTEIN SUPPLEMENTS ON INTAKE AND DIGESTION OF LOW-QUALITY TALLGRASS-PRAIRIE FORAGE BY BEEF STEERS [1]

H. H. Kster, R. C. Cochran, E. C. Titgemeyer, E. S. Vanzant[2], and G. St Jean[3]

Summary

Twelve ruminally fistulated steers were used to evaluate the effect of changing the proportion of supplemental degradable intake protein (DIP) derived from urea on forage intake and digestion. Steers had ad libitum access to a low-quality tallgrass-prairie hay. Supplemental treatment groups were: 1) 0% of the supplemental DIP from urea, 2) 20% of the supplemental DIP from urea, and 3) 40% of the supplemental DIP from urea. Supplements were formulated to contain 30% CP and were fed with prairie hay once daily. Results from this study indicated that urea can replace up to 40% of the supplemental DIP without affecting forage intake and digestion.

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

Introduction

Because true protein (e.g., soybean meal) is one of the most costly components in winter range supplements, there has been a long-standing interest in the potential of nonprotein nitrogen (NPN) to substitute for true protein in supplements. Recent work at Kansas State University suggests that, conservatively, up to 50% of the supplemental DIP can be provided by urea without compromising forage intake and digestion. However, in that study, the supplements were infused into the rumen, so it is unclear how different levels of urea inclusion might affect supplement palatability or livestock performance. Therefore, this digestion study was conducted in conjunction with a performance study to evaluate forage intake and digestion responses when urea accounted for up to 40% of the supplemental DIP in supplements fed to beef cattle consuming low-quality, tallgrass-prairie forage.

Experimental Procedures

Twelve ruminally fistulated steers (average BW = 835 lb) were used in a randomized complete block design to evaluate the effect of changing the proportion of supplemental degradable intake protein (DIP) derived from urea on forage intake, digestion, and ruminal fermentation characteristics. Animals were housed in a partially enclosed barn (one side open) in 6 ft 18 ft individual pens and had ad libitum access to water and low-quality, tallgrass-prairie hay (2.4% CP, 73.5% NDF). Steers were assigned randomly to one of three supplemental treatment groups: 1) 0% of the supplemental DIP from urea (0% supplemental CP from urea), 2) 20% of the supplemental DIP from urea (15% supplemental CP from urea), and 3) 40% of the supplemental DIP from urea (30% supplemental CP from urea). Supplements were formulated with soybean meal, urea, sorghum grain, and molasses to contain approximately 30% CP and a N:S ratio of 10:1. Steers received 3.63 lb of supplement DM daily. Based on previous research, the amount of DIP provided by the supplements and forage should have been sufficient to maximize digestible OM intake (DOMI) of the low-quality forage fed.

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

[2]KSU Agricultural Research Center - Hays.

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Supplements and forage were fed once daily in the morning (8 AM) with the supplement offered just before feeding the hay. Generally, all supplements were consumed within 45 minutes. The experimental period consisted of a 14-day adaptation followed by 7-day intake and 7-day total fecal collection periods. Feed and orts samples from days 21 to 27 and fecal samples obtained during the 7-day fecal collection period (days 22 to 28) were used to estimate OM, NDF, and N digestibility. Ruminal DM and fluid content were determined by manually evacuating the rumen just before (0 hour) and 4 hours after feeding. Fluid dilution rate, pH, ammonia N, and volatile fatty acid (VFA) concentrations were determined on ruminal fluid samples collected at feeding (0 hour) and 3, 6, 9, 12, and 24 hours after feeding.

Results and Discussion

Increased proportions of supplemental DIP from urea did not change ($P \geq .38$) forage OM intake, total OM intake, or DOMI in this study (Table 1). Similarly, total tract OM and NDF digestibilities did not respond ($P \geq .37$) to increasing urea level.

These responses agree with previous work from our laboratory and others reporting that forage intake and digestion were similar for cattle fed supplements containing different proportions of the supplemental DIP as urea. This suggests that negative performance responses generally observed when true protein is replaced by NPN would not be due to differences in intake and digestion. Ruminal DM contents were relatively constant ($P=.39$) across urea levels. In contrast, the apparent quadratic response ($P \leq .06$) for ruminal fluid contents and fluid dilution rate, although small in magnitude, was unexpected. Increasing urea levels did not affect ($P \geq .25$) ruminal pH or total VFA concentration. However, ammonia N concentrations increased linearly ($P \leq .01$) as percentage of supplemental DIP from urea increased. This probably reflects the more rapid rate of hydrolysis for urea then for the true protein. None of the individual VFA proportions were altered substantively ($P \geq .10$) with increasing urea level, indicating that the level of urea substitution was limited enough to minimize the chance of observing VFA shifts. In conclusion, urea can replace up to 40% of the supplemental DIP (30% of CP) in a supplement with 30% total CP without affecting forage intake and digestion.

Table 1. Effect of Different Proportions of DIP from Urea on OM Intake, OM, NDF, and N Digestibility, Ruminal DM and Fluid Content, and Fermentation Characteristics in Steers Fed Dormant, Tallgrass-Prairie Forage

	% Supplemental DIP from Urea[a]				Contrasts[b]	
Item	0	20	40	SE	L	Q
Forage OM intake, g/kg BW $^{.75}$	74.1	69.3	70.6	4.83	.63	.63
Supplement OM intake, g/kg BW $^{.75}$	16.4	17.0	16.6	.12	.41	.02
Total OM intake, g/kg BW $^{.75}$	90.5	86.3	87.2	4.86	.65	.68
Digestible OM intake, g/kg BW $^{.75}$	43.9	41.3	42.9	1.51	.72	.38
Total tract OM digestibility, % of intake	48.5	47.8	49.5	1.75	.70	.58
Total tract NDF digestibility, % of intake	50.0	48.8	52.5	1.92	.43	.37
Total tract N digestibility, % of intake	36.8	46.0	42.8	4.40	.18	.12
Ruminal DM content, g/kg BW	29.6	27.9	27.7	1.47	.39	.69
Ruminal fluid content, g/kg BW	163	148	181	8.36	.19	.06
Fluid dilution rate, %/h	7.13	8.70	7.32	.46	.77	.04
pH	6.65	6.64	6.71	.03	.25	.37
Ammonia N, m*M*[c]	.18	.94	1.77	.20	<.01	.89
Total VFA, m*M*[c]	74.3	78.2	73.6	2.79	.87	.26
Acetate, mol/100 mol	76.8	76.8	77.6	.52	.31	.57
Propionate, mol/100 mol	13.9	13.9	13.6	.22	.38	.48
Butyrate, mol/100 mol	7.76	8.01	7.45	.07	.50	.32
Isobutyrate, mol/100 mol	.48	.40	.42	.02	.10	.11
Valerate[c], mol/100 mol	.50	.49	.52	.02	.49	.37
Isovalerate, mol/100 mol	.46	.36	.46	.05	.92	.13
Acetate:propionate	5.55	5.52	5.73	.13	.35	.47

[a]Percent of the total supplemental N from urea is 0, 15, and 30, respectively.
[b]Probability of a greater F value. L = lin ear change with increasing urea, Q = quadratic change with increasing urea.
[c]Trt time (P ≤.02).

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

H. H. Kster, R. C. Cochran, K. C. Olson, T. J. Jones, E. S. Vanzant[2], and E. C. Titgemeyer

Summary

Ninety pregnant Angus Hereford cows consuming low-quality, tallgrass-prairie hay were used to evaluate the influence of changing the amount of supplemental degradable intake protein (DIP) derived from urea on body weight and body condition changes, pregnancy rate, and calf performance. Supplemental treatment groups were: 0, 20, and 40% of the supplemental DIP from urea. Supplements were formulated to contain 30% CP. When sufficient DIP was offered to prepartum cows to maximize DOMI, urea could replace up to 40% of the DIP in a high-protein (30%) supplement without causing problems of supplement palatability. However, trends in body weight and condition indicate that performance may be enhanced if the percent of supplemental DIP from urea is less than 40%.

(Key Words: Cows, Forage, Nonprotein Nitrogen, Intake, Digestibility.)

Introduction

Feeding degradable intake protein (DIP) to pregnant beef cows grazing low-quality forage will increase forage intake and digestion and subsequently enhance animal performance. True proteins such as soybean meal commonly are used as DIP sources in protein supplements. However, to minimize supplement costs, previous research has evaluated the efficacy of substituting nonprotein nitrogen (e.g., urea) for true protein. A ruminal infusion study conducted at Kansas State University found that a limited amount of urea ($\leq$50% of supplemental DIP) can replace DIP from true protein without negatively affecting forage intake and digestion. However, earlier studies have reported supplement unacceptability and reduced animal performance when higher levels of urea (>50% of CP equivalent) are included in supplements.

This study was conducted to evaluate supplement palatability and animal performance when urea accounted for up to 60% of the supplemental DIP in supplements fed to beef cows consuming low-quality, tallgrass-prairie forage.

Experimental Procedures

A performance study was conducted to evaluate the influence of changing the amount of supplemental degradable intake protein (DIP) derived from urea on body weight and body condition changes and pregnancy rate of beef cows consuming low-quality, tallgrass-prairie hay and calf performance.

The experiment was intended to have four supplement treatment groups: 1) 0% of the supplemental DIP from urea (0% of the supplemental CP from urea), 2) 20% of the supplemental DIP from urea (15% of the supplemental CP from urea), 3) 40% of the supplemental DIP from urea (30% of the supplemental CP from urea), and 4) 60% of the supplemental DIP from urea (45% of the supplemental CP from urea). However, refusal to consume the high-urea supplement (60% DIP

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

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from urea) by the cows grazing tallgrass prairie resulted in elimination of this treatment.

Ninety Angus Hereford cows (BW = 1111 lb; final 3 to 5 months of pregnancy) were assigned randomly to supplemental treatments. Cows received approximately 4.76 lb/day of supplement DM. Supplements were formulated with soybean meal, urea, sorghum grain, and molasses to contain approximately 30% CP and a N:S of 10:1. Based on previous KSU research, the amount of DIP provided by the supplements and forage should have been sufficient to maximize digestible OM intake (DOMI) of the grazed forage.

Body weight and body condition were measured at approximately 5-wk intervals until calving, starting on November 28, with additional measures postcalving (48 h after calving), before breeding (April 27, actual breeding season was from May 15 to July 15), and at weaning (October 5). After calving, all cows were handled as a group and received 10 lb/day of alfalfa hay (as fed basis; 88.3% DM; 23% CP and 34% NDF on DM basis) until sufficient new grass growth was available (end of April).

Birth weights of calves were recorded within 48 h. Calf ADG was calculated as weaning weight minus birth weight divided by the number of days from birth. Cows were bred by natural service. A single shot of PGF2$_{\alpha}$ was given at the beginning of the breeding season.

Results and Discussion

The palatability problems experienced with the high-urea supplement (60% of supplemental DIP from urea) clearly indicates that caution must be exercised in determining the quantity of urea to include in supplements for beef cattle grazing low-quality forage.

Body weight (BW) change of cows decreased (linear; P=.02) with increasing urea levels within the first 5-wk period of supplementation (Table 1). Treatment had limited influence ($P \geq .17$) on BW change within subsequent periods until breeding. In contrast, body condition (BC) change was not affected greatly ($P \geq .18$) by treatment during individual periods or when cumulative response was evaluated. However, the numerical trends were similar to those observed for BW change. In general, the treatment differences for BW and BC change were not great, although their trends indicated some decline in performance for the group receiving 40% of supplemental DIP as urea.

The birth weight of calves, calf ADG, and calf weaning weight were not affected ($P \geq .25$) by the level of urea fed to their dams before calving (Table 2). Pregnancy rate tended to be affected (P=.13) by treatment, with the lowest pregnancy rate observed with the greatest level of urea. Therefore, for prepartum supplementation of pregnant beef cows, we recommend not exceeding 40% of the supplemental N in the DIP as urea. Maximal performance likely would be observed at a somewhat lower urea level.

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

	% Supplemental DIP from Urea [b]				Contrasts [c]	
Item	0	20	40	SEM [d]	L	Q
No. of cows	30	30	30			
Initial BW, lb	1115	1104	1115	22.55	.97	.67
Period BW change, lb						
28 November - 3 January	17.4	11.9	-5.3	4.30	.02	.32
4 January - 7 February	31.1	30.0	19.6	4.87	.17	.48
8 February - 21 March (calving)	-145.2	-148.3	-143.9	12.7	.94	.82
calving - 27 April (breeding)	-54.7	-45.2	-42.3	6.44	.24	.68
27 April - 5 October (weaning)	196.3	218.2	199.2	7.71	.81	.09
Cumulative BW change, kg						
28 November - 7 February	48.3	41.9	14.3	7.32	.03	.31
28 November - 21 March (calving)	-97.0	-106.5	-129.6	15.85	.22	.75
28 November - 27 April (breeding)	-151.6	-151.6	-171.9	14.3	.37	.59
28 November - 5 October (weaning)	51.6	62.4	27.3	10.1	.17	.14
Initial BC	5.04	5.00	5.02	.04	.70	.71
Period BC change						
28 November - 3 January	-.03	-.01	-.13	.05	.27	.32
4 January - 7 February	-.07	-.06	-.11	.06	.67	.73
8 February - 21 March (calving)	-.24	-.14	-.22	.08	.84	.45
calving - 27 April (breeding)	-.21	-.29	-.26	.05	.55	.43
27 April - 5 October (weaning)	.88	.90	1.07	.08	.18	.53
Cumulative BC change						
28 November - 7 February	-.10	-.07	-.23	.08	.32	.38
28 November - 21 March (calving)	-.34	-.21	-.45	.10	.50	.21
28 November - 27 April (breeding)	-.55	-.50	-.71	.11	.37	.40
28 November - 5 October (weaning)	.38	.39	.36	.16	.93	.95

[a]Body condition scal e: 1 = extremely emaciated; 9 = extremely obese. [b]Percent of the total supplemental N from urea is 0, 15, and 30, respectively. [c]L = Linear, Q = Quadratic. [d]Standard error of the mean (n=3).

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	20	40	SEM [c]	L	Q
No. of cows	30	30	30			
Calf birth weight, lb	91.9	88.8	87.7	2.18	.25	.76
Calf ADG, birth-weaning, lb	2.23	2.27	2.20	.04	.91	.30
Calf weaning weight, lb	560	566	544	10.45	.34	.34
Pregnancy rate , % [d]	92.6	100	86.2	-	-	-

[a]Percent of the total supple mental N from urea is 0, 15, and 30, respectively. [b]L = Linear, Q = Quadratic.
[c]Standard error of the mean (n=3). [d]Calculated by chi-square data analysis; *P*=.13.

THE INFLUENCE OF VARIOUS LEVELS OF SUPPLEMENTAL STARCH AND DEGRADABLE INTAKE PROTEIN ON PRAIRIE HAY INTAKE AND DIGESTION BY BEEF STEERS

T. J. Jones, R. C. Cochran, K. C. Olson, E. S. Vanzant[1], and E. C. Titgemeyer

Summary

A study was conducted to determine the effect of varying the amount of supplemental degradable intake protein (DIP) and starch on prairie hay intake and digestibility. In general, DIP increased forage intake, whereas starch decreased intake. Diet digestibility also improved with increasing DIP; however, the effect of starch on digestion depended on the level of feeding. Digestible dry matter intake (which estimates total energy input) responded dramatically to DIP but not to starch. These results illustrate the positive effect of DIP on forage intake and digestibility; however, supplying additional starch within a DIP level appeared to have minimal effect on altering total energy supply.

(Key Words: Steer, Intake, Protein and Starch Supplementation.)

Introduction

Supplements with high crude protein concentration increase the forage intake and digestibility of forages containing less than 7% crude protein. However, because protein is expensive, it is important to quantify how much is needed to achieve a given level of response. Recent studies at KSU have determined the amount of degradable intake protein (DIP; i.e., ruminally available protein) required to maximize the use of low-quality, tallgrass-prairie forage. However, it is unclear how the addition of energy in the form of starch will affect the response to DIP supplementation. This study was designed to evaluate the interaction between supplemental starch and DIP with regard to their effect on prairie-hay intake and digestibility.

Experimental Procedures

Thirteen Angus Hereford steers (average initial body weight = 570 lb.) were used in a four-period, 13-treatment, incomplete, Latin square. The treatments were arranged in a 3 4 factorial arrangement with a negative control. Within the supplementation treatments, there were three levels of supplemental starch (corn starch grits; 0, .15, and .30% BW) and four levels of supplemental DIP (casein; .031, .062, .092, and .123% BW). Supplements were placed in the rumen of each steer prior to feeding prairie hay (5% CP) at 115 % of the previous 5-day average intake. Each period consisted of a 14-day adaptation followed by a 9-day sampling period. Digestibility was determined via total fecal collection.

Results and Discussion

Forage intake generally responded positively to increasing DIP supplementation (Figure 1). In contrast, addition of supplemental starch within a DIP level typically resulted in reduced forage intake. Previous KSU research determined that forage intake would be maximized when approximately 11% of the digestible material in the total diet was present as DIP. In our study, this level was approximated at the highest level of DIP supplementation. Thus, we would predict maximum forage intake for the group receiving the highest level of DIP and no supplemental starch.

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As noted for forage intake, the effect of increasing DIP on diet digestion was generally positive (Figure 2). However, response to increasing starch was somewhat variable. This probably was due to conflicting effects of starch on fiber digestion versus total diet digestion. The starch added to the rumen was more highly digestible than the forage material. If the addition of starch within a DIP level had no effect on forage digestion, we would expect the total diet digestion to increase slightly. This occurred in some instances, particularly at the intermediate levels of DIP supplementation. In contrast, if the starch addition depressed forage digestion sufficiently, the total diet digestion should decrease, compared to forage alone. This appeared to be the case for the high level of starch addition when DIP supplementation was low.

Total digestible dry matter intake (DDMI) is the product of intake and digestion and roughly represents the total energy supply (Figure 3). Because of the positive effects of DIP supplementation on forage intake and digestion, the total DDMI generally increased with increasing DIP supplementation. However, because of the variable and, at times, conflicting effects of starch on intake and digestion, total DDMI remained relatively constant with increasing starch addition. As a result, little improvement in total energy supply would be expected with starch addition within a DIP level. These results suggest that ruminally available protein is more limiting to the utilization of low-quality forage than is ruminally available energy. Therefore, supplementation programs for livestock consuming low-quality forage should give first consideration to providing adequate DIP.

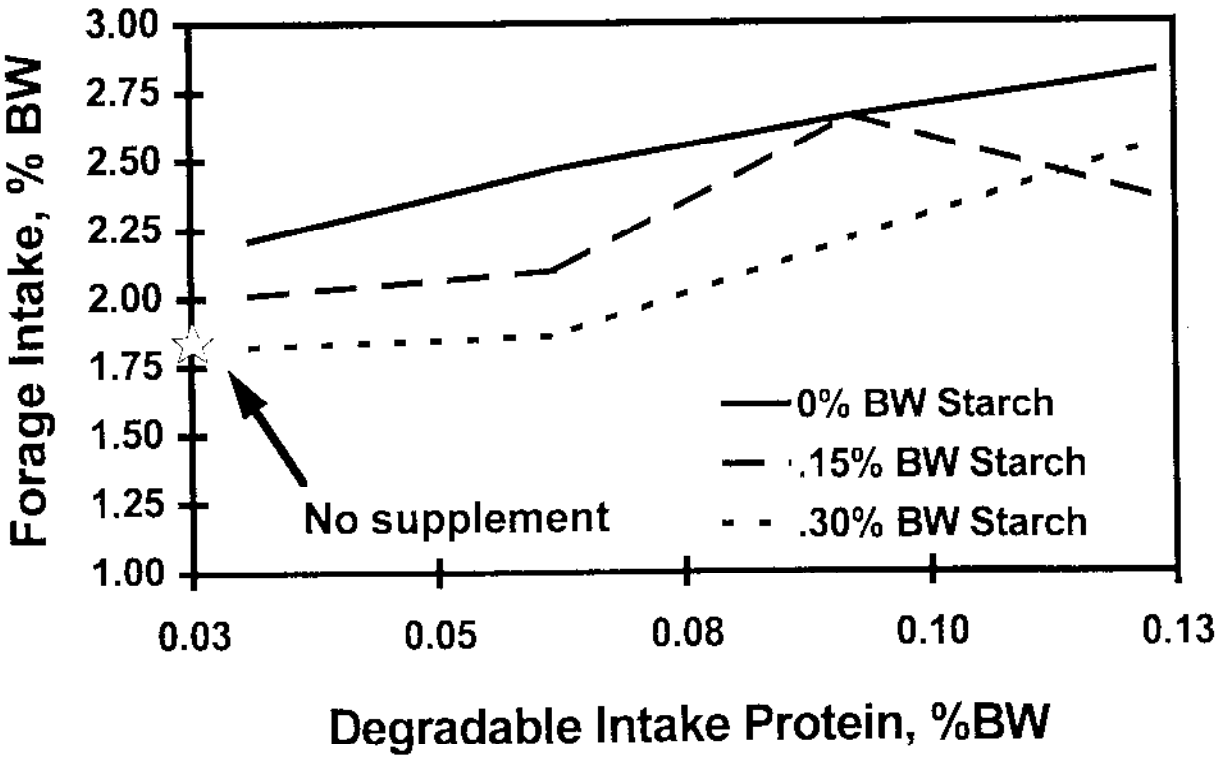

Figure 1. Effects of Level of Supplemental Starch and Degradable Intake Protein on Forage Intake

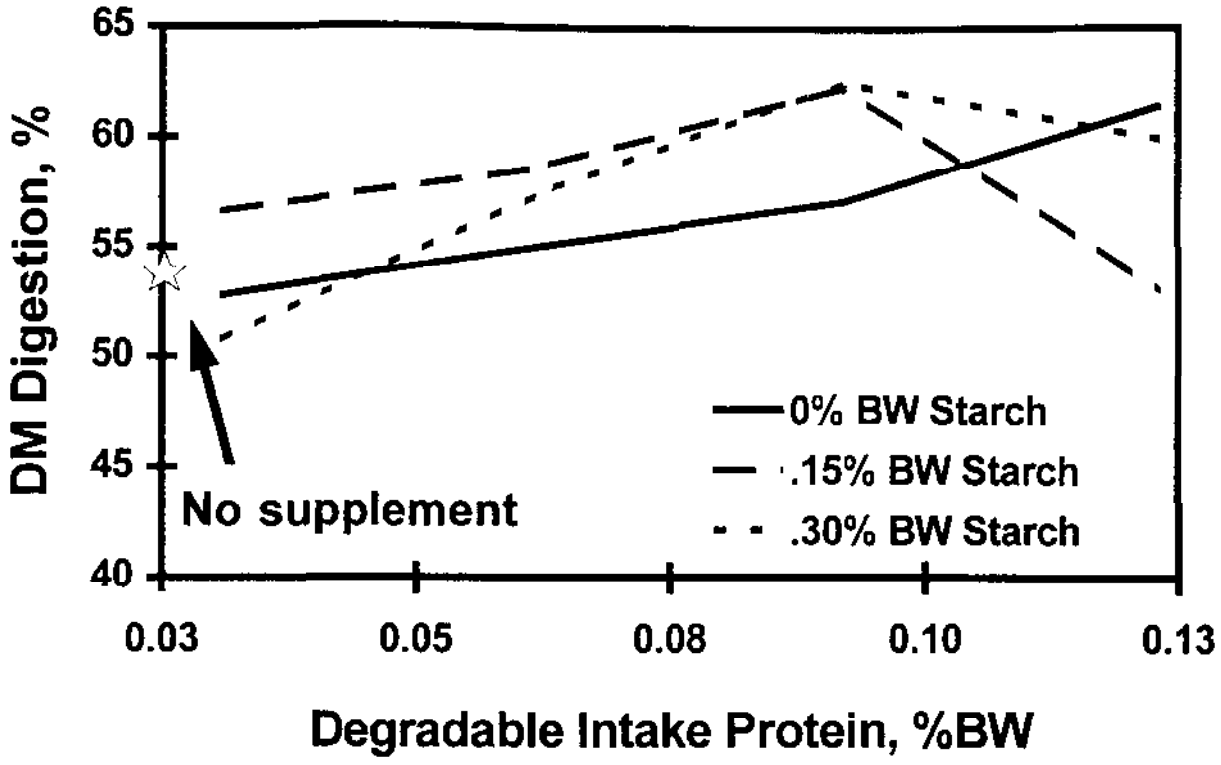

Figure 2. Effects of Level of Supplemental and Degradable Intake Protein on Dry Matter Digestion

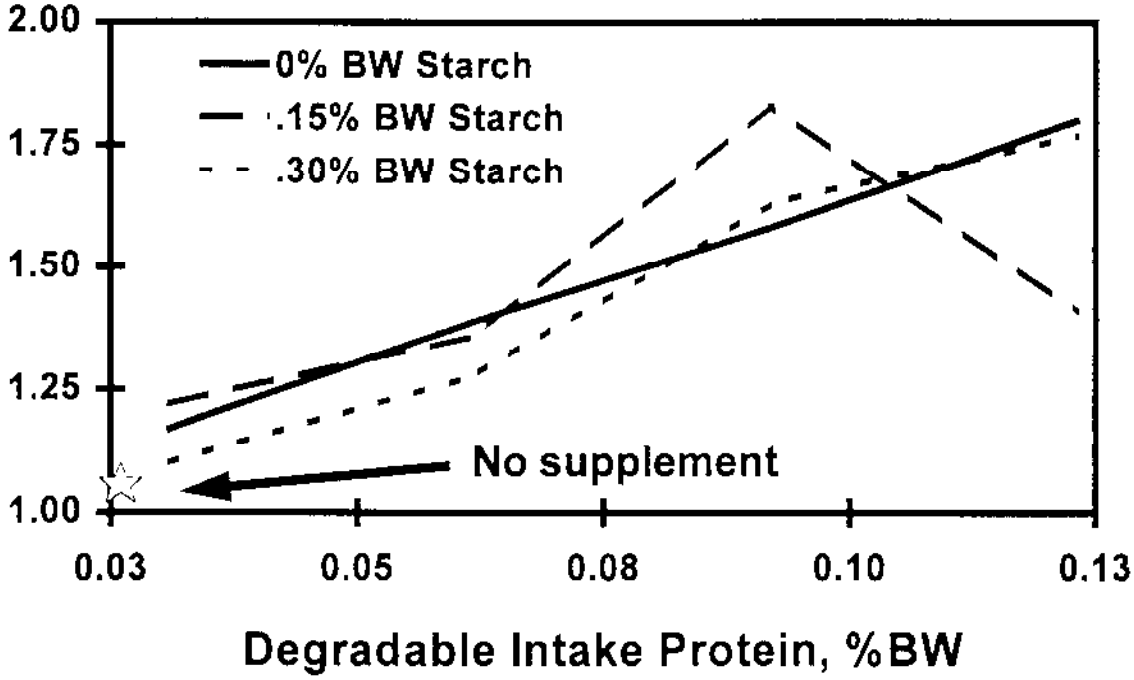

Figure 3. Effects of Level of Supplemental Starch and Degradable Intake Protein on Total Digestible Dry Matter Intake

ASSESSING NUTRIENT COMPOSITION AND DIGESTIBILITY OF TALLGRASS-PRAIRIE HAY

K. C. Olson, R. C. Cochran, E. C. Titgemeyer, and T. J. Jones

Summary

Thirteen steers were used in a 4 13 incomplete Latin square to determine chemical composition and digestibility for 13 samples of tallgrass prairie hay. Hays were collected from a variety of locations in east-central Kansas and represented a wide array of harvest dates and storage conditions. Steers were fed prairie hay and soybean meal at 1.5% and .2% of body weight, respectively, to equalize intakes relative to body weight and prevent degradable intake protein (DIP) from limiting extent of digestion. Prairie hay samples were analyzed for N, ADIN, ADF, NDF, ADIA, monosaccharides (sugars), and alkali-labile phenolic acids (lignin components). The relationships of various forage chemical components to diet organic matter digestibility (OMD) were examined using simple, linear regression. There was a close relationship between OMD and ADF (r^2 = .62; OMD = .822 [ADF] + 96.47). In addition, the ratio of xylose:glucose (r^2 = .62; OMD = 41.93[X:G] + 94.14) explained significant amounts of the variation in OMD. Defining the chemical composition of bluestem hay may be of value in predicting organic matter digestibility and, ultimately, energetic value.

(Key Words: Hay Digestibility, Hay Chemical Composition, Forage.)

Introduction

In the Flint Hills, bluestem hay often comprises an important portion of beef cattle diets. However, the energetic value of bluestem hay is defined poorly. Because information about dietary energy is critical to predicting cattle performance, a clearer description of the energy availability of bluestem hay is needed. The largest loss of ingested energy for many forages is fecal energy, so precise definition of that loss from bluestem hay diets will improve prediction of beef cattle performance.

Digestible energy (DE; intake energy fecal energy) is related directly to dietary organic matter digestibility (OMD). Percent OMD and % DE rarely differ by more than a few units. However, neither can be measured conveniently by livestock producers. Dietary chemical composition, on the other hand, is measured easily and can be useful to predict both DE and OMD. The objective of this study was to construct mathematical models to predict DE and OMD of bluestem prairie hays from their chemical compositions. This preliminary paper discusses the inherent variability in chemical composition of bluestem hay and proposes mathematical models that can be used to predict OMD from chemical composition.

Experimental Procedures

Thirteen steers (average initial body weight = 609 lb) were used in a four-period incomplete Latin square design to determine chemical composition and digestibility of 13 samples of tallgrass prairie hay. Hays were collected from a variety of locations in east-central Kansas. Cutting dates ranged from late June to late August; seven hay samples were stored outdoors in large round bales and six were stored indoors in small square bales. All hay samples were tub ground to a uniform particle size (approximately 4 in.) and stored dry in weather-resistant receptacles. Samples that exhibited visual indications of mildew or were noticeably moist and warm in the interior of the bale at the time of grinding were considered to be heat damaged. Four samples were heat damaged to some degree.

Steers were housed in individual stanchions and fed prairie hay and soybean meal at 1.5% and .2% of body weight, respectively, to equalize intakes relative to body weight and prevent degradable intake protein (DIP) from limiting extent of digestion. The appropriate level of DIP was determined in a previous study. Four 23-day experimental periods were conducted during the late winter and spring of 1995, consisting of a 14-day adaptation phase and a 9-day collection phase. Hay and supplement were offered at 7 AM. Supplement consumption was complete each day, and, with the exception of 5 observations, hay consumption was complete as well. Hay intake and refusals were measured on days 15 - 21 and days 16 - 22, respectively. Fecal samples were collected on days 17 - 23. Acid detergent insoluble ash (ADIA) was used as a marker to determine fecal output.

Prairie hay samples were analyzed for crude protein (CP), acid detergent insoluble crude protein (ADICP), acid detergent fiber (ADF), neutral detergent fiber (NDF), ADIA, monosaccharides (sugars), and alkali-labile phenolic acids (lignin components). The relationships of various forage chemical components to diet organic matter digestibility (OMD) were determined via regression analysis.

Results and Discussion

Chemical composition, measured OMD, and a brief description of each prairie hay sample are presented in Table 1. Dates of harvest ranged from June 23 (sample K) to August 31 (sample H), roughly a 9-week interval. Seven of the hay samples were stored as small square bales. The remaining samples were stored as large round bales. Of the four heat damaged samples, three were put up as large round bales. Mean, standard deviation, minimum, and maximum values for chemical composition and OMD of the hay samples are shown in Table 2. Directly measured diet OMD ranged from 55.1% for heat-damaged, late-harvested bluestem hay (sample H) to 69.5% for early-harvested hay with no heat damage (sample K). Sample H had the lowest crude protein content (1.4%) and sample C the highest (4.9%). Unavailable forage crude protein, as indicated by ADICP, was relatively uniform among hay samples when expressed on a dry matter basis. However, when unavailable CP was expressed as a percentage of the total CP, it ranged from approximately 17% (Sample B) to 68% (Sample H). The extent to which bluestem hay is digested is highly dependent upon available dietary protein. Nitrogen from dietary protein is necessary for ruminal bacteria to grow and reproduce. When bacterial growth is inhibited by a protein deficiency, hay digestibility decreases. At realistic intake levels, hay crude protein concentrations observed in this study were insufficient to meet protein requirements for growth or maintenance for nearly all classes of beef cattle. In the event that bluestem hay comprises a large proportion of a beef cattle diet, supplemental protein will likely be needed to optimize hay digestibility and support the desired level of production.

The relative amount of forage fiber varied considerably among hay samples. The minimum-maximum values for NDF and ADF were 60.7 to 74.0% and 36.2 to 49.6%, respectively. Forage NDF and ADF commonly are used as indices to judge the relative quality of many hay types. Typically, as ADF and NDF increase in a sample of hay, digestibility decreases, making these chemical characteristics of forage useful as indicators of quality. In our study, NDF was moderately correlated to OMD ($R = .56$); ADF was related more highly to OMD ($R = .78$).

Lignin is a fraction of forage fiber that is associated negatively with forage quality. Some specific constituents of lignin, namely para-coumaric acid (PA) and ferulic acid (FA), ranged from .42 to .85% and .43 to .57%, respectively. The largest fraction, PA, was correlated positively with forage NDF, ADF, and ADIN ($R>.74$; $P<.002$), indicating that PA increased as forage fiber and unavailable nitrogen increased. However, PA was correlated only moderately to OMD ($R = .41$).

Another factor that may be of use in estimating forage digestibility is the monosaccharide (simple sugar) composition of various forage carbohydrates. Carbohydrates differ in their monosaccharide profile. This information may be useful to predict forage OMD. Glucose

is the major constituent of starch and cellulose. Both are highly digestible in their pure forms. Glucose constituted 20.0 to 24.6% of the hay dry matter in this study and was correlated moderately to OMD (R = .54). It is likely that very little starch was present in our hay samples, so most of the glucose came from cellulose. Xylose is the major monosaccharide in hemicellulose and ranged from 15.4 to 24.6% in the hays we studied. Xylose was correlated negatively to OMD (R = .65), indicating that as xylose, and presumably hemicellulose, increased, OMD decreased. The xylose to glucose ratio, which is indicative of the relative proportions of hemicellulose and cellulose, also had a high, negative correlation to OMD (R = .79).

Based on results from the regression analysis, various models were constructed to predict OMD from forage chemical components. Acid detergent fiber (ADF) was an acceptable predictor of OMD (Figure 1), accounting for 62% of the variation associated with hay digestibility. Although NDF was correlated moderately to OMD, it was less useful than ADF in predicting OMD in this study (y = .056[ADF]+98.97; R^2 = .31). Similarly, PA and FA did not predict OMD with accuracy (R^2<.17). The xylose to glucose ratio (X:G) was also an acceptable predictor of OMD (R^2 = .62; Figure 2). Xylose alone accounted for only 42% of the variation in hay OMD, despite its high correlation to OMD.

The formulae presented in Figures 1 and 2 can be used to predict OMD of bluestem hay by substituting forage ADF and X:G (%) for x in their respective equations. However, in order for the equation to produce a reliable estimate, the following conditions must be met: 1) the animal must not be deficient in ruminally degradable dietary protein and 2) the ADF and/or X:G value must fall within the range of ADF and/or X:G values for the hay samples used in this study.

It is evident from these data that bluestem hay is not a uniform entity. Factors such as growing conditions, plant maturity, and storage methodology play a role in determining its nutritional quality. These environmental factors can interact to create wide variations in nutritional quality of bluestem hay, even in a relatively small geographical area like the Flint Hills.

The ability to predict performance of animals consuming a bluestem hay-based diet is contingent upon knowing the diet's energetic value. Our results suggest that, with an adequate description of forage chemical composition, one can do an acceptable job of predicting digestibility and, ultimately, energetic value.

Table 1. Description and Chemical Composition of Prairie-Hay Samples

	Hay Sample												
Item	A	B	C	D	E	F	G	H	I	J	K	L	M
Harvest date	8/6	8/2	8/2	7/17	7/19	8/13	8/20	8/31	7/19	8/25	6/23	8/25	7/23
Bale type	Round	Square	Round	Round	Round	Round	Round	Square	Square	Square	Square	Square	Square
Heat damage	Yes	No	No	Yes	No	No	Yes	Yes	No	No	No	No	No
% OMD[a]	58.3	61.5	63.1	58.7	63.3	61.9	58.7	55.1	64.3	66.2	69.5	57.0	62.6
	% dry matter												
Crude protein	4.3	4.4	4.9	4.5	4.4	3.4	4.3	1.4	4.1	3.5	4.7	3.4	3.6
ADICP	1.13	.75	.94	1.13	.88	.94	1.13	.94	.88	.88	.81	.81	.75
NDF	69.0	62.4	66.7	68.8	67.0	68.7	73.9	74.0	69.3	66.2	60.7	62.4	67.4
ADF	46.3	38.4	40.2	43.4	42.1	45.0	47.3	49.6	41.4	38.9	36.2	41.3	42.9
Glucose[b]	22.4	23.0	23.3	21.5	24.3	22.2	21.2	21.9	22.1	24.6	22.1	20.0	24.1
Galactose[b]	1.6	1.9	1.8	1.8	1.6	1.5	1.6	1.6	1.6	1.6	1.9	2.1	1.7
Mannose[b]	.75	.71	.62	.55	.76	.85	.58	.50	.52	.53	.73	.84	.60
Xylose[b]	17.4	16.5	16.6	17.5	17.5	19.0	18.8	19.6	17.1	16.7	15.4	16.9	18.0
Arabinose[b]	3.4	3.8	3.7	3.8	3.5	3.1	3.5	3.9	3.5	3.7	3.7	4.1	3.7
Rhamnose[b]	.34	.37	.36	.38	.29	.38	.23	.29	.27	.32	.40	.40	.22
Para-coumaric acid[c]	.66	.46	.48	.70	.51	.74	.85	.60	.55	.50	.45	.42	.54
Ferulic acid[c]	.46	.52	.52	.57	.51	.47	.54	.46	.54	.52	.52	.43	.51

[a]OMD directly measured. [b]Monosaccharide sugars. [c]Alkali-labile phenolic acids.

Table 2. Mean, Standard Deviation, Minimum, and Maximum Values of Organic Matter Digestibility and Chemical Composition of Bluestem Prairie-Hay Samples (DM Basis)

Variable	# Observations	Mean (%)	Standard Deviation	Minimum	Maximum
OMD[a]	13	61.5	4.0	55.1	69.5
DM	13	91.4	.99	89.3	92.6
OM	13	83.4	1.6	80.4	85.5
NDF	13	67.4	4.0	60.7	74.0
ADF	13	42.5	3.8	36.2	49.6
ADIA	13	4.8	.94	3.6	6.7
Crude protein	13	3.9	.88	1.4	4.9
ADICP	13	.94	.13	.75	1.13
Glucose[b]	13	22.5	1.3	20.0	24.6
Galactose[b]	13	1.7	.17	1.5	2.1
Mannose[b]	13	.66	.12	.50	.85
Xylose[b]	13	17.5	1.2	15.4	19.6
Arabinose[b]	13	3.6	.25	3.1	4.1
Rhamnose[b]	13	.33	.06	.22	.40
Para-coumaric acid[c]	13	.57	.13	.42	.85
Ferulic acid[c]	13	.50	.04	.43	.57

[a]OMD directly measured. [b]Monosaccharide sugars. [c]Alkali-labile phenolic acids.

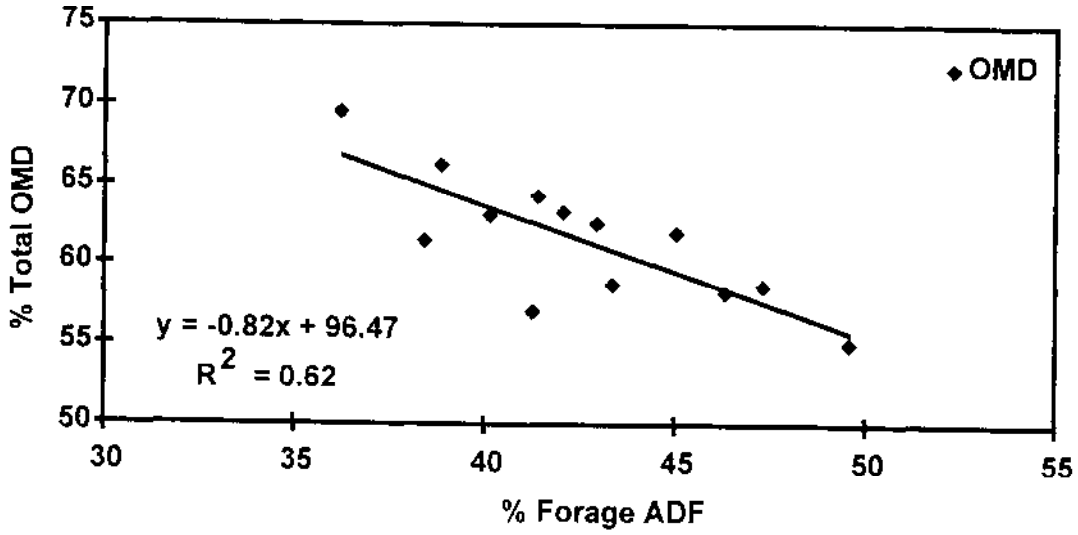

Figure 1. Prediction of Total OMD (%) from Forage ADF

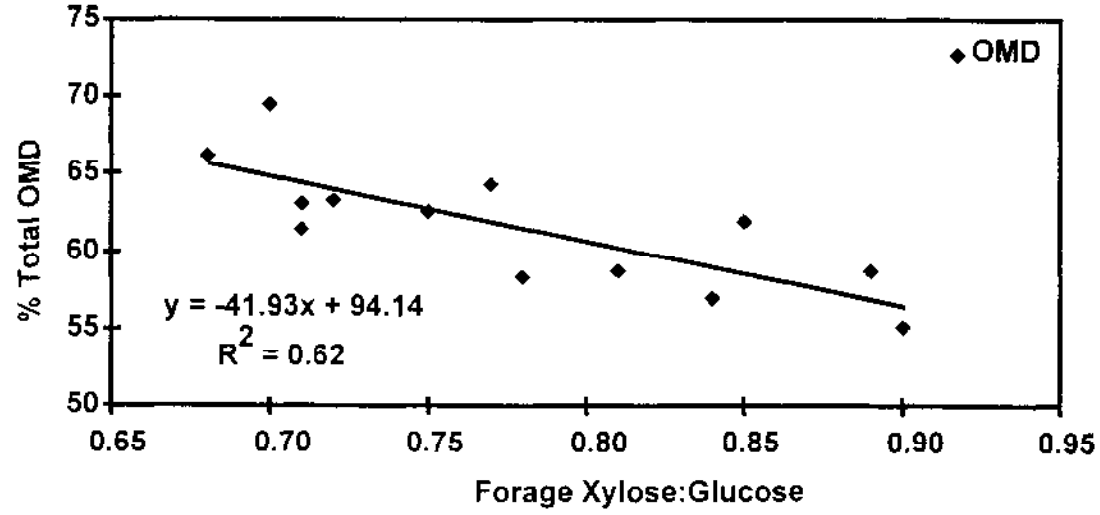

Figure 2. Prediction of Total OMD (%) from Forage Xylose:Glucose Ratio

IN VITRO ESTIMATION OF RUMINAL PROTEIN DEGRADABILITY OF FORAGES

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Summary

Ruminal degradation of alfalfa and prairie hay protein was estimated using a proteolytic enzyme from *Streptomyces griseus* with or without pretreatment with cellulase or a broad spectrum carbohydrase (driselase). Estimates of the undegradable intake protein (UIP) as a percentage of total protein derived from the protease alone were higher than that measured in the animal (i.e., *in vivo*). Pretreatment of hay samples with cellulase (48 h incubation) or driselase improved the accuracy of UIP predictions compared with those determined using the protease alone.

(Key Words: Protein Degradability, Cellulase, Driselase, Forage.)

Introduction

Forage protein includes that degraded in the rumen (degradable intake protein = DIP) and that escaping the rumen (undegradable intake protein = UIP). New feeding systems for ruminants require knowledge of the DIP and UIP contents of feedstuffs. Either of these can be measured by use of intestinally fistulated animals (*in vivo*), by nylon bags placed in the rumen of fistulated livestock (*in situ*), or by laboratory procedures. Once one fraction is known (DIP or UIP), the other can be calculated as the difference from total protein. *In vivo* and *in situ* estimations of UIP require maintenance of intestinally and (or) ruminally fistulated animals, which are typically unavailable to commercial feed laboratories. *In vitro* procedures using semipurified proteolytic enzymes have shown promise as routine laboratory techniques for this purpose. However, fibrous components of forages may affect results derived from proteolytic enzymes alone. Therefore, we designed this experiment to evaluate the effect of pretreating forages with fiber digesting enzymes (cellulase or driselase) when attempting to determine the UIP value using a standard proteolytic enzyme assay.

Experimental Procedures

Ruminal protein degradation of samples of alfalfa and prairie hay samples was estimated using a protease from *Streptomyces griseus*. The *in vitro* procedure was preceded by incubation with cellulase, driselase, acetate buffer, or no pretreatment. Cellulase and driselase concentrations were determined in a preliminary experiment and represented 8000 units of cellulase and 800 mg of driselase per g of hay sample. Cellulase, driselase, or acetate buffer pretreatments consisted of incubating alfalfa or prairie hay samples containing 15 mg nitrogen at 39°C for 2 or 48 hours. After the appropriate incubation time, samples were treated with the *S. griseus* protease for .25, .5, 1, 2, 4, 8, 12, 24, and 48 h. Following incubation, samples were filtered, residues were washed with deionized water, and nitrogen content in residues was determined. The UIP content was expressed as a percentage of total protein. In each run, cellulase, driselase, and acetate buffer pretreatment, no pretreatment (control), and blanks were included.

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Results and Discussion

The UIP contents determined *in vivo* for the alfalfa and prairie hay samples were 17 and 44% of total protein, respectively. Determined using the *S. griseus* procedure without pretreatment, the UIP content of alfalfa and prairie hay samples were 27 and 53% of total protein (Table 1). For both forages, the UIP content was overestimated by the *S. griseus* procedure when no pretreatment was used. For both alfalfa and prairie hay, carbohydrase pretreatments resulted in lower UIP estimates that were closer to the *in vivo* values than when no pretreatment was used.

Driselase generally yielded lower UIP estimates than cellulase. For alfalfa hay, the duration of pretreatments exerted only a slight effect on UIP estimates when driselase was used, whereas for prairie hay, the 48-hour cellulase and driselase pretreatments resulted in lower UIP values. UIP estimates with pretreatment were more similar to the *in vivo* values than those from hay without carbohydrase pretreatment. This improvement in UIP prediction was most evident when alfalfa hay was pretreated with driselase for 48 hours and when prairie hay was pretreated with driselase for 2 hours or cellulase for 48 hours.

Table 1. Effect of Pretreatment on the Undegradable Intake Protein Content (% of Total Protein) of Alfalfa and Prairie Hay Determined by *Streptomyces griseus* Protease

		Cellulase		Driselase		Acetate Buffer		No Pre-	
Forage	*In vivo*	2 h	48 h	2 h	48 h	2 h	48 h	treatment	SEM
Alfalfa hay[abcd]	17	22.1	21.4	12.3	14.1	28.4	28.0	27.2	.52
Prairie hay[abcde]	44	61.5	45.6	43.8	37.8	55.7	58.1	53.1	1.14

[a]No pretreatment vs pretreatment ($P<.05$).
[b]Cellulase vs driselase ($P<.05$).
[c]Acetate buffer vs no pretreatment ($P<.05$).
[d]Driselase treatment for 2 vs 48 h ($P<.05$).
[e]Cellulase treatment for 2 vs 48 h ($P<.05$).

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EFFECT OF ANNUAL FIRE ON TALLGRASS PRAIRIE LEGUMES

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Summary

Total legume density was significantly higher in annually burned prairie (8.0 stems/ m^2) than in unburned prairie (3.0 stems/ m^2). Densities of six species were higher ($P<.05$) in burned than in unburned prairie, whereas only one legume species decreased from annual fire. Total legume biomass did not differ between burned (11.3 g/m^2) and unburned prairie (10.5 g/m^2). Most legume species either are favored by fire or are fire tolerant, and their persistence in annually burned grassland suggests that they may play an important role in the nitrogen budget of tallgrass prairie.

(Key Words: Fire, Forage, Legumes, Tallgrass Prairie.)

Introduction

Fire plays a dominant role in manipulating plant composition of tallgrass prairie. Annual burning favors warm-season perennial grasses and reduces most forb species. Legumes are common forbs in tallgrass prairie, but their response to fire, or to the absence of fire, is unknown.

In the Kansas Flint Hills, annual burning reduces available soil nitrogen. Plants that have the potential to fix atmospheric nitrogen may have a competitive advantage in this nitrogen-stressed environment. Thus, we hypothesized that legumes would be more abundant in annually burned tallgrass prairie than in unburned prairie.

Experimental Procedures

The study was conducted at Konza Prairie Research Natural Area on two ungrazed pastures burned annually in April and two adjacent long-term unburned pastures. In mid-July 1993 and 1994, 1 25 m belt transects (n=16) were placed at random locations in the four pastures (128 total transects). All legume stems rooted within the plot were counted, clipped at ground level, sorted by species, oven-dried, and weighed.

Tests for normality indicated that distributions of all legume species were highly skewed. Therefore, the data were analyzed nonparametrically using exponential scores computed from the ranks. Treatment means that were associated with a significant F statistic ($P<.05$) were separated by Fisher's least significant difference.

Results and Discussion

Total legume density was higher ($P<.05$) in annually burned sites (8.0 stems/ m^2) than in unburned sites (3.0 stems/m^2). Except for one species, all either tolerated or were favored by annual burning (Table 1). Six species responded positively to fire or alternatively were significantly inhibited by the environmental conditions created in the absence of fire. Stem density of leadplant (*Amorpha canescens*), the most common legume in tallgrass prairie, was 2.5 times greater in burned prairie than in unburned prairie, because fire stimulated vigorous

[1]Division of Biology.

resprouting. Other species that had a higher density in burned than in unburned prairie included white prairieclover (*Dalea candida*), purple prairieclover (*Dalea purpurea*), prairie lespedeza (*Lespedeza violacea*), manyflower scurfpea (*Psoralea tenuiflora*), and catclaw sensitive brier (*Schrankia nuttallii*). In contrast, Illinois tickclover (*Desmodium illinoense*) was the only legume that decreased from annual fire.

Annual burning did not affect total legume biomass (11.3 g/m^2 in burned prairie and 10.5 g/m^2 in unburned prairie). Manyflower scurfpea and white prairieclover both produced significantly greater biomass in burned than in unburned areas, but biomass of other legumes did not differ between burn treatments. Based on average biomass production for Konza Prairie, legumes comprised approximately 25% of the forb biomass in annually burned prairie and approximately 11% of the forb biomass in unburned prairie.

The nitrogen-deficient soils of annually burned prairie may provide ideal conditions for legumes, if they symbiotically fix nitrogen. The ability to nodulate and fix atmospheric nitrogen varies widely among prairie legume species. Consequently, the overall contribution of legumes to the nitrogen budget of tallgrass prairie has been estimated to be small. However, those nitrogen inputs may be far greater in annually burned sites where legume populations are dense.

Plants that persist in annually burned prairie must be able to tolerate chronic soil nitrogen deficiency and the direct effects of fire. Native legumes are among the few forb species that have adapted to these conditions. Despite this advantage, however, legumes are not the most abundant forbs in tallgrass prairie. Periodic droughts and competitive interactions with the warm-season grasses likely prevent legume species from dominating.

In summary, fire is an important factor influencing the density of legume species in tallgrass prairie. The persistence of legumes in both burned and unburned prairie reflects their adaptability to a pyrogenic habitat. Higher legume density in annually burned areas than in unburned sites suggests that these plants may play an important role in the nitrogen budget of tallgrass prairie.

Table 1. Density and Biomass of Tallgrass Prairie Legumes in Burned and Unburned Prairie

	Density (stems/m^2)		Biomass (g/m^2)	
Species	Burned	Unburned	Burned	Unburned
Leadplant	4.26[a]	1.64	5.72	7.04
Plains wildindigo	.17	.17	.92	1.16
Blue wildindigo	.01	.01	.16	.16
White prairieclover	.76[a]	.07	.55[a]	.09
Purple prairieclover	.31[a]	.15	.37	.24
Illinois tickclover	.01[a]	.06	.07	.10
Roundhead lespedeza	.84	.51	.79	.87
Prairie lespedeza	.66[a]	.12	.11	.07
Manyflower scurfpea	.56[a]	.11	2.06[a]	.55
Catclaw sensitivebrier	.27[a]	.06	.45	.17
Total legumes	7.97[a]	3.00	11.29	10.54

[a]Different from unburned prairie (P<.05).

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IMPROVING SILAGE QUALITY

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M. K. Siefers, G. L. Huck, and J. E. Turner

Summary

Results at Kansas State University from over 200 laboratory-scale trials and 28 farm-scale trials showed that bacterial inoculants consistently improved preservation efficiency and nutritive value of the ensiled material. In contrast, anhydrous ammonia or urea decreased dry matter recovery and production per ton of crop ensiled. Economic analysis also favored the use of bacterial inoculants over nonprotein-nitrogen additives. Research conducted using corn, sorghum, and alfalfa silages showed that sealing the exposed surface dramatically reduced top spoilage losses in bunker, trench, or stack silos.

(Key Words: Silage, Inoculant, Nonprotein Nitrogen, Top Spoilage.)

Introduction

Advances in silage technology, which include high-capacity precision chop harvesters, improved silos, polyethylene sheeting, shear-cutting silage unloaders, and total mixed rations, have made silage the principal method of forage preservation for dairy and beef cattle producers in North America in the 1990's. Silage quality and nutritional value are influenced by numerous biological and technological factors, including: the crop species, stage of maturity and dry matter (DM) content at harvest, chop length, type of silo, rate of filling, forage density after packing, sealing technique, feedout rate, weather conditions at harvest and feedout, additive use, timeliness of the silage-making activities, and the training of personnel. Because many of these are interrelated, it is difficult to discuss their significance individually. However, there are two dominant features of every silage: 1) the crop, including its stage of maturity and its "ensileability" and 2) the management and know-how imposed by the silage maker.

To understand the effect of inoculants, other additives, and ensiling practices on silage quality, it is necessary to know how preservation occurs in ensiled forages. In "perfect" silage, available carbohydrates are converted by anaerobic bacteria (mainly "homofermentative" lactic acid bacteria) to lactic acid. That lowers the pH rapidly and preserves the silage. In even the best of circumstances, some DM is lost during lactic acid production. But the ensiling process is seldom perfect. Whenever oxygen is present, carbohydrates are converted to carbon dioxide and water, accompanied by the generation of considerable heat. The results are serious DM losses. Many of the good silage-making techniques involve eliminating as much oxygen as possible.

Silage Additives

Additives have been used throughout the 20th century to improve silage preservation by ensuring that lactic acid bacteria (LAB) dominate the fermentation phase. However, the silage additive industry did not play a significant role in silage production in the U.S. until the past two or three decades. Additives can be divided into three general categories: 1) fermentation stimulants, such as bacterial inoculants and enzymes; 2) fermentation inhibitors, such as propionic, formic, and sulfuric acids; and 3) substrate or nutrient sources, such as molasses, urea, and anhydrous ammonia.

Perhaps no other area of silage management has received as much attention among both

researchers and livestock producers in recent years as bacterial inoculants. Effective bacterial inoculants promote a faster and more efficient fermentation of the ensiled crop, which increases both the quantity and quality of the silage. The bacteria in commercial products include one or more of the following species: *Lactobacillus plantarum* or other *Lactobacillus* species, various *Pediococcus* species, and *Enterococcus faecium*. These strains of LAB have been isolated from silage crops or silages and were selected because: 1) they are homofermentative (i.e., ferment sugars predominantly to lactic acid) and 2) they grow rapidly under a wide range of temperature and moisture conditions. Bacterial inoculants have inherent advantages over other additives, including low cost, safety in handling, a low application rate per ton of chopped forage, and no residues or environmental problems.

Enzymes are capable of degrading plant cell walls and starch, which could provide additional sugars for fermentation to lactic acid and increase the nutritive value of the ensiled material. Although enzymes offer potential to improve silage quality, considerable work needs to be done before they will become commonly used additives.

The justifications for using nonprotein nitrogen (NPN) have been prolonged aerobic stability during the feedout phase and the addition of an economical nitrogen source to low-protein crops, such as corn and sorghum. However, major drawbacks to ammoniation are the potentially dangerous volatile and caustic properties of anhydrous ammonia plus the need for specialized application and safety equipment. NPN always acts as a buffer during fermentation, requiring extra lactic acid to be produced to lower the pH enough for preservation. Thus, NPN addition always increases DM loss.

Silage Additive Research at Kansas State University. Evaluation of silage additives began in 1975 in the Department of Animal Sciences and Industry and continues today. These 20 years have lead to the following general conclusions about inoculant and NPN additives.

Question: When should a bacterial inoculant be used?
Answer: Inoculants should be applied to every load of forage ensiled!!
Question: When should NPN, such as urea and anhydrous ammonia, be used?
Answer: Never!! Unless this is the only means of preventing aerobic deterioration during the feedout phase.

Results from over 200 laboratory-scale studies, which involved nearly 1,500 silages and 25,000 silos, indicated that bacterial inoculants were beneficial in over 90% of the comparisons. Inoculated silages had faster and more efficient fermentations -- pH was lower, particularly during the first 2 to 4 days of the ensiling process, and lactic acid content and the lactic to acetic acid ratio were higher than in control silages. Inoculated silages also had lower ethanol and ammonia-nitrogen values compared to untreated silages.

Results from 28 farm-scale trials (KAES Report of Progress 651, page 101), which evaluated 71 silages, showed that bacterial inoculants consistently improved fermentation efficiency, DM recovery, feed to gain ratio, and gain per ton of crop ensiled in both corn and forage sorghum silages. Applying urea or anhydrous ammonia adversely affected fermentation efficiency, DM recovery, average daily gain, feed to gain ratio, and gain per ton of crop ensiled, particularly for the higher moisture forage sorghums. An additive with a urea-molasses blend had less negative influence on silage preservation and cattle performance than urea or anhydrous ammonia.

Economics of Bacterial Inoculants and NPN Silage Additives. An effective bacterial inoculant is a sound investment for every beef and dairy cattle producer who makes and feeds silage. Based upon the results at Kansas State University, a 3 to 4 lb increase in gain per ton of crop ensiled produces $2 to $4 increases in net return per ton of corn or sorghum ensiled. If producers use NPN, they actually lose $4 to $6 per ton of crop ensiled because of the decreased DM recovery, increased feed to gain ratio, and added cost of replacing the loss of volatile nitrogen. These results apply to beef producers

who background cattle or grow replacement heifers and to dairy producers who raise heifers.

The use of a bacterial inoculant by dairy producers who make and feed whole-plant corn or sorghum silages and alfalfa silage or haylage in their lactation rations is also a good management decision. The additional "cow days" per ton of crop ensiled, because of the increased DM recovery, and the increased milk per cow per day from the inoculated silage or haylage (.25 to 1.25 lb) produce $4 to $8 increases in net return per ton of corn or sorghum ensiled and $6 to $10 increases in net return per ton of alfalfa ensiled.

Recommendations. Why leave the critical fermentation phase to chance by assuming that the indigenous microorganisms (those occurring naturally on the forage) are going to be effective in preserving the silage crop? Even if a dairy or beef cattle producer's silage has been acceptable in the past--because silage-making conditions in Kansas are generally good-- there are always opportunities for improvement.

Although whole-plant corn and sorghum ensile easily, research data clearly show that the quality of the fermentation and subsequent preservation and utilization efficiencies are improved with bacterial inoculants. Alfalfa (and other legumes) are usually difficult to ensile because of a low sugar content and high buffering capacity. However, adding an inoculant helps ensure that as much of the available substrate as possible is converted to lactic acid, which removes some of the risk of having a poorly preserved, low-quality silage.

Finally, if producers already are doing a good job but using a bacterial inoculant for the first time, they probably will not see a dramatic difference in their silage. But the benefit will be there -- additional silage DM recovery and significantly more beef or milk production per ton of crop ensiled!

Selecting a Bacterial Inoculant. The inoculant should provide at least 100,000 colony-forming units of viable LAB per gram of forage. These LAB should dominate the fermentation; produce lactic acid as the sole end product; be able to grow over a wide range of pH, temperature, and moisture conditions; and ferment a wide range of plant sugars. Purchase an inoculant from a reputable company that can provide quality control assurances along with independent research supporting the product's effectiveness.

Protecting Silage from Air and Water

Everyone in the silage business acknowledges that sealing (covering) a horizontal silo (i.e., bunker, trench, or stack) ranks high on the troublesome list, but high on the quality reward list, too. Because so much of the surface of the ensiled material is exposed to air, great potential exists for excessive DM and nutrient losses. The extent of these losses in the top 2 to 4 ft if there is no protection is far greater than most people realize. This has been documented in several studies at Kansas State University (KAES Reports of Progress 623, page 70; 651, page 127; and 727, pages 59 and 63). A barrier must be built against air and water after the filling operation is completed.

Although future technology might bring a more environmentally and user-friendly product, polyethylene is the most effective sealing (covering) material today. After it is put over ensiled forage, the sheet must be weighted down. Tires are the most commonly used weights, and they should be placed close enough together that they touch (about 20 to 25 tires per 100 sq ft). In a 1,000-ton bunker silo, an effective seal to protect the top 3 ft of silage can prevent the loss of $500 to $2,500 worth of silage, depending on the value of the crop. The bottom line is that sealing the exposed surface is one of the most important management decisions in any silage program.

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EFFECT OF GRAIN CONTENT ON THE NUTRITIVE VALUE OF WHOLE-PLANT GRAIN SORGHUM SILAGE

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Summary

This experiment was conducted to determine the effect of grain content on the nutritive value of whole-plant grain sorghum silage. Silage dry matter (DM), organic matter (OM), and crude protein (CP) contents increased with increasing levels of grain in the reconstituted, whole-plant silages, whereas neutral detergent fiber (NDF) and acid detergent fiber (ADF) contents decreased as the level of grain increased from 0 to 48%. When fed to sheep (used as a model), voluntary DM intake and DM and OM digestibilities increased in a linear manner, whereas ADF digestibility decreased with increasing level of grain. Crude protein and NDF digestibilities responded in a quadratic fashion to increasing grain content. These results suggest that the optimum level of grain in whole-plant grain sorghum silage is at least 48% of the DM in a high silage-based ration.

(Key Words: Grain Sorghum, Silage, Silage Grain Content, Silage Nutritive Value.)

Introduction

Grain sorghum hybrids commonly are selected for grain yield potential and not necessarily for their silage traits. Previous research has shown that sorghum hybrids (both grain and forage) that contain a high proportion of grain in the whole plant DM are generally superior nutritionally to those with a low grain content (KAES Reports of Progress 678, page 16 and 704, pages 74 and 77).

We compared an all-stover grain sorghum silage (grain removed) with silage reconstituted to contain approximately 12 to 48% grain (DM basis).

Experimental Procedures

DeKalb 42Y grain sorghum was planted on June 7 near the Kansas State University campus at Manhattan in Reading silt loam soil at a seeding rate of approximately 35,200 plants per acre. Anhydrous ammonia was applied prior to planting at 100 lb per acre. Furadan 15G insecticide was applied in the furrow at planting, and Ramrod atrazine was applied as a preemergance herbicide. The hybrid was grown under dryland conditions and harvested at the late-dough stage of kernel maturity.

Three days before harvest, 30 randomly selected whole plants were taken from a cross section of the experimental plot. The fresh plants were weighed and separated into head and stover fractions. Fresh weights of the separated parts were recorded, and samples of each were dried to determine their approximate proportions in the whole-plant DM.

The remaining plants were harvested on September 6. The heads were removed by hand, leaving the stover portion. The heads and stover then were chopped separately with a FieldQueen, precision, forage harvester. The chopped heads and stover were combined to provide 12, 24, 36, and 48% grain in the reconstituted material (DM basis) and mixed in a Harshfi mixer wagon. Stover without grain also was used. All silages were made in polyethylene lined, 55-gallon drum, pilot-scale silos.

After about 90 days of storage, a voluntary intake and digestion trial was conducted to determine the nutritive value of the five silages. Because quantities of silage were too small for cattle, sheep were used as a model. Thirty wether lambs were blocked by weight and individually housed in metabolism crates, which were located in a climate controlled room. The five silages were assigned randomly within each block. Rations contained 90% silage and 10% supplement (DM basis) and were formulated to provide 11.0% CP (DM basis) with ground corn, soybean meal, and urea. Rations supplied equal amounts of calcium; phosphorus; trace minerals; and vitamins A, D, and E. The trial consisted of a 7-day adaptation, 7-day voluntary intake, 2-day transition, and 5-day total fecal collection phases. During the transition and collection phases, all lambs were restricted to 90% of their mean voluntary DM intakes.

Results and Discussion

The pH, DM content, and chemical composition of the five silages are presented in Table 1. All silages were well preserved, as evidenced by low pH values. Silage DM, OM, and CP contents increased, whereas NDF and ADF contents decreased with increasing levels of grain in the reconstituted silages.

Voluntary DM intake and digestibilities of DM, NDF, and ADF are shown in Figures 1 through 4, respectively. Digestibilities of CP and OM are not shown. Voluntary DM intake and DM and OM digestibilities increased in a linear manner with stepwise increases in the grain content in the reconstituted silages. Crude protein and NDF digestibilities responded in a quadratic fashion to increasing levels of grain. Acid detergent fiber digestibility increased slightly between the 0 and 12% levels of grain and then decreased gradually as the level of grain increased to 48%.

The optimum level of grain in the reconstituted, whole-plant, grain sorghum silages was at least 48%, at which DM intake was highest (53.8 g per kg $BW^{.75}$) and DM and OM digestibilities reached their maxima (64.6 and 65.1%, respectively). These results are consistent with a previous study in which the optimum level of grain in whole-plant corn silage to maximize the nutritive value was about 52.5% (KAES Report of Progress 704, page 70).

Table 1. pH, DM Content, and Chemical Composition of the All-Stover and Four Reconstituted, Whole-Plant, Grain Sorghum Silages [a]

Grain Content, % of the Whole-Plant Silage	pH	DM	CP	NDF	ADF	OM
		%	% of the silage DM			
0	3.84	24.7	6.1	59.3	32.4	85.3
12	3.80	29.7	6.6	55.0	31.0	87.6
24	3.76	31.9	7.5	57.7	30.1	89.0
36	3.75	35.6	8.1	52.1	27.2	90.4
48	3.74	41.7	8.3	40.3	21.6	90.8

[a]DM = dry matter, CP = crude protein, NDF = neutral detergent fiber, ADF = acid detergent fiber, and OM = organic matter.

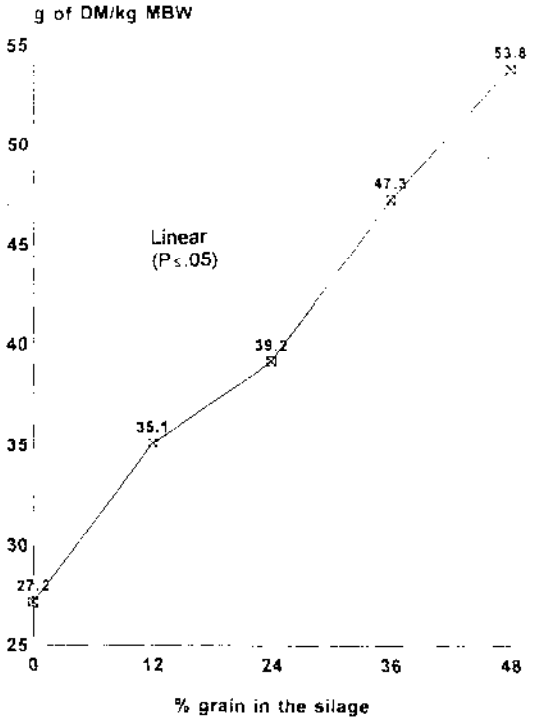

Figure 1. Effect of Grain Content on Voluntary DM Intake by Lambs. MBW is $BW^{.75}$

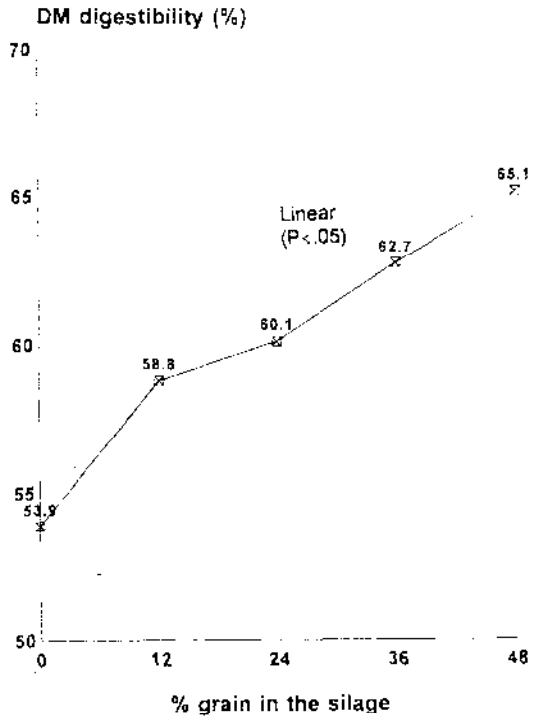

Figure 2. Effect of Grain Content on DM Digestibility by Lambs

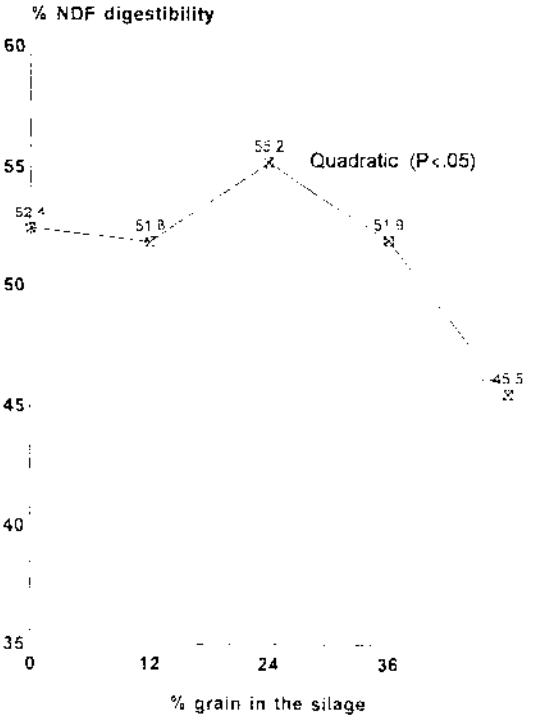

Figure 3. Effect of Grain Content on NDF Digestibility by Lambs

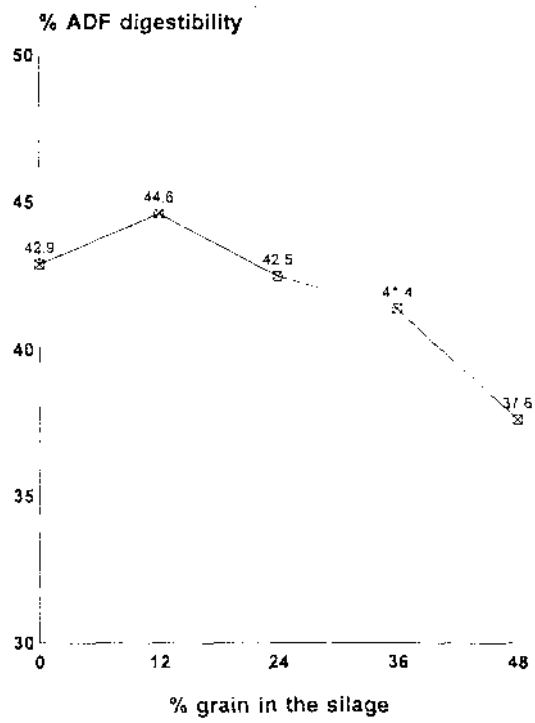

Figure 4. Effect of Grain Content on ADF Digestibility by Lambs

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AGRONOMIC AND SILAGE QUALITY TRAITS OF WINTER CEREALS

M. K. Siefers, G. L. Huck, M. A. Young, J. E. Turner, J. S. Pendergraft, and K. K. Bolsen

Summary

Agronomic and silage quality traits were examined for 12 winter cereals harvested at two stages of maturity. Forage dry matter (DM) yields were higher at the mid-dough than the early-heading stage. Post 90 barley had the highest whole-plant DM yield at the early-heading stage, and Presto triticale had the highest yield at the mid-dough stage. Newton wheat had the lowest whole-plant DM yield at both stages of maturity. The first cutting of all varieties originally was intended to be at the late-boot stage, but harvest was delayed by frequent rainfall and wet soils in May, and field-wilting conditions were less than ideal. The range in heads emerged was 23 to 87%, and the range in the silage DM content at early-heading stage was 19.2 to 46.4%. Both crude protein (CP) and ash contents were higher for the early-heading cereals than the mid-dough. All 24 silages were of relatively low forage quality, as evidenced by high neutral detergent fiber (NDF) and acid detergent fiber (ADF) percentages. Only five silages, the early-heading stage Tomahawk wheat; mid-dough stage Presto triticale; and the mid-dough stage Kanby, Post, and Post 90 barleys, had less than 60% NDF and 40% ADF. Extensive lodging occurred in virtually all cereals before the mid-dough stage harvest.

(Key Words: Winter Cereals, Silage, Winter Cereal Variety, Winter Cereal Maturity, Winter Cereal Yield.)

Introduction

Although winter cereals generally are planted for grain, they also are used as forage (i.e., pasture, hay, or silage) by many livestock producers in Kansas. Small grain cereals are harvested as forage for several reasons: 1) land can be double-cropped; 2) the risk of crop loss from rain, wind, or hail is decreased; and 3) circumstances sometimes make it desirable, even necessary, to use these crops for forage even though they were planted for another purpose, i.e., weather-stressed wheat with a low level of grain production might be more profitable if harvested as forage. Earlier studies in the 1970's and 1980's (KAES Bulletin 613R and KAES Report of Progress 539, page 190) have shown that stage of maturity and variety have large impacts on both agronomic and silage quality traits of winter cereals.

Our objective was to document agronomic performance and silage quality traits of several of the leading winter cereal varieties currently grown in Kansas.

Experimental Procedures

Twelve winter cereals were planted on October 11, 1994, and grown under dryland conditions near the Kansas State University campus in a Reading silt loam soil. The winter cereals included eight wheat varieties (Karl 92, Tam 107, 2163, Tomahawk, Jagger, 2137, Newton, and Arkan); three barley varieties (Kanby, Post, and Post 90); and one triticale (Presto). Only Arkan and Kanby were included in the most recent winter cereal forage studies (KAES Report of Progress 539). The winter cereals were planted in a randomized complete block design with three replicate plots for each variety. Single plots were 18 ft wide and 30 ft long. Anhydrous ammonia was applied at 80 lb of nitrogen per acre, and the seeding rate was 75 lb per acre for all varieties.

The winter cereals were harvested at the early-heading and mid-dough stages of maturity.

Shortly before each harvest, the ends of the plots were trimmed to remove border effects. Agronomic data collected included plant height, whole-plant dry matter (DM), whole-plant DM yield, and percent head emergence for the early-heading stage. Four drill rows 18 ft in length were harvested from each plot leaving a 4-inch stubble height. The early-heading stage harvest was between May 15 and 19, and the mid-dough stage harvest was between June 12 and 19. The early-heading stage cereals were cut with a sickle-bar mower and field-wilted for 48 hr before being chopped with a FieldQueen forage harvester. Because of the wet soil conditions and severe lodging during the mid-dough stage harvest, the four drill rows from each plot were hand cut with a serrated knife and chopped immediately with the FieldQueen harvester.

Chopped material from each plot was ensiled in a 4 12 inch PVC laboratory-scale silo and packed to similar densities using a hydraulic press. Silos were opened after a 90-day storage period. The fresh-cut and pre-ensiled forages from all plots were analyzed for DM content. 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 12 winter cereals harvested at two stages of maturity is presented in Table 1. The effect of stage of maturity at harvest on whole-plant DM content, DM yield, and silage quality traits is shown in Table 2. Whole-plant DM content and DM yield were higher at the mid-dough stage than the early-heading stage. Post 90 barley had the highest whole-plant DM yield at the early-heading stage, and Presto triticale had the highest yield at the mid-dough stage. Newton wheat had the lowest whole-plant DM yield at both stages of maturity. The fresh cut, early-heading forages had an average DM content of 18.2%, with a range of 15.2 to 21.1%, whereas the mid-dough forages averaged 36.7% DM, with a range of 33.5 to 44.9%. Plant heights were similar at the early-heading stage, but Presto triticale was taller than all eight wheat varieties at the mid-dough stage.

Silage quality traits of the 12 winter cereals are presented in Table 3. All mid-dough silages were satisfactorily preserved, as evidenced by a pH range of 4.0 to 4.4. Frequent rain and high humidity occurred during the 48 hr field-wilting period for the early-heading forages. Seven of the 12 early-heading silages had DM contents below 30% and pH values at or above 5.0. Several of these silages had undergone secondary fermentations, which were characterized by the presence of butyric acid and ammonia. Crude protein and ash contents were higher for the early-heading cereals than the mid-dough. All 24 silages were of relatively low forage quality, as evidenced by high NDF and ADF percentages. Only five silages, the early-heading stage Tomahawk wheat; mid-dough stage Presto triticale; and the mid-dough stage Kanby, Post, and Post 90 barleys, had less than 60% NDF and 40% ADF contents.

Table 1. Agronomic Performance of the 12 Winter Cereals Harvested at Two Stages of Maturity

	Early-Heading Stage			Mid-Dough Stage		
Winter Cereal and Variety [1]	Whole-Plant DM	Plant Height	Whole-Plant DM yield	Whole-Plant DM	Plant Height	Whole-Plant DM yield
Wheat	%	inches	tons/acre	%	inches	tons/acre
Karl 92 (81)	19.6	35	3.9	37.7	36	4.9
Tam 107 (87)	19.8	37	3.7	44.9	37	5.0
2163 (43)	18.3	37	3.9	33.5	36	4.7
Tomahawk (28)	19.0	35	3.0	37.8	35	4.4
Jagger (57)	19.3	36	4.0	36.2	36	4.7
2137 (34)	17.1	36	3.3	40.8	37	4.7
Newton (23)	19.4	38	2.9	34.8	37	3.9
Arkan (45)	21.1	38	3.7	34.3	37	4.3
Barley						
Kanby (34)	17.8	40	3.8	40.8	41	4.5
Post (43)	15.2	38	3.7	35.3	39	4.4
Post 90 (24)	16.0	38	4.2	30.2	37	4.3
Triticale						
Presto (63)	15.3	40	3.8	33.9	43	5.3
Average (47)	18.2	37	3.7	36.7	38	4.6
LSD (P<.05) [2]	1.7	6	.5	9.9	5	.4

[1]Percent heads emerged from the flag leaf at the early-heading stage cutting is shown in parentheses.
[2]The LSD (least significant difference) is valid only within a column.

Table 2. Effect of Stage of Maturity at Harvest on Whole-Plant DM Content, DM Yield, and Silage Quality Traits [1]

	Whole-Plant		Silage					
Stage of Maturity	DM	DM Yield	pH	DM	CP	NDF	ADF	Ash
	%	tons/acre		%	———% of the silage DM———			
Early-heading	18.2	3.7	5.3	29.3	13.5	61.5	41.3	13.2
Mid-dough	36.7	4.6	4.2	35.4	11.7	60.2	40.6	10.2
LSD (P<.05) [2]	1.9	.1	.2	2.1	.4	1.4	2.4	.5

[1]CP = crude protein; NDF = neutral detergent fiber; and ADF = acid detergent fiber.
[2]The LSD (least significant difference) is valid only within a column.

Table 3. Silage Quality Traits of the 12 Winter Cereals Harvested at Two Stages of Maturity [1]

Winter Cereal and Variety	Early-Heading Stage						Mid-Dough Stage					
	pH	DM	CP	NDF	ADF	Ash	pH	DM	CP	NDF	ADF	Ash
		%	——% of the silage DM——					%	——% of the silage DM——			
Wheat												
Karl 92	4.7	31.9	12.8	60.3	40.9	13.3	4.0	36.7	10.4	60.0	40.1	9.3
Tam 107	5.3	28.0	13.4	63.2	42.3	12.9	4.1	43.6	11.7	63.3	43.0	9.3
2163	5.5	24.9	13.2	62.7	43.1	13.3	4.2	32.0	11.7	61.3	41.7	10.5
Tomahawk	4.8	36.8	15.3	58.7	39.6	11.9	4.1	37.3	12.7	60.6	40.7	10.0
Jagger	5.7	26.2	14.1	61.4	41.2	14.2	4.1	34.3	12.1	58.6	40.1	9.9
2137	5.0	23.2	14.0	60.9	41.7	14.1	4.0	38.9	11.0	58.9	40.4	9.3
Newton	4.9	36.1	14.5	60.9	40.3	13.4	4.2	33.5	12.4	63.6	42.7	10.9
Arkan	4.9	46.4	12.9	63.0	41.9	13.3	4.2	33.1	12.2	62.0	41.7	10.0
Barley												
Kanby	5.0	29.6	11.9	62.9	41.3	12.0	4.3	39.0	11.3	59.7	39.7	11.1
Post	6.3	26.4	13.0	62.7	41.4	12.7	4.2	34.5	12.7	58.0	39.1	11.8
Post 90	6.4	22.6	14.2	60.9	42.3	14.1	4.4	27.9	13.4	57.4	38.6	12.5
Triticale												
Presto	5.2	19.2	13.0	60.7	40.0	12.6	4.0	33.3	9.2	59.4	39.4	8.2
Average	5.3	29.3	13.5	61.5	41.3	13.2	4.2	35.5	11.7	60.2	40.6	10.2
LSD (P<.05) [2]	1.0	6.3	1.4	2.4	2.0	1.8	.3	9.8	1.9	6.0	2.1	1.6

[1]CP = crude protein; NDF = neutral detergent fiber; and ADF = acid detergent fiber.

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

Cattlemen's Day 1996

EFFECT OF BACTERIAL INOCULANTS ON THE FERMENTATION OF ALFALFA SILAGES [1]

K. K. Bolsen, D. R. Bonilla [2], M. A. Young, and R. A. Hart-Thakur

Summary

The efficacy of 13 commercial bacterial silage inoculants was evaluated on 3rd and 4th cutting alfalfa. All inoculants supplied at least 100,000 colony-forming units (cfu) of lactic acid bacteria (LAB) per gram of ensiled crop, and each inoculant increased the rate and efficiency of the ensiling process. Inoculated alfalfa silages had lower pH values; higher lactic acid contents; and lower acetic acid, ethanol, and ammonia-nitrogen contents than control (untreated) silages. The addition of dextrose (fermentable substrate) in combination with a bacterial inoculant improved the quality of the fermentation phase in both cuttings of alfalfa.

(Key Words: Silage, Inoculant, Fermentation, Alfalfa.)

Introduction

The effect of silage additives on fermentation dynamics has been documented in over 100 experiments using laboratory-scale silos at Kansas State University in the past 10 years. Results showed that the vast majority of inoculants supplied a high number of LAB (at least 100,000 cfu per gram of forage) and improved silage fermentation efficiency in all silage crops. Our objective study was to measure the efficacy of 13 silage inoculants available in 1992, using third and fourth cutting alfalfa. Because alfalfa is often a sugar-limited crop when ensiled below 35% dry matter (DM), dextrose and a combination of dextrose and inoculant were included as additional treatments.

Experimental Procedures

The 13 inoculants evaluated and their LAB content as listed by the manufacturer or distributor are shown in Table 1. Two trials were conducted using alfalfa grown near Manhattan, Kansas. A description of each alfalfa, including harvest date, chemical composition, and epiphytic microflora, is presented in Table 2.

The laboratory silos used were 4 × 14 inch PVC pipes closed with Jim-caps on each end. One Jim-cap was fitted with a Bunsen valve to allow gases to escape. For filling, 100 lb of chopped alfalfa were placed on a polyethylene sheet, and the inoculants were applied and mixed thoroughly with the forage. All inoculants were applied as water solutions and used within 2 to 3 weeks after being received from the manufacturer or distributor. The colony-forming units (cfu) of LAB supplied per gram of pre-ensiled alfalfa by the inoculants is shown in Tables 3 and 4. Dextrose was applied at 2% of the forage DM. After all treatments were prepared, the silos were filled on an alternating schedule, which distributed the time from harvest (chopping) through silo filling equally across all treatments. The silos were packed with a hydraulic press, which excluded air and filled all silos to similar densities. Silos were stored at approximately 76 to 80°F. Three silos per treatment were opened at 1/2, 1, 3, 7, and 90 days postfilling.

[1]Financial assistance was provided by Lallemand S.A. Laboratorie Equipharm, Saint-Simon, France.

[2]Former graduate student. Current address: San Juan, Puerto Rico.

Table 1. List of the 13 Inoculants Evaluated in the Two Trials, Their Manufacturer or Distributor, and Their Lactic Acid Bacteria (LAB) Content

Inoculant	Manufacturer or Distributor	LAB[1]
Lallemand	Lallemand S.A. Laboratorie Equipharm, Saint-Simon, France	*L.*[2] *plantarum and P. acidilactici*
Biomate	Chr. Hansen's BioSystems, A Division of Chr. Hansen's, Inc., Milwaukee, WI	*L. plantarum and P. cerevisiae*
Ecosyl	ICI, Inc., Wilmington, DE	*L. plantarum*
Sil All	Alltech, Inc., Nicholasville, KY	*L. plantarum, P. acidilactici, and S. faecium*
Biotal	Biotal, Inc., Eden Prairie, MN	*L. plantarum and P. pentosaceus*
Bio Power	BioTechniques Laboratories, Inc., Redmond, WA	*S. faecium and L. plantarum*
Quest	Quest International, Hoffman Estates, IL	*L. plantarum*
Kem Lac	Kemin Industries, Inc., Des Moines, IA	*L. plantarum, L. bulgaricus, and L. acidophilus*
AgMaster	Marshall Products, A Division of Rhone-Poulenc, Inc., Madison, WI	*L. plantarum and P. acidilactici*
1174	Pioneer Hi-Bred International, Inc., Des Moines, IA	*L. plantarum and S. faecium*
Trilac	Quali Tech, Inc., Chaska, MN	*L. plantarum and P. acidilactici*
H/MF	Medipharm USA, Des Moines, IA	*L. plantarum, S. faecium, and Pediococcus* sp.
SI Concentrate	Laporte Biochem, Inc., Milwaukee, WI	*L. plantarum, L. brevis, P. acidilactici, S. cremoris, and S. diacetylactis*

[1]None of the additives contained enzymes.
[2]*L = Lactobacillus*; *P = Pediococcius*; *S = Streptococcus*.

Table 2. Chemical Composition and Epiphytic Microflora of the Chopped, Pre-ensiled Forages Used in Trials 1 and 2

Item[1]	Trial 1: 3rd Cutting Alfalfa	Trial 2: 4th Cutting Alfalfa
Harvest date[2]	July 21	August 6
Dry matter, %	32.4	40.5
pH	5.95	5.82
Buffering capacity, meq/100 g of DM	56.8	43.6
	——% of the forage DM——	
WSC	5.6	6.8
CP	21.2	20.4
NDF	38.8	40.6
ADF	27.4	31.2
	——cfu/g of forage——	
LAB	1.2 10 ^{5}	6.7 10 ^{6}
Yeast and mold	1.8 10 ^{5}	2.6 10 ^{4}

[1]WSC = water-soluble carbohydrates; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; and LAB = lactic acid bacteria. [2]Alfalfa

Chemical and Microbial Analyses of the Pre-ensiled Alfalfas and Silages. Pre-ensiled alfalfa was analyzed for DM; pH; total nitrogen; buffering capacity; water-soluble carbohydrates (WSC); neutral detergent and acid detergent fiber contents; and total epiphytic LAB, yeast, and mold counts. Silages fermented from 12 hours to 7 days were analyzed for pH and lactic acid; end-product silages (90 days postfilling) were analyzed for pH, lactic acid, volatile fatty acids, ethanol, and ammonia-nitrogen.

Statistical Analyses. Mean responses of each inoculant- and dextrose- treated silage were compared to the mean response of the control silage by the analysis of variance procedure for a complete block design.

Results and Discussion

Shown in Tables 3 and 4 are pH and lactic acid over time for the alfalfa silages in Trails 1 and 2, respectively. Presented in Tables 5 and 6 are pH and fermentation characteristics of the alfalfa silages at 90 days postfilling in Trials 1 and 2, respectively.

Trial 1. The pre-ensiled alfalfa had a relatively high buffering capacity and low WSC content. As a result, the 90-day pH values were relatively high (4.78 to 4.91), except for the two dextrose-treated silages (4.57 and 4.54). All of the nine inoculants supplied at least 100,000 cfu of LAB per gram of crop, but the rate of fermentation was fastest for the inoculant that supplied the highest number of LAB (Trilac). All inoculated silages had lower pH's ($P<.01$) and higher lactic acid contents ($P<.01$) than the control silages at 3, 7, and 90 days postfilling. The nine inoculated, 90-day silages were characterized by having significantly higher lactic acid contents and lactic to acetic acid ratios and lower acetic acid, ethanol, and ammonia-nitrogen contents than controls. The dextrose + inoculant silage underwent a more homofermentative ensiling process than its dextrose-treated counterpart.

Trial 2. The pre-ensiled alfalfa had a lower buffering capacity (43.6 vs. 56.8 meq per 100 g of DM), higher WSC content (6.8 vs. 5.6% of the forage DM), and a higher epiphytic LAB population (6.7 10 ^{6} vs. 1.2 1 0^5/g) than the alfalfa used in Trial 1. As a result, the fermentation phase began within the first 12 hours postfilling for all silages, including the control silage. Also, the 90-day pH values were relatively low (4.17 to 4.34) for all inoculant- and dextrose-treated silages.

All 12 inoculants supplied at least 100,000 cfu of LAB per gram of crop, and all inoculated silages had a faster rate of fermentation than the control. Only the control silage had a pH value above 4.90 (5.13) at 3 days postfilling. All inoculated silages had a lower pH ($P<.01$) and higher lactic acid content ($P<.01$) than the control silages at 12 and 24 hr and 3, 7, and 90 days postfilling. All 12 inoculated, 90-day silages underwent a more efficient ensiling process than the control silage. The fermentation characteristics indicated that the dextrose + inoculant treatment gave the most favorable 90-day silage.

Table 3. pH and Lactic Acid over Time for the 12 Alfalfa Silages in Trial 1

		Time Postfilling[1]				
Treatment[2,3]		12 hrs	24 hrs	3 days	7 days	90 days
Control	pH	5.90	5.84	5.43	5.24	4.91
	LA	.2	.3	1.4	2.1	4.0
Lallemand	pH	5.86^{x}	5.39	5.10	4.88	4.78
(5.4 1 0^5)	LA	.2^{x}	1.6	3.8	4.6	5.4
Dextrose	pH	5.92^{x}	5.85^{x}	4.99	4.74	4.57
	LA	.2^{x}	.3^{x}	3.9	5.2	5.9
Lallemand	pH	5.85^{x}	5.29	4.67	4.68	4.54
+ Dextrose	LA	.3^{x}	1.6	4.9	5.5	6.0
ICI	pH	5.84	5.81^{x}	5.11	4.98	4.82
(1.0 1 0^5)	LA	.3^{x}	.3^{x}	3.7	3.9	4.9
Alltech	pH	5.88^{x}	5.77^{x}	5.02	4.92	4.78
(2.4 1 0^5)	LA	.2^{x}	.4^{x}	3.7	4.5	5.2
Biotal	pH	5.84	5.38	4.97	4.90	4.83
(1.0 1 0^5)	LA	.3^{x}	1.7	4.2	4.6	5.1
BioTechniques	pH	5.87^{x}	5.70	5.01	4.95	4.83
(1.8 1 0^5)	LA	.2^{x}	.5	3.6	4.5	4.9
Kemin	pH	5.86^{x}	5.77^{x}	5.20	5.09	4.84
(1.0 1 0^5)	LA	.2^{x}	.5	3.3	4.1	5.1
Marschall	pH	5.90^{x}	5.73	5.21	5.10	4.85
(1.8 1 0^5)	LA	.2^{x}	.4^{x}	3.4	4.1	4.9
Pioneer	pH	5.88^{x}	5.79^{x}	5.11	5.05	4.78
(1.4 1 0^5)	LA	.2^{x}	.3^{x}	3.4	4.2	5.3
Quali Tech	pH	5.40	4.82	4.78	4.69	4.78
(8.1 1 0^5)	LA	1.3	3.2	4.6	5.2	5.3

[1]LA = lactic acid expressed as a % of the silage dry matter.
[2]LAB supplied per gram of pre-ensiled crop is shown in parentheses.
[3]Inoculant- and dextrose-treated means differ (P<.01) from control means, unless the treated mean has a superscript (x).

Table 4. pH and Lactic Acid over Time for the 15 Alfalfa Silages in Trial 2

		Time Postfilling[1]				
Treatment[2,3]		12 hrs	24 hrs	3 days	7 days	90 days
Control	pH	5.52	5.35	5.13	4.94	4.56
	LA	1.0	1.6	2.4	4.2	4.4
Lallemand	pH	5.29	5.17	4.75	4.68	4.30
(5.0 1 0^5)	LA	1.7	3.0	4.9	5.7	6.1
Dextrose	pH	5.18	5.10	4.72	4.67	4.28
	LA	2.0	3.1	4.5	5.1	5.9
Lallemand	pH	5.13	5.03	4.47	4.43	4.17
+ Dextrose	LA	2.3	3.5	5.8	6.4	6.7
Chr. Hansen's	pH	5.26	5.11	4.75	4.66	4.28
(1.3 1 0^5)	LA	1.8	3.0	4.8	5.6	6.1
ICI	pH	5.29	5.22	4.81	4.72	4.32
(1.0 1 0^5)	LA	1.6	2.5	4.6	5.3	6.1
Alltech	pH	5.29	5.21	4.77	4.66	4.30
(3.1 1 0^5)	LA	1.7	2.8	4.7	5.5	6.0
Biotal	pH	5.27	5.16	4.78	4.71	4.31
(1.1 1 0^5)	LA	1.8	2.9	4.8	5.5	6.2
BioTechniques	pH	5.30	5.25^x	4.85	4.72	5.34
(1.3 1 0^5)	LA	1.7	2.4	4.3	5.3	6.1
Quest	pH	5.29	5.24^x	4.81	4.78	4.33
(1.7 1 0^5)	LA	1.6	2.5	4.5	4.9	5.8
Kemin	pH	5.29	5.24^x	4.81	4.71	4.33
(1.4 1 0^5)	LA	1.7	2.6	4.7	5.7	5.9
Marschall	pH	5.28	5.18	4.88	4.67	4.31
(3.0 1 0^5)	LA	1.8	3.0	4.5	5.4	6.0
Pioneer	pH	5.29	5.21	4.77	4.65	4.32
(1.5 1 0^5)	LA	1.7	2.9	4.8	5.7	6.1
Medipharm	pH	5.21	5.04	4.73	4.66	4.28
(3.4 1 0^5)	LA	2.0	3.1	4.9	5.7	6.5
Laporte	pH	5.28	5.23^x	4.79	4.69	4.34
(1.7 1 0^5)	LA	1.5	2.4	4.6	5.0	5.7

[1]LA = lactic acid expressed as a % of the silage dry matter.
[2]LAB supplied per gram of pre-ensiled crop is shown in parentheses.
[3]Inoculant- and dextrose-treated means differ (P<.05) from control means, unless the treated mean has a superscript (x).

Table 5. pH and Fermentation Characteristics for the 12 Alfalfa Silages at 90 Days Postfilling in Trial 1

Treatment[1]	pH	Lactic Acid	Acetic Acid	Ethanol	NH_3-N	Lactic to Acetic
		——% of the silage DM ——				
Control	4.91	4.0	2.9	.44	.36	1.4
Lallemand	4.78	5.4	2.0	.18	.21	2.7
Dextrose	4.57	5.9	2.8[x]	.38[x]	.21	2.1
Lallemand + Dextrose	4.54	6.0	1.8	.18	.20	3.4
ICI	4.82	4.9	2.1	.26	.23	2.3
Alltech	4.79	5.2	2.1	.23	.21	2.4
Biotal	4.83	5.1	2.2	.21	.20	2.2
BioTechniques	4.83	4.9	2.3	.25	.24	2.1
Kemin	4.84	5.1	2.1	.25	.21	2.4
Marschall	4.85	4.9	2.2	.24	.24	2.2
Pioneer	4.79	5.3	2.1	.19	.20	2.5
Quali Tech	4.78	5.3	1.9	.17	.20	2.7

[1]Inoculant- and dextrose-treated means differ (P<.01) from control means, unless the treated mean has a superscript (x).

Table 6. pH and Fermentation Characteristics for the 15 Alfalfa Silages at 90 Days Postfilling in Trial 2

Treatment[1]	pH	Lactic Acid	Acetic Acid	Ethanol	NH_3-N	Lactic to Acetic
		——% of the silage DM ——				
Control	4.56	4.4	2.3	.28	.33	2.0
Lallemand	4.30	6.1	1.6	.13	.21	3.4
Dextrose	4.28	5.9	2.1[x]	.26[x]	.20	2.8
Lallemand + Dextrose	4.17	6.7	1.5	.08	.18	4.5
Chr. Hansen's	4.28	6.1	1.7	.14	.20	3.6
ICI	4.32	6.1	1.7	.15	.22	3.5
Alltech	4.30	6.0	1.6	.11	.19	3.7
Biotal	4.31	6.2	1.6	.16	.20	3.9
BioTechniques	4.34	6.1	1.6	.13	.21	3.7
Quest	4.33	5.8	1.7	.14	.20	3.3
Kemin	4.33	5.9	1.6	.10	.20	3.8
Marschall	4.31	6.0	1.7	.16	.21	3.5
Pioneer	4.32	6.1	1.6	.14	.18	3.9
Medipharm	4.28	6.5	1.7	.10	.18	3.8
Laporte	4.34	5.7	1.9	.18	.24	3.0

[1]Inoculant- and dextrose-treated means differ (P<.01) from control means, unless the treated mean has a superscript (x).

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EFFECT OF A PROPIONIC ACID BACTERIAL INOCULANT ON FERMENTATION AND AEROBIC STABILITY OF WHOLE-PLANT CORN SILAGE [1]

K. K. Bolsen, D. R. Bonilla [2], G. L. Huck, M. A. Young, and R. A. Hart-Thakur

Summary

The effects of a strain of *Propionibacterium shermanii*, applied with and without lactic acid bacteria (LAB), on the ferment ation and aerobic stability of whole-plant corn silage was determined using laboratory-scale silos. The addition of LAB increased the rate of fermentation, and all inoculated silages underwent a more efficient ensiling process than control silage. Only silages made with *P. shermanii* had measurable levels of propionic acid in the 90-day silages. Corn silages made with *P. shermanii* were more stable when exposed to air than control or LAB-inoculated silages.

(Key Words: Silage, Aerobic Spoilage, Inoculant, Propionic Acid.)

Introduction

Aerobic instabilit y during the feedout phase (i.e., short bunk life) is often a problem with whole-plant corn, sorghum, and winter cereal silages, particularly if the dry matter (DM) content exceeds 35%. When the silo is opened, oxygen has unrestricted access to the exposed feeding face. Aerobic microorganisms (i.e., yeast, mold, and bacteria) present in the silage can consume soluble nutrients, including lactic acid, which increases the te mperature and pH of the silage. If allowed to continue, the deterioration and spoilage can cause a silage to have virtually no nutritional value. A rapid removal of silage and correct sizing of the height and width of the feeding face can help minimize DM losses during the feedout phase.

Presently, there is considerable interest in using biological inoculants to overcome the problem of aerobic instability. These additives should produce substances in the silage that have antimycotic properties, which would inhibit the growth of yeast and mold in silage exposed to air. Propionic acid bacteria can ferment soluble carbo hydrates and lactic acid to propionic acid, which is an eff ective antimycotic agent. Although the production of propionic acid during the fermentation phase is a sound concept, results in a limited number of controlled experiments have been inconsistent.

Our objective was to deter mine the effect of a propionic acid bacterial inoculant on aerobic stability of whole-plant corn silage.

Experimental Procedures

A description of the whole-plant corn used in the trial, including harvest date, chemical composition, and epiphytic microflora, is presented in Table 1. The hybrid was Pioneer 3377, grown under irrigation and harvested at approximately 60 to 70% milk line stage of kernel maturity.

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[1]Financial assistance and bacterial inoculants were provided by Lallemand S.A. Laboratorie Equipharm, Saint-Simon, France.

[2]Former graduate student. Current address: San Juan, Puerto Rico.

Table 1. Chemical Composition and Epiphytic Microflora of the Chopped, Pre-Ensiled, Whole-Plant, Corn Forage

Item[1]	Value
Harvest date	August 21
Dry matter, %	33.5
pH	5.86
Buffering capacity, meq/100 g of DM	21.6
WSC[2]	11.4
CP[2]	8.2
NDF[2]	53.0
ADF[2]	24.8
LAB[3]	1.2×10^{7}
Yeast[3]	8.0×10^{6}
Mold[3]	1.2×10^{4}

[1]WSC = water-soluble carbohydrates; CP = crude protein; NDF = neutral detergent fiber; ADF = acid detergent fiber; and LAB = lactic acid bacteria.
[2]Expressed as a percent of the forage DM.
[3]Colony-forming units per gram of forage.

The following six treatments were compared: 1) control (no additive), 2) Lallemand inoculant (to supply 700,000 cfu of LAB per gram of crop) (LAB), 3) *Propionibacterium shermanii* (to supply 1.4×10^{5} cfu per gram of crop) (PS 10^{5}), 4) treatment 2 + treatment 3, 5) *P. shermanii* (to supply 1×10^{6} cfu per gram of crop) (PS 10^{6}), and 6) treatment 2 + treatment 5. The Lallemand inoculant contained selected strains of *Lactobacillus plantarum* and *Pediococcus acidilactici*.

In preparation of the silages, 250 lb of chopped forage were placed on a polyethylene sheet, and the inoculants were applied and mixed thoroughly with the forage. All inoculants were applied as water solutions and used within 2 weeks after being received from the manufacturer. After all silages were prepared, the silos were filled on an alternating schedule, which distributed the time from harvest through silo filling equally across all treatments. The silos were packed with a hydraulic press, which exclude d air and filled all silos to similar densities.

There were 21 PVC laboratory-scale silos (4.5 lb capacity) and three polyethylene pail silos (35 lb capacity) per treatment. Three PVC silos per treatment were opened at 1/4, 1/2, 1, 2, 4, 7, and 90 days postfilling. The pail silos were opened at 90 days postfilling, and the silage from each treatment was composited. Aerobic stability was measured over a 10-day period using insulated, 4.5 lb capacity containers and thermocouple wires.

Chemical and Microbial Analyses of the Pre-ensiled Forage and Silages. Pre-ensiled forage was analyzed for DM; pH; total nitrogen; buffering capacity; water-solu ble carbohydrates; neutral detergent fibe r; acid detergent fiber; and total epiphytic LAB, yeast, and mold counts. Silage fermented from 6 hours to 7 days was analyzed for pH and lactic acid; end-product silages (90 days postfilling) were analyzed for pH, lactic acid, volatile fatty acids, ethanol, ammonia-nitrogen, and total yeast and mold counts. Silages in the aerobic stability measurements were analyzed for pH and total yeast and mold counts after 2, 4, 6, 8, and 10 days of exposure to air.

Results and Discussion

Although all six corn silages had very rapid rates of fermentation, those made with LAB (Treatments 2, 4, and 6) had lower ($P<.01$) pH values and higher ($P<.01$) lactic acid contents during the first 4 days postfilling than control silage (data not shown).

Fermentation characteristics and pH for the corn silages at 90 days postfilling are presented in Table 2. All five inoculated silages ensiled more efficiently than the control silage -- as evidenced by higher ($P<.05$) lactic acid contents and lactic to acetic acid ratios and lower ($P<.05$) acetic acid and ethanol contents. These results are consistent with several previous

studies on inoculated corn and sorghum silages (KAES Report of Progress 651, page 101). Only the four silages made with *P. shermanii* (with or without LAB) contained detectable amounts of propionic acid at 90 days. However, the level of this acid varied considerably among silages for each treatment and ranged from .06 to .33% of the silage DM.

Results of the aerobic stability measurements are shown in Tables 3 and 4. Corn silage treated with only PS 10^6 (Treatment 5) was clearly the most aerobically stable, and this silage also had the highest level of propionic acid (.22%). Corn silage made with only LAB (Treatment 2) had a slightly higher yeast count after the 90-day storage phase than the other five silages and also was the least stable in air. Its temperature exceeded the ambient by about 5°F after 94 hrs of exposure to air. Control and LAB + PS 10^5 silages (Treatments 1 and 4, respectively) began to heat and had yeast counts near $\log_{10}$ 8.00 after 118 to 122 hrs. PS 10^5 and LAB + PS 10^6 silages (Treatments 3 and 6, respectively) were the next to undergo aerobic spoilage after 146 to 148 hrs of exposure to air. When aerobic deterioration began in the four silages treated with *P. shermanii* it was at a slow rate and not the typical rapid increases in temperature and pH observed in aerobically unstable corn silage.

These results suggest that the strain of *P. shermanii* used was capable of competing with other microorganisms in the ensiling process; it produced propionic acid that was detectable in the 90-day corn silages. Silages inoculated with this organism were more stable during the feedout phase than control or LAB-inoculated silages. The *Propionibacterium* was more effective when applied at 10^6 cfu per gram of ensiled forage and when not in combination with LAB (i.e., *L. plantarum* and *P. acidilactici*).

Table 2. pH and Fermentation Characteristics for the Six Whole-Plant Corn Silages at 90 Days Postfilling

Treatment[1]	pH	Lactic Acid	Acetic Acid	Propionic Acid	Ethanol	NH_3-N	Lactic to Acetic
		% of the silage DM					
1. Control	3.67	4.75[d]	2.10[d]	ND[2]	.82[c]	.22[b]	2.3[b]
2. LAB	3.65	5.25[b]	1.64[ab]	ND	.50[a]	.16[a]	3.2[a]
3. PS 10^5	3.65	5.15[c]	1.88[c]	.17	.67[b]	.20[b]	3.1[a]
4. LAB + PS 10^5	3.66	5.10[c]	1.67[ab]	.08	.54[a]	.14[a]	3.1[a]
5. PS 10^6	3.66	5.12[c]	1.72[b]	.22	.64[b]	.21[b]	3.0[a]
6. LAB + PS 10^6	3.66	5.43[a]	1.56[a]	.17	.46[a]	.13[a]	3.5[a]

[1]LAB = lactic acid bacteria and PS = *P. shermanii*
[2]ND = not detected.
[a,b,c,d]Means in the same column with different superscripts differ ($P < .05$).

Table 3. Hour of Initial Temperature (Temp.) Rise, Peak Temperatures, and pH for the Six Whole-Plant Corn Silages during the 10-day Aerobic Stability Measurements

Treatment[1]	Initial Temp. Rise, hrs	First Peak Temp. hrs	First Peak Temp. °F	Second Peak Temp. hrs	Second Peak Temp. °F	Days Exposed to Air 4	6	8	10
						pH			
1. Control	118	146	101	210	122	3.67	4.00	5.37	6.11
2. LAB	94	140	106	238	121	4.03	5.20	6.00	5.93
3. PS 10^5	146	*	*	238	106	3.65	3.68	3.92	5.08
4. LAB + PS 10^5	122	*	*	204	98	3.66	4.00	4.49	5.13
5. PS 10^6	166	*	*	210	94	3.66	3.67	3.79	3.97
6. LAB + PS 10^6	148	*	*	210	98	3.66	3.69	3.92	4.27

[1]LAB = lactic acid bacteria and PS = *P. shermanii*.
*No distinguishable first peak. These si lages exhibited at gradual increase in temperature following the initial temperature rise.

Table 4. pH and Yeast and Mold Counts over Time for the Corn Silages during the 10-day Aerobic Stability Measurements

Treatment[1,2]		Days to Exposure to Air 0	2	4	6	8	10
		Log_{10} cfu/g of silage					
1. Control	Y	<2.0	4.62	7.08	8.38	8.84	8.36
	M	4.04	3.41	4.68	7.26	7.61	7.82
2. LAB	Y	4.30	6.53	8.43	9.34	9.34	9.08
	M	<2.0	<2.0	4.32	6.76	7.46	7.61
3. PS 10^5	Y	2.84	4.18	7.20	7.65	8.11	8.59
	M	3.28	3.83	4.57	6.49	7.57	8.18
4. LAB + PS 10^5	Y	2.74	5.54	6.75	8.88	9.23	9.40
	M	<2.0	<2.0	4.26	6.40	6.98	7.57
5. PS10^6	Y	<2.0	4.38	7.90	6.56	6.98	8.46
	M	<2.0	<2.0	4.34	6.32	7.40	8.18
6. LAB + PS 10^6	Y	2.95	4.48	6.18	7.92	8.18	9.04
	M	<2.0	<2.0	4.54	6.41	7.49	7.64

[1]LAB = lactic acid bacteria and PS = *P. shermanii*.
[2]Y = yeast count and M = mold count.

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USING NEAR-INFRARED REFLECTANCE SPECTROSCOPY FOR RAPID NUTRIENT EVALUATION OF SORGHUM SILAGE

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Summary

This research was designed to develop a set of prediction equations to measure nutrient composition of Kansas sorghum si lages by near-infrared reflectance spectroscopy (NIRS). Because sorghum silages are highly variable in grain content, we included a large number of cultivars to develop a robust set of equations for dry matter, crude protein, neutral detergent fiber, and acid detergent fiber. The results indicate that NIRS analysis of sorghum silages is feasible.

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

Introduction

The near-infrared reflectance spectrometer (NIRS) is designed to rapidly determine the nutrient content of feeds and foods. The instrument scans a feed using reflected wavelengths just above those we can see, sends the information to a computer programmed with equations for various nutrients, and returns nutrient value in less than 1 minute. The reliability of the instrument is based on equations that compare NIRS outputs to traditional chemical analyses. Such equations exclusively for sorghum silages are generally not available.

Experimental Procedures

Two hundred 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 108 scans that differed enough to be useful in developing equations. Those samples were analyzed in duplicate for crude protein, neutral detergent fiber, and acid detergent fiber.

Sixty-eight samples were selected by the instrument's computer to be used for development of calibration equations. The remaining 40 samples were used for validation.

Results and Discussion

Statistical summaries of the calibrations and validations are shown in Table 1 and the "best fit" equations and corre sponding wavelengths in Table 2.

Of the original 68 samples selected for calibration, several were omitted because the chemical values were outside the expected norm relative to the respective spectra. Neutral detergent fiber had the highest standard error because of the variation in samples; however, the R^2 indicated acceptable cor relations between the spectra and chemical analyses. Acid detergent fiber and crude protein had lower SEC values. Moisture, as e xpected, did not correlate well with laboratory data. Perhaps that problem can perhaps be resolved by using Karl Fischer titration instead of oven drying for laboratory water measurement.

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[1]Graduate student, Department of Grain Science.

Regression equations (Table 2) indicate that either four or five wavelengths were needed for prediction.

In summary, these data indicate that the development of robust equations by NIRS for sorghum silage is feasible, but additional work is needed on moisture measurement.

Table 1. Selected Means, Standard Errors, and Coefficients for Nutrient Components of Sorghum Silages

Variable	N	Mean	SEC[a]	R^2	SEV[b]	R^2
Dry matter	64	93.51	.71	.78	.73	.76
Crude protein	65	7.81	.36	.92	.39	.91
Neutral detergent fiber	65	48.22	1.41	.92	1.50	.91
Acid detergent fiber	65	30.54	.87	.96	.92	.95

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

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

Variable	Component	Coefficient	F	Wavelengths (mm)
Dry matter	B_0	82.50		
	B_1	66.31	10.11	1636
	B_2	4.80	35.24	688
	B_3	64.04	18.07	2212
	B_4	100.99	55.19	2476
	B_5	102.84	99.89	1444
	B_6	205.84	20.65	1292
Crude protein	B_0	24.08		
	B_1	34.10	12.86	1700
	B_2	60.76	30.34	1228
	B_3	40.71	37.46	2180
	B_4	22.66	104.16	2228
Neutral detergent fiber	B_0	141.93		
	B_1	40.26	21.23	440
	B_2	588.20	265.62	1220
	B_3	561.70	153.40	2340
	B_4	47.40	11.98	632
Acid detergent fiber	B_0	33.32		
	B_1	89.15	16.37	2260
	B_2	266.85	34.58	2148
	B_3	346.58	107.85	1436
	B_4	330.28	353.94	2276

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NATIONAL FORAGE SURVEY RESULTS: TRACE MINERAL AND RELATED NUTRIENT LEVELS

L. Corah, D. Dargatz [1], and C. Peters

Summary

A National Forage Survey was conducted in 18 states to determine the trace mineral and related nutrient content of forages grown in the United States. Most forages sampled were harvested hays utilized as winter feed for beef cow herds. The trace element most commonly deficient in the forages sampled was zinc. Copper and cobalt levels were adequate in 36 and 34.1% of the samples, respectively. In contrast, manganese was adequate (above 40 ppm) in 76% of the samples and was deficient (below 20 ppm) only in 4.7%. The copper antagonists, such as iron and molybdenum, were marginal to high in 28.7% and 57.8% of the samples, respectively, indicating that both of these elements are often present in levels that can cause a reduction in copper availability. Of the 352 samples collected in 18 states, the trace mineral most likely to be deficient was zinc, followed by selenium and cobalt.

(Key Words: Trace Minerals, Forage Survey, Forages.)

Introduction

Harvested and grazed forage represents the major cost associated with cow-calf and stocker production. Although forage analysis is encouraged as a profitable management practice, only a limited number of producers traditionally utilize forage testing to determine supplementation strategies. Even fewer producers utilize trace mineral analyses of their forages.

Reported below are the results of a National Forage Survey conducted in 18 cooperating states to determine the nutrient and trace mineral profiles of various forages commonly used by cow-calf producers.

Experimental Procedures

To determine the health status and production practices used by producers, the USDA Animal and Plant Health Inspection Veterinary Services conducted a 48-state survey involving 2,539 cow-calf producers. This project, which took 16 months, profiled cow-calf health and production parameters and has been published in a series of five national reports entitled "Cow-Calf Health and Productivity Audit (CHAPA) Reports".

As a component of this national audit, 18 states were designated to participate in a National Forage Survey, as follows:

State	No. of Samples Submitted
Alabama	8
Arkansas	16
California	7
Colorado	17
Florida	4
Georgia	8
Iowa	25
Kansas	28
Kentucky	10
Mississippi	20
Missouri	23
Nebraska	47

[1]Beef Specialist, APHIS-VS, Center of Epidemiology and Animal Health, Fort Collins, CO.

New Mexico	9
Oklahoma	19
Tennessee	17
Texas	45
Virginia	11
Wyoming	38
TOTAL:	352

Producers participating in the survey were offered the opportunity to have a single sample of harvested forage collected and analyzed without cost. All samples were collected by state and federal veterinary personnel and mailed to Kansas State University. All cooperating veterinary personnel were trained in proper forage sampling procedures to ensure that uniform samples were collected for analysis. Samples were collected using a standard forage probe.

Samples were dried in the Nutrition Lab at Kansas State University and then were ground and submitted to a commercial lab (Peterson Labs, Hutchinson, KS) for analysis. Samples were analyzed for crude protein (CP), acid detergent fiber (ADF), phosphorus (P), copper (Cu), cobalt (Co), iron (Fe), manganese (Mn), molybdenum (Mo), and zinc (zn).

For analytical purposes, forages were combined into nine categories as follows.

Alfalfa/Alfalfa Mix Thirty nine samples were coded as alfalfa and 25 were classified as alfalfa mix, predominantly grass-alfalfa combinations.

Brome Eight samples were clearly designated as brome.

Bermuda Of 36 samples designated as bermuda, one was a bermuda grass/orchard grass mix.

Fescue/Fescue Mix This category included 16 samples designated as fescue and 10 as fescue-clover combinations.

Sudan/Sudan Sorghum This classification included sorghum silage, forage sorghums, baled sorghams, sorghum forage, and straight sorghums and sudans.

Cereal Forages The designatio n included 17 samples of wheat, oats, and barley.

Grass The grass category included 139 samples considered native or local for the respective state and may have included brome mixes, timothy, mixed grasses, and other grass-hay combinations.

Silage The nine samples classified as silage were coded predominantly corn silage. (Three sorghum silage samples were included in the sudan/sudan sorghum category.

Other This group included 26 forages not fitting into other categories and is not discussed in the report.

Results and Discussion

The means of nutrient and trace mineral analyses are shown in Table 1. To help interpret the trace mineral values, Table 2 indicates the amounts of the trace elements needed to meet dietary needs. In the case of antagonistic trace elements, such as iron and molybdenum, amounts that would lead to problems with copper are shown.

Copper. In the national sample s, 36% were classified as having adequate levels of copper, with 14.2% being deficient (below 4 ppm; Table 3). For most of the forage samples collected, the mean values for copper fell in the range of 5-8 ppm. This is usually adequate if high levels of antagonists, such as iron and molybdenum in the forage or sulfur in the water, are not present to cause a copper "tie-up".

Of concern was the fact that 28.7% of the forage samples contained levels of iron that could be antagonistic to a copper. Of even greater concern was the fact that 57.8% of the samples contained molybdenum le vels that were high enough to tie up copper.

Zinc. This was the most commonly deficient trace element. Only 2.5% of the samples contained adequate zinc (at least 40 ppm), and

63.4% of the samples were classified as deficient (below 20 ppm zinc).

Cobalt. On a national basis, 34.1% of the samples contained adequate cobalt, whereas 48.6% were classified as deficient. However, part of this high deficiency level may reflect limitations in the laboratory procedures. The small levels of cobalt (commonly less than .2 ppm) in most forage samples a re near the detection limits of practical laboratory techniques.

Manganese. Of all the trace minerals analyzed, manganese was the one most commonly present in a high enough le vel to meet the dietary requirements of cattle. Because manganese is fairly poorly digested, it's important that the forage contain an adequate level. Seventy-six percent of the samples sampled nationally had an adequate level.

Selenium. On a national basis, 19.7% of the samples collected were classified adequate in selenium and 44.3% were classified as deficient. Selenium varies widely throughout the United States, often being deficient in certain areas and in excess in others. Even more of a problem is the fact that some st ates have regions of both deficiency and toxicity. In the National Survey, 16.7% of the sam ples were classified as having excess (>.4 ppm) selenium.

Table 1. Nutrient Profile, National Forage Survey

Forage	No.	Nutrient Analysis,[1] %				Trace Mineral Analysis, ppm						Trace Mineral Antagonist, ppm	
Type	Samples	D.M.	Protein	ADF	P	Cu	Mn	Zn	Co	Se[2]	Cu:Mo Ratio	Fe	Mo
Alfalfa/Alfalfa Mix	64	87.3	16.4	38.9	.25	7.4	51	19.1	.26	321	5.2:1	20	2.1
Brome	8	85.3	11.1	43.3	.26	5.7	67.7	13.6	.17	147	4.8:1	165.5	1.8
Bermuda	36	90.5	9.6	39.4	.21	8.5	125.2	22.4	.22	202.9	14.7:1	121.8	.9
Fescue	26	88.5	10.9	42.7	.27	6.2	122.3	17.8	.22	63.2	11.9:1	99.7	.99
Sudan and sorghum	27	81.1	7.9	43.1	.21	7.5	57	24.4	.33	216.9	8.3:1	363.7	1.4
Cereal	17	87.7	10.9	41.2	.21	5.5	69.4	15.1	.17	184.5	5.4:1	148	1.3
Grass	139	85.4	10.0	42.1	.20	6.6	111.0	19.2	.28	177.4	7.5:1	239.8	1.5
Silage	9	33.5	7.3	35.1	.22	5.3	52.1	18.3	.25	153.8	5.1:1	157.3	1.5

[1]Protein, ADF and phosphorus reported on a DM basis.

[2]Se = selenium and reported as ppb; Mn = manganese; Cu = copper; Mo = molybdenum; Co = cobalt.

Table 2. Classification of Trace Elements Relative to Their Ability to Meet Dietary Requirements or Cause an Antagonistic Problem with Other Trace Elements

Trace Minerals	Deficient, ppm	Marginal, ppm	Adequate, ppm
Copper	below 4	4-7	7+
Manganese	below 20	20-40	above 40
Zinc	below 20	20-40	above 40
Cobalt	below .1	---	.1-.25
Selenium	below .1	.1-.15	.15-.3
Copper:Mo Ratio	below 4:1	4-4.5:1	4.5-5:1

Trace Mineral Antagonist	Ideal ppm	Levels above This Can Cause Copper Tie Ups ppm
Iron	50-200	400*
Molybdenum	below 1	above 3**

* Above this level can cause a copper tie up.
**Above 1 can cause copper tie up -- ratio of copper to molybdenum should be 4:5 or above.

Table 3. The Trace Mineral Classification for the 352 Forage Samples

					Antagonist Levels	
Trace Element	Adequate	Deficient	Marginal	High	Marginal	Very High
Copper	36%	14.2%	49.7%	---		
Manganese	76%	4.7%	19.3%	---		
Zinc	2.5%	63.4%	34.1%	---		
Cobalt	34.1%	48.6%	17.3%	---		
Selenium (n=305)	19.7%	44.3%	19.3%	16.7%		
Iron	62.8%	8.4%	---	---	17%	11.7%
Molybdenum	42.2%	---	---	---	48.6%	9.2%

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AMINO ACID SUPPLEMENTATION TO GROWING AND FINISHING STEERS

C. G. Campbell, E. C. Titgemeyer, and C. T. Milton

Summary

One hundred British and British cross steers, averaging 631 lb (initial wt) were used in a growing and finishing study to evaluate the effects of unprotected amino acid supplementation on cattle performance and carcass characteristics. All diets contained 1% of a nonprotein nitrogen source, and treatments were: no additional supplemental protein (UREA), 2) supplemental protein from soybean meal (SBM), 3) 13 grams/day of an amino acid supplement (Low AA), and 4) 26 grams/day of an amino acid supplement (High AA). The Low AA treatment supplied 2 grams methionine, 8 grams lysine, 2 grams threonine, and 1 gram tryptophan per day, whereas the High AA treatment provided twice those amounts. The grower diet was based on whole-plant sorghum silage, and the finishing diet was based on rolled corn and corn silage. During the growing period, gains were higher (P<.05) for SBM-supplemented steers than for UREA steers and intermediate for amino acid-supplemented steers. Intakes were higher for steers supplemented with Low AA than for those supplemented with UREA or High AA. Few significant differences among treatments were observed in cattle performance during the finishing period. Hot carcass weights, dressing percentage, KPH fat, and yield grade were unaffected by amino acid supplementation. In this study, supplementing growing and finishing cattle with unprotected amino acids did not significantly improve steer performance or carcass characteristics, suggesting either that these amino acids were not limiting in these steers or that not enough of these supplemented amino acids escaped ruminal degradation to affect steers' performance.

(Key Words: Amino Acids, Steers, Feedlot, Performance.)

Introduction

The type of cattle fed in feedlots has changed considerably in recent years. Improvements in cattle nutrition , management, and genetics, along with newer feed additives and hormonal implants have resulted in average daily gains in the feedlot that can exceed 4 lb. Further, the composition of gain has shifted from fat to protein, and this has led some researchers to suggest that certain amino acids may be limiting performance. Supplementing protected amino acids to growing cattle in commercial situations is often cost prohibitive. However, if similar performance could be obtained by feeding higher levels of unprotected amino acids, then amino acid supplementation to growing and finishing cattle might be economical. Additionally, those supplemental amino acids might supply the rumen ecosystem with an essential nitrogen source, thereby enhancing ruminal fermentation.

Experimental Procedure

One hundred British and British cross steers averaging 631 lb initial weight were used in a randomized block design. Steers were allotted to one of five blocks based on initial weight and stratified into one of four pens within each block (five steers/pen). All growing diets contained 1% urea. Treatments were: 1) no supplemental protein (UREA) , 2) 4.7% soybean meal (SBM), 3) 13 grams/day of an amino acid supplement (Low AA), and 4) 26 grams/day of an amino acid supplement (High AA). All finishing diets contained .8% urea and .2% ammonium sulfate, and treatments were the same as in the growing phase. The Low AA

treatment supplied 2 grams methionine, 8 grams lysine, 2 grams threonine, and 1 gram tryptophan per day, whereas the High AA treatment supplied 4, 16, 4, and 2 grams/steer/day of methionine, lysine, threonine, and tryptophan, respectively. It has been suggested that these amino acids most limit growth in cattle. The levels used were based on estimates of the amount of each amino acid that would be required to meet the steers' supplemental amino acid requirement, assuming 25% escaped ruminal destruction. Steers remained on the same treatment throughout the trial. For the growing phase, the diet was based on whole-plant sorghum silage (Table 1) and was fed for 85 days prior to a 13-day step-up to a finishing diet based on rolled corn and corn silage (Table 1). Steers remained on the finishing diet for 89 days prior to slaughter. Steers were weighed on 2 consecutive days at the initiation and end of the growing and finishing periods. During the step-up period, steers were moved into one of four dirt lots and remained on their respective treatments. All steers were implanted with Synovex-S at the initiation of the growing period and reimplanted with Revalor-S at the initiation of the finishing phase.

Results and Discussion

During the growing period, dry matter intakes were higher (P<.05) for steers fed SBM than for steers fed the UREA diet and also tended to be higher for steers fed the Low AA diet (Table 2). During the finishing period, however, intakes were similar across treatments. The higher intakes during the growing period and the higher intakes observed during the step-up period for SBM fed steers resulted in higher intakes for SBM fed steers for the whole study. For the whole study, intakes were higher for steers fed the Low AA diet than for steers fed the UREA or High AA diets. During the growing phase, average daily gains were higher (P<.05) for SBM-supplemented steers than for UREA steers. Gains were intermediate for amino acid-supplemented steers. During the finishing period and the total study, no significant differences were observed among nitrogen sources for daily gains. However, for the total study, daily gains were numerically (but not statistically) higher for SBM-supplemented steers than for steers fed UREA or supplemented with amino acids.

During the growing phase, feed to gain conversions were numerically better for SBM-fed cattle than UREA-fed steers. However, during the step-up and the finishing periods, the UREA-fed steers had numerically improved efficiencies relative to SBM-supplemented steers, which probably represents a compensation for poorer gains during the growing period. For the whole trial, conversion efficiency was poorer for steers on the Low AA diet than for steers fed the UREA or High AA diets. Marbling score and 12th rib back fat were higher for SBM-supplemented steers than for steers supplemented with only UREA (P<.10). Marbling score was higher for steers supplemented with the Low AA treatment than for steers fed UREA or High AA. Quality grade was poorer for UREA-supplemented steers than for SBM-supplemented steers. Quality grade was similar for amino acid-supplemented steers and SBM-supplemented steers. No differences were observed between treatments for hot carcass weight; dressing percentage; or percents kidney, pelvic, and heart fat.

The lack of significant response to amino acid supplementation in this study suggests that either the supplemented amino acids were not limiting growth in these cattle or that not enough of these amino acids escaped ruminal degradation to alter cattle performance. If these amino acids stimulated ruminal fermentation, their effect on steer performance was not apparent.

Table 1. Composition of Diets Fed to Steers (% of Diet DM)

	Treatment			
Item	UREA	Low AA	High AA	SBM
Grower period				
Whole-plant sorghum silage	83.5	83.5	83.4	78.9
Rolled milo	9.3	9.2	9.1	9.2
Soybean meal				4.7
Molasses	3.0	3.0	3.0	3.0
Vitamin and mineral mix [a]	2.2	2.2	2.2	2.2
Urea	1.0	1.0	1.0	1.0
Rumensin and Tylan premix [b]	1.0	1.0	1.0	1.0
Amino acid mixture		.1	.3	
Crude protein	10.8	10.8	10.9	12.6
Finishing period				
Dry-rolled corn	79.7	79.7	79.6	75.5
Corn silage	10.1	10.1	10.1	10.1
Soybean meal				4.2
Ground sorghum	3.6	3.5	3.4	3.7
Vitamin and mineral mix [a]	2.5	2.5	2.5	2.4
Molasses	2.2	2.2	2.2	2.2
Rumensin and Tylan premix [b]	.9	.9	.9	.9
Urea	.8	.8	.8	.8
Ammonium sulfate	.2	.2	.2	.2
Amino acid mixture		.1	.3	
Crude protein	11.2	11.3	11.4	13.1

[a]To supply complete diets containing .8% Ca and .4% P.
[b]To supply 275 mg Rumensin and 90 mg Tylan/steer/day.

Table 2. Effects of Unprotected Amino Acids on Growing and Finishing Steer Performance and Carcass Characteristics

	Treatment				
Item	UREA	Low AA	High AA	SBM	SEM
Grower period (85days)					
Beginning wt, lb	632	631	630	630	1.1
Ending wt, lb[a]	834	846	840	860	9.2
Dry matter intake, lb/d[bc]	20.2	21.5	20.8	21.8	.41
Gain, lb/d[c]	2.37	2.53	2.47	2.70	.10
Feed:gain	8.51	8.55	8.43	8.15	.30
Step-up period (13 days)[d]					
Dry matter intake, lb/d	22.9	23.0	22.5	25.5	
Gain, lb/d	3.09	2.78	2.54	3.04	
Feed:gain	7.41	8.27	8.85	8.40	
Finishing period (89 days)					
Beginning wt, lb[ae]	874	882	873	899	9.4
Ending wt, lb	1223	1225	1226	1242	13.3
Dry matter intake, lb/d	22.9	23.4	23.1	23.5	.71
Gain, lb/d	3.92	3.85	3.97	3.85	.08
Feed:gain	5.84	6.09	5.85	6.12	.14
Total feeding trial (187 days)					
Dry matter intake, lb/d[bc]	21.6	22.6	22.0	22.9	.33
Gain, lb/d	3.16	3.17	3.19	3.27	.07
Feed:gain[b]	6.85	7.11	6.93	7.04	.11
Carcass					
Hot carcass wt, lb	742	735	742	747	9.8
KPH, %	2.12	2.08	2.12	2.16	.04
Dressing %	60.6	60.0	60.5	60.1	.31
Backfat, in[a]	.43	.47	.47	.50	.03
REA, sq in[b]	12.48	11.82	12.10	12.14	.19
Yield grade	2.8	3.3	3.0	3.1	.12
Marbling score[abf]	2.7	3.2	2.9	3.1	.14
Quality grade[cg]	2.8	2.3	2.4	2.3	.14

[a]Effect of UREA vs SBM (P<.10).
[b]Quadratic effect of amino acid supplement (P<.11).
[c]Effect of UREA vs SBM (P<.05).
[d]No statistics because steers were grouped by treatments into a single pen per treatment.
[e]Effect of amino acid supplement vs SBM (P<.09).
[f]2 = slight, 3 = small.
[g]2 = choice, 3 = select.

SUPPLEMENTING GROWING HOLSTEIN STEERS FED A CORN-UREA DIET WITH A MIXTURE OF ESSENTIAL AMINO ACIDS INCREASES PERFORMANCE

R. H. Wessels and E. C. Titgemeyer

Summary

Six ruminally cannulated Holstein steers (550 lb) implanted with Revalor-S were infused abomasally with water or a mixture of six amino acids in a crossover experiment (two 14-day periods) to evaluate effects on nitrogen balance. The mixture was comprised of amino acids that potentially may be limiting in lightweight steers, namely (g/day): lysine (5.3), methionine (3.3), threonine (3.2), tryptophan (1.0), histidine (2.1), and arginine (5.5). Steers were fed at levels just below ad libitum intake. The diet contained 86% rolled corn, 10% prairie hay, 3% mineral and vitamin premixes, and 1% urea (as-fed). Amino acid infusion increased nitrogen retention by 17.9% over the control, from 27.9 g N/day to 32.9 g N/day. This indicates that implanted steers fed a high concentrate diet are able to respond to amino acid supplementation, suggesting that at least one of the infused amino acids was limiting in the basal corn-urea diet.

(Key Words: Holstein Steers, Corn, Urea, Amino Acids.)

Introduction

For optimum growth performance, cattle need adequate amounts of metabolizable protein (i.e., protein available for absorption in the small intestine). Also, for cattle to make efficient use of metabolizable protein, that protein must have an amino acid composition that closely matches the animal's amino acid requirements. The amino acids most likely to be in short supply in typical feedlot diets are lysine, followed by methionine, tryptophan, histidine, and threonine (in no particular order of importance), and possibly arginine. When high corn diets are fed to rapidly growing implanted steers with urea as the sole protein supplement, the adequacy of essential amino acid supply may be of concern. Thus, our objective was to see if we could increase performance of implanted steers fed a corn-urea diet by supplementing postruminally with potentially limiting amino acids.

Experimental Procedures

Six Holstein steers (550 lb) fitted with rumen cannulas were implanted with Revalor-S (120 mg trenbolone acetate, 20 mg estradiol; Hoechst-Roussel) and housed in an environmentally controlled room (constant temperature, humidity, and lighting) in metabolism crates to facilitate total collection of feces and urine. Feed was offered to each steer individually in equal portions twice daily (6 AM and 6 PM) with individual intakes set at a level slightly less than ad libitum. The diet consisted of (as-fed basis) 86% rolled corn, 10% prairie hay, 3% mineral and vitamin premixes, and 1% urea (Table 1). Steers were adapted to the high grain diet before the start of the first experimental period. The design was a simple crossover, with two 14-day periods (6-day adaptation and 8-day collection of all feces and urine). Steers were subjected to two treatments: continuous abomasal infusion of either a mixture of six amino acids in 4 l/day water (amino acid treatment) or water alone (control treatment). The amino acid treatment contained (g/day) methionine (3.3), lysine (5.3), threonine (3.2), tryptophan (1.0), histidine (2.1), and arginine (5.5). Abomasally infusion was done with tubes running through the ruminal cannula and into the abomasum via the reticulo-omasal orifice. Amino acid levels were calculated, using the Cornell Net Carbohydrate and Protein model, as the amounts needed by 550 lb steers to gain .55 lb/day more than gains on the basal diet. The amount of methionine we infused was

double the calculated requirement, in order to avoid any possible cysteine deficiency. As a safety measure, we also infused twice the calculated amount of tryptophan because of the large variation in estimates of tryptophan requirement.

Results and Discussion

Infusing amino acids directly into the abomasum bypasses the confounding influences of ruminal fermentation, thereby eliminating guesswork as to the nutrient profile arriving at the small intestine. Thus, we could increase the metabolizable protein supply to the animal with confidence and be assured of supplying an amino acid profile that closely matched animal needs.

Amino acid infusion increased nitrogen retention by 17.9% over the control, from 27.9 g N/day to 32.9 g N/day (Table 2). Nitrogen retention is a sensitive measure of lean growth. Assuming that the protein content of live weight gain was 18%, the 5 g increase in retained nitrogen amounts to an additional weight gain of about .4 lb/day. Thus, we conclude that a high corn diet with urea as the only protein supplement does not supply adequate metabolizable protein to support maximal gains in steers; at least one essential amino acid is deficient.

Table 1. Diet Composition

Item	%, Dry Matter Basis
Ingredient:	
Rolled corn	85.2
Prairie hay	10.4
Urea	1.1
Limestone	1.5
Dicalcium phosphate	.5
Trace mineral salt [1]	.5
Sulphur	.1
Potassium chloride	.6
Vitamin ADE [2]	.1
Monensin [3]	+
Tylosin [4]	+
Nutrient:	
Dry matter	89.0
Crude protein	12.4
Calcium	.72
Phosphorus	.42
Potassium	.73

Table 2. Nitrogen Balance of Holstein Steers Infused Abomasally with a Mixture of Six Potentially Limiting Amino Acids

Nitrogen, g/day	Control	Amino Acids [1]	SEM
Feed	90.1	89.9	1.4
Infused	--	4.2	
Fecal	31.6	30.9	.3
Urinary	30.5	30.3	1.2
Retained [2]	27.9	32.9	2.0

[1] 5.3 g lysine, 3.3 g methionine, 3.2 g threonine, 1.0 g tryptophan, 2.1 g histidine, and 5.5 g arginine per day.
[2] Means differ (P=.15).

EFFECT OF FEEDING RUMEN-PROTECTED LYSINE WITH DIFFERENT LEVELS OF SOYBEAN MEAL TO GROWING STEERS

R. H. Wessels and E. C. Titgemeyer

Summary

To test the efficacy of rumen-protected lysine and methionine, six steers (486 lb) were used in a 6 4 incomplete Latin square design and fed corn-urea diets (85% concentrate) alone or supplemented with 2 or 4% soybean meal to give dietary crude protein levels of 12.5, 13.2, and 14.0% (as fed-basis). Each diet was fed with or without 5 g/day Smartamine-ML (rumen-protected lysine and methionine). Steers were fed to gain 2.6 lb/day. Nitrogen retention increased linearly, from 30.7 g/day (0% soy) to 35.5 g/day (4% soy) as the level of soybean meal and, thus, crude protein, increased in the diet. Suppl ementing steers with lysine had no effect on n itrogen retention. Total tract organic matter digestibility was similar for all treatments. No protein level lysine interaction occurred. We conclude that lysine was not the first limiting amino acid in the corn-urea-soybean meal diets used in this study.

(Key Words: Rumen-Protected Lysine, Soybean Meal, Steers.)

Introduction

Lysine often is identified as the amino acid most likely to be limiting in feedlot diets because cereal grains, especially corn, contain relatively low levels of lysine. A dietary deficiency of an essential amino acid will cause cattle to use metabolizable protein less efficiently. Rumen-protected amino acids may afford the opportunity to correct amino acid deficiencies without having to increase the quantity of metabolizable protein. Alternately, it may be possible to decrease protein levels while still maintaining current levels of performance. Thus, our objectives were to investigate whether we could supplement steers with rumen-protected lysine to 1) increase steer nitrogen balance at a given level of dietary protein or 2) feed lower levels of crude protein without compromising performance.

Experimental Procedures

We used six steers (5 Hereford and 1 Angus; 486 lb average body weight) implanted with Compudosefi 200 (25.7 mg estradiol; Elanco Animal Health). Steers were housed in an environmentally controlled room (constant temperature, humidity, and lighting) in metabolism crates. We collected all feces and urine excreted. By subtracting nitrogen excreted in the urine and feces from nitrogen intake, we calculated nitrogen retained in the body. Steers were adapted to a high grain diet before the start of the first experimental period. The experiment was designed as a 6 4 incomplete Latin square. Each of the four 14-day periods contained a 9-day adaptation phase followed by a 5-day collection phase. Six dietary treatments (arranged in a 3 2 factorial structure) were evaluated: three levels of crude protein (the basal corn-urea diet alone or supplemented with 2 or 4% soybean meal), each level with and without 5 g/day of Smartamine-MLfi (Rh ne-Poulenc), which provided 2.5 and .75 g of rumen-protected lysine and methionine, respectively. Dietary compositions of the three crude protein level treatments are given in Table 1. Feed intake was programmed to achieve an average daily gain (ADG) of 2.6 lb/day. Feed allocated to each steer was fed in equal portions twice daily (7 AM and 7 PM). Feed allocations were adjusted for projected changes i n body weight at the start of each new period.

Results and Discussion

No interaction occurred between level of dietary crude protein and rumen-protected lysine. Therefore, results of only the main effects are presented in Table 2. Retained nitrogen increased linearly (P=.12) as crude protein level increased via the addition of soybean meal. If we assume that live weight gain contained 18% protein, retained nitrogen values translate into gains of 2.35, 2.57, and 2.71 lb/day for the 0, 2, and 4% soybean meal levels, respectively. The increase in gain with dietary crude protein level resulted in better feed efficiencies, because feed intakes were similar, by design, between treatments. Thus, even though ration cost increased as more soybean meal was fed, economic return increased as well, making the 4% soybean meal ration the most profitable in this study.

Adding rumen-protected lysine had no effect on nitrogen balance. Surprisingly, even adding lysine to the diet containing only urea as a protein source did not enhance nitrogen retention. Possibly, those diets were not deficient in lysine. However, it is more probable that other amino acids may have been co-limiting with lysine, thereby inhibiting use of the supplemented lysine by body tissues. In a related study reported in this publication (previous paper), supplementing Holstein steers with a mixture of six amino acids increased nitrogen balance. Because the dietary regimen was very similar to that of the corn-urea diet in the present study, we expect that the same amino acids would have been limiting in both studies. The lack of response to lysine on its own suggests that one or more of the other amino acids were also limiting in the basal diet. Consequently, feeding rumen-protected lysine or lowering dietary crude protein level had no benefit in this study.

Table 1. Composition of Experimental Diets [1] Containing Three Different Levels of Soybean Meal Fed to Steers

	Level of Soybean Meal (%)		
Item	0	2	4
Ingredient	% (dry matter basis)		
Rolled corn	79.65	77.47	75.29
Alfalfa	15.39	15.39	15.39
Soybean meal	--	2.18	4.36
Urea	.90	.90	.90
Rumensin premix [2]	2.11	2.11	2.11
Trace mineral salt [3]	.50	.50	.50
Limestone	1.20	1.20	1.20
Dicalcium phosphate	.20	.20	.20
Vitamin ADE premix [4]	.05	.05	.05
Composition			
Organic matter	95.1	95.1	94.9
Crude protein	14.0	14.8	15.7
Calcium	.73	.73	.74
Phosphorus	.36	.37	.38
Potassium	.57	.61	.65
	Mcal/lb		
NEm	.92	.92	.92
NEg	.62	.62	.62

[1]Each diet was fed with or without 5 g/d Smartamine-ML (rumen-protected lysine) . [2]Contained (as-fed) 94.7% ground milo, 3.0% molasses, 1.4 % Rumensinfi 80, and .9% Tylanfi 40, to provide 275 mg monensin/hd/d and 90 mg tylosin/hd/d . [3]Composition (%): NaCl (95 to 99); Mn (> .24); Cu (> .032); Zn (> .032); I (> .007); Co (> .004). [4]Provided 1,000 IU of vitamin A, 500 IU of vitamin D, and 3 IU of vitamin E/lb of diet.

Table 2. Nitrogen Balance of Steers Fed a Corn-Urea Diet with Three Levels of Soybean Meal with or without Rumen-Protected Amino Acids

	Soybean Meal				Smartamine-ML[a]		
Item	0%	2%	4%	SEM	0 g/day	5 g/day	SEM
Nitrogen, g/day							
Intake	106.4	111.8	120.4	3.8	113.8	111.9	3.1
Fecal	29.5	29.0	30.5	1.1	29.7	29.7	.9
Urine	46.2	49.2	54.4	2.5	49.7	50.2	2.0
Retained[b]	30.7	33.6	35.5	2.0	34.4	32.1	1.7
Digestibility, %							
Dry matter	77.3	78.5	78.3	1.2	79.2	76.9	1.0
Organic matter	78.1	79.5	79.1	1.2	80.0	77.8	1.0

[a]Supplied 2.5 g/day lysine and .75 g/day methionine.
[b]Linear response of nitrogen retention to level of soybean meal (P=.12).

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NATURAL DEGRADABLE PROTEIN AND ROUGHAGE TYPE FOR IMPLANTED FINISHING STEERS FED DRY-ROLLED CORN DIETS

C. T. Milton, E. C. Titgemeyer, R. T. Brandt, Jr. [1]*, G. L. Kuhl, and J. S. Drouillard*

Summary

Three hundred eighty-four crossbred, yearling steers (810 lb) were used to evaluate soybean meal (SBM), sunflower meal (SFM), and combinations of the two as protein supplements and supplemental protein effects in diets containing silage or alfalfa as dietary roughage. All diets contained 1.0% urea (dry matter basis). An additional 2 percentage units of crude protein were either not provided or provided as SBM, SFM, or a 50:50 combination (protein basis) of SBM and SFM. Steers were implanted with Revalor-S and fed experimental diets for 126 days. No interactions between protein supplementation and roughage source were observed. Daily feed intake and feed efficiency were unaffected by additional supplemental protein compared to urea alone. Averaged across both roughage sources, provision of supplemental SBM tended to increase daily gain. Dressing percentage decreased when supplemental SBM was provided and increased when alfalfa was fed as the roughage source. Based on carcass-adjusted performance, feeding alfalfa as the dietary roughage source improved daily gain by 3.9% and feed efficiency by 4.8% compared to sorghum silage. Carcass finish, marbling score, and carcasses grading Choice were unaffected by treatment. Carcass-adjusted growth rate and conversion efficiency were enhanced when alfalfa was fed independent of dietary crude protein concentration.

(Key Words: Sunflower Meal, Soybean Meal, Urea, Finishing Steers.)

Introduction

The goal of protein supplementation of feedlot diets is to provide amino acids (metabolizable protein) to the animal and to optimize ruminal fermentation. Urea in high grain diets has been demonstrated to enhance ruminal digestion, but not to increase metabolizable protein supply. Natural, degradable protein sources such as soybean meal (SBM) contain both a degradable and a ruminal escape protein fraction. Recent research conducted at Kansas State University demonstrated that yearling steers consuming dry-rolled corn finishing diets supplemented with 1% urea responded to supplementation with a natural, rumen degradable protein source. Sunflower meal (SFM) is degraded readily in the rumen. However, information on its usefulness in finishing diets is limited. Because of its relatively low crude protein content and low energy density, the resulting reduction in dietary NEg concentration when SFM is fed could alter feedlot performance.

Roughage sources can vary dramatically in crude protein concentration and degradability and, therefore, also can affect responses to supplemental protein. Alfalfa hay and sorghum silage are two roughage sources commonly used in finishing diets and differ in their protein concentration. Our objectives were: 1) to compare SBM, SFM, and a combination of the two as supplemental proteins in diets already containing 1% urea and 2) to examine the potential interaction between roughage source and supplemental protein in corn-based diets fed to implanted, finishing, yearling steers.

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Experimental Procedures

Three hundred eighty-four crossbred yearling steers (810 lb) were allotted to one of five weight replicates and stratified to one of six pens within each replicate. Steers were stepped up to an 80% concentrate ration prior to beginning the experiment. All diets (Table 1) contained 1.0% urea and 10% roughage as either sorghum silage or alfalfa hay and were formulated to contain .72% Ca, .36% P, .7% K, and a 10:1 nitrogen: sulfur ratio (dry matter basis). An additional 2 percentage units of crude protein were either not provided or provided by SBM, SFM, or by a 50:50 combination (protein basis) of the two in diets containing sorghum silage as roughage. To address the possible interaction between additional supplemental protein and roughage source, 2 percentage units of crude protein were either not provided or provided as SBM in diets containing alfalfa as the roughage source. Steers were fed 275 mg Rumensinfi and 90 mg Tylanfi per head daily. Initial and final weights were the averages of two consecutive early morning weights. Steers were implanted with Revalor-Sfi and fed experimental diets for an average of 126 days. The two heaviest replicates were slaughtered following 114 days on feed, and the remaining three replicates at 133 days. Steers were slaughtered at a commercial plant, and carcass data were obtained following a 24-hour chill. Statistical analyses allowed comparisons of: 1) urea alone versus additional supplemental protein, 2) SBM versus SFM as additional supplemental protein, 3) urea versus additional SBM supplementation, 4) interaction between roughage source and protein supplementation, and 5) effect of roughage source.

Results and Discussion

Steer performance and carcass traits are reported in Table 2. Interactions between roughage source and protein supplementation were not evident. Daily feed intake and feed efficiency were unaffected by treatment. Averaged across roughage source, steers supplemented with SBM tended (P=.15) to gain faster than those fed only urea. However, daily gains of steers supplemented with SFM or the combination of SBM and SFM were similar to those of steers supplemented with urea alone. Dressing percentage was decreased (P<.10) when steers were supplemented with SBM and increased (P=.05) when steers were fed alfalfa as the dietary roughage source.

Because treatment affected dressing percentage, daily gain and feed efficiency also were determined using final weights calculated from hot carcass weights and a 63% dressing percentage. Based on that carcass-adjusted performance, daily gain and feed efficiency were unaffected by supplemental protein. When steers were fed alfalfa as the dietary roughage source, carcass-adjusted daily gain increased by 3.9% (P<.10) and feed efficiency was improved by 4.8% (P<.07) compared to steers fed sorghum silage. Marbling score, carcass finish, and percentage of carcasses grading USDA Choice were unaffected by treatment. The provision of supplemental SBM increased (P<.10) ribeye area and tended (P=.17) to improve yield grade.

The lack of a larger response in animal performance to the provision of natural, degradable protein is inconsistent with previous reports. Based on actual live weights, SBM supplementation tended (P=.15) to improve gain relative to either no supplementation, SFM supplementation, or supplementation with a combination of SBM and SFM. However, when based on carcass weights, no difference existed between protein sources. Lack of a significant response to supplemental protein limits the conclusions that can be drawn about the relative value of these protein sources. Based on carcass-adjusted final weights, increased daily gain and improved feed efficiency when alfalfa was fed suggests a roughage response independent of dietary crude protein concentration.

Table 1. Diet Composition (% of Dry Matter)

	Treatment[a]					
	Sorghum Silage				Alfalfa Hay	
Item	None	SBM	SFM	SFM/SBM	None	SBM
Rolled corn	83.6	79.5	76.0	77.7	84.0	79.9
Sorghum silage	10.0	10.0	10.0	10.0	--	--
Alfalfa hay	--	--	--	--	10.0	10.0
Urea	1.0	1.0	1.0	1.0	1.0	1.0
Soybean meal	--	4.4	--	2.2	--	4.4
Sunflower meal	--	--	7.9	4.0	--	--
Vitamins/minerals[b]	2.9	2.6	2.6	2.6	2.5	2.2
Molasses	2.5	2.5	2.5	2.5	2.5	2.5
% Crude protein	10.8	12.8	12.8	12.8	11.9	13.9

[a]None= no additional supplemental protein; SBM= soybean meal; SFM= sunflower meal. [b]Formulated to provide dietary levels of 1500 IU/lb vitamin A, 15 IU/lb vitamin E, .72% Ca, .36% P, and .7% K.

Table 2. Effects of Supplemental Protein Source and Roughage Type on Performance and Carcass Traits of Steers Fed a Dry-Rolled Corn-Based Diet

	Treatment						
	Sorghum Silage				Alfalfa Hay		
Item	None	SBM	SFM	SFM/SBM	None	SBM	SEM
No. pens	5	5	5	5	5	5	
No. steers	64	64	64	64	64	64	
Initial wt, lb	812	810	809	809	809	810	3.7
Final wt[a], lb	1251	1266	1259	1245	1257	1266	9.1
Daily feed, lb	24.01	24.59	23.88	24.04	24.31	23.82	.40
Daily gain[b], lb	3.52	3.66	3.52	3.49	3.58	3.64	.07
Gain/feed	.147	.149	.148	.145	.148	.153	.003
Carcass Traits							
Hot carcass wt[c], lb	793	790	787	787	800	805	6.3
Dressing %[d,e]	63.35	62.30	62.94	63.23	63.59	63.49	.31
Fat 12th rib, in	.43	.40	.44	.41	.42	.43	.02
KPH, %	2.47	2.51	2.40	2.44	2.48	2.53	.03
Ribeye area[f], sq in	12.9	13.3	12.9	13.2	13.1	13.4	.17
Marbling score[g]	5.09	4.95	5.17	4.90	5.04	5.09	.10
Yield grade[h]	2.95	2.77	2.96	2.78	2.90	2.83	.09
Percent Choice	70.3	60.9	68.8	65.6	71.9	59.4	
Carcass Adjusted Performance[i]							
Daily gain[j], lb	3.56	3.56	3.52	3.53	3.68	3.73	.08
Gain/feed[j]	.149	.145	.148	.147	.152	.156	.004

[a]Final weight pencil shrunk 4%. [b]Urea vs additional SBM (P= .15). [c]Silage vs alfalfa (P= .11). [d]Silage vs alfalfa (P= .05). [e]Urea vs additional SBM (P<.10). [f]Urea vs additional SBM (P<.05). [g]4= slight; 5=small; 6=modest. [h]Urea vs additional SBM (P=.17). [i]Daily gain and conversion calculated using final weights= hot carcass wt/.63. [j]Silage vs alfalfa (P<.10).

Cattlemen's Day 1996

EFFECTS OF TEMPORARILY ALTERING ALFALFA LEVELS IN HIGH-CONCENTRATE DIETS ON SUBACUTE ACIDOSIS

B. J. Healy and R. T. Brandt, Jr. [1]

Summary

Four ruminally cannulated crossbred steers (882 lb) were used to investigate the effects of temporarily altering the levels of alfalfa in a high-concentrate diet on ruminal characteristics during a bout of experimentally induced subacute acidosis. A diet based on dry rolled corn with 8% alfalfa hay was fed before and after a 2-day challenge phase when steers were forced to consume 2.5% of their body weight in 90 minutes each day after a prior 24-hour fast. During the challenge phase, steers were fed diets containing 5, 8, 11, or 14% alfalfa. Feed intake quickly recovered for steers fed all but the 5% alfalfa diet, with a tendency for a linear ($P<.11$) decline in feed intake as alfalfa was decreased in the challenge diet. The intensity and duration of the pH drop were increased as the level of alfalfa decreased. Mean pH decreased, total VFA concentration increased, and the ratio of acetate:propionate decreased linearly ($P<.06$) as level of alfalfa decreased. Because the ruminal parameters measured for the 8% and 11% alfalfa diets were similar, the data suggest that temporarily increasing the basal diet to more than 11% alfalfa is necessary to mitigate the effects of a forced disruption in feed intake. Increasing the level of alfalfa hay from 8 to 14% of diet dry matter increased fluid dilution rate, lowered time that ruminal pH was below 5.5, and resulted in higher mean ruminal pH in steers with experimentally induced acidosis.

(Key Words: Steers, Acidosis, Roughage Level, Alfalfa.)

Introduction

Modern feedlot management attempts to force the square peg of feeding high concentrate diets through the round hole of an animal adapted by evolution to an all-forage diet. Ruminal acidosis often can be the result of this geometric improbability. Practical considerations make roughage a useful component of high-grain diets for finishing cattle, because it helps protect against effects of intake variation on ruminal function. Because feeding equipment sometimes breaks down and weather is variable, roughage levels often are temporarily increased to moderate the ruminal ecosystem of feedlot cattle and to minimize disruptions in feed intake. However, experimental data regarding the viability of this approach, as well as how much roughage levels should be increased, are lacking. Our objective was to simulate a severe disruption in feed intake and determine whether temporarily increasing roughage levels was effective in moderating the ruminal insult from experimentally induced variability in feed intake.

Experimental Procedures

Four ruminally cannulated crossbred steers (882 lb) were used in an experimental subacute acidosis model. Steers were fed an 8% alfalfa diet (Table 1) at 2% of BW in two equal feedings (8 AM and 8 PM) for a 10-day adaptation period. On day 11, steers received their 8 AM feeding, but the PM feeding was omitted. Steers were challenged on the mornings of days 12 and 13 by being offered diet dry matter at 1.5% of BW in the feed bunk, followed by introduction of diet dry matter at 1% of BW via the ruminal cannula 1.5 hrs postfeeding. Any offered feed that was not consumed also was placed into the

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rumen through the cannula at that time. The challenge was followed by a 3-day (days 14 to 16) intake recovery period when the 8% alfalfa diet was offered. Ruminal samples were obtained at feeding (0 hr) and 3, 6, 9, and 12 hrs after (day 10) or 3, 6, 9, 12, 18, and 24 hrs after (days 12 and 13) and 12 and 24 hr after the AM feeding on days 14 to 16. Prior to the beginning of each period, rumens of all steers were observed for gross appearance to verify health of the ruminal epithelium. Dietary treatments (Table 1) were imposed on days 12 and 13 during the challenge phase. The sequence of dietary treatments was designed to evaluate the effects of altering roughage level in situations where wide fluctuations in intake are known to exist (e.g., prior to an impending weather change, after a storm system has passed, or after a mechanical breakdown). The 8% alfalfa diet represented no management change, the 11% and 14% alfalfa diets represented two levels of increased roughage (i.e., storm rations), and the 5% alfalfa diet served as the negative control.

Results and Discussion

A nearly complete recovery of feed intake occurred after the challenge phase for steers challenged with all dietary treatments except the 5% alfalfa diet (Table 2). As a result, feed intake tended ($P<.11$) to have a linear decline as alfalfa level was decreased. A linear ($P<.01$) and a cubic ($P<.02$) increase in the hours that pH was below 5.5 occurred as the dietary level of alfalfa decreased. A linear ($P<.03$) decline in pH, a linear ($P<.06$) increase in VFA concentration, and a linear ($P<.05$) decrease in acetate:propionate ratio occurred as the level of alfalfa in the challenge diets was decreased. Ruminal lactate concentrations were unaffected by treatment and were low. These data are similar to those from other acidosis experiments and suggest that ruminal acidosis in cattle adapted to high grain diets is a function of increased VFA production and not accumulation of lactate. Although fluid dilution rate was similar among treatments on the first day of the challenge phase, on the second day of the challenge, fluid dilution rate was highest for steers receiving the 14% alfalfa diet. The challenge became more severe on the second day, as reflected by VFA concentrations (Table 3). Increased fluid dilution, if associated with increased salivary flow, would help to buffer rumen contents. The increased fluid dilution rate for steers fed the 14% alfalfa diet combined with the lesser amount of corn presented to the rumen likely explains the greater pH, lower VFA concentration, and greater acetate:propionate ratio. Given that steers fed the 5% level of alfalfa were presented with greater amounts of fermentable substrate when challenged, it is not surprising that the ruminal parameters were indicative of a greater acid insult. What is more difficult to explain is the similarity between the 8% and 11% alfalfa levels in ruminal measurements. The similarity in ruminal profiles of steers challenged with those diets suggests that increasing chopped alfalfa from 8% to 11% was ineffective in moderating the ruminal insult induced by our experimental model. Although feed intake recovered quickly in all steers except those fed the negative control diet, our data suggest that the acidotic insult was moderated only at dietary levels of alfalfa above 11%.

Table 1. Composition of Experimental Diets (%, Dry Matter Basis)

	Level of Alfalfa			
Ingredient	5%	8%	11%	14%
Dry rolled corn	86.05	83.05	80.05	77.05
Chopped Alfalfa	5.00	8.00	11.00	14.00
Supplement [a]	6.45	6.45	6.45	6.45
Molasses	2.50	2.50	2.50	2.50

[a]Formulated so diets contained: 12.5% crude protein, .7% Ca, .3% P, .7% K, 1435 IU/lb vitamin A, 16 IU/lb vitamin E, 27 ppm monensin, and 10 ppm tylosin.

Table 2. Effects of Alfalfa Level on Intake and Ruminal Fermentation Characteristics

	Level of Alfalfa					Statistical Contrasts[a]		
Item	5%	8%	11%	14%	SEM	L	Q	C
Intake,% BW[b]	1.65	1.99	2.00	1.96	.11	.11	.14	.58
Hours pH <5.5[c]	17.9	11.5	14.9	9.5	1.33	.01	.76	.02
Dilution rate, %/hr								
day 12	4.50	4.21	4.56	4.76	.54	.66	.66	.75
day 13	3.32	3.62	2.45	5.79	.78	.12	.10	.14
pH	5.34	5.48	5.41	5.61	.06	.03	.63	.12
VFA, mM	128.3	119.6	118.0	113.9	4.2	.06	.60	.64
A:P[d]	1.08	1.18	1.11	1.41	.08	.05	.28	.22
Lactate, mM	.26	.28	.25	.24	.10	.84	.86	.92

[a]Effect of alfalfa level: L = linear, Q = quadratic, C = cubic . [b]During recovery days (days 14 to 16). [c]During challenge days (days 12 and 13) . [d]Acetate:Propionate.

Table 3. Effects of Alfalfa Level on Total Volatile Fatty Acid Concentrations (mM)[a]

	Level of Alfalfa			
Hours after Feeding	5%	8%	11%	14%
Day 10 (Baseline)				
0	12	112.9	112.2	102.9
3	11	119.1	118.2	107.5
6	11	112.2	106.3	104.6
9	11	110.5	108.9	105.0
12	10	109.0	106.5	99.6
First challenge (Day 12)				
0	99.	95.7	98.2	95.9
3	14	134.6	129.9	129.9
6	15	147.0	127.5	119.4
9	13	123.7	131.6	126.8
12	11	108.8	127.8	114.3
18	12	116.0	117.4	109.6
24	11	104.7	106.7	104.6
Second challenge (Day 13)				
3	17	164.1	158.3	143.2
6	18	154.6	145.3	149.6
9	15	136.4	128.5	142.8
12	13	132.6	127.7	125.4
18	12	128.8	130.5	115.0
24	12	115.0	118.1	109.5
Recovery, a.m. feeding (Day 14)				
12	11	102.9	105.9	103.8
24	11	117.6	109.1	94.6
36	11	108.4	95.2	99.7
48	11	108.6	107.1	104.2
60	10	98.1	100.7	111.2
72	12	115.5	113.8	115.5

[a]Pooled standard error = 9.0.

EFFECT OF MONENSIN ON GRAIN BLOAT IN CATTLE

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Summary

Twelve ruminally cannulated Holstein steers were used to determine the effect of monensin (0, 20, 30, and 40 g/ton) on grain bloat. Steers were fed a bloat-provocative, high-grain diet at 1% of body weight twice daily. Monensin premix was added directly to individual steers diets at the time of feeding. The severity of bloat was scored daily on a scale of 0 (no bloat) to 5 (severe bloat). The scoring was based on the degree of frothiness and abdominal distention. Bloat scores (mean of wk 2, 3, and 4) were lower (P<.0l) for monensin-fed steers than for the controls. The mean bloat scores were 1.43, 1.18, 1.00, and .93 for 0, 20, 30 and 40 g/ton monensin, respectively. Total gas production during in vitro ruminal fermentation tended to be higher (P=.12) for control than for monensin-fed steers. Ruminal pH and total volatile fatty acid concentrations were unaffected by treatment. Monensin decreased frothy bloat caused by the bloat-provocative diet, and the degree of control appeared to be greater with higher levels of monensin.

(Key Words: Monensin, High Grain Diet, Frothy Bloat.)

Introduction

Bloat continues to be of concern to the feedlot industry because of reduced animal performance and death loss and is considered to be the major cause of digestive deaths in the feedlot. The cause of feedlot bloat is not fully understood. Feedlots have utilized several management techniques to control digestive death loss from bloat. Strict bunk management, quality control of dietary ingredients, and addition of antibiotics to the diet have proven beneficial. Monensin (Rumensin[fi]) has been used to reduce grain bloat in feedlot cattle. A study conducted by researchers at Eli Lilly involving 988 Holstein steers in a commercial feedlot showed that 40 g/ton of monensin was more beneficial in reducing the incidence of digestive deaths than 30 g/ton (Table 1). Digestive deaths were .94 and 2.39% with 40 g/ton and 30 g/ton, respectively. The reduction in digestive death loss may have been due to more effective control of grain bloat. The objective of our study was to determine the effect of monensin (0, 20, 30, and 40 g/ton on a 90% dry matter basis) on frothy bloat in cattle fed a high-grain diet.

Experimental Procedures

Twelve ruminally cannulated Holstein steers were used in a replicated 4x4 Latin square design with 28-day periods. The interval between each period was 3 to 4 weeks. Steers were adapted to an alfalfa hay diet for 3 weeks prior to the beginning of the trial. At the start of each period, cattle were stepped up to 30%, 60%, and 100% of the bloat-provocative grain diet in successive increments, with 3 days for each step. The final diet was a 100% bloat-provocative, high-grain diet fed at 1% of BW twice daily. Steers were fed an alfalfa diet during the

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intervals between each period. The composition of the bloat diet was 60% cracked sorghum grain, 22% dehydrated alfalfa, 16% soybean meal, 1% salt, and 1% dicalcium phosphate. Monensin premix was added directly to individual steers diets at the time of feeding. The severity of bloat was scored daily at 3 hours after morning feeding with the following scale: 0 = no froth; 1 = slight froth but no pressure and abdominal distention; 2 = definite froth with sufficient pressure to expel froth but no abdominal distention; 3 = definite froth with sufficient pressure to cause abdominal distention on the left side; 4 = definite froth with sufficient pressure to cause abdominal distention on the left and right side; and 5 = definite froth, severe abdominal distention, animal in severe distress, terminal unless pressure is relieved. Ruminal samples were collected to monitor in vitro gas production and fermentation characteristics (pH and volatile fatty acids).

Results and Discussion

Bloat scores (mean of weeks 2, 3, and 4) were lower (P<.0l) for monensin-treated steers than for the control steers. The mean bloat scores were 1.43, 1.18, 1.00, and .93 for 0, 20, 30, and 40 g/ton, respectively (Figure 1). Total in vitro gas production tended to be higher (P=.12) for controls than for the monensin-fed steers (Table 2). Reduction in total gas production in the rumen will contribute to less froth formation. Ruminal pH and total volatile fatty acid concentrations were unaffected by treatment (Table 2). Acetate proportion was lower and propionate proportion was higher in steers fed monensin. Monensin decreased frothy bloat caused by feeding a bloat-provocative diet, and the degree of control appeared to be greater with higher doses of monensin. However, monensin is not approved for use in cattle above 30 g/ton.

Table 1. Effect of Rumensin[fi] plus Tylan on Mortality Data for Holstein Steers Fed for 370 Days[1]

	Rumensin Level	
Item	30 g/ton	40 g/ton
No. of pens	6	6
No. of steers	503	514
Starting weight, lb	286	284
Final weight, lb	1289	1287
Total mortality, %	3.84	2.54
Digestive mortality, %	2.39[a]	.94[b]

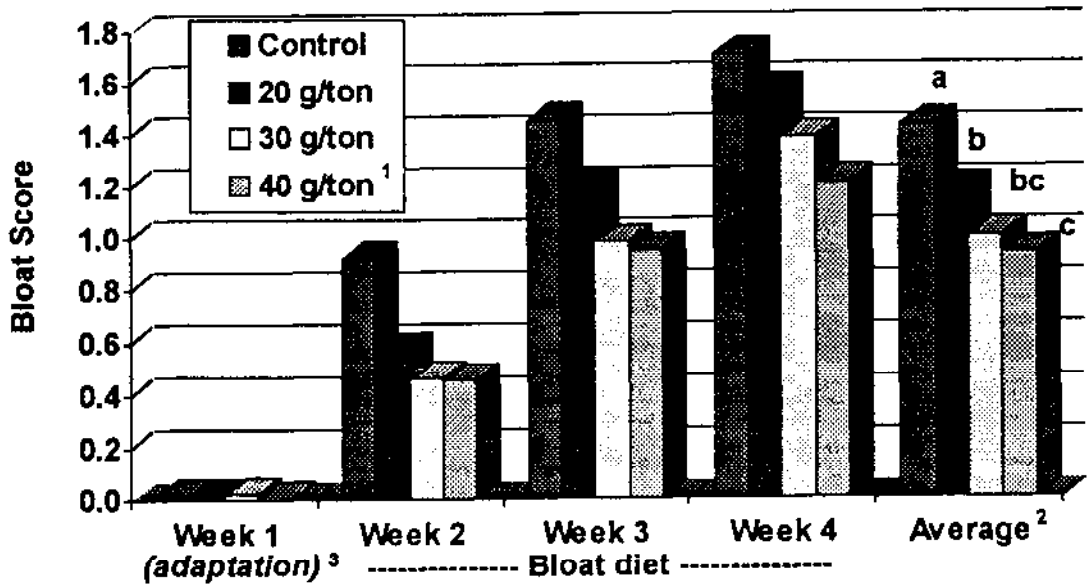
[1]Adapted from Laudert S.B., G.J. Vogel, J.C. Parrott, and D.R. White. 1994. The effect of two levels of Rumensin on the feedlot performance of young Holstein steers fed to slaughter. J. Anim. Sci. 72 (Suppl. 1):291.

[a,b]Means not bearing a common letter in their superscripts differ (P < .06).

Table 2. Effect of Monensin on Ruminal Fermentation Characteristics

	Monensin, g/ton				
Item	0	20	30	40[1]	P-value
In vitro gas production, ml/6 hours	114.9	107.9	102.3	106.1	.12
Total VFA[2], mM	75.5	76.0	76.2	76.5	.96
Acetate, molar %	58.5[a]	57.4[ab]	56.2[b]	56.2[b]	.09
Propionate, molar %	20.8[a]	22.9[b]	24.8[b]	24.4[b]	.01
Acetate/propionate ratio	2.9	2.6	2.4	2.7	.31

[1]Monensin is not approved for use in cattle above 30 g/ton.
[2]VFA = volatile fatty acid.
[a,b]Means not bearing a common letter in their superscripts differ (P< .05).



[1]Monensin is not approved for use in cattle above 30 g/ton.
[2]Average bloat scores are means of weeks 2, 3, and 4.
[3]Adaption is 30% grain diet on days 1, 2, and 3 and 60% grain diet on days 4, 5, and 6.
[a,b,c]Means not bearing a common letter in their superscripts differ (P<.07).

Figure 1. Effect of Monensin on Bloat Score

EFFECT OF IMPLANTATION AND MELENGESTROL ACETATE FEEDING ON BLOOD SERUM PROFILES AND PERFORMANCE OF HEIFERS

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C. T. Milton, and N. Campbell

Summary

Payout characteristics of Revalor-H and Finaplix-H were measured in 30 heifers (678 pounds) assigned to one of six treatments: 1) negative control, 2) melengestrol acetate (MGA) (.5 mg/hd/d), 3) Finaplix-Hfi, 4) Finaplix-H + MGA, 5) Revalor-Hfi, and 6) Revalor-H + MGA. Blood samples were collected by jugular puncture on days 0, 1, 3, 5, 7, 13, 21, 28, 42, 56, 84, 112, and 140. Following implantation with either Revalor-H or Finaplix-H, serum trenbolone (TB) increased markedly at 1 and 3 days after implantation, then decreased through day 42. A second peak in serum TB was observed on day 56. Between days 56 and 84, a drop in serum TB was observed. Although TB in heifers implanted with Revalor-H or Finaplix-H was lowest between 84 and 140 days, the observed TB may still have been adequate to modify heifer performance over this period of time. Average daily gain and feed efficiency demonstrated an implant MGA interaction. Heifers with no implant responded to MGA supplementation with increased rate of gain, whereas heifers receiving either Revalor-H or Finaplix-H had less weight gain when fed MGA.

(Key Words: Implants, Heifers.)

Introduction

Revalor-H is an implant recently approved for use in feedlot heifers. In order to help the industry use it to its greatest potential, information is needed relative to length of payout and the relationship of circulating levels of anabolic hormones to finishing heifer performance. In our study, concentrations of trenbolone (TB) and estradiol (E2) in serum of heifers implanted with Revalor-H and Finaplix-H and fed with or without melengestrol acetate (MGA) were measured. Our objectives were to determine the payout characteristics of the implants and, to the extent that was possible, to establish relationships between serum hormone levels and performance

Experimental Procedures

Thirty heifer calves (678 pounds) with no previous anabolic treatments were used. Heifers were assigned to one of six treatments (five heifers per treatment): 1) negative control, 2) MGA (.5 mg/hd/d), 3) Finaplix-H, 4) Finaplix-H + MGA, 5) Revalor-H, and 6) Revalor-H + MGA. Heifers were housed individually and fed in open-front barns in a 140-day study. Blood samples were collected by jugular puncture twice (45 minutes apart) on days 0, 1, 3, 5, 7, 13, 21, 28, 42, 56, 84, 112, and 140. All implants were made in the right ears of heifers, and all blood samples were collected from the right jugular vein. Serum was harvested, composited within day for each animal, and analyzed for serum E2 and TB concentrations. Individual intakes were measured, and feed refusals were collected and weighed weekly. At the conclusion of the study, heifers were slaughtered in a commercial packing plant, and carcass data were collected.

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Results and Discussion

Serum E2 concentration was not affected by feeding of MGA (data not shown). However, implantation with Revalor-H led to marked increases in serum E2 (Figure 1). Implantation with Revalor-H increased serum E2 from an initial level of 4 pg/ml to an average of 25 pg/ml from day 1 to 13 after implantation. Serum E2 then increased between days 21 and 56 after implantation (average E2 over this period was 67 pg/ml) before dropping to an average value of 19 pg/ml for days 84 through 140 after implantation. Although serum E2 remained moderately elevated by Revalor-H implantation for up to 140 days, a large drop was observed between 56 and 84 days.

Serum TB concentrations remained essentially zero for nonimplanted heifers, but increased markedly following implantation with either Revalor-H or Finaplix-H. Over the entire experiment, serum TB was greater for heifers receiving Finaplix-H than those receiving Revalor-H (259 vs 204 pg/ml; Figure 2) and for heifers fed MGA than those not fed MGA (187 vs 122 pg/ml; data not shown). The overall pattern of serum TB in response to implantation was similar for Finaplix-H and Revalor-H. It increased markedly at 1 and 3 days after implantation, then decreased through day 42. A second peak in serum TB was observed on day 56. Between days 56 and 84, a large drop in serum TB was observed. Although TB in heifers implanted with Revalor-H or Finaplix-H was lowest between 84 and 140 days, the observed TB may still have been adequate to modify heifer performance over this period of time.

Averaged over the entire experiment, treatments did not alter feed intake (Table 1). Average daily gain demonstrated an implant MGA interaction ($P<.05$). Heifers with no implant responded to MGA supplementation with increased rate of gain, whereas heifers receiving either Revalor-H or Finaplix-H had less weight gain when fed MGA. The depression in ADG with MGA was less for heifers implanted with Finaplix-H than for those implanted with Revalor-H. Feed efficiency showed a response similar to ADG; heifers with no implant were more efficient when fed MGA, whereas heifers implanted with Revalor-H were less efficient when fed MGA. Because dressing percents were not affected by treatment, hot carcass weights followed the same trends as did gain (Table 2). MGA supplementation increased marbling score ($P<.05$). Nonimplanted heifers tended to have larger REA when fed MGA, whereas Revalor-H implanted heifers tended to have smaller REA when fed MGA. In summary, anabolic agents (implants or MGA) improved heifer performance. However, the effects of the implants in combination with MGA were not additive.

Table 1. Effect of Anabolic Treatment on Heifer Performance (140 days)

	Implant						
	None		Revalor-H		Finaplix-H		
Item	0	MGA	0	MGA	0	MGA	SEM
No. heifers	5	5	5	5	5	5	
Daily feed, lb DM	19.0	18.5	20.1	19.1	19.1	18.4	.8
Daily gain, lb[a]	2.93	3.36	3.79	3.21	3.43	3.21	.19
Gain/Feed[a]	.15	.18	.19	.17	.18	.17	.01

[a]Implant MGA interaction ($P<.05$).

Table 2. Carcass Characteristics of Heifers with or without Anabolic Treatment

	Implant						
	None		Revalor-H		Finaplix-H		
Item	0	MGA	0	MGA	0	MGA	SEM
Carcass wt, lb[a]	680	700	759	676	709	686	17
Dressing %	61.8	61.7	61.9	60.7	60.8	61.2	.55
Back fat, in	.79	.87	.78	.75	.66	.84	.12
KPH, %	2.6	2.8	3.0	2.7	2.9	2.9	.25
Marbling[b]	5.8	6.8	5.7	6.6	5.0	5.9	.44
REA, in^2	10.5	11.6	12.2	11.1	11.7	11.4	.47

[a]Implant MGA interaction (P<.05).
[b]Effect of MGA (P<.05).

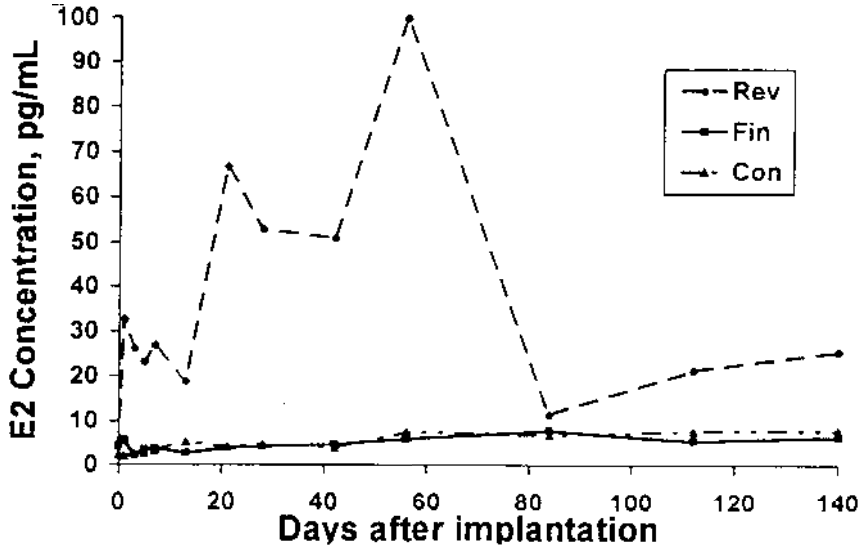

Figure 1. Serum Estradiol Concentrations

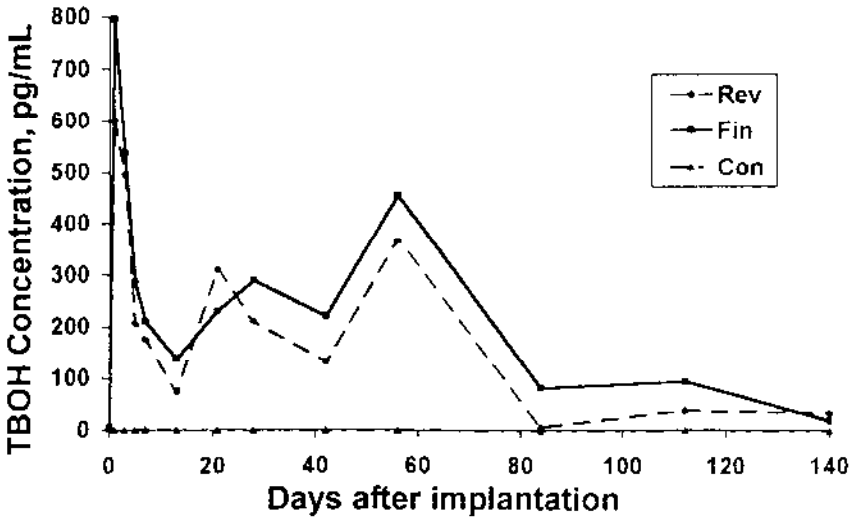

Figure 2. Serum Trenbolone Concentrations

IMPLANT STRATEGIES FOR FINISHING CALVES

C. T. Milton, R. T. Brandt, Jr.[1], *G. L. Kuhl, and P. T. Anderson*[2]

Summary

Two hundred-sixteen Angus and Angus-cross steer calves (690 lb) were used in a 129-day finishing study to evaluate different implant strategies, including an experimental new implant for feedlot cattle that contains 28 mg of estradiol benzoate and 200 mg of trenbolone acetate (EBTBA). Treatments were 1) nonimplanted control, 2) implanted and reimplanted with Synovex-Sfi, 3) single initial implant with EBTBA, 4) single initial implant with Revalor-Sfi, 5) implanted with Synovex-S and reimplanted with EBTBA, and 6) implanted and reimplanted with EBTBA. Initial implants and reimplants were administered on day 0 and 63, respectively. All implant treatments increased feed intake, slaughter and carcass weights, and rate and efficiency of gain. Compared with other implant treatments, the use of EBTBA as a reimplant treatment (trts 5 and 6) resulted in improved (P<.08) rate and efficiency of gain and heavier carcass weights (P<.07). However, only 58.3% of cattle in trts 5 and 6 graded Choice vs. 86.1% for controls and 80.6% for steers implanted twice with Synovex-S (P<.07). Carcasses were more masculine (P<.07) for steers in trts 5 and 6 than for nonimplanted controls, steers implanted with Revalor-S, and steers implanted twice with Synovex-S. Performance of steers implanted once with EBTBA did not differ from that of steers implanted once with Revalor-S or twice with Synovex-S, but carcasses were more masculine (P<.07) for EBTBA vs. Revalor-S steers. Implant treatment did not affect meat tenderness, as measured by Warner-Bratzler shear force determinations. Single EBTBA or Revalor-S implants resulted in performance and carcass traits similar to those resulting from implanting twice with Synovex-S.

(Key Words: Implant, Estradiol, Trenbolone Acetate, Steers.)

Introduction

Anabolic implants are proven, safe, and effective management tools to enhance both feeder profitability and red meat production. In order to optimize performance and maximize net return, implant programs should be custom designed and based on cattle type, projected days on feed, and market or contract specifications for finished cattle.

Combinations of trenbolone acetate (TBA) and estradiol or other estrogenic compounds have been shown to improve rate and efficiency of gain compared to either type of compound administered separately. Currently, the only approved implant containing both TBA and estradiol for feedlot steers is Revalor-S (120 mg TBA plus 24 mg estradiol). A new experimental implant containing 200 mg of TBA and 28 mg of estradiol benzoate (EBTBA) may be available for use in feedlot steers, pending FDA approval. The objective of this study was to evaluate performance and carcass traits of finishing steer calves that received the new implant.

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Experimental Procedures

Two hundred-sixteen Angus and Angus-cross steer calves (690 lb) were utilized in a 129-day finishing study. Six treatments were evaluated in a randomized complete block design experiment: 1) control (nonimplanted), 2) Synovex-S on day 0 and again on day 63, 3) EBTBA on day 0, 4) Revalor-S administered on day 0, 5) Synovex-S administered on day 0 followed by EBTBA on day 63, and 6) EBTBA on day 0 followed by EBTBA on da y 63. Steers originated from two sources; one group was purchased at an auction in Montana, and the other consisted of calves from the KSU Animal Science commercial cow herd. Steers arrived at the feedlot, were commingled, and were fed a growing ration for approximately 55 days before the trial began. Init ial weights were early morning, full weights obtained on day -1 and day 0 of the study. The first-day weights also served as allotment weights. Steers were blocked by weight to one of six blocks and then assigned randomly to each of six treatments within each block. Steers were dewormed and vaccinated against IBR, BVD, PI3, and BRSV (modified live vaccine) and *Clostridium perfringens* types C and D. The study was conducted from January 14 to May 23, 1994.

Steers were brought to full feed in 11 days using three step-up rations based on dry rolled corn and containing 40, 25, and 15% sorghum silage (DM basis). The finishing ration contained 10% sorghum silage (DM basis), was formulated to contain 13.5% CP, and provided 275 mg of Rumensinfi and 90 mg of Tylanfi per head daily.

Final weights were the averages of two consecutive early-morning full weights. Steers were slaughtered at a commercial packing plant on the same day that the last weight was obtained. Carcass data were obtained by a team of trained meat scientists following a 24-hour chill. Steaks from the wholesale rib of each carcass were removed, vacuum packaged for aging periods of 14 or 28 days, and subjected to Warner-Bratzler shear force determination. Two steers were removed from treatment three (EBTBA) because of lameness.

Results and Discussion

Implanting steers improved (P<.0001) rate and efficiency of gain compared to nonimplanted control steers (Table 1). Steers implanted twice with EBTBA gained faster (P<.08) than those in any other implant treatment. Steers implanted with Synovex-S initially and reimplanted with EBTBA gained faster (P<.08) than steers implanted and reimplanted with Synovex-S or those implanted once only with either EBTBA or Revalor-S. Rates of gain were similar for steers implanted once with EBTBA or Revalor-S.

Dry matter intake (DMI) was greater (P<.002) for implanted vs. control steers when expressed as lb/day, but did not differ between treatments as a percentage of mean body weight (Table 1). Also, no differenc es occurred among implanted steers in DMI as either lb/day or percentage of body weight. Further, no treatment differences in DMI existed among treatment groups during the first 35 days of the study (data not shown), suggesting that implanting did not directly increase DMI.

Feed required per unit of gain was lower (P<.08) for steers reimplanted with EBTBA (trts 5 and 6) than for all other implant treatments (Table 1). Feed/gain did not differ between steers implanted once with EBTBA compared with those implanted once with Revalor-S (P=.33) or twice with Synovex-S (P=.46).

Implanting increased (P<.0001) hot carcass weights of steers (T able 2). Hot carcasses were heavier (P<.07) for steers reimplanted with EBTBA (trts 5 and 6) than for other implant treatments. Carcass weights did not differ between steers implanted once with EBTBA or Revalor-S or twice with Synovex-S. Dressing percentage did not differ among treatments. Ribeye areas were greater (P<.10) for steers reimplanted with EBTB A (trts 5 and 6) than for control, reimplanted Synovex-S, or Revalor-S steers, but were actually smaller (P<.10) than those of control steers when expressed as area per 100 lb of carcass weight.

Backfat thickness was greater (P<.07) for all implanted groups compared to nonimplanted controls. Neither percentage of kidney, pelvic, and heart fat (KPH) nor yield grade differed among treatments.

Lean maturity was unaffected by treatment (Table 2). Skeletal maturity was increased (P<.01) by all implant treatments when compared with nonimplanted controls. Skeletal maturity was higher (P<.07) for steers implanted twice with EBTBA than for steers implanted once with EBTBA (trt 5), once with Revalor-S, or twice with Synovex-S. Overall maturity, a combination of lean and skeletal maturity, closely paralleled skeletal maturity.

Marbling score was lower (P<. 07) for steers implanted and reimplanted with EBTBA (trt 6) than for any other treatment group (Table 2). Compared to steers implanted twice with Synovex, using EBTBA as a reimplant (trts 5 and 6) reduced (P<.07) Choice and prime carcasses from 80.6% to 58.3%. Single initial EBTBA and Revalor-S implants (trts 3 and 4) numerically (P>.60) reduced percentage Choice and Prime carcasses, compared to steers implanted twice with Synovex-S.

Masculinity score, a composite evaluation of the carcass crest and jump muscles, was lower (more masculine) for all EBTBA treatments (trts 3, 5, and 6) than for non-implanted controls, steers implanted twice with Synovex-S, or those implanted with Revalor-S (P<.07; Table 2). Steers implanted once with EBTBA had more (P<.07) masculine carcasses than steers implanted with Revalor-S. Masculinity scores of steers implanted with Revalor-S did not differ from those of steers implanted twice with Synovex-S. Warner Bratzler shear force for longissimus steaks was unaffected by treatment after either 14 or 28 days of aging (Table 2), in agreement with previous work evaluating the effects of steroidal implants on meat tenderness in steers.

Using EBTBA either as a terminal implant (trt 5) or twice in reimplant programs (trt 6) resulted in increased rate and efficiency of gain compared to a single initial EBTBA or Revalor-S implant or implanting and reimplanting with Synovex-S. However, those implant strategies resulted in a dramatic reduction in Choice-grading carcasses and also increased masculine appearance. Use of a single EBTBA implant in a 129-day feeding period did not improve performance and resulted in more masculine appearing carcasses compared to Revalor-S. Use of a single EBTBA or Revalor-S implant and implanting twice with Synovex-S resulted in similar performance and carcass traits.

Table 1. Effect of Implant Strategy on Performance of Finishing Calves (129 days)

	Treatment						
	1	2	3	4	5	6	
	None	Synovex	EBTBA	Revalor	Synovex	EBTBA	
Item	None	Synovex	None	None	EBTBA	EBTBA	SEM
No. Pens	6	6	6	6	6	6	
No. Steers	36	36	34	36	36	36	
Initial wt, lb	689	689	690	690	689	689	
Final wt, lb	1114[a]	1190[b]	1191[b]	1190[b]	1215[c]	1236[d]	7.8
Daily gain, lb	3.30[a]	3.88[b]	3.89[b]	3.88[b]	4.08[c]	4.24[d]	.061
DM intake,							
lb/day	20.6[a]	22.0[b]	21.7[b]	22.1[b]	22.1[b]	22.3[b]	.28
% of BW	2.29	2.35	2.31	2.36	2.32	2.32	.028
Feed/Gain	6.27[d]	5.68[c]	5.58[bc]	5.71[c]	5.42[ab]	5.27[a]	.095

[a,b,c,d]Means in a row not bearing a common letter differ (P<.08).

Table 2. Effect of Implant Strategy on Carcass Traits (Initial Implant, Day 0; Second Implant, Day 63)

	Treatment						
	1	2	3	4	5	6	
	None	Synovex	EBTBA	Revalor	Synovex	EBTBA	
Item	None	Synovex	None	EBTBA	EBTBA	EBTBA	SEM
Hot weight, lb	674[c]	727[de]	725[d]	723[d]	742[ef]	753[f]	5.9
Dressing %	60.5	61.1	61.1	60.7	61.0	60.9	.27
Ribeye area,							
in^2	12.20[g]	12.20[g]	12.79[hi]	12.49[gh]	12.97[i]	12.97[i]	.191
in^2/cwt HCW	1.82[e]	1.68[c]	1.77[de]	1.73[cd]	1.75[d]	1.72[cd]	.025
Backfat, in	.48	.54	.57	.52	.53	.54	.035
KPH, %	2.11	2.09	2.11	2.10	2.07	2.07	.074
Yield grade	2.78	3.13	3.02	2.96	2.91	2.99	.125
Maturity							
Lean	A[56]	A[56]	A[52]	A[54]	A[56]	A[56]	1.7
Skeletal	A[25c]	A[50d]	A[51de]	A[47d]	A[50d]	A[57e]	2.5
Overall	A[40c]	A[53de]	A[52d]	A[51d]	A[53de]	A[57e]	1.7
Marbling[a]	5.60[d]	5.46[d]	5.48[d]	5.25[cd]	5.24[cd]	5.06[c]	.150
Pct Choice	86.1[c]	80.6[c]	73.5[cd]	75.0[cd]	58.3[d]	58.3[d]	8.1
Abscessed							
livers, % 8.3	5.7	11.1	13.9	5.6	8.3		
Masculinity score[b]	4.33[e]	4.31[de]	4.11[cd]	4.36[e]	4.08[c]	3.92[c]	.085
Dark cutters, n	0	2	0	0	0	0	
Shear force, lb[j]							
14 days	8.81	8.75	8.60	8.38	8.59	8.93	.38[k]
28 days	8.14	8.38	8.40	8.31	7.97	8.13	

[a]Small[0] = 5.0, small[50] = 5.5, etc.

[b]Scored on scale of 1 to 5; 1 = very masculine, 5 = not masculine.

[cdef]Means in a row not bearing a common letter differ (P<.07).

[ghi]Means in a row not bearing a common letter differ (P<.10).

[j]Effect of aging (P<.05).

[k]SEM for shear force pooled across days of aging.

PERFORMANCE OF FINISHING STEERS OFFERED MAGNESIUM-MICA IN THE FEEDLOT RATION [1]

K. P. Coffey [2] and F. K. Brazle [3]

Summary

Forty-eight mixed-breed steers from two sources were used in a 141-day feedlot study to compare a control ration (C) with a ration containing magnesium-mica (MM; 9 lb/ton). No diet cattle source interactions were detected. Steer gain, efficiency, and cost of gain did not differ (P>.10) between diets. Marbling score tended (P<.10) to be greater and the percentage of cattle grading USDA Choice and net carcass value were greater (P<.05) for steers fed MM. Feeding MM in a feedlot ration may have a substantial economic impact on feedlot cattle.

(Key Words: Magnesium-Mica, Feedlot Cattle, Marbling Score.)

Introduction

Magnesium-mica (MM) is a mined product that is used as a pellet-binding and feed-diluting agent. Previous work at KSU-SEARC has shown a tendency for increased digestibility and increased rumen fermentation products from cattle fed MM. Our objective was to measure the effect of MM on performance and carcass characteristics of feedlot cattle.

Experimental Procedures

Twenty-four mixed-breed steers previously grazing tall fescue pastures and 24 Angus Simmental crossbred steers previously grazing smooth bromegrass were allotted within cattle source into eight groups of six head each on January 20, 1994. The groups then were allotted randomly to receive one of two finishing diets consisting of 80% ground grain sorghum, 15% corn silage, and 5% protein supplement (50% CP) on a dry matter basis (Table 1). Cattle received the finishing diet for 141 days and then were slaughtered at a commercial packing plant. Carcass data were collected following a 24-hour chill.

Results and Discussion

No diet by cattle source interaction was detected in the study. Therefore, data are expressed within main effects. Steers receiving MM were somewhat heavier at the initiation of the study than were C steers (Table 2). Final weight and gain, feed cost, feed efficiency, and feed cost per cwt of gain did not differ (P>.10) between diets. However, total feed cost was numerically $16.47 lower per steer and cost of gain was numerically

[1]Appreciation is expressed to Micro-Lite, Inc., Chanute, KS for providing financial support; to SmithKline Beecham, West Chester, PA for providing Bovishield 4+L5, and Ultrabac/somnubac vaccinations; and to Syntex Animal Health, West Des Moines, IA for providing oxfendazole and Synovex-S.

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$3.00 less per cwt of gain for steers fed MM than for steers fed C.

Hot carcass weight, dressing percentage, fat thickness, and USDA Yield Grades did not differ (P>.10) between diets (Table 3). Marbling scores averaged over one third of a quality grade higher (P<.10) for steers fed MM. Steers in this study graded poorly. Therefore, this increase in marbling score from steers fed MM resulted in a substantial increase (P<.05) in the percentage of steers grading USDA Choice, which further resulted in a $50.92 higher (P<.05) carcass value.

Magnesium-mica had no effect on feedlot gain, consumption, efficiency, carcass weight, or fat thickness but had a substantial effect on carcass marbling. Although this study utilized a limited number of animals (48) and marbling score is highly variable, the fact that 13 of 24 steers fed MM graded Choice (versus only 3 of 24 control steers) certainly casts doubt that the differences were due to chance. Although a biological explanation for the improved marbling score by steers fed MM is not clear, this improvement potentially represents a significant economic benefit.

Table 1. Compositions of Diets Offered to Finishing Steers

Ingredient	Control	Magnesium-Mica
Ground grain sorghum	80.0	80.0
Corn silage	15.0	15.0
Soybean meal	2.5	2.6
Wheat middlings	.81	.25
Ground limestone	.50	.50
Urea	.43	.45
TM salt	.25	.25
Cane molasses	.15	.15
Dicalcium phosphate	.13	.13
Potassium chloride	.13	.13
Vitamin A,D,E premix	.10	.10
Rumensin premix	.0125	.0125
Magnesium-mica	-	.45

Table 2. Performance by Finishing Steers Offered Magnesium-Mica (9 lb/ton) in the Feedlot Ration

	Diet		Cattle Source[a]	
Item	Control	Magnesium Mica	Purchased	SEARC
Initial wt., lb[b]	862	879	811	930
Final wt., lb[b]	1340	1354	1248	1446
Gain, lb[c]	478	475	437	516
Daily gain, lb[c]	3.4	3.4	3.1	3.7
Daily DM intake, lb[b]	29.0	28.3	26.4	30.9
Gain/feed, lb/lb	.117	.119	.118	.119
Feed cost, $[c]	257.25	240.78	226.20	271.83
Feed cost, $/cwt gain	53.98	50.98	51.78	53.18

[a]Purchased steers were exotic mixed-breed steers. SEARC steers were Angus Simmental and Simmental Angus crossbred steers.
[b]Differences between cattle sources were detected (P<.05).
[c]Differences between cattle sources were detected (P<.10).

Table 3. Carcass Characteristics of Finishing Steers Offered Magnesium-Mica (9 lb/ton) in the Feedlot Ration

	Diet		Cattle Source[a]	
Characteristic	Control	Magnesium Mica	Purchased	SEARC
Hot carcass wt, lb[b]	804	814	747	871
Dressing %[c]	60.0	60.0	59.8	60.3
Fat thickness, in	.30	.28	.28	.30
Longissimus eye area, in^2	13.8	13.8	13.6	14.1
Marbling score[def]	386	499	387	498
% USDA Choice[bg]	12.5	54.2	20.8	45.8
USDA Yield Grade[b]	1.4	1.6	1.2	1.8
Net carcass value, $[bg]	786.80	837.72	750.56	873.95

[a]Purchased steers were exotic mixed-breed steers. SEARC steers were Angus Simmental and Simmental Angus crossbred steers.
[b]Differences between cattle sources were detected (P<.05).
[c]Calculated using actual unshrunk live weight.
[d]300 = Select$^-$; 400 = Select^0; 500 = Select$^+$.
[e]Differences between diets were detected (P<.10).
[f]Differences between cattle sources were detected (P<.10).
[g]Differences between diets were detected (P<.05).

Cattlemen's Day 1996

EFFECT OF MAGNESIUM-MICA DURING GRAZING AND/OR FEEDLOT PHASES ON PERFORMANCE OF STEERS [1]

K. P. Coffey [2], F. K. Brazle [3], and L. W. Lomas [2]

Summary

Seventy-two mixed breed steers (679 lb avg BW) grazing smooth bromegrass pastures for 112 days were fed 2.2 lb/day of either a control supplement (PC) or one containing .075 lb/day of magnesium-mica (PMM). Following the grazing period, steers were placed in a feedlot with pasture groups split such that two of the groups fed each pasture supplement were fed a control supplement (FC) and two groups were fed a supplement containing 10% magnesium-mica (FMM). Steers fed PMM tended to gain faster than those fed PC during the pasture phase (2.41 vs. 2.32 lb/day). Steers fed PMM had higher dressing percentage (P<.05) and net carcass values (P<.06). Percent grading Choice was 41.7 for PMM vs. 27.8 for PC, and that difference also was reflected in marbling scores. No differential effect of feedlot supplement was detected for carcass measurements. Magnesium-mica fed during a pasture phase may affect subsequent marbling scores.

(Key Words: Magnesium-Mica, Smooth Bromegrass, Feedlot, Marbling Score.)

Introduction

Previous work at KSU-SEARC has shown a tendency for increased digestibility and increased rumen fermentation products from cattle fed magnesium-mica (MM). Carcass marbling scores and the percentage of steers grading Choice were higher from feedlot steers fed MM compared with steers fed our typical feedlot diet in another study. Our objective was to measure grazing and subsequent feedlot performance and carcass characteristics of cattle fed magnesium-mica in the grazing and(or) feedlot phases.

Experimental Procedures

Seventy-two mixed-breed steers were weighed on April 6 and 7, allotted into eight groups of nine head each, and assigned randomly to one of eight 10-acre smooth bromegrass pastures. Half of the steers were fed 2.2 lb/day of a grain sorghum-based control supplement (PC), whereas half were fed 2.2 lb/day of a supplement containing MM to provide .075 lb of MM/head daily.

Following a 112-day grazing period, steers were transported to the SEARC feedlot facility at Mound Valley, KS, blocked by previous pasture treatment, and assigned randomly to one of two finishing diets (80% ground grain sorghum, 15% corn silage, and 5% protein supplement on a dry matter basis). One group was fed the control supplement (FC), and the other group was fed a supplement with 10% of the wheat middlings replaced by MM (FMM; Table 1); both contained 50% CP. At the end of a 120-day finishing period, steers were

[1]Appreciation is expressed to Micro-Lite Inc., Chanute, KS for providing financial support; to SmithKline Beecham, West Chester, PA for providing Bovishield 4+L5, Ultrabac/somnubac, and Boveye vaccinations; to Syntex Animal Health, West Des Moines, IA for providing oxfendazole and Synovex-S; and to Mallinckrodt Veterinary, Mundelein, IL for Ralgro, De-Lice, and Saber Extra fly tags.

[2]KSU-Southeast Agricultural Research Center, Parsons, KS.

[3]Southeast Kansas Area Extension Livestock Specialist, Chanute, KS.

slaughtered at a commercial packing plant, and carcass data were collected following a 24-hour chill.

Table 1. Composition of Feedlot Supplements Fed to Finishing Steers [a]

Ingredient	Control	Magnesium-Mica
Soybean meal	50.0	53.0
Wheat middlings	13.0	-
Ground limestone	14.0	14.0
Urea	8.9	8.9
TM salt	5.0	5.0
Cane molasses	2.85	2.85
Potassium chloride	4.0	4.0
Vitamin A,D,E premix	2.0	2.0
Rumensin 80 premix	.25	.25
Magnesium-mica	-	10.0

[a]Supplement was fed at 5% of the ration dry matter.

Results and Discussion

Although steers fed PMM gained faster during the pasture period (2.41 vs. 2.32 lb per day), the difference was not statistically significant. No significant pasture treatment feedlot treatment interactions were detected (P>.05) for any of the performance or carcass measurements. Therefore, feedlot data were pooled across the main effects of pasture treatment and feedlot treatment. Neither pasture nor feedlot treatment affected feedlot gain, efficiency, or cost of gain (Table 3). These data are in agreement with those from a previous SEARC study.

Feedlot supplements had no effect on any of the carcass measurements evaluated in this study. However, steers fed PMM had heavier (P=.11) hot carcass weights and higher (P<.06) dressing percentages than those fed PC. Fifty percent more steers graded USD A Choice in the groups fed PMM compared with those fed PC. These factors combined to produce a $19.92 higher (P<.06) net carcass value.

Considering these data with previous data, we conclude that MM fed at a level of 9-10 lb/ton of dry matter should have minimal effects on gain and efficiency of feedlot steers, but feeding MM during the grazing or feedlot period may have a significant impact on carcass marbling score and, therefore, value of the cattle.

Table 2. Performance by Steers Grazing Smooth Bromegrass Pastures and Fed Magnesium-Mica (.075 lb/day) in a Grain Supplement [a]

Item	Control	Magnesium-Mica
Initial wt, lb	677.5	680.0
Gain, lb	260.4	270.4
Gain, lb/day	2.32	2.41

[a]No significant differences (P<.10) were detected.

Table 3. Performance and Carcass Characteristics of Finishing Steers Fed Magnesium-Mica[a] in a Pasture or Feedlot Supplement

	Pasture Treatment[b]		Feedlot Treatment	
Item	PC	PMM	FC	FMM
Initial wt, lb	938	950	945	943
Final wt, lb	1335	1336	1334	1336
Gain, lb	396	385	389	392
Daily gain, lb	3.4	3.3	3.3	3.3
Daily DM intake, lb	24.2	24.1	24.2	24.2
Gain/feed, lb/lb	.136	.133	.134	.135
Feed cost, $/cwt gain	37.13	38.03	37.85	37.30
Hot carcass wt, lb[c]	784	796	791	790
Dressing %[de]	58.8	59.7	59.3	59.1
Fat thickness, in	.28	.32	.29	.31
Longissimus eye area, in^2	14.1	13.9	14.0	13.9
Marbling score[f]	418	441	439	420
% USDA Choice	27.8	41.7	33.3	36.1
USDA yield grade	1.9	1.9	1.8	1.9
Net carcass value, $[eg]	852.28	872.20	861.73	862.75

[a]Magnesium-mica levels were .075 lb/day in the pasture supplement and 10 lb/ton DM in the feedlot ration.

[b]PC and PMM = control and magnesium-mica supplements during the pasture phase; FC and FMM = control and magnesium-mica supplements during the feedlot phase.

[c]Differences between pasture supplements were detected (P=.11).

[d]Calculated using actual unshrunk live weight.

[e]Differences between pasture supplements were detected (P<.06).

[f]400 = Select^0; 500 = Select$^+$.

[g]Net carcass value is based on a base price of $113/cwt hot carcass weight with discounts of $6/cwt for Select grade and $16/cwt for yield grade 4 or carcasses heavier than 950 lb.

Cattlemen's Day 1996

BACTERIAL FLORA OF LIVER ABSCESSES FROM FEEDLOT CATTLE FED WITH OR WITHOUT TYLOSIN

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Summary

Fusobacterium necrophorum was the predominant bacterial isolate from liver abscesses of feedlot cattle fed with or without tylosin. The major difference in the bacterial flora of liver abscesses between cattle groups was the higher incidence of *Actinomyces pyogenes* in the tylosin-fed cattle. Because the minimum inhibitory concentration of tylosin was not different between bacterial isolates from cattle in the two treatments, we concluded that continuous feeding of tylosin does not induce resistance. The source of *A. pyogenes* infection and significance of *A. pyogenes* interaction with *F. necrophorum* in tylosin-fed cattle are not known.

(Key Words: Liver Abscesses, *Fusobacterium necrophorum*, *Actinomyces pyogenes*, Tylosin.)

Introduction

Liver abscesses in feedlot cattle constitute a serious economic problem; their incidence averages 25 to 30% in cattle at slaughter. Liver abscesses results from a disease complex known as the 'acidosis-rumenitis-liver abscess complex.' It is theorized that ruminal acidosis impairs the integrity of the rumen wall, permitting opportunistic bacteria to colonize, cause infection (rumenitis), and then gain entry into the liver via portal blood.

Fusobacterium necrophorum, a normal inhabitant of the rumen, is the primary causative agent of liver abscesses in cattle. Two subspecies (subsp) of *F. necrophorum*, subsp. *necrophorum* and subsp. *funduliforme* (previously called biotype A and biotype B, respectively) are recognized.

The most common method of liver abscess prevention is to feed a low level of an antibiotic, tylosin[3]. Cattle fed tylosin (10 g/ton of feed) have significantly lower incidences of abscesses (about 40 to 50% reduction) compared to nontylosin-fed controls. However, tylosin feeding, in most situations, does not prevent liver abscesses completely. It is reasoned that either (1) liver abscesses in cattle fed tylosin may be caused by bacteria other than *F. necrophorum* or (2) continued tylosin feeding may have induced antibiotic resistance in *F. necrophorum*. In order to test this, a study was conducted to compare bacterial flora of liver abscesses from cattle fed with or without tylosin.

Experimental Procedure

Liver abscesses were collected at the time of slaughter from cattle from feedlots that have fed tylosin continuously for at least 2 years and from cattle from feedlots not having fed tylosin for at least 2 years. Each group included five different feedlots. The number of liver abscesses cultured from each feedlot ranged from 1 to 12; 36 abscesses came from the tylosin group, and 41 from the no-tylosin group (Table 1). Abscesses were collected at the slaughter plant, using the following criteria: a) 1 to 5 cm in diameter and b) relatively soft, with active inflammation at the outer edge.

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Slices of liver with intact abscesses (usually one) were placed in plastic bags, sealed, packed in ice, and shipped overnight to the laboratory. The capsule of the abscess was seared with a hot spatula and then opened with a sterile scalpel. The purulent material was collected aseptically under anaerobic conditions (anaerobic glove box) and cultured for anaerobic and facultative bacteria. Isolation and characterization of facultative bacteria were done at the Veterinary Diagnostic Laboratory in the College of Veterinary Medicine.

Susceptibility and resistance of the predominant isolates to tylosin were determined by a micro broth-dilution method, using micro titer plates. Minimum inhibitory concentration (MIC) was the lowest concentration of tylosin that resulted in the absence of growth in the micro titer plate. MIC determinations were replicated three times.

Results and Discussion

The mean incidences of liver abscesses ranged from 6 to 16.7% in feedlots using tylosin and from 7.3 to 29.2% in feedlots without tylosin (Table 1). Anaerobic bacteria were isolated from all abscesses, and facultative bacteria were isolated from 22/36 (61%) and 23/41 (56%) abscesses from tylosin and non-tylosin-fed cattle, respectively (Table 2).

Fusobacterium necrophorum was isolated from all abscesses in both groups. However, the occurrence of subsp. *necrophorum* alone (82 vs 50%) was greater ($P<.05$), and conversely, the occurrence in association with subsp. *funduliforme* (12 vs 42 %) was lower ($P<.05$) in the no-tylosin than the tylosin group. Subspecies *funduliforme* is less pathogenic than subsp. *necrophorum* and is generally associated with mixed infections.

The other anaerobes isolated from liver abscesses included species of *Porphyromonas, Bacteroides, Clostridium,* and *Peptostreptococcus*. Among facultative bacteria, *Actinomyces pyogenes* was the most predominant isolate. The incidence of *A. pyogenes* was greater in tylosin-fed than non-tylosin-fed cattle (53 vs 10%). The other facultative bacteria included species of *Streptococcus, Staphylococcus, Escherichia*, and *Pasteurella.*

Fusobacterium necrophorum and *A. pyogenes* isolates were susceptible to tylosin. MIC values of tylosin for *F. necrophorum* and *A. pyogenes* isolates were similar between isolates from abscesses of cattle fed with or without tylosin (Table 3).

The major difference in the bacterial flora of liver abscesses between cattle fed with and without tylosin was the higher incidence of *A. pyogenes* in the tylosin-fed cattle. This is surprising, because the organism is quite sensitive to tylosin, and we saw no evidence of resistance being induced. Although the origin of *F. necrophorum* found in liver abscesses is well known, the source of *A. pyogenes* is not known. Because *A. pyogenes* is aerobic, it is not a normal inhabitant of the rumen. However, the bacteria may remain dormant and multiply if conditions (such as entry into the liver) become conducive. Also, some synergistic interaction may exist between *F. necrophorum* and A. *pyogenes* in causing liver abscesses.

We conclude that long-term usage of tylosin in feedlots does not promote development of resistance to tylosin in *F. necrophorum* populations. However, tylosin feeding permits a greater incidence of another bacterium, *A. pyogenes*; the reason is not known.

Table 1. Incidence and Severity of Liver A bscesses in Feedlots Using or Not Using Tylosin

Feedlots	Severity of Abscesses [a] A-	A	A+	Total	No. of Abscesses Cultured
	---------- % ----------				
Tylosin Feedlots					
A	3.4	.7	1.9	6.0	5
B	6.3	2.4	6.1	14.8	4
C	8.3	3.0	5.4	16.7	12
D	7.2	2.7	3.1	13.0	6
E	3.0	4.2	5.3	12.6	9
Non-tylosin Feedlots					
F	7.0	2.6	5.9	15.5	10
G	9.9	3.3	4.9	18.1	10
H	9.4	5.6	6.7	21.7	11
I	2.9	2.2	2.2	7.3	9
J	8.5	7.1	13.6	29.2	1

[a]A- = Livers with one or two very small abscesses or abscess scars ; A = Livers with two to four well-organized abscesses generally < 2.5 cm in diameter; A+ = Livers with one or more large active abscesses or many abscesses.

Table 2. Bacteria from Liver Abscesses of Cattle Fed with or without Tylosin [a]

Bacteria	Tylosin	No Tylosin
No. of abscesses cultured	36	41
Anaerobic bacteria	36/36	41/41
Fusobacterium necrophorum	36/36	41/41
Subspecies *necrophorum* alone [b]	18/36 (50)	34/41(82)
Subspecies *necrophorum* mixed with *funduliforme* [b]	15/36 (42)	5/42 (12)
Other anaerobes	22/36 (61)	23/41 (56)
Facultative bacteri a	23/36 (64)	13/41 (32)
Actinomyces pyogene s [b]	19/36 (53)	4/41 (10)
Other facultative bacteria	5/36 (14)	9/41 (22)

[a]Numbers in parentheses are percentages.
[b]Chi-square test P<.01.

Table 3. Minimum Inhibitory Concentrations of Tylosin (Mg/L)

Bacteria	Tylosin	No Tylosin	SEM
Fusobacterium necrophorum	10.5	11.5	1.2
Actinomyces pyogenes	3.4	2.6	.8

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FINANCIAL PERFORMANCE MEASURES FOR KANSAS BEEF COW FARMS

M. R. Langemeier [1]

Summary

Financial performance measures assist managers in making strategic plans and tracking progress in relationship to a farm's goals. Kansas Farm Management Association data were used to compute average financial performance measures by herd size for beef cow farms. Farms with over 200 cows derived a larger percent of their income from beef cow production, tended to be larger in terms of gross farm income and total assets, were more profitable, and had lower debt ratios. Differences in financial performance among beef cow farms suggest that comparisons should be made only with herds that are similar in size.

(Key Words: Profitability, Liquidity, Solvency, Financial Efficiency, Cows.)

Introduction

Financial performance measures can be used to assess the profitability, liquidity, solvency, and financial efficiency of a business. These measures provide information about the financial position and health of a business. Financial performance measures typically are used as warning signals and to track progress towards specific goals.

The objective of this study was to provide benchmark performance measures by size of herd for beef cow farms in Kansas. This information can be used by beef cow producers and farm financial analysts for comparative purposes.

Experimental Procedures

Kansas Farm Management Association data from 1985 to 1994 were used in this study. Recommendations of the Farm Financial Standards Task Force were used to define profitability, liquidity, solvency, and financial efficiency measures. Specific definitions of each measure can be found in Cooperative Extension publication MF-2148, *Measuring Farm Financial Performance* , October 1995.

Profitability measures explain the efficiency with which a farm uses its resources to produce profits. Profitability measures used in this analysis included net farm income, return on assets, return on equity, and the profit margin ratio. Net farm income was calculated by subtracting cash operating expenses and depreciation from gross farm income. Return on assets represented the return to both debt and equity capital, and return on equity measured the residual return to equity capital. The profit margin ratio expressed profit as a percentage of gross farm income. Rate of return measures were adjusted for operator labor and management charges.

Liquidity measures were used as indicators of a farm's ability to meet financial obligations as they came due, without disrupting the normal operations. Liquidity measures used in this analysis included the current ratio (current assets divided by current liabilities) and working capital (current assets minus current liabilities).

A farm's ability to cover all debt obligations was examined using percent intermediate debt, percent long-term debt, the debt to asset ratio,

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and net worth. The debt to asset ratio is the most commonly used solvency measure. This ratio was calculated by dividing total debt by total assets.

Financial efficiency measures show the intensity with which a business uses its assets to generate revenue and the effectiveness of production, purchasing, pricing, and financing decisions. The asset turnover ratio, the operating expense ratio, the depreciation expense ratio, the interest expense ratio, and the net farm income ratio were used to analyze financial efficiency. The asset turnover ratio was calculated by dividing gross farm income by total assets. This measure shows how efficiently capital is being used in the business. The expense and net farm income ratios were calculated by dividing expense or net farm income by gross farm income.

Results and Discussion

Table 1 presents average farm financial measures by size of herd. Most of the herds in Kansas and surrounding states are smaller than 100 cows. Thus, it was not surprising to find a significant number of farms with less than 100 cows in the Kansas Farm Management Association. The larger farms tended to derive more of their income from the beef cow enterprise. The farms with smaller herds tended to be smaller, and more diversified.

On average, the farms with larger beef cow herds had higher gross farm incomes, net farm incomes, rates of return, and profit margin ratios. Because so much difference in profitability occurs between farms with different herd sizes, it is important to take herd size into account when making financial performance comparisons.

Farms with larger herds tended to have more working capital, but lower debt ratios. For example, intermediate debt averaged only 11% for farms with more than 200 cows, but was 30% for farms with less than 50 cows. Intermediate assets and debt would include breeding livestock. Lower debt ratios make it easier to adjust to declining asset values. Though not presented here, over this 10-year period, beef cow operations tended to have lower debt to asset ratios than crop, swine, and dairy farms.

On average, about 63% to 65% of gross farm income was used to cover operating expenses. Another 18% to 21% was used for interest and depreciation expenses. The remaining 15% to 17% represented net farm income or profit.

To assess a farm's financial progress, financial performance measures should be computed and compared with the farm's goals and industry averages. If a farm's performance is below the industry average, corrective action may be needed.

Table 1. Average Financial Measures by Herd Size for Kansas Beef Cow Farms, 1985-1994

	Number of Beef Cows			
Measure	1-50 Head	51-100 Head	101-200 Head	Over 200 Head
Number of farms	380	263	176	57
Percent of Income from Beef Cow Herd	18%	30%	40%	51%
Profitability measures				
Gross farm income	$130,245	$149,928	$208,571	$310,472
Net farm income	$25,355	$28,961	$38,007	$60,583
Return on assets	3.78%	4.24%	4.90%	5.56%
Return on equity	0.19%	1.10%	2.45%	3.08%
Profit margin ratio	3.09%	8.04%	11.81%	14.66%
Liquidity measures				
Current ratio	1.65	1.61	1.52	1.83
Working capital	$54,680	$65,392	$81,401	$150,905
Solvency measures				
Percent intermediate debt	30%	23%	17%	11%
Percent long-term debt	36%	34%	31%	31%
Debt to asset ratio	37%	36%	34%	29%
Total assets	$385,179	$483,198	$664,703	$1,115,980
Net worth	$254,878	$326,824	$447,757	$832,639
Financial efficiency measures				
Asset turnover ratio	40%	35%	34%	33%
Operating expense ratio	63%	63%	64%	65%
Depreciation expense ratio	11%	11%	9%	8%
Interest expense ratio	10%	11%	10%	10%
Net farm margin ratio	15%	16%	17%	17%

Source: Kansas Farm Management Association.

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SUMMARY OF GRAZING RESEARCH ON KANSAS CONSERVATION RESERVE PROGRAM LAND [1]

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

Summary

Animal performance and the net return per acre for four CRP research sites in Kansas in 1994 and 1995 were examined. 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 or burning treatments were not repeated in 1995, the second year of the analysis. Second-year animal performance was similar between the untreated plots and those that were mowed or burned in 1994. Net returns per acre for the site that was grazed by cow-calf pairs ranged from -$5.96 to $4.92. For the sites grazed by stockers, net returns per acre varied from -$5.76 to $22.46. The potential seems to be greater for grazing stockers than cow/calf pairs on post-CRP land.

(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 land productivity, improvement of water quality, enhancement of wildlife, reduction of sedimentation, reduction of surplus commodities, and income support for farmers.

The first CRP contracts expired in 1995. Contract holders with 1995 contracts were given the option to renew their contracts for an additional year. A vast majority of 1995 contract holders chose renewal. A major proportion of the CRP contracts in Kansas will expire during the next 2 to 3 years. Alternative uses of post-CRP land have been given little attention. In response to the need expressed by contract holders, a research project was initiated in Kansas to determine the effect of spring mowing or burning on grazing potential of CRP land. This report summarizes the grazing results for the first 2 years of the analysis.

Experimental Procedures

An exemption was obtained from 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 grazing sites and use were Edwards County (cow/calf grazing), Greeley County (early-intensive grazing of heifers), Kearny County (season-long grazing of steers), and Reno County (season-long grazing of steers).

Each CRP site was divided into: 1) no treatment, 2) spring mowing, and 3) spring burning plots. All animals were weighed and identified before being placed into the plots and weighed at the end of the grazing period. Data collected included days on grass, gain per head, average daily gain, gain per acre, and stocking rate.

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

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Weather conditions and condition of the grass were used to determine the length of the grazing season. In Edwards County, cow-calf pairs grazed for 144 days in 1994 and 168 days in 1995. In Greeley County, heifers grazed for 58 days in 1994 and 72 days in 1995. The steers on the Kearny County site grazed for 130 days in 1994 and 103 days in 1995. In Reno County, steers grazed for 103 days in 1994 and 141 days in 1995.

Budgets were used to estimate gross income, total cost, and net return per acre for each of the treatments. Long-term average (1990 to 1994) prices were used in the analysis. 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 in the cost analysis. All other costs, including hired and operator labor, were accounted for. Thus, the net return per acre for each analysis 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 treatment and .72 lb/day higher for the burned treatment than for the untreated plots. In 1995, stocker performance was higher for the mowed or burned plots than for the untreated plots in Kearny and Reno counties. On the Greeley County site, stocker performance was highest on the untreated plot. The cow/calf site showed the least enhancement from mowing or burning. Calf performance was similar on the three plots during both years.

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 Greeley, Kearny, and Reno county sites. The increase in calf performance on the Edwards County site was not large enough to justify either mowing or burning. As expected, the differences in net returns per acre among the three treatments were not as large in 1995.

We can use an average of the net returns per acre on the burned plots to assess potential profitability of grazing CRP land. The average return for cow/calf grazing was about $2 per acre. The average return for stocker grazing ranged from about $10 to about $15 per acre. Thus, stocker grazing seems to have more potential than cow/calf grazing on post-CRP land.

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

	1994		1995	
Research Site and Treatment	Average Daily Gain, lb	Net Return per Acre, $	Average Daily Gain, lb	Net Return per Acre, $
Edwards County	——144 days——		——168 days——	
(Cow-calf grazing, calf performance)				
None	2.36	1.12	2.20	3.31
Spring mowed	2.44	-5.96	2.22	4.92
Spring burned	2.48	.22	2.12	4.28
Greeley County	——58 days——		——72 days——	
(Early-intensive grazing, heifers)				
None	2.73	12.03	2.56	17.11
Spring mowed	3.07	8.98	2.27	12.24
Spring burned	3.47	17.78	2.33	13.96
Kearny County	——130 days——		——103 days——	
(Season-long grazing, steers)				
None	1.16	.07	1.61	4.19
Spring mowed	1.27	-5.76	1.64	3.76
Spring burned	1.93	10.87	2.10	10.46
Reno County	——103 days ——		——141 days——	
(Season-long grazing, steers)				
None	2.01	13.15	1.15	2.55
Spring mowed	2.55	15.34	1.24	4.58
Spring burned	2.65	22.46	1.39	7.84

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INJECTION-SITE REACTIONS FROM CLOSTRIDIAL VACCINES: A CRITICAL CONTROL POINT?

B. J. McFarlane, G. L. Stokka, and R. Basaraba [1]

Summary

One 550 lb steer was injected subcutaneously twice, once on each side of the neck, with 5 milliliters of Ultrabac 7fi clostridial vaccine with a new 16 gauge, 3/4 inch needle. The injections were given 30 days and 36 hours prior to euthanasia, at which time the two resultant lesions were collected. The lesions were evaluated for tissue damage, and physical descriptors were recorded. The 36-hour injection caused an acute lesion with higher than normal levels of neutrophils and erythrocytes in its center. Within the surrounding skeletal muscle, levels of fibrin and edem a fluid were increased, causing s eparation of the muscle fibers and hemorrhaging. The 30-day injection formed a chronic lesion differing from the 36-hour lesion, primarily by the increased amounts of fibrous connective tissue forming its center. This fibrous connective tissue also extended into surrounding skeletal muscle bundles. The surrounding skeletal muscle also showed signs of degeneration with minimal regeneration. These findings describe the tissue damage that can occur with subcutaneous injection of a clostridial vaccine.

(Key Words: Injection-Site, Muscle Tissue, Clostridial, Cattle.)

Introduction

Livestock producers with effective herd-health programs administer drugs and vaccines on a periodic basis for the prevention and(or) treatment of infectious diseases and spend millions of dollar s annually. The most effective means of building a long-lasting immunity to a particular disease is to recov er from exposure to that disease. However, the risk of herd infection because of a disease outbreak makes this too impractical. Therefore, injections of pharmaceutical products are given, which produce immunity nearly as good as recovering from a disease. Many of these injections are given intramuscularly in the rump between the hooks and pins. A lack of integrati on and communication between the sectors of the beef industry has resulted in many animals receiving multiple injections over their lifespan; in some cases, as many as six clostridial injections. These injections can cause severe tissue damage within the muscles of the top sirloin butt. Because this tissue damage can lead to collagen (connective tissue) formation, a decrease in beef tenderness can result up to 3 inches from the injection site. The occurrence of such muscle tissue damage represents a quality control problem and an economic loss to the beef industry of nearly $55,000,000 per year. In the Face-To-Face Interview Phase of the National Beef Quality Audit (1992), injection-site lesions ranked second, second, third, and second as major quality concerns of purveyors, restaurateurs, retailers, and packers, respectively.

When injections are given, either intramuscularly or subcutaneously, an acute inflammatory reaction occurs v ery rapidly. The severity of the reaction depends on the stimulus incurred. Very little information has been published on injection-site reactions and their effects on the red meat industry. The National Cattleman s Association has been responsible for the majority of this information. Our objective was to collect, evaluate (visually and histopathologically), and characterize lesions result-

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ing from the use of clostridial vaccines in beef cattle.

Experimental Procedures

One 500 lb steer (vaccination history not known) was injected subcutaneously twice, once on each side of the neck, with 5 milliliters of Ultrabac 7fi clostridial vaccine with a new 16 gauge, 3/4 inch needle. The injections were given 30 days and 36 hours prior to euthanasia. The resultant lesions were collected and evaluated at the veterinary diagnostic laboratory at Kansas State University. The selected tissues included haired skin, subcutaneous tissue, and underlying skeletal muscle. The tissues were fixed in 10% neu tral buffered formalin, embedded in paraffin, sectioned at 5 microns (m), and stained with hematoxylin and eosin.

Results

Injection-site reactions were noted on the steer within 24 hours of each injection and resulted in firm, raised, circular areas visible with the naked eye (Figure 1).

The 36-hour lesion was categorized as a dermatitis/cellulitis/stea titis. It was described as an acute (intense) necrosuppurative lesion with edema (swelling), hemorrhage (bleeding), and necrosis (dyin g tissue). A sharp separation was visible between the affected and nonaffected tissue, evidenced by: increased edema, fibrin (building blocks for connective tissue), neutrophilic infiltrates (white cells that fight infection), and hemorrhage. The normal structure of the subcutaneous tissue had been destroyed and showed dense cavitations containing edema, numerous sheets of neutrophils, extravasated erythrocytes within the s ubcutaneous tissue, and the muscle fibers separated by edema fluid. An additional section composed primarily of skeletal muscle had increased amounts of fibrin and edema fluid, was sharply demarcated, and extended into the underlying adipose tissue (steatitis). The junction between the abscess and the skeletal muscle had increased amounts of edema, fibrin, neutrophilic infiltrates, and hemorrhage. Conglomerations of neutrophils, lymphocytes, and plasma cells were found around blood vessels throughout the lesion. In some sections of the lesion, neutrophils and eosinophils extended into the papillary dermis.

Histologically, the 30-day lesion was characterized as dermatitis/myosi tis/cellulitis. It was described as chronic (persistent), lymphoplasmacytic, and fibrosing (forming connective tissue for structural support) with mineralization. The major differences from the 36-hour lesion were the increased amounts of fibrous connective tissue in the center of the lesion with alternatin g loose and dense accumulations of mixed inflammatory cells: lymphocytes, plasma cells, and histiocytes. The center of the lesion was composed of sheets of degenerated neutrophils (amphophilic cellular debris, i.e., greenish pus) surrounded by mixed mononuclear cells, then fibrous con nective tissue with abundant neovascular ization extending outward between the muscle bundles. Scattered degeneration of skeletal muscle had occurred throughout the lesion with minimal regeneration.

Discussion

Injection-site reactions can occur for many reasons and produce various responses with each animal. The pronounced reaction in this steer appears to be a response to both tissue injury brought about by irritation from the injected vaccine and a delayed-type hypersensitivity, which results from repeated exposure to a product. The lesions were comprised mainly of a dense accumulation of lymphocytes and macrophages, which are characteristic of a delayed-type hypersensitivity reaction. This type of reaction is considered to be typical of specific cellular immunity. The lesions appear to have been caused by a combination of physical irritation from the injection, repeated exposure to the vaccine, and possible tissue injury by the adjuvant itself.

The fact that the 30-day r eaction diminished over time demonstrates that injections and the resultant reactions by themselves may not be detrimental to the animal s well-being. However, they may be a critical control point in the production of high quality beef because of the inflammatory response that can leave permanent scarring in the tissues. The appearance of the reactions in this animal indicated that, if the

vaccine were injected intramuscularly, it could result in significant degeneration of skeletal muscle tissue and infiltration of fibrous connective tissue. A resultant blemish would not be revealed until later, when that part of the animal s carcass was cut into roasts or steaks.

This irritating response also could be evidence that the antigenic material was not processed properly. Antigenic material that stimulates an immune response also can cause a localized reaction at the site of injection. Irritating products such as oil of turpentine or oil adjuvant vaccines will cause more severe irritation and injection-site reactions, but the immune response also may be greater. Producers of biological products need to produce less irritating, yet effective, adjuvants. Additionally, contamination can occur through the use of old or dirty needles or when skin is wet and dirty. Using old needles (used more than 5 times) with clostridial vaccine will increase the number of lesions and the weight of the lesions. It also has been reported that in cattle, a three-fold increase in bacterial numbers can occur with a used versus a new needle. Also, unused portions of vaccines should never be used at a later time, because they usually are contaminated and can cause an acute postvaccination reaction.

Both sterile and infected abscesses can result from injections, and if they occur in the muscle, then primal cut trim-outs can occur. During the most recent audit (March, 1993), the incidence of injection-site blemishes in top sirloin butts was determined to be 11 %, with an average weight per blemish of 124 grams (over l/4 lb). It has been shown that heavier trim weights were needed when the injections were administered earlier in the animal s life. This implies that either growth of the injection-site lesion corresponds to the animal s muscle growth or the dosage was too large on a per weight basis and the resulting reaction was more severe than normal.

Summary

We recommend that 1) clostridial vaccines be given subcutaneously in the neck with the tented technique using sterile needles and syringes (new or boiled in water for 5 minutes), 2) intramuscular injections for all products be avoided whenever alternate routes of administration are available on the label s directions, and 3) clostridial vaccinations be limited to primary immunization. Properly administered subcutaneous injections keep damage to nearby muscle tissue to a minimum, helping to ensure the production of high quality beef demanded by consumers.

Figure 1. 24 Hour Injection-Site Reaction from Clostridial Vaccine

Cattlemen's Day 1996

THE EFFECT OF IMPLANTS ON GAIN OF STEERS AND HEIFERS GRAZING NATIVE GRASS [1]

F. K. Brazle [2]

Summary

Four trials were conducted to determine the effect of different implants on steers and heifers grazing native grass pastures for different lengths of time. In addition, two groups of steers were followed through a feeding period to determine if previous implanting had a residual effect on gain. The implanted (Ralgrofi, Ralgrofi Magnum , Synovex Sfi) steers gained faster than the controls; however, no differences in gain occurred among implants. In the finishing group that went on grass at 687 lb, implants had no effect on subsequent feedlot gain. In the second group (on grass at 569 lb and grazing for 80 days), controls gained faster in the feedlot than those that had been implanted on grass, resulting in essentially equal weights for all treatments. Among the heifer groups, no differences occurred in pasture gains. Genetic differences in cattle, length of grazing, and other factors may change implant results.

(Key Words: Implants, Native Grass, Stocker Cattle Gains.)

Introduction

Implants have been used for years in grazing and feedlot cattle. With the variety of implants available, and differences in weight, grazing time, sex, etc., a number of implant strategies are possible. The objective of this study was to evaluate combinations of implants, sex, and length of grazing time in relation to cattle gain.

Materials and Methods

Trial I. Yearling steers (British Continental crossbred) were purchased in late winter and spring and were not implanted until being placed on native grass in April. Steers were allotted randomly to 1) Ralgrofi, 2) Ralgrofi Magnum , 3) Synovex Sfi, or 4) control (no implant) treatments. The steers grazed one burned native grass pasture for 81 days and were stocked at one steer per 2.5 acres. Steers had access to a free-choice salt-mineral mixture containing Rumensinfi (150 mg/hd/day).

The steers were shipped to the Brookover Ranch feedlot at Garden City and were all implanted with Revalorfi at days 1 and 60 during the 130-day feedlot. Carcass weights were collected for the steers at slaughter and live weights were determined by using a standard dressing percent of 64%.

Trial II. Yearling steers (British Continental crossbred) were purchased in the spring and were not implanted until being placed on native grass in April. The crossbred steers were allotted randomly to: 1) Ralgro, 2) Ralgro Magnum, 3) Synovex S, or 4) control (no implant) treatments. The steers grazed eight burned native grass pastures. All treatments were allotted equally to each pasture. One hundred fifty-four steers were grazed in four pastures (80 days) stocked at one steer per 2 acres. The other 106 steers were grazed in four pastures (110 days) stocked at one steer per 3 acres. Steers had access to a free-choice salt-mineral mixture containing chlortetracycline

[1]Appreciation is expressed to Mallinckrodt Veterinary, Inc. for partial funding; Frank Bills for providing cattle; and Dr. Twig Marston and Dr. Kelly Kreikemeier for collecting carcass weights.

[2]Extension Livestock Specialist, Southeast Kansas.

(350 mg/hd/day).

The steers grazed for 80 days and then were shipped to Great Bend Feeders and fed for 136 days. They received the Revalor implants at days 1 and 60. Carcass weights were collected, and live weights were calculated as in Trial I.

Trial III. Yearling heifers (British Continental crossbred) were purchased in late winter and spring and were not implanted until being placed on native grass in April. The heifers were allotted randomly to: 1) Ralgro, 2) Synovex Hfi, or 3) control (no implant) treatments. All treatments were allotted equally to each pasture (stocking rate, one heifer per acre) and grazed for 88 days. Heifers had access to a free-choice salt-mineral mixture containing Rumensin (150 mg/hd/day).

Trial IV. Heifer calves (British Continental crossbred) were purchased in the spring and were not implanted until being placed on native grass in April. The heifers were allotted randomly to: 1) Ralgro, 2) Synovex Hfi, and 3) control (no implants) treatments. Heifers grazed burned native grass pastures at a stocking rate of one heifer per 4 acres for 147 days. Heifers had access to a free-choice salt-mineral mixture containing Rumensin (150 mg/hd/day).

All implants were placed aseptically in the mid-third of the ear. Old implants were removed from the steers' and heifers' ears in all trials, but the stage of activity could not be determined.

Results

In Trial I involving 700 lb steers, all implanted steers gained faster on grass (Table 1, $P<.02$) than controls; however, no differences occurred among implants. The previous (grass) implant treatments had no effect on feedlot gains.

In Trial II (Tables 2 and 3) with 500 to 600 lb steers, no differences occurred among implant groups in pasture ADG, but all implanted steers gained faster ($P<.01$) than the nonimplant steers. Control steers that grazed for 80 days gained faster ($P<.05$) than Ralgro or Ralgro Magnum groups in the feedlot after all steers were implanted with Revalor (Table 2). Consequently, weights of steers not implanted on grass were equal at slaughter to the average weight of the steers implanted on grass.

In Trial III (Table 4), no differences occurred in ADG among treatment groups for heifers placed on grass at 500 to 600 lb and grazing for 88 days.

In Trial IV (Table 5), no differences in ADG occurred among treatment groups of heifers grazing for 147 days.

The interaction between effects of implants on grazing cattle and on feedlot steers may be confounded with types of implants in both phases relative to cattle weight on grass, ADG, and length of time grazed. A clearer picture of how implanting cattle on grass interacts with implanting in feedlot cattle is needed to fully maximize the benefits of implants under both grazing and feedlot conditions. For 500 to 600 lb steers, not implanting on grass and implanting with Revalor in the feedlot may result in slaughter weights equal to those of steers implanted on grass and implanted with Revalor in the feedlot.

Table 1. Effects of Implants on Steers Grazing Native Grass Pastures for 81 Days and Fed for 130 Days in a Feedlot

Item	Ralgro	Ralgro Magnum	Synovex S	Control
No. steers	26	24	26	25
Pasture				
Starting wt, lb	688	686	685	689
Ending wt, lb	825	812	810	801
Gain, lb	137	126	125	112
ADG, lb	1.69[a]	1.56[a]	1.55[a]	1.37[b]
Feedlot				
ADG, lb	3.74	3.65	3.86	3.86
Slaughter wt, lb	1311	1287	1312	1303

[a,b]Means in the same row with unlike superscripts are different (P<.02).

Table 2. Effects of Implants on Steers Grazing Native Grass Pastures for 80 Days and Fed for 136 Days in a Feedlot

Item	Ralgro	Ralgro Magnum	Synovex S	Control
No. steers	40	38	38	38
Pasture				
Starting wt, lb	563	580	563	569
Ending wt, lb	790	803	782	765
Gain, lb	227	223	219	196
ADG, lb	2.83[a]	2.78[a]	2.74[a]	2.46[b]
Feedlot				
ADG, lb	3.52[d]	3.43[d]	3.69[d]	3.78[c]
Slaughter wt, lb	1269	1269	1283	1279

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

Table 3. Effects of Implants on Steers Grazing Native Grass Pastures for 110 Days

Item	Ralgro	Ralgro Magnum	Synovex S	Control
No. steers	26	25	26	25
Starting wt, lb	594	577	566	573
Ending wt, lb	878	855	859	816
Gain, lb	284	278	293	243
ADG, lb	2.58[a]	2.53[a]	2.66[a]	2.21[b]

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

Table 4. Effects of Implants on Heifers Grazing Native Grass Pastures for 88 Days

Item	Ralgro	Synovex H	Control
No. heifers	51	46	47
Starting wt, lb	536	539	549
Ending wt, lb	705	708	709
Gain, lb	169	169	160
ADG, lb	1.92	1.92	1.82

Table 5. Effects of Implants on Heifers Grazing Native Grass Pastures for 147 Days

Item	Ralgro	Synovex H	Control
No. heifers	38	36	39
Starting wt, lb	485	490	495
Ending wt, lb	727	764	739
Gain, lb	242	274	244
ADG, lb	1.65	1.86	1.66

Cattlemen's Day 1996

EFFICACY OF ELECTRONIC IDENTIFICATION IN BEEF CATTLE

A. R. Spell, S. D. Utter, and L. R. Corah

Summary

To evaluate the potential of using electronic implants (transponders) for maintaining identity from birth to slaughter, calves born and implanted in Montana were followed through the feedlot phase to their ultimate slaughter at commercial packing plants. At spring branding, 138 calves were implanted with electronic identification transponders positioned underneath the scutiform cartilage at the base of the ear. Four steers died prior to weaning. After weaning, 109 steers were transported to a commercial feedlot in Kansas (group 1) and the remaining 25 steers (group 2) were maintained at the Montana ranch for 1 year and then placed in a commercial feedlot in Colorado. Following the two feeding periods, steers were slaughtered at commercial packing plants in Colorado or Kansas under Food Safety Inspection Service authority. From implanting to weaning (156 days), retention was 100%, and 98.5% of the implants remained operable. Of the 106 steers that survived in the first group, implant retnetion was 98.1%, and all implants were recovered at slaughter. Of the 25 steers in the second group, identity was maintained on 20 steers up to slaughter, 661 days postbranding. This study illustrated that electronic implants will maintain identity on a very high percentage of cattle from birth to slaughter and that the implants can be recovered at the time of slaughter.

(Key Words: Electronic Identification, Identification System.)

Introduction

In order to assure food wholesomeness and maintain consumer confidence in beef products, a consistent and diligent effort must be put forth by all sectors of the beef cattle industry to use approved drugs and other animal products correctly and to maintain strict adherence to established withdrawal periods. Cattlemen are eager to exercise prudent and responsible drug usage, but need rapid and convenient record keeping systems to improve the management of their health programs and assist in decision making. Additionally, modern cattle management systems require effective means to identify individual animals. Over the years, many different methods have been used, but the need for a permanent, reliable identification system still persists in the industry.

Approximately 10 years ago, electronic identification of animals was just starting to be evaluated by animal scientists and allied industries. Initial progress was slow because of FDA's requirement of all manufacturers of implantable electronic identification systems that such devices be harmless to the animal and be removed successfully at slaughter. Initial work at Kansas State University in 1992 evaluated the placement of electronic identification transponders and their subsequent removal at a commercial slaughtering plant under guidance and supervision of the Food Safety Inspection Service (FSIS). The objectives of this experiment were to evaluate further the recovery potential of electronic identification implants at commercial slaughter facilities and to determine their retention and function in steers from birth to slaughter.

Experimental Procedures

Spring-born crossbred calves (n=138) in Montana were implanted at 2 to 3 months of age with Destron[1] 20mm injectable transponders. Figure 1 shows the transponder unit. Figure 2 shows the implanting tool and the

reader. The implant was positioned underneath the scutiform cartilage at the base of the ear. At weaning, all live calves (n=134) were scanned for functional, retained implants and were divided into two groups. Two calves had non-functional implants at weaning. One group of the weaned calves was sent to a Kansas feedyard (n=l09), whereas the second group (n=25) remained in Montana on grass for approximately 1 year. Steers in the second group subsequently were sent to a Colorado feedyard. Following the feeding periods, the steers were slaughtered at commercial packing plants under the authority of FSIS. Implants were dissected from all steers at slaughter. Data were collected regarding the number of implants retained and the number of implants that remained functional for the duration of the trial.

[1]Destron • Fearing, 490 Villaume Ave., So. St. Paul, MN 55075.

Results and Discussion

Data are shown in Figure 3. Of the 138 steers originally entering the trial, eight died throughout the testing period because of extreme weather conditions. All remaining steers (100%) retained the electronic identification implant from implanting to weaning (phase I), with 98.5% of the implants remaining functional. Group I steers had 98.6% retention, and 98.1% of the implants remained functional through the weaning to slaughter period (phase II). Group II steers had 84% retention, and 80% of the implants remained functional from weaning to slaughter. Overall, 97.4% of the implants were retained, and 95.4% remained functional. Although the system is not perfect, it can maintain continuous identity from owner to owner, which should assure herd security. Ultimately, electronic identification should increase consumer confidence in the cattle industry s ability to produce a high quality and safe food product.

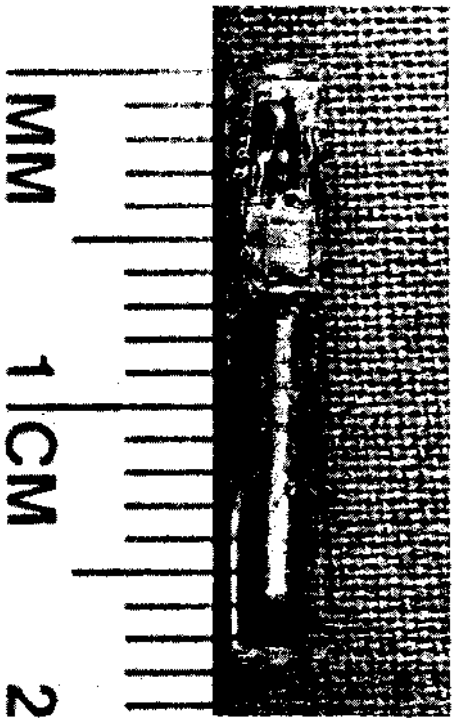


Figure 1. Electronic Identification Implant (Transponder)

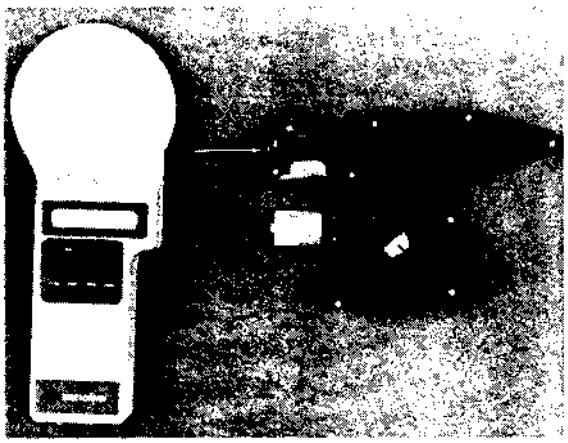


Figure 2. Implanting Tool (L); Reading Tool (R)

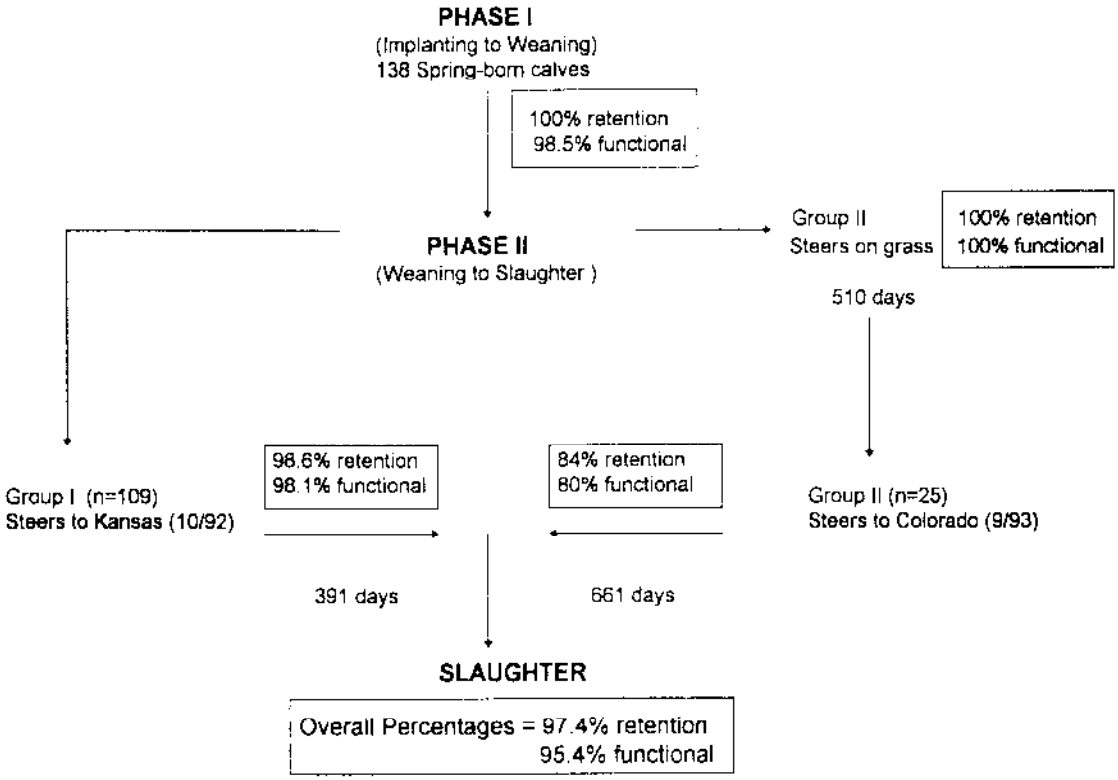


Figure 3. Percentages of Implant Retention and Function through All Phases

INDEX OF KEY WORDS

Indexer's note: The pages identified here are the first pages of each article which uses the listed key word.

BIOLOGICAL VARIABILITY AND STATISTICAL EVALUATION OF DATA

The variability among individual a nimals 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 ch ance 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.

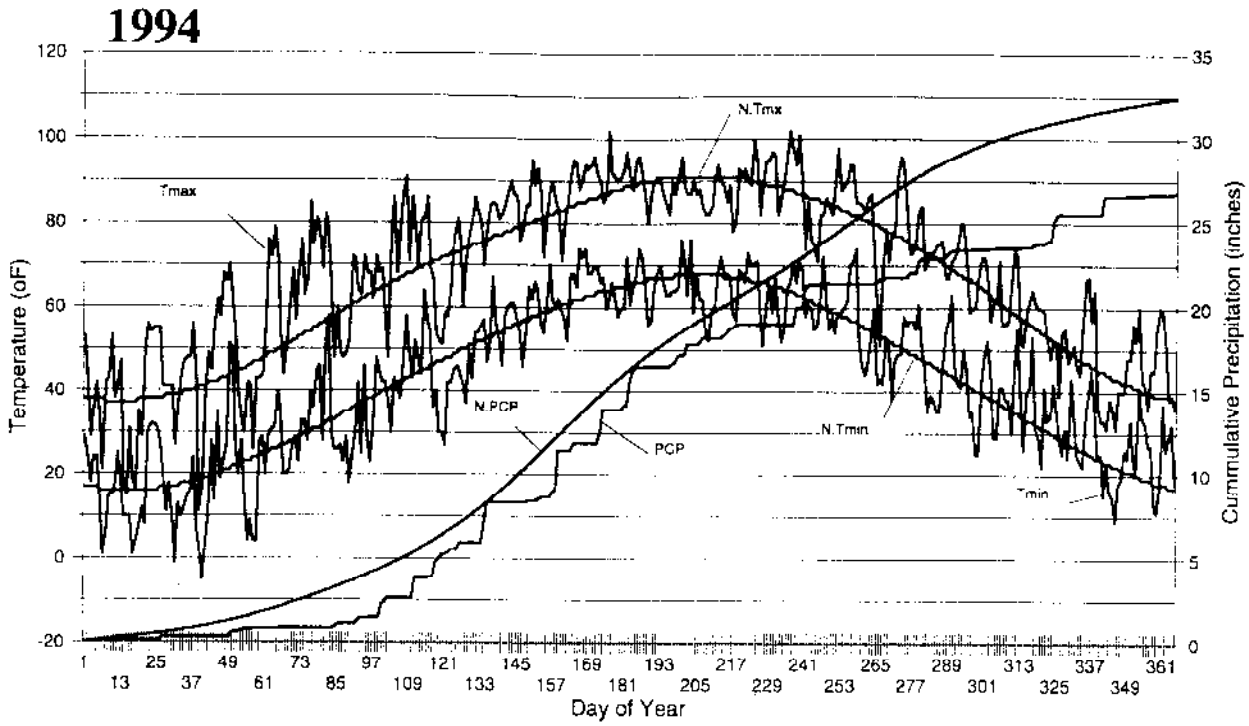
Many animals per treatment, replicating treatments sever al times, and using uniform animals all increase the probability of finding real differences when they actually exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals in an experiment. In the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

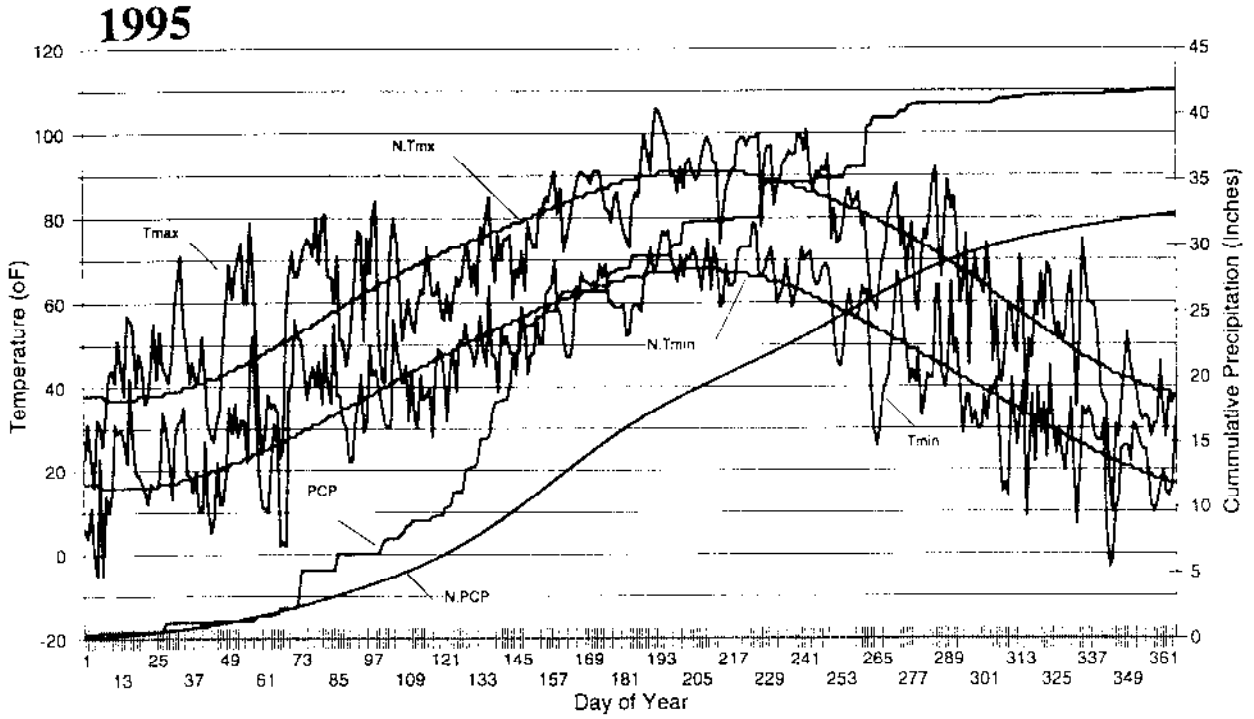
In most experiments, the statistical a nalysis is too complex to present in the space available. Contact the authors if you need further statistical information.

WEATHER DATA, 1994-1995

On the following page are graphs of the 1994 and 1995 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 th e 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 lin e 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 fo rage yields, can be influenced by weather. Weather graphs have been included in Cattlemen’s Day publications since 1985.





Summaries of Weather in Manhattan, KS, 1994 and 1995

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*Degussa Corp, Allendale, New Jersey
*Destron•Fearing, St. Paul, Minnesota
*ECCO Ranch, Buffalo, Kansas
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Farnam Industries, Phoenix, Arizona
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