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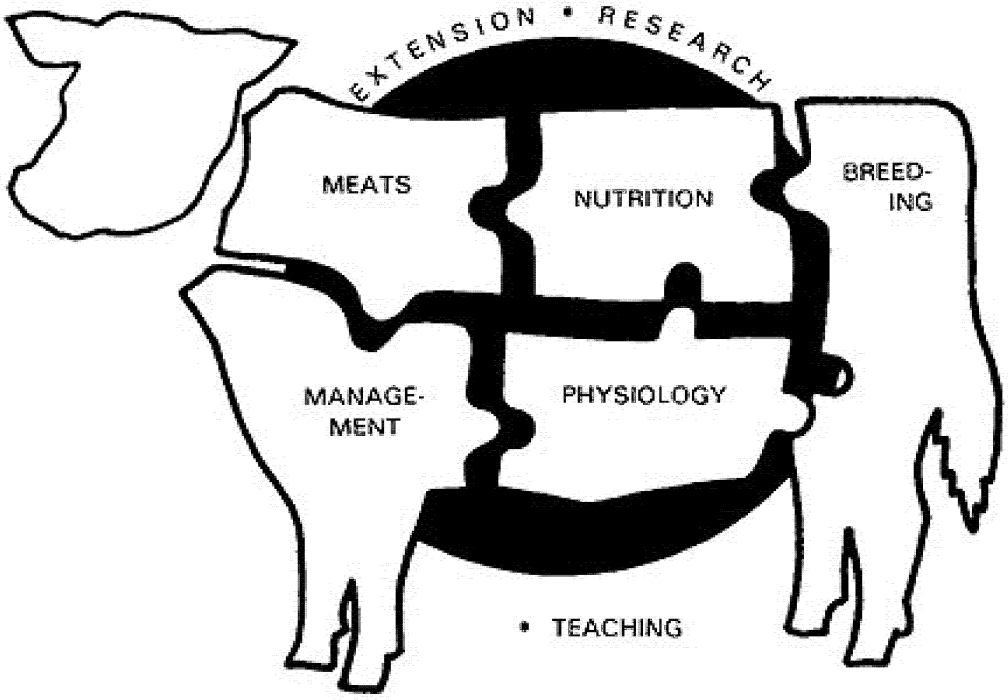
1996 Beef Cattle Report

NEBRASKA



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Range or Meadow Regrowth Grazing and Weaning Effects on Two Year-Old Cows

James Lamb
Don Adams
Terry Klopfenstein
Greg Lardy[1]

Summary

Eighty two-year-old spring calving primiparous cows and their calves were assigned to two weaning and two grazing treatments (20 cows/treatment) from September 7 to November 7 in 1991, 1992, and 1993. Grazing treatments were: 1) native Sandhills range, and 2) subirrigated meadow regrowth. Weaning treatments were: 1) weaning on September 7, or 2) weaning on November 7. Calves weaned on September 7 grazed subirrigated meadow regrowth after weaning. Diet samples collected from meadow were lower in fiber and higher in crude protein and in vitro organic matter digestibility than diets collected from native range. Forage intake was similar for cows grazing either meadow or range regardless of weaning treatments. Cows grazing meadow with or without calves or cows with calves weaned in September gained body weight and body condition. Cows grazing range with or without calves or cows with calves weaned in November lost body weight and body condition. Calves nursing cows on meadow gained 62.9 lb more than calves nursing cows on range and 54.1 lb more than weaned calves grazing subirrigated meadow. We concluded that weaning in September and(or) grazing subirrigated meadow regrowth during September and October increased body condition score over cows grazing range or nursing a calf.

Introduction

Body condition of cows at calving affects pregnancy rate and breeding date. Body condition at calving of spring calving cows wintered on range is influenced by fall body condition. A Montana study showed that lactating cows grazing range lost body condition during August and September. The loss of body condition was attributed to an inadequate consumption of crude protein. Diet samples of cattle grazing Sandhills range during August to October contain 6% to 8% crude protein. Loss of body condition of spring calving, primiparous cows grazing Nebraska Sandhills range during the fall is a concern. Subirrigated meadow regrowth is a higher quality forage than upland range in the fall. Diet samples collected from cattle grazing regrowth from subirrigated meadow during October contained approximately 11% crude protein.

Two potential ways of maintaining or increasing cow body condition during the fall is to wean the calf, thus reducing the cow's nutrient requirements, or increase the potential to meet crude protein requirements with higher quality forage. Our objectives were to determine if September weaning or grazing subirrigated meadows would improve body condition score of spring calving primiparous beef cows during September and October, and to determine nutrient intakes by dry and lactating cows grazing native range or subirrigated meadow regrowth.

Procedure

The study was conducted at the University of Nebraska-Lincoln Gudmundsen Sandhills Laboratory near Whitman, Nebraska. Eighty, two-year-old crossbred primiparous beef cows and their calves were assigned to two weaning and two grazing treatments from September 7 to November 7 in 1991, 1992, and 1993. Cows were 1/4 Hereford, 1/4 Angus, 1/4 Simmental and 1/4 Gelbvieh. Grazing treatments were: 1) native Sandhills range, and 2) subirrigated meadow regrowth after July haying. Weaning treatments were: 1) weaning on September 7, and 2) weaning on November 7. Calves weaned September 7 grazed subirrigated meadow regrowth after weaning in 1992 and 1993.

The range site was mostly sands. The dominant grass species were: little bluestem, prairie sandreed, sand bluestem, switchgrass, sandlovegrass and blue grama. Common forbs and shrubs include western ragweed and leadplant.

The subirrigated meadow soils are classified as Gannett-Loup fine sandy loam (course-loamy mixed mesic Typic Haplaquoll). Dominant vegetation in

(Continued on next page)

subirrigated meadows was: smooth bromegrass, redtop, timothy, slender wheatgrass, quackgrass, Kentucky bluegrass, prairie cordgrass and several species of sedges and rushes. Less abundant grass species were big bluestem, indiangrass, and switchgrass; forbs were a minor vegetation component.

Individual cows and calves were weighed and cows scored for body condition after 16 hours without feed or water on September 7 and November 7. Body condition scores (scored from 1, thinnest to 9, fattest) were based on a palpated determination of fleshing over the ribs and thoracic vertebrae.

Voluntary forage intake and digestibility was determined for 40 cows (10 cows/treatment) October 7 through 12, 1991 and October 14 through 19, 1992. To estimate fecal output, each cow on the intake trial was orally dosed with an intraruminal continuous chromium releasing device five days before the 5-day fecal collection period.

Twelve esophageally-fistulated cows (six cows/treatment, average body weight = 1100 lb) were used to obtain diet samples from range and meadow during 1991 and 1992. Diets were collected October 9, 1991 and October 15, 1992. Cows were fitted with canvas, screen bottom-bags, and forage samples were collected from the esophagus during a 30 to 45 minute grazing period.

Eight steers in 1991 and seven steers in 1992 (average body weight = 880 lb) were assigned to each of the range and meadow treatments. Steers were fitted with fecal collection bags for total collection and dosed with the same intraruminal continuous chromium releasing device as the cows to obtain a correction factor for fecal output.

Organic matter, in vitro organic matter digestibility (IVOMD), crude protein (CP), neutral-detergent-fiber (NDF) and acid-detergent-fiber (ADF) were determined on all extrusa samples. Fecal samples were analyzed for chromium concentration by atomic absorption spectrophotometry. Fecal output was determined for intake cattle by dividing daily chromium released by the intraruminal chromium releasing device by the concentration of chromium in the feces. Fecal output was then corrected using the correction factor obtained from bag steers.

Forage organic matter intake was calculated by dividing fecal organic matter output by the in vitro organic matter indigestibility of esophageal extrusa.

Results

Crude protein and in vitro organic matter digestibility were higher, and ADF and NDF were lower in diets collected from subirrigated meadow than from range (Table 1).

Forage organic matter intake was greater ($P < .10$) in 1992 (23.1 lb/day, 2.3% of body weight) than in 1991 (16.9 lb/day, 1.8% of body weight). Forage organic matter intake was similar for range and subirrigated meadow and for cows nursing calves and dry cows.

Differences in cow body weights and body condition scores occurred between range and meadow and between September and November weaning dates. Cows grazing subirrigated meadow regrowth gained more body weight and were heavier ($P < .01$) at the end of the trial than

Table 1. Crude Protein, in vitro digestibility (IVOMD), neutral-detergent-fiber (NDF), and acid-detergent-fiber (ADF) content of diets collected from esophageally-fistulated cows grazing native range or subirrigated meadow.

	Forage type	
Item	Range	Meadow
Crude protein, % of OM[a]	7.6*	12.3*
ADF, % of OM	47.8*	42.9*
NDF, % of OM	79.6*	64.9*
IVOMD, %	55.1*	61.1*

[a] OM = Organic matter.
* Range and meadow least squares means differed P<.01, year x forage type interaction was non-significant P>.10.

Table 2. Body weight, body weight gain, body condition score, and body condition score gain of dry and nursing cows grazing range or subirrigated meadow regrowth during September and October.

	Treatments				Contrasts			
	Range		Meadow		Forage type	Weaning	Range	Meadow
Item	Dry[1]	Nursing	Dry	Nursing	Range vs. meadow	Dry vs. nursing	Dry vs. nursing	Dry vs. nursing
	---------- Cow body weight ----------							
End of trial, lb.	1012.0	956.8	1046.3	1019.3	NS[2]	*	*	*
Gain during trial, kg.	92.2	-28.4	206.4	135.7	NS	*	*	*
	---------- Cow body condition ----------							
End of trial	5.3	4.9	5.9	5.2	NS	*	*	*
Gain during trial	0.0	-0.4	0.6	0.0	NS	*	*	*

*Contrast significant P<.01.
[1]Dry, calves weaned September 7; nursing calves weaned November 7.
[2]NS, contrasts were not significant (P>.10)

Table 3. Body weight and body weight gains of nursing calves grazing range or subirrigated meadow and weaned calves grazing subirrigated meadow during September and October.

Item	Nursing[a]		Weaned
	Range	Meadow	Meadow
End body wt., lb.	511.3[b]	582.8[c]	507.3[b]
Gain during trial, lb.	65.3[b]	142.3[c]	73.9[b]

[a] The treatment x year interaction was not significant P>.10.
[bc] Means in same row with different letters differ P<.01.

cows grazing on range (Table 2). Cows which had calves weaned in September gained more body weight and were heavier (P < .01) at the end of the trial than cows that had calves weaned in November.

Cows grazing subirrigated meadow that had calves weaned in September gained .6 body condition score, while nursing cows grazing meadow maintained body condition (i.e., no gain or loss) throughout the trial. Cows grazing range that had calves weaned in September, maintained body condition, while nursing cows grazing range lost .4 body condition across the trial. Loss of body weight and body condition of nursing cows on range have been reported during the late fall in other studies.

Calf body weight on November 7 and body weight gains over the trial were greater for calves nursing cows on subirrigated meadow than calves nursing cows on range or weaned calves grazing on subirrigated meadow (Table 3). When quality of diets is compared for range and meadow regrowth it is not surprising that calves on meadow had greater gains, however the magnitude of the difference between weaned and nursing calves grazing meadow is surprising. Ending body weight of calves weaned in September and grazing meadow regrowth was similar to nursing calves grazing range. The increased gain of calves nursing cows and grazing meadow regrowth over calves nursing cows and grazing range is partially explained by the potential difference in chemical composition of diets between range and meadow, especially crude protein. The protein content of the forages would have affected the quality of the calf diets and possibly the amount of milk produced by the cow and consumed by the calf. The improved body weight gain of nursing calves on meadow over weaned calves on meadow is best explained by more rumen escape protein provided by the milk at the intestines. Work conducted at the Gudmundsen Sandhills Laboratory found that nursing calves grazing native range would be limiting in escape protein before energy or rumen degradable protein. Moreover, it is unlikely that rumen degradable protein would be limiting with a diet of 15% crude protein.

Management Implications

Weaning and(or) forage effects on a production system would be affected by amount of milk produced, body condition score of the cow in late summer and feed resources. Cows with higher levels of milk production have greater nutrient requirements and are more likely to lose body weight and body condition when grazing low quality forages during the fall. If cows are thin in late summer, weaning or grazing subirrigated meadow would likely be beneficial. On ranches where low quality range forage or low quality hay is utilized during winter months, benefits of September weaning and(or) grazing meadow during September and October could be important. Thin cows grazing range during late fall and winter will likely be thin at spring calving. Increases in cow body condition score during winter months should not be expected with or without supplements. Harsh winter weather would also affect the importance of a higher body condition score going into the winter. During harsh weather, cows consume less range forage and digestibility is reduced. Maintenance requirements of the cow are also increased during cold stress, making it difficult for cows to consume enough forage to meet nutrient requirements. Thinner cows also have a greater energy requirement than fatter cows, which could make it more difficult for thinner cows to consume enough forage to meet their energy demands.

Body condition score is more closely related to reproduction than body weight in beef cattle. Cows in low body condition score (i.e. < 4) at calving may breed later or fewer will breed during a controlled breeding season than cows in higher body condition (i.e., > 5), especially if cows are loosing body condition between calving and the beginning of the breeding season. If cow body condition cannot be increased with feed resources on the ranch, cows thin in the fall will likely be thin at calving potentially reducing reproductive performance or creating a need to purchase concentrated feed.

Conclusions

Weaning in September and(or) grazing subirrigated meadow regrowth increased body condition score of 2-year-old cows during September and October. For production systems where cows are wintered on low quality forages, increasing body condition during the fall months could be a benefit. Calf gains were greatest for calves nursing cows on subirrigated meadow, but weaned calves grazing subirrigated meadow had gains in body weight similar to calves nursing cows on range. Where there is not enough subirrigated meadow regrowth to support cows and calves, weaning the calf early and grazing the calf on meadow regrowth and the cow on range offers potential to maintain calf gains while improving body condition of the cow.

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Grazing: An Alternative to Haying Subirrigated Meadows in the Nebraska Sandhills

Marc Horney
Don Adams
Walter Schacht
Steven Waller
Terry Klopfenstein[1]

Summary

Ninety-six cow/calf pairs were allotted to four grazing/feeding treatments. Treatments were defined by grazing/feeding management within two time periods: an early period (May 10 to June 10) and a late period (June 11 to July 25). Treatments were 1) early period grazing meadow and late period grazing range, 2) both early and late periods grazing meadow, 3) early period fed meadow hay and late period grazing meadow, and 4) early period fed meadow hay and late period grazing range. Effects on cow body weight, cow body condition score, subsequent calving date, and calf gains were tested. Calves grazing meadow during the early period gained an average of 15 lb more (P<.01) than calves from the hay-fed groups. Body condition score of cows grazing meadow had increased an average of .41 condition score units over cows fed hay by the end of the early period. This difference was still present at weaning. There were no differences among treatments during the late period. Cows which grazed meadow during the early period in '93 calved an average of 10 days earlier than those which were fed hay during the early period and then grazed native range.

Introduction

Subirrigated meadow in the Nebraska Sandhills are used extensively for hay production. Hay harvest takes place in late June through July, generally after the forage has reached full maturity. Crude protein content of this hay commonly falls in the range of 6 to 8%. This is below the nutritional requirement of lactating cows that are often fed this hay until the native range is ready for grazing in late May/early June. Harvesting hay at an earlier maturity would improve its nutritive value, but is not an option on some meadows because much of the surface remains saturated well into the summer. Allowing cattle to graze subirrigated meadows during the growing season (which coincides with lactation in spring-calving herds) should result in higher growth rates and more rapid replenishment of body condition than would occur on marginal quality meadow hay. A few weeks of spring grazing might also delay meadow forage maturity enough that producers would have the option, once the meadows were dry, of taking hay from less mature stands (yielding higher quality but lower tonnage) or allowing the forage to complete its growth and harvest for tonnage rather than nutritional value. An early meadow grazing program could cut several weeks worth of hay out of the spring feeding program as well. Because of these things, meadow grazing might help increase ranch profitability in some situations.

Procedure

A 2-year study was initiated in 1993 to evaluate the effects of meadow grazing on cow-calf performance and forage production. This paper reports the cow-calf production results. The meadow trial was split into two time periods, an early grazing period (May 10 to June 10) and a late grazing period (June 11 to July 25). Ninety-six cow-calf pairs were stratified by cow age and randomly assigned to one of four replicated grazing/feeding treatments (12 pairs/replicate) each spring. Treatments were: 1) early period grazing meadow and late period grazing range, 2) both early and late periods grazing meadow, 3) early period fed meadow hay and late period grazing meadow, and 4) early period fed meadow hay and late period grazing range. All treatments were replicated twice, using two separate meadows. Weights and body condition scores were taken May 10, June 10, July 25, and October 6. Bulls were placed with the cows as they were moved out to their late period pastures (June 10), and remained with them until July 25.

Both meadow and upland range pastures were grazed continuously through each grazing period, and pastures were grazed by the same treatment groups both years. Forage allowances on the meadow were adjusted according to the distribution of certain key plant communities through each pasture and the amount of growth anticipated in each plant community during the grazing period. Non-grazed sites dominated by smooth bromegrass and intermediate wheatgrass produced approximately 3,800 lbs DM/acre in a season. Wetter sites dominated by sedges produced about 2,600 lb DM/acre, and areas having heavy stands of the small rush, produced nearly 1,400 lbs DM/acre in a season (May 10 through August 1). The forage allowance used provided for 816 lb forage dry matter for each cow-calf pair per month. The upland pastures provided for summer grazing were dominated by little bluestem, prairie sandreed, sand bluestem, and blue grama.

Results

The main treatment response occurred in association with early

meadow grazing. Calf gain and cow body condition score data are presented in Tables 1 and 2. Calves grazing meadow during the early period gained an average of 15 lb more than those in the hay lots (P<.01) and maintained this weight advantage through weaning in 1993, but not in 1994.

Cows grazing meadow during the early period gained an average of .41 condition score points over cows fed hay in the drylots (P<.01). They maintained this higher level of condition through weaning (P<.01) regardless of whether they remained on meadow or grazed range in the late period. The weight trends generally reflect the condition score data (Table 3).

Calving dates in 1994 were compared for cows on the '93 meadow trial (Table 4). Both early meadow groups calved an average of 8 days earlier than the hay-range group (P<.01). Data for the early hay-late meadow group had to be thrown out because of an unsound bull. Current-year calving data for the cows in the '94 meadow trial have not been analyzed yet.

This study has shown that meadow grazing during the first few weeks of meadow forage availability can improve cow body condition and calf gains over that of animals being fed marginal quality hay. The results also seem to indicate that gains in weight and condition may oftentimes carry over through weaning. Though these performance improvements are interesting, they alone are insufficient to make the case for Sandhills meadow grazing. Data pertaining to seasonal forage production and quality, hay production, and the relative costs of different forage management systems are being analyzed in order to explore how Sandhills meadows may be better used to increase ranch profitability and longevity.

[1]Marc Horney, graduate student, Animal Science, Lincoln; Don Adams, Associate Professor, West Central Research & Extension Center, North Platte; Walter Schacht, Assistant Professor; Steven Waller, Professor, Agronomy, Lincoln; and Terry Klopfenstein, Professor, Animal Science, Lincoln.

Table 1. Mean calf gains (lb) by period, for 1993 and 1994

	Early period	Late period	Summer range	Overall mean
Early meadow	62.5	112.1	143.4	318.5
Late range Early meadow	64.1	114.1	146.3	325.1
Late meadow Early hay	48.7	106.4	137.4	293.0
Late range SE	2.6	3.3	7.0	9.7

Table 2. Mean cow body condition score changes by period, for 1993 and 1994

	Early period	Late period	Summer range	Overall mean
Early meadow	+.47	+.33	-.02	+.78
Late range Early meadow	+.54	+.32	+.02	+.89
Late meadow Early hay	+.04	+.20	+.14	+.38
Late meadow Early hay	+.15	+.39	-.11	+.43
Late range SE	.083	.100	.096	.108

Table 3. Mean cow weight changes (lb) by period for 1993 and 1994

	Early period	Late period	Summer range	Overall mean
Early meadow	42.3	82.4	-32.4	92.5
Late range Early meadow	46.5	54.4	10.6	111.9
Late meadow Early hay	44.0	20.3	10.6	74.9
Late meadow Early hay	53.7	38.1	-17.2	74.4
Late meadow SE	8.6	0.1	7.3	8.8

Table 4. Average 1994 Julian calving dates for the 1993 study cows

Early meadow	Late range Early meadow	Late meadow Early hay	Late range	Early hay Late meadow	SE
——	89	88	97	NA	2.2

Multi-Elemental Analysis of Sandhills Meadow Hay

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Dennis Bauer
Dennis Brink
Mike Carlson
Norm Schneider[1]

Summary

Sixty-six meadow hay samples were collected from 11 cooperating producers in Cherry, Brown, Rock and Holt counties during the two years of this survey. The objective was to develop a database that could be used to predict sampling and supplementation strategies for elements. Analyzed elements were found to be in sufficient quantities to meet the gestating beef cows requirement in most of the samples collected, when hay is fed as the sole diet to beef cows. In all but one sample, Mn was found to exceed the optimal dietary requirement for beef cattle. Many of the hay samples contained levels of Mo shown to reduce Cu availability in the presence of high S. Regression equations to predict element levels and supplementation strategies could not be developed for this data base with the current number of samples.

Introduction

Traditionally, ranches in the Sandhills of Nebraska feed meadow hay to cows during the winter. Trace element composition of meadow hay varies. To determine if, when and where trace element supplementation is necessary, it is important to characterize the trace element concentrations in the hay. If the variation in trace element content of hay among location and years can be predicted, ranch managers and advisors may develop appropriate strategies for sampling hay and preventing trace element deficiencies. Our objective was to develop a data base of trace element content of meadow hay from various locations over two years. The data base could be used to predict needs for sampling and supplementation strategies.

Procedure

Hay samples (n = 66) were collected with a hay sampling probe from 11 cooperating producers in Cherry, Brown, Rock and Holt counties in north central Nebraska during the fall of 1993 and 1994. Cooperating ranches were identified by the county extension educators and participation was on a voluntary basis. The selected hay samples represented the diversity of hay harvested within that county for that year. Only one set of samples was received from one ranch in Brown county, the analysis was completed but it was removed from the statistical analysis due to a lack of replication.

Lab Analyses

All hay samples were ground through a 1 mm screen and analyzed by Near Infrared Spectroscopy for the macro nutrients (CP, TDN, etc.). The samples were then analyzed for mineral concentrations by inductively coupled argon plasma emission spectroscopy (ICP).

Statistical Analysis

Statistical analysis was performed using Least Square Means and the Stepwise Regression procedures in SAS.

Results

Figure 1 shows the number of samples and the approximate location of the ranch. Calcium (Ca) and iron (Fe) concentrations were not different ($P < .10$) for ranch, county or year and remained at about .64% $\pm$ .21 and 130 $\pm$ 87 ppm of the forage dry matter, respectively. Statistical differences ($P < .05$) occurred between ranches and between years for copper (Cu), zinc (Zn), manganese (Mn), molybdenum (Mo), phosphorus (P), magnesium (Mg) and potassium (K). Table 1 shows the range of element concentrations within a county by year, typical range of values commonly found in forages and the NRC recommended levels for beef cattle. It was not possible to identify ranches that were consistently low or high for a particular element, because

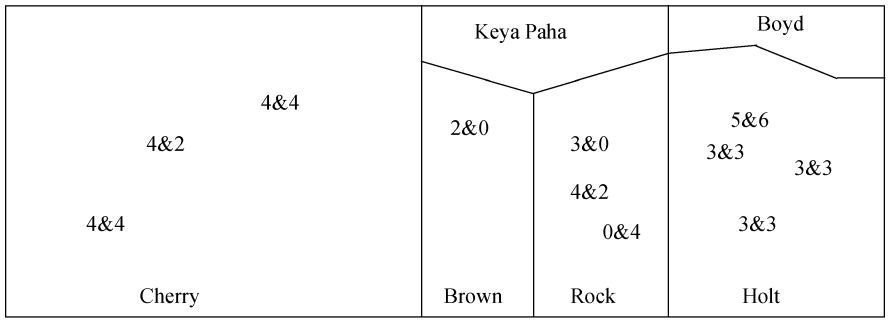

Figure 1. Sandhills Meadow Hay Project Cooperative Ranches, 1993 and 1994.[1]

[1]The first number is the number of samples collected in 1993 followed by the number of samples collected in 1994.

of the wide range of values for a particular element and the variation among samples were not consistent within a ranch. A greater than normal rainfall and below normal temperature in 1993 and near normal rainfall and temperature in 1994 may have accounted for some of the difference between years.

Copper was highest in ranches sampled in Cherry county and higher in 1993 than in 1994 in ranches sampled in Cherry and Rock counties (Table 2 and Table 3). Only one hay sample collected during the two years had a Cu concentration below 4 ppm, which is considered to be the low end of the optimum range for dietary intake (Table 1). However, the Mo concentrations in the hay sampled in 1994 were near the maximum tolerable dietary level. However, these maximum dietary levels were established with analytical equipment that may under-estimate the Mo concentration.

Because of some interactions that occur in the rumen between Mo and Cu, the relatively high level of Mo may decrease the availability of the Cu to the animal. The normal Cu:Mo ratio should be about 3:1. The ratios, among ranches sampled, were 1.5:1 for Cherry county and about 1:1 for Rock and Holt counties. However, the Cu:Mo interaction also requires sulphur (S), which was not measured in this study. Copper, Mo and S form an insoluble complex in the rumen and is unavailable for absorption in the small intestine. Thus, with the high levels of Mo, available Cu may not be adequate in the hay especially if S is also high.

Zinc was not different (P = .08) by county when averaged over the two years, but was higher in 1993 than in 1994 in Cherry and Holt counties. Fifteen of 66 samples collected during the 2 years had Zn concentrations lower than 20 ppm, the minimum value in the optimal range. These samples were from a variety of ranches from each county. Twenty to 40 ppm Zn is considered to be the optimal range for performance and the mean for each county was within this range.

All but one sample collected from all ranches in both years had a Mn value that exceeded the desired range of 20 to 50 ppm of the dry matter. The Mn concentrations were higher (P < .05) from ranches sampled in Rock and Holt counties. No performance depression would likely occur from feeding these higher levels, because the animals homeostatic control mechanisms will not allow absorption.

Cobalt was below the ICP detection limit for about half the samples in this study. However, the detection limit was at .5 ppm and about half the samples were between .5 and 1 ppm. The beef cattle requirement is about .10 ppm in the diet dry matter. Thus, it is safe to assume that the low Co is a detection limit problem and that in most cases, Co deficiency will not be a problem on the ranches sampled.

Phosphorus concentrations were in the normal range of published values for grass hay in Nebraska. However, the ranches sampled in Holt county were lower during both years than those in Rock county and lower than those in Cherry county in 1993. Cattle requirements for P varies with stage of growth and production. Phosphorus in the hay sampled was near the requirement for beef cows during gestation, but is on the low end of the optimum range for lactation if hay is fed as the sole diet.

(Continued on next page)

Table 1. The range of elemental concentrations of hay by county, year, typical values[a] and beef cattle recommendations[b].

Element	Year	Cherry	Rock	Holt	Typical Range	NRC
Zn, ppm	93	20.5 - 72.7	17.0 - 28.5	17.0 - 42.0	20-80	20-40
	94	17.2 - 22.1	16.8 - 28.5	18.6 - 43.3		
Cu, ppm	93	6.82 - 20.45	5.68 - 9.09	4.55 - 7.95	4-8	4-10
	94	3.61 - 11.05	4.70 - 7.43	4.10 - 8.71		
Mn, ppm	93	52.3 - 253.4	69.3 - 148.9	64.8 - 280.7	40-200	20-50
	94	30.1 - 165.9	51.5 - 239.9	61.3 - 346.2		
Mo[c], ppm	94	4.00 - 8.19	4.77 - 7.01	3.95 - 7.03	.5-3.0	—
P, %	93	.132 - .823	.089 - .389	.085 - .284	.1-.3	.2-.3
	94	.105 - .254	.107 - .389	.086 - .340		

[a] Range of element levels common in forage, Livestock Feeds and Feeding (Church, 1991).
[b] Recommendations, National Research Council Nutrient Requirements for Beef Cattle (1984).
[c] Mo was only analyzed in 1994.

Table 2. Element concentrations for hay samples by county.

Element	Cherry	Rock	Holt	S.E.
Cu, ppm	9.42[a]	6.70[b]	6.47[b]	.93
Zn, ppm	26.1[a]	25.5[a]	27.5[a]	2.0
Mn, ppm	85.9[a]	111.9[b]	131.5[b]	13.27
Mo, ppm	6.10[a]	6.09[a]	6.11[a]	.40
P, %	.25[a]	.29[a]	.15[b]	.03
Mg, %	.17[ab]	.19[b]	.16[a]	.01
K, %	1.07[a]	1.63[b]	1.26[a]	.12

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

Table 3. Mean element concentrations within county by year.

County	Year	Cu, ppm	Zn, ppm	P,%
Cherry	93	12.21[a]	32.6[b]	.34[c]
	94	6.61[b]	19.6[a]	.16[ab]
Rock	93	7.10[b]	23.0[a]	.28[bc]
	94	6.31[b]	28.0[ab]	.30[bc]
Holt	93	6.33[b]	31.3[b]	.15[a]
	94	6.61[b]	23.8[a]	.15[a]

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

In all samples collected, Mg and K concentrations were within or exceeded the normal range to be considered adequate in the diet if hay is fed as the sole diet.

In an attempt to build prediction equations to determine under what conditions trace element supplementation may be necessary, stepwise regression analysis was used. We thought that since the average harvest date was 6 weeks later in 1993 than in 1994, some of the variation could be accounted for by an increase in physiological maturity. We used ADF as an indicator of this, and found it to have the best relationship to Mo (highest R^2). When only other nutrients were included in the model, P and Mg predicted Cu concentration best (R^2 = .41). When building prediction equations, it is best to use as few variables as possible. Adding more variables to the model, in this case, did not improve the R^2 significantly; therefore, only 2 variable models are presented (Table 4). Also a R^2 of less than .70 is considered to be a weak indicator. Other 2 variable models are: Ca and Cu to predict Zn (R^2 = .37), Fe and Cu to predict Mn (R^2 = .41), TDN and ADF to predict Mo (R^2 = .25) and Cu and K to predict P (R^2 = .54). Table 4 gives the best 2 non-nutritive or Near Infrared Spectrophotometry determined variables to predict the elemental concentrations. Even when all the variables measured were included in the model, reliable prediction equations could not be calculated.

Table 4. Shows the best 2 variable model and R^2 for predicting the element content of hay using ranch, county, year and NIR[a] measured nutrients as the independent variable.

Element	Model	R^2
Cu	county and year	.22
Zn	year and TDN[b]	.27
Mn	ranch and ADF[c]	.16
Mo	month and ADF[c]	.28
P	county and year	.20

[a] NIR = Near Infrared Spectrophotometry
[b] TDN = Total Digestible Nutrients
[c] ADF = Acid Detergent Fiber

In conclusion, the results of this study indicate that hay samples should be analyzed for Cu and Mo and a Cu:Mo ratio calculated on an annual basis until a given ranch can determine under what conditions supplementation is necessary. Zinc and P analysis should also be completed on ranches which have marginal levels for the desired performance. There is not enough data in the current data base to build reliable prediction equations. So, until more information is available, the best indicator of the element concentration of a hay sample, is a lab analysis for that element.

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Use of a Metabolizable Protein System to Predict Deficiencies in Diets of Cattle Grazing Sandhills Native Range and Subirrigated Meadow

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Summary

Diet samples from native range and subirrigated meadows were collected with esophageally-fistulated cows and analyzed for CP, IVDMD, in situ protein degradability, and fiber components. Escape protein (EP) and degradable intake protein (DIP) of the samples were calculated. The objectives of this research were to characterize the seasonal changes in forage quality and protein degradability of diet samples and to use a metabolizable protein system to predict deficiencies in energy, degradable protein, and metabolizable protein. The subirrigated meadow was very high in CP in late April and early June but declined during July before increasing in August as regrowth occurred. Meadow samples were highest in IVDMD during periods of active growth (April, June, July, and August). Native range samples were highest in CP and IVDMD during June, July and August, which is the period of active growth for these warm season species. The metabolizable protein system, in general, predicted that during gestation, degradable protein was more deficient than metabolizable protein. However, during lactation, metabolizable and degradable protein were both deficient when cows were fed meadow hay or grazed dormant forage.

Introduction

Many Sandhills ranches have two distinctly different forage resource bases; native upland range and subirrigated meadow. These two sites have different grass species composition and different plant growth characteristics. Familiarity with the nutritional composition of these sites is a valuable management tool for cattle producers in the Sandhills. The grazing animal has the ability to select a diet that is higher in nutritive value than would be obtained by analyzing clipped samples of the same pasture. The use of esophageally-fistulated animals to sample pastures gives the best estimate

of the animal's diet.

A metabolizable protein system (NRC, 1985) expresses protein requirements on a degradable intake protein (DIP) and a metabolizable protein (MP) basis. Degradable intake protein is the protein which is degradable in the rumen and available to the microorganisms present in the rumen. Metabolizable protein is the sum of the digestible microbial protein flowing to the small intestine and the digestible escape protein flowing to the small intestine. Metabolizable protein is the protein which the animal uses for maintenance, growth, lactation, and gestation. Expressing protein requirements in this manner should enable producers to more precisely estimate type and amount of supplemental protein needed compared to simply using the crude protein system.

The objectives of this research were to characterize the seasonal changes in forage quality and protein degradability of diet samples and to use a metabolizable protein system to predict deficiencies in energy, degradable protein, and metabolizable protein.

Procedure

Diet samples were collected on both subirrigated meadows and native range sites at Gudmundsen Sandhills Laboratory using esophageally-fistulated cows during different times of the year throughout 1992. Samples were freeze-dried, ground, and analyzed for CP, IVDMD, NDF, ADF, neutral detergent insoluble nitrogen (NDIN), in situ protein degradability, and acid detergent insoluble nitrogen (ADIN). Based on these values, rumen escape protein and rumen degradable protein of the samples were calculated.

The native range pastures had been lightly grazed in the spring. These pastures are typically used as winter pastures. The subirrigated meadow was hayed in July and then grazed in the fall of the year.

Precipitation during April and May was 1.8 and 2.8 inches below normal, respectively. Total precipitation for the 1992 calendar year was 4 inches below normal. Average high temperatures in June, July and August were 7 to 10°F below normal. In late May, two consecutive days of below freezing overnight lows (30 and 20°F) were recorded which likely influenced grass growth and quality patterns.

When laboratory analysis was completed, the metabolizable protein system (NRC, 1985) was used to predict dietary deficiencies in Net Energy for Maintenance (NEm), MP, and DIP. Estimates of grazed dry matter intake were based on previous research conducted at the Gudmundsen Sandhills Laboratory. **All requirements calculated in Tables 3-5 were obtained using thermoneutral conditions. The reader is cautioned that under conditions of cold stress, requirements for energy increase.** No supplement was included in the calculations of nutrient balances. Therefore these should only be used as guidelines.

Assumptions were as follows:

1. Mature cow body weight = 1100 lb
2. Milk production = 18 lb per day
3. Calving Date = March 1 for spring calving cows
4. Calving Date = July 1 for summer calving cows
5. Weaning Date = October 15 for spring calving cows
6. Weaning Date = Dec 31 for summer calving cows
7. Meadow hay was assumed to be of average quality (8% CP, 56% TDN)
8. No supplement was included in any calculations.
9. DIP requirement equals IVDMD x .13
10. Estimates of dry matter intake were based on previous research conducted at the Gudmundsen Sandhills Laboratory.
11. For the growing heifer, weaning weight = 500 lb and breeding weight was 715 lb (65% of mature body weight).

Differences from these assumptions will result in changes in requirements.

Results

Table 1 shows the seasonal changes in chemical composition and digestibility for diet samples collected from the subirrigated meadows in 1992. Because the subirrigated meadows at Gudmundsen Sandhills Laboratory are made up predominantly of cool season species, CP increased rapidly in the spring and then declined over the summer before increasing again during the fall as regrowth occurred. Crude protein was very high in diet samples collected in late April and remained high at the June collection. In vitro dry matter digestibility was also high at the

(Continued on next page)

Table 1. Laboratory analysis of meadow diet samples collected at Gudmundsen Sandhills Laboratory in 1992

Sample date and type		CP (%)	NDIN[a] (%)	ADIN[a] (%)	Escape protein (%)	Degradable protein (%)	NDF (%)	ADF (%)	IVDMD (%)
1/28/92	Meadow	10.26	.64	.10	2.06	7.58	65.41	42.59	51.14
3/17/92	Meadow	14.07	.77	.18	1.58	11.35	56.58	35.87	61.27
4/24/92	Meadow	25.26	.79	.02	1.86	23.26	42.29	23.44	71.89
6/3/92	Meadow	20.34	.64	.11	1.32	18.34	44.75	26.44	71.27
7/10/92	Meadow	9.8	.49	.08	1.11	8.22	61.26	32.12	68.04
8/5/92	Meadow	18.25	.71	.05	1.59	16.36	45.4	35.21	66.82
9/23/92	Meadow	14.82	.52	.09	1.04	13.22	52.14	31.60	59.82
10/15/92	Meadow	12.03	.55	.11	1.09	10.25	51.6	35.65	60.17
12/16/92	Meadow	6.42	.40	.14	.75	4.81	69.51	45.52	56.27

[a]NDIN, Neutral Detergent Insoluble Nitrogen; ADIN, Acid Detergent Insoluble Nitrogen.

April and June collections. Conversely, NDF and ADF values were relatively low at these collection dates. Forage CP declined during the summer months before increasing in August as regrowth started to occur. The CP remained quite high into October before declining in December after growth had ceased. The diet samples collected on the subirrigated meadow were also relatively high in IVDMD as only the January and December samples were below 60% IVDMD. Escape protein of the meadow diet samples ranged from .75 to 2.06% of dry matter. The highest EP values were noted in January.

Table 2 shows the seasonal changes in chemical composition and digestibility of diet samples collected from native upland range sites. On the native upland range sites CP increased later relative to the subirrigated meadows since the upland sites contain more warm season grass species. Grass growth on these sites started in late April as the CP content approached 12%. The cool season species present on these sites initiate growth earlier than the warm season species and the CP content was higher than expected in April. Crude protein values for the diet samples remained between 11 and 13% for the duration of the summer before declining to 6% by late September. In vitro dry matter digestibility was highest during the summer months (the period of active growth). Cows were able to select a diet containing greater than 5% CP throughout the winter months. Escape protein of the range diet samples was highest during the summer months and declined during periods of dormancy. This is contrary to what occurred with the meadow samples.

Table 3 shows the nutrient balance predictions for mature spring calving cows. When cows were fed meadow hay during lactation (March, April, and May), they were in negative energy balance, had a MP deficit, and were slightly deficient in DIP. A DIP deficiency also occurred when cows grazed native range in September, December, and January. The MP system predicted a DIP deficiency of about 200 g/day for cows grazing dormant winter range. This is larger than the 140-168 g/day deficiency predicted by Hollingsworth-Jenkins et al (p. 14 of this report). The MP system assumes no net recycling of nitrogen (urea) through the saliva. Recycling could have occurred under the conditions of that study. In addition, the MP system assumes an efficiency of conversion of TDN to bacterial CP of 13%. This value is then used as the DIP requirement (TDN * .13). The efficiency could be lower than the 13 % on dormant forages. This would reduce the DIP requirement. According to the MP system, cows had ample nutrient supply during the remainder of the year.

It is assumed in the MP system that the DIP requirement will be met. Therefore a DIP deficiency does not reduce MP in the MP system. Metabolizable protein can be supplied by either bacterial CP or EP. In this system, since it is assumed that DIP deficiencies will be met, MP deficiencies can only be met by supplying EP. Supplying additional DIP beyond the requirement will not increase MP supply.

The MP system was also used to calculate the requirements of a two year old spring calving cow (data not shown). The results were very similar to the mature spring calving cow (nutrient deficits occurred during the same

Table 2. Laboratory analysis of range diet samples collected at Gudmundsen Sandhills Laboratory in 1992

Sample date and type		CP (%)	NDIN[a] (%)	ADIN[a] (%)	Escape protein (%)	Degradable protein (%)	NDF (%)	ADF (%)	IVDMD (%)
1/28/92	Range	5.45	.39	.13	.75	3.88	72.89	45.74	55.66
3/17/92	Range	5.30	.33	.04	.87	4.19	71.31	45.75	52.15
4/24/92	Range	11.80	.74	.09	1.95	9.27	64.18	32.97	65.42
6/3/92	Range	11.32	.76	.08	2.27	8.54	69.02	35.16	65.41
7/10/92	Range	12.59	.90	.12	2.53	9.31	66.19	32.96	67.31
8/5/92	Range	11.44	.80	.16	2.04	8.39	65.07	36.98	64.77
9/23/92	Range	6.28	.51	.09	1.49	4.23	69.3	41.95	59.81
12/16/92	Range	5.80	.39	.05	1.15	4.34	71.04	44.88	53.76

[a]NDIN, Neutral Detergent Insoluble Nitrogen; ADIN, Acid Detergent Insoluble Nitrogen.

Table 3. Nutrient balances for a spring calving cow as predicted by the metabolizable protein system (NRC, 1985)

Diet	Meadow hay		Range				Meadow		Range		Meadow hay	
Item	April	May	June	July	August	Sept.	Sept.	Oct.	Dec.	Jan.	Feb.	March
NEm balance, Mcal	-1.5	-2.5	1.9	4.9	3.9	.6	3.1	6.3	2.2	2.1	.7	-1.1
MP available, g	576	576	877	908	747	556	669	595	476	418	524	524
MP requirement, g	733	802	764	696	627	570	570	531	454	401	556	656
MP balance, g	-157	-226	113	212	120	-14	99	64	22	17	-32	-132
DIP available, g	768	768	1044	1336	1135	506	1619	1277	463	468	698	698
DIP requirement, g	799	799	1018	1135	1009	776	931	898	663	687	727	727
DIP balance, g	-31	-31	26	201	126	-270	688	379	-200	-219	-29	-29
DM Intake, lb	24.2	24.2	26.4	28.6	26.4	22	26.4	25.3	20.9	20.9	22	22

Table 4. Nutrient balances for a spring-born heifer (8 months of age through calving) as predicted by metabolizable protein system (NRC, 1985)

Diet	Meadow hay				Range				Meadow		Range	Meadow	Meadow hay	
Item	Nov.	Jan.	March	May	June	July	August	Sept.	Sept.	Oct.	Dec.	Dec.	Jan.	March
NEm balance, Mcal	-.5	-.5	-.3	-.2	1.8	2.3	1.7	.2	1.6	1.4	-.8	——	-1.2	-3.4
MP available, g	238	267	295	324	565	565	523	404	467	430	392	375	417	445
MP requirement, g	375	396	417	438	561	564	585	441	441	449	488	488	534	726
MP balance, g	-137	-129	-122	-114	4	1	-62	-37	26	-19	-96	-113	-117	-281
DIP available, g	317	355	393	431	672	831	795	368	1128	924	381	465	555	593
DIP requirement, g	330	370	410	449	656	707	707	564	649	650	546	601	578	618
DIP balance, g	-13	-15	-17	-18	16	125	88	-196	479	274	-165	-136	-23	-25
DM Intake, lb	10	11.2	12.4	13.6	17	17.8	18.5	16	18.4	18.3	17.2	18.1	17.5	18.7
Body weight, lb	500	560	620	680	710	770	830	860	860	890	950	950	1000	1100
DM Intake, % of BW	2	2	2	2	2.39	2.31	2.23	1.86	2.14	2.06	1.81	1.91	1.75	1.70

Table 5. Nutrient balances for a summer calving cow as predicted by metabolizable protein system (NRC, 1985)

Diet	Range		Meadow			Range			
Item	August	Sept.	Sept.	Oct.	Dec.	Dec.	Jan.	March	June
NEm balance, Mcal	2.3	-2.8	-.3	-.3	.1	-1.5	2	2.4	4.3
MP available, g	747	556	669	595	501	501	440	488	804
MP requirement, g	733	802	802	764	627	627	412	432	556
MP balance, g	14	-246	-133	-169	-126	-126	28	56	248
DIP available, g	1135	506	1610	1277	622	487	492	443	957
DIP requirement, g	1009	776	931	898	804	698	723	677	934
DIP balance, g	126	-270	688	379	-182	-211	-230	-234	23
DM Intake, lb	26.4	22.0	26.4	25.3	24.2	22.0	22.0	22.0	24.2

months as for the mature cow). However, the magnitude of the nutrient deficits was larger for the two-year old cow at each given time point.

Table 4 shows the nutrient balances for a spring born replacement heifer from weaning until two months prior to her first lactation. The table includes a target weight for each month (providing all requirements are met). The most serious deficits occurred when feeding meadow hay. Energy, MP, and DIP were all deficient any time meadow hay was fed. Degradable intake protein deficits also occurred during September and December while grazing range and in December while grazing meadow regrowth. Metabolizable protein deficits occurred during August and December while grazing native range, and during December while grazing meadow regrowth. A slight energy deficit also occurred during December while grazing native range.

Table 5 shows the nutrient balances for a mature summer calving cow. Energy, MP, and DIP deficits occurred during September and December while grazing native range. During September and October, cows were deficient in MP and slightly deficient in energy while grazing meadow regrowth. Degradable intake protein deficiencies occurred in December, January, and March on range and in December while grazing the meadow regrowth. Metabolizable protein deficiencies also occurred in December on both range and meadow.

In general, the metabolizable protein system predicted that when lactating cows were fed meadow hay or grazed dormant forage, they were deficient in DIP, MP, and energy. For gestating cows which were not lactating, the metabolizable protein system predicted that only DIP was deficient.

Protein supplements differ in the proportion of the protein which is degradable and the portion which is escape protein. Examples of sources high in DIP would be sunflower meal, alfalfa hay, corn steep liquor, urea, and biuret. Sources which contain both degradable and escape protein would be soybean meal and cottonseed meal. Sources which are high in escape protein but contain very little DIP would be blood meal and feather meal.

For the gestating cow, a supplement high in DIP is adequate because she is not deficient in MP. For the lactating cow, which needs both DIP and MP, a supplement which contains both degradable and escape protein is necessary. For the growing heifer, a supplement containing some EP as well as DIP is necessary when she is fed meadow hay after weaning and before calving.

Use of the metabolizable protein system should allow producers to more accurately predict the type and amount of supplements necessary to winter the cow herd. By feeding the correct type of supplement at the proper time, overall cost of supplementation could be reduced.

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Rumen Degradable Protein Requirements of Gestating Beef Cows Grazing Dormant Native Sandhills Range

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Summary

Two grazing trials were conducted to determine the rumen degradable protein requirement of gestating beef cows grazing dormant native Sandhills range. In Trial 1, 80 crossbred cows (1150 lb) were randomly assigned to one of the following treatments: 1) 50%, 2) 75%, 3) 100%, or 4) 125% of the estimated supplemental rumen degradable protein requirement. In Trial 2, 80 crossbred cows (1150 lb) were assigned to: 1) 29%, 2) 65%, 3) 100%, or 4) 139% of the estimated supplemental rumen degradable protein requirement. In Trial 1, daily gain, and condition score were not significantly different across treatments. In Trial 2, the 65% level increased gain compared to the 29%, 100%, and 139% levels (.40, .11, .13, .02 lb/day, respectively). Condition score was maintained at the 65% level and lost at 29%, 100%, 139% levels (0, -.2, -.4, -.3 respectively). Forage intake was not different in either trial although digestibility increased linearly in Trial 1 and tended to increase linearly in Trial 2. Gestating beef cows grazing native winter Sandhills range need between .31 and .37 lb/day supplemental rumen degradable protein to meet their daily requirement of .95 to 1.1 lb/day.

Introduction

Protein, the most expensive winter supplement, may be overfed because the actual rumen degradable and escape protein requirements are unknown. Rumen degradable protein is protein degraded by the rumen microorganisms and used by them for their growth and protein synthesis. Escape protein is protein which is not degraded in the rumen but enzymatically digested in the small intestine for use by the animal at the tissue level. Metabolizable protein is the combination of digestible microbial protein and escape protein that flows to the small intestine for use by the host animal. Previous Nebraska reports (Karges et al., *1991 Beef Cattle Report*) indicated that the metabolizable protein required for the wintering, gestating beef cow can be met by microbial flow to the small intestine. Therefore, our objective was to determine the rumen degradable protein requirement of gestating beef cows grazing dormant native Sandhills range.

Procedures

Trial 1

Eighty crossbred gestating beef cows were randomly assigned to: 1) 50%, 2) 75%, 3) 100%, or 4) 125% of the estimated supplemental rumen degradable protein requirement. Supplements were combinations of corn steep liquor and soyhulls to provide the varying protein levels while keeping all supplements isocaloric (Table 1). Steep liquor was used as the source of rumen degradable protein because it is a source of protein, peptides, and amino acids which is completely degraded in the rumen. The estimated daily rumen degradable protein requirement was 1.35 lb, of which .60 lb was estimated to be supplied by the forage. The cows were fed daily in groups of 10 hd (2 pastures/treatment) from November to February. Forage intake was measured (eight cows/treatment) in December and in February for five days each. Cows were individually fed during the fecal collection. Cows were given Captec chromium devices that released chromium at a steady rate into the rumen. Fecal output was determined by dividing the amount of chromium released by the Captec chromium device daily by the concentration of chromium in the feces. Forage intake was estimated by dividing fecal output by the indigestibility of the forage diet. Diet samples were collected monthly with eight to ten esophageally-fistulated cows to determine the protein and fiber contents, and digestibility of the range diets. Weights were taken monthly and condition score (CS) was determined in November and in February by palpation of cover over the back and ribs.

Table 1. Supplement composition for gestating cows grazing Sandhills winter range.

	Supplemental rumen degradable protein requirement, % of required			
Trial 1[a]	50%	75%	100%	125%
	lb DM/day			
Steep liquor	.59	1.2	1.8	2.4
Soyhulls	1.9	1.3	.62	——
Trial 2[b]	29%	65%	100%	139%
	lb DM/day			
Steep liquor	——	.57	1.1	1.7
Soyhulls	1.7	1.2	.62	——

[a]50%, 75%, 100%, and 125% of the estimated supplemental rumen degradable protein requirement (.75 lb).
[b]29%, 65%, 100%, 139% of the estimated supplemental rumen degradable protein requirement (.47 lb).

Trial 2

Eighty crossbred gestating beef cows were randomly assigned to 1) 29%, 2) 65%, 3) 100%, or 4) 139% of the estimated supplemental rumen degradable protein requirement. Supplements were similar to those in Trial 1 (Table 1). However, the estimated daily rumen degradable protein requirement was 1.28 lb of which .80 lb was supplied by the forage. Data collection procedures were the same as in Trial 1.

Results

The ADG and CS were not different among treatments in Trial 1 (Table 2). Cows maintained weights and CS suggesting that even the lowest level of steep liquor supplied sufficient rumen degradable protein to meet the needs of the rumen microorganisms. It also suggests that the rumen degradable protein was sufficient to meet the cow's metabolizable protein requirement and additional escape protein would not be required.

In Trial 2, there was a quadratic (P<.01) response in ADG and a cubic response in CS to increasing levels of steep liquor (rumen degradable protein). The CS did not change for cows on the 65% level of rumen degradable protein while CS was lost at all other levels. Daily gains at the 65% level were higher than those at the 29, 100, and 139% levels.

The decrease in gains and CS as level of degradable protein was increased from 65% to 100 and 139% may be due to a reduced supply of energy for the rumen microorganisms. Even though the diets were formulated to be isocaloric, the soyhulls provide digestible energy for the microbes while the steep liquor supplies organic acids for the energy needs of the host animal but little or no energy for the microbes. As steep liquor replaced soyhulls, microbial energy decreased and microbial protein synthesis likely decreased. The positive weight gain and maintenance of CS also suggest the metabolizable protein requirement was met at the 65% supplemental level but not at the higher levels. We concluded the supplemental need for rumen degradable protein must be between the 50% level (.37 lb; 170 g) in Trial 1 and the 65% level (.31 lb; 140 g) in Trial 2.

Forage intake was not different (P >.10) across treatments in Trial 1 or Trial 2 with the average intake being 2.2 and 2.0% BW respectively. The protein fractions for both trials were similar (Table 3), however the fiber content appeared to be higher and in vitro digestibility lower in Trial 2. Possibly this difference in fiber content was due to summer grazing on the pastures, and therefore, regrowth, before Trial 1. No summer grazing was incorporated before Trial 2. In Trial 1 in vivo OM digestibility increased with increasing

(Continued on next page)

Table 2.Weight and condition score (CS) change of gestating beef cows grazing winter Sandhills range.

	Supplemental rumen degradable protein, % of required			
Trial 1[a]	50%	75%	100%	125%
ADG, lb	.13	.09	.20	.14
Initial wt, lb	1160	1145	1159	1127
CS change[b]	-.6	-.9	-.8	-.8
Supplemental RDP intake, lb	.37	.56	.75	.94
Total RDP intake, lb	1.06	1.32	1.43	1.66
Trial 2[c]	29%	65%	100%	139%
ADG, lb[d]	.10	.39	.14	.02
Initial wt	1166	1158	1166	1165
CS change[e]	-.2	0	-.4	-.3
Supplemental RDP intake, lb	.14	.31	.47	.66
Total RDP intake, lb	.75	.95	1.09	1.25

[a]50%, 75%, 100%, and 125% of the estimated supplemental rumen degradable protein (RDP) requirement (.75 lb).
[b]Initial condition score = 5.7.
[c]29%, 65%, 100%, 139% of the estimated supplemental rumen degradable protein requirement (.47 lb).
[d]Quadratic effect (P < .01).
[e]Initial CS = 5.2; cubic effect (P<.01).

Table 3. Crude, escape, and rumen degradable protein, acid and neutral detergent fiber, and in vitro OM disappearance of Sandhills winter range (% of OM) (Trial 1 and 2)

	CP[a]	EP[b]	RDP	ADIN[c]	ADF	NDF	IVOMD
Trial 1							
November	5.6	1.10	3.6	.90	40.7	66.9	60.5
December	4.3	.81	2.7	.79	42.3	72.3	55.8
January	4.7	.84	3.1	.76	43.0	72.3	60.7
February	4.4	.85	2.7	.85	46.4	77.1	55.1
Trial 2							
November	5.7	.88	3.8	1.0	49.6	75.9	57.8
December	4.4	.54	2.5	1.4	51.6	74.0	54.0
January	4.8	.71	2.4	1.7	50.9	73.8	55.3
February	4.5	.71	2.7	1.1	52.5	80.1	56.1

[a]CP=crude protein, EP=escape protein, RDP=rumen degradable protein, ADF=acid detergent fiber, NDF=neutral detergent fiber, IVOMD=in vitro organic matter disappearance.
[b]EP is corrected for microbial attachment and ADIN, calculations were made from 8, 16, 24 hr in situ rumen incubation and a 2%/hr rate of passage.
[c]ADIN = acid detergent insoluble nitrogen, assumed to be unavailable to the animal.

Table 4. In vivo OM digestibility (%) of native Sandhills winter range as affected by rumen degradable protein supplementation (Trial 1 and 2).

	December	February
Trial 1[a]		
50%	48.2	52.6
75%	52.8	53.7
100%	52.6	54.7
125%	52.9	55.2
Trial 2		
29%	48.8	54.3
65%	49.8	54.9
100%	50.0	55.7
139%	51.2	55.7

[a]Period effect (P< .05) in both trials, Linear effect (P< .05) of treatment in Trial 1.

levels of supplemental rumen degradable protein ($P < .01$), while in Trial 2 treatment had no affect on in vivo OM digestibility (Table 4). In both trials, in vivo OM digestibility increased from December to February ($P < .05$), but not enough to affect forage intake.

Conclusions and Implications

We conclude that the rumen degradable protein requirement for gestating beef cows grazing winter Sandhills range is .95 to 1.1 lb/day and .31 to .37 lb/day of supplemental rumen degradable protein is required. Supplemental protein may be overfed to gestating beef cows grazing winter native range in many production systems. The cost of supplementing gestating beef cows could be reduced by choosing a highly degradable protein source and supplementing to meet the rumen degradable protein needs of the gestating beef cow grazing native range. It is critical to know the amount of rumen degradable protein supplied by the forage. This value may vary from year to year and across production systems. Therefore, it is important to know the protein fractions of the forage so supplements can be fed accordingly.

A rancher could provide .3 lb of rumen degradable protein by supplementing 1.1 lb (as is basis) of soybean meal. However, because the protein in SBM is only 70% degradable, unnecessary escape protein is also being fed. Sunflower meal protein is approximately 80% degradable and 1.1 lb/day of sunflower meal would supply .3 lb rumen degradable protein. Steep liquor protein is all degraded in the rumen and 1.95 lb (as is) would supply .3 lb rumen degradable protein. Steep liquor is 60% moisture and is the least expensive per unit of rumen degradable protein.

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Multi-Elemental Analysis of Liver Biopsies and Serum to Determine Trace Element Status of Cows

David Hickok
Pablo Martin
Dennis Brink
Rick Rasby
Mike Carlson
Norm Schneider[1]

Summary

Liver biopsies and serum were collected from 20 MARC II cows four times annually during the three-year study conducted at the Dalbey - Halleck Farm in southwest Nebraska. The 20 cows were randomly selected from a herd of 200 cows. The entire herd did not receive trace element supplementation. Liver and serum samples were collected pre- and post-calving, mid-summer and at weaning in the fall of each year. All samples were analyzed for trace elements by an inductively coupled argon plasma emission spectrophotometer. Copper concentration in the liver and serum did not change during the study and was not effected by season. Molybdenum concentration was highest in the summer and fall, but had no effect on liver or serum Cu. Liver Zn did not change during the 3 years, but was higher pre-calving. Serum Zn was higher during the summer. Liver Mn was higher post-calving and in the fall and also increased in concentration each year. Mean liver concentration of trace elements did not decrease during the study. Results indicate some seasonal flux in trace element concentrations in the serum and liver; however, reproductive performance was maintained without trace element supplementation.

Introduction

Cattle producers have commonly supplemented trace elements to prevent deficiencies. The beef cow, primarily grazing forage or fed harvested forage, may be able to store adequate amounts of trace elements in the liver during periods of excess availability to maintain homeostasis during periods of marginal availability. Therefore, the objective of this study was to determine the seasonal effects on trace element status of multiparous cows in the absence of supplementation. Trace element concentrations in the liver biopsy were compared with serum concentrations removed at the same time.

Procedure

Twenty, multi-parous Marc II March and April calving cows were randomly selected from a herd of 200 at the UNL owned Dalbey - Halleck Farm, Virginia, NE. The entire herd received no supplemental trace elements, grazed smooth bromegrass and mixed warm season grasses in the summer, and were supplemented with mixed warm season hay and alfalfa during the winter.

Cattle Management

The trace mineral supplement was eliminated at the time of the first liver biopsy in the spring of 1992. All cows were bred by natural service during a 60-day period except during the 1993 breeding season when a 21 day A. I. period was followed by 39 days of natural service. Calves born in 1991 and 1994 were sired by Angus bulls and calves born in 1992 and 1993

were MARC II sired. Breeding started on May 21 of each year for a projected calving start date of March 1. Calves were weaned between Oct. 5 and Oct. 20 of each year.

Sampling Procedure

The 20 cows were liver biopsied four times annually during the three-year study. Biopsies were taken pre-calving (2/15) and post- calving (5/1), during the summer (8/1) and at weaning (10/15). Liver biopsies were removed between the twelfth and thirteenth rib, 20 cm ventral to the mid-line using a Tru-Cut® biopsy needle. Samples of 5-8 consecutive biopsies weighed approximately .1 g (wet weight). Liver biopsy samples were placed in plastic tubes and frozen at 0°F until mineral analysis. Blood samples were collected at the same time by jugular bleeding. Serum was stored at 0°F until mineral analysis.

Mineral analysis

Serum was analyzed directly and biopsy samples were dried, digested overnight in nitric acid, and analyzed for trace elements using an inductively coupled plasma emission spectrophotometer equipped with an ultrasonic nebulizer.

Statistical Analysis

Statistical analysis was performed using the General Linear Models procedures in SAS.

Results

Sodium chloride and dicalcium phosphate were supplemented free-choice. Grass tetany had been a problem, so cows were allowed access to a Mg supplement post-calving. Magnesium was highest ($P < .01$) post-calving, but can be explained by the additional supplementation at that time.

Liver Cu and Zn concentrations did not change ($P < .05$) during the study (Table 1). Copper concentrations in the liver and serum (Table 2 and Table 3) were not effected by season ($P < .05$). But, liver Zn was greatest pre-calving and serum Zn was greatest during the summer.

Table 1. Mean trace element concentrations in the liver during the fall of each year (mg/kg, dry wt.).

Year	Cu	Zn	Mn	Fe	Mo
92	71.2[a]	109[a]	8.59[a]	283[a]	1.35[a]
93	81.0[a]	116[a]	9.70[b]	341[b]	4.06[b]
94	72.6[a]	111[a]	10.2[c]	358[b]	2.47[a]

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

Table 2. Mean trace element concentrations of the liver at different times (mg/kg, dry wt).

Element	Summer	Fall	Pre	Post	S.E.
Cu	75.3[a]	76.8[a]	68.3[a]	65.5[a]	5.78
Zn	91.0[a]	102[a]	147[b]	96.9[a]	6.70
Fe	305[a]	364[c]	358[bc]	321[ab]	16.9
Mn	9.12[a]	10.3[b]	8.60[a]	10.4[b]	.398
Mo	3.75[a]	4.66[a]	1.96[b]	1.59[b]	.470

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

Table 3. Mean trace element concentrations of the serum at different times of the year (mg/kg, dry wt.).

Element	Summer	Fall	Pre	Post	S.E.
Cu	.616[a]	.612[a]	.603[a]	.598[a]	.238
Zn	.758[a]	.655[b]	.658[b]	.555[b]	.036
Fe	2.12[ab]	1.87[a]	2.22[b]	1.84[a]	.08

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

The ratio between Cu and Zn has been used as an indicator of health to predict culling in dairy cattle. The Cu:Zn serum ratio was lowest during the summer ($P < .05$) and higher pre- and post-calving. Whereas, the Cu:Zn ratio in the liver was lowest pre-calving ($P < .05$) and highest during the summer.

Liver and serum Fe demonstrated some seasonal flux and was high at all time points when compared to published values (Puls, 1994. Mineral Levels in Animal Health: Diagnostic Data). Manganese and Fe increased, and Mo was greatest during the second year ($P < .05$). Manganese was highest in the liver post-calving and in the fall, but is considered to be in the adequate range. Liver Mo was highest during the summer and fall probably because the Mo concentration in the forage was increasing as the plant matured (1994 Nebraska Beef Report, pp. 8-11). Molybdenum did not have a negative impact on liver or serum Cu.

There was no statistical correlation between liver element levels and serum levels. This is due to the homeostatic control mechanisms that maintain serum element concentrations within an adequate range, at the sacrifice of liver mineral stores.

Herd reproduction and calf performance data are shown in Table 4. The data for 1991 are with trace element supplementation and 1992 through 1994 data reflect the performance without supplementation. Reproductive performance did not decrease when trace element supplementation was removed. Also, mean liver concentration did not decrease ($P < .10$) for any element during the three years. Previous analysis (1994 Nebraska Beef Report, pp. 8 - 11) indicated that the forage was adequate to meet the cows requirement most of the time. The cow also has the ability to store elements during times of excess to be used during periods of marginal availability. Calf weaning percentage was higher in 1991 and 1994, probably due to to a change in sire breeds rather than nutrition. Weaning weights increased during the four years and cows tended to calve earlier in 1994 than in 1991 or 1992.

Results of the three-year study

(Continued on next page)

Table 4. Reproduction and performance data of the entire herd[a] by year.

	Year			
	1991	1992	1993	1994
Pregnant[b], %	95.5	88.0	92.3	95.0
Weaning[c], %	92.2	82.0	86.0	92.0
Weaning[d] wt, lb				
Heifers	459	480	518	522
Steers	492	527	536	549
Calving date[e]	3/22	3/24	3/20	3/16

[a]Herd size was maintained at 200 cows and heifers.
[b]Percentage of cows exposed that calved in year indicated.
[c]Percentage of cows exposed that weaned a live calf.
[d]Actual weaning wt of calves.
[e]Mean calving date of all pregnant cows.

indicate some seasonal flux in liver trace element concentrations. A need for additional trace element supplementation was not established for this area, because reproductive performance of the herd was maintained in the absence of trace element supplementation.

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Multi-Elemental Analysis of Bovine Liver Biopsy and Whole Liver

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Gene Deutscher
Pete Olson[1]

Summary

Five, single parity MARC II cows were biopsied, slaughtered, liver recovered and used to compare the element concentration of the liver biopsy with the concentration of that site, post-slaughter and the concentration in the entire liver. Each liver was cut into 20 pieces, homogenized and a 1 g sub-sample analyzed for element concentration using an inductively coupled argon plasma emission spectrophotometer. Element concentrations were different between animals, but element concentrations between sites within a liver were only different for Mn, and Mg. The two regions of the liver that accounted for this difference were regions caudal and cranial to the portal vein on the lateral side. These regions also tended to be higher for Zn, Cu and Fe. The pre-slaughter liver biopsies over-estimated the concentration of Fe, Na, and Ca, and underestimated Zn, Cu, Mn, Mg and P compared to the post slaughter analysis of the same site. The results indicate the concentration of trace elements in liver tissue obtained at slaughter depends on the location from which the tissue was removed. The site used for liver biopsies in this study, may not represent the highest concentration of elements in the liver of the live animal.

Introduction

Liver biopsies are used to assess trace element status of cattle for diagnostic and experimental purposes and generally provide better information than serum samples. Liver tissue collected at necropsy or slaughter is also used. The liver usually serves as the storage site for minerals. Serum concentrations may be maintained within adequate concentration ranges, at the sacrifice of liver mineral stores. If animals are receiving insufficient mineral, but have not yet depleted their liver stores enough to significantly lower the serum concentration, analysis of serum will be misleading. But analysis of liver biopsy samples may detect low liver trace element status.

Most published data used to establish the adequate liver mineral concentration ranges were collected from livers under experimental conditions at necropsy or slaughter. Few comparisons of trace element concentrations in liver biopsy and whole liver samples are available. There are no published mineral concentration ranges based upon liver biopsy samples. The objectives of this study were 1) to determine if trace element concentrations in the liver depended upon the liver section from which the sample was collected, 2) to compare the trace element content of pre-slaughter liver biopsy samples with post mortem trace element concentrations of the entire liver, 3) to determine if the magnitude of the concentration differences was sufficient to effect interpretation of nutritional status and 4) to determine if any gross affect was evident in livers from which previous biopsy samples had been collected.

Procedure

Five, single parity MARC II females, which had previously been

liver biopsied four times, were biopsied again, and then slaughtered five hours later. Pre-slaughter liver biopsies were removed from the most caudal region of the liver from between the twelfth and thirteenth rib, 20 cm ventral to the mid-line using a Tru-Cut® biopsy needle. A total of five to eight consecutive biopsy cores were obtained on each cow and weighed approximately .1 g (wet weight). The entire liver was recovered at slaughter and iced. The liver was marked into a grid using repeatable structures on the liver, cut into 20 sections (Figure 1), and stored frozen until analyzed. Frozen liver sections were thawed and blended using a Waring blender until liquidous. A 1 g subsample was removed and digested in concentrated nitric acid overnight. Four pieces were randomly selected from each liver for duplicate analysis. The digests were diluted and analyzed for calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), molybdenum (Mo), sodium (Na), phosphorus (P), and zinc (Zn), using an inductively coupled argon plasma atomic emission spectrometer equipped with an ultrasonic nebulizer.

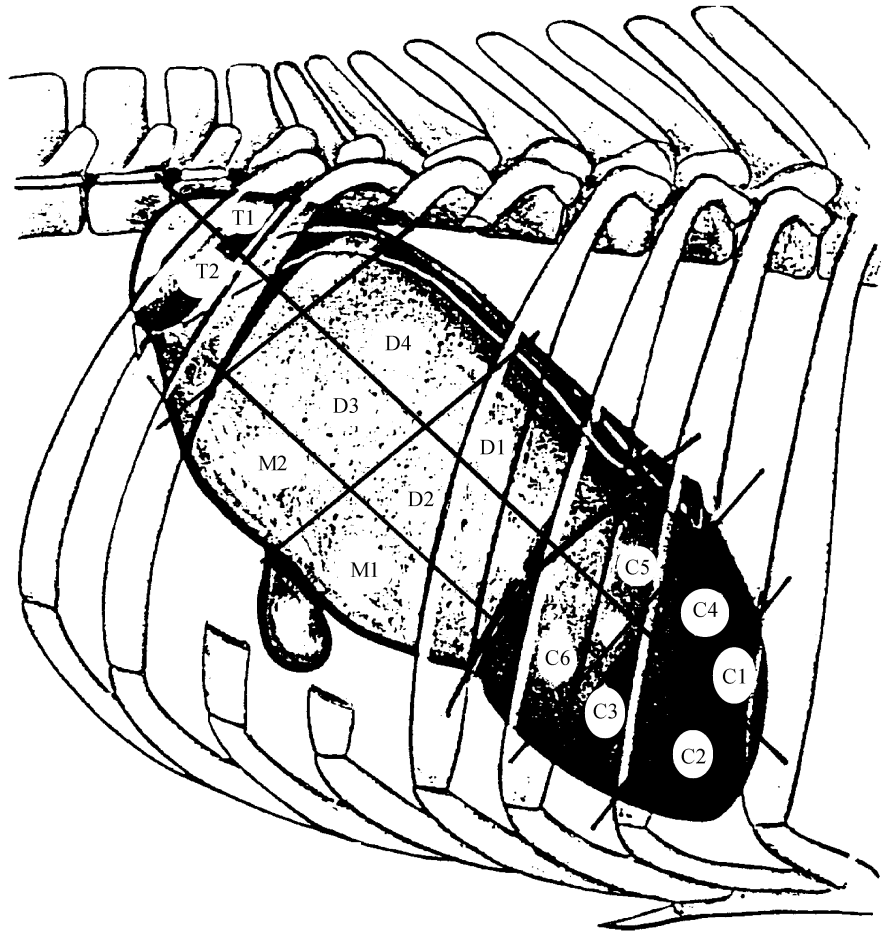

Figure 1.

Results

Due to normal biological variation between animals, element concentrations were different between livers ($P < .05$) for all elements except P and Ca ($P > .05$). Examples of the differences detected for Cu, Zn, and Mn are shown in Table 1. The reason Ca and P concentrations did not differ may be because the bone, not liver serves as the primary storage site for Ca and P. Therefore, liver concentrations of both elements are similar between animals. Furthermore, Ca homeostasis is vital to life, and biological variation may be less than other minerals.

Significant differences in concentration by site within liver were detected only for Mn, and Mg ($P < .05$). Two regions of the liver, designated D1 and D3, consistently were found to contain higher concentrations of Mn, Mg, and Mo than other regions of the liver (Table 2). Regions D1 and D3 were caudal and cranial to the portal vein on the lateral side, respectively. Those regions also tended to be higher for Zn ($P = .06$), Fe ($P = .11$) and Cu ($P = .09$).

The liver generally serves as a significant storage site for many elements. Liver cells (hepatocytes) actively absorb them from the blood stream. Regions nearer the portal vein,

(Continued on next page)

Table 1. Means for trace element concentrations of the entire liver, by animal (mg/kg, wet weight).

Animal	Cu	Zn	Mn
1	41.7[a]	38.7[a]	2.32[a]
2	67.8[b]	61.3[c]	2.55[ab]
3	53.3[a]	38.1[ab]	2.71[b]
4	62.3[b]	33.2[b]	2.31[a]
5	46.6[a]	42.5[a]	3.18[c]
S.E.	2.5	1.82	.12

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

Table 2. Comparison of means of trace element concentrations of sites D1 and D3, caudal and cranial to the portal vein on the lateral side, with the mean value of the entire liver (mg/kg, wet weight).

Element	Mean	D1	D3	SE	P-value
Cu	52.6[a]	65.3[b]	68.3[b]	5.0	P = .09
Zn	41.2[a]	57.2[b]	52.7[b]	3.7	P = .06
Mn	2.55[a]	3.65[b]	3.44[b]	.23	P = .05
Fe	44.9[a]	55.3[b]	54.4[b]	3.8	P = .11
Mg	190.4[a]	252.2[b]	239.8[b]	13.3	P = .01
Mo	.97[a]	1.18[b]	1.17[b]	.08	P = .15
Ca	44.8[a]	61.7[b]	53.1[b]	5.8	P = .08
Na	696.2[a]	795.2[b]	743.8[b]	53.7	P = .30

[ab]Means in a column with different superscripts are statistically different.

Table 3.Trace element concentration mean and range for the liver of Cow 2 (mg/kg, wet weight).

Element	Mean	S.E.	Low	High	Adequate[1].
Cu	68.3	12.0	32.6	99.9	25-100
Zn	63.0	10.9	42.1	111	25-100
Mn	2.60	.51	1.43	4.62	2-6
Fe	46.0	7.3	37.4	75.0	45-300
Mg	202	25	161	310	100-250
Ca	43.3	9.2	32.8	75.1	30-200
Na	740	153	529	1210	530-3450

[1] Puls (1994).

Table 4. Mean comparison of trace element concentrations of the biopsy (pre-slaughter) with the same site in the liver (T1 and T2) post-slaughter (mg/kg, wet weight).

Element	Biopsy	T1	T2	S.E.
Cu	20.9[a]	62.9[b]	56.1[b]	5.77
Zn	22.9[a]	41.0[b]	41.8[b]	1.9
Mn	1.45[a]	2.40[b]	2.61[b]	.16
Fe	107[a]	43.2[b]	45.4[b]	10.0
Mg	127.2[a]	184.8[b]	191.8[b]	7.61
Ca	62.5[a]	45.6[b]	45.7[b]	5.3
Na	2600[a]	666[b]	720[b]	248

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

entrance into the liver, may contain blood with higher concentrations of elements. Consequently, hepatocytic uptake of elements in those regions may be greater than it is in regions "down stream," because in those regions blood contains a relatively lower element content. Higher concentrations of most elements found in regions designated D1 and D3 may be related to blood flow through the liver.

To illustrate the variation of element concentrations within the liver, Cow 2 was selected at random. The mean, lowest and highest concentrations for all trace minerals found in that liver are listed in Table 3. We found that trace element concentration does vary within the liver. Assessment of trace mineral status based upon an analysis of a sample from one section of liver could lead to erroneous conclusions. Table 3 also compares the highest and lowest mineral concentrations found in Cow 2 to the adequate concentration ranges reported by Puls (1994, Mineral Levels in Animal Health: Diagnostic Data). Some of the highest and lowest concentrations found fall outside of the adequate range. Assessment of trace mineral status based upon samples tending to contain higher or lower mineral amounts than the average may lead to erroneous conclusions, therefore, it is important that the section of liver from which a sample is taken be identified. Better interpretation of the results of analysis should be possible with such information. If assessment of possible trace element deficiency is desired, it is best to take a liver sample from the area near the portal vein at the top of the liver. If trace element concentrations are low in that area, then the animal is likely deficient.

Results of pre-slaughter liver biopsy sample analysis tended to overestimate the concentration of Fe, Ca and Na ($P < .01$), and under-estimated the concentrations of Zn, P, Mn, Mg and Cu ($P < .05$), compared to results from whole livers (Table 4). The areas designated T1 and T2 were the most distal region of the liver with T1 being dorsal to T2. Four of the five biopsies were removed from T1 and the remaining biopsy was from both T1 and T2.

Comparison of results from liver biopsy analysis to the normal concentration ranges derived from whole liver analysis should be made with caution. The concentrations detected in the biopsy sample will differ from mean whole liver concentrations and the amount of difference will depend upon the site from which the biopsy sample was taken. One possible reason for the difference between biopsy and post slaughter trace element content may be due to the relative amounts of blood contained in each. The animals in this study were exsanguinated at slaughter before their livers were removed. The difference found for Fe and Na is likely due to the difference in whole blood content of the biopsy and whole liver samples. The concentrations of Zn, P, Mn, Mg and Cu may have been increased, with respect to the liver biopsy samples, after exsanguination.

Biopsy sites were difficult to find even though biopsies were taken only five hours before slaughter. Close inspection of this section of liver revealed no significant lesions. Even dissection of the liver revealed no scaring from any of the biopsies. This indicates repeated biopsies from the same site does not cause any long term liver structure damage.

Conclusions

Liver biopsy samples can be used to assess the mineral element status of individual animals, but the site within the liver from which the biopsy sample was collected must be known for the best assessment.

Comparison of trace element content in liver biopsy samples to normal trace element ranges derived from whole liver data should be made with caution. Results from biopsy samples may be significantly higher or lower than mean whole liver concentrations. The site used for liver biopsies in this study may not represent the highest trace element concentrations in the liver of the live animal.

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[1]David Hickok, graduate student, Animal Science, Mike Carlson, research technician, Veterinary Diagnostic Center, Dennis Brink, Professor, Animal Science, Norm Schneider, Associate Professor, Veterinary Diagnostic Center, Lincoln, Gene Deutscher, Professor, Pete Olson, graduate student, West Central Research and Extension Center, North Platte.

The Incidence of Precocious Puberty in Developing Beef Heifers

Michael Wehrman
James Kinder[1]

Summary

The objectives were to determine the incidence of precocious puberty in developing beef heifers and if exposure to sterile bulls affects the incidence of precocious puberty. The experiment was conducted during 1990 and 1991 in which 120 MARC III heifers were used. Heifer calves and their dams were randomly assigned to be pastured in the presence (n=30 head/year) or absence (n=30 head/year) of a sterile bull starting at 140 ± 1.4 days of age through the duration of the study (402 ± 1.4 days of age). Heifers were considered to have exhibited a precocious puberty if the onset of luteal function was prior to 300 days of age. Average age of puberty in the beef physiology herd is 430 ± 8.7 days of age. There was no effect of exposure to a mature sterile male on the incidence of precocious puberty, therefore, the data were pooled within year. The incidence of precocious puberty was greater in 1990 (25.0 ± 5.5%; 15 of 60) compared to 1991 (8.3 ± 3.5%; 5 of 60). There was no effect of year on the time of initiation of precocious puberty (194 ± 12.4 days of age), duration of time over which estrous cycles occurred (65 ± 10.5 days) or the resumption of anestrus (260 ± 15.3 days of age). Precocious puberty does occur in developing beef heifers with as much as 25% of heifers showing some signs of luteal function before 300 days of age. However, exposure to a sterile bull had no effect on the incidence of precocious puberty.

Introduction

In the current cow-calf production system in the United States when restricted breeding seasons are used a heifer must calve by two years of age to obtain maximum lifetime productivity. Heifers that reach puberty at a younger age and have ≥ 3 estrous cycles have a greater chance of conceiving early in their first breeding season than contemporaries. Due to the longer postpartum period of anestrus of first-calf cows calving at two years age, heifers that conceive early in the breeding season have a greater opportunity to initiate estrous cycles before the next breeding season and become pregnant. In contrast, heifers that do not reach puberty until after the breeding season starts, conceive later in the breeding season and subsequently calve later the following year. Calving late in the calving season increases the chances of heifers not becoming pregnant during the following breeding season and being lost from the herd. Therefore, age at puberty is an important reproductive trait in developing replacement heifers.

Improved management practices and selection of reproductive traits have enhanced the physiological processes associated with attainment of puberty to maximize the number of heifers that reach puberty before the breeding season. Development of replacement heifers in the presence of a mature sterile bull is a management practice that decreases the age at which puberty is attained compared to heifers developed in the absence of a bull. However, increased selection pressure applied to age of puberty in heifers and the subsequent decrease in age at puberty has some disadvantages. Heifers reaching puberty and initiating estrous cycles at a young age while still suckling their dams are often exposed to fertile bulls during the dams breeding season or to intact male calves before weaning. Exposure to fertile bulls during this time period could result in heifers that become pregnant at a very young age and calve as yearlings. These heifers usually conceive late in the breeding season and calve late or after the normal calving season as yearlings. These heifers are of small body size which increases the chances of dystocia that sometimes results in loss of the calf and/or heifer, increased labor and time required for postpartum recovery. The combination of small body size and increased dystocia result in the majority of these animals failing to conceive during the following breeding season. Money invested in developing the heifer would be lost. In addition, precocious puberty in heifers that are destined to be sold as market animals results in heifers becoming pregnant prior to entering the feedlot. Pregnant feedlot heifers have decreased feed efficiency and growth rate compared to non-pregnant heifers which is a factor for lower prices paid by feedlots for heifers compared to steers. The research objectives were to determine the percentage of heifers developed at the University of Nebraska research station that exhibit precocious puberty and if exposure to bulls would affect the incidence of precocious puberty.

Procedure

The experiment was conducted at the Cow/Calf Unit of the University of Nebraska Agriculture Research and Development Center located at Mead Nebraska during 1990 and 1991. A total of 120 MARC III (25% Angus, 25% Hereford, 25% Red Poll and 25% Pinzgauer) heifers were used over two years (60 heifers/year). Heifer calves and their dams were randomly assigned when heifers

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were 140 ± 1.4 days of age to be pastured with or without sterile bulls throughout the duration of the study. After weaning (October 12 each year), heifers were maintained within their group on pasture and supplemented as needed with a corn-based diet and prairie hay to gain 1.25 pounds daily. Blood samples were collected weekly through 402 ± 1.4 days of age to determine the concentrations of progesterone indicative of the onset of luteal function and puberty. Heifers were determined to have luteal function when concentrations of progesterone increased above 1 ng/ml for two consecutive samples (7 days apart) or above 2 ng/ml in one sample with continued cyclic profiles of progesterone concentration indicative of normal estrous cycles. After initiation of luteal function, heifers were determined to have returned to anestrus if the concentrations of progesterone in three consecutive samples (14 days apart) were below 1 ng/ml. Previous research showed heifers within this herd reach puberty at an average of 430 ± 8.7 days of age. Heifers were considered to have precocious puberty when luteal function was initiated before 300 days of age.

Results and Discussion

There was no affect of exposure of heifers to sterile bulls on the frequency or the age of precocious puberty, therefore, data were pooled within year. Frequency of precocious puberty is presented in Table 1. The frequency of precocious puberty was greater ($P < 0.02$) in 1990 (25.0 ± 3.5%; 15 of 60) compared to 1991 (8.3 ± 3.5%; 5 of 60). Figure 1 depicts the progesterone profiles of four representative heifers. Figure 1A depicts progesterone concentrations in a representative heifer which attained puberty at a typical time for this herd. Figure 1B through 1D depicts progesterone concentrations of

Table 1. Characteristics of precocious puberty in developing beef heifers.

	No. of Heifers	Heifers with Precocious Puberty (n)	(Percent[a])	Age at Puberty (Day)	Age at Anestrus (Day)	Duration of cycles (Day)
1990						
Bull Exposed	30	7	23.3	190±1.6	256±2.2	66±2.0
Non-exposed	30	8	26.7	220±2.4	292±2.7	73±1.8
1991						
Bull Exposed	30	3	10.0	164±2.5	210±2.5	46±2.4
Non-exposed	30	2	6.7	150±1.0	220±2.9	70±2.8

[a]The percentage of heifers exhibiting precocious puberty was affected by year ($P<0.02$).

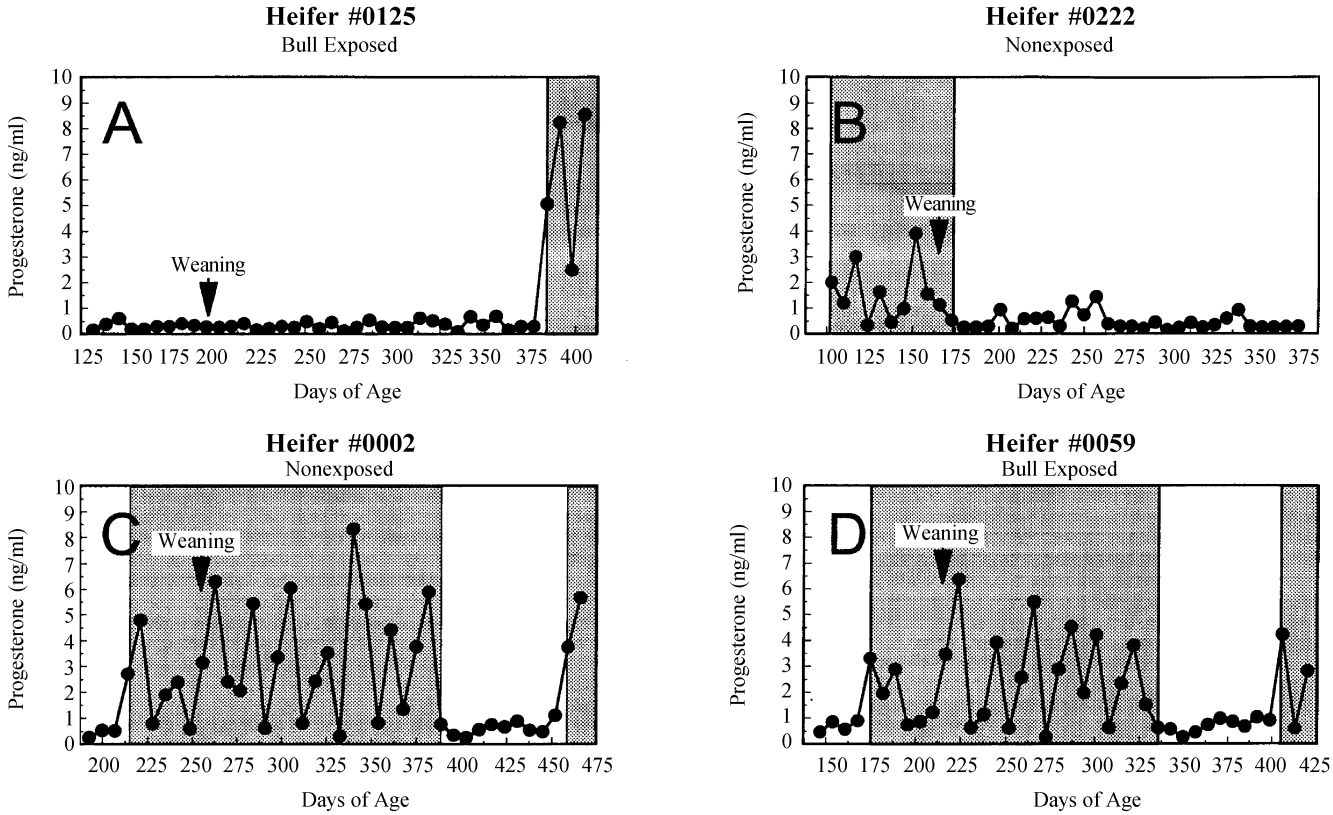

Figure 1. Representative progesterone profiles of developing beef heifers with either a normal (A) onset of luteal function or a precocious (B, C and D) onset of luteal function. Shaded areas identify periods of time when heifers were determined to have luteal function indicative of typical estrous cycles.

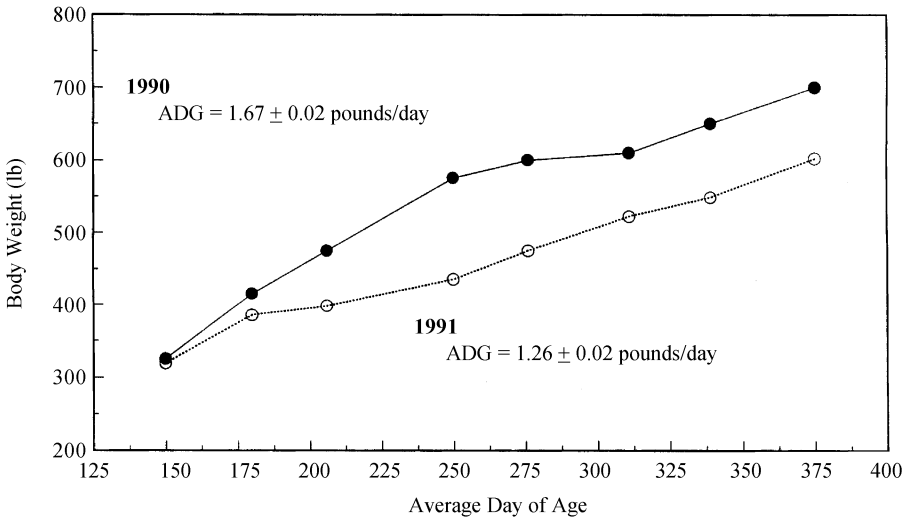

Figure 2. Average weight of developing beef heifers maintained on pasture and supplemented with a corn based diet and prairie hay.

heifers in which precocious puberty was detected. Heifer number 0222 (Figure 1B) had increased concentrations of progesterone at the initiation of the study at 100 days of age and would have had estrous cycles during the dams breeding season. However, this individual was in the non-exposed group and was not exposed to a fertile bull. In each heifer that exhibited a precocious puberty, there is a periodic increase in concentrations of progesterone indicative of cyclic luteal function. All heifers that did exhibit precocious puberty became anestrus for a period of time before the end of the study.

There was no affect of year on the time of initiation of precocious puberty (194 ± 12.4 days of age), duration of luteal function (65 ± 10.5 days) or the time of resumption of anestrus (260 ± 15.3 days of age). Figure 2 depicts the growth rate of the heifers during 1990 and 1991. During 1990, the availability of forage was much greater which likely resulted in heifers gaining a greater amount of weight during the 2 months after weaning compared to heifers in 1991. The increased growth rate resulted in an overall average daily gain of 1.67 ± 0.02 pounds/day compared to 1.26 ± 0.02 pounds/day. The greater growth rate after weaning resulted in heifers reaching approximately the same body weight at 275 days of age in 1990 compared to 375 days of age in 1991. The greater growth rate and overall body weight in 1990 could explain the increased incidence of precocious puberty in 1990 compared to 1991. At the completion of the study (402 ± 1.4 days of age), the percentage of heifers that had not initiated luteal function was 55% (33 of 60) in 1990 and 82% (49 of 60) in 1991.

The current study indicates precocious puberty does exist in developing beef heifers. The incidence of precocious puberty is not affected by the presence of a bull. In addition, the incidence of precocious puberty may be related to growth rate of the heifer around the time of weaning.

These studies indicate that the incidence of precocious puberty may be more related to internal cues and less responsive to environmental cues that are normally associated with the attainment of puberty. Precocious puberty does occur in developing heifers with as many as 25% of heifers exhibiting transient luteal function before 300 days of age. Therefore, producers should consider the possibility of precocious puberty in heifers when making management decisions such as prolonged breeding seasons or delayed castration of herd mates.

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Winter Temperatures May Affect Calf Birth Weights

David Colburn
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Pete Olson[1]

Summary

A 3-year study was conducted to evaluate effects of high and low air temperatures and wind chills during winter months on subsequent calf birth weights and calving difficulty of spring-born calves. Records on approximately 400 2-year-old heifers and their calves were used. Heifer and calf genetics were the same each year. Heifers were fed similar quality hay ad libitum each year before calving. High temperatures during the 1994-95 winter were 9 degrees higher than during the 1992-93 winter. The low temperatures were five degrees higher for 1994-95 compared to 1992-93. The greatest differences in monthly temperatures between years were found during December, January and February. Average temperatures for these three months increased 11°F over the three years. Average calf birth weights decreased 11 pounds (81 to 70) from 1993 to 1995. A 1:1 ratio was observed. Although calving difficulty was high due to the

(Continued on next page)

research design, it also decreased from 57% to 35% from 1993 to 1995. Results indicate that cold temperatures influenced calf birth weight. Weather cannot be controlled; however, with below average winter temperatures, larger birth weight calves and more calving difficulty may be expected in the spring.

Introduction

Calving difficulty incurred by 2-year-old heifers is a major problem. Research has shown the basic cause is a disproportion between the calf size at birth (birth weight) and the heifer's birth canal (pelvic area). Several factors affect calf birth weight, including genetics of sire and dam, dam nutrition, calf sex and climatic conditions. Weather conditions may have a significant effect on calf birth weight. When a pregnant animal is exposed to cold temperatures, blood is concentrated internally to maintain its core body temperature. Therefore, during prolonged periods of cold weather, the fetus may receive more nutrition because more blood flows to the uterus. Research has shown that blood flow is the primary determinant of nutrient uptake by the uterus.

Calf birth weights have been found to be heavier in northern climates than in southern climates. Research has also shown that calves born in summer and fall have lower birth weights with less calving difficulty than those born in late winter and early spring. The objective of this research was to determine how changes in climatic temperatures and wind chill during winter months influence calf birth weights in the spring.

Procedure

A study was conducted at the University of Nebraska, West Central Research and Extension Center (WCREC), North Platte to evaluate the effects of high and low air temperatures and wind chill during the winter months of 1992-93, 1993-94 and 1994-95 on birth weight of calves and calving difficulty during the following spring. Approximately 400 2-year-old heifers from the Gudmundsen Sandhills Laboratory (GSL), which were on a calving difficulty study, were used for this research. Heifers were at GSL from October through December, then moved to North Platte in January for spring calving. Heifers were MARC II breeding each year and artificially inseminated as yearlings to the same four Angus sires. Two sires had low birth weight EPDs and two sires had high EPDs to study calving difficulty. (Results of this study will be reported next year.) The heifers were fed and managed similarly each year. They were on native range at GSL until January and then fed bromegrass hay ad libitum with alfalfa hay as a supple-ment to meet NRC requirements at WCREC. Heifers had similar pre-calving body weights (968 $\pm$ 14 pounds), condition scores (5.1 $\pm$ .1), and pelvic sizes (244 $\pm$ 4 cm^2) each year.

Calving data included birth weight and date, calving difficulty, calf vigor plus five external measurements of the calves. The calving season lasted for 7 weeks each year from approximately February 9 to March 25. For the analysis, calf birth dates were divided into three 2-week periods. Period 1 included calf birth dates from February 9 to 22, Period 2 from February 23 to March 8, and Period 3 from March 9 to 25. Since only a few heifers calved during the seventh week, they were included with the sixth week.

Weather data were collected for three months (October, November, December) during 1992 to 1994 at the GSL weather station near Whitman and for three months (January, February, March) during 1993 to 1995 at the WCREC weather station near North Platte. Weather factors evaluated were high and low air temperatures and wind chill.

Data were analyzed by least squares analyses. High and low air temperatures and wind chill temperatures had main effects of month and year. Calf birth weights were analyzed by week, month and year with calf sire and sex removed. Calving difficulty percentages were tested by Chi-square analysis.

Table 1. Average high temperatures (°F) by month over the three winters

Month	Winter of 1992-93	Winter of 1993-94	Winter of 1994-95
October	49[a]	48[a]	62[b]
November	42[a]	42[a]	47[b]
December	33[a]	41[b]	44[b]
January	30[a]	35[a]	41[b]
February	31[a]	35[a]	49[b]
March	50[a]	59[b]	51[a]
Average	39[a]	44[b]	48[c]

[abc]Rows with unlike superscripts differ (P < .10).

Table 2. Average low temperatures (°F) by month over the three winters

Month	Winter of 1992-93	Winter of 1993-94	Winter of 1994-95
October	33[a]	14[b]	26[a]
November	19[ab]	16[b]	23[a]
December	10[a]	19[b]	17[b]
January	8[a]	13[b]	13[b]
February	6[a]	12[b]	19[c]
March	25	24	25
Average	16[a]	18[b]	21[c]

[abc]Rows with unlike superscripts differ (P < .10).

Results and Discussion

The high monthly temperatures for the three winters are shown in Table 1. Temperatures tended to increase from 1992-93 to 1994-95. The largest differences (P < .10) were between the winters of 1992-93 and 1994-95. The average high temperatures by winter period were 39, 44 and 48 °F for 1992-93, 1993-94 and 1994-95, respectively. Table 2 shows the low monthly temperatures for the three winters. As with the high temperatures, a trend existed for the low temperatures to increase from the first winter to the last. For the average low temperatures, the greatest differences (P < .10) were between the 1992-93 and 1994-95 winters.

After analyzing the temperature data, the greatest differences were found for the months of December, January and February, so the wind chill data were only analyzed for these three months. The average of the high and low air temperatures and wind chill for

Table 3. Average temperatures and wind chills (F°) by months over the three winters

Winters	December	January	February	Average difference
Avg. temperature				
1992-93	22[a]	19[a]	19[a]	
1993-94	30[b]	24[b]	23[a]	
1994-95	31[b]	27[b]	34[b]	
Largest difference[c]	+9	+8	+15	+11
Wind chill				
1992-93	12[a]	12[a]	13[a]	
1993-94	19[b]	17[a]	19[a]	
1994-95	21[b]	21[b]	26[b]	
Largest difference[c]	+9	+9	+13	+10

[ab]Columns within category with unlike superscripts differ (P < .10).
[c]Largest differences each month were between winters of 1992-93 and 1994-95.

Table 4. Calf birth weights and calving difficulty by 2-week calving periods over 3 years

Years	No. calves	Two-week calving periods[d] 1	2	3	Average difference
Calf birth weight (lbs)					
1993	138	79[a]	80[a]	85[a]	
1994	134	75[a]	76[b]	77[b]	
1995	112	69[b]	70[c]	73[b]	
Largest difference[e]		-10	-10	-12	-11
Calving difficulty (%)					
1993	138	49[a]	52[a]	77[a]	
1994	134	48[a]	51[a]	50[b]	
1995	112	24[b]	31[b]	55[b]	
Largest difference[e]		-25	-21	-22	-22

[abc]Columns within category with unlike superscripts differ (P < .10).
[d]Calving periods were: 1 - Feb. 9 to 22; 2 - Feb. 23 to Mar. 8; 3 - Mar. 9 to 25.
[e]Largest differences each calving period were between years 1993 and 1995.

the three months are shown in Table 3. The largest differences (P < .10) were between the winters of 1992-93 and 1994-95 for each month. During December, the average temperature was nine degrees higher for the last winter compared to the first, with eight °F difference in January and 15 °F in February. The overall increase in temperatures was 11°F between the two winters. Wind chills were also considerably different (P < .10) between the two winters for each of the months. The winter of 1994-95 was quite warm compared to the winter of 1992-93 with an overall higher wind chill temperature of 10 °F. This difference in temperature was obvious to most beef producers as they described the winter of 1992-93 as severely cold compared to that of 1994-95 as quite mild.

Calf birth weights by 2-week periods for the three years are shown in Table 4. Significant differences (P < .10) were found between 1993 and 1995 for each period, with birth weights decreasing an average of 11 lb (81 versus 70 pounds, respectively). Percentage of calving difficulty is also shown in Table 4. There were significant differences (P < .10) between 1993 and 1995 for each calving period, with an average decrease of 22%. Beef producers in Nebraska also reported having greater calving difficulty in 1993 compared to 1995 due to several reasons including larger calves.

This research helps explain the changes in calf birth weight and calving difficulty experienced by beef producers over various years. Our data showed calf birth weights were an average of 11 lb lighter in 1995 compared to 1993, along with a decrease of 22% in calving difficulty, while average air temperatures and wind chills were 10 to 11 degrees warmer in 1995. These data show a 1:1 ratio between the changes in temperature and calf birth weights. Therefore, these results support the theory that weather conditions do affect calf birth weights. Heifers do consume more hay during colder temperatures which can increase nutrients to the fetus; however, research indicates calf birth weights may change only a couple of pounds. Increased blood flow to the uterus due to cold temperatures is thought to be the major factor increasing fetal growth.

It appears from this data set that the months of December, January and February (which had the coldest temperatures) had the greatest affect on fetal growth. Calf birth weights each year were heavier at the end of the calving season compared to the beginning (Table 4). This may indicate that heifers that calved in February endured a shorter period of cold temperatures and had lighter calves than heifers calving in March.

Other factors which could have influenced heavier calves in March would be longer gestation lengths, more male calves, and/or a higher level of nutrition to the heifers. Average calf gestation length was not different between the calving periods. Also, the influence of calf sex was removed by statistical analysis. Heifers calving in March had a slightly longer precalving feeding period, but the effects on calf birth weight would have been small.

More research is needed to confirm these findings. However, if a cold winter is experienced, producers may expect heavier calves at birth and more calving difficulty. Providing wind protection or shelter to heifers during the winter would reduce the wind chill effects and may be beneficial at calving.

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Evaluation of Animal Byproducts for Escape Protein Supplementation

Daniel Herold
Terry Klopfenstein
Mark Klemesrud[1]

Summary

Animal byproduct meals were obtained to determine the influence of raw materials and processing conditions on escape protein, protein digestibility, and other measures defining feed value. Escape protein was estimated using both polyester bags in situ and ammonia release in vitro. Lambs were used as a model for cattle to estimate true protein digestibility in vivo. Correlations were performed to test relationships between byproduct characteristics and protein ruminal degradation, and intestinal digestion. Product raw materials (based on ash content) were more related to protein availability than processing temperatures in this study. Escape protein values determined by in situ analysis were highly correlated (r = .92) to escape values determined by ammonia release. However, incubation in situ may overestimate protein degradation due to DM exiting the bag while rinsing. Meat and bone meal ash content was related to both in situ escape protein (r = .51) and escape protein determined through ammonia release (r = .44). Results of this study indicate that animal byproduct meals vary in escape protein but the protein is generally highly digested.

Introduction

Blood meal, meat and bone meal, and feather meal are high in escape protein, relative to oil meals and forages, and increase performance when included in forage-based diets sufficient in rumen degradable protein. Two factors that influence the nutritive value of animal byproduct meals are processing conditions and raw materials.

Renderers apply heat to drive off moisture, extract fat, and eliminate bacterial contamination from animal tissues. This cooking also denatures proteins, creating cross links and insoluble bonds within and between protein chains; enhancing resistance to microbial degradation in the rumen. However, processing at very high temperatures can limit the extent of enzymatic breakdown of proteins, reducing digestibility and absorption in the small intestine.

Variable inputs (deadstock, tankage, meat trimmings and bones) contribute to the great diversity encountered in commercial meat and bone meals. Concentration of meat and bone meal components, specifically bone, hair, and lean tissues, influence protein quantity and quality. Bone content, exhibited through ash, is negatively correlated with crude protein, whereas hair is high in protein but poorly digested. Animal performance with meat and bone meal supplementation has been inconsistent, and may result from inadequate escape protein and(or) poor protein digestibility arising from raw materials or processing conditions.

The objectives of this study were to determine how processing temperature and composition of animal byproduct meals influence in vivo true protein digestibility and escape protein concentrations, and to compare in situ and in vitro ammonia release techniques for measuring escape protein.

Procedure

Meat and bone meal from various species (n = 36), feather meal (n = 9) and blood meal (n = 2) samples were obtained from renderers throughout the United States, and represent various processing conditions and raw material inputs which generate commercially available meals. All samples were incubated in situ and in vitro to estimate escape protein, ashed at 1,112 °F to determine mineral content, and fed to lambs to determine ruminant protein digestibility in vivo.

The results of several lamb digestibility trials were compiled to generate a large data set. Soybean meal and corn gluten meal were included to serve as standards of comparison for crude protein digestibility. In each experiment, individually fed lambs were assigned randomly to treatments, and at least five observations were obtained for each protein source. Fecal samples were acquired during a seven-day collection period which immediately followed a 10-day adaptation phase. Control lambs consumed a basal diet DM consisting of 72.7% ensiled corncobs, 15% alfalfa pellets, 10% finely ground corn, 1.48% urea, and .82% supplemental minerals and vitamins.

To determine true protein digestibility, treatment lambs consumed the basal diet at the same percentage of

body weight (DM basis) as control lambs, with an additional 3.75% of the basal diet DM intake as units of CP from an animal byproduct meal. Test protein sources comprised 27% of the total CP intake for treatment lambs, and were individually weighed and hand-mixed into the basal diet at the time of feed-ing. Apparent CP digestibility was calculated for control animals: {(CP consumed - CP excreted)/CP consumed}. Subsequently, true protein digestibility of animal byproducts was computed using the following formula: (A-(B*C))/D, where: A = digestibility of CP in total treatment diet; B = digestibility of CP in basal feed; C = proportion of total CP in diet supplied by basal feed; and D = proportion of total CP in diet supplied by treatment protein.

Escape protein was determined using both in situ, and in vitro ammonia release techniques. For in situ analysis, four grams of each protein source were weighed into polyester bags in duplicate. Bags were ruminally-incubated for 12 hours using a mature crossbred steer. The animal was adapted to a cool season grass hay diet, and was fed immediately after placement of the bags. Upon removal from the rumen, bags were hand washed in warm water until the rinse water was clear to remove contamination. Escape protein was calculated as the percentage of CP remaining after 12 hours of incubation.

In the ammonia release procedure, triplicate samples of each byproduct containing 20 mg N were weighed into 50 ml in vitro tubes. Soybean meal and treated soybean meal (Soypass) were included to serve as standards for computing escape protein. Rumen contents collected from two ruminally fistulated steers, consuming either grass hay or ground corncobs, was strained through cheese cloth, mixed, and combined with McDougall's buffer in a 1:1 ratio. This inoculum was maintained at 102°F under a constant stream of CO_2, while 30 ml was dispensed into each tube. Following incubation for 18 and 24 hours in a 102°F water bath, tubes were centrifuged and the supernate analyzed for ammonia concentration. Ammonia content as a percent of total N was assessed for each test protein, and compared to the soybean meal standards, in which the escape protein content was known (30 and 78%). This calculation provided a relative degradability, and allowed an estimate of escape protein based on soybean meal equivalence.

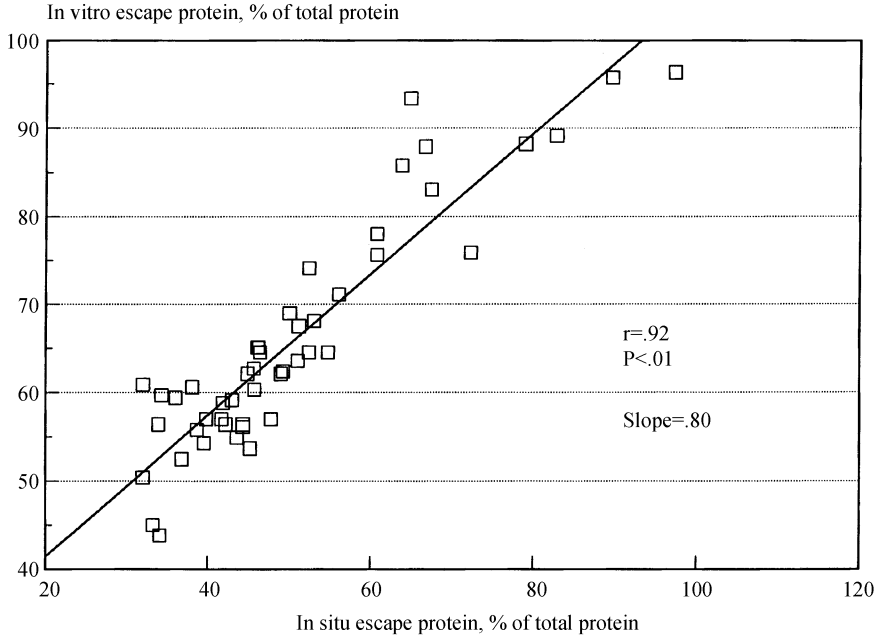

Figure 1. Correlation of soybean meal equivalent value, obtained through ammonia release, and in situ escape protein for meat and bone, and poultry byproduct meals.

Metabolizable protein (MP) and escape protein digestibility (EPD) were determined for individual animal byproducts using computed values for escape protein (EP) and true nitrogen digestibility (TND). Metabolizable protein was calculated as EP - (100-TND), and is the portion of crude protein which escapes microbial degradation and is digested in the small intestine. Escape protein digestibility was determined by dividing MP by EP. Correlations were used to detect relationships between measured and computed values for animal byproducts. Effect of processing temperature on protein availability was tested using the GLM procedure of SAS, with samples separated into low or high temperature groups.

Results

Processing temperatures were known for fifteen of the meat and bone meals. Fourteen of these products stemmed from seven individual batches obtained from different producers. These batches were divided, and the same raw materials were processed at a low and high temperature. Low and high mean processing temperatures were 249°F and 286°F, respectively. Temperature did not influence TND, EP, EPD, or MP, and no significant correlations were exhibited ($P > .05$). Processing temperatures of materials in this study were not to the extreme which would substantially decrease protein digestibility. However, they are within the range routinely used in the rendering industry.

In vitro ammonia release and in situ incubation were highly correlated as measures of escape protein. However, calculations of escape protein based on ammonia release exhibited higher values than those determined in situ, especially in products with higher degradability (Figure 1). This may have been the result of DM loss from the

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Table 1. Summary of analyses and calculated values for animal byproducts

Item (n)	Ash[a]	Crude protein[a]	Escape protein[b]	True nitrogen digestibility	Metabolizable protein[c]	Escape protein digestibility[d]
MBM+PBM[e] (36)			In situ			
Range	12.3 - 50.6	39.5 - 69.5	32.0 - 56.1	76.4 - 97.8	18.6 - 46.5	52.1 - 95.2
Mean	27.2	54.6	43.5	87.8	31.3	72.0
SD	9.3	7.2	6.7	5.2	7.0	10.9
			NH_3 Release[f]			
Range			43.8 - 74.1		31.1 - 58.7	61.1 - 96.4
Mean			59.5		47.4	79.6
SD			6.4		7.0	8.4
Feather meal (9)						
Range	1.2 - 3.1	81.7 - 92.1	50.0 - 82.8	80.8 - 94.9	34.1 - 74.8	68.2 - 93.0
Mean	2.4	86.8	67.1	87.8	54.9	80.7
SD	.7	3.7	10.0	5.2	14.1	9.9
Blood meal (2)						
Range	1.9 - 3.6	82.1 - 93.5	89.6 - 97.3	84.9 - 86.0	75.6 - 82.2	84.4 - 84.5
Mean	2.7	87.8	93.5	85.5	78.9	84.4
SD	1.2	8.1	5.4	.8	4.7	.1
Soybean meal (2)						
Range	7.3 - 7.8	42.8 - 49.3	30.0 - 31.6	91.4 - 91.7	21.7 - 23.0	72.3 - 72.7
Mean	7.5	46.1	30.8	91.6	22.4	72.5
SD	.3	4.6	1.1	.2	.9	.3
Corn gluten meal (1)						
	1.7	63.9	64.9	96.7	61.6	94.9

[a]Expressed as a percentage of dry matter.
[b]Percentage of crude protein remaining after 12 hours ruminal incubation, in situ unless otherwise indicated.
[c]Calculated as: escape protein - (100 - true nitrogen digestibility).
[d]Calculated as: (metabolizable protein/escape protein) x 100.
[e]Meat and bone meal (MBM), poultry byproduct meal (PBM).
[f]Soybean meal equivalent value.

polyester bags during the in situ washing procedure; therefore, underestimating the escape protein content of meat and bone and poultry byproduct meals. Correlations were conducted using escape values obtained through ammonia release, as these were considered to be more accurate estimates. Table 1 summarizes values for measured variables and product components, and illustrates the disparity in values between in vitro ammonia release and in situ procedures.

Ash content of meat and bone meal exhibited a positive relationship with escape protein (r = .44, $P < .01$). Protein identified with bone is comprised predominantly of collagen, and may be more resistant to degradation by ruminal microorganisms than protein in lean tissues. Although ash concentration was related to microbial protein degradation, it had no significant negative relationship to TND (r = -.26, $P = .13$). This suggests the protein associated with bone is adequately digested in the ruminant small intestine. Although ash content was positively related to escape protein, a relationship was not observed between ash and MP (r = .20, $P = .22$).

True nitrogen digestibility of meat and bone meal did not exhibit a strong negative correlation with escape protein (r = -.28, $P = .09$), but the accompanying probability level suggests a negative relationship may exist. High escape protein content in meat and bone meal may stem from either processing technique or raw materials. Unhydrolyzed hair is known to bypass the rumen, and is very resistant to enzymatic degradation. Contamination with hair could explain this correlation, although in the absence of a direct measure, we are unable to make this conclusion.

The digestibility of the escape protein in meat and bone and poultry byproduct meals ranged from 61 to 96%. Only 4 of the 36 samples were below 70%. The average escape protein digestibility of the meat and bone and poultry byproduct meals was equal to that of soybean meal.

Hydrolyzed feather meal samples ranged from 68 to 93% digestibility of the escape protein. Escape values ranged from 50 to 83%.

Metabolizable protein is the protein calculated to be absorbed as amino acids from the small intestine. These MP values ranged from 31 to 59% for meat and bone and poultry byproduct meals. Feather meals ranged from 34 to 75%. This suggests that there is an opportunity to select sources of these products with higher feeding values.

This study indicates meat and bone meal, feather meal, and blood meal possess adequate protein digestibilities, when properly processed, which are comparable to soybean meal and corn gluten meal. Raw materials (based on ash contents) were correlated with measures of feed value of animal byproducts in our evaluation more than processing temperature, and in situ incubation may not be the appropriate means to determine escape protein content of meat and bone meals.

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[1]Daniel Herold, research technician, Terry Klopfenstein, Professor, Mark Klemesrud, research technician, Animal Science, Lincoln.

Treated Meat and Bone Meal and Rumen Protected Methionine and Tryptophan for Growing Calves

Mark Klemesrud
Terry Klopfenstein[1]

Summary

Two calf growth trials determined the effects of feeding meat and bone meal treated by the non-enzymatic browning reaction with sulfite liquor. For both trials, protein efficiencies tended to be greater for treated meat and bone meal relative to the untreated controls. Escape protein, estimated from 24-hour ammonia release, was also greater for treated meat and bone meal. Addition of rumen protected methionine to meat and bone meal resulted in a significant increase in protein efficiency. These data indicate treatment of meat and bone meal by non-enzymatic browning with sulfite liquor is a feasible means of increasing escape protein value and protein efficiency in growing calves. However, methionine still remains the first limiting amino acid.

Introduction

To optimize production in growing calves, escape protein is often supplemented to meet the animal's metabolizable protein requirement. Meat and bone meal (MBM) is a rendered animal byproduct often used as a source of escape protein. However, previous studies have shown a lower protein efficiency for MBM relative to blood meal. This has been attributed to the escape protein and/or amino acid composition of MBM being inadequate to meet the specific needs of the growing calf. Collagen, which can comprise a fraction of MBM protein, contains negligible amounts of the essential amino acids methionine and tryptophan.

Recent research has identified methionine as the first limiting amino acid in MBM. Efficiency of protein utilization was greater in steers consuming MBM plus rumen protected methionine than for MBM alone. Rumen protected methionine and lysine did not improve protein efficiency over methionine alone, suggesting MBM contained adequate lysine.

Two methods for increasing the flow of methionine to the small intestine are supplementation with a rumen protected form of methionine, or increasing the amount of methionine from MBM that escapes ruminal degradation. While non-enzymatic browning of soybean meal with sulfite liquor has been successful in increasing the escape protein value from 30% to 75%, the value of this procedure in increasing the escape protein of MBM remains undetermined.

The objectives of this research were to evaluate MBM treated by non-enzymatic browning with sulfite liquor as a protein source, and the effects of rumen protected methionine on protein efficiency in growing calves.

Procedure

Two calf growth trials were conducted using MBM and MBM treated with sulfite liquor. Trial 1 was conducted using 60 steer calves (535 lb) individually fed diets (DM basis) of 44% corn silage, 44% corncobs, and 12% supplement (Table 1). Steers were assigned randomly to treatment and level of treatment protein. Treatments consisted of: 1) urea (control); 2) MBM; 3) Treated MBM; 4) MBM plus rumen protected methionine; 5) Treated MBM plus rumen protected methionine. Protein sources were fed at 20, 30, 40, and 50% of the supplemental nitrogen, with urea supplying the remainder. Therefore,

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Table 1. Supplement composition for Trial 1 (% DM basis).

	Supplement[a]				
Ingredient	Urea	MBM	Treated MBM	MBM+Met	Treated MBM+Met
Meat and bone meal	—	39.7	—	39.7	-
Treated meat and bone meal	—	-	38.7	—	38.7
Urea	15.8	9.0	9.0	9.0	9.0
Soybean hulls	71.4	46.3	47.3	45.8	46.8
Smartamine M	—	-	—	.5	.5
Dicalcium phosphate	7.8	—	-	—	-
Salt	2.5	2.5	2.5	2.5	2.5
Ammonium sulfate	1.7	1.7	1.7	1.7	1.7
Trace mineral premix	.4	.4	.4	.4	.4
Vitamin premix	.3	.3	.3	.3	.3
Selenium premix	.1	.1	.1	.1	.1

[a]Meat and bone meal, treated meat and bone meal, meat and bone meal plus protected methionine, and treated meat and bone meal plus protected methionine, mixed with urea supplement to supply 20, 30, 40, or 50% of supplemental protein.

Table 2. Supplement composition for Trial 2 (% DM basis).

Ingredient	Supplement[a]		
	Urea	MBM	Treated MBM
Meat and bone meal	—	59.4	—
Treated meat and bone meal	—	—	59.4
Urea	15.7	5.8	5.8
Soybean hulls	71.6	28.8	28.8
Smartamine M	—	.4	.4
Promate T	—	.6	.6
Dicalcium phosphate	7.7	—	—
Salt	2.5	2.5	2.5
Ammonium sulfate	1.7	1.7	1.7
Trace mineral premix	.4	.4	.4
Vitamin premix	.3	.3	.3
Selenium premix	.1	.1	.1

[a]Meat and bone meal and treated meat and bone meal, mixed with urea supplement to supply 30, 40, 50 or 60% of supplemental protein.

regardless of the assigned level, all steers consumed a diet containing 11.5% CP (DM basis). Rumen protected methionine was included by feeding 3.5 grams/day of Smartamine M™ (Rhône-Poulenc Animal Nutrition, Atlanta, GA), which supplied 2.2 grams/day metabolizable methionine at the highest level fed and proportionally less for the other levels.

Trial 2 was conducted using 24 steer calves (606 lb) individually fed diets of 44% sorghum silage, 44% corncobs, and 12% supplement (Table 2). Steers were assigned randomly to treatment and level of treatment protein. Treatments consisted of: 1) urea (control); 2) MBM; 3) Treated MBM. Protein sources were fed at 30, 40, 50, and 60% of the supplemental nitrogen, with urea supplying the remainder. Rumen protected methionine and tryptophan were included in both MBM treatments so that protein efficiency could be evaluated without being limited by methionine or tryptophan content. 2.8 grams/day of Smartamine M™ supplied 1.8 grams/day metabolizable methionine, and 4.0 grams/day of Promate T (Showa Denko, Tokyo, Japan) supplied 1.0 grams/day metabolizable tryptophan at the highest level fed and proportionally less for the other levels.

All steers were implanted with Compudose on day 1. For each trial, steers were individually fed (at an equal percentage of body weight) once daily using Calan electronic gates. Weights were collected before feeding on three consecutive days at the beginning and end of each 84-day trial. Protein efficiency, calculated as gain above the urea control vs natural protein intake, was plotted for each treatment using the slope-ratio technique.

For each trial, material for the treated MBM was collected from the same run of rendered material as the untreated MBM to keep the composition of the products as homogeneous as possible. The MBM products differed between trials, with the treated MBM used in Trial 2 being processed more extensively for a greater escape protein value. The escape protein values of the MBM products were determined by 24-hour in vitro ammonia release. A lamb digestion trial was conducted to determine the true protein digestibility of the MBM products relative to a urea control.

Results

Trial 1

Averaged across level of protein fed, differences in daily gain and feed efficiency approached significance (P=.12 and .15, respectively; Table 3). The urea control steers gained 1.57 lb/day, while maximum gain due to protein supplementation, determined by nonlinear regression, was .78 lb/day above the urea controls (2.35 lb/day).

There was no MBM source x methionine supplement interaction so results were pooled for analysis of protein efficiency. Sulfite liquor treated MBM tended (P=.15) to be used with greater efficiency of protein utilization than untreated MBM (1.35 vs 1.19), suggesting treated MBM was higher in escape protein than untreated MBM. This is consistent with laboratory ammonia release values in which untreated MBM had an escape value of 51.9% while treated MBM had an escape value of 66.0%.

True protein digestibility of untreated MBM in lambs was 93.9%, while treated MBM was 94.8%. Overheating during processing, which has been blamed for reduced N digestibility, did not appear to be a problem for either MBM. This indicates that while non-enzymatic browning with sulfite liquor increased escape protein value of MBM, it did not affect protein digestion.

Methionine supplementation increased (P<.10) protein efficiency

Table 3. Performance of steers fed meat and bone meal[a], Trial 1.

Supplement[b]	Daily gain, lb[c]	Daily DMI, % body weight	Gain/ feed[d]
Urea	1.57	2.08	.130
MBM	1.62	2.08	.133
Treated MBM	1.59	2.08	.130
MBM+Met	1.79	2.08	.145
Treated MBM+Met	1.72	2.08	.139

[a]Averaged across protein levels.
[b]Meat and bone meal, treated meat and bone meal, meat and bone meal plus protected methionine, and treated meat and bone meal plus protected methionine.
[c]P=.12.
[d]P=.15.

Table 4. Performance of steers fed meat and bone meal[a], Trial 2.

Supplement[b]	Daily gain, lb	Daily feed, % body weight	Gain/ feed
Urea	.39[c]	1.84	.034[c]
MBM	.85[d]	1.84	.073[d]
Treated MBM	.98[d]	1.84	.084[d]

[a]Averaged across protein levels.
[b]Meat and bone meal, and treated meat and bone meal.
[c,d]Values in the same column with different superscripts differ (P<.05).

in steers consuming MBM (1.62 vs .86), indicating that methionine is the first limiting amino acid in MBM. Based on protein and amino acid composition of live weight gain, the 2.2 grams of metabolizable methionine supplied at the highest level of protein supplementation is adequate for .50 lb of gain, while the difference in gain was only .23 lb. This would suggest that once the requirement for methionine was met, another amino acid likely limited the potential for growth. Tryptophan, because of its reported low concentration in MBM, may have become limiting.

Trial 2

Steers that received the untreated and treated MBM supplements gained .85 and .98 lb/day, respectively, which were greater (P<.05) than the .39 lb/day gained by the urea control steers (Table 4). The increase in gain was due to additional metabolizable protein (MP) supplied by these MBM supplements. Feed efficiency was also greater (P<.05) for these treatments (Table 4) due to the increase in gain since daily feed intake was equal for all treatments.

Protein efficiency was numerically greater for treated MBM than untreated MBM (2.55 vs 1.58, respectively), however this difference was not statistically significant due to a large standard error. The trend, however, would suggest a greater escape protein value for treated MBM which is consistent with measured escape protein values, determined by ammonia release, of 49.5% and 71.4% for untreated MBM and treated MBM, respectively.

The greater protein efficiency and escape protein values for the treated MBM used in trial 2 relative to trial 1 would suggest the more extensive processing was beneficial. Likewise, the greater protein efficiency of the untreated MBM used in trial 2 relative to trial 1, despite its lower escape protein value, could be due to the addition of both rumen protected methionine and tryptophan.

Results of this research indicate treatment of MBM by non-enzymatic browning with sulfite liquor is a feasible means of increasing escape protein value and protein efficiency in growing calves. The added response to protected methionine suggests methionine is the first limiting amino acid in MBM. It is not possible to determine from this research if tryptophan is the second limiting amino acid.

To make the best use of treated MBM, adequate supplies of methionine or sulfur containing amino acids (SAA) should be assured. Corn protein is a good source of methionine so corn gluten meal or distillers grains would complement treated MBM. Obviously high corn diets would also have good supplies of methionine. Feather meal is a good source of SAA but much is in the form of cystine rather than methionine. Feather meal should complement treated MBM but it is not clear just how effectively cystine can replace the methionine requirement. Finally, protected methionine is an effective means of supplementing treated MBM to assure adequate methionine supplies.

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[1]Mark Klemesrud, research technician; Terry Klopfenstein, Professor, Animal Science, Lincoln.

Dried Poultry Waste as a Nonprotein Nitrogen Source for Ruminants

Sheri Bierman
Terry Klopfenstein
Rick Stock
Dan Herold[1]

Summary

Two trials were conducted to evaluate the use of dried poultry waste as a source of degradable intake protein in growing and finishing ruminant diets. Trial 1 utilized eighty-eight crossbred lambs (62 lb) in a 60-day growing period and subsequent 60-day finishing period. In the growing period, lambs were fed seven levels of degradable intake protein, 5.6 to 7.7% of diet DM (7.6 to 9.7% CP) from either urea or dried poultry waste. In the finishing period, lambs (71 lb) were fed a control diet containing no added N, 5.1% degradable intake protein (9.6% CP) or six levels of degradable intake protein, 5.7 to 8.5% (10.1 to 12.6% CP) from either urea or dried poultry waste. In the growing phase, no response to level of degradable intake protein was observed. Feed efficiencies for urea and dried poultry waste were equal. In the finishing phase, dried poultry waste was equal to urea as a source of degradable intake protein. In Trial 2, four ruminally-fistulated

(Continued on next page)

crossbred yearling steers (642 lb) were used to evaluate rumen ammonia concentration from feeding dried poultry waste or urea. Steers were ruminally dosed with .08 lb of nitrogen from either urea or dried poultry waste. Steers dosed with urea had greater ammonia concentrations at two and four hours compared to those dosed with dried poultry waste. Dried poultry waste was utilized as efficiently as urea in growing and finishing lamb trials and concentration of ammonia in the rumen was less for dried poultry waste.

Introduction

Waste management is a concern of the livestock and poultry industries and feeding waste products to animals is a management tool that can be used. Research has shown that consumption of poultry waste by ruminants results in a higher recovery of nutrients than use as fertilizer. Dried poultry waste (DPW) contains an average of 28% CP, of which 54% is true protein with the remainder mostly in the form of rumen degradable uric acid.

Dried poultry waste can be used in supplements for both growing and finishing diets. The value of DPW in ruminant feeding programs has not been critically evaluated. The objective of this experiment was to determine if DPW is a viable source of degradable intake protein for growing and finishing diets.

Procedure

Trial 1 — Growing-Finishing

Thirty-four ewes and fifty-four crossbred wethers (62 lb ± 1.9) were randomly assigned to one of 14 treatments for a 60-day growing period. Treatments consisted of seven levels of degradable intake protein (DIP) from either urea or DPW, 5.6% to 7.7% DIP (7.6 to 9.7% CP). Diets were a 50:50 mixture of ensiled corncobs and corn silage that made up 89% of the diet DM, the remainder of the diet was dry rolled corn and mineral supplement. Diets were balanced to be isocaloric and contain a minimum .7% calcium and .35% phosphorus. For the different treatment levels, urea and DPW supplied 40 to 60% of total dietary N (DM basis). The diets for low and high treatment levels were mixed once weekly and appropriate amounts of each diet were mixed for each lamb in order to obtain the proper treatment level. The amount of DIP consumed by each lamb was calculated based on amount of degradable protein from DPW or urea, ensiled corncobs, and corn silage. The lambs were weighed on three consecutive days at beginning and end of 60-day period. Three days before the final weights, lambs were fed 2.1% (DM basis) of BW to reduce differences in gut fill.

The same eighty-eight lambs (71 lb ± 2.6) were used in 60-day finishing period. Lambs were randomly assigned to 13 treatments, which included a diet containing no supplemental N, 5.1% DIP (9.6% CP) or six levels of DIP from either urea or DPW, 5.7 to 8.6% DIP (10.1 to 12.6% CP). Diets were based on dry rolled corn, alfalfa, ensiled corncobs, molasses, and mineral supplement and balanced to be isocaloric and contain a minimum of .7% calcium and .35% phosphorus. Urea and DPW supplied 0 to 34% of total dietary N (DM basis). The control and highest treatment level diets were mixed once weekly. Appropriate amounts of each diet were mixed for each lamb to obtain the proper treatment level. The amount of DIP consumed by each lamb was calculated based on amount of degradable protein from DPW or urea, corn, corn silage, and alfalfa consumed by each lamb. Lambs were weighed on three consecutive days at the beginning and end of the period. Beginning weights were the ending weights from the growing period.

Degradable intake protein efficiency was assessed using the slope ratio technique and determined by regression of feed efficiency on DIP. Individual slopes of DPW and urea protein efficiencies were analyzed statistically with a two tailed t-test.

Trial 2 — Metabolism

Four ruminally-fistulated crossbred yearling steers (642 lb) were used. The steers were assigned to treatments according to a 4 x 4 Latin square design. Dietary treatments were: two growing rations balanced for 7.0% DIP (9.0% CP) supplemented with either DPW or urea; two finishing rations balanced for 9.7% DIP (12% CP) supplemented with either DPW or urea. The growing rations consisted of 44% corn silage, 44% ensiled corncobs, 9% dry rolled corn, and 3% supplement. The finishing rations consisted of 79% dry rolled corn, 5% corn silage, 5% alfalfa hay, 8% molasses, and 3% supplement. All diets were balanced to contain a minimum of .70% calcium, and .30% phosphorus. The growing diet included 25 g/ton Rumensin and the finishing ration included 25 g/ton Rumensin and 10 g/ton Tylan. Each steer had a 10-day adaptation period to diets containing either urea or DPW when the percentage of body weight each steer would consume was determined. After 10 days, steers were fed, at their determined percentage of body weight, a diet that contained no urea or DPW for 36 hours before sample collection. The diet was fed at 2-hour intervals throughout the sample collection period.

After the 36-hour period, 40 grams of N (quantity of urea consumed if fed the urea supplemented diet) from urea or DPW were intraruminally dosed into each steer. Rumen fluid was collected at 0, 2, 4, 6, 8, 12, and 16 hours after dosing. Ruminal pH was measured immediately after collection.

Ammonia concentrations were statistically analyzed using the GLM procedures of SAS as repeated measures. Each steer was an experimental unit with period, steer, and treatment as sources of variation and time as the repeated measure.

Results

Treatments were formulated to contain increasing increments of DIP, therefore the calculated intakes of

degradable protein were different ($P < .05$) among treatment levels for both urea and DPW treatments in the growing period. Dry matter intake was not significantly different among treatments. Data analyzed as nonlinear regression showed no response to level of DIP. Average gain/feed (.08) of the lambs consuming DPW and urea were equal.

To observe a protein response, DIP must be fed below the lamb's requirement. The 5.6% DIP treatment was apparently not below the lambs requirement when consuming this growing diet. The DIP requirement for the lambs was estimated before the trial using TDN of the diet times the efficiency of rumen microbes to convert energy to microbial crude protein (MCP). It has been estimated that the efficiency of rumen microbes to convert energy into MCP is 13%. The diet in this trial contained 61% TDN so the estimated DIP requirement was 7.9%. However, we did not observe a response to the 5.6% DIP level, indicating a lower efficiency should have been utilized or recycling of N to the rumen is greater than predicted.

During the finishing period lambs were fed a DIP level below the requirement, resulting in a numerical increase in efficiency due to level of DIP. Numerically less DIP was required from DPW to reach maximum efficiency compared to urea (Figure 1). The efficiency with which lambs utilized the N in DPW and urea are indicated by slopes of .043 and .031, respectively. These slopes were not different ($P > .10$).

The DIP requirement for finishing lambs was calculated as previously described. However, a lower rumen microbial efficiency to convert energy to MCP was used. The DIP required for lambs on the finishing diets was calculated as 85% TDN times 8.03% microbial efficiency compared to a forage diet. An efficiency of 8.03% was used because a high concentrate diet has a lower rumen pH and reduced microbial efficiency compared to a forage diet. Therefore, the DIP requirement for lambs consuming the finishing diets was 7%. The results from this trial indicate DIP requirements were 6% for DPW and 6.3% for urea.

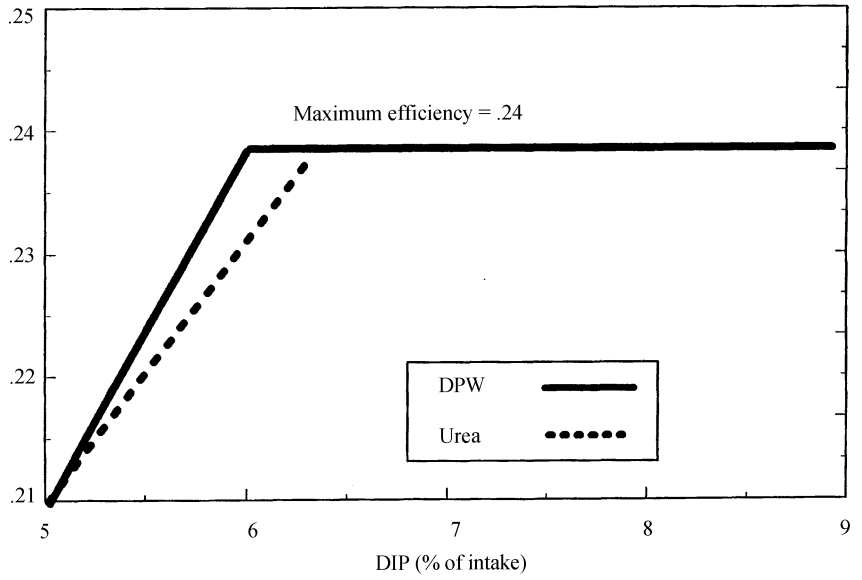

Figure 1. Nonlinear regression of feed efficiency on degradable intake protein for finishing period.

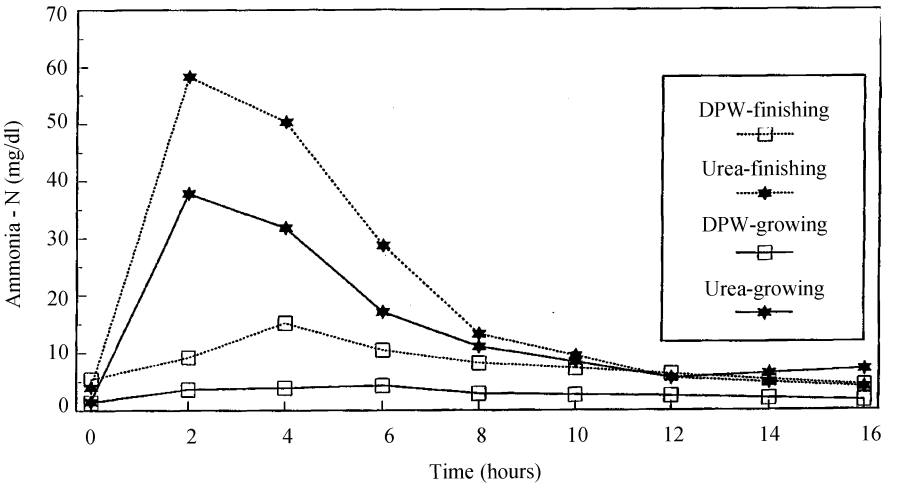

Figure 2. Ruminal ammonia concentration from dosing DPW or urea when feeding growing or finishing diets.

The feed efficiencies for lambs receiving finishing diets supplemented with DPW or urea above the DIP requirement were equal, (.24) as were daily gains (.69 lb/day). Dry matter intakes were not different among treatments.

In the metabolism trial, steers dosed with urea had higher ammonia concentrations ($P < .03$)and ruminal pH ($P < .10$) 2 and 4 hours after dosing than steers dosed with DPW (Figure 2). Thus urea provided a greater concentration of ammonia for the rumen microbes quickly, while DPW provided ammonia at a low concentration over time.

Results from these trials indicate that DPW is an acceptable source of rumen degradable protein for ruminants. The two trials indicate that DPW is efficiently utilized by rumen microbes in both growing and finishing diets, and can be used to meet the animals' degradable intake protein requirement.

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[1]Sheri Bierman, graduate student; Dan Herold, research technician; Terry Klopfenstein and Rick Stock, Professors, Animal Science.

Manipulation of Microbial Protein Degradation in the Rumen: Development of the "Smugglin Concept" to Control Protein Digestion

Humberto Madeira
Mark Morrison[1]

Summary

One approach that might slow down ruminal protein degradation is the "smugglin concept", which involves incorporation of growth-inhibitory compounds into larger molecules (peptides) that are normally transported by protein-degrading rumen microorganisms. The effects of peptides containing toxic amino acid analogs, as well as the polycationic peptide salmine, on the growth of ***Prevotella ruminicola*** *were assessed. Results obtained indicate that the smugglin concept may be applicable for the study and manipulation of peptide metabolism by P. ruminicola and, probably, other peptide-fermenting bacteria in the rumen. Such manipulation could be used to control protein digestion in the rumen.*

Introduction

It has been estimated that as much as 25% of the protein fed to grazing and forage-fed animals is wasted due to its rapid degradation by the rumen microorganisms. Therefore, from an economic and environmental perspective, the nitrogen cycle of intensive livestock systems could be managed more effectively. Compounds such as ionophores can reduce ruminal ammonia production, but their anti-bacterial effects are too broad for its widespread use with grazing and forage-fed livestock. Another strategy to manipulate the activities of rumen bacteria responsible for protein degradation is the "smugglin concept". The "smugglin concept" involves the selective inhibition of microorganisms by the incorporation of inhibitory compounds into the normally transported peptides. We report here the effects of several synthetic peptides, as well as the polycationic peptide salmine, on the growth of *Prevotella ruminicola,* an important proteolytic rumen bacterium.

Procedure

Determination of mode of action of salmine

We have previously reported that salmine is bacteriocidal to *P. ruminicola* (1995 Nebraska Beef Report, p. 13). The minimal inhibitory concentration (MIC) is between 10 and 15 μg ml^{-1}. Although salmine can interfere with DNA replication, polycationic peptides like salmine can also permeabilize the outer membrane of Gram negative bacteria such as *E. coli*. Therefore, it was necessary to assess whether the smugglin concept would be involved with the inhibition of *P. ruminicola*, by ruling out other modes of action such as permeabilization of the cell. Permeabilization of the outer membrane increases the sensitivity of Gram negative bacteria to hydrophobic antibiotics. *P. ruminicola* strains were tested for increased sensitivity to monensin and novobiocin, either in the presence or absence of a sub-MIC of salmine (~5 μg ml^{-1}). Cultures were incubated at 37°C in a defined, anaerobic medium containing ammonia and glucose as nitrogen and energy sources, respectively, for up to 48 hours, and growth was assessed by the final optical density (OD_{600}) of the cultures. Levels of novobiocin and monensin ranged from 0.1 to 40 μg/ml and 0.7 to 5 μg/ml, respectively.

To conclusively demonstrate that salmine disrupted the outer membrane of *P. ruminicola*, we tested for such an effect by measuring the release of alkaline phosphatase, a periplasmic enzyme, following treatment of mid-log phase cells with salmine. Cells grown to mid-log phase were harvested, washed and treated with either sucrose followed by cold water (osmotic shock; positive control) or salmine, and release of alkaline phosphatase into the menstruum was measured and compared with cell-free supernatant from washed cells (negative control).

Effects of ethionine- or oxalysine-peptides upon ***P. ruminicola***

Ethionine acts as an inhibitor of methyltransferases because of its structural similarity with methionine. Oxalysine appears to affect ribosomal RNA and probably, protein biosynthesis in a variety of prokaryote and eukaryote microorganisms. Pentapeptides containing either ethionine or oxalysine were kindly provided by Dr. L. Zhang and Dr. F. Naider, Department of Chemistry, CUNY, Staten Island, NY. These peptides were used in disk diffusion assays with *P. ruminicola* B_14 and D31d, grown on basal agar media, in the presence or absence of 0.2% (w/v) Trypticase (BBL). Sterile paper-filter disks were placed on the surface of the plates and saturated with the solutions of peptides. The bacterial strains were tested for susceptibility (indicated by the appearance of a zone of clearance around the disks) to increasing amounts of either triornithine, Tyr-Asp-Ala-Orn-Orn-Orn-Ala ($YDAO_3A$), Tyr-Asp-Chloroalanine-Asn-Ser-Chloroalanine-Ala (YDCNSCA), Oxalysine-Leu-Leu-Leu-Gly (OL_3G), Lys-Leu-Leu-Ala-Ethionine (KL_2AEth) or Lys-Leu-Leu-Leu-Ethionine (KL_3Eth).

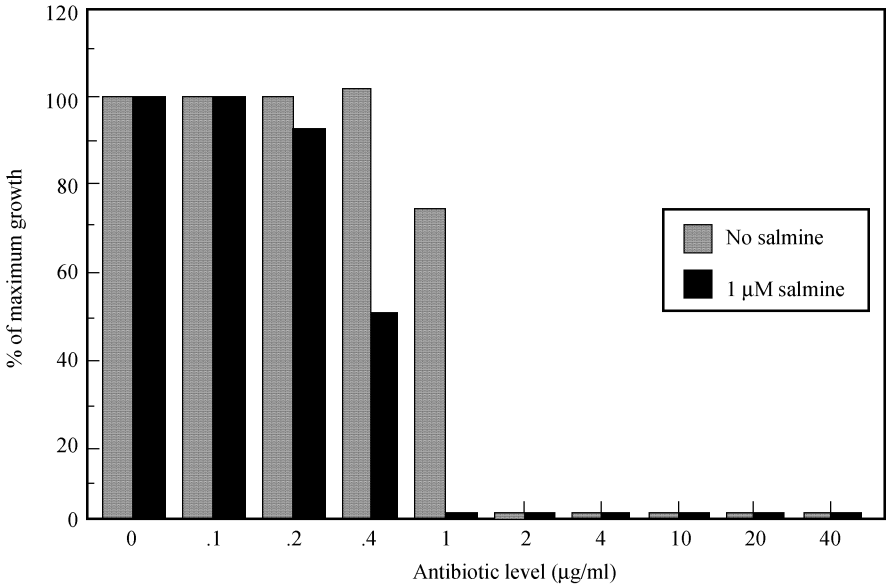

Figure 1. Effect of sub-MIC of salmine on the sensitivity of *P. ruminicola* to the hydrophobic antibiotic novobiocin.

Results

In the presence of a sub-MIC of salmine, there was a four-fold increase in the sensitivity of *P. ruminicola* to novobiocin (Figure 1), and a ten-fold increase in sensitivity to monensin (data not shown). Because the mode of action of these two antibiotics is very different, it seems likely that salmine is exerting its effect by making the membrane more accessible to these hydrophobic antibiotics. The release of alkaline phosphatase activity following treatment with salmine (Table 1) indicates that the outer membrane of *P. ruminicola* is sufficiently damaged by polycationic peptides to permit the release of periplasmic proteins and result in cell death.

Levels as high as 1.5 mg of tri-ornithine did not inhibit growth of either *P. ruminicola* strain, but 75 µg of $YDAO_3A$ was inhibitory to *P. ruminicola* B_14. The peptide YDCNSCA did not inhibit growth of *P. ruminicola* within the range tested (0-250 µg). OL_3G (50 µg) and KL_3Eth (100 µg) were inhibitory to strain B_14 growing on ammonia, causing zones of clearing of 1.8 cm (Figure 2). Inhibition by these last two oligopeptides was prevented by including peptone (0.2 % w/v) in the growth medium. We consider these findings evidence that the same transport system was being used for the uptake of both the synthetic and the peptone peptides. Moreover, the findings are consistent with earlier studies that showed that only oligopeptides ranging from four amino acid residues in length up to 2,000 Da are utilized for growth, whereas free amino acids and a range of di- and tri-peptides are either poorly or not used.

Table 1. Distribution of alkaline phosphatase activity in cell fractions of *P. ruminicola,* and total recovery of enzyme activity in treated cells as compared with control cultures.[1]

Fraction	% of total activity[1] Osmotic shock	Salmine (20 µM)
Sucrose supernatant	2.5 (±0.35)	——
Cold water - periplasmic fraction	53.0 (±5.65)	——
Supernatant after salmine treatment	——	14.2(±1.1)
Periplasm-less cells after osmotic shock	25.0(±4.9)	——
Periplasm-less cells after salmine treatment	——	67.0(±2.8)
% Recovery[2]	84	84

[1]Average of 2 experiments; ± SD.
[2]Relative to untreated cells harvested from the same culture used to provide cells for osmotic shock and salmine treatment.
Less than 3.5% of total alkaline phosphatase activity was present in cell-free culture fluid and wash fractions.

Conclusions

Results obtained with oxalysine- and ethionine-containing peptides indicate that the smugglin concept may be applicable for the study and manipulation of peptide metabolism by *P. ruminicola* and, probably, other peptide-fermenting bacteria in the rumen. Such manipulations are warranted to reduce nitrogen excretion in animal waste, as well as production costs. Previous studies have suggested that peptides that are hydrophobic in nature and/or possess proline residues are less susceptible to hydrolysis in the rumen. Salmine has a bacteriocidal effect on *P. ruminicola*, probably due to the polycationic nature of the protein disrupting the outer membrane of the bacterium. Although micromolar concentrations of polycationic peptides like salmine may not inhibit growth, the sensitivity of *P. ruminicola* to monensin could be dramatically increased. Considering that some cereal grains possess polycationic proteins, perhaps some of the variability in the ruminal digestion of grain proteins can be attributed to their deleterious effect on bacteria such as *P. ruminicola.* Therefore, unlike the other peptides tested, salmine does not appear to possess great potential for use as a smugglin agent, because of its action of disrupting the outer membrane of *P. ruminicola.* However, it may still prove useful in other studies of ruminal protein digestion.

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[1]Humberto Madeira, Graduate Student, supported by a Freedom From Hunger Scholarship from The Rotary Foundation. Mark Morrison, Assistant Professor, Animal Science Department and Center for Biotechnology, University of Nebraska-Lincoln. Work supported by USDA National Research Council Competitive Grant Program.

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I. With Peptides

II. Without Peptides

Figure 2. The effect of chloroalanine, ethionone, or oxalysine-containing peptides on growth of *P. ruminicola* in the presence (I) or absence (II) of 0.2% (w/v) Trypticase. Disks are saturated with either anaerobic water (a); 10 mM acetic acid (b); 100 µg KL_3G (c); 50 µg oxalysine-L_3 (d); 100 µg KL_3-ethionine (e); 100 µg KL_2-A-ethionine (f); and 250 µg YD-chloroalanine-NS-Chloroalanine-A (g).

Characterization of Ammonia Utilization by *Prevotella ruminicola* $B_1$4

Zezhang Wen
Mark Morrison[1]

Summary

The efficiency of microbial protein synthesis in the rumen has a profound impact upon metabolizable protein supply to grazing cattle. ***Prevotella ruminicola*** *is found in large numbers in the rumen and can use ammonia as well as peptides for growth. The major enzyme involved with ammonia assimilation, glutamate dehydrogenase, is affected by the type and amounts of nitrogen available for growth. Ammonia concentrations of 1 mM or less result in the highest specific activities, but peptides decreases the specific activity by five-fold. Thus when peptides are readily available in the rumen, ammonia is more likely to be produced rather than used by this bacterium. In addition to earlier observations that* ***P. ruminicola*** *will ferment carbohydrates without growth (energy spilling), fluctuations in nitrogen availability in the rumen could affect the amount of microbial protein synthesized from diets with similar digestibility.*

Introduction

P. ruminicola is a predominant member of the rumen microflora, and in addition to its important role in fiber digestion, it is one of the major proteolytic bacteria from the rumen. It is capable of using both large peptides and ammonia as its nitrogen source, but not free amino acids, small peptides, and other low molecular weight N compounds. Also, prior growth with peptides appears to inhibit ammonia assimilation, and results in fermentation uncoupled from microbial growth, so called "energy spilling".

For the great majority of grazing ruminants, ammonia is the major N source in the rumen, and it is imperative to maximize microbial protein synthesis per unit of energy fermented. However, little is known about ammonia assimilation and N regulation in rumen bacteria that possess a quantitatively important role in fiber digestion, such as *P. ruminicola.* We report here a preliminary characterization of an NADPH-dependent glutamate dehydrogenase (GDH), the major enzyme involved with ammonia assimilation in *P. ruminicola* strain $B_1$4.

Procedure

Effect of ammonia concentration on the GDH activity

Prevotella ruminicola was grown using a glucose minimal medium prepared to contain either .5, 1.0, 10, or 50 mM ammonium chloride (NH_3). Cells were harvested at mid-log phase of growth, washed once with 1% (w/v) KCl, and resuspended in 1/10 volume of 1% KCl.

Glutamate dehydrogenase activity was measured by monitoring the oxidation of NAD(P)H at 340 nm at 37°C by using a computerized spectrophotometer. Specific activity was expressed as nanomols of NAD(P)H oxidized per minute per microgram of cell protein.

Effect of peptide concentration on the GDH activity

Previous studies showed a relatively high concentration of peptide-N (1.5% w/v) inhibited ammonia assimilation, as measured by $(^{15}NH_4)_2SO_4$ tracer studies. To evaluate whether peptide-N has any effect on GDH, *P. ruminicola* was grown in glucose minimal medium with either .25 or 1.5% (w/v) of trypticase peptone, and compared to cultures of *P. ruminicola* grown with a non-limiting concentration of ammonia.

Cloning and isolation of the GDH structural gene of ***P. ruminicola***

A library of *P. ruminicola* $B_1$4 chromosomal DNA was constructed using the plasmid cloning vector pEcoR251, and was used to transform an *E. coli* glutamate auxotroph (mutant strain PA340) to glutamate protrophy and ampicillin resistance. Transformants were restreaked and plasmid DNA isolated for restriction enzyme mapping and secondary transformations. A 3.5 kilobase *Xba*I - *Sca*I fragment from the initial clone (pANS700) could be subcloned in the plasmid pBluescript II in both orientations, and the resulting plasmids (pANS701 and pANS702) transform strain PA340 to glutamate protorophy. These various clones were also tested for the expression of GDH activity in the *E. coli* strain by the procedures outlined above.

Results

Prevotella ruminicola $B_1$4 possesses a GDH capable of catalyzing glutamate biosynthesis in the presence of either NADPH or NADH. However, the addition of potassium (K+) ions to the assay mixture can completely eliminate the NADH-dependent activity, but increases the NADPH-dependent activity more than two-fold. Because the intracellular K+ concentration in *P. ruminicola* is high, it seems unlikely that the NADH-dependent activity has any physiological significance.

The NADPH-dependent specific activity of *P. ruminicola* $B_1$4 was increased ($P < .1$) in response to low external concentrations of ammonia, but NADH-dependent GDH activity is unaffected (Table 1). Increasing concentrations of peptides as main N source resulted in as much as a five-fold decrease ($P < .1$) (Table 2) in NADPH-dependent GDH specific activity.

The results of the cloning experiments indicate that both NADPH- and NADH-dependent activities can be attributed to the same gene product, and possess characteristics similar to that seen with *P. ruminicola* $B_1$4 whole cells (data not shown). Southern blot analysis also confirmed the *gdh* clone actually originated from strain $B_1$4. There was no cross hybridization with chromosomal DNA isolated from *P. ruminicola* strains D31d and 23; nor with *E. coli* strain PA340, *Bacteroides fragilis* , or *B. thetaiotaomicron* (data not shown). Therefore, *P. ruminicola* probably possesses only one GDH enzyme which is genetically not closely related to those in other *P. ruminicola* strains.

The NADPH-dependent GDH activity of *P. ruminicola* is affected by ammonia concentration, as well as by the availability of peptide-N in the rumen. In addition to earlier observations that *P. ruminicola* will ferment carbohydrates without growth (energy spilling), fluctuations in nitrogen sources (i.e. peptides vs. ammonia) could affect the amount of microbial protein synthesized from diets with similar digestibility. Future studies will involve the construction of GDH gene mutants to assess whether GDH acts as the primary pathway of ammonia assimilation with limiting and excess concentrations of ammonia; whether GDH gene expression is modulated in response to peptide-N; and if this modulation of ammonia assimilation is responsible for the "energy spilling" observed when peptide availability is limited.

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[1]Zezhang Wen, graduate student and recipient of a Center for Biotechnology Graduate Research Associateship; Mark Morrison, Assistant Professor of Animal Sciences and Center for Biotechnology, Lincoln. This work was supported by the USDA National Research Council Competitive Grant Program.

Table 1. Effect of various concentrations of ammonia on the glutamate dehydrogenase activity of *P. ruminicola* $B_1$4.

	0.5 mM	1.0 mM	10.0 mM	50.0 mM
NADPH	534.7 ± 1.0[a]	666.7 ± 128.5[a]	306.6 ± 67.3[b]	237.6 ± 65.9[b]
NADH	57.1 ± 15.9[a]	88.2 ± 16.8[a]	59.3 ± 3.2[a]	51.2 ± 16.1[a]

[a]NADPH- and NADH-dependent specific activity is defined as nanomols of NAD(P)H oxidized per minute per milligram of protein.
[b]Values represent means (± SD) of no less than 4 separate observations.
[c]Values within rows, with unlike superscripts differ ($P<0.1$).

Table 2. Effect of various concentrations of peptides on the glutamate dehydrogenase activity of *P. ruminicola* $B_1$4.

	0.25% (w/v) Trypticase	1.5% (w/v) Trypticase	10.0 mM NH_4Cl
NADPH	143.7 ± 34.0[a]	61.9 ± 6.3[b]	293.2 ± 57.6[c]
NADH	30.1 ± 0.3[a]	22.6 ± 13.9[a]	64.3 ± 9.7[b]

[a]Abbreviations are the same as those in Table 1.
[b]Values represent means (± SD) of no less than 4 separate observations.
[c]Values within rows, with unlike superscripts differ ($P<0.1$).

Cellulose Adherence Factors in *Ruminococcus albus*

Randall Pegden
Mark Morrison[1]

Summary

*The cell wall of the bacterium **Ruminococcus albus** was mixed with cellulose particles, allowing any molecules with an affinity for cellulose to bind. The cellulose particles and any bound molecules can be retrieved by centrifugation, providing a relatively simple procedure to enrich for molecules involved with attachment of the bacterium to plant fiber. Four proteins have been identified using this procedure, suggesting that adherence involves a protein-carbohydrate interaction. The quantity of these proteins appears to be affected by the nutrient composition of the medium used to grow the bacterium. It seems likely that nutrients which stimulate cellulose degradation also positively affect the amount of the adherence factors present on the bacterial cell surface.*

Introduction

Grazing and forage-fed animals depend upon the rumen microorganisms' ability to breakdown polysaccharides present in the leaf and stems of plants. The rate and extent of this breakdown has a major impact on animal nutrition, therefore understanding the mechanics of this process offers the potential to optimize and further improve animal performance. The limited published studies to-date suggest that: 1) colonization and adherence by some rumen bacteria are specific in nature and; 2) adherence can be modified by nutrients and growth conditions, such as ruminal pH. Better understanding and future improvements of fiber digestion in the rumen will be afforded by the identification and isolation of the molecules controlling bacterial colonization and adherence.

Procedure

Detection of proteins with an affinity for cellulose

The rumen bacterium *R. albus* strain 8 was used for study, because it is a very active degrader of plant material. The

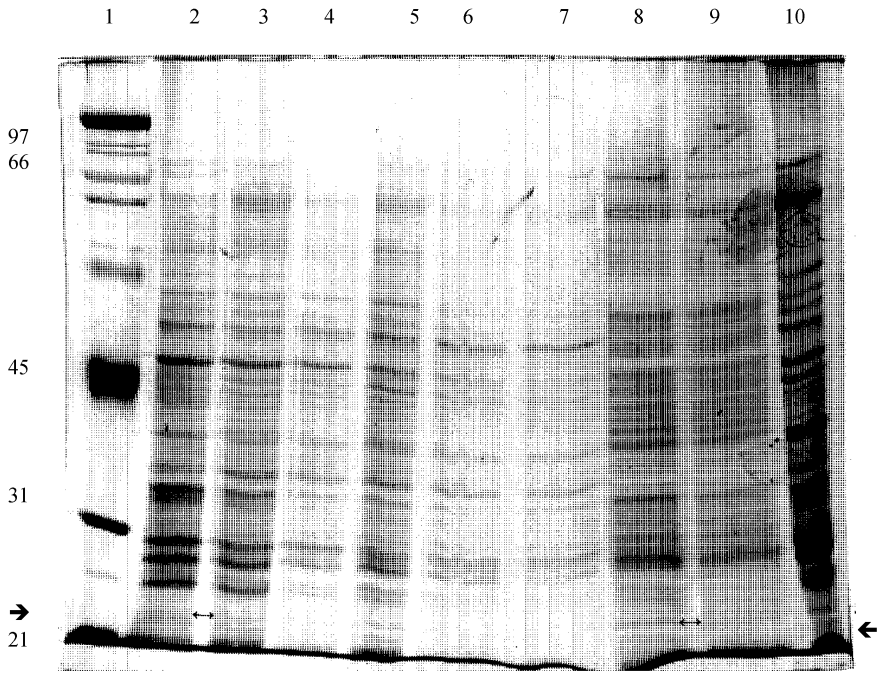

Figure 1. Identification of a 22 kDa protein from *R. albus* 8 membrane fractions, on the basis of its affinity for cellulose. Membrane fragments with or without cellulose added were incubated at room temperature for 1 hour, then subjected to centrifugation. Note the disappearance of a 22 kDa protein in lane 2 (arrowed, + cellulose), compared with the control (- cellulose, lane 3). Lanes 4 through 7 represent the wash fractions. The 22 kDa protein is virtually absent in these fractions but is readily visible in lane 8 (arrowed), following the boiling of the cellulose pellet in SDS-PAGE running buffer. Lane 10 is a sample of the crude membrane fragments.

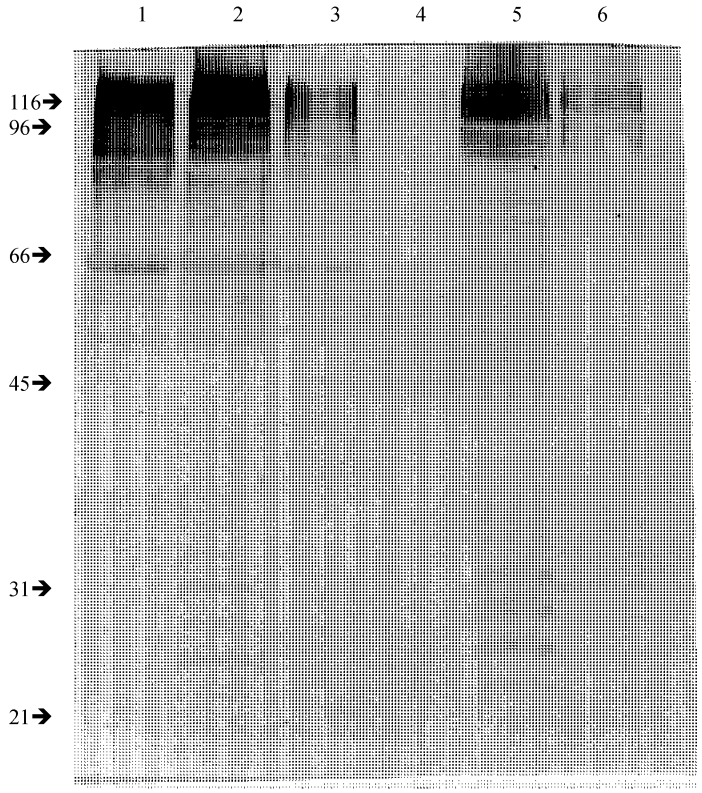

Figure 2. Identification of glycosylated proteins from *R. albus* 8 membrane fractions, on the basis of their affinity for cellulose. Membrane fragments, with or without cellulose added, were incubated at room temperature for 1 hour, then subjected to centrifugation. Note the disappearance of the glycosylated proteins between the 21 and 32 kDa molecular weight range in lane 1 (+ cellulose), compared to the control (lane 2, - cellulose). Lanes 3 and 4 represent the supernatant fractions obtained after washing the control and test reactions with phosphate buffer, containing 0.05% (w/v) Triton X-100. The proteins are virtually absent in these wash fractions, but are readily visible in lane 5 (arrowed) following the boiling of the cellulose in SDS-PAGE sample running buffer.

bacterium was grown using media with or without added rumen fluid. Rumen fluid is known to contain nutrients which can affect cellulose degradation, and potentially then, the ability of the bacterium to attach and degrade the substrate. The bacterial cells were harvested by centrifugation and the cell wall fragmented by passage through a French pressure cell. The membrane fragments contain proteins and other molecules that may be involved with adherence, and these molecules were released from the cell wall by treatment with a detergent. The suspension was then mixed with cellulose, and incubated with occasional agitation at room temperature for one hour. The cellulose particles were harvested by centrifugation and washed, first with phosphate buffered saline, then with detergent. The washes and a sample of the cellulose were boiled with a protein running buffer, then subjected to denaturing polyacrylamide gel electrophoresis (SDS-PAGE). Membrane fragments without added cellulose were subjected to the same procedures, and also subjected to SDS-PAGE.

*Reaction of **R. albus** whole cells with lectins and erythrocytes*

We anticipate that the binding process between the bacteria and the plant surface involves either a protein-carbohydrate, or a carbohydrate-carbohydrate interaction. One approach to identify such interactions is to incubate the bacteria with lectins (proteins that recognize a specific carbohydrate on the bacterium's surface). Another is to incubate the bacteria with erythrocytes from different species of animals. The erythrocytes possess different carbohydrates on their outer surface and will bind (hemagglutinate) with bacteria that possess a protein which can bind that particular carbohydrate. Agglutination of the bacteria upon incubation with lectins and(or) erythrocytes will provide new information, which will be useful for the isolation of the adherence molecules.

Cultures of *R. albus* 8 and *Prevotella ruminicola* strains D31d, 23, and $B_1$4 were harvested at mid-log phase of growth by centrifugation, washed, and resuspended in buffer to give a consistent cell density. Fifty microliter a liquots of the cell suspensions were then mixed in microtiter dishes with lectin suspensions (50 µg total) derived from jack bean, peanut, castor bean, winged pea, wheat germ, and lentil. Cell-lectin mixtures were shaken for 15 minutes, then left stationary at room temperature for two hours.

Erythrocytes obtained from rabbit, ox, calf, guinea pig, horse, sheep, and goat were washed and resuspended in phosphate buffered saline. Cell-erythrocyte mixtures were treated in the same manner as described above. With both assays, agglutination can be easily distinguished by macro- and microscopic observations. A positive reaction results in the dispersion of the mixture, rather than the formation of a tight "button" in the bottom of the assay well.

Results

The results of the cellulose-binding assays are shown in Figure 1. Despite the presence of some background protein bands, a protein of approximately 22 kDa molecular weight is clearly absent following incubation with cellulose (compare lanes 2 and 3 of Figure 1), but is readily visible once the cellulose particles are washed and boiled in protein running buffer to remove bound protein(s) (lane 8). This type of assay has since been combined with staining procedures to identify glycosylated proteins. No less than four protein bands, all ranging in size between 21 and 31 kDa possess affinity for cellulose with

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the assay conditions used (Figure 2). Moreover, the presence of these glycoproteins in the membrane fragments of *R. albus* requires growth of the bacterium in the presence of rumen fluid. These glycosylated proteins seem to be excellent candidates for further investigation by a variety of molecular-based approaches.

Of the seven lectins tested so far, only the winged pea lectin caused agglutination of *P. ruminicola* D31d cells. This lectin has affinity for terminal L-fucose (deoxygalactose) residues. None of the lectins tested so far agglutinate *R. albus* 8 whole cells, indicating some difference(s) from previous studies with another type of *R. albus.*

Both *P. ruminicola* D31d and *R. albus* 8 cell preparations can agglutinate rabbit erythrocytes. However, hemagglutination appears to be affected by the age of the erythrocytes, suggesting some removal of the terminal sugars recognized by these putative "adhesins". The results with *R. albus* 8 to date have been the most variable. So far, all assays have been conducted under aerobic conditions, and this may have some impact upon the results.

Although these studies are still preliminary, the findings support the contention that glycosylated proteins present in the bacterial membrane will bind specifically with cellulose. Further studies are underway to better characterize these proteins. The potential impact from these studies could be far-reaching. It may be possible to identify the "rate limiting" binding/receptor sites, in either plant tissue or ruminal bacteria, that affect adherence. Factors affecting the expression and(or) chemical "viability" of binding/receptor sites (e.g. ruminal pH), and the relationship between these specific interactions and cellulose-degrading enzymes may be identified. Finally, the information gained may ultimately be utilized to model the impact of ruminal conditions, plant quality, and the adherence mechanism(s) upon the kinetics of ruminal fiber digestion.

[1]Randall Pegden, research technician, University of Nebraska-Lincoln, and Mark Morrison, Assistant Professor of Animal Sciences and Center for Biotechnology, University of Nebraska-Lincoln. This research was supported by funds made available by the SoyPass Research Fund.

Effect of Sorghum and Cornstalk Grazing on Crop Production

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Jim Gosey
Mark Schroeder[1]

Summary

Effects of cattle grazing crop residues on subsequent crop yields and residue cover was evaluated. Also, grazing of crop residues in ridge-till and conventional disk-plant irrigated corn production systems were compared. Cattle performance, residue cover, ridge height, soil compaction, and crop yield were measured. Grazing corn residue by cows reduced residue cover 25% and produced no effect on subsequent soybean yields. Cattle performed comparably for ridge-till vs conventional systems. Ridge heights were maintained, residue cover was reduced an average of 13% on the ridge-till and 7% on the conventional, and soil compaction was not affected by grazing in 1993-94. The effect of grazing on subsequent corn yields was inconsistent. In other studies, subsequent crop yields following grazing were not affected by the grazing of crop residues and residue cover was reduced 19 and 13% for corn and grain sorghum residue, respectively.

Introduction

Crop residues remaining after harvest are an important feed resource for the cattle. While many of the 1.8 million head of beef cows and many calves in Nebraska graze harvested fields during the winter months, little information is available on the effect of grazing on subsequent residue cover or crop yields. Beginning in the fall of 1992, experiments were begun at several different sites on the Integrated Crop/Livestock Farm at the Agricultural Research and Development Center to study the effect of cattle grazing crop residues on subsequent crop yields, residue cover, and soil compaction.

Procedure

Experiment 1

An experiment was initiated in the fall of 1992 in cooperation with the Biological Systems Engineering Department and the Cow/calf Unit. Two adjacent center pivots were used in each of the two years of the study. Soil type under each center pivot is a silty clay loam. Each center pivot was in a corn/soybean rotation, with one half in corn and one half in soybeans each year. Following harvest, one quarter of each pivot was fenced for grazing cornstalks, while the cornstalks on the other quarter of each pivot were left ungrazed. Twenty-one head of beef cows grazed 29.2 acres of corn residue for 60 days, from December 3, 1992 through February 3, 1993. The following spring residue

cover was measured on the grazed and ungrazed areas using the line-transect method as described by Shelton et al., *NebGuide G92-1133*. In the fall of 1993, soybean yields were compared between previously grazed and ungrazed areas. This experiment was repeated in 1993-1994 on the alternate half of each center pivot. Twenty head of beef cows grazed twenty-nine acres of corn residue for 69 days, from November 5, 1993 through January 13, 1994. Residue cover and soybean yields were measured in the spring and fall of 1994, respectively.

Experiment 2

An experiment was conducted during the fall and winters of 1993-1994 and 1994-1995 to evaluate the performance of calves grazing cornstalks, the effect of grazing on crop yields, residue cover, and soil compaction in ridge-till and conventional disk-plant irrigated corn production systems. This experiment was conducted on a silty clay loam soil site. A 100-acre irrigated corn field under a linear move irrigation system was divided into six fields, three for each corn production system. Six rows in each tillage system were fenced out and left ungrazed in each field so comparisons could be measured on the previously mentioned variables, between grazed and ungrazed cornstalks. The fields were established during the fall of 1992 and cattle were allowed to graze. Data were not measured on soil compaction, residue cover, or ridge height until the fall of 1993. Each year, before machine harvest, 15 ft. of row in four areas of each field were hand harvested to determine yield estimates of stalks, leaves, husks, and corn grain. Following machine harvest, the residual corn in each field was estimated.

In 1992-93, calves grazed cornstalks for 56 days, from November 17, 1992 through January 11, 1993. In 1993-1994 calves grazed cornstalks for 58 days, from December 4, 1993 through February 2, 1994. In 1994-1995, calves grazed for 78 days, from December 12, 1994 through February 27, 1995. Stocking rate for this experiment was 1.2 calves/acre. Daily gain was recorded for calves on the different systems each year. Before grazing in the fall of each year, residue cover, ridge height, and soil bulk density were measured in the grazed and ungrazed areas of each field for each system. Soil bulk density was measured in the row and in the interrow for the top 3 in. of soil for both systems. Cattle walked between the rows in the ridge-till system, so we wanted to determine if this had any effect on soil compaction (bulk density). In the spring of each year following grazing, these measurements were repeated. Corn yields were measured in the fall of 1994.

Experiment 3

An experiment was initiated in the fall of 1992 to evaluate the effect of calves grazing corn, grain sorghum, and soybean residue on subsequent crop yields in a dryland strip cropping system on a silty clay loam soil site. These crops were planted in 8, 30-in. row alternating strips in a north-south orientation in a 27-acre field. The crops were rotated each year, with corn following soybeans, grain sorghum following corn, and soybeans following grain sorghum. Four replications of four grazing enclosures (4 ft. x 5 ft. each) were placed in strips of each crop. Eighty-one head of calves were allowed to graze the crop residue for 30 days, from December 4, 1992 through January 4, 1993. The following fall, yields of corn, soybeans, and grain sorghum were measured. Paired comparisons were made by hand harvesting two 5-ft. rows of each crop in the grazed and ungrazed plots. The location of these enclosures was maintained during the winters of 1993-94 and 1994-1995 so yield comparisons could continually be measured. In the winter of 1993-94, different groups of calves grazed the field in November and December. Ewes grazed the field throughout the winter. In 1994-95, calves grazed the field in early December, and then again in February and March. Crop yields were taken in the fall of 1994, similar to that previously described. Residue cover measurements were also taken following grazing in the spring of 1995.

Experiment 4

Several other enclosures were placed in fields before stalk grazing in 1992 and 1993, to measure the effect of grazing crop residues on subsequent crop yields. Enclosures were placed in grain sorghum and different corn fields to measure yields of soybeans following grain sorghum or corn, or corn following corn for grazed and ungrazed plots. Yields of soybeans and corn were measured by hand harvesting plots. In the fall of 1994, more enclosures were placed in fields, and in the spring of 1995 residue cover was measured for grazed and ungrazed plots.

Results

Experiment 1

In both 1992-93 and 1993-94, soybean yields were not affected by grazing. Soybean yields were 51 and 53 bu/acre following grazing in 1992-93 for the grazed and ungrazed treatments, respectively. Following grazing in 1993-94, soybean yields for the grazed and ungrazed treatments were 62 and 61 bu/acre, respectively. In 1992-93, cows were turned out on stalks later in the season, so much of the time the ground was frozen. In 1993-94, cows were on the corn stalks earlier when it was relatively dry, and then later after precipitation occurred, it became very cold and the ground froze. This would reduce the amount of compaction that would be caused by the tracking of cows. It may also be possible that freezing and thawing over the winter may alleviate any effect cows may have had on soil compaction. Shelton et al., *1995 ASAE Technical Paper*, reported that residue cover was reduced an average of 25% by grazing in this study. Residue cover as measured in the spring of the year averaged 83.1% for the

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ungrazed fields and 61.9% for the grazed fields for the 2-year period. It should be noted that soybeans were no-till planted into the corn residue following grazing the previous fall and winter, and no additional tillage was required in grazed areas.

Experiment 2

Daily gain of cattle was .09 lb less on the ridge-till system compared with the conventional system (Table 1). This was attributed to muddy conditions during the 1992-93 grazing season that resulted in much of the corn residue being trampled into the mud. In a ridge-till system, the residue generally falls into the furrows between the rows where the cattle tend to walk. Ultimately this resulted in a shorter grazing period, as cattle became short of feed. In 1993-94, yield estimates for the corn residue and residual corn were higher for the ridge-till compared to the conventional system (Table 2). The lower dry matter production on the conventional system was due to lower plant populations and a severe infestation of grassy weeds. The lower yields on the conventional system were reflected in poorer cattle performance in 1993-94 (Table 1). The cattle on the ridge-till system also benefitted from the ground being frozen for most of the grazing period. The frozen ground prevented cattle from trampling the residue into the mud in the furrows as occurred in 1992-93. In 1994-95, yield estimates were similar for both systems, which is reflected in comparable cattle performance. Cattle were removed from the cornstalks before mud was a problem in the ridge-till system.

Corn grain yields were measured in the grazed and ungrazed areas of each system. Yields were inconsistent between grazed and ungrazed plots and are not reported. Soil bulk density measurements taken before grazing 1993-94 indicated a 15% higher ($P<.05$) bulk density (1.32 vs 1.15 gm/cm^{-3}) for the inter-row compared with the row in the grazed ridge-till system. In the ungrazed area, there was no difference between the row and inter-row. These higher bulk densities

Table 1. Performance of cattle grazing corn residue in a ridge-till or conventional production system in 1993-94 and 1994-95.

Treatment	Year	ADG lb/hd/day	Standard deviation
Conventional	1992/93	.63	.38
Ridge-till	1992/93	.54	.32
Conventional	1993/94	0.40	.29
Ridge-till	1993/94	0.61	.37
Conventional	1994/95	0.45	.33
Ridge-till	1994/95	0.47	.28

Table 2. Yield estimates of corn stalks, husks, leaves, grain and residual grain for ridge-till and conventional tillage systems for 1993 and 1994.

		Yield estimates lb dm/ac			bu/ac	Estimate bu/ac
Treatment	Year	Stalks	Leaves	Husks	Corn	Residual corn
Conventional	1993	2045	1082	582	94	2.0
Ridge-till	1993	2777	1501	548	123	4.9
Conventional	1994	3201	1259	812	157	2.3
Ridge-till	1994	3188	1202	691	150	1.9

Table 3. The effect of grazing on % residue cover in a ridge-till and conventional production system.

Treatment	Date of measurement	% residue cover
Ridge-till Grazed	Fall 1993	81
Ridge-till Ungrazed	Fall 1993	79
Conventional Grazed	Fall 1993	97
Conventional Ungrazed	Fall 1993	96
Ridge-till Grazed	Spring 1994	53
Ridge-till Ungrazed	Spring 1994	67
Conventional Grazed	Spring 1994	77
Conventional Ungrazed	Spring 1994	81
Ridge-till Grazed	Fall 1994	99
Ridge-till Ungrazed	Fall 1994	99
Conventional Grazed	Fall 1994	100
Conventional Ungrazed	Fall 1994	100
Ridge-till Grazed	Spring 1995	84
Ridge-till Ungrazed	Spring 1995	90
Conventional Grazed	Spring 1995	86
Conventional Ungrazed	Spring 1995	95

Table 4. Effect of grazing crop residues on subsequent crop yields in a strip cropping system.

Treatment	Year	Crop	Yield (bu/ac)
Grazed	1993	Soybean	36
Ungrazed	1993	Soybean	41
Grazed	1993	Grain Sorghum	71
Ungrazed	1993	Grain Sorghum	72
Grazed	1993	Corn	187
Ungrazed	1993	Corn	180
Grazed	1994	Soybean	55
Ungrazed	1994	Soybean	51
Grazed	1994	Grain Sorghum	145
Ungrazed	1994	Grain Sorghum	141
Grazed	1994	Corn	219
Ungrazed	1994	Corn	209

of the inter-row of the grazed ridge-till system may be due to grazing the previous fall and winter when conditions became very muddy. In the conventional system, there was no difference between the row or inter-row or grazed or ungrazed and bulk densities ranged from 1.19 to 1.24 gm/cm^{-3}. Cattle in this system generally walked in the rows and between the rows because the ridges were very small and did not affect the cattle. Soil bulk density measurements taken during the spring of 1994 following grazing showed no changes in bulk densities compared to the previous fall for the different systems. The soil was generally frozen while the cattle were grazing during the fall and winter of 1993-94, so grazing did not affect soil compaction.

Ridge heights were not affected by grazing in either year for the ridge-till system. Following grazing in 1992-93 and 1993-94, ridge heights were 6.6 and 6.3 in. for the grazed compared to 6.7 and 6.1 in. for the ungrazed treatment, respectively. A concern of the ridge-till system was that cattle may destroy ridges during grazing; but following three years of grazing, ridges have been maintained and it has caused no problems in planting on the ridges. Initial residue cover measurements were lower (P<.05) on the ridge-till compared with the conventional in the fall of 1993 (Table 3). This may be due to the conventional system having more grassy weeds as cover and the ridge-till system having residue concentrated between the row and not as evenly distributed. Measurements in the spring of 1994 following grazing showed a 35% reduction in residue cover for the grazed ridge-till system compared to the fall of 1993. The ungrazed ridge-till was reduced 15%, indicating a 20% reduction due to grazing. The conventional grazed system showed a 21% reduction in residue cover compared to the fall of 1993, with the ungrazed conventional system reduced 16%. Grazing only reduced residue cover 5% in this system. In the fall of 1994, residue cover measurements were very high (99-100%) for both systems due to higher yields and some grass cover in the plot measurement areas. Residue cover for the ridge-till grazed system was reduced 15%, compared to 9% for the ridge-till ungrazed, attributing only 6% from grazing. The conventional grazed system reduced residue cover 14% through the winter, compared to a 5% reduction for the conventional ungrazed, a 9% reduction from grazing alone.

Table 5. The effect of grazing crop residues on subsequent corn and soybean yields.

Treatment	Year	Previous crop	Crop	Yield (bu/ac)[a]
Grazed	1993	Corn	Corn	127
Ungrazed	1993	Corn	Corn	132
Grazed	1994	Corn	Corn	206
Ungrazed	1994	Corn	Corn	204
Grazed	1994	Corn	Soybean	43
Ungrazed	1994	Corn	Soybean	41
Grazed	1994	Grain Sorghum	Soybean	47
Ungrazed	1994	Grain Sorghum	Soybean	45

Experiment 3

The effect of grazing strip crops was minimal (Table 4) and varied from year to year. Soybeans followed grain sorghum in the rotation, so this area was subject to possible compaction from cattle grazing the residue. In the spring of 1994, compost was applied on all the strips. This added organic matter to the soil and may have helped alleviate any compaction problems due to grazing, as yields of all crops were comparable. Corn followed soybeans in the rotation so tracking from grazing was probably less compared to the other crops. Residue cover for the grazed and ungrazed areas measured in the spring of 1995, only showed a significant (P<.05) reduction of 19% (100 vs 81%) for grazed corn.

Experiment 4

In two fields where irrigated corn residue was grazed (Table 5), corn crop yields the following year were unaffected by grazing. Soybeans following grazed corn or grain sorghum residue yielded similar to ungrazed areas. Residue cover measurements taken in the spring of 1995 showed grazing significantly (P<.05) reduced residue cover 14% (93 vs 80%) and 18% (98 vs 80%) for grazed grain sorghum and corn residues respectively.

Conclusions

Results of these experiments indicate corn residue cover will be reduced from grazing cornstalks 5 to 25%, averaging 15%; grain sorghum residue was reduced 11%. The amount of the residue reduction was influenced by several factors: size of cattle (cows vs calves), amount of residue present before grazing, tillage system (no-till, conventional, or ridge-till), condition of field (muddy or dry), and length of time on the field. The effect of grazing crop residues on subsequent crop yields has been minimal. A management plan that removes cattle from the fields under very muddy conditions would probably alleviate any detrimental effect on soil compaction and crop yields the following year, and increase the grazing season on the stalks, particularly in a ridge-till system. The grazing of cornstalks in a ridge-till system appears to be successful as ridges have not been affected and the performance of cattle has been comparable to a conventional disk-plant tillage system. Long-term effects on soil physical properties and crop yields should be measured under a wide range of environmental conditions for the ridge-till and other cropping systems to determine the best management strategy.

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Winter Calf Grazing and Field Windbreaks

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James Brandle
Rick Stock
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Mark Klemesrud[1]

Summary

A grazing trial during the winter of 1994-95 was conducted to determine if conifer windbreaks would reduce cold stress on calves grazing grain sorghum residues as measured by increased calf gain. Daily gains were similar between calves grazing protected and unprotected fields. Calves used the natural surroundings and topography of the land to minimize cold stress, however, tree windbreaks provided an easy access to shelter. Windbreaks did not improve calf performance during a normal to mild winter but they may be advantageous during a more severe winter.

Introduction

Windbreaks have been recommended as shelter for wildlife, minimizing erosion, trapping of snow, and protection for livestock and humans. Windbreaks have been shown to benefit crop production by increasing grain yield. Protection from windbreaks extends 10 to 12 times the height of the windbreak on the leeward side and three to five times on the windward side. Windbreak benefits depend on the height, density, number of rows, species, length, orientation, and maturity of the windbreak.

In Nebraska, the grazing of crop residues in the winter provides an inexpensive source of feed for growing calves. However, cold and wet winter conditions can affect the performance of the cattle. Livestock in adverse winter conditions may consume more feed, however, the energy is likely used to meet maintenance needs and is not available for productive processes, such as daily gain. A combination of temperature, moisture, and wind velocity can severely affect livestock performance during winter including reduced grazing time and reduced intake.

The objectives of this trial were 1) to compare the performance of calves grazing grain sorghum residue in protected and unprotected field conditions, and 2) to determine the influence of conifer field windbreaks on livestock grazing habits.

Procedure

Grazing Trial

Sixty eight weaned crossbred steers (483 lb) were randomly assigned to one of five grain sorghum fields, with three fields having conifer windbreaks and two fields being unprotected. The protected fields had north:south 40 ft conifer windbreaks; thus the east protected field had a windbreak on the west side, the middle protected field had a windbreak on the west and east side, and the west protected field had a windbreak on the east side. The topography of the protected west field had slightly rolling hills, the east and middle protected fields were flat with slight depressions. The topography of one of the unprotected fields was very long with slight depressions, the other unprotected field was rolling with larger depressions. The protected fields were fenced (trees on the outside)to prevent cattle from having access to the tree rows.

Grain sorghum residue from each field was sampled by taking four 15 x 2.5 ft strips. Leaves were separated to determine the amount of available forage (leaf material) in each field. The leaves were analyzed for crude protein, in vitro dry matter digestibility, and neutral detergent fiber (Table 1). Stocking rates were calculated on the available pounds of leaf dry matter per acre, resulting in a stocking rate of 1.0 animal per acre for the protected fields and .76 animal per acre for the unprotected fields (Table 2). Each field had three anemometers placed in the middle of the field spaced equally apart; 256 sq ft cages were put around each anemometer to protect them from the livestock. A protein supplement was fed to all treatments at 1.5 lb/hd/day (DM basis). The cattle were turned out November 22, 1994 and removed February 3, 1995. Anemometers were observed throughout the length of the trial. The average wind speed recorded at the nearby meteorology site was 6.6 mph. Wind direction was obtained from the University weather station at Mead. Observations and walks through the fields were conducted to observe where the cattle were bedding in relation to the windbreaks or slopes of the fields.

Results

The amount of leaf material was greater ($P < .10$) in the protected fields compared with the unprotected fields (Table 1). The higher available forage in the protected fields may be attributed to the ability of the windbreaks to improve moisture use by the sorghum plant.

The daily gains for the cattle did not differ ($P > .10$) between the protected and unprotected treatments (Table 2). The similarity in gain for the two treatments during the winter grazing season could be that the grazing cattle were able to find shelter whether it was by a windbreak or a low area in the pasture to reduce the windchill effects. Fences that were around unprotected field may have provided some shelter and the grain sorghum plants also may have provided some shelter. It also appears that the cattle were bedding down by

Table 1. Grain and leaf yield and chemical composition of leaf samples

	Protected	Unprotected	SE
Grain yield, bu/acre[a]	157	123	15
Leaf yield, lb/acre[b]	1970	1491	135
Crude protein, %	13.0	12.1	.9
IVDMD	49.0	49.3	1.0
NDF	69.5	73.0	1.5

[a]protected > unprotected (P<.2).
[b]protected > unprotected (P<.10).

Table 2. Calf performance, stocking rates, and wind speed measurements

	Protected	Unprotected	SE
Initial wt, lb	482	484	1
Final wt, lb	528	530	16
ADG, lb	.59	.59	.2
Stocking rate, head/acre	1.00	.76	.1
Acres	15.0	11.5	1.1
Windspeed, mph	3.6	4.4	.2

the anemometer cages for protection in both the protected and unprotected fields.

Wind speed measurements, using the anemometers in the fields, indicated that the average wind speed for the protected fields was lower (P<.01) than the unprotected fields (Table 2). The average wind direction was evenly split coming from the northwest, northeast, and the southwest. Average temperature was 26.5° F for the trial which is below the critical temperature for cattle with a winter coat.

For November to February in eastern Nebraska, the 30-year average temperature is 24.5° F, wind speed is 11.2 mph, and precipitation is 2.16 inches. The winter had a few occasional cold periods and precipitation levels causing the cattle to become cold stressed; however, over the total 78 days, winter conditions were simi-lar to or milder than the 30-year averages resulting in the calves not being exposed to constant cold stress. When grazing grain sorghum residue, performance of calves may not be improved by windbreaks under average winter conditions. Observations of the fields showed that steers used the topography of the land for shelter. Windbreaks around fields certainly helped the calves find easy shelter and allowed more uniform grazing on windy days. If weather conditions were more severe for longer periods of time, the windbreaks may have provided a constant shelter for calves and improved grazing patterns and calf gains.

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[1]Cynthia Morris, graduate student; Terry Klopfenstein and Rick Stock, Professors; Drew Shain and Mark Klemesrud, research technicians, Animal Science; James Brandle, Associate Professor, Forestry, Fisheries & Wildlife, Lincoln.

Use of Cell Culture to Study Muscle Growth in Beef Cattle

Timothy Woods
Carol Smith
Steven Jones[1]

Summary

Muscle cell proliferation and differentiation were observed microscopically and biochemically. The cell DNA content increased for the first four days of culture, then decreased slightly. The muscle creatine kinase activity increased dramatically throughout the study. Protein turnover was measured in myotubes incubated with either dexamethasone or insulin in serum-free media. Protein degradation was increased with increasing dexamethasone levels, but protein synthesis was not affected. Increasing insulin levels increased protein synthesis and decreased protein degradation. The insulin action at high levels was most likely due to its binding to insulin-like growth factor receptors, which is known to increase protein synthesis. This study demonstrates that bovine primary cultures can be used to study muscle growth.

Introduction

Muscle growth is the primary objective of meat animal livestock producers and represents a major source of amino acids and energy within the animal. Endogenous and exogenous factors that impinge on muscle cell development may influence the animal throughout its life cycle. In the adult animal, treatment with hormones, such as anabolic steroids or insulin, can affect muscle metabolism. Attempting to determine a compound's effects on muscle cell development and metabolism can be obscured in animal trials, since other organs and tissues are altering the environment.

Muscle cell culture provides a research tool to determine the direct effects of a specific compound. There are several advantages to cell culture use. First, the cells can be grown as a "pure" culture. Ideally, the cells are of the same type. Secondly, the culture environment can be controlled. The environment includes the atmosphere, temperature, pH, and the available nutrients. Finally, the sample processing can be simple and rapid. Cell culture results permit researchers to look at complex problems in a simplified model; however, these results need to take the complex nature of the animal into account.

There have been many reports using muscle cell culture; however, most reports involve established cell lines from either mouse or rat sources. The definition of a cell line is a cell culture that has been passaged, or transferred to a new culture dish, many times. Many established cell lines have been routinely cultured for years, and the cell characteristics may have changed from the original tissue source with time. Few researchers have used bovine muscle cells in their studies. It is difficult for most researchers to obtain a reliable source of fetal tissue. Nebraska has a number of beef processing facilities available, which would provide a convenient fetal tissue source. The objective of this study is to develop a muscle cell culture system derived from bovine fetal muscle tissue. This cell culture system would permit the study of

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potential economically important compounds and their effects on bovine muscle.

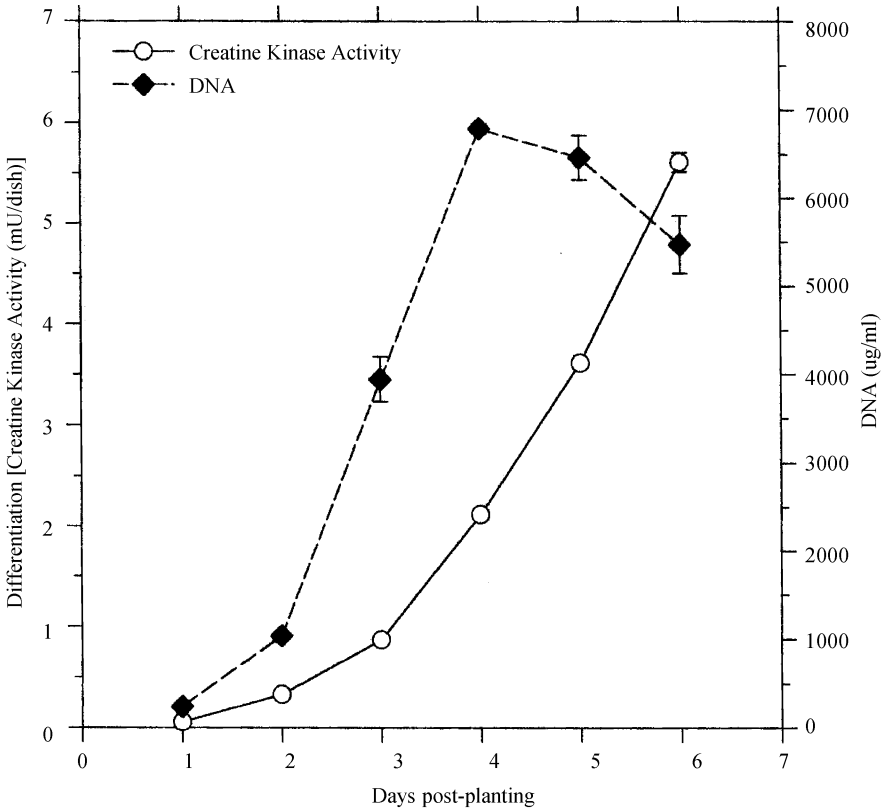
Procedure

Uteri from recently slaughtered cows were obtained from a local slaughter house. These uteri were transported intact to the UNL Meat Research Laboratory. The fetus from each uterus was removed and the crown-rump length measured. The fetal crown-rump length is indicative of the fetus age. For all experiments, 3-4 foeti ranging from 5.5-7.0 inches were processed. The fetus was rinsed with 70 % (v/v) ethanol, and the hindlimbs were dissected. The skin surrounding the hindlimb was peeled from the muscle, and the muscle was dissected from the bone. The muscle was transferred to a clean petri dish and was minced into small pieces. The muscle pieces were placed in a sterile flask containing a phosphate-balanced saline with trypsin and collagenase. Trypsin is a general proteolytic enzyme that removes the undifferentiated cells from the muscle fibers. Collagenase is an enzyme that degrades collagen, a connective tissue component. The muscle and enzyme mixture was incubated at 37°C for one hour. Next, the muscle fragments were separated from the dissociated cells by a low speed centrifugation. The cells in the supernatant were pelleted by centrifugation, and they were resuspended in complete medium (70 % Delbucco's minimal medium (DMEM), 20 % M-199 medium, and 10 % fetal bovine serum (FBS)). The cell number present in the suspension was determined using a Coulter counter, and the cells (approximately 20 x 10^6 cells/flask) were plated onto 75 cm^2 flasks with 15 ml of complete medium. The cells were incubated for one hour, and the medium was replaced with fresh medium. After 48 hours, the media were removed, and the cells released from the plate surface using trypsin. The cell number was determined using a Coulter counter. For experiments, cells were diluted to 2 x 10^5 cells/ml, and 0.5, 1.0, and 2.0 ml of this suspension was added to 24-, 12-, and 6-well plates, respectively. The remaining cells (2 x 10^6 cells/ml) were frozen in 70 % DMEM, 20 % FBS, and 10 % dimethylsulfoxide at -80°C for subsequent experiments.

A growth study was performed with the cells grown on 6-well culture plates. These cells were grown over a 7-day period. Every day, one plate was removed from the incubator, and the media removed from the wells. Each well was washed twice with phosphate-buffered saline, in order to remove any residual media left on the plate. Each plate was frozen at -80°C, until DNA and differentiation (phosphocreatine kinase) assays were performed.

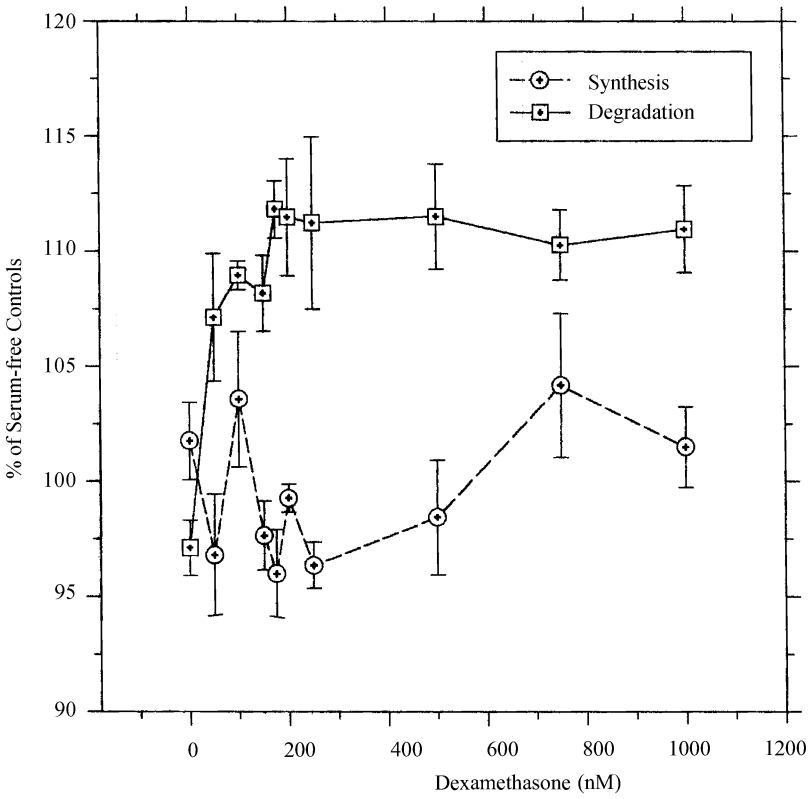
The phosphocreatine kinase is one of several muscle specific marker proteins. Other such marker proteins include myosin, α-actin, desmin, and α-actinin. As muscle cells differentiate by fusing into myotubes, these muscle specific proteins increase in concentration. Therefore, the presence of these proteins indicates the myogenic capacity of the cells. Phosphocreatine kinase activity was determined using a kinetic enzyme assay using a 96-well microplate spectrophotometer. DNA was determined using a fluorometric procedure.

For protein turnover studies, the cells were plated and allowed to grow and fuse into myotubes. The cells were treated with either dexamethasone or insulin in serum-free DMEM. The insulin levels were 0.5, 1.0, 5.0, 10, 50, 75,100, 500, 1000 ng/ml in DMEM. The dexamethasone levels were 50, 100, 150, 175, 200, 250, 500, 750, 1000 nM in DMEM. Protein synthesis was measured by the incorporation of radioactive tyrosine into the myotubes over a four-hour period. Protein degradation was measured by the release of radioactive tyrosine from myotubes over a twenty-hour period. Both protein synthesis and turnover were expressed as a percentage of serum-free controls containing no hormones.



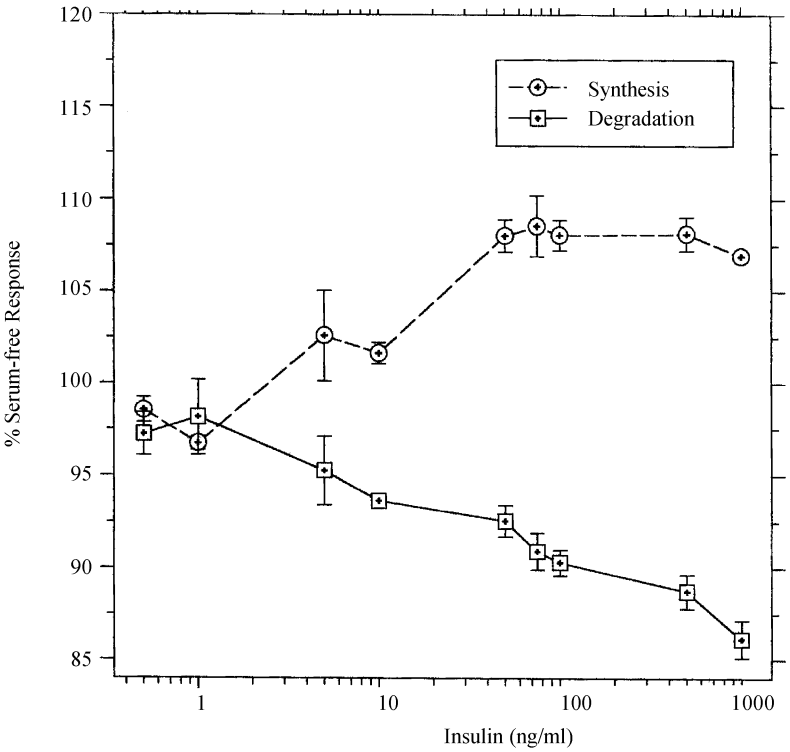
Cells were plated at 1 x 10^5 cells/ml in DMEM/M-199 plus 10% FBS. After 48 h post-plating, the media was changed to DMEM plus 2% Horse serum (HS). Thereeafter, the media was changed every 48 h. Data is expressed as mean ± SEM.

Figure 1. Differentiation and DNA content in bovine primary muscel cell cultures incubated over time.



The test media consisted of DMEM with dexamethasone. The results were compared to serum-free controls (mean ± SEM). Each point represents n = 8.

Figure 2. Protein turnover in bovine primary myotubes incubated with dexamethasone.



The test media consisted of DMEM with insulin. The results were compared to serum-free controls (mean ± SEM). Each point represents n = 8.

Figure 3. Protein turnover in bovine primary myotubes incubated with insulin.

Results

Individual cells had a tapered appearance, when observed under the microscope. The cells multiplied over a 2-3 day period, and the dishes were almost covered with cells by day 3. The cells tended to align parallel to each other at confluence. Fusion of neighboring cells into myotubes could be observed between day 3 and 4 in culture. By day 5, myotubes were the predominant feature of the culture dish.

The DNA content in the dish increased from day 1 to 4, and slightly decreased from day 5 to 6 (Figure 1). The early increase in DNA content is indicative of the cells undergoing rapid proliferation. However, the creatine kinase activity increased throughout the culture (Figure 1), with the increase occurring rapidly after day 3. The increase in creatine kinase and DNA profiles are representative of muscle cells. Creatine kinase is a muscle specific protein, which appears after the cell has begun to undergo differentiation. The decreased DNA content was due to some cell death occurring during the cell fusion into myotubes. Myosin content within the culture increased with differentiation (data not shown). These observations led to the conclusion that muscle cells were isolated from the fetal tissue, and these cells could be viably maintained in culture.

Dexamethasone increased protein degradation but did not influence protein synthesis ($P>.05$) in bovine muscle cell cultures (Figures 2). The increased protein degradation was 12 % of serum-free controls ($P<.05$), when the media contained dexamethasone (Figure 2). This increased degradation occurred between 0 and 200 nM, and the dexamethasone response was maximal at 200 nM.

Insulin altered both protein synthesis and degradation in the bovine muscle cells (Figure 3). The synthesis was increased 8 % compared to serum-free controls ($P<.05$) and was maximal at 75 ng/ml (Figure 3). Protein degradation linearly decreased ($P<.05$)

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in the muscle cells by 10 % (Figure 3). The insulin effects observed at the higher concentrations was likely a pharmacological response of insulin on the muscle cells, rather than a physiological response. This pharmacological response observed represents the insulin binding to the muscle insulin-like growth factor receptors, as well as its insulin receptors. The insulin-like growth factors are potent proteins, which exert a strong growth response and stimulate differentiation in the cells. Protein turnover in muscle cells was shifted towards a net protein accumulation in the muscle cells, when the cells were incubated with insulin.

Future research will proceed with the development of bovine muscle cell clones. These clones are cell lines that have been derived from a single cell. This will provide a useful tool to study the effects of compounds without the interference of other cell types, such as fibroblasts, which may produce localized hormones that may influence the muscle cell culture response. The development of a serum-free culture media will also provide future studies with a controlled nutrient and hormonal environment to grow the cells. With these tools, studies involving the effects of hormones on the development of bovine muscle cells can be readily undertaken.

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[1]Timothy Woods, graduate student; Carol Smith, graduate student; and Steven Jones, Associate Professor, Animal Science, Lincoln.

Grazing Systems Utilizing Forage Combinations

Drew Shain
Terry Klopfenstein
Rick Stock
Mark Klemesrud[1]

Summary

One hundred ninety-two medium framed, British-breed steers were used to evaluate combinations of grazed forages during the summer and fall of 1994, and subsequent finishing performance. Steers were wintered on a low-input wintering system consisting of cornstalk grazing followed by feeding of alfalfa hay. Steers were allotted to one of six September (removed September 7) or two November (removed November 12) pasture removal grazing systems. Systems in the September removal consisted of grazing (1) bromegrass and native Sandhills range, (2) native Sandhills range, (3) continuous bromegrass, (4) rotational bromegrass, (5) rotational red clover inter-seeded in bromegrass, and (6) brome and warm season grasses. Systems in the November removal included grazing of (7) bromegrass, warm-season grasses, and turnips/rye, and (8) bromegrass and turnips/rye. Following grazing, steers were finished on a 93% concentrate diet. Systems in the September removal using native Sandhills range or grazing red clover inter-seeded in bromegrass had the lowest slaughter breakeven costs. Maximizing grazed forage gain, while cost of gain is low, reduces overall breakeven costs of forage systems.

Introduction

Grazing bromegrass throughout the summer provides weight gains of up to two pounds a day during early and late summer. However, during July and August bromegrass growth and quality is low and weight gains of cattle grazing bromegrass are reduced. Grazing combinations of warm and cool season forages allows for optimizing forage quality by rotating to warm season grasses during July and August. Another alternative may be to inter-seed red clover in bromegrass to optimize forage quality. Inter-seeding red clover would provide a higher quality forage when bromegrass growth and quality is low and, in addition, provide a source of nitrogen for the bromegrass, thus reducing nitrogen fertilization costs. Grazing these forages during the summer when quality is high, and following a winter and spring period of limited animal growth, should produce excellent animal weight gains while reducing cost of gain.

Objectives of the research were to evaluate the influence of different forage combinations on summer and fall grazing gains and to evaluate the effect of each of these combinations on the economics of the entire growing/finishing system.

Procedure

One hundred ninety-two medium framed, British-breed steers (488 lb) were purchased in the fall, processed and allowed a 28-day weaning and acclimation period. Steers were then assigned to a low-input wintering system consisting of grazing irrigated cornstalks from December 3, 1993 to January 31, 1994. Following cornstalk grazing, steers were fed alfalfa hay and a mineral supplement ad libitum until May 7, 1994. This diet allowed for .42 lb/day gain and maintained animal health while keeping costs to a minimum.

On May 7, 1994, steers were implanted with Compudose, blocked by weight and assigned to one of eight grazing systems (Table 1): (1) bromegrass or native Sandhills range until September 7, (2) native Sandhills range until September 7, (3) continuous bromegrass until September 7, (4) rotational bromegrass until September 7, (5) rotational red clover inter-seeded in bromegrass until September 7, (6) brome or warm-season grasses until September 7, (7) brome or warm-season grasses until September 7 with bromegrass or turnip/rye grazing until

Table 1. Summer systems grazing acreage.

Forage system	Treatment #	Total acre/head	Acres	Days grazed
September Removal				
Bromegrass	1	.4	9.6	34
Sandhills range		4.95	119	95
Sandhills range	2	6.9	166	129
Continuous bromegrass	3	1	24	129
Rotational bromegrass	4	1	24	129
Red clover/bromegrass	5	.75	18	141
Bromegrass rest		.25	6	
Bromegrass	6	.4	9.6	34
Warm season grasses		.6	14.4	95
November Removal				
Bromegrass	7	.6	14.4	149
Warm season grasses		.6	14.4	
Turnips/rye		.62	14.9	40
Bromegrass	8	1.2	29	149
Turnips/rye		.62	14.9	40

November 12, (8) bromegrass until September 7 with bromegrass or turnip/rye grazing until November 12. Bromegrass, warm-season grass and turnip/rye pastures were located at the University of Nebraska ARDC, Mead location. Native Sandhills range pasture was located approximately 20 miles north of North Platte, Nebraska. Days of grazing and assigned acres for each system are listed in Table 1.

Cattle in the red clover/bromegrass system (5) grazed a seven-paddock rotation. Six of these paddocks were in the first, second or third year following red clover seeding, two paddocks each. The seventh paddock was only bromegrass, was twice the size of the other paddocks, and was used as an area for animals to graze while allowing appropriate rest for the red clover/bromegrass paddocks. Cattle were rotated among paddocks every 5 days. Cattle in the rotational bromegrass system (4) served as the control group for the red clover/bromegrass system with paddock size, paddock number and rotation time the same as the red clover/bromegrass system.

Cattle in systems using a combination of forages (excluding red clover/bromegrass) were rotated based upon forage quality and quantity to assure that the highest quality forage was available at all times. Warm season grass pastures were predominately switchgrass and big bluestem seeded. Grazing of warm-season grass pastures began on June 10, 1994. Turnips and rye were drilled into wheat stubble following a one disked tillage of wheat stubble in late July. Grazing of turnips and rye began on October 2.

Following grazing, steers were re-implanted with Compudose and fed a 93% dry rolled corn diet during the finishing period which averaged 98 days and 93 days for the early and late grazing groups, respectively. Steers were adjusted to the final diet using four adaptation diets containing 45, 35, 25, and 15% (DM basis) forage (alfalfa hay and corn silage mixture) and were fed for 3, 4, 7, and 7 days, respectively. The final diet contained 80% dry rolled corn, 10% supplement, 5% alfalfa hay, and 5% corn silage (DM basis) and was formulated (DM basis) to contain 12% CP, .7% calcium, .35% phosphorus, .7% potassium, 25 g/ton Rumensin, and 10 g/ton Tylan. Steers were fed in pens of 12 head each with two pens per forage system.

Initial and final weights for each stage of the system were the average of two weights taken on consecutive days following a three-day feeding of a 50% alfalfa hay and 50% corn silage diet (DM basis). Intakes during these periods were limited to 2% (DM) of body weight. Final weights were estimated from hot carcass weight using a 62% dressing percentage. Carcass measurements included hot carcass weight, liver abscess score, fat thickness, quality grade, and yield grade.

Breakeven cost was used as the measure of success of each system and included all input costs. Data were analyzed as a completely randomized design with grazing treatment as the main effect and feedlot pen as the observation unit for statistical analysis. Breakeven correlation coefficients (r) for amount of gain achieved during the summer grazing, combined summer and fall grazing, and finishing periods were determined to evaluate which period, within each system, had the most influence on breakeven cost.

Results

Winter Period

Calves grazed cornstalks for 56 days and were fed alfalfa hay for an additional 99 days. Gain during the winter period was .42 lb/day.

Summer Period

The amount of red clover in the red clover/bromegrass paddocks was variable. A previous wet summer (1993) reduced the amount of red clover present in paddocks in their third year following seeding with an estimated red clover amount of 5% of the available biomass. Paddocks in their second year following seeding had an estimated red clover amount of 15% of the available biomass. Red clover in paddocks in their first year following seeding did not germinate resulting in no red clover in these paddocks. In addition, cattle in the red clover/bromegrass treatment were allowed access to their pastures 12 days earlier to reduce bromegrass competition with the red clover.

Gains for cattle grazing bromegrass and Sandhills range or only Sandhills range were higher ($P<.05$, Table 2) than cattle grazing bromegrass (continuous or rotational) or cattle in the November removal systems. Gains for cattle grazing red clover/bromegrass or bromegrass and warm season pastures in the September removal were greater ($P<.05$) than cattle grazing continuous

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Table 2. Total system performance for steers grazing different forage combinations.

Forage System:	September removal						November removal	
Item Treatment:	Bromegrass Sandhills 1	Sandhills 2	Continuous bromegrass 3	Rotational bromegrass 4	Red Clover bromegrass 5	Brome-grass, warm season 6	Brome-grass, warm season turnips/rye 7	Brome-grass turnips/ rye 8
Weight, lb								
May 7	619	623	624	623	612	619	622	623
Sept., 13	868	879	828	836	878	851	837	833
Nov., 16	——	——	——	——	——	——	879	905
Final[a]	1227	1236	1160	1187	1241	1201	1193	1225
Daily gain, lb								
Summer[b]	2.01[c]	2.06[c]	1.64[d]	1.72[de]	1.89[ce]	1.87[ce]	1.74[de]	1.70[de]
Fall[f]							.70[c]	1.20[d]
Total grazing	2.01	2.06	1.64	1.72	1.89	1.87	1.40	1.54
Finishing performance								
DMI, lb/day	28.64[cde]	28.44[cde]	27.70[ce]	27.03[ce]	28.91[de]	26.81[c]	27.83[ce]	30.03[d]
Daily gain, lb	3.70[cd]	3.65[cd]	3.38[cd]	3.61[cd]	3.73[c]	3.58[cd]	3.36[d]	3.45[cd]
Feed/gain[g]	7.74[cd]	7.78[cd]	8.19[ce]	7.47[d]	7.75[cd]	7.48[d]	8.27[ce]	8.69[e]
Carcass data								
Fat, in	.34	.42	.35	.41	.42	.40	.47	.42
Yield grade	2.2	2.6	2.3	2.4	2.4	2.4	2.4	2.3
% Choice	50	67	63	54	65	61	54	67

[a]Calculated from carcass weight adjusted for 62% dressing percentage.
[b]May 7 to September 13.
[cde]Means in the same row with unlike superscripts differ (P<.05).
[f]September 14 to November 16.
[g]Feed/gain was analyzed as gain/feed. Gain/feed is the reciprocal of feed/gain.

bromegrass. In general, cattle grazing only bromegrass tended (P=.15) to have the lowest daily gains compared to cattle grazing forage combinations.

Fall Period

Cattle grazing bromegrass and turnips/rye (treatment 8) exhibited greater (P<.05, Table 2) gains than cattle grazing the combination of bromegrass, warm season grasses, and turnips/rye (treatment 7).

Finishing Period

Differences among treatments for daily gain, dry matter intake, and feed efficiency varied (Table 2). Cattle with the lowest summer daily gains tended (P=.22) to have the lowest finishing daily gains (treatments 3, 7, and 8). No differences were noted in carcass measurements (fat thickness, yield grade, or quality grade) among treatments indicating that all cattle were finished to a similar endpoint.

Economics

Cattle on the red clover/bromegrass treatment (5), bromegrass and Sandhills range (treatment 1) or only Sandhills range (treatment 2) had the most desirable breakeven costs (Table 3). Cattle grazing continuous bromegrass and cattle in the November removal systems had the least desirable breakeven costs. Breakeven cost correlation coefficients (r) for summer gain, the combined summer and fall gain, feedlot gain, and feedlot efficiency were -.76 (P<.001), -.42 (P<.10), -.80 (P<.001), and -.58 (P<.02), respectively, indicating that summer grazing gain and feedlot gain had the most effect on breakeven cost.

Gains for cattle on the red clover/bromegrass treatment were lower than anticipated. However, cattle had access to red clover approximately one half of the grazing time due to the variable amount of red clover present. Therefore, if red clover was available in paddocks as planned, gains should have been higher.

Transporting cattle to warm season grasses to optimize forage quality rather that developing warm season pastures is economical as evidenced by the Sandhills range treatments (Treatments 1 & 2). The stress and body weight shrink associated with transporting animals did not negatively influence weight gain. The transportation costs associated with the Sandhills range treatments would increase breakeven cost by $.91/100 lb resulting in no change in ranking of breakeven costs among treatments.

Breakeven values at slaughter reflect the final weight of each system. Further, the final weight for each system was influenced by the amount of gain achieved during the summer grazing period. In addition, systems with a higher gain during the summer maintained a higher gain during the finishing period. Forages that maximize summer grazing gain, when grazing cost is fixed, result in a lower cost of gain. Therefore, cattle entering the feedlot at a heavier weight and having achieved a low summer cost of gain, maintained their weight advantage through the finishing period resulting in heavier final weights and lower breakeven values.

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[1]Drew Shain, Mark Klemesrud, research technicians, Rick Stock, Terry Klopfenstein, Professors, Animal Science, Lincoln,

Table 3. Total system economics of steers grazing different forage combinations.

Forage System:	September removal						November removal	
Item Treatment:	Bromegrass Sandhills 1	Sandhills 2	Continuous bromegrass 3	Rotational bromegrass 4	Red Clover bromegrass 5	Brome-grass warm season 6	Brome-grass, warm season turnips/rye 7	Brome-grass turnips/ rye 8
Steer cost,$[a]	462.65	465.50	473.10	458.85	465.50	465.50	455.05	458.85
Interest[b]	46.14	46.43	47.19	45.77	46.43	46.43	51.56	51.99
Health[c]	19.00	19.00	19.00	19.00	19.00	19.00	19.00	19.00
Winter costs,$								
Feed[d]	72.64	72.64	72.64	72.64	65.84	72.64	72.64	72.64
Supplement[e]	18.60	18.60	18.60	18.60	16.60	18.60	18.60	18.60
Summer & Fall costs,$								
Grazing[f]	43.40	43.40	43.40	43.40	49.35	43.40	64.40	64.40
Finishing costs,$								
Yardage[g]	29.25	29.25	29.25	29.25	29.25	29.25	27.75	27.75
Feed[h]	167.54	166.37	162.05	158.13	169.12	156.84	154.46	166.67
Total costs, $[i]	873.20	875.12	878.97	859.23	874.97	865.20	880.10	897.11
Final weight, lb[j]	1227	1236	1160	1187	1241	1201	1193	1225
Slaughter Breakeven, $/100 lb[k]	71.18[lm]	70.81[lm]	75.75[n]	72.41[lm]	70.54[l]	72.12[lm]	73.77[mn]	73.24[lmn]

[a]Initial weight x $95/100 lb.
[b]9% interest rate.
[c]Health costs = implants, fly tags, etc.
[d]Receiving = 28 days at $.74/day; stalk grazing = 56 days at $.12/day; alfalfa hay = 99 days at $.30/day; grazing and alfalfa hay feeding yardage = 155 days at $.10/day.
[e]Supplement = 155 days at $.12/day.
[f]Grazing costs = $.35/hd/day.
[g]$.30/day.
[h]Average diet cost = $.06/lb (DM) and 9% interest for 1/2 of feed.
[i]Total costs include 2% death loss for each system.
[j]Calculated from hot carcass weight adjusted for 62% dressing percentage.
[k]Trucking cost to Sandhills range would increase breakeven ($/100 lb) by $.0019/mile.
[lmn] Means in the same row with unlike superscripts differ (P<.05).

Beef Production Systems from Weaning to Slaughter in Western Nebraska

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Summary

Systems for managing weaned British-breed steer calves through winter growing, summer grazing, and finishing periods were studied over three years. Calves were winte red at two rates of gain: less than 1.00 lb/day (Slow) and approximately 2.00 lb/day (Fast), and then split for summer grazing from May to July (62 days; Short) or September (120 days; Long). Following the grazing period all steers were fed a common 90% concentrate finishing diet for 121 days (Short) and 127 days (Long) until it was visually estimated that the cattle had 0.4 inches of fat over the thirteenth rib. Extending the length of summer grazing decreased finishing gain and efficiency but increased final weight and total costs. Cattle that grazed corn stalks with a relatively low winter gain (.79 lb/day) compensated during the summer and experienced faster summer gains then those wintered at a higher rate. Steers that grazed for the full summer grazing period (120 days) had the greatest gain on grass, however most of the compensatory gain was achieved with the Slow winter growth cattle during the first 62 days of grazing. Cattle that were on grass for the Short grazing period had faster finishing gain and tended to be more efficient. Economically there were not differences when representative costs were used in calculating breakevens. The cattle that were wintered at a fast rate and pastured for the full summer period had a higher breakeven. Cattle wintered at a fast rate of gain should only be grazed in the spring and early

(Continued on next page)

summer when the quality of forage is high enough to support higher pasture gains, to be economically competitive with systems that have lower winter input costs.

Introduction

Numerous alternatives exist for feeding and managing weaned medium-frame steers to slaughter. Efficiency of beef production includes the total growing and finishing period. Often economics of production only considers a single part of the production systems. As a consequence one segment of the industry may make decisions based on maximum profit while they own or manage an animal that may adversely effect the profit of a subsequent owner, possibly causing overall economic efficiency to be lowered. For example, cost per pound of gain is usually lower when calves are wintered at a relatively fast rate of gain and consequently feedlot operators tend to want relatively fast gains so cost of gain will be relatively low. However, this may not be cost effective if the cattle are going to be grazed the following summer.

Range land comprises about 60% of western Nebraska land mass which produces high quality forages for cow-calf producers and yearling stocker operators. Historically many yearlings were grazed on the rangeland after they had been weaned and wintered on the ranch at a relatively slow rate of gain. As more cattle were moved to confinement feeding on higher energy rations questions arose about what the proper wintering gain for weaned calves is and what the proper length to graze yearlings with varied winter gain is. Tremendous quantities of crop residues such as cornstalks are available to winter calves and even though the winter gain is relatively low and cost per pound of gain is high, total winter cost of gain can be very low. Cattle subjected to periods of low energy intake normally exhibit compensatory growth during subsequent periods of adequate energy intake. Cattle that experience compensatory growth are also more efficient than comparable cattle grown on a higher energy ration. Because of compensatory gains, considerable gain can be put on light yearlings on grass at a very low cost which would lower the overall cost of production. Because of the low winter moisture in western Nebraska, cornstalk quality is relatively high throughout the winter, allowing low cost winter gains and long grazing.

The objectives of this research were to 1) evaluate the effect of winter management and length of summer grazing on subsequent finishing performance with medium-frame steers, and 2) economically evaluate these systems of production.

Procedure

Systems for managing crossbred, medium-frame steer calves were evaluated over three years, using 432 British crossbred steers averaging 527 lb. The steers were managed in a 2×2 factorial arrangement of treatments. Factors included: winter rate of gain (Slow at less than 1 lb/day, or Fast at 2 lb/day) and summer grazing season (Short for 62 days, or Long for 120 days).

The wintering period averaged 127 days with the Slow treatment, grazing cornstalks approximately 52 days of the winter season followed by the feeding of limited energy diets (approximately, 2.1% of body weight) consisting (DM basis) of 37.5% haylage, 37.5% corn silage, 23% dry rolled corn, and 2% supplement to maintain a daily gain (less than 1 lb/day) similar to that obtained on the cornstalks. Fast winter gaining cattle were placed in the feedlot and fed ad libitum amounts of the basal diet used for the Slow treatment. Wintering groups were randomly assigned by pen (10 pens per treatment) to either a Short (62 days) or Long (120 days) grazing season. Steers grazed pastures, primarily crested wheatgrass and native grass, from mid-May to mid-September. The steers were implanted at the start of the grazing season and reimplanted at the start of the finishing period with Synovex S. Free choice minerals were supplied during grazing.

Evaluation of economic analysis for each system included current costs for all inputs. Costs that were used to get the final breakeven prices and total costs are: processing and health costs $14, corn stalks $0.15/day, spring feed $0.45/day, yardage $0.25/day, interest 9.0%, summer grass $0.33/day, and final ration feed cost $.05/lb. Breakeven prices were used to evaluate the overall economic returns of each system.

Rumen fill differences after the grazing season were minimized by feeding a common diet of 50% corn silage and 50% haylage (DM basis) at 2.0% body weight for 3 days before weighing on two consecutive days to determine the final weight for the grazing season.

Steers were fed a common finishing diet for 121 days (Short) and 127 days (Long) until it was visually estimated that the cattle had 0.4 inches of fat over the thirteenth rib. After collecting carcass data, 84% had reached the Choice grade. The finishing diet consisted (DM basis) of 44% high moisture corn, 40% rolled corn, 10% roughage (corn silage and/or haylage), and 6% supplement. The supplement provided Rumensin and Tylan at 29 and 10 grams of ration dry matter, respectively. There were 4 step up diets containing 50%, 40%, 30%, and 20% roughage (DM basis) fed for approximately 15 to 20 days.

Data within in each year were analyzed by analysis of variance using the General Linear Models procedure (SAS, 1985). Experimental design was a completely randomized design with a 2 × 2 factorial treatment arrangement, with pen as the experimental unit. When the treatment × year interaction was determined not significant (P>.10), all three years were pooled for analysis.

Results

Total winter gains (Table 1) for the Slow and Fast wintering treatments were 98 and 242 lb, respectively (P<.10). Compensatory growth during summer grazing by the Slow winter group continued through and was greater during the last part of the grazing season (interaction, P<.10) than the Fast winter group (88 vs 65 lb). This was expected because the calves that were wintered at a Slow rate were carrying less body

Table 1. Steer performance in winter and summer management systems

Winter Gain Grazing Season	Slow Short	Slow Long	Fast Short	Fast Long
No. of Steers	109	107	108	108
Initial weight, lb	524	528	526	529
Winter				
Total gain, lb[a]	96	100	240	244
ADG, lb/d[a]	.78	.80	2.01	2.04
Summer				
Total gain, lb[b]	151	239	88	153
ADG, lb/d[b]	2.45	2.01	1.44	1.29

[a]Winter gain (P<.10).
[b]Winter gain x Grazing season (P<.10).

Table 2. Steer performance during finishing

Winter Gain Grazing Season	Slow Short	Slow Long	Fast Short	Fast Long
Finishing gain, lb[ab]	439	411	422	384
Finishing F/G[ab]	6.45	7.13	6.70	7.77
Finishing ADG, lb[ab]	3.69	3.28	3.55	3.06
Finishing DMI, lb	23.87	23.40	23.78	23.76

[a]Winter gain (P<.10).
[b]Grazing season (P<.10).

Table 3. Economic performance in management systems

Winter Gain Grazing Season	Slow Short	Slow Long	Fast Short	Fast Long
Final weight, lb[ab]	1211	1276	1277	1310
Total costs, $[abc]	827.67	872.86	865.72	914.23
Breakeven, $/100 lb[d]	69.85	69.94	69.27	71.41

[a]Winter gain (P<.10).
[b]Grazing season (P<.10).
[c]Costs assumed are: processing and health costs $14, corn stalks $0.15/day, spring feed $0.45/day, yardage $0.25/day, interest 9.0%, summer grass $0.33/day, and final ration feed cost $.05/lb.
[d]Winter gain x Grazing season (P<.10).

condition when turned out to grass and had more of an opportunity to gain body condition. In contrast, the cattle that were wintered at a Fast rate were carrying considerable more condition when turned out to grass and consequently had less opportunity to add weight through body condition. Total summer grazing gains during the Short grazing season were 151 and 88 lb for the Slow and Fast winter groups, respectively. Cattle on the Fast winter growth were 146 lb heavier (actual weight 770 lb) when going to pasture than the Slow growth cattle. At the end of the Long grazing season, the Slow winter growth cattle had gained within 59 lb of the Fast winter growth steers (867 vs 926 lb actual weight for the Slow and Fast winter growth, respectively). The cattle on the Slow winter growing program made up 59% of the winter weight gain difference. Total summer gains during Long grazing season were 239 and 153 lb for the Slow and Fast winter groups, respectively. Finishing feed to gain ratios (Table 2) were lower (P<.10) for the Short grazing season than for the Long (6.58 vs 7.45). The combination of Slow winter gains with Short season grazing resulted in the lowest finishing feed to gain ratio each year. The improvement in feed efficiency is primarily the result of improved gain during the finishing period. Apparently the Slow winter growth and Short grazing cattle still had some opportunity to exhibit compensatory gain. Also the cattle that were taken off of pasture at mid-summer were finished in more temperate weather and possibly better feeding conditions than those brought off of grass in mid-September and marketed in January.

Finishing dry matter intake was not different among the four systems (Table 2). Finishing ADG was higher (P<.10) for steers that were finished after the first half of the summer grazing season compared to those grazed for the Long season.

Total costs (Table 3) were lower (P<.10) for the Short season than for the Long season of grazing ($846.70 vs $893.55, respectively). Total final weight was increased for the Fast winter gain and Long grazing group (P<.10), however total costs were also increased and breakeven for this treatment was higher than for the other three treatments. Under the conditions that this trial was conducted and with the assumed costs, the breakeven was not different for the cattle that were wintered at a Slow rate of gain or those wintered at a Fast rate but only grazed until mid summer. Many factors could alter the breakeven value such as the cost and availability of stalks and the type and cost of summer forage. Perhaps a larger factor that influences profits is the price when cattle are marketed. Producers may use forages to extend the time of marketing cattle when seasonal prices are historically high. Breakevens can be lowered when low cost forages are utilized to grow cattle. This decrease in breakeven was primarily due to the increased weight when the cattle were slaughtered. In this trial, even though slaughter weight was a major factor in determining breakevens, the cattle that grazed for the entire summer were not heavy enough to offset the costs of achieving slaughter weight.

Conclusions

Opportunities exist for producers to take advantage of low input expenses for winter management, causing larger summer gains on pasture. Cattle wintered at a fast rate of gain should be grazed for a shorter period of time to be economically competitive with wintering systems that have lower input costs and gains before they are turned out to grass.

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Feeding Value of Light-Test Weight Corn for Growing and Finishing Steers

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Summary

Light-test weight corn from two consecutive years at 47.7 and 45.9 lb per bu was compared to corn at 56.5 and 55.9 lb when fed to large-frame crossbred steer calves during a growing phase and a subsequent finishing phase in both years. Performance results from both years were similar, and after combining the data, steers gained as fast and as efficiently on the light-test weight corn as they did on the heavier corn during both the growing and finishing phases. When carcass data were combined for the two years, hot carcass weights were significantly greater for the light-test weight corn, but other measurements were similar. The data from these trials indicate that corn with a test weight as low as 45.9 lb per bu has equal feeding value to normal U.S. No. 2 corn for cattle on growing and finishing diets.

Introduction

When a corn growing season is not long or warm enough for corn to reach full maturity, the test weight can fall substantially below the standard. Currently the top market price is based on No. 2 corn, which in the U.S. is 54 lb per bu. Most grain dealers and beef feedlot operators will discount the corn price by increments as test weights fall below the standard U.S. No. 2, indicating that feed value is less. However, feeding trials over the years with light-test weight corn in poultry and swine diets and with grain sorghum fed to cattle have generally shown little difference in feed value from normal test-weight corn or milo when compared on an equal weight basis. There is little research data on the feed value of light-test weight corn for growing or finishing cattle. Because of early frost and a cool growing season, light-test weight corn was available from the 1992 and 1993 corn crops in the Nebraska Panhandle. Consequently, feeding trials were conducted to compare the light-test weight corn to normal corn in two growing trials with steer calves fed a moderate level of grain, and during subsequent finishing trials when a high level of grain was fed.

Procedure

Light-test weight corn was evaluated during two consecutive years in growing and finishing diets for crossbred, large-frame steer calves. The source of the calves was the same in both years. In years 1 and 2, there were 6 pens of 12 and 4 pens of 11 steers, respectively, on each treatment. Test weight comparisons were 56.5 to 47.7 and 55.9 to 45.9 lb per bu in years 1 and 2, respectively. The light-test weight corn was purchased from a single source the first year and from two sources the second year. The control corn was produced at the Panhandle Research and Extension Center. Test weights were determined by a Dickey-John Grain Analysis Computer II. The growing diet dry matter fed in both years consisted of 32.9% corn silage, 22.3% alfalfa haylage, 37.0% dry rolled corn and 7.8% supplement providing Rumensin and minerals. In both years, final finishing diet dry matter consisted of 9.2% corn silage, 86.2% dry rolled corn and 4.6% protein supplement. The corn was coarsely processed with a roller mill. The rollers were set the same for both test weights of corn. The roller adjustment was such that approximately 90% of the light-test weight corn was broken at least once.

The rations were calculated on a dry matter basis to contain 14.8% crude protein and .50 Mcal/lb NEg in the

Table 1. Corn comparisons for two years of feeding trials

Corn	Normal	Light
Year 1		
Corn test wt/bu, lb	56.5	47.7
Corn moisture, %	11.7	13.4
Corn DM protein, %	9.8	10.2
Year 2		
Corn test wt/bu, lb	55.9	45.9
Corn moisture, %	14.3	15.4
Corn DM protein, %	8.6	9.9

Table 2. Two years of performance data for light-test weight corn fed to growing steers

Corn	Normal	Light	SEM
Year 1, 71 days			
No. of steers	73	72	
No. of pens	6	6	
Initial wt, lb	598	597	
Daily gain, lb	2.49	2.51	0.050
Feed DM/day, lb	16.5	16.8	0.25
Feed/gain	6.65	6.70	0.14
Year 2, 105 days			
No. of steers	45	44	
No. of pens	4	4	
Initial wt, lb	614	632	
Daily gain, lb	2.39	2.49	0.056
Feed DM/day, lb	17.2	17.8	0.28
Feed/gain	7.16	7.12	0.16
Combined data, 2 years			
No. of steers	118	116	
No. of pens	10	10	
Initial wt, lb	604	610	
Daily gain, lb	2.46	2.51	0.055
Feed DM/day, lb	16.8	17.2	0.27
Feed/gain	6.85	6.86	0.15

Table 3. Two years of performance data for light-test weight corn fed to finishing steers

Corn	Normal	Light	SEM
Year 1, 182 days			
No. of steers	73	71	
No. of pens	6	6	
Final wt, lb	1267	1287	
Daily gain, lb	2.71[a]	2.83[b]	.038
Feed DM/day, lb	18.7	18.3	.24
Feed/gain	6.92	6.47	.13
Year 2, 135 days			
No. of steers	44	43	
No. of pens	4	4	
Final wt, lb	1337	1381	
Daily gain, lb	3.50	3.61	.048
Feed DM/day, lb	23.5	22.7	.29
Feed/gain	6.65	6.32	.16
Combined data, 2 years			
No. of steers	117	114	
No. of pens	10	10	
Final wt, lb	1294[c]	1324[d]	
Daily gain, lb	3.12	3.22	.043
Feed DM/day, lb	21.1	20.5	.26
Feed/gain	6.79	6.40	.15

[ab]Means differ (P<.05).
[cd]Means differ (P<.1).

Table 4. Two years of carcass data for light-test weight corn fed to growing and finishing steers

Corn	Normal	Light	SEM
Year 1, total 253 days			
Hot carcass wt, lb	785	798	
Dressing percent	64.0	64.2	0.001
Fat thickness, in	.41[a]	.45[b]	0.010
Marbling score	6.09	6.01	0.098
Rib eye area, sq in	12.1	12.2	0.091
Yield grade	3.16[c]	3.20[d]	0.044
Year 2, total 240 days			
Hot carcass wt, lb	829	856	
Dressing percent	62.7	63.0	0.001
Fat thickness, in	.44[c]	.40[d]	0.013
Marbling score	5.89	5.88	0.126
Rib eye area, sq in	14.0	14.9	0.117
Yield grade	2.77	2.48	0.057
Combined data, 2 years			
Hot carcass wt, lb	802[c]	821[d]	5.0
Dressing percent	63.5	63.7	0.001
Fat thickness, in	.42	.43	0.011
Marbling score	6.01	5.96	0.11
Yield grade	2.95	2.92	0.50
Rib eye area, sq in per cwt of hot carcass wt	1.60	1.61	

[ab]Means differ (P<.05).
[cd]Means differ (P<.1).
[e]Marbling scores: Small = 5.0, modest = 6.0.

growing diet and 11.4% crude protein and .66 Mcal/lb NEg in the finishing diet. The calculations assumed corn to contain 9.0% crude protein (dry matter basis). Actual chemical analyses for the corn at both test weights in both years are shown in Table 1. The corn generally contained higher levels of protein than initially assumed, so the rations contained slightly higher protein levels than calculated. The crude protein percentages in the finishing rations were 12.0, 12.4 and 11.0, 12.1 for normal and light weight corn in trials 1 and 2, respectively. Rumensin was included in both diets and the steers were implanted with Synovex at the start of the growing and finishing periods.

Carcass measurements were taken at slaughter and final live weight were calculated by dividing hot carcass weights by a common dressing percentage (62). Using statistical procedures described in SAS (1988), performance and carcass data were analyzed for each year as well as for a combined basis for the two years which involved 10 pens on each treatment.

Results

In the two growing trials of 71 and 105 days, there were no significant differences in daily gain, dry matter feed intake, or feed required per unit of gain in large-frame steer calves fed normal or light-test weight corn (Table 2). Thus combining the data for the two years resulted in 10 pens on each corn with similar performances during the growing phase, feeding a diet that contained 37% dry rolled corn.

The finishing trials that followed the growing trials were for 182 and 135 days in years 1 and 2, respectively. Daily gains were improved (P<.05) on the light-test weight corn in year 1, but not in year 2 and not in the combined data for the 2 years (Table 3). Treatment differences for dry matter feed intake and feed required per unit of gain were not statistically significant for years 1 and 2 or the combined data.

Carcass comparisons are shown in Table 4. Hot carcass weight was significantly greater (P<.05) for the light-test weight corn in the combined data. The other measurements in the combined data were similar, including rib eye area when expressed as sq in per hundredweight of hot carcass weight.

Data from these trials indicate that when test weight of corn is at least 46 lb per bu, the feeding value is equal to normal U.S. No. 2 corn, which is in agreement with steer metabolism data from Birkelo et al. (1994 South Dakota Beef Report, pp. 2-5) and data from swine and poultry trials.

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Roughage Source and Particle Size in Finishing Diets

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Summary

Two hundred twenty-four crossbred yearling steers were used to evaluate the effect of roughage source and particle size in finishing diets. Treatments consisted of an all-concentrate diet or diets containing equal levels of NDF provided by alfalfa hay or wheat straw with each roughage source ground to pass through a 3/8", 3", or 5" screen. Cattle fed the all-concentrate diet consumed less feed, gained slower, but were similar in efficiency to cattle fed diets containing roughage. Cattle fed diets containing alfalfa hay gained 7.7% faster and 7.7% more efficiently than cattle fed diets containing straw. As roughage particle size increased, daily gain tended to decrease and feed conversion tended to increase with no differences in dry matter intake. Roughage sources used in high grain finishing diets may not respond similarly when used at equal NDF levels. Decreasing roughage particle size may enhance performance.

Introduction

When compared to an all concentrate diet, roughage addition (5 to 15% of diet DM) stimulates intake, chewing, rumination and possibly particulate and liquid outflow from the rumen. Roughage addition, therefore, reduces acidosis by diluting concentrate intake and/or increasing salivation and buffering capacity of the rumen.

Alfalfa hay is a commonly fed roughage source. If the use of the fiber fraction within alfalfa roughage is to simply dilute concentrate intake and help prevent acidosis, then any fiber source fed at a similar NDF level should respond similarly to alfalfa hay.

Particle size plays a major role in determining ruminal retention time. The smaller the particle size the faster the passage rate from the rumen. If roughage added to a finishing diet consists of small particles, then the dilution effect desired from roughage addition to finishing diets may be negligible. However, if roughage particle size is too large, total intake and energy consumed may decrease due to an increase in ruminal retention. Objectives of our research were to evaluate the effect of alfalfa hay and wheat straw with differing particle sizes on performance of steers fed a high-concentrate finishing diet.

Procedure

Two hundred twenty-four crossbred yearling steers (744 lb) were blocked by weight and randomly allotted within block to one of seven treatments. Treatments consisted of an all-concentrate diet or diets containing alfalfa hay or wheat straw ground to pass through a 3/8-, 3-, or 5-inch screen. All diets were balanced to contain 12% crude protein, .7% calcium, .35% phosphorous, .7% potassium, 25 g/ton Rumensin, and 10 g/ton Tylan. Diets containing roughage were balanced to provide equal NDF levels and contained (DM basis) 10% alfalfa hay (42.8% NDF) or 5.2% wheat straw (82.0% NDF). Calculated NE_g contents of the all concentrate, alfalfa and straw diets was .67, .63, and .64 Mcal/lb, respectively. All diets contained dry rolled corn as the concentrate source and urea as the source of supplemental protein, with 5% molasses and 5% supplement included in all treatments.

All cattle received common adaptation diets while adapting to their final treatment diets. Dietary treatments were implemented following a 27-day, five-step grain adaptation period. Cattle received the final diet for an average of 76 days and were fed once daily. Cattle were implanted with Compudose at the start of the trial and then implanted with Finaplex on day 28. The trial was conducted from August 23 to December 16, 1994.

Initial weights were the average of two weights taken on consecutive days before feeding. Hot carcass weight adjusted for 62% dressing percentage was used to estimate final live weight. Hot carcass weight, 12th rib fat thickness, liver score, quality and yield grade were recorded. Data were analyzed as a randomized complete block design with treatment and replication included in the model. Orthogonal contrasts were used to analyze treatment effects of roughage type and particle size.

Results

Cattle receiving alfalfa or straw diets consumed more feed ($P<.05$) and gained faster ($P<.05$) than cattle receiving the all-concentrate diet (Table 1). No difference in feed efficiency was noted when comparing cattle receiving alfalfa, straw, or all-concentrate diets. Cattle fed the alfalfa or straw diets had heavier hot carcass weights ($P<.10$) and greater 12th rib fat thickness ($P<.05$) than cattle fed the all-concentrate diet. No differences were noted in quality grade or yield grade among treatments.

No differences were noted in dry matter intake between cattle receiving alfalfa or straw in the finishing diet. However, cattle fed alfalfa finishing diets gained faster ($P<.05$), were more efficient ($P<.05$), and had greater 12th rib fat thickness ($P<.10$) than cattle fed the straw diets (Table 1). Although diets containing roughage were balanced to provide equal levels of forage NDF, it appears that NDF content may not act similarly between alfalfa and wheat straw when fed as a roughage

Table 1. Effect of roughage type and particle size on finishing performance.

Roughage Source:		Alfalfa			Wheat Straw		
Screen size:		3/8 in	3 in	5 in	3/8 in	3 in	5 in
Item	All Concentrate						
Dry matter intake, lb/day[a]	23.00	25.45	26.08	25.13	26.00	25.93	25.18
Daily gain, lb[ab]	3.36	3.92	3.81	3.74	3.58	3.63	3.44
Feed/gain[bc]	6.86	6.50	6.84	6.72	7.27	7.14	7.32
Carcass Characteristics							
Hot carcass weight, lb[bd]	679	715	708	704	694	698	682
Fat thickness, in[ae]	.28	.36	.37	.32	.32	.30	.33
% Choice	56.3	56.3	59.4	43.7	50.0	40.6	40.6

[a]All-concentrate vs other treatments, P<.05.
[b]Alfalfa vs straw, P<.05.
[c]Feed/gain was analyzed as gain/feed. Feed/gain is reciprocal of gain/feed.
[d]All-concentrate vs other treatments, P<.10.
[e]Alfalfa vs straw, P<.10.

source for dry rolled corn finishing diets.

No particle size by roughage source interaction was observed. Therefore, further discussion of results will examine differences among particle sizes of the alfalfa and straw treatment groups.

Current theory for the addition of roughage to a high-grain finishing diet is to provide a "scratch factor" that may stimulate rumination, increase salivation and thereby reduce the severity of acidosis. However, cattle receiving either straw or alfalfa ground through a 5-inch screen had numerically lower daily gains and higher feed conversions. In contrast, cattle receiving the 3/8-inch grind alfalfa diet gained 8% faster than the fastest gaining straw treatment and were 9% more efficient that the most efficient straw treatment.

Results from this study indicate that the addition of roughage to a high-grain finishing diet increased feed intake and daily gain by diluting energy concentration of the diet and reducing subacute acidosis. However, feed efficiency was not improved by roughage addition. Furthermore, it appears that different roughage sources used in a high-grain finishing diet may not respond similarly.

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Effect of Energy Source and Escape Protein on Receiving and Finishing Performance and Health of Calves

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Gene White[1]

Summary

One receiving trial and one finishing trial evaluated the effect of energy source and protein supplement on performance and health of large-frame calves. In the receiving trial, diets were comprised (DM basis) of 45% alfalfa hay, and either 55% dry rolled corn, molasses, and supplement or 55% wet corn gluten feed and supplement. Diets contained a supplement without or with escape protein. Calves fed wet corn gluten feed consumed less dry matter, had a lower metabolizable protein supply, were more efficient, but gained similarly to calves fed dry rolled corn. Calves supplemented with escape protein had a greater metabolizable protein supply than calves not supplemented with escape protein. Health was not affected by dietary treatment. In the finishing trial, energy sources included dry rolled corn, dry rolled corn/wet corn gluten feed, high moisture corn, high moisture corn/wet corn gluten feed, and dry rolled corn/high moisture corn. Diets contained a supplement without or with escape protein. An energy source × protein supplement interaction was observed for daily gain and feed/gain. Results suggest wet corn gluten feed, fed in combination with dry rolled corn or high moisture corn, has an energy value similar to those grains fed individually.

Introduction

Large-frame calves are well suited to a production system in which finishing begins shortly after weaning.

(Continued on next page)

Compared with yearlings, calves are less mature and deposit more lean tissue relative to fat when placed in the feedlot. Therefore, the need for metabolizable protein is greater with calves.

Wet corn gluten feed (WCGF) has been shown to be an excellent energy source in beef cattle diets. Compared with dry rolled corn (DRC), WCGF is higher in crude protein, but the escape protein value of WCGF is substantially lower (60 vs 20%). Previous research (1995 Nebraska Beef Report, pp. 28-30) showed supplemental escape protein improved efficiency of calves fed DRC/alfalfa and WCGF/alfalfa receiving diets. Most of this response was due to escape protein improving efficiency of calves fed WCGF. Calves fed DRC- or DRC/WCGF-based finishing diets performed similarly, regardless of escape protein supplementation, but metabolizable protein supply was near or exceeded the animal's requirement in all dietary treatments.

High moisture corn (HMC) is used widely in beef cattle diets. The crude protein content of HMC and DRC is similar, however, the escape protein value of HMC is lower than that of DRC (40 vs 60%). The lower escape protein potential of WCGF and HMC may create a deficiency in metabolizable protein and enhance the need for escape protein supplementation when these two feeds are fed together.

The objective of this research was to determine the effect of feeding WCGF and escape protein on performance and health of calves during the receiving period and subsequent finishing period. This report represents the second year of research with this objective. Additionally, HMC, HMC/WCGF, and DRC/HMC were included as energy sources in the second year's finishing trial to evaluate the need for supplemental escape protein in these diets.

Procedure

Receiving Trial

Three hundred fifteen large-frame steer calves (556 lb) from three groups were used in the receiving trial. Calves were delivered directly from ranches or sale barns and were representative of those typically available to Nebraska cattle feeders. Calves were received at the Nebraska Agricultural Research and Development Center, Mead, during the fall of 1994. Groups one and three had access to grass hay and water for approximately one hour before weighing and processing. Group two was weighed and processed shortly after arrival and did not have access to feed or water. Within each group, calves were assigned randomly to treatments.

Diets were comprised (DM basis) of 45% alfalfa hay, 45% DRC, 6% molasses, and 4% supplement or 45% alfalfa hay, 52% WCGF (Minnesota Corn Processors), and 3% supplement. Based on results from Year 1, 19.5% DRC was included in WCGF diets for the initial 7 days of feeding to increase feed intake during the first week. Each diet was fed without or with supplemental escape protein [80% feather meal:20% blood meal combination (CP basis)]. Dietary crude protein levels were 15.1% for DRC/urea, 16.3% for DRC/escape protein, 17.3% for WCGF, and 19.1% for WCGF/escape protein. Diets were formulated to meet the rumen degradable protein requirement based on Burrough's equation for growing diets (TDN x .13), which would meet or exceed the nitrogen needs of ruminal microbes. Additionally, diets were formulated to contain a minimum of .5% Ca, .35% P, and 1.3% K. Diets containing WCGF were also formulated to supply a minimum of 50 mg thiamine/head/day.

Calves were observed daily for sickness. Sick calves were moved from their pen to respective hospital pens, maintained on their dietary treatment, and treated with antibiotics until health was restored.

The receiving trial lasted 20 to 32 days; group one was fed 32 days, group two was fed 28 days and group three was fed 20 days. Final weights were determined as the average weights of two consecutive days at completion of the receiving period. Final weights were shrunk 2% for groups one and three and 4% for group two to minimize differences with incoming shrink.

Finishing Trial

Three hundred twenty calves (658 lb) were used in the finishing trial. Steers were blocked by weight and assigned randomly, within block, to one of ten pens (8 head/pen). Five concentrate energy sources were evaluated (Table 1): DRC; DRC/WCGF; HMC; HMC/WCGF; and DRC/HMC. Each diet was fed without or with supplemental escape protein. Steers were adapted to final finishing diets using four adaptation diets containing (DM basis) 45 (2 days), 35 (6 days), 25 (7 days), and 15% (7 days) roughage.

Diets were formulated for a minimum of 12% crude protein. Actual crude protein values of DRC, HMC, and corn silage were lower than expected, resulting in reduced dietary crude protein levels (Table 1). An 80% feather meal:20% blood meal combination (CP basis) was used as the escape protein supplement. Diets were formulated to meet the rumen degradable protein requirement (TDN x .081), based on the Cornell Net Carbohydrate and Protein system (Ainslie et al., J. Anim. Sci., 1993). Additionally, diets were formulated to contain a minimum of .7% Ca, .35% P, .7% K, 25 g Rumensin/ton and 10 g Tylan/ton. Diets containing WCGF were also formulated to supply a minimum of 50 mg thiamine/head/day. Steers were implanted with Revalor at the start of the finishing trial and at 83 days. Steers were finished for an average of 164 days and final weights were determined by using hot carcass weight, assuming a 62% dressing percentage. Fat thickness at the 12th rib, USDA yield and quality grades, and liver score were recorded.

Results

Receiving Trial

Calves fed WCGF consumed less DM ($P<.01$), had a lower metabolizable protein supply ($P<.01$), gained similarly, but were more efficient ($P<.10$) than calves fed DRC (Table 2) . Results from Year 1 (1995 Nebraska Beef Report, pp. 28-30) also showed lower DM intake and metabolizable protein

Table 1. Finishing diet composition (% DM basis)

Ingredient	Energy source and escape protein[a]									
	DRC	DRC/ WCGF	HMC	HMC/ WCGF	DRC/ HMC	DRC/ EP	DRC/ WCGF/ EP	HMC/ EP	HMC/ WCGF/ EP	DRC/ HMC/ EP
Dry rolled corn	78.91	42.00	—	—	36.91	77.91	40.00	—	—	37.91
Wet corn gluten feed	—	45.00	—	45.00	—	—	45.00	—	45.00	—
High moisture corn	—	—	78.91	42.00	42.00	—	—	77.91	40.00	40.00
Molasses	6.09	—	6.09	—	6.09	6.09	—	6.09	—	6.09
Alfalfa hay	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Corn silage	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Urea	1.17	—	1.17	—	1.17	1.17	—	1.17	—	1.17
Feather meal	—	—	—	—	—	1.76	1.76	1.76	1.76	1.76
Blood meal	—	—	—	—	—	.45	.45	.45	.45	.45
Supplement[b]	3.83	3.00	3.83	3.00	3.83	2.62	2.79	2.62	2.79	2.62
Crude protein[c]	10.4	10.7	10.8	11.0	10.6	12.2	12.6	12.7	12.8	12.4
Degradable intake protein[d]	6.7	7.3	8.1	8.1	7.4	7.4	8.0	8.8	8.7	8.1

[a]DRC = dry rolled corn; WCGF = wet corn gluten feed; HMC = high moisture corn; EP = supplemental escape protein.
[b]Includes vitamins, minerals, and feed additives.
[c]Based on analysis of individual ingredients.
[d]Degradable intake protein requirement calculated as TDN × .081 = 6.8%.

supply with calves fed WCGF (P<.01). However, calves fed WCGF in Year 1 gained less (P<.05) than calves fed DRC and were more efficient only when supplemented with escape protein. In one group, one to two weeks passed before DM intake of calves fed WCGF diets approached that of calves fed DRC diets. However, no intake reduction was observed in the other two groups. Some calves may initially have a slight aversion to diets containing 32.5% WCGF.

Calves supplemented with escape protein had a higher metabolizable protein supply (P<.05) than calves not supplemented with escape protein, but daily gain and feed efficiency were not different. In Year 1, calves supplemented with escape protein also had a higher metabolizable protein supply (P<.01); however, supplemental escape protein improved feed efficiency (P<.10) in Year 1.

When data were pooled across years, a year × energy source interaction (P<.10) was observed for daily gain, DM intake, and feed/gain. In Year 1, calves gained faster when fed DRC than WCGF, but efficiency was similar. In Year 2, gains were similar but feed efficiency was greater with WCGF. Additionally, a year × protein supplement interaction was observed for daily gain (P<.10). Escape protein numerically (P>.10) increased gain in Year 1, but numerically (P>.10) decreased gain in Year 2. Performance during the receiving period can be highly variable. The number of cattle treated for respiratory disease was greater in Year 1 than Year 2. The reduced sickness may explain the higher dry matter intakes and daily gains observed with all cattle in Year 2 and the lack of improvement in daily gain and feed efficiency with escape protein supplementation. The number of calves requiring treatment for respiratory disease [27 (15.0%), 22 (12.4%), 31 (17.4%), and 29 (16.4%) for DRC/urea, DRC/escape protein, WCGF, and WCGF/escape protein, respectively] was not different (P>.15). However, a negative correlation existed between metabolizable protein supply and number of calves treated for respiratory disease (r=-.66; P<.01) indicating that in-creased metabolizable protein supply may have reduced sickness in these calves.

Table 2. Effect of energy and protein source on receiving performance and health

Item	Treatment[a]			
	DRC/Urea	DRC/EP	WCGF	WCGF/EP
Total head/treatment	79	78	79	79
DM intake[b], lb/day	14.99	14.71	12.98	12.48
Daily gain, lb	2.39	2.20	2.47	2.21
Feed/gain[cd]	6.61	7.00	5.30	5.68
Number of dead cattle	0	0	1	0
Number of treated cattle[e]	7	5	6	8
MP supply[bfg], lb/day	1.31	1.44	1.13	1.21
Degradable intake protein[h], %	10.6	10.6	12.6	13.1

[a]Performance does not include dead cattle. DRC = dry rolled corn; EP = escape protein; WCGF = wet corn gluten feed.
[b]DRC vs WCGF (P<.01).
[c]DRC vs WCGF (P<.10).
[d]Feed/gain analyzed as gain/feed. Feed/gain is reciprocal of gain/feed.
[e]Treated with antibiotic injection to control respiratory disease.
[f]No escape protein supplement vs escape protein supplement (P<.05).
[g]Metabolizable protein (MP) requirement of a 588 lb steer (average trial weight) gaining 2.47 lb/day (maximum trial gain) = 1.21 lb/day (Ainslie et al., J. Anim. Sci., 1993).
[h]Degradable intake protein requirement calculated as TDN × .13 = 9.4%.

Finishing Trial

An energy source × protein supplement interaction was observed for daily gain (P<.10) and feed/gain (P<.01) (Table 3). The biological

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Table 3. Effect of energy source[a] and protein supplement on finishing gain and efficiency.

	Without escape protein					With escape protein				
Item	DRC	DRC/ WCGF	HMC	HMC/ WCGF	DRC/ HMC	DRC	DRC/ WCGF	HMC	HMC/ WCGF	DRC/ HMC
Daily gain[b], lb	3.55	3.65	3.54	3.49	3.60	3.74[c]	3.51[d]	3.75[c]	3.47[d]	3.60[cd]
Feed/gain[f]	6.61[c]	6.26[d]	6.44[cd]	6.18[d]	5.91[e]	6.08[cd]	6.27[c]	5.96[d]	6.25[c]	6.14[cd]

[a]DRC = dry rolled corn; WCGF = wet corn gluten feed; HMC = high moisture corn; EP = supplemental escape protein.
[b]Energy source × protein supplement interaction (P <.10).
[cde]Means within a protein supplement and within a row having unlike superscripts differ (P<.10).
[f]Energy source × protein supplement interaction (P <.01).

Table 4. Effect of energy source on finishing dry matter intake, metabolizable protein supply, and carcass characteristics.

	Energy source[a]				
Item	DRC	DRC/ WCGF	HMC	HMC/ WCGF	DRC/ HMC
DM intake, lb/day	23.18[b]	22.40[c]	22.56[bc]	21.63[d]	21.67[d]
MP supply[e], lb/day	1.82[b]	1.73[c]	1.61[d]	1.59[d]	1.62[d]
Quality grade[f]	19.0[b]	18.7[c]	18.7[c]	18.5[c]	18.6[c]
Yield grade	2.69[b]	2.48[c]	2.59[bc]	2.58[bc]	2.65[bc]
Fat thickness	.51[b]	.45[c]	.48[bc]	.46[c]	.49[bc]

[a]DRC = dry rolled corn; WCGF = wet corn gluten feed; HMC = high moisture corn.
[bcd]Means within a row with unlike superscripts differ (P<.10).
[e]Metabolizable protein (MP) requirement of a 952 lb steer (average trial weight) gaining 3.75 lb/day (maximum trial gain) = 1.75 lb/day (Ainslie et al., J. Anim. Sci., 1993).
[f]19.0 = low choice.

explanations for these interactions are unclear. Escape protein supplementation improved the performance of calves fed DRC, which supplied the greatest amount of metabolizable protein, but did not improve the performance of calves fed diets containing WCGF, which supplied lower levels of metabolizable protein. Most likely, the significant interactions are associated with random variation associated with 10 treatments and only four replications. Within treatments not supplemented with escape protein, calves fed DRC/HMC were the most efficient (P<.10). Additionally, calves fed DRC/WCGF or HMC/WCGF were more efficient than calves fed DRC (P<.10) with calves fed HMC being intermediate. Energy source had no effect on daily gain for these treatments.

Within treatments supplemented with escape protein, calves fed DRC or HMC gained faster (P<.10) than calves fed DRC/WCGF or HMC/WCGF with calves fed DRC/HMC being intermediate. Calves fed HMC were more efficient than calves fed DRC/WCGF or HMC/WCGF (P<.10) with calves fed DRC or DRC/HMC being intermediate.

Calves fed HMC/WCGF and DRC/HMC consumed less DM (P<.10) than calves fed DRC, DRC/WCGF, or HMC (Table 4). Calves fed DRC/WCGF consumed less DM (P<.10) than calves fed DRC which agrees with results from Year 1 (1995 Nebraska Beef Report, pp. 28-30). Metabolizable protein supply was lower (P<.10) for calves fed HMC, HMC/WCGF, or DRC/HMC compared to calves fed DRC or DRC/WCGF. Calves fed DRC/WCGF had a lower metabolizable protein supply than calves fed DRC (P<.10), as in Year 1. Quality grade was higher (P<.10) for calves fed DRC although differences were small. Yield grade and fat thickness were lower (P<.10) for calves fed DRC/WCGF compared to calves fed DRC, but again, differences were small. Liver score was not affected (P>.10) by dietary treatment (data not shown). Metabolizable protein supply of calves fed supplemental escape protein was higher (P<.01) than calves not fed supplemental escape protein (data not shown).

In Year 1 and 2, performance of calves fed DRC and DRC/WCGF was evaluated. A year × energy source × protein supplement interaction was observed for daily gain (P<.05) and feed/gain (P<.10). Escape protein improved daily gain and feed efficiency of calves fed DRC in Year 2, but did not affect performance of calves fed either DRC or DRC/WCGF in Year 1, or DRC/WCGF in Year 2.

The amount of supplemental escape protein required to meet the metabolizable protein needs of finishing cattle is small. It is likely that calves fed finishing diets containing DRC or DRC and 45% WCGF are deficient in metabolizable protein during early finishing (0 to 90 days) when rapid muscle growth occurs, but the need for supplemental escape protein declines as cattle fatten.

Results of this research suggest wet corn gluten feed, fed in combination with dry rolled corn or high moisture corn, has an energy value similar to those grains fed individually. Receiving diets containing wet corn gluten feed and finishing diets containing wet corn gluten feed or high moisture corn may supply metabolizable protein near the requirement. However, metabolizable protein supply is also dependent on other dietary components and intake. Therefore, escape protein supplementation may be necessary to ensure maximum performance.

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Evaluation of Levels of Wet Corn Gluten Feed and Addition of Tallow

Chris Richards
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Summary

One feedlot trial evaluated the effect of level of wet corn gluten feed and the addition of tallow on finishing performance. Wet corn gluten feed was fed to replace 0, 50, or 100% of the dry rolled corn and the molasses-urea supplement in the diet. All diets were fed with or without addition of tallow. Steers fed 50% gluten feed gained faster and more efficiently than steers fed dry rolled corn. Steers fed 100% gluten feed were more efficient than steers fed dry rolled corn without tallow. Feeding 3% tallow increased gain and feed efficiency when added to the dry rolled corn or 50% gluten feed diets. The energy value of wet gluten feed was 10 (100% gluten feed) to 20% (50% gluten feed) greater than the dry rolled corn and molasses-urea supplement replaced.

Introduction

Wet corn gluten feed (WCGF) is a byproduct of the wet corn milling industry and contains 90 to 110% of the relative energy value of corn in finishing diets. Wet corn gluten feed (Cargill) contains higher levels of protein (20%), phosphorus (1.0%), and potassium (1.2%) than corn. Wet corn gluten feed is higher in rumen degradable (80 vs 40%) and lower in escape protein (20 vs 60%) when compared with corn. The lipid contents of WCGF and corn are similar, at 5%.

Wet distillers byproducts (wet grains and thin stillage) are byproducts of the dry milling industry and have been shown to improve feed efficiency from 2 to 17% when fed at levels of 5.2 to 40% of the diet DM. Due to increased feed efficiency when added to the diet, wet distillers byproducts had a relative energy value of 153% compared to dry rolled corn. Wet distillers byproducts contain 29% crude protein, in which 50% is considered escape protein, and greater than twice the lipid content (12%) found in corn or WCGF.

If ruminal degradable and metabolizable protein requirements of the animal are met, differences in protein supplied should not account for differences in energy estimations between WCGF and wet distillers byproducts. Additional lipid in wet distillers byproducts when compared with WCGF may explain the differences in energy estimations. Therefore, the objectives of this trial were to determine the feeding value of WCGF when fed at different levels in the diet and determine the effect of adding tallow to WCGF finishing diets.

Procedure

Two hundred and forty steers (762 lb) were limit fed 15 lb (DM) of a 50% corn silage and 50% alfalfa hay diet (DM basis) for five days. Weights were taken on two consecutive days before feeding. Steers were blocked by weight (4 blocks) and randomly allotted within block to one of six treatments (10 steers/pen, 4 pens/treatment) in a 3 x 2 factorial arrangement of treatments. Wet corn gluten feed (Cargill, Eddyville, IA) was fed to replace 0, 50, or 100% of the dry rolled corn (DRC) and a molasses-urea supplement (DM basis). The various levels of WCGF and DRC were fed with or without the addition of 3% tallow (DM basis).

Final finishing diets (Table 1) were formulated (DM basis) to contain a minimum of 13% CP, .70% Ca, .30% P, .65% K, and included 30 g/ton Rumensin and 10 g/ton Tylan. The 100% WCGF diets contained 17% CP. Diets containing WCGF had 53 ppm added thiamine.

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Table 1. Composition of final finishing diets fed to steers

	Treatment[a]					
Item[b]	DRC	DRC + tallow	50%DRC: 50% WCGF	50% DRC: 50% WCGF + tallow	100% WCGF[c]	100% WCGF + tallow[c]
Dry rolled corn	82.0	78.9	43.0	41.4	—	—
Wet corn gluten feed	—	—	44.0	42.5	86.6	84.7
Molasses-urea supplement	5.0	5.0	—	—	—	—
Tallow	—	3.0	—	3.0	—	3.0
Corn silage	5.0	5.0	5.0	5.0	5.0	5.0
Alfalfa hay	5.0	5.0	5.0	5.0	5.0	5.0
Dry supplement[d]	3.0	3.1	3.0	3.1	3.4	2.3

[a]DRC = dry rolled corn; WCGF = wet corn gluten feed.
[b]% DM basis.
[c]100% WCGF treatments re-randomized on day 42 and placed on a 50% DRC:50% WCGF or 100% WCGF treatment.
[d]Contained urea, minerals, vitamins, feed additives, and thiamin. Additional copper supplement was added on day 42 to all diets containing WCGF.

Table 2. Effect of wet corn gluten feed and tallow on finishing steer performance

	Treatment[a]					
Item	DRC	DRC + tallow	50% DRC: 50%WCGF	50% DRC: 50% WCGF + tallow	100% WCGF[b]	WCGF-DRC/WCGF[b]
DM intake[c], lb/day	24.57	24.15	23.89	24.01	22.71	23.65
Daily gain[de], lb	3.44	3.60	3.76	3.97	3.50	3.60
Feed/gain[defg]	7.06	6.63	6.29	6.01	6.41	6.53
MP supply[fhij], lb/day	1.96	1.87	1.86	1.81	1.63	1.86
DIP[dfik], lb/day	2.07	2.08	2.22	2.26	3.33	2.20
Fat thickness, in	.38	.37	.36	.40	.36	.38
Quality grade[l]	18.6	18.4	18.4	18.8	18.1	18.1

[a]DRC = dry rolled corn; WCGF = wet corn gluten feed.
[b]100% WCGF treatments re-randomized on day 42 and placed on a DRC/WCGF without tallow or 100% WCGF without tallow treatment.
[c]DRC without tallow vs 100% WCGF (P<.05).
[d]DRC vs 50% DRC:50% WCGF (P<.01).
[e]0 vs 3% tallow (P<.05).
[f]DRC without tallow vs 100% WCGF (P<.01).
[g]Feed/gain analyzed as gain/feed. Feed to gain is the reciprocal of gain/feed.
[h]DRC vs 50% DRC:50% WCGF (P<.10).
[i]WCGF-DRC/WCGF vs 100% WCGF (P<.01).
[j]Metabolizable protein supplied was calculated excluding TDN from tallow. Requirement (Ainslie et al., J. Anim. Sci. 1993) of a 980 lb steer gaining 3.97 lb/day = 1.87 lb/day.
[k]Degradable intake protein. Requirement (TDN × .081) of a 86% TDN diet with a DMI of 24.57 lb/day = 1.71 lb/day.
[l]18.0 = high select, 19.0 = low choice.

All steers were adapted to final diets in 21 days by feeding 45, 35, 25, and 15% roughage diets for 2, 5, 7, and 7 days, respectively. Revalor implants were given on day 1 and the lightest replication received a second implant on day 78. The trial began December 21, 1994 and steers were fed for an average of 121 days.

On days 19, 23, and 40, one steer each day was removed from a 100% WCGF treatment because of polio-like symptoms (blindness, muscle tremors, weakness). In an attempt to identify feeding scenarios that may be solutions to these health problems, steers on both 100% WCGF diets were re-randomized on day 42 and half of the steers were fed 100% WCGF diet without tallow and the remainder were fed the 50% DRC:50% WCGF diet without tallow (WCGF-DRC/WCGF). In addition, steers from the 100% WCGF treatment gaining less than 3 lb/day were injected with 4 ml of thiamine (500 mg/ml thiamine HCL), and all cattle receiving WCGF (50 and 100% levels) were fed a supplement (1% DM basis) containing an additional 5000 ppm of copper as copper oxide to increase the dietary copper level by 50 ppm.

At slaughter, hot carcass weights and liver scores were recorded. After a 48-hour chill, 12th rib fat thickness, quality grade and yield grade were evaluated. Final weights were calculated from hot carcass weight using a constant dressing percentage of 62%.

Because of the re-randomization of cattle on day 42, the 100% WCGF treatment was statistically compared with the WCGF-DRC/WCGF treatment and the DRC without tallow treatment. The remaining four treatments were evaluated as a 2 × 2 factorial treatment arrangement.

Results

Steers fed the 50% DRC:50% WCGF diets gained faster (P<.01) and more efficiently (P<.01) than steers fed DRC diets (Table 2). Daily gains of steers were higher (P<.05) and more efficient (P<.05) when 3% tallow was included in the diets. The 100% WCGF and WCGF-DRC/WCGF treatments produced similar (P>.10) gains and efficiencies. The steers fed the 100% WCGF treatment consumed more feed (P<.05) and were more (P<.05) efficient than the steers fed DRC without tallow. No significant differences (P>.10) in 12th rib fat thickness, liver score, quality grade, or yield grade were observed among treatments.

The 50% DRC:50% WCGF diets supplied more (P<.01) degradable intake protein (DIP) than the DRC diets. The 100% WCGF diet had a greater amount of DIP than the DRC without tallow diet (P<.01) or the WCGF-DRC/WCGF diet (P<.01). However, the calculated DIP requirement was exceeded for all six treatments. Metabolizable protein (MP) supply of steers fed the DRC diets was greater (P<.10) than steers fed the 50% DRC:50% WCGF diets. Steers fed the DRC without tallow diet (P<.01) and WCGF-DRC/WCGF diet (P<.01) received more MP than steers consuming the 100% WCGF diet. All diets except the 100% WCGF diet appeared to have met the calculated MP requirement for these steers. The 100% WCGF diet was calculated to have a deficiency in MP, assuming a 20% escape protein value for the WCGF, but feed/gain was similar to the WCGF-DRC/WCGF treatment and lower than the DRC without tallow treatment. Therefore, we may have underestimated the amount of MP supplied with the WCGF diet or overestimated the requirement of the steers. An underestimation of the MP supplied may be due to an under estimation of the escape protein content in WCGF or a greater efficiency of microbial growth with a highly digestible fiber source.

The improved feed conversion (10.2%) of the 50% DRC:50% WCGF

diets compared with the DRC diets indicates that the energy value of WCGF was 120% of the net energy value in the DRC and the molasses-urea supplement replaced. When the 100% WCGF diet was compared with the DRC without tallow, feed conversion improved 9% and the relative net energy value of WCGF was calculated to be 110% of the DRC and supplement. Addition of tallow to the DRC and 50% DRC:50% WCGF diets increased feed conversion 6 and 4.5%, respectively. Compared with the DRC without tallow diet, the 50% DRC:50% WCGF with tallow diet had a 15% greater feed efficiency and a relative energy value for the WCGF and tallow that was 30% greater than the DRC and the molasses-urea supplement. This energy value approached the value (153%) previously observed with wet distillers byproducts.

The procedures followed for the 100% WCGF treatment on day 42 were to prevent further health problems. We cannot determine the degree of success of the different procedures. Thiamine addition has been previously included in diets containing greater than 40% (DM) WCGF. Thiamine injections have been reported to be beneficial for clinical cases of polio, but have also been used for other health problems. Addition of copper oxide, to supply an additional 50 ppm of copper was used based on literature values with sheep experiencing polio. The copper was fed in an attempt to precipitate high sulfur levels (.8%) that were present in the WCGF (.8%) at day 42. Sulfur levels of the WCGF ranged from .40 to .95%. After dietary changes were made, no further signs of polio occurred, nor were brain lesions observed at slaughter.

Results of this trial indicate that the addition of WCGF (50% of the concentrate DM) or tallow (3% DM) to DRC finishing diets resulted in improved gains and feed efficiencies. The combination of WCGF and tallow improved feed efficiency similar to that previously calculated using wet distillers byproducts.

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Evaluation of Wet Distillers Byproducts Composite for Finishing Ruminants

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Summary

Two finishing trials evaluated a composite of feed ingredients formulated to be similar in nutrient composition as wet distillers grains plus solubles. Trial 1 used 60 crossbred lambs assigned to one of four treatments: dry rolled corn, dried distillers grains plus solubles, wet corn gluten feed, and wet distillers byproducts composite. Lambs fed the composite diet were more efficient than lambs fed wet corn gluten feed. In Trial 2, 60 yearling steers were fed one of five treatments: dry rolled corn, wet corn gluten feed, wet distillers byproduct composite, wet distillers byproducts composite minus tallow (-FAT), wet distillers byproducts composite minus corn gluten meal (-CGM). Steers fed the composite diet were more efficient than steers fed wet corn gluten feed. A wet distillers byproducts composite can be formulated that improves feed/gain compared with wet corn gluten feed. Additions of corn gluten meal, tallow, and condensed solubles to wet corn gluten feed may help improve the feeding value of wet corn gluten feed and subsequent finishing performance of ruminants.

Introduction

Demand for ethanol and corn sweeteners is on the rise and is predicted to increase in the future. This trend will result in an abundance of byproducts that are potentially economical alternatives to corn. Wet distillers grains and wet corn gluten feed are currently used as sources of protein and energy in feedlot diets. Previous research indicates that wet corn byproducts (distillers grains and thin stillage) are higher in net energy than corn grain; however, wet corn gluten feed (WCGF) is similar in net energy to corn. Potential differences between wet distillers byproducts and WCGF include lipid content, escape protein level, and NDF level. Therefore, two finishing trials evaluated the effect of a composite of feed ingredients formulated to be similar in nutrient composition as wet distillers byproducts.

Procedure

Trial 1

A 60-day finishing trial used 60 crossbred lambs (77 lb) in a randomized complete block design. Lambs were blocked by sex and weight and assigned randomly within block to one of four treatments. Treatments consisted of 1) dry rolled corn, 2) corn dried distillers grains plus solubles (DDGS), 3) wet corn gluten feed (WCGF), and 4) wet distillers byproducts composite (COMP1). The COMP1 was balanced (DM basis) to contain a minimum of 31.6% CP, 16.1% lipid, 16.8% degradable intake protein, and 14.8% undegradable intake protein and consisted of 47.9% WCGF, 11.9% condensed distillers solubles, 30.5% corn gluten meal, and 9.7% tallow (DM basis). All final diets contained 78.9% dry rolled corn or dry rolled corn plus 40% corn byproducts, 10% alfalfa hay,

(Continued on next page)

6.1% molasses, and 5% dry supplement (DM basis). Diets were formulated (DM basis) to contain a minimum of 12.5% CP, .7% Ca, .35% P, .7% K, and 6.7% degradable protein, and contained 25 g/ton Rumensin. Supplemental protein for the control diet was supplied by urea.

Lambs were adapted to final diets in 21 days using four grain adaptation diets containing 45 (3 days), 35 (4 days), 25 (7 days), and 15% roughage (7 days; DM basis). Lambs were housed individually in a temperature-controlled room and were allowed ad libitum access to feed. Orts were weighed each morning, mixed with the day's diet, and re-fed to the lambs.

Trial 2

A finishing trial using 60 yearling crossbred steers (600 lb) was conducted from July 11 to December 17, 1994. Steers were blocked by previous experimental gain and assigned randomly to one of five treatments. Treatments consisted of a dry rolled corn, WCGF, wet distillers byproducts composite (COMP2), (WCGF, corn gluten meal, tallow), COMP2 minus tallow (-FAT) and COMP2 minus corn gluten meal (-CGM). The tallow and corn gluten meal were replaced with wet corn gluten feed. The COMP2 diet was formulated (DM basis) to contain 12.5% degradable protein, 12.5% undegradable protein, 13.1% lipid, and 32.7% NDF and consisted of 65.8% WCGF, 26.3% CGM, and 7.9% tallow (DM basis). All diets contained (DM basis) 79.1% dry rolled corn or dry rolled corn plus 40% corn byproducts, 5% corn silage, 5% alfalfa, 5.9% molasses based supplement, and 5% dry supplement. Diets were formulated (DM basis) to contain a minimum of 12.0% CP, .7% Ca, .3% P, and .65% K, and contained 25 g/ton Rumensin and 10 g/ton Tylan.

Steers were adapted to the final diets in 21 days using four grain adaptation diets containing 45 (3 days), 35 (4 days), 25 (7 days), and 15% roughage (7 days; DM basis). Roughage was a mixture of alfalfa hay and corn silage with corn silage assigned a roughage value of 50%. Cattle were individually fed once daily using Calan gates and were allowed ad libitum access to feed. Cattle were implanted with Compudose at the onset of the trial and reimplanted with Finaplex-S on day 60. Steers were housed in covered pens with 15 head per pen. Initial weights were based on an average of three consecutive day weights taken before feeding. Hot carcass weight adjusted to 62% dressing percentage was used to calculate final weight. Hot carcass weights and liver abscess scores were recorded at slaughter. Fat thicknesses measured at the 12th rib, quality grades, and yield grades were recorded after a 48-hour chill.

Table 1. Effect of wet distillers byproducts composite (COMP1) on finishing lamb performance

	Treatment[a]			
Item	Control	WCGF	DDGS	COMP1
DM intake, lb/day	2.70	2.85	2.78	2.57
ADG, lb	.62[bc]	.53[b]	.69[c]	.71[c]
Feed/gain[d]	4.35[b]	5.38[c]	4.03[b]	3.62[b]

[a]WCGF = wet corn gluten feed; DDGS = dried distillers grains plus solubles; COMP1 = wet corn gluten feed, condensed distillers solubles, corn gluten meal, and tallow.
[b,c]Means within a row with unlike superscripts differ (P<.10).
[d]Feed/gain was analyzed as gain/feed. Feed/gain is the reciprocal of gain/feed.

Table 2. Effect of wet distillers byproducts composite (COMP2) on finishing steer performance

	Treatment[a]				
Item	DRC	WCGF	COMP2	-FAT	-CGM
DM intake, lb/day	21.55[b]	20.81[bc]	19.52[c]	20.16[bc]	20.94[bc]
ADG, lb	3.09	2.89	2.98	2.92	3.03
Feed/gain[d]	7.09[b]	7.29[c]	6.79[b]	6.89[bc]	6.72[b]
Fat depth, in	.42[b]	.41[b]	.41[b]	.40[b]	.31[c]

[a]DRC = dry rolled corn; WCGF = wet corn gluten feed; COMP2 = wet corn gluten feed, corn gluten meal, and tallow; -FAT = composite minus tallow; -CGM = composite minus corn gluten meal.
[d]Feed/gain was analyzed as gain/feed. Feed/gain is the reciprocal of gain/feed.
[b,c]Means within a row with unlike superscripts differ (P<.10).

Results

In Trial 1, dry matter intake was not different among treatments (P<.10). However, lambs fed the COMP1 diet gained faster and were more efficient (P<.10) than lambs fed WCGF (Table 1). Although the difference in feed efficiency between the control and COMP2 was not significant, there was a 12% advantage obtained with the COMP1 diet which is similar to previous results with finishing cattle, comparing dry rolled corn and corn wet distillers byproducts. In addition, lambs fed DDGS were intermediate in efficiency between lambs fed dry rolled corn and the COMP1 diet which agrees with previous results with finishing cattle comparing DDGS, corn wet distillers byproducts, and dry rolled corn diets.

In Trial 2, steers consuming the COMP2, -CGM, and dry rolled corn diets were more efficient (P<.10) than the steers fed WCGF (Table 2). No difference in ADG was observed among treatments (P>.10). Steers fed the COMP2 diet consumed less (P<.10) feed than steers fed the dry rolled corn diet with the steers fed WCGF, -FAT, and -CGM being intermediate (P>.10) to these two treatments. Steers consuming -CGM were the leanest among treatments (P<.10). Liver abscess score, quality grade, and yield grade were not different among treatments (P>.10).

A composite of feeds can be formulated that improves efficiency of gain compared with WCGF. However, it is not clear what level of fat, fiber, or escape protein or how the interactions of these ingredients may contribute to the increases in feeding value observed with distillers byproducts. Our results indicate that the lipid fraction of the distillers byproducts may be responsible for the largest increase in efficiency.

[1]Shanna Lodge, graduate student; Rick Stock and Terry Klopfenstein, Professors; Drew Shain, former research technician; Daniel Herold, research technician, Animal Science, Lincoln.

Digestibility of Wet and Dry Distillers Grains from the Fermentation of Corn or Sorghum

Shanna Lodge
Rick Stock
Terry Klopfenstein
Dan Herold[1]

Summary

A lamb digestibility study was conducted to evaluate differences in digestibility between distillers byproducts produced from the fermentation of corn or sorghum. Sixteen lambs were assigned randomly to one of four treatments consisting of corn wet distillers grains, corn dried distillers grains plus solubles, sorghum wet distillers grains, and sorghum dried distillers grains plus solubles. Fiber digestibility did not differ among treatments. Crude protein and organic matter digestibility were highest for corn wet distillers grains but lowest for corn dried distillers grains plus solubles. Sorghum wet distillers grains were higher in organic matter digestibility than sorghum dried distillers grains plus solubles. The nutritive content and feeding value of distillers byproducts may be effected by type of grain fermented and drying the grains with the solubles.

Introduction

Research conducted at the University of Nebraska has evaluated wet and dry distillers byproducts as energy sources for cattle. The majority of the research has been conducted with distillers byproducts resulting from the fermentation of corn. However, in the dry milling industry various cereal grains may be used to produce ethanol and distillers byproducts. The resulting byproducts have the potential to have a different feeding value when compared to byproducts produced from corn. A Nebraska trial (1995 Nebraska Beef Report, pp. 25-26) conducted by Lodge et al. indicated steers consuming diets containing distillers byproducts (40% of diet DM) produced from the fermentation of primarily sorghum gained less and were less efficient than previous research with corn byproducts would have predicted. These data imply that distillers byproducts produced from grain sorghum may have a lower feeding value than corn based distillers byproducts. One explanation for this difference in performance may be related to differences in digestibility between corn and sorghum distillers byproducts. Therefore, a lamb digestibility trial was conducted to evaluate the digestibility of wet and dried distillers byproducts produced from the fermentation of corn or sorghum.

Procedure

Sixteen crossbred wether lambs (121 lb) were randomly assigned to one of four treatments consisting of the following: 1) corn wet distillers grains, 2) sorghum wet distillers grains, 3) sorghum dried distillers grains plus solubles, 4) corn dried distillers grains plus solubles. Sorghum wet grains and sorghum dried distillers grains plus solubles were the same as the byproducts used by Lodge et al. (1995 Nebraska Beef Report, pp. 25-26); however the sorghum dried distillers grains plus solubles were from a different fermentation batch. Corn wet distillers grains were produced by a commercial dry milling plant (High Plains Corp., York, NE). Diets consisted of 80% distillers byproduct, 10% molasses, 8% alfalfa hay, and 2% dry supplement (DM basis). Diets were fed at 3.0% (DM basis) of body weight. The trial consisted of a 7-day adaptation period and a 7-day fecal collection period and was replicated twice. No lamb received the same diet in both replications.

Individual feeds, feces and orts were oven dried at 140°F, ground to pass through a 1 mm screen (Wiley Mill) and analyzed for dry matter, neutral detergent fiber, Kjeldahl nitrogen, and ash. Distillers byproducts were also analyzed for lipid content using chloroform/methanol extraction and starch content. Feces were analyzed for neutral detergent insoluble nitrogen to calculate true nitrogen digestibility of distillers byproducts.

Results

Sorghum distillers byproducts numerically contained more crude protein and starch than corn distillers byproducts (Table 1). Corn wet

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Table 1. Nutrient composition of corn and sorghum distillers byproducts (% of DM)

Item	CWDG[a]	SWDG[a]	SDDGS[a]	CDDGS[a]
Crude Protein	29.6	31.6	31.4	29.2
Lipid	13.7	11.3	11.8	11.4
NDF	52.0	45.4	51.1	51.3
Starch	4.6	10.2	7.4	5.1
Ash	1.2	2.5	1.8	2.0

[a]CWDG = corn wet distillers grains; SWDG = sorghum wet distillers grains; SDDGS = sorghum dried distillers grains plus solubles; CDDGS = corn dried distillers grains plus solubles.

distillers grains contained more lipid than all the other byproducts.

Apparent organic matter, apparent crude protein, and true crude protein digestibilities were highest (P<.10) with corn wet distillers grains diet (Table 2). Apparent organic matter digestibility of sorghum wet distillers grains diet was higher (P<.10) than either sorghum or corn dried distillers grains plus solubles. Apparent and true crude protein diet digestibilities of sorghum wet distillers grains and sorghum dried distillers grains plus solubles were higher than corn dried distillers grains plus solubles. Neutral detergent fiber digestibility was not different among treatments.

Table 2. Digestibility % of corn and sorghum distillers byproducts

Item	CWDG[a]	SWDG[a]	SDDGS[a]	CDDGS[a]
Apparent OM	85.69[b]	80.8[c]	73.7[d]	71.6[d]
NDF	77.8	75.9	76.3	71.7
Apparent protein	82.8[b]	77.3[c]	74.2[c]	65.5[d]
True protein[e]	93.8[b]	89.4[c]	88.1[c]	78.4[d]

[a]CWDG = corn wet distillers grains; SWDG = sorghum wet distillers grains; SDDGS = sorghum dried distillers grains plus solubles; CDDGS = corn dried distillers grains plus solubles.
[b,c,d]Means within a row with different superscripts differ (P<.10).
[e]Estimated by determining neutral detergent insoluble nitrogen in feces.

These data indicate that the nutritive content and feeding value of distillers byproducts may be affected by type of grain fermented and drying the grains with condensed solubles.

[1]Shanna Lodge, graduate student. Rick Stock, and Terry Klopfenstein, Professors; Dan Herold, research technician, Animal Science.

Use of Direct Fed Microbials to Alleviate Subacute Acidosis

Shanna Lodge
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Rick Stock
Dan Herold[1]

Summary

Five ruminally-fistulated steers were used in a 5 × 5 Latin square design to determine the effect of four different direct fed microbial products on subacute acidosis. Treatments included 1) control, 2) Lactobacillus acidophilus (LA) , 3) Saccharomyces cerevisae (YC), 4) Lactobacillus acidophilus and Saccharomyces cerevisae(LA+YC) , and 5) Lactobacillus acidophilus, Saccharomyces cerevisae, and Streptococcus faecium (LA+YC+SF). Steers were fed a basal diet containing 50% concentrate and 50% roughage (DM basis). Rumen fluid was collected at 24 and 12 hours before dosing to determine a steady state for each animal. Treatments had no effect on steady state pH, VFA concentration, acetate plus butyrate to propionate ratio, or lactate production. Acidosis was induced by intraruminally dosing a 50:50 blend of fine ground corn and dry rolled wheat (DM basis) at 1.6% of body weight. Acetate plus butyrate to propionate ratio was highest for LA+YC+SF and lowest for LA. The average pH for the control diet was the lowest during the acidosis challenge compared to all other treatments. These data indicate that products containing Lactobacillus acidophilus, Saccharomyces cerevisae, or Streptococcus faecium may alter rumen function and may help to alleviate subacute acidosis by stabilizing rumen pH.

Introduction

Direct fed microbials are feed additives composed of live cultures of microorganisms that are currently being used in the feedlot industry to improve animal performance. Reported beneficial effects include increased feed intake and weight gain. The efficacy of these supplements have been associated with their abilities to alter rumen function, such as volatile fatty acid production, stabilization of pH, and reduction of the amount of lactate produced. This experiment was conducted to determine the effect of the direct fed microbials on rumen steady state and to evaluate their ability to alleviate subacute acidosis.

Procedure

Five ruminally fistulated steers (900 lb) were used in a 5 X 5 Latin square. Six additional ruminally fistulated steers were used as donors of ruminal contents and were fed a diet of either alfalfa (1 steer), grass hay (3 steers), 86% dry rolled corn and 7.5% alfalfa (1 steer), or corncob/soybean meal (1 steer). Steers were randomly allotted to treatments. Treatments consisted of 1) control, 2) *Lactobacillus acidophilus* (LA), 3) *Saccharomyces cerevisae* (YC), 4) LA + YC, and 5) LA + YC + *Streptococcus faecium* All direct fed microbials were refrigerated and stored in vials as freeze dried powder. From day 1 - 12 steers were fed a basal diet via automatic feeders every three hours and fed at 1.8% of body weight. The animals received a total of 7.1 g of direct fed microbial per day which contained 1×10^9 colony forming units of each microbial source when included in the treatment. Microbials were added directly to the feed twice per day. The basal diet consisted of 30% dry rolled corn, 33% corn silage, 33% alfalfa, and 4% dry supplement (DM basis). No Rumensin or Tylan was included in the

diet. Donor animals were fed once daily. On day 1 of each period, steers were ruminally evacuated and ruminal contents were replaced with rumen fluid from the donor animals to equalize microbial populations.

On the morning of day 13, steers were dosed with an all concentrate diet at 1.6% (DM basis) of body weight. The all concentrate diet consisted of 48% fine ground corn, 48% dry rolled wheat, 2.3% molasses based supplement that contained urea, .63% limestone, .3% salt, and .31% potassium chloride and was placed directly into the rumen via the cannula. The all concentrate diet was balanced to meet the degradable intake protein requirements of the steers so that amount of nitrogen available for fermentation would not limit fermentation. On day 14 steers were fed a grass hay diet to allow for recovery from the acidosis challenge.

Rumen samples were collected at 24, 12 hours before dosing and, 0, 3, 6, 9, 12, 15, 18, 21, and 24 hours after dosing. Ruminal pH was measured immediately on each sample and then the sample was frozen for later volatile fatty acid and lactate analyses.

Table 1. Effect of direct fed microbials on acidosis.

	Treatment[a]				
Item	Control	LA	YC	LA+YC	LA+YC+SF
Total VFA, mM[b]	107.7	107.1	103.3	109.3	88.1
Area[c]	6.55	5.33	3.72	4.30	4.79
AB:P[de]	4.07	3.37	3.73	4.09	4.34

[a]Control = lactose; LA= *Lactobacillus acidophilus;* YC = *Saccharomyces cerevisae;* LA + YC = *Lactobacillus acidophilus* plus *Saccharomyces cerevisae*; LA + YC + SF = *Lactobacillus acidophilus, Saccharomyces cerevisae,* plus *Streptococcus faecium.*
[b]Total VFA - LA vs LA+YC+SF (P<.05); LA+YC vs LA+YC+SF (P<.05).
[c] Area = time by units pH below 6.0.
[d]AB:P = acetate plus two times butyrate to propionate ratio.
[e]AB:P - LA vs LA+YC+SF (P<.05); LA vs LA+YC (P<.10).

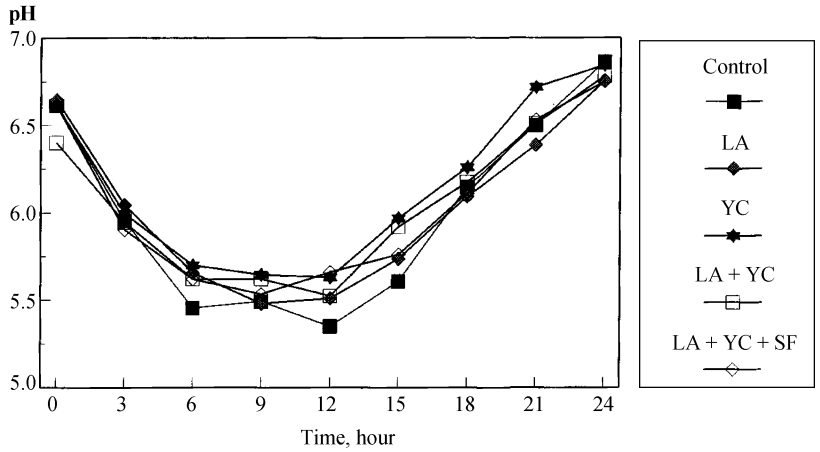

Figure 1. Effect of direct fed microbials on rumen pH during an acidosis challenge.

Results

Measurements were taken at 24 and 12 hours before dosing to determine a steady state for each animal. Prior to dosing, the average ruminal pH was 6.6 for all treatments. Additionally, VFA concentrations, acetate plus butyrate to propionate ratios and lactate concentrations did not differ among treatments during steady state (P>.10). In order to calculate the severity of acidosis, a pH curve was calculated (Figure 1). A ruminal pH of 6.0 was chosen to determine the area under the curve for each treatment (Table 1). The larger values represent longer periods of time below pH 6.0 and(or) lower pH values. The curve areas did not differ statistically (P>.10) among treatments, but the ruminal pH of the control treatment tended to have the greatest area under the curve (6.55). The treatment containing *Saccharomyces cerevisae*, tended to have the smallest area (3.72) under the curve indicating that acidosis was less severe (Table 1). The other three treatments were intermediate.

Total VFA concentrations were different among treatments. When comparing treatment two to five, the steers receiving LA + YC + SF had the lowest concentration of VFAs (P<.05). *Lactobacillus acidophilus* plus *Saccharomyces cerevisae* had the highest concentration of VFAs and was statistically different from LA + YC + SF (P<.05). The acetate plus butyrate to propionate ratio was different among treatments. Treatment five contained a three-way combination of *Lactobacillus acidophilus, Saccharomyces cerevisae,* and *Streptococcus faecium* and had the highest AB:P ratio. When comparing treatment two, which contained only *Lactobacillus acidophilus,* to LA + YC + SF, treatment two had the lower ratio. Production of propionate may be reduced during the acidosis challenge when steers are supplemented with products containing *Lactobacillus acidophilus, Saccharomyces cerevisae,* and *Streptococcus faecium.* The production of L-lactate was also determined: however, the concentrations obtained were so small the effect of L-lactate on rumen pH is questionable and therefore, the data are not presented.

Our results indicate a three-way combination reduces VFA concentration and may also shift the amount or alter the concentrations of VFAs produced. In this trial, areas under the pH curve tended to be lowest when steers were supplemented with the direct fed microbials indicating some added benefit from supplemental direct fed microbials in reducing subacute acidosis.

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[1]Shanna Lodge, graduate student. Terry Klopfenstein and Rick Stock, Professors, Animal Science; Dan Herold, research technician.

An Enzyme-Microbial Feed Product for Finishing Steers

Burt Weichenthal
Ivan Rush
Brad Van Pelt[1]

Summary

The feeding of MSE (Multiple Stabilized Enzymes in an enzyme-microbial feed product) to finishing yearling steers at the rate of 2 lb of product per ton of diet dry matter improved daily gain about 10% and feed conversion 7.5% over values for steers receiving Rumensin-Tylan at 29 and 10 grams per ton, respectively. The steers were not implanted. MSE fed steers had a higher dressing percentage, but other carcass characteristics were similar. Feed dry matter intakes were similar, so the feeding of MSE resulted in improved feed utilization during the 119 day trial. There was only one abscessed liver in the study.

Introduction

The MSE feed product contains multiple enzymes plus four strains of bacteria, two strains of yeast and three strains of fungi. The bacteria were three Lactobacillus acidophilus cultures and one strain of Bacillus subtilis; the yeasts were three strains of Saccharomyces cerevisiae; and the fungi were two strains of Aspergillus oryzae and one of Aspergillus niger. Potential benefits for feeding MSE to finishing beef cattle could be improvement in daily gain and feed utilization. Thus, a feedlot trial was designed to compare MSE to an ionophore-antibiotic combination often fed to finishing cattle on a high grain diet to improve feed utilization and control the percentage of abscessed livers at slaughter.

Procedure

Ninety-two British crossbred yearling steers were allotted by weight to four pens of eight and two pens of seven steers for each of two treatments: (1) Rumensin fed at 29 grams and Tylan at 10 grams per ton of diet dry matter, and (2) the enzyme-microbial feed product MSE fed at two pounds per ton of diet dry matter. Three step-up diets were fed to reach the final diet. During the first 72 hours on feed, MSE was fed at six pounds per ton of diet dry matter (3 times higher than the long-term feeding rate). Rumensin was fed at 25 grams per ton of diet dry matter for the first 3 days, at 28 grams during diet step two and at 29 grams thereafter. A pelleted protein supplement with and without Rumensin-Tylan was used in the study. Calculated crude protein contents of the final finishing diets were 12.5% of diet dry matter. The calculated NEg values for these diets averaged .65 Mcal/lb. The final diet dry matter consisted of 82.75% dry rolled corn, 10% corn silage, and 7.25% protein-mineral supplement. The MSE was premixed at the rate of two pounds of MSE with eight pounds of finely ground corn and added to the mixer truck after all other ingredients were added. The steers were not implanted. They had been used in a grazing study the previous summer, but were fed a low grain diet from the end of the grazing study in early September to the start of the finishing trial on November 2, 1994. They were fed once a day. The steers were slaughtered after 119 days on test and carcasses were evaluated for dressing percentage, fat thickness over the 13th rib, marbling, quality grade, rib eye area, and yield grade. The data from four steers (one from Rumensin-Tylan and three from MSE treatments) were removed from the summary and analysis due to low performance or carcass trim which were unrelated to treatments.

Daily gains and carcass measurements for individual steers were analyzed by utilizing PC SAS (Statistical Analysis System), using Proc GLM (General Linear Model). Initial weight was used as a covariate. Feed intakes and feed conversions were analyzed by SAS also, using pen means.

Results

Daily gain was improved (P<.05) for the steers fed the MSE enzyme-microbial product over those fed Rumensin-

Table 1. Rumensin-Tylan vs MSE[a], an enzyme-microbial feed product, in finishing diets

	Rumensin-Tylan	MSE
No. of pens	6	6
No. of steers	45	43
Initial weight, lb	864	866
Final weight, lb[b]	1249[c]	1287[d]
Daily gain, lb[b]	3.22[c]	3.54[d]
Feed DM intake, lb	22.9	23.3
Feed/gain	7.1[e]	6.6[f]
Hot carcass weight, lb	773[c]	799[d]
Dressing percent	62.5[g]	63.3[h]
Fat thickness, in	.54	.55
Rib eye area, sq in	12.9[i]	13.2[j]
Rib eye area, sq in per cwt of carcass	1.67	1.65
Marbling score[k]	5.53	5.55
Quality grade[l]	18.9	18.7
Yield grade	3.0	3.0

[a]MSE = Multiple Stabilized Enzymes, an enzyme-microbial product of Nature's Way Inc., Horton, KS.
[b]Final weight and daily gain were calculated by dividing hot carcass weight by a common dressing % (62).
[cd]Means differ (P=.02).
[ef]Means differ (P=.08).
[gh]Means differ (P=.01).
[ij]Means differ (P=.05).
[k]Marbling scores; Small = 5.0, Modest = 6.0.
[l]Quality grade; Select+ = 18, Choice- = 19.

Tylan (Table 1). The improvement in daily gain for MSE was about 10%. The numerical increase in dry matter consumption for the MSE fed steers was not statistically significant (P=.54). Figure 1 shows the dry matter feed consumptions by treatment during each week of the 119-day trial. An expected reduction in feed intake for Rumensin occurred during the first week when cattle were adjusting to this ionophore. Cattle on MSE went off feed during the third and fourth weeks, but after recovering, appeared to average higher in feed intake during the remainder of the trial. There was an improvement (P=.08) in feed conversion for the MSE fed steers that was 7.5% greater than the average for the steers fed Rumensin-Tylan at typical finishing diet levels.

Carcass measurements showed an increase (P<.01) in dressing percentage for MSE fed steers. It is not known why this occurred, as fat cover was the same for both treatments. In addition to heavier hot carcass weights (P<.05) for MSE fed steers, rib eye area was also greater (P=.05) for MSE fed steers. This increase in rib eye can be attributed to increased carcass weight as rib eye area per cwt of carcass was not different. Quality and yield grade means were similar for the two treatments. There was only one abscessed liver in all of the steers.

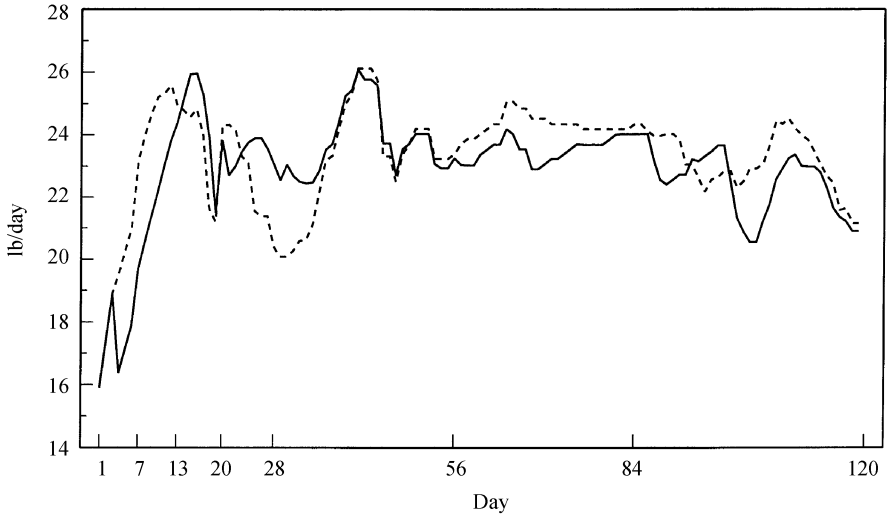

Figure 1. Dry matter intake/day for MSE (----) and Rumensin-Tylan (——).

The chances for affecting fermentation with the MSE enzyme-microbial feed product would suggest that it improved utilization of the high grain diet during fermentation and digestion. However, the mechanism for achieving this improvement with a multiple component product is yet to be defined.

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[1]Burt Weichenthal and Ivan Rush, Professors, Animal Science; Brad Van Pelt, research technician, Panhandle Research and Extension Center, Scottsbluff.

Effects of Bovatec, Rumensin or GainPro Fed to Yearling Summer Grazing Steers

Ivan Rush
Burt Weichenthal
Brad Van Pelt

Summary

Yearling steers on summer pasture were fed Bovatec (lasalocid), Rumensin (monensin) or GainPro (bambermycins) in a mixture of 2 lb of corn and .2 lb of dry molasses per day. Control steers received the same supplement without an additive. Daily gains during the 113-day grazing season on primarily crested wheatgrass pastures were improved (P<.1) by all three additives, averaging 17.8, 13.3 and 22.2% greater for Bovatec, Rumensin and GainPro, respectively. There were no significant differences in daily gains among the additives.

Introduction

Studies of beef production systems often indicate profitability can be increased in calf growing and feeding programs if yearling cattle are grazed at least during part of the growing phase. If yearling cattle are grazed on summer range, it is important that the summer gain be as efficient and economical as possible. The use of implants and ionophores can improve gain in grazing cattle. A feed additive, bambermycins (GainPro™), has been released for the purpose of improving weight gain in cattle, especially in those consuming high roughage diets. Data from practical grazing conditions are limited with bambermycins so the objective of this trial was to evaluate the effect of bambermycins, lasalocid (Bovatec®) and monensin (Rumensin®) on weight gain of yearling grazing steers when hand-fed daily on summer pasture.

(Continued on next page)

Procedure

Yearling crossbred steers were purchased and placed on a common diet for approximately 30 days. Upon arrival the cattle were vaccinated for IBR, BVD, PI_3, BRSV and 7-way blackleg. After the receiving period, the cattle were individually weighed on two consecutive days. Ninety six steers were randomly allotted to one of eight pasture groups. The pasture groups were then randomly allotted to four treatment groups.

The summer pastures consisted primarily of crested wheatgrass with an estimated 10% warm season grasses (primarily buffalo and blue grama). The steers were initially implanted with Synovex-S, ear tagged with one horn fly insecticide tag, tagged with a color coded tag for each pasture group, and drenched with Safe-Guard® for internal parasites. The average of the two initial weights, which were taken after holding steers off water overnight, was used as the starting weight on trial. The cattle were also treated with Safe-Guard on the 28th and 56th day of the trial when they were weighed.

Four treatment groups were randomly allotted within two pasture blocks of four pastures each. These pasture groups (treatments) were rotated within each pasture block every 14 days to minimize pasture effects. This allowed eight rotations for a total of 113 days on trial, with each treatment group in each pasture twice. Pastures were 105 acres in size. The pastures were not grazed the previous year.

Treatments were imposed by daily feeding of 200 mg of Bovatec, 150 mg of Rumensin or 20 mg of GainPro in a mixture of 2 lb of ground corn and .2 lb of dry molasses per steer (as fed basis) in bunks. Control steers received the same supplement without an additive. Bioassay of the supplements revealed that additive levels were very close to expected values.

Because of the ample lush spring grass at the beginning of the trial and the fineness of grind of the corn, the steers were reluctant to consume the supplements during the first 3 to 5 days. To encourage consumption after four days on test, 0.4 lb of dried molasses/head daily (17.2% of supplement) was hand mixed in with the cracked corn at the time of feeding. This was continued for six days and then the level of dried molasses was reduced to 0.2 lb/head daily (6.5% of supplement) for the remainder of the trial.

At the end of the trial all steers were individually weighed on two consecutive days after being held off water for 12 to 14 hours. The average of the two consecutive weights was used as the final weight.

The data were analyzed utilizing PC SAS (Statistical Analysis System) using Proc GLM. The data were analyzed as a randomized complete block. Initial weight was used as a covariate with treatments being tested by replication (block) by treatment interaction. Orthogonal contrasts compared control versus all supplements containing additives, GainPro versus Rumensin, and the combination of Bovatec and GainPro versus control, using individual steer gains as the experimental unit.

Table 1. Effects of Bovatec, Rumensin or GainPro on weight gains of yearling steers grazing summer crested wheatgrass pasture

	Treatment			
Additive	Control	Bovatec	Rumensin	GainPro
Level, mg/hd/day	0	200	150	20
Number of pastures	2	2	2	2
Steers per pasture	12	12	12	12
Initial wt, lb	612	612	613	611
ADG, 113 days, lb[ab]	1.35[a]	1.59[b]	1.53[b]	1.65[b]
Supplement intake/day, lb	2.2	2.2	2.2	2.2

[ab]Daily gains for additives differ from control (P<.1).

Results

The feed additives improved rate of gain over the control (P<.1) when evaluated for the total 113 day trial (Table 1). There were no significant differences between the gains from the three feed additives. Numerically, the cattle supplemented with GainPro gained the fastest which was .3 lb daily or 22.2% higher than the control. Bovatec and Rumensin supplemented cattle gained 27 and 20 lb or 17.8 and 13.3% more than the control, respectively. After approximately the first two weeks, the consumption of the supplements was not a problem and all of the supplement was usually consumed within 30 min of feeding. It was noted that the monensin containing supplement was slightly less palatable, especially during rainy or humid days. Consistent and adequate consumption of the additive is important for enhancing performance of grazing cattle. Previous research at this location has shown that when cattle were offered ionophores in self fed minerals and consumed at low levels, the improvement in gain has been minimal. Cattle gains were lower than has previously been experienced with similar cattle in these pastures in past years, especially during the first 28 days when gains are usually very high. The reason for the low initial gain is not clear; however the abundant old growth of grass in the pasture may have been consumed at levels that lowered the overall quality of the forage consumed. In the latter part of the grazing period, forage quality and quantity were lowered considerably due to drought and higher than normal daily temperatures. This resulted in a lower daily gain during the last 28 days of grazing. Under these conditions, all of the additives were effective at increasing summer weight gains in steers grazing primarily crested wheatgrass pastures.

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Growth Implants for Steers

Terry Mader
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Summary

In a 112-day experiment, feedlot steers (mean initial weight = 811 lb) that received a new estradiol benzoate + trenbolone acetate implant, Synovex® Plus, gained faster and more efficiently than non-implanted or Synovex® S implanted steers. Steers receiving Revalor® S implants also gained faster than control steers or Synovex® S treated steers, but were not found to be more efficient than Synovex® S implanted steers. No significant differences in gain and feed efficiency were found between Revalor® S and Synovex® Plus implanted steers. Dry matter intake differences were not detected among treatments. Hot carcass weights were heavier for steers receiving Synovex® S, Revalor® S, or Synovex® Plus compared with non-implanted steers. No differences were detected among treatments for dressing percentage, fat thickness, ribeye area, marbling score or yield grade. Steers receiving Revalor® S or Synovex® Plus had less kidney, pelvic, and heart fat percentage than non-implanted steers. Synovex® Plus is an effective implant for use in finishing feedlot steers.

Introduction

Trenbolone acetate (TBA), an implant (Finaplix®) with androgenic activity, stimulates growth and enhances feed efficiency much like implants with estrogenic activity (Ralgro®, Synovex®, Implus® and Compudose®). Because androgenic and estrogenic products tend to have different mechanisms of action, the combination of TBA and an estrogenic implant have been shown to be most beneficial. Revalor® S, a combination product containing 24 mg estradiol (E2) and 120 mg TBA, is an effective implant, particularly when used in feedlot steers 100 to 120 days before slaughter. Other products and combinations of TBA and estradiol may be just as effective. The objective of this study was to evaluate Synovex® Plus, a new combination implant currently being considered for use in the beef cattle industry.

Procedure

One hundred ninety-two British and British crossbred steers which had not received any previous implants were purchased near Oshkosh, Nebraska and shipped to the Northeast Research and Extension Center at Concord. After a two-week initial receiving period, steers were treated for parasites, weighed, eartagged, and vaccinated for IBR, PI_3, BRSV, Haemophilus somnus, and clostridial infections. Steers were assigned to one of six weight blocks; within block, steers were stratified by weight and randomly allocated to four pens which were randomly assigned the following treatments: 1) control (no implant), 2) Synovex® S [20 mg estradiol benzoate (14 mg E2) + 200 mg progesterone], 3) Revalor® S (24 mg E2 + 120 mg TBA), and 4) Synovex® Plus [28 mg estradiol benzoate (20 mg E2) + 200 mg TBA].

On the day the trial began, steers were weighed, implanted according to treatment assignment, and placed in designated pens. Initial weight was based on the average of weights taken over two consecutive days. During the receiving period, steers were fed receiving diets and stepped up to a 56 NEg Mcal/cwt diet. Three days before the start of the study, steers were fed a 60 NEg Mcal/cwt diet and were subsequently adjusted to a 64.45 NEg Mcal/cwt finishing diet which contained on a DM basis: 28.00% snapped ear corn, 60.61% dry rolled corn, 4.22% soybean meal, 5.14% liquid supplement, and 2.03% dry supplement. Diets contained 13.5% crude protein (DM basis), 25 g/ton Rumensin®, and 10 g/ton Tylan®. During the trial, two steers receiving the Revalor® S implant were treated for prolapsed prepuce. At the end of the 112-day feeding period, steers were weighed and shipped for slaughter. Liver abscess score and hot carcass weight were recorded the next day during slaughter. Additional carcass data were obtained after a 48-hour chill. Adjusted final weights used for performance calculations were determined from hot carcass weight assuming a 62% dressing percentage.

Data were analyzed as a randomized complete block design using analysis of variance procedures with weight block and implant treatment as independent variables in the model. Protected LSD's were used as the mean separation technique.

Results

Steers that received Revalor® S or Synovex® Plus had greater ($P < .05$) gains and final weights than Synovex® S implanted steers which in turn had greater ($P < .05$) gains and final weights than non-implanted steers (Table 1). No dry matter intake differences were detected among treatment groups; however, steers implanted with Revalor® S or Synovex® Plus had lower ($P < .05$) feed to gain ratios than non-implanted steers. Only Synovex® Plus steers had lower ($P < .05$) feed to gain ratios than Synovex® S. No difference in feed efficiency was detected between Revalor® S and Synovex® Plus implanted steers.

Implanted steers had greater ($P < .05$) carcass weights than non-implanted steers (Table 2), while steers implanted with Revalor® S and Synovex® Plus had greater ($P < .05$) carcass weights than steers implanted with Synovex® S. Steers that received Synovex® Plus implants had a lower ($P < .05$) percent-

(Continued on next page)

Table 1. Effect of implant on steer performance

Variable	Treatment			
	Control	Synovex® S	Revalor® S	Synovex® Plus
Initial wt, lb	812	810	812	810
Final wt, lb[a]	1163[b]	1185[c]	1207[d]	1217[d]
Daily gain, lb[a]	3.11[b]	3.32[c]	3.50[d]	3.60[d]
DM intake, lb/day	22.85	23.16	23.86	23.41
Feed/gain[a]	7.36[b]	7.00[bc]	6.81[cd]	6.50[d]

[a]Based on hot carcass weight assuming a common 62% dressing percentage.
[b,c,d]Means within a row lacking a common superscript letter differ ($P < .05$).

Table 2. Effect of implant on steer carcass characteristics

Variable	Treatment			
	Control	Synovex® S	Revalor® S	Synovex® Plus
Hot carcass wt, lb	721[a]	735[b]	749[c]	755[c]
Dressing percentage	60.5	60.7	60.4	60.4
Fat thickness, in	.39	.41	.43	.37
Ribeye area, in^2	13.1	13.1	13.0	13.0
KPH fat, %	2.44[a]	2.42[ab]	2.27[bc]	2.22[c]
Marbling score[de]	530	542	535	527
Choice+, %[e]	64.6	60.4	59.5	58.3
Yield grade[e]	2.4	2.5	2.6	2.4
Liver abscesses, %	14.6	8.6	4.2	0
No. of dark cutters	0	2	3	0

[a,b,c]Means within a row lacking a common superscript letter differ ($P < .05$).
[d]Modest = 600 to 699; small = 500 to 599; slight = 400 to 499.
[e]As determined by federal grader at slaughter plant.

age of kidney, pelvic, and heart (KPH) fat than non-implanted or Synovex® S implanted steers while no differences in KPH fat were detected between Revalor® S and Synovex®S implanted steers. Other carcass traits tended to be similar among treatment groups. Non-implanted steers had a numerically greater percentage of carcasses grading choice; although, marbling scores were similar among treatment groups. A numerically higher incidence of liver abscesses was also observed for the non-implanted steers.

Data indicate that Synovex® Plus, a combination product containing estradiol benzoate and TBA, is an effective implant for use in improving feedlot steer performance.

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Implant and Slaughter Time for Finishing Cattle

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Mark Klemesrud[1]

Summary

Three hundred seventy-four British-breed, yearling steers were used to evaluate the influence of implants on finishing performance, and carcass characteristics, at two slaughter times (80 and 109 days on feed). Following a summer grazing period, steers were fed a common finishing diet and allotted to either an estradiol or trenbolone acetate/estrogen implant. Steers implanted with trenbolone acetate/estrogen gained 5.8% faster and 4.8% more efficiently than steers implanted with estradiol. Carcass measurements were similar between implant treatments within slaughter time; however, trenbolone acetate/estrogen implanted steers had numerically heavier carcasses. Steers implanted with trenbolone acetate/estrogen and slaughtered at 109 days had the most desirable slaughter breakeven cost. Hormonal payout from a TBA/estrogen implant appears to remain above threshold limits required to stimulate a response in daily gain for a period of 109 days.

Introduction

The use of growth promoting implants with finishing cattle is common feedlot practice to increase weight gain. However, the payout of hormone from the implants decreases with time. As the concentration of hormone(s) in the blood decreases, it is not completely clear how the growth response of the cattle is affected. Trenbolone acetate (TBA, a synthetic product of the male hormone testosterone) combined with estrogen may increase mature body size by increasing lean tissue growth. However, there is limited information available to determine if TBA/estrogen continues to stimulate weight gain throughout a four-month feeding period. Therefore, the objective of this research was to evaluate the influence of TBA/estrogen implants during the final 30 days of the finishing period on performance, carcass characteristics, and the economics of finishing yearling steers.

Procedure

Two finishing trials were conducted in consecutive years using 182 (843 lb, year 1) and 192 (883 lb, year 2) British-breed yearling steers. Steers were blocked by previous summer grazing treatment, randomly allotted to one of two implant treatments, and fed in separate pens (13 hd/pen, Year 1; 12

hd/pen, Year 2). Treatments consisted of steers in a pen receiving either 24 mg estradiol β-17 or 120 mg trenbolone acetate (TBA) and 24 mg estrogen. All steers were fed the same diets and were adjusted to the final diet using four adaptation diets containing (DM basis) 45 (3), 35 (4), 25 (7), and 15% (7 days) forage (alfalfa hay and corn silage mixture). The final diet contained 80.25% dry rolled corn, 5% liquid supplement, 4.75% dry supplement, 5% alfalfa hay, and 5% corn silage (DM basis) and was formulated (DM basis) to contain 12% CP, .7% Ca, .35% P, and, .7% K, and contained 25 g/ton Rumensin and 10 g/ton Tylan.

Steers within a pen were randomly selected for slaughter at two different times (1/2 at each slaughter) to facilitate data collection for a rate of finishing study (1995 Nebraska Beef Report, pp.46-49). The average time, for both years, steers were fed was 80 and 109 days for the early and late slaughter times, respectively.

Initial weights were the average of two weights taken on consecutive days following a 3-day feeding period of a 50% alfalfa hay and 50% corn silage (DM basis) diet. Intake during this period was limited to 2% (DM) of body weight. Final weights were estimated from hot carcass weight using a 62% dressing percentage. Daily gain for the last 29 days for steers in the second slaughter group was calculated using final live weight for the second slaughter time and calculated live weight at the time of first slaughter from steers slaughtered in the first group. Carcass measurements included hot carcass weight, liver abscess score, fat thickness, quality grade, and yield grade.

Costs of inputs associated with each implant treatment were used to calculate slaughter breakeven costs. Data were analyzed as a completely randomized design with animal as the observation unit. Individual animal data for dry matter intake and feed efficiency were not available, therefore, results for dry matter intake and feed efficiency are pen data.

Table 1. Effect of implant and time of slaughter on finishing performance.

Slaughter Time:	80 days on feed		109 days on feed	
Item Implant:	Estradiol	TBA/estrogen	Estradiol	TBA/estrogen
Dry matter intake, lb/day[a]	27.34	27.67	27.51	27.73
Daily gain, lb	3.43[b]	3.59[bc]	3.43[b](3.39)[d]	3.67[c](3.78)[d]
Feed/gain[ae]	8.00[bc]	7.71[bc]	8.07[b]	7.59[c]
Carcass Characteristics				
Hot carcass weight, lb	704[b]	713[b]	760[c]	777[c]
Fat thickness, in	.34[b]	.34[b]	.43[c]	.43[c]
Yield grade	2.20[b]	2.26[b]	2.51[c]	2.49[c]
% Choice	51.1[b]	41.1[b]	77.3[c]	70.1[c]
Slaughter breakeven $/100 lb[f]	68.73[b]	68.17[b]	68.36[b]	67.20[c]

[a]Values based on pen data.
[bc]Means within row with different superscripts differ (P<.05).
[d]Daily gains in parentheses are estimated for the last 29 days of the trial.
[e]Feed/gain analyzed as gain/feed. Feed/gain is reciprocal of gain/feed.
[f] Inputs include:$70/100 lb purchase price, 9% interest, $.06/lb DMI, $.30/day yardage, $5/hd health & handling, $1.80/estradiol implant, $2.50/TBA-estrogen implant.

Results

Steers within a slaughter time were fed to a similar endpoint as noted with similar values for fat thickness, yield grade and number of steers grading Choice (Table 1). No differences in dry matter intake or feed efficiency were observed between implant treatments for steers slaughtered at 80 days. However, steers slaughtered at 80 days and implanted with TBA/estrogen gained faster (P=.07) and were numerically more efficient (P=.18) than steers implanted with estradiol. No differences were noted in any carcass measurements between implant groups for steers slaughtered at 80 days.

Steers fed for 109 days and implanted with TBA/estrogen gained 7% faster (P<.05) and 5.9% more efficiently (P<.05) than steers implanted with estradiol with no difference in dry matter intake between implant treatments. No differences were noted in any carcass measurements between implant groups for steers slaughtered at 109 days.

Daily gains for steers, during the 29-day period between the two slaughter times, was increased 11.5% in cattle receiving the TBA/estrogen implants compared with steers receiving an estradiol implant (data in parentheses). During the final 29 days response to the estradiol implant appeared to remain constant resulting in similar weight gains between steers slaughtered at 80 or 109 days. However, response to the TBA/estrogen implant appeared to continue to elicit a positive response in daily gain. Although blood hormone levels of TBA and estrogen have been shown to decrease with time, it appears in this case that hormone levels remained above threshold limits required to stimulate a response in daily gain during the final 29 days of the 109-day finishing period.

Slaughter breakeven values were the most desirable for steers fed for 109 days and receiving a TBA/estrogen implant (Table 1). Similar slaughter breakeven values were noted between implants in the 80-day slaughter group and steers receiving estradiol in the 109-day slaughter group. The percentage of Choice steers was numerically lower for the TBA/estrogen implant groups in either slaughter time. However, based on estimated returns (data not shown), these steers were able to compensate for a reduced quality grade by increasing feed efficiency and hot carcass weight.

Results from this study indicate that hormonal concentrations of TBA and estrogen remain above threshold limits required to stimulate a response in daily gain for the final 30 days of the finishing period.

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[1]Drew Shain and Mark Klemesrud, research technicians, Rick Stock and Terry Klopfenstein, Professors, Animal Science, Lincoln,

Evaluation of Nitrogen, Phosphorus, and Organic Matter Balance in the Feedlot as Affected by Nutrition

Sheri Bierman
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Drew Shain[1]

Summary

A steer finishing trial was conducted to evaluate level and source of dietary fiber on nitrogen, phosphorus, and organic matter excretion. One-hundred twenty steers were fed one of the following treatments: wet corn gluten feed (41.5% of diet DM), 7.5% roughage diet, and all concentrate diet. Nitrogen, phosphorus, and organic matter intake of steers fed wet corn gluten feed were greater than the other two treatments. Fecal nitrogen output was greatest with the wet corn gluten feed diet. All treatments lost about 50% of excreted nitrogen through volatilization. The all concentrate treatment had the highest percentage of phosphorus and organic matter in runoff compared to the other two treatments. All treatments had 65 to 78% of excreted phosphorus and 35 to 55% of excreted organic matter incorporated into the top three inches of the soil. The wet corn gluten feed treatment had the greatest percentage of excreted nitrogen, phosphorus, and organic matter removed from the pens when compared with the other treatments. Different diets can affect the amount of nutrients excreted and subsequently the retention or loss of nutrients from the waste.

Introduction

Development of better balanced diets, which reduce the amount of nitrogen (N) and phosphorus (P) excreted, will help assure continued growth in the livestock industry while reducing deleterious effects on the environment.

The degree of hindgut fermentation is affected by dietary sources of carbohydrates, which subsequently affects the amount of excreted fecal N and organic matter (OM). Often more hindgut fermentation occurs when fiber is fed compared to starch, because cellulose and hemicellulose have a slower rate of fermentation than starch. Therefore, ruminal digestion of fiber is limited, resulting in greater quantity of fiber reaching the hindgut undigested. Starch is extensively degraded in the rumen and small intestine, minimizing the amount of starch reaching the hindgut. Hindgut fermentation increases the amount of fecal N and decreases the amount of urinary N.

It has been estimated that 50% of N excreted on the feedlot surface is lost before pens are cleaned, decreasing the nutrient value of manure as a fertilizer. If more N is excreted in the feces versus urine then, more N should be retained on the feedlot surface. More N is retained when volatilization is decreased and it is assumed that volatilization is less from feces than urine. The objectives of this study were to reduce the loss of nitrogen from the feedlot surface by shifting the distribution of excreted N from urine to feces through increased hindgut fermentation from dietary carbohydrate source, and to evaluate retention and loss of N, P, and OM from excreta.

Procedure

A digestion trial was conducted in the metabolism area of the Animal Science Complex to determine the digestibility of three dietary treatments and their affect on the distribution of N between feces and urine. The digestibility values were used for various calculations for the trial conducted at the feedlot.

Finishing Trial

One hundred twenty crossbred yearling steers (741 lb) were stratified by weight and randomly allotted to one of the three dietary treatments on May 27, 1994. Dietary treatments were wet corn gluten feed (WCGF), 7.5% roughage (7.5% R), and all concentrate diet (All Con). The WCGF was used as an ingredient to increase fiber content of the diet and the All Con diet as a means of reducing fiber content compared to the conventional 7.5% R diet. The WCGF diet consisted (DM basis) of 41.5% WCGF, 43.5% dry rolled corn, 5% corn silage, 5% alfalfa hay, and 5% supplement. The 7.5% R diet consisted of 78.8% dry rolled corn, 5% corn silage, 5% alfalfa hay, 6.2% molasses, and 5% supplement. The All Con diet consisted of 88.8% dry rolled corn, 6.2% molasses, and 5% supplement. All diets were formulated to contain a minimum of 12% CP, .7% calcium, .3% phosphorus, .65% potassium and included 25 g/ton Rumensin and 10 g/ton Tylan per head daily. Because of a low CP content of the corn, actual CP content was 11.5, 11.3, and 10.9% for WCGF, 7.5% R, and All Con diets, respectively. Steers were adapted to final diets in 21 days by feeding 45, 35, 25, and 15% roughage diets for 4, 3, 7, and 7 days, respectively. Steers receiving the 7.5% R and All Con diets were fed the same adaptation diets with corn as the concentrate source and a mixture of corn silage and alfalfa hay as forage sources. Steers receiving the WCGF diet were fed adaptation diets with wet corn gluten feed replacing corn as the concentrate source and a mixture of corn silage and alfalfa hay as forage sources. Steers were implanted with Revalor. Steers were allowed ad libitum amounts of feed once daily and had access to water. The steers were adapted to final rations in non-test pens

and then moved to the test pens after seven days on the final ration. At slaughter, hot carcass weights and liver scores were recorded. After a 48-hour chill, 12th rib fat thickness, and quality grade were evaluated.

The bottom of each pen was fenced off by electric wire to avoid build-up of waste material next to the fence line at the bottom of the pens. The pens had 644.8 ft^2 of pad space and 2439.6 ft^2 total pen area, leaving an area of 244 ft^2 per head. Pens were designed with a fence line between pens on top of the mound with the other fence line in the valley between mounds. Therefore, runoff from two pens that were assigned to the same dietary treatment, was collected in one retention pond. Retention ponds were constructed of dirt berms and lined with plastic.

Retention ponds were connected underground with 4-inch PVC pipe. The pipe had a riser in each retention pond which was used to determine the volume of runoff. Retention ponds were calibrated using known volumes of water. Pens were cleaned 30 days before the cattle being placed into the pens. Three core soil samples from each pen were taken to a 3-inch depth with a soil probe before cattle were placed in the pens and again after the cattle were removed and pens were cleaned. Pens were cleaned immediately after the cattle were removed. When cleaning the pens, only the waste material and minimal amounts of soil were removed. The material was piled on the concrete pad in the pen, mixed, sampled, then removed and weighed.

Input of N to the cattle was calculated by N concentration in ration times dry matter intake. Total N output by the cattle was the difference between N input and N retained by the animal. Retained N was calculated from performance data and using the NRC (1985) net protein gain equation. Fecal N (lb) was calculated by dry matter intake times DM indigestibility (from N digestibility trial) times the concentration of fecal N. Nitrogen contents of feces were similar in samples collected from the feedlot and from the digestion trial. Urinary N was the total N output minus fecal N. Nitrogen removed from the feedlot surface was determined by the amount of material removed after cleaning the pens times the N concentration of the manure sample. Nitrogen lost in runoff was calculated as the quantity of runoff times the N concentration of runoff samples. Nitrogen incorporated in the soil was the difference between 414.3 ft^3 of soil times N concentration of samples taken before and after the cattle were in the pens. Amount of N volatilized was the difference between amount of N excreted and that removed when the pens were cleaned, in runoff, and incorporated into the soil. Phosphorus calculations were the same except the amount of P retained by the animal was calculated by a P retention equation (NRC, 1984) and it was assumed that there was no P volatilization. Organic matter was calculated the same as P and N values, except OM excreted was calculated using the indigestibility of diets (from the digestibility trial) times OM in the feces, as determined by ashing the fecal samples taken from the pens during the feedlot trial.

Results

Steers consuming WCGF had a greater ($P < .04$) intake of nutrients compared with other treatments because a higher percentages of nutrients (N, P, and OM) were supplied by the WCGF diet coupled with a greater ($P < .05$) dry matter intake (Table 1). Subsequently, steers fed the WCGF diet retained the least ($P < .10$) and excreted the most nutrients ($P < .03$) as a percentage of intake. No differences in feed efficiency were observed among treatments.

Table 1. Performance and carcass characteristics of steers for entire feeding period (115 days)

Item	WCGF[a]	7.5% R[a]	All Con[a]
DM intake, lb/day	29.00[b]	26.02[c]	24.77[c]
Daily gain, lb	3.80[b]	3.46[c]	3.31[c]
Feed/gain[d]	7.70	7.41	7.27
Final weight, lb	1206[b]	1164[c]	1146[c]
Fat thickness inches	.51	.47	.47
Quality grade[e]	18.3	18.0	18.3

[a]WCGF = wet corn gluten feed diet; 7.5% R = 7.5% roughage diet;
All Con = all concentrate diet.
[b,c]Means with unlike superscripts within rows differ ($P < .05$).
[d]Feed/gain analyzed as gain/feed. Feed/gain is the reciprocal of gain/feed.
[e]18 = high select.

Tables 2, 3, and 4 show the major components of mass balance of nutrients in the feedlot. The values are expressed in two ways, in pounds of nutrient per head over the entire finishing period (87 days) and percentage of nutrient excretion. Fiber in WCGF increased the amount of fecal N compared to dry rolled corn. Previous research has determined that more post ruminal digestion of NDF occurs when cattle are fed WCGF versus dry rolled corn. Thus, WCGF stimulated hind

(Continued on next page)

Table 2. Nitrogen mass balance in the feedlot

Criteria[b]	WCGF[a]		7.5% R[a]		All Con[a]	
	lb[c]	%[d]	lb	%	lb	%
Input	45.2[e]	100	39.8[f]	100	36.6[f]	100
Retention	4.0[ef]	8.9[h]	4.1[f]	10.4[i]	3.85[e]	10.6[i]
Excreted	41.2[e]	100	35.7[f]	100	32.8[f]	100
Feces	14.5[e]	38.5[h]	10.2[f]	31.8[i]	7.4[g]	19.1[j]
Urine	23.0[e]	61.5[h]	21.7[e]	68.2[i]	19.9[f]	80.9[j]
Removed	8.5[e]	20.8[h]	5.1[f]	14.5[i]	3.1[g]	9.6[j]
Soil	4.5	11.1[h]	6.7	19.0[i]	5.2	16.1[hi]
Runoff	2.1[e]	5.1[h]	2.4[ef]	7.1[hi]	7.0[f]	21.4[i]
Volatilized	26.0[e]	62.9	21.5[ef]	59.4	17.5[f]	52.9

[a]WCGF = wet corn gluten feed diet; 7.5% R = 7.5% roughage diet; All Con = all concentrate diet.
[b]Retention = retention by the animal; removed = waste material removed from feedlot surface when cleaned; soil = nitrogen in the soil after the pens were cleaned.
[c]Pounds of nitrogen per head over the feeding period (87 days).
[d]Retention is expressed as percentage of nitrogen intake, the remaining values are expressed as percentage of excreted nitrogen.
[e,f,g]Unlike superscripts within a row under the pounds column differ ($P < .10$).
[h,i,j]Unlike superscripts within a row under the percentage column differ ($P < .10$).

Table 3. Phosphorus mass balance in the feedlot

Criteria[b]	WCGF[a]		7.5% R[a]		All Con[a]	
	lb[c]	%[d]	lb	%	lb	%
Input	8.1[e]	100	5.4[f]	100	5.2[f]	100
Retention	.98[e]	12.0[h]	1.00[e]	18.5[i]	.94[f]	18.0[i]
Excreted	7.1[e]	100	4.4[f]	100	4.2[f]	100
Removed	2.8[e]	39.5[h]	1.5[f]	34.1[hi]	1.1[f]	26.2[i]
Soil	4.3[e]	60.5[h]	2.9[f]	65.4[hi]	3.1[f]	73.8[i]
Runoff	.002	.02	.001	.02	.006	.15

[a]WCGF = wet corn gluten feed diet; 7.5% R = 7.5% roughage diet; All Con = all concentrate diet.
[b]Retention = retention by the animal; removed = waste material removed from feedlot surface when cleaned; soil = phosphorus in the soil after pens were cleaned.
[c]Pounds of phosphorus per head over the feeding period (87 days).
[d]Retention values are expressed as a percentage of phosphorus intake, the remaining values are expressed as percentage of excreted phosphorus.
[e,f,g]Unlike superscripts within a row under the pounds column differ (P < .10).
[h,i,j]Unlike superscripts within a row under the percentage column differ (P < .10).

Table 4. Organic matter mass balance in the feedlot

Criteria[b]	WCGF[a]		7.5% R[a]		All Con[a]	
	lb[c]	%[d]	lb	%	lb	%
Input	2291[e]		2046[f]		1957[f]	
Excreted	597[e]	100	368[f]	100	269[g]	100
Removed	206[e]	34.5[h]	123[f]	33.7[hi]	69.7[g]	26.3[i]
Soil	209	34.8[h]	207	55.4[i]	139	50.8[hi]
Runoff	7.1[e]	2.6[h]	8.4[e]	4.0[h]	19.1[f]	15.6[i]
Volatilized	166.4[e]	28.0[h]	24.4[f]	6.9[i]	17.6[f]	7.3[i]

[a]WCGF = wet corn gluten feed diet; 7.5% R = 7.5% roughage diet; All Con = all concentrate diet.
[b]Removed = waste material removed from feedlot surface when cleaned; soil = organic matter in the soil after pens were cleaned.
[c]Pounds of organic matter per head over the feeding period (87 days).
[d]All values expressed as percentage of excreted organic matter.
[e,f,g]Unlike superscripts within a row under the pounds column differ (P < .10).
[h,i,j]Unlike superscripts within a row under the percentage column differ (P < .10).

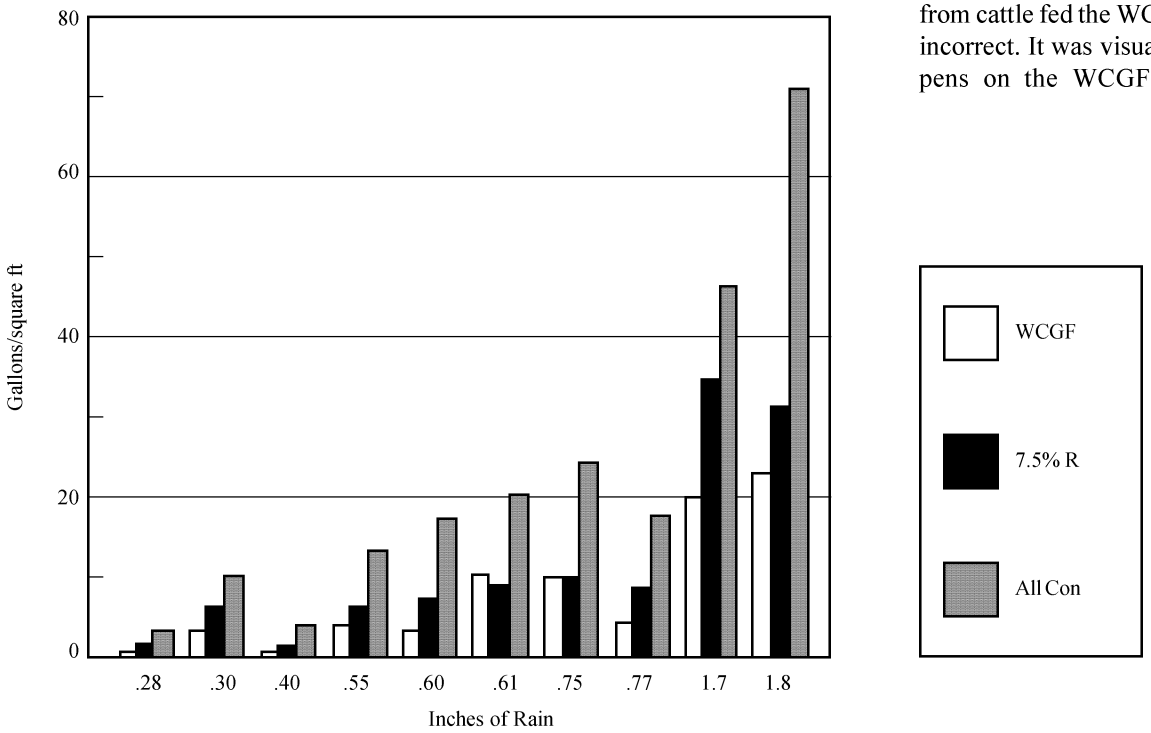

Figure 1. Effect of dietary treatments on quantity of runoff.

gut fermentation and increased the amount of fecal N output compared to the 7.5% R treatment. The WCGF treatment increased (P < .03) fecal N and reduced (P < .10) urinary N compared to the other treatments.

The quantity of manure removed from the feedlot was greatest (P < .04) for the WCGF treatment. The quantity of material removed for WCGF, 7.5% R, and All Con treatments was 2.6, 1.7, and 1.2 tons per pen (DM basis), respectively. The amount of excreted N that was removed from the feedlot surface by cleaning was only 18.8, 12.8, and 8.5% of N intake for WCGF, 7.5% R, and All Con treatments, respectively. It is assumed that nutrients in the soil would eventually be removed as manure in subsequent cleanings.

A significant amount of OM volatilized from pens on the WCGF treatment because that treatment had the greatest percentage of excreted OM. Thus, more OM was exposed to the environment and lost through volatilization. Even though more of the nitrogen excreted by the cattle fed WCGF was in the form of fecal N rather than urinary N, the percentage losses of N were similar among all three treatments (Table 2). Our hypothesis that more N would be retained in the manure from cattle fed the WCGF appears to be incorrect. It was visually observed that pens on the WCGF treatment were

wetter than pens assigned to other dietary treatments. When the pen is wet, microbial activity is stimulated and subsequently volatilization of N as ammonia may be increased. The amount of N (lb/animal) volatilized from pens of cattle fed the WCGF diet was greater ($P < .10$) than that volatilized from the All Con diet because a greater amount of N was excreted. More N was removed from the pens in the manure from the cattle fed WCGF compared to the 7.5% R and All Con diets, also because more N was excreted.

Pens on All Con diets had the greatest quantity ($P < .01$) of runoff (Figure 1) because there was less fecal material in these pens to "trap" rainfall on the surface. The pens on the 7.5% R and WCGF treatments had greater accumulations of fecal material on the feedlot surface, causing some pooling of water. The variation in quantity between runoff events was due to variation in precipitation and the degree of soil saturation. More runoff from the All Con treatment ($P < .01$) resulted in a greater ($P < .10$) percentage of excreted nutrients lost in the runoff. The percentage of excreted N lost in runoff was 5.1, 7.1, and 21.4% for WCGF, 7.5% R, and All Con treatments, respectively. These percentages are in agreement with the 3 to 6% loss of excreted material to runoff reported by previous research. The percentages of excreted P and OM lost in runoff were less than 1%.

The results from this trial indicate that fiber apparently increased the amount of hindgut fermentation, resulting in increased N excretion in feces and less in urine. There were no significant differences among treatments in the percentage of excreted N volatilized, however, there was significantly greater total quantity of N volatilized from the WCGF treatment when compared to the All Con treatment. Shifting N excretion to feces did not reduce the percentage of N lost through volatilization. The goal of the waste management system may dictate what dietary feed sources are best.

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Composting - A Feedlot Waste Management Alternative

Gary Lesoing
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Summary

A composting operation was initiated in 1993 in cooperation with the Integrated Farm Project at the Agricultural Research and Development Center (ARDC) Beef Feedlot. Compost was hauled from the feedlot and placed in windrows, where it was turned for composting. In 1993, a very wet year, 2500 tons of beef feedlot manure were composted. The compost contained a considerable amount of soil and only averaged 4.3 lb of N/ton and 5.6 lb of P/ton. In 1993, a front-end loader was used to turn the compost for most of the year. In 1994, a pull-type compost turner allowed compost to be turned in a more timely manner and the compost contained 12.4 lb of N/ton and 7.7 lb of P/ton. Costs for composting were $3.50/ton in 1993 and $3.75/ton in 1994. A nutrient recovery experiment indicated that 67 to 76% of OM and 64 to 77% of N was recovered during composting, depending upon the feedlot diet. Check strips established in fields where compost was applied indicated a crop response on soils low in OM and P.

Introduction

Implementation of nitrogen management plans by Natural Resource Districts may require feedlots to evaluate the environmental soundness of their waste management plans. Composting may be a manure management system that can provide a method of using the nutrients in feedlot manure as a resource in an environmentally sound manner. Composting is an aerobic (oxygen requiring) decomposition of organic matters, such as manure, by microorganisms. Composting has been shown to provide many benefits. Moisture content and volume of composted feedlot manure are reduced 50% compared with raw feedlot manure. This improves handling and requires fewer trips to the field when applied to cropland. It may also be economically feasible for compost to be transported longer distances and be used as a valuable resource for crop production. Composting stabilizes nitrogen and makes it less susceptible to leaching and runoff when surface applied. This also provides flexibility in application to cropland. Unlike raw manure, compost does not have to be incorporated into the soil immediately following application to prevent nitrogen losses. Odor is generally reduced compared

(Continued on next page)

with stockpiled manure; and land applied composted feedlot manure is nearly odorless.

Drawbacks to composting include: time, money, land, and potential loss of nitrogen. Composting takes considerable labor, time and careful management if done properly. It may require the purchase of additional equipment to turn the windrows. Adequate land is needed for properly locating the composting site so it can function correctly. Runoff needs to be controlled, but adequate drainage is required to reduce muddy conditions during wet periods. In composting feedlot manure, loss of nitrogen from volatilization of ammonia is a major concern. Compost may contain only 50% of the nitrogen that was in raw manure. This may be due to a low (C:N) ratio, approximately 15:1. While adding carbon sources to the feedlot manure would reduce this problem, it usually is not economically feasible unless a source is delivered to the site free or a fee is received for the carbon source.

The objectives of this study were: 1) Determine the cost of composting beef feedlot manure, 2) Determine the nitrogen and phosphorus content and economic value of composted feedlot manure, 3) Calculate the recovery of organic matter and nitrogen during the composting process, and 4) Evaluate crop response to application of compost.

Procedure

The 1200 head feedlot at the Agricultural Research and Development Center began composting in the spring of 1993. A site was selected in the fall of 1992 for composting. The site was located so runoff from the windrows of composting feedlot manure would be contained and flow into a swine lagoon. Manure was hauled out of the feedlot and put in windrows three to five ft high and 12 to 15 ft wide. Windrows were then turned periodically as the temperature of the windrows heated to 140 to 160° F during the composting process. A front-end loader and a specially designed compost turner were used to turn the windrows. Turning the windrows served two purposes. First, it aerated the material to replenish it with oxygen so the composting process continued; and second, it cooled down the windrow to reduce nitrogen losses from volatilization of ammonia. When the composting process worked correctly, water, heat, and CO_2 were generated.

Costs for turning and spreading compost were estimated per ton of compost produced during 1993 and 1994. In 1993, costs were based on $10/hr for labor, $20/hr for rental of loader, $19.50/hr rental on the tractor, and $500 for one month rental for the compost turner or $.20/ton of compost. Spreading costs were based on a computer model developed by Ray Massey, Extension Specialist, Agricultural Economics. These costs are calculated using several variables that are entered into the equation. These variables include: spreader cost, $20,000; spreader life, 10 years; diesel price, $.75/gallon; wages, $10/hr; road speed, 15 mph; field speed, 6.5 mph; field size, 60 acres; distance to the field, 1 mile; tons per acre, 10; spreader capacity, 15 ton; and swath width, 17 feet. These variables provided the information for this model to give an estimate of the average costs of spreading compost in 1993. In 1994 costs were similar for labor, loader rental, and tractor rental. Cost of rental of the compost turner was $500/month, for a five month period. Beef feedlot manure was turned an average of four times during this period. The cost of the turner was $.60/ton of compost. In 1994, the spreader was recalibrated to improve the accuracy of compost application. Average spreading costs were calculated using the computer model, with the following variables being used: field speed, 6.3 mph; distance to the field, 3 miles; tons per acre, 12; and swath width, 12 feet.

An experiment was also conducted to determine recovery of N and OM from three different finishing diets. A diet containing 7.5% roughage, a wet corn gluten feed diet, and an all concentrate diet were fed to finishing cattle in the feedlot (Bierman et al., p 74). Following completion of the trial, manure from pens on each diet was collected, weighed, hauled to the compost site, sampled, and analyzed for N and OM before composting. Manure from each pen was composted separately. After the manure was composted, it was sampled and analyzed for N and OM to determine recovery of these nutrients using ash as an internal marker.

In 1993 and 1994, check strips were established in fields where compost was applied as a P source and were supplemented with commercial N according to soil tests for the subsequent crop. The check strips also received commercial N, but no compost. Paired comparisons for yield between strips were made in 1994 for wheat, soybeans, and corn.

Results

Dry matter, N, and P content of compost in 1993 were 83.2%, 4.3 lb N/ton, 5.6 lb P/ton on an "as is " basis. The very wet year of 1993 made composting feedlot manure difficult. It was difficult to clean pens in a timely manner, and a considerable amount of soil was hauled from the pens with the manure to the compost site. This material did not compost well as it did not heat properly. The manure was too wet early in the summer, or too dry when the pens were cleaned in late summer. Ideally, material for composting should range from 40 to 65% moisture, have a carbon to nitrogen (C:N) ratio of 20:1 to 40:1, and temperature range of 110 to 150°F. If the material is too wet, oxygen will not be sufficient, and anaerobic decomposition of the material will occur. Anaerobic processes generate little heat to evaporate water, and produce methane, hydrogen sulfide, and other organic substances that cause strong odors. If the moisture content of the material is below 40%, it is difficult to initiate the composting process and the material will compost very slowly. If the C:N ratio is below 20:1, the available carbon is fully utilized before all of the nitrogen is stabilized resulting in excess nitrogen being lost to the atmosphere as ammonia or nitrous oxide. The low nitrogen content of the compost was attributed to nitrogen either volatilized in the pens as ammonia or washed away in the runoff. Initially, the windrows

were turned with a large payloader. The loader did not aerate the manure very well. In late summer, a pull-type compost turner was leased. The compost turner did a much better job of aerating the manure and getting the composting process started. Despite all the difficulties, 2500 tons of compost were produced from the feedlot.

In 1994, average dry matter, N, and P content of compost were 77.3%, 12.4 lb N/ton and 7.7 lb P/ton of compost. With considerably less rainfall in 1994, composting of beef feedlot manure went very well. The pens were cleaned in May and June in a timely manner and the manure had much lower soil content. The windrows were turned an average of four times during the summer. Temperature of the compost was monitored in the windrows. Windrows were turned as temperatures reached 140 to 150° F. The lower temperatures reduced the amount of nitrogen volatilized as ammonia during composting. Research at the ARDC *(Eghball, personal communication)* has shown that from 15 to 40 % of the N from manure is lost during composting depending upon the diet fed to the cattle and initial N content of manure. Although lower temperatures during composting may reduce N losses, they may also limit the destruction of weed seeds. While only 500 tons of compost were produced in 1994, it was higher in nutrient value than in 1993.

The higher nutrient content of the compost in 1994 increased its value considerably. Compost was priced according to its N and P content, based on commercial fertilizer value of N and P. Based upon prices during the spring of 1995, $.19/lb for N and $.58/lb for P, value of composted feedlot manure was $4.07 and $6.82/ton for 1993 and 1994, respectively.

Costs for labor, turning and spreading compost were estimated to be $3.50/ton in 1993. Costs were based on $1.25/ton for turning the compost and $2.25/ton for delivery to the field, and spreading the compost. These costs do not include costs associated with cleaning of the pens and hauling to the compost site. In 1994, costs were $3.75/ton for producing compost, delivering it to the field, and spreading the compost. Cost of turning and spreading the compost averaged 1.25/ton and $2.50/ton, respectively.

Table 1. Effect of compost application on crop yields in 1994.

Treatment	Crop	Yield (bu/ac)
Compost applied	Soybeans[a]	55
No compost applied	Soybeans[a]	58
Compost applied	Soybeans[b]	54
No compost applied	Soybeans[b]	49
Compost applied	Wheat	58
No compost applied	Wheat	55
Compost applied	Corn	123
No compost applied	Corn	114

[a]Soil conditions were a silty clay loam, OM 3%.
[b]Soil conditions were a sandy loam, OM 1.5 to 2%

Results of the nutrient recovery experiment showed a 67.0, 70.6, and 75.6% recovery of organic matter for the 7.5% roughage, WCGF, and all concentrate diets respectively. The recovery of N for these respective diets was 65.5, 63.9, and 76.5%. The recoveries for OM and N after composting are in the range of previous research results.

Yield results of paired comparisons to evaluate the effect of compost application on crop yields are shown in Table 1. Results indicate crops tended to respond to compost more when applied on poorer soil. In a large 75-acre field which tested low in P, compost was applied following corn during the fall and winter of 1993-94. Two check strips were established, one on a silty, clay loam soil higher in organic matter (3%), and the other on a sandy, loam soil with a lower organic matter (1.5 to 2%). In 1994, yield comparisons on soybeans in this field showed no yield response on the soil higher in organic matter, but a 10% increase (5 bu/acre) on the lower organic matter soil. In 1995, additional check strips will be compared to evaluate the effect of compost on crop production.

Conclusions

Results of this study indicate that successful composting is highly dependent upon the material that is delivered to the compost site from the feedlot pens. Manure that is very wet or dry and contains considerable quantities of soil will not compost well and nitrogen content of compost is low. When manure is lower in soil content and contains sufficient moisture, it will heat up when put in windrows. The composting process will continue and go to completion if the windrows are turned when temperatures reach 140 to 150°F. This method will conserve the most nitrogen and add value to the compost. This study suggests the value of the N and P in the compost will pay for the cost of composting. The effect of compost on crop yields indicates compost is best utilized on poorer soils low in organic matter and as a phosphorus source. Based on these results, compost is being used on the ARDC as a P source for crops. It is being applied during the fall and winter to fields that have soil tested low in P. Compost is also being used as a P source for established alfalfa and also before planting alfalfa. Compost is being applied at rates from 8 to 12 ton/acre to supply enough P for two or more years, depending upon what crops are grown. Compost is being prioritized for use in fields low in P, under irrigation, and for alfalfa production. The method of compost application being used on the ARDC provides for a systematic application of P and a stabilized form of N that is released slowly to the crops. This reduces the risk of ground and surface water contamination. Composting has allowed flexibility in our application times without the risk of polluting our environment and causing soil compaction. It may provide additional benefits to the soil that will be identified over time.

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Predicting Wholesale Value of Beef Carcasses

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Summary

Electromagnetic scanning (EMS) has been studied as a method to determine the lean content of beef carcasses. In this study the capability of EMS to predict wholesale value of beef carcasses was examined. Yield grades, as assigned by a USDA grader (GRADER), and yield grades calculated to the nearest hundredth (CALC), were also examined to compare their predictive value. Beef hindquarters (n=219) were obtained from the U.S. Meat Animal Research Center's germ plasm evaluation project, Cycle V. Fat thickness ranged from .10 to .90 inches with calculated yield grades ranging from 1.26 to 5.46. When side value was determined from estimates of subprimal cut weight with 0.0 inches of fat trim, EMS had an R^2 of .91 (root mean square error [RMSE] of $9.92), CALC had an R^2 of .88 (RMSE of $11.03), and the GRADER method produced an R^2 of .85 (RMSE of $12.49). When side value was predicted from subprimal cuts with 0.3 inches of fat, differences between methods were reduced. Expressing the value on a percentage of carcass weight basis ($/cwt) revealed calculated yield grade to provide the most precise estimates (higher R^2), followed by EMS and GRADER estimates. Addition of fat thickness to the EMS model increased predictive accuracy (lower RMSE). Electromagnetic scanning appears to provide a more accurate estimate of total wholesale beef carcass value than the USDA yield grade system, as currently applied.

Introduction

The growing interest in value-based marketing elevates the importance of accurate assessment of individual carcass merit. Retailers, meat plants, and producers must find a way to reduce the production and marketing of fat. Instant feedback to producers, in the way of a higher dollar value for preferred cattle, gives a clear signal on what type of beef is desirable. Electromagnetic scanning (EMS) has the capability to accurately provide an assessment of lean content on a single carcass basis.

Previous research at the University of Nebraska has shown that EMS has the ability to predict lean composition of beef carcasses (1994 Nebraska Beef Report, pp. 61-64; 1993 Nebraska Beef Report, pp. 68-69). This project was conducted to evaluate the use of EMS to predict wholesale value of beef carcass sides. The relationships of grader-assigned and calculated USDA yield grades to carcass value were also compared.

Procedure

Hindquarters (n=219) were obtained from steers used for the U.S. Meat Animal Research Center's germ plasm evaluation project, Cycle V. These steers were slaughtered at a commercial midwest packing plant at four intervals. USDA yield grades were calculated from carcass data obtained at the slaughter plant following a 24-hour chill. The whole number yield grade assigned by a USDA grader was also recorded.

One carcass side from each animal was transported to the U.S. Meat Animal Research Center facilities at Clay Center, Nebraska for dissection. The right hindquarter from each side was scanned using a model MQI-Pork Carcass electromagnetic scanner at 2.5 MHz. Deep internal temperature and total length of each hindquarter were measured.

The hindquarters were scanned shank first, fat side down. The entire side was then dissected into bone, fat, lean trim, and subprimal cuts. The weight of each subprimal was recorded at 0.30 inches of fat trim and at 0.0 inches of fat trim.

Using the variables scan peak, hindquarter weight, and hindquarter length, weights of subprimal cuts were predicted using linear regression. Actual side values were calculated by summing the actual value of each subprimal cut. Subprimal prices from the USDA Agricultural Marketing Service in late 1994 were used. Calculated and whole number (GRADER) yield grades were used to create estimates of percentage of carcass weight represented by individual sub-primal cuts. These estimates were converted to weight (using actual carcass weight) and subsequently to value using reported prices. The R^2 statistic represents the proportion of the variation explained by the technology. A higher R^2 means a stronger relationship between predicted values and actual values. Root mean square error (RMSE) is the standard deviation of the predicted value, an indication of precision.

Results

Yield grades ranged from 1.26 to 5.46 with actual fat thicknesses ranging from 0.10 inches to 0.90 inches (Table 1). Hot carcass weights ranged from 471 lb to 990 lb. The cattle used in this study were genetically diverse. The wide range in weights and fat thicknesses represent the variation seen at commercial packing plants.

Table 2 shows the R^2 and RMSE for each method of determining total side value through estimates of weights for each subprimal cut. Electromagnetic scanning had the highest R^2 and the lowest RMSE at 0.30 inch level of fat trim, although calculated yield grade provided similar estimates.

Table 1. Mean carcass characteristics of beef steers[1].

Variable	Mean	SD[2]	Minimum	Maximum
Hot carcass weight, lb	717.7	86.0	471.4	989.8
Fat thickness, in	.38	.16	.10	.90
Ribeye area, in^2	11.6	1.19	9.0	15.0
Kidney, pelvic, and heart fat, %	2.7	.56	1.0	4.5
Calculated yield grade	3.00	.69	1.26	5.46

[1] n=219.
[2] Standard deviation.

Table 2. Prediction of total side value at 0.0 and 0.3 in of fat trim.

	0.3 in fat trim		0.0 in fat trim	
Prediction method	R^2	RMSE[1], $	R^2	RMSE[1], $
Electromagnetic scanning	.92	8.12	.91	9.92
Calculated yield grade	.91	8.34	.88	11.03
Grader yield grade	.89	9.17	.85	12.49
Electromagnetic scanning + fat thickness	.92	8.11	.92	9.50

[1]RMSE = Root mean square error.

Table 3. Prediction of value/cwt at 0.0 and 0.3 in of fat trim.

	0.3 in fat trim		0.0 in fat trim	
Prediction method	R^2	RMSE[1], $	R^2	RMSE[1], $
Electromagnetic scanning	.43	1.25	.57	1.66
Calculated yield grade	.53	1.13	.64	1.51
Grader yield grade	.41	1.26	.52	1.73
Electromagnetic scanning + fat thickness	.47	1.21	.64	1.52

[1]RMSE = Root mean square error.

At the 0.0 inch fat level, EMS estimates of total side value had RMSE below $10 per side, while either yield grade method had RMSE of $11 or more. These data imply that EMS is more precise than yield grade in predicting the overall side wholesale value. The increased accuracy of EMS at leaner levels also becomes important as more fat is trimmed at packing plants.

Addition of fat thickness to the EMS model (Table 2) did not improve accuracy (R^2) and had little beneficial effect on precision (RMSE) of total value estimates. This was expected as EMS measures lean content and most of the excess fat is removed in preparing trimmed subprimal cuts.

When value ($/cwt) was expressed as a percentage of carcass weight (total side value/side wt*100), then calculated yield grades provided more precise (lower RMSE) estimates of value (Table 3). The EMS estimates were intermediate between the calculated yield grade and the yield grade applied by the USDA grader. This suggests that EMS could provide objective estimates of value that are equal or superior to the yield grade system as currently applied. Such an approach to value determination would also be objective and less subject to biases or errors in human judgement of composition. The magnitude of the R^2 values for prediction of $/cwt (Table 3) is much lower than for prediction of total value (Table 2). Any time data are expressed on a percentage basis. This reduction in R^2 is noted because percentage yield varies due to both lean and fat and thus is more difficult to predict.

When carcass fat thickness was added to the EMS model at 0.0 in of fat trim, the R^2 for $/cwt improved to the level of calculated yield grade. The R^2 also improved at 0.3 in of fat, but not to the same extent. These results would be expected as a measure of fatness needs to be coupled with a measure of lean for prediction of percentage. Carcasses containing the same amount of lean, but different amounts of fat would have different percentages of lean.

Traditionally, packers and producers have defined carcass value on the basis of percentage yield of subprimal cuts. This might be the consequence of deriving value based on the cost of the raw material. With the pricing strategy enabled by the technology presented here, it is now possible to estimate value based on the weight and price of subprimal cuts. This approach reflects the amount of money an individual animal is worth on the wholesale, subprimal, beef market - regardless of initial carcass weight. Such a value-determining system should allow prompt, efficient transfer to producers of market demands for specific products.

The data from this study suggest EMS can provide more precise, objective estimates of value than the yield grading system as currently applied. Measurement of factors for, and calculation of, yield grade to the nearest hundredth of a grade appears equally effective, but would be more labor and time intensive. Selection of a value-determining system could be influenced by the objective nature of the technology and the potential to automate it. Electromagnetic scanning offers potential in this application.

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Connective Tissue/Acidic Phosphate Preblends In Low Fat, High Added-Water Frankfurters

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Summary

Preblending modified beef connective tissue with an acidic phosphate has been shown to increase collagen solubility of the connective tissue. Increased collagen solubility may improve the textural properties and other characteristics of the final product to which the preblend is added. The objective of this research was to determine the effects on product quality of adding an acidic phosphate/ connective tissue preblend to low-fat, high added-water frankfurters. Product analyses included proximate composition, emulsion stability, yield, pH, collagen solubility, purge loss, color, objective texture and consumer acceptance. Preblending modified connective tissue with acidic phosphate provided few textural or yield advantages to the final product. However, preblending with subsequent addition of alkaline phosphate to the final batter created a product similar to the control. Employing the preblending concept may also add flexibility to production schedules. Use of modified connective tissue increases profitability of desinewing operations while maintaining or improving the quality of the final product to which it is added.

Introduction

The demand for low fat meat products continues as health-conscious consumers search for low-fat alternatives. Research in fat reduced meats has identified several problems often associated with removal of fat from processed meat products: tough rubbery texture, lack of flavor, lack of juiciness and darker color. Substituting water for fat has proven successful in countering some of these negative attributes, however, new concerns about product quality accompany water addition. Water is difficult to maintain in the product through production and storage. When water was added in combination with connective tissue, processing yields and purge loss were controlled and texture improved in low fat, high added-water products (1992 Nebraska Beef Report, pp. 50-52).

Phosphates have been added to meat products to improve water retention. In Europe, acidic phosphates have been preblended with pig skins to soften the skin and solubilize collagen before addition to meat emulsions. Preblending modified connective tissue with an elevated concentration (3.5%) of a specially processed sodium acid pyrophosphate increased collagen solubility in the preblends (1994 Nebraska Beef Report, pp. 59-62). Incorporation of these preblends into processed meats may increase water binding and modify texture. This study determined if altering the characteristics of the preblend can influence final frankfurter quality.

Procedure

Frankfurters were formulated at two fat/added water (AW) levels (30% fat/ 10% AW and 10% fat/25% AW) and each formulation was manufactured according to one of four treatments: 1. Control (CONT) with no phosphate and no modified connective tissue added; 2. Modified connective tissue added alone (CT); 3. Modified connective tissue preblended with acidic phosphate (PB); 4. Preblending modified connective tissue with acidic phosphate and adjusting final product pH by adding alkaline phosphate (ALK).

Preblend Preparation

Connective tissue was obtained from a commercial desinewing operation and modified by freezing, grinding, then flaking to a powder-like form and stored at -15°F. The modified connective tissue (MCT) was added at 20% of the meat block regardless of preblending. The acidic phosphate utilized was a specially processed sodium acid pyrophosphate (pH 2.8) and the alkaline phosphate was a blend of sodium tripolyphosphate and sodium hexametaphosphate (pH 9.0). The preblends for the PB treatments were prepared by mixing a 3% acidic phosphate solution in a 1:1 ratio with MCT. The ALK treatment used a 2% acidic phosphate solution to allow for addition of the alkaline phosphate and not exceed the regulatory limit of 0.5% total phosphate in the final product. Preblends were prepared by mixing the phosphate solution and MCT for 10 min in a table-top bowl chopper 18 h prior to frankfurter manufacture to facilitate processing schedules. Previous studies found time of preblending did not affect final preblend characteristics.

Frankfurter Production

Frankfurters were produced in a bowl chopper by first chopping lean meat, ice water and salt. Cure and sodium erythorbate were added, followed by MCT (as a preblend or free-flowing). Seasoning, sucrose, fat trimmings and remaining water were added last and chopping continued for a total of 4.5 min. Frankfurter batter was passed once through an emulsion mill, stuffed into casings, thermally processed to 158°F, chilled, peeled, vacuum packaged and stored at 34°F.

Frankfurter Analysis

Frankfurter batter was analyzed for emulsion stability. Frankfurters were

analyzed for proximate composition, pH, purge loss (42-day storage), processing yield and collagen content. External and internal color were evaluated by obtaining 650/570nm ratio for cured color intensity and L* and a* values for lightness and redness, respectively, on days 1, 15 and 30 of storage. The textural variables of hardness, chewiness, cohesiveness and springiness were determined instrumentally. A consumer acceptance panel evaluated frankfurters for the attributes of flavor, texture and overall acceptability on an 8 point Hedonic scale.

Results

Frankfurters of the PB treatment had the highest emulsion stability fluid and gel loss (P<.01; Table 1) and the lowest smokehouse yield (Table 1), possibly due to the lower pH of the PB batter (data not shown). The ALK franks also had more gel and fluid loss than CONT or CT, however, smokehouse yields of these treatments were similar. It appears that the addition of alkaline phosphate, or the reduction in acidic phosphate, is successful in reducing the detrimental effects the acidic phosphate may impose on final product quality, as a higher pH was noted for the ALK product (Table 1).

Preblending MCT with acidic phosphate did not increase collagen solubility in frankfurters as was seen in previous work on preblends alone (1995 Nebraska Beef Report, pp. 59-62). This may be explained by a dilution effect since the preblend becomes incorporated into the final frankfurter batter before heat is applied. Earlier tests on preblends alone applied heat while the phosphate was still in a concentrated amount which may affect collagen solubility. Purge loss was lowest (P<.05) for the CT treatments, but did not exceed 1.20% for any treatment (Table 1). Purge increased for the preblend-containing treatments versus CT, but was not different versus CONT.

Instron compression measurements for the attributes of hardness, chewiness and springiness indicated no differences among treatments (P>.05; Table 2). The fact that up to 20% (meat basis) of MCT could be added without altering these textural attributes provides support for the use of MCT in comminuted products of high or low-fat content.

A consumer acceptance panel did not detect differences (P>.05) for flavor, texture or overall acceptability at either formulation or for any treatment

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Table 1. Emulsion Stability, Smokehouse Yield, Collagen Values, pH and Purge Loss

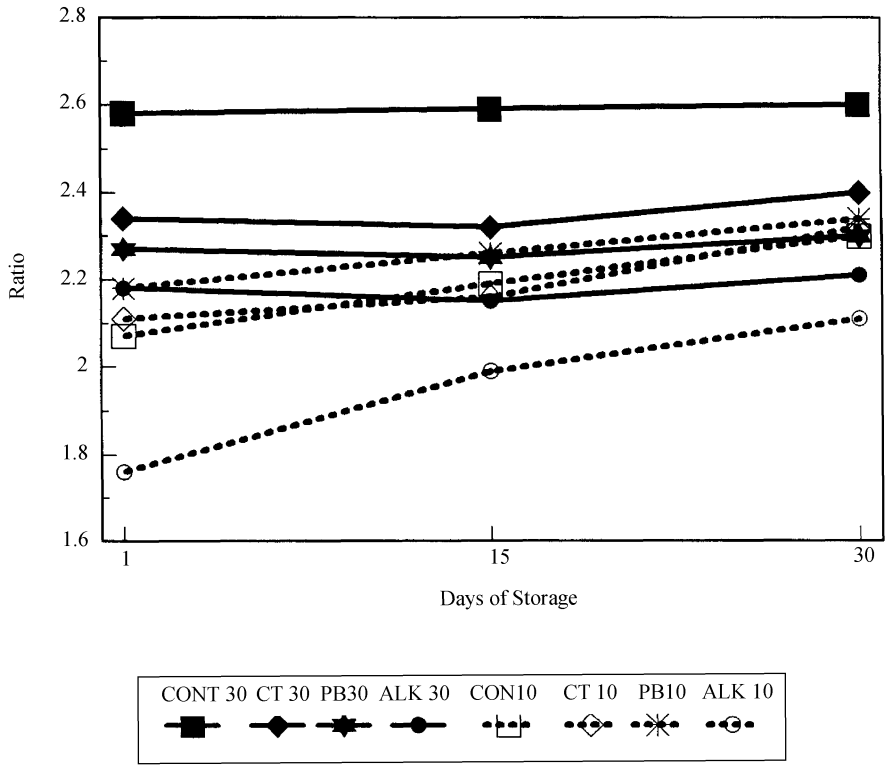
		Fat/AW[a]			Treatment[b]				
Variable	Units	30/10	10/25	S.E.	CONT	CT	PB	ALK	S.E.
Emulsion stability									
-Total Fluid	ml/100g	14.10*	17.50	0.97	8.14[c]	10.10[c]	28.36[d]	16.59[e]	1.38
-Gel Water	ml/100g	12.79*	16.58	0.88	7.21[c]	9.07[c]	26.96[d]	15.49[e]	1.24
- Fat	ml/100g	1.32	0.92	0.11	0.93	1.03	1.40	1.10	0.24
Smokehouse yield	%	84.32*	76.09	0.24	81.24[c]	80.79[c]	78.37[d]	80.41[c]	0.34
Collagen values									
- soluble	mg/g	2.98*	2.67	0.11	1.13[c]	3.15[d]	3.12[d]	3.10[d]	0.16
- insoluble	mg/g	21.73*	17.38	0.30	10.44[c]	22.40[d]	23.87[e]	21.51[d]	0.43
pH		5.96*	5.98	0.01	6.06[c]	6.09[d]	5.77[e]	5.96[f]	0.01
Purge Loss	%	0.71*	1.30	0.07	1.03[c]	0.71[d]	1.20[c]	1.08[c]	0.09

[a] AW = USDA added water = % moisture - (4 x % protein).
[b] CONT = no phosphate, no MCT; CT = no phosphate, MCT; PB = phosphate, MCT, preblended; ALK = phosphate, MCT, preblended + alkaline phosphate.
[c-f] Mean values in a row within Treatment followed by different letters are significantly different (P< 0.05).
* Significantly different (P<.05).

Table 2. Objective Texture (Compression) and Consumer Acceptance Panel Results

		Fat/AW[a]			Treatment[b]				
Variable	Units	30/10	10/25	S.E.	CONT	CT	PB	ALK	S.E.
Compression									
-Hardness	N/g	8.25	8.46	0.35	8.97	7.84	8.17	8.44	0.50
-Cohesiveness	Unitless	0.26*	0.31	0.01	0.30[c]	0.27[d]	0.29[cd]	0.27[d]	0.01
-Chewiness	N m/g	0.09	0.10	0.01	0.11	0.09	0.09	0.09	0.01
-Springiness	mm	43.22*	38.58	1.03	41.44	41.11	39.72	41.33	1.46
Flavor[e]		4.92	5.04	0.13	4.84	4.82	4.82	5.44	0.18
Texture		5.07	4.83	0.13	4.99	4.90	4.61	5.29	0.18
Overall Acceptability		4.86	4.83	0.12	4.75	4.70	4.65	5.29	0.17

[a]AW = USDA added water = % moisture - (4 x % protein).
[b]CONT = no phosphate, no MCT; CT = no phosphate, MCT; PB = phosphate, MCT, preblended; ALK = phosphate, MCT, preblended + alkaline phosphate.
[cd]Mean values in a row within Treatment followed by different letters are significantly different (P<0.05).
[e]Flavor, Texture and Overall Acceptability were measured on an 8 point Hedonic scale. 1=dislike extremely, 8=like extremely
*Significantly different (P<.05).



Formulation x Treatment (P<.01) S.E. = 0.04; Formulation x Day (P<.01) S.E. = 0.02

Figure 1. Cured Color Intensity (650/570nm reflectance ratio).

(Table 2). Scores did not fall below 4.6 for any attribute on the 8-point scale, indicating the acceptability of connective tissue in these formulations.

Frankfurter exterior and interior became lighter when phosphate and MCT were added, as indicated by the higher L* values (data not shown). Treatment effects were more pronounced in the 30% fat/10% AW formulations versus the 10% fat/25% AW formulations due to the slightly larger meat block of these formulations which allowed for more MCT, a less pigmented meat source that has been shown to contribute to increased lightness and decreased redness. Interior redness was lowest in the ALK frankfurters for either formulation as indicted by lower a* values formulation, but redness improved during storage for the 10% fat/25% AW formulations (data not shown).

Cured color intensity was described by formulation by treatment and formulation by day interactions (Figure 1). Cured color was higher for the 30% fat/10% AW versus the 10% fat/25% AW formulations. The ALK treatment had the lowest cured color for either formulation. During storage, the cured color of the ALK treatment at the 10% fat/25% AW level displayed the largest improvement and reached the level of cured color the control displayed at the beginning of storage

Preblending MCT with a concentrated amount (3%) of specially processed sodium acid pyrophosphate before addition to frankfurter batter provided few advantages to final frankfurter quality. Preblending MCT with this acidic phosphate at a lower concentration (2%), with subsequent addition of an alkaline phosphate, allowed for a product similar to the control. This procedure allows processors the opportunity to employ the preblending concept to facilitate production schedules. Addition of MCT provides a use for this byproduct of desinewing operation which enhances profitability while maintaining or improving low-fat, high added-water frankfurter characteristics.

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Gelatinized High Added-Water Beef Connective Tissue Protein Gels as Potential Water Binders

Wesley N. Osburn
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Summary

Heating beef connective tissue (BCT) from desinewing operations may enhance its water binding ability due to partial conversion of connective tissue collagen to gelatin. Upon cooling, the gelatinized protein gel partially reforms, and may further entrap added water. Incorporation of this recovered protein as a gel in low-fat products may improve product juiciness and palatability. The objectives of this study were to determine temperature and time variables that enhance conversion of connective tissue collagen to gelatin (Experiment I) and determine basic properties of high added-water beef connective tissue gels (Experiment II). Heating BCT at 158°F for 30 min released less gel-water and fat indicating binding of fluids by gelatin. Added water levels of 100, 200, 300, 400, 500 and 600% were used to determine how much water heated BCT could bind. Soluble collagen levels averaged 7% allowing the production of stable protein gels with as much as 400% AW.

Increasing added water levels softened gel texture and lightened gel color. The potential exists to incorporate high added-water BCT protein gels into low-fat beef products to enhance product attributes.

Introduction

Research in fat reduction of processed meats has recognized problems associated with removal of fat: toughness, rubbery texture, lack of flavor and juiciness, and a darker color. Regardless of the importance of diet and health issues to consumers, low-fat products will not be purchased if they have unacceptable palatability or appearance. Current technologies for fat replacement include the addition of water, protein-based, carbohydrate-based, or synthetic compounds, alone or in combination. The addition and retention of water by these fat replacers is effective in improving the palatability attributes of low-fat meat products. Beef connective tissue (BCT), a byproduct of desinewing operations, may be used as a potential water binder to replace fat in low-fat meat products. The mechanism for this improvement may lie in the thermal denaturation of collagen during cooking and its conversion to gelatin, a water binding agent. This study consisted of two experiments. The objective of Experiment I was to determine temperature and time variables that enhance conversion of beef connective tissue to gelatin. The objective of Experiment II was to determine basic properties of high added-water beef connective tissue gels.

Procedure

Experiment I

Beef connective tissue (BCT) that had been passed through a desinewing machine twice was obtained from a commercial beef slaughter facility. The BCT was frozen, coarse ground (0.5 in), refrozen and flaked (0.06 in) in an Urschel Comitrol, double bagged in polyethylene plastic bags and frozen (-26°F) until analyzed for proximate composition and released fluids. The BCT samples (17 g) were placed in tubes, which were heated in a water bath at a single temperature (122, 140, 158 or 176°F) and removed at a specified time period (0.5, 1.0, 1.5 or 2.0 hours). Additional BCT samples were used to monitor temperature by placing a thermocouple in the geometric center of the "test" samples. Time did not begin until the samples reached the appropriate internal temperature. Water bath and sample temperatures were monitored every 10 min and adjusted as necessary. Fluids released from each sample were decanted into graduated tubes, and the tubes centrifuged for 10 min at 5500 rpm. Total fluids, fat, gel-water and solids released were recorded. Each temperature x time treatment combination was averaged and reported as mL released fluids per 100 g sample. The experiment was designed as a split plot with a 4 × 4 factorial arrangement of treatments. Water bath temperature was the whole plot factor and time period the split plot factor. Fishers Least Significant Difference was used to separate significant main effects and interactions. The experiment was replicated twice (N = 32).

Experiment II

The BCT described in Experiment I was used to determine its ability to form a gel and bind added water. Appropriate amounts of BCT and distilled, deionized water were combined in 600 mL beakers to produce ~ 500 g BCT gels containing 100, 200, 300, 400, 500 or 600% added water (AW) (Table 1).

Based on the results from Experiment I, BCT x water treatments were heated at 158°F for 30 min. The beakers were removed from the water bath, placed on stirring plates and mixed with stir bars in a refrigerated cooler (43±2°F) at high speed until the gels thickened and the stir bars could not move. This was done to enhance the uniform dispersion of flaked BCT throughout the BCT gel matrix. The stir bars were removed, beakers covered with parafilm and remained refrigerated 8-10 hr until analyzed. The pH of each BCT gel was determined. Samples were obtained from each BCT gel treatment by pushing a stainless steel coring device down the long axis of the gel to produce a sample cylinder that was then into 0.5 inch sections, producing samples measuring 1 inch (diameter) x 0.5 inch (height). Three sub-sample discs were used for HunterLab Colorimeter analysis (Illuminant A, 2° standard observer). One reading was taken on each surface of the sample discs for HunterLab L* (lightness), a* (redness), and b* (yellowness) values. Three sub-sample discs were used to compress each sample twice to 25% of average sample height. Hardness, cohesiveness, springiness and chewiness were determined. Analysis for hydration, a measure of water binding, was conducted by removing duplicate 25 gram (g) subsamples, placing them in centrifuge tubes and centrifuging at 15,000 rpm for 15 min at 36°F. Samples were removed and the expressed fluids collected. Hydration of each sample was determined and expressed as g water held/g wet tissue. Variability in total amount of BCT contained in each gel treatment was accounted for by expressing hydration on a fat-free basis. Cook stability was determined by placing 25 g samples into tubes, placing them in a 120°F water bath, and heating until the internal temperature reached 156°F within 1.25 to 1.50 hours. The free liquid was decanted and cook stability expressed on a sample percentage and fat-free BCT basis. The experiment was designed as a randomized complete block design with a single factorial (AW) treatment design. Fishers Least Significant Difference was used to separate significant main effects. The

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Table 1. Treatment Formulations for the Manufacture of BCT Gels (Experiment II).

Treatment	Connective Tissue	Added Water
1	250 g	250 g (100%)
2	167 g	334 g (200%)
3	125 g	375 g (300%)
4	100 g	400 g (400%)
5	83 g	415 g (500%)
6	71 g	426 g (600%)

experiment was replicated three times (N = 18).

Results and Discussion

Experiment I

Proximate analysis showed BCT composition to be 56.92% moisture, 18.47% fat and 25.49% protein. A temperature x time interaction ($P<0.01$) existed for BCT for total released fluids (Figure 1) and released gel-water ($P<0.01$) (Figure 2). Less total fluids were released from BCT at 158°F than the other temperatures. The main effect of temperature was significant for released fat. No fat was released at 140 or 158°F (Data not shown). The observed decrease in released fluids may be due to conversion of connective tissue collagen to gelatin, which may absorb any moisture and fat released from the BCT sample. Least squares means of temperature x time interaction within the 158°F treatment means for each time period indicated no significant differences for released gel-water (Figure 2). Based on the results of Experiment I, it was concluded that heating BCT at a temperature of 158°F for approximately 30 min is sufficient to convert collagen to gelatin, thereby enhancing its potential capacity to bind added water.

Experiment II

Added water (AW) decreased percent fat and protein, while increasing moisture content. Percentages ranged from 7.88 to 2.66% (fat), 14.31 to 4.68% (protein) and 80.27 to 94.00% (moisture), for 100 and 600% AW, respectively. The addition of water did not effect gel pH. Increasing water decreased soluble collagen content, with values ranging from 14.94 to 0.67 mg/g and total collagen content from 85.69 to 27.18 mg/g (100 and 600% AW, respectively). Percent soluble collagen values ranged from 17 to 2% among the gel treatments (average value of 7.01%), indicating similar conversion of collagen to gelatin among treatments. As AW increased, hydration values increased ($P<0.0001$) from 0.95 (100% AW) to 2.88 (600% AW) g water held per g tissue. Fat-free hydration values increased ($P<0.0001$) from 2.37 (100% AW) to 4.71 (600% AW) g water held per g tissue. Cook stability values decreased (82.97 to 26.77%) for 100 and 600% AW treatments, respectively, indicating solubilization of gelatin and subsequent release of water. AW did not affect cook stability expressed on a BCT fat-free basis. Values ranged from 49.86% (100% AW) to 43.26% (600% AW) (Table 2). Only the 100, 200, 300 and 400% AW treatments produced gels firm enough to analyze for color and texture. Higher AW resulted in a linear decrease in L* (lightness), a* (redness),

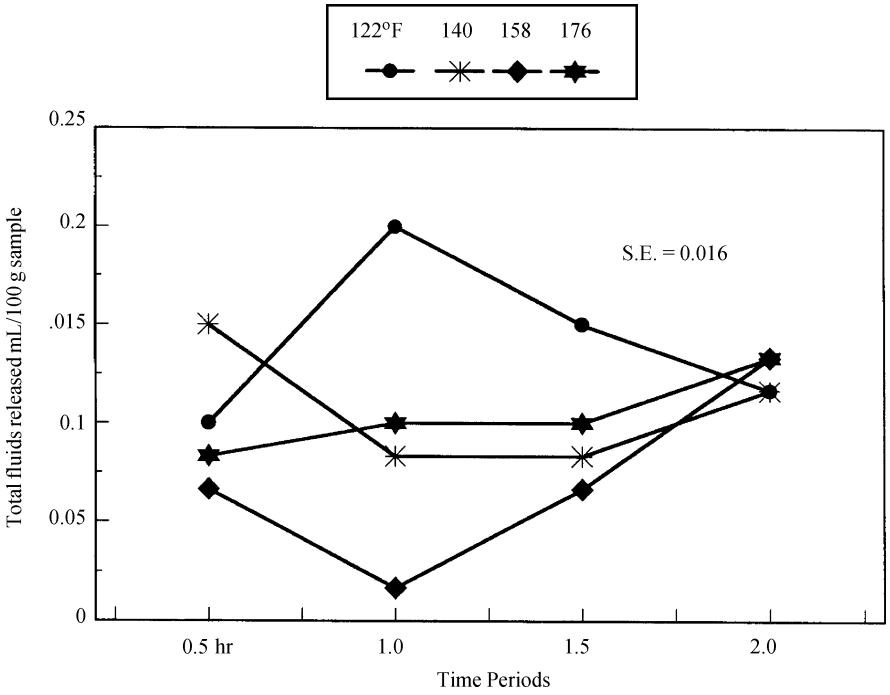

Figure 1. Least squares means separation for temperature ranges within each time period.

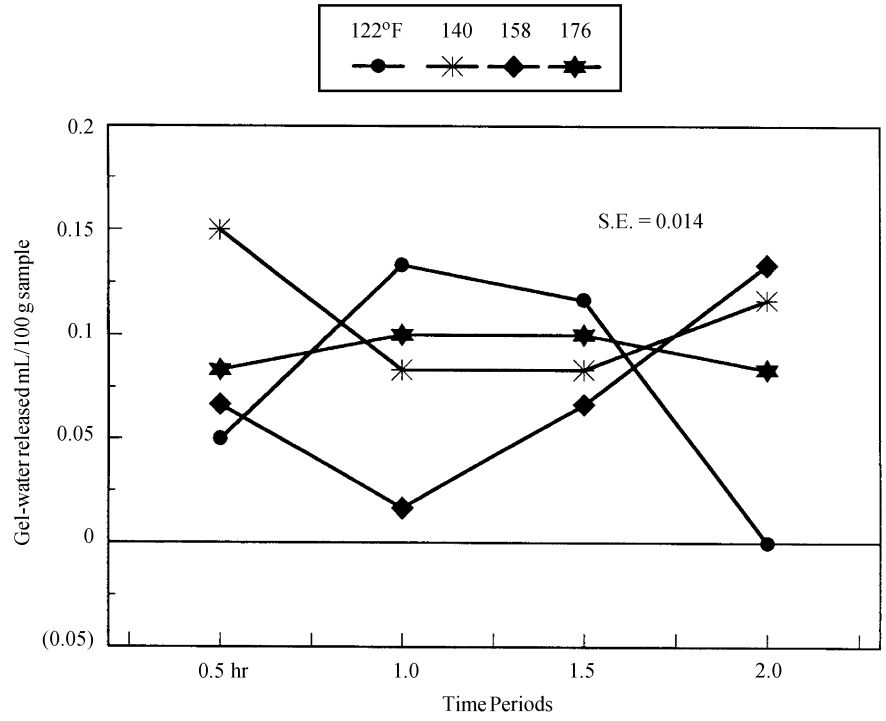

Figure 2. Least squares means separation for temperature ranges within each time period.

Table 2. Proximate Composition, Collagen Content, Hydration, and Cook Stability for High-Added Water Beef Connective Tissue Gels[f].

		Added Water Treatments (%)					
	SEM	100	200	300	400	500	600
Proximate Composition (%)							
Moisture	0.42	80.27[a]	85.48[b]	90.31[b]	91.67[cd]	93.12[d]	94.01[d]
Fat	0.28	7.88[a]	6.29[b]	4.41[c]	3.57[cd]	3.12[d]	2.66[d]
Protein	0.40	14.31[a]	10.37[b]	8.40[c]	6.91[d]	5.38[e]	4.68[e]
Collagen Content (mg/g)							
Total	4.44	85.69[a]	68.41[b]	51.70[c]	39.60[cd]	31.10[d]	27.19[d]
Soluble	0.73	14.94[a]	6.60[b]	5.10[c]	1.53[cd]	0.84[cd]	0.67[d]
Insoluble - (By difference)		70.75	61.81	48.60	36.03	30.26	26.52
% Soluble		17.43	9.64	5.99	3.86	2.70	2.46
Hydration (g H_2O held/g tissue)							
Sample	0.10	0.95[a]	1.82[b]	1.99[bc]	2.19[cd]	2.44[d]	2.88[e]
Fat-Free	0.15	2.37[a]	3.42[b]	3.71[b]	3.87[bc]	4.25[cd]	4.71[d]
Cook Stability (%)							
Sample	1.86	82.97[a]	58.67[b]	47.55[c]	36.48[d]	30.14[e]	26.77[e]
Fat-Free	1.86	49.86[a]	46.42[a]	43.47[b]	45.40[ab]	44.10[ab]	43.26[b]

[a-e]Means within row with different superscripts are different (P<0.05).

Table 3. Color Values and Textural Attributes for High-Added Water Beef Connective Tissue Gels.

	Added Water Treatments (%)				
	SEM	100	200	300	400
Color					
L *	0.84	63.12[a]	58.88[b]	59.15[b]	57.24[b]
a *	0.24	7.06[a]	5.29[b]	3.83[c]	2.95[d]
b *	0.14	6.17[a]	5.28[b]	4.58[c]	4.25[c]
Textural Attributes					
Cohesiveness	0.015	0.19[a]	0.13[b]	0.08[c]	0.11[bc]
Hardness (N)	11.31	52.17[a]	12.95[b]	4.38[b]	1.16[b]
Springiness (mm)	0.76	21.61[a]	13.40[b]	5.18[c]	3.36[c]
Chewiness (J)	0.061	0.25[a]	0.02[b]	0.002[b]	0.0007[b]

[a-e]Means within row with different superscripts are different (P<0.05).
[f]Sample temperatures for color and texture profile analysis were 36°F.

and b* (yellowness) values and tended to cause gels to become less cohesive and less springy. Added water decreased hardness values (P<.10), with 100% AW treatment approximately 4X harder (52.17 N) than 200% AW treatment (12.95 N). Chewiness values decreased linearly with increasing amounts of water (Table 3).

Based on the results from Experiment II, heating BCT increases its water binding capacity, allowing production of high added-water protein gels. The softer texture, lighter color and water binding capacity of these protein gels may enhance overall product attributes if incorporated into low-fat products.

Results from this study indicate the feasibility of heating recovered beef connective proteins to form protein gels capable of binding large amounts of added water. The mechanism for this increase in water binding capacity appears to be due to conversion of ~7% of the connective tissue collagen to gelatin. Improvements in texture and color and palatability may result from the addition of gelatinized beef connective tissue protein gels into low-fat beef. Additionally, economic benefits may be realized by using beef connective tissue protein gels to replace a percentage of the expensive lean tissue required for many low-fat beef products.

[1]Wesley Osburn, graduate student; Roger Mandigo, Professor, Animal Science, Lincoln.

Mechanically Recovered Neck Bone Lean Alters Textural and Sensory Properties of Ground Beef Patties

Brian Demos
Roger Mandigo[1]

Summary

The objective was to characterize ground beef patties manufactured with mechanically recovered neck bone lean (MRNL). Two fat levels (10 and 20%) and four MRNL levels (0, 15, 30 and 45%) were used. Level of MRNL did not affect raw moisture, protein, fat or ash content. Cook yield, water-holding capacity and consumer sensory panel flavor,

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texture or overall desirability were not affected by addition of MRNL. The consumer panel found that juiciness increased in a linear fashion as MRNL level increased. Force necessary to shear a ground beef patty decreased with increasing levels of MRNL. Ground beef patty springiness, hardness and chewiness decreased in a linear fashion as MRNL increased. Patties made with 10% fat were less juicy , harder, and chewier than those with 20% fat. Mechanically recovered lean levels of as little as 15% in low-fat patties (10%) are sufficient to mimic sensory texture and juiciness of 20% fat patties.

Introduction

Beef neck bones are one part of a carcass that can yield a substantial quantity of lean trim. Typically, neck bones are trimmed by hand. This is a labor intensive process that can lead to high levels of ergonomic stress if performed for an extended period of time. This process can also be inefficient, leaving salvageable lean on the bone.

Mechanical systems that recover lean tissue from beef cervical vertebrae portions have been introduced. These systems allow rapid, efficient recovery of lean tissue by hydraulic pressure with minimal bone breakage, temperature rise or increase in calcium content. Lean tissue is pressed away from the bone, leaving the bone mass intact. The final product from this process is finely textured and similar to finely ground beef product (approximately .05 inch diameter). Lean tissue recovered in this fashion has altered functional properties such as increased pH, metmyoglobin reducing ability, water-holding capacity and pigment content.

Sensory and physical differences of processed products containing mechanically deboned meat from older recovery systems have been shown. The objectives of this study were to determine the effects of MRNL on physical, chemical and sensory properties of 10 and 20% fat ground beef patties.

Procedure

Lean and fat beef trim from USDA Select and Standard carcasses was obtained from the University of Nebraska Loeffel Meat Laboratory. All trim was coarse ground, vacuum packaged and frozen in an air blast freezer at -40°F for 14 days. Fresh beef neck bones were sawed to conform to a Protecon PAD 400 automatic trimmer. Pressed lean from the Protecon PAD 400 trimmer was processed through a Baader Lean Separator. The Baader processes the intermediate material between a specially designed neoprene belt and a drum-screen configuration that is effective in removing sinews, tendons, connective tissue and significant bone chips. Mechanically recovered lean was frozen at -40°F.

Grab samples of all raw materials were taken for fat determination by ether extraction. All raw materials were tempered 24 h at 35°F. Lean and fat beef trim and MRNL were combined in the appropriate ratios to yield the following treatments: 10% fat/0% MRNL, 10% fat/15% MRNL, 10% fat/30% MRNL, 10% fat/45% MRNL, 20% fat/0% MRNL, 20% fat/15% MRNL, 20% fat/30% MRNL, 20% fat/45% MRNL. Each 25 lb formulation was mixed five minutes and ground through a 0.19 inch plate. Quarter pound patties were formed with a Hollymatic patty machine. Each patty was separated with double wax paper interleaving. Patties were double bagged in polyethylene, eight patties to a bag, and frozen in an air blast freezer at -40°F until further analyses.

Chemical analysis included moisture, protein, fat and ash content and water-holding capacity by a filter paper press method and reported as percentage expressible moisture. Frozen patties were cooked on an electric grill to an internal temperature ranging from 160 to 170°F. A consumer sensory panel evaluation was conducted. Panelists were asked to evaluate juiciness, texture, flavor and overall desirability for each replication. Cooking measurements included cook yield, and percentage change of diameter and thickness. Comprehensive texture analysis was completed using a Kramer-Shear cell attached to an Instron to determine total energy and peak force and a compression attachment to determine hardness, cohesiveness, springiness and chewiness.

Results

No significant differences were observed among raw patties made with all levels of MRNL for protein, moisture, fat and ash (Table 1). This shows that MRNL can be added to ground beef patties up to 45% without significantly altering basic composition. Of particular interest is the observation that ash content was not different among MRNL levels. Lean recovered from systems that grind bones before lean retrieval normally causes elevated ash levels in the final processed meat to which it is added. This elevation was not seen with this current system of lean retrieval.

No significant differences were observed among cooked patties made with all levels of MRNL for moisture,

Table 1. Raw and cooked proximate composition of ground beef patties manufactured with mechanically recovered neck bone lean (MRNL).

		Fat Level		MRNL Level			
		10%	20%	0%	15%	30%	45%
Raw							
Moisture	(%)	69.72[a]	63.22[b]	65.89	66.48	66.00	67.32
Fat	(%)	10.10[a]	18.88[b]	14.49	14.49	15.02	13.66
Protein	(%)	20.76[a]	18.49[b]	20.28	19.47	19.53	19.22
Ash	(%)	.93[a]	.84[b]	.89	.91	.90	.84
Cooked							
Moisture	(%)	58.59[a]	54.28[b]	56.58	57.27	54.93	56.96
Fat	(%)	13.44[a]	18.78[b]	14.78	15.60	18.11	15.96
Protein	(%)	28.39	26.97	29.53[a]	27.48[b]	27.09[b]	27.21[b]
Ash	(%)	1.47	1.37	1.50	1.42	1.32	1.44

[ab]Means on the same line, within a main effect, with different superscripts are different (P<.05)

Table 2. Cooking measurements, water-holding capacity and consumer sensory juiciness of ground beef patties manufactured with mechanically recovered neck bone lean (MRNL).

	Fat Level		MRNL Level			
	10%	20%	0%	15%	30%	45%
Cook Yield (%)	70.27[a]	67.60[b]	68.10	69.61	68.80	69.23
Raw Water-holding Capacity[c]	37.73[a]	33.58[b]	37.09	36.37	35.50	33.66
Cooked Water-holding Capacity[c]	55.10[a]	49.81[b]	53.71	54.34	48.79	3.00
Juiciness[d]	5.06[a]	5.38[b]	4.92	5.04	5.35	5.59

[ab]Means in a row, within main effect, with different superscripts are different (P<.05).
[c] Reported as percent expressible moisture.
[d] Juiciness: 8=extremely desirable, 1=extremely undesirable

Table 3. Instrumental measurements of ground beef patties manufactured with mechanically recovered neck bone lean (MRNL).

	Fat Level		MRNL Level				
	10%	20%	0%	15%	30%	45%	Effect[c]
Kramer Shear							
Peak Force (Newtons/g)	37.16[a]	32.48[b]	45.80	33.70	32.74	27.05	L
Total Energy (Joules/g)	.42[a]	.38[b]	.52	.38	.38	.31	L
Compression							
Springiness (mm)	23.00[a]	21.81[b]	24.75	22.46	21.54	20.88	L
Cohesiveness (Unitless)	.58[a]	.52[b]	.58[a]	.55[ab]	.53[b]	.53[b]	—
Hardness (Newtons/g)	77.83[a]	62.47[b]	85.39	72.76	65.11	57.35	L
Chewiness (Joules/g)	1.06[a]	.72[b]	1.24	.91	.75	.65	L

[ab] Means in a row, within a main effect, with different superscripts are different (P<.05).
[c] L=linear effect, (P<.01).

fat and ash. Patties made with 15%, 30% and 45% MRNL had less (P<.05) protein than patties with 0% MRNL. Raw and cooked patties made with 10% fat had higher (P<.05) moisture and lower (P<.05) fat content than patties made with 20% fat. There were no significant differences in ash or protein content between cooked patties with 10% and 20% fat.

Raw ground beef patties made with 10% fat had lower water-holding capacity than those made with 20% fat (Table 2). There were no significant differences among raw patties made with all MRNL levels, however, there was a trend that showed water-holding capacity increased as MRNL level increased. Because MRNL had a higher pH than standard trim (6.68 vs 5.80, respectively), it is likely that higher levels of MRNL in ground beef formulations result in slightly higher water-holding capacity. Cooked ground beef patties with 10% fat had lower water-holding capacity than those made with 20% fat (Table 2). There were no significant differences among cooked patties made with all MRNL levels. The slight trend that was noted for increased water-holding capacity due to MRNL addition in raw patties was not seen in cooked patties.

No significant differences were observed for cook yield among patties made with all levels of MRNL (Table 2). Patties made with 10% fat had higher cook yields than patties made with 20% fat. Changes in patty diameter (Table 2) due to cooking were not significantly different among patties made with all levels of MRNL. Patties made with 20% fat decreased more in diameter than 10% fat patties. Patties made with 10% fat and 15, 30 and 45% MRNL decreased 8 to 11% in thickness due to cooking while the 10% fat control decreased over 20% in thickness (Figure 1). In patties with 20% fat, decrease in patty thickness became more severe as MRNL level increased from 0 to 45%.

Patties made with 20% fat showed lower peak force (Table 3) and total energy values than 10% fat patties. Fat reduction in comminuted meat products results in less desirable texture due to significant changes in hardness. Peak force and total energy decreased in a linear fashion as MRNL level was increased. With 15% MRNL added to the 10% fat ground beef formulation, the peak force and total energy values were reduced to levels below those for the 20% fat control. It is possible that MRNL could be used as a texture modifying agent in low-fat ground beef patties. Mechanically recovered lean itself is 16-18% fat.

Ground beef patties with 10% fat showed higher values for springiness, cohesiveness, hardness and chewiness than patties with 20% fat (Table 3). Ground beef patty springiness, hardness and chewiness decreased in a linear fashion as MRNL level increased offsetting some of the common criticisms of low-fat patty texture, such as patty "rubberiness". Patties made with 30% and 45% MRNL were less cohesive than patties with 0% MRNL. There were no differences in cohesiveness (P>.05) among patties that contained 15%, 30% and 45% MRNL. The recovery process for this lean source screens out larger pieces of connective tissue that may be found in conventional ground beef and results in a fine, uniform structure. When MRNL is added to a product that normally has a coarse structure (ground beef), it causes a reduction in hardness that is illustrated

(Continued on next page)

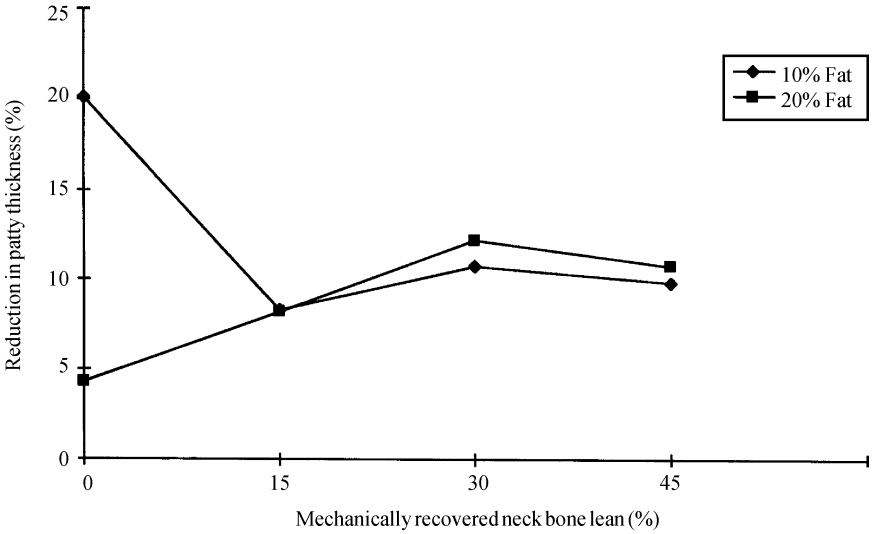

Figure 1. Fat x mechanically recovered beef neckbone lean interactions on reduction in patty thickness due to cooking (P<.05, sem = 3.43).

by the reduction in textural measurements.

Consumer panelists rated 20% fat patties more juicy than 10% fat patties. Juiciness increased in a linear fashion as MRNL level increased. Fat level had no effect on texture, flavor or overall desirability (data not shown). Mechanically recovered neck bone lean also had no significant effect on texture, flavor or overall desirability. Recent advances in mechanical recovery technology have not only changed the recovery process, but also have likely improved the quality of the final product. Modern recovery systems do not grind bones or raise temperatures as severely as previous systems. As a result the final product is of higher quality.

Sensory data does not completely agree with the instrumental texture data. Kramer shear peak force and total energy and compression springiness, hardness and chewiness all decreased as MRNL increased, yet consumer panelists found no differences in texture among MRNL levels. In addition, consumer panelists found ground beef patty juiciness increased as MRNL level increased, yet cook yield and cooked water-holding capacity were not different. Panelists may associate juiciness with a particular attribute of ground beef that was not specifically tested. It is likely that panelists experienced a different texture, but because of the different mouthfeel, they interpreted (and scored) this as a difference in juiciness. These discrepancies are not necessarily downfalls of the research, but merely an indication that an objective variable can be manipulated without affecting the perceived corresponding subjective variable, and vice versa.

Data from this project showed a general softening and reduction in toughness in ground beef patties as a result of MRNL addition. This is likely due to the fine particle size of the MRNL. The final step in manufacture of MRNL forces the lean through a screen with .05 inch diameter holes, thus maximum particle size of MRNL is .05 inch, as compared to .19 inch particle size for controls. Despite the objective texture measurements, consumer sensory panelists found no differences among MRNL levels for texture. It may be that although product toughness was decreased by MRNL, it was not decreased to undesirable levels as perceived by consumer panelists. Consumer panelists did find patties made with MRNL juicier than controls.

Because consumers expect low-fat ground beef to have acceptable tenderness, juiciness and flavor, it is possible that MRNL could be used in manufacture of low-fat processed meat products. Mechanically recovered lean levels of as little as 15% in low-fat patties (10%) are sufficient to mimic sensory texture and juiciness of 20% fat patties. Higher levels of MRNL were tested in this study in an attempt to determine maximum levels of incorporation, however due to potential color problems revealed in a previous study, MRNL levels of 15% or less are more practical for industry applications.

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[1]Brian Demos, former graduate student; Roger Mandigo, Professor, Animal Science, Lincoln.

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