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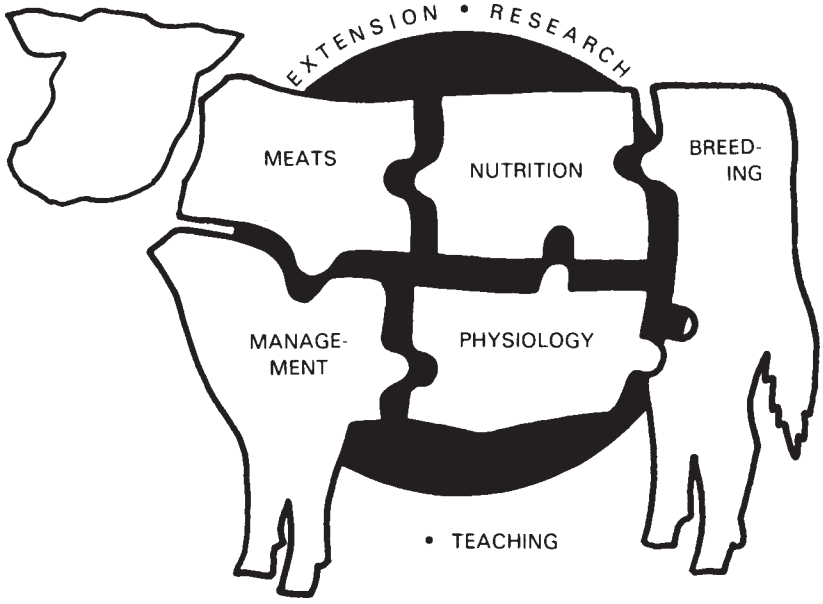
2003 Beef Cattle Report

NEBRASKA



MP 80-A

2003 Beef Cattle Report

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Evaluation of Cow and Calf Performance and Profit Potential in Beef Systems

Rosemary Anderson
Rick Rasby
Terry Klopfenstein
Casey Macken[1]

Extending grazing for cows and for calves post-weaning using corn stalks and pasture before finishing increases production and profit potential of beef systems.

Summary

A three-year experiment was conducted to determine the production efficiencies of two beef systems. Spring-calving, crossbred cows were either wintered on pasture (Control System) or on corn stalks (Treatment System). Control System steers were transported to a feedlot, fed a finishing diet and harvested. Treatment System steers were wintered on corn stalks, grazed pasture, fed a finishing diet, and harvested. Cow weights and condition differed but pregnancy rates were similar. Control System steers spent more days in the feedlot, had lower feed conversions and higher marbling scores. Treatment System steers had higher average daily gains and produced heavier carcasses.

Introduction

The costs associated with feeding harvested forages contribute to a large proportion of the total feed costs in maintaining a cowherd in Nebraska. Additionally, most traditional beef finishing systems in the United States use large amounts of grain fed to calves after weaning for extended periods of time. Crop-residue grazing is one management strategy to minimize feed costs for both spring-calving cows and calves post-weaning. Yearling systems that employ extensive grazing of pasture and/or crop residues before a short finishing period before slaughter suggest carcass quality is similar to calf-feeding systems (*2002 Nebraska Beef Cattle Report* pp. 42-45).

There are data in the literature that evaluate various beef production systems from weaning to harvest, but the literature is almost void of data that includes the cow/calf enterprise as part of a total system. Therefore, the objectives of this study were to compare cow and calf performance and carcass characteristics of a traditional beef production system with a system that matches cattle to the forage resource in a diversified crops operation that includes a cow/calf enterprise.

Procedure

In year one of this three-year experiment, 170 MARC II (1/4 Angus, 1/4 Hereford, 1/4 Simmental, 1/4 Gelbvieh) spring calving cows were blocked by age, weight, body condition score, and expected calving date, and assigned randomly to two treatment groups. Cows remained in their treatment groups throughout the experiment unless culled for reproductive failure. The control (CON; n=85) treatment consisted of cows grazing dormant cool-season pasture through the fall and winter and fed hay. The treatment (TRT; n=85) group consisted of cows grazing corn stalks through the fall and winter and fed hay for a short period. Grazing quality of the corn stalks was evaluated each year by estimating the amount of grain remaining in the field after harvest. The amount of hay and supplement fed to both groups were monitored and recorded annually. Both groups were managed to achieve a mean body condition score (BCS) of 5 (1=emaciated; 9=obese) by calving. Each year, cows were managed as a single group from calving until corn stalks were available for TRT cows. Weights and body condition scores of all cows were determined at weaning, immediately before corn stalk grazing and immediately after corn stalk grazing.

Each year at weaning, steer (n = 42 per year) calves from CON cows were transported to the feedlot, were implanted with Synovex-S© blocked by weight and assigned randomly to one of two pens. After a 28-day receiving period, steers were fed a series of five step-up rations beginning with a 50% concentrate diet and progressing to a 90% concentrate finishing diet (TDN 84%, CP 12%) that was fed until slaughter. Steers were reimplanted with Revalor-S© after 90 days on feed. Steers were harvested when visually appraised to be 0.5 inch 12th-rib fat thickness. CON steers were weighed at weaning, at the beginning of the 28-day receiving period, and at reimplantation. Days on feed (DOF), pen dry matter intake (DMI), average daily gain (ADG) and feed conversion (F/G)

(Continued on next page)

were measured. Carcass traits were recorded and included hot carcass weight (HCW), twelfth-rib fat thickness (FAT), marbling score (MARB; 500 = small[00]), Yield Grade (YG) and ribeye area (REA). Final weight was estimated by dividing HCW by 63% dress.

Steers (n = 44 per yr) from TRT cows were transported to the ARDC each year at weaning and were drylotted until corn stalks became available for grazing. While in drylot, steers were fed ammoniated wheat straw ad libitum and supplemented with 5 lb/steer/day (DM basis) of wet corn gluten feed and mineral. Corn stalk grazing was also supplemented with mineral and corn gluten feed. Hay was fed during heavy snowcover. After grazing corn stalks, TRT steers again were drylotted for the remainder of the wintering period until pasture was available for spring and summer grazing. Steers were implanted with Revalor-G© in the spring before grazing cool- and warm-season grass pastures. Following the summer grazing period, TRT steers entered the feedlot, were reimplanted with Revalor-S©, blocked by weight and assigned randomly to one of two pens. Steers then were fed similarly to CON steers for the step-up and finishing periods. Twelfth-rib fat thickness was estimated in years 1 and 2 every two weeks near the end of the finishing period using ultrasound technology. TRT steers subsequently were sorted and serially slaughtered according to weight and fat thickness of 0.5 inch. In year 3, TRT steers were not ultrasounded; instead, steers were slaughtered after a predetermined number of days on finishing diets based on the previous two years of data. TRT steers were weighed at weaning and at the beginning of the wintering period, summering period and finishing period. Weights were also taken simultaneously with ultrasound readings every two weeks near the end of the finishing period during years 1 and 2. Days per period were recorded each year and ADG was calculated for each period. DMI and F/G also were calculated for the finishing period. Upon slaughter, carcass data were collected similar to CON steers.

Data were analyzed using the MIXED procedures of SAS and year was included in the model as a random variable. Pregnancy data were analyzed as a binomial distribution using the logit transformation statement. Because 12th rib fat thickness at slaughter was different between CON and TRT steers, carcass data, DOF, and final weights were adjusted to 28% empty body fat (Guiroy et al., 2001; J. Anim. Sci. 79: 1983-1995). The 1996 NRC for beef cattle assumes that steers at 28% empty body fat would have marbling scores of Small[oo] and grade USDA Quality Grade of Low Choice.

Table 1. Performance of treatment steers during the winter and summer across years.

Item	Year 1	Year 2	Year 3	SEM
Number of Steers	43	47	42	
Winter				
Days	200[a]	188[b]	203[c]	
Initial Weight	509[d]	486[e]	516[d]	9
ADG, lb	1.17[d]	1.08[e]	1.23[d]	0.03
Summer				
Days	112[a]	145[b]	96[c]	
Initial Weight	746[d]	688[e]	765[d]	12
ADG, lb	2.20[a]	1.97[b]	2.01[b]	0.05

[abc]Means within a row with unlike superscripts differ (P < 0.01).
[de]Means within a row with unlike superscripts differ (P < 0.05).

Table 2. Feedlot performance of steers in the control (CON) and treatment (TRT) groups using year as random variable.

Item	CON	Adj.[a]	TRT	Adj.[a]	SEM
Number of Steers	127		132		
Days on Feed	211[c]	171	90[d]	72	5
Initial Feedlot wt.,lb	496[c]		977[d]		9
ADG, lb	3.31[e]		4.31[f]		0.16
Final Weight, lb[b]	1193[e]	1061	1364[f]	1286	33
DMI, lb	18.9[c]		30.7[d]		1.0
F:G	5.78[c]		7.29[d]		0.15

[a]Data adjusted to 28% Empty Body Fat.
[b]Calculated from hot carcass weight adjusted to a 63% dressing percentage.
[cd]Means within a row with unlike superscripts differ (P < 0.01).
[ef]Means within a row with unlike superscripts differ (P < 0.05).

Table 3. Adjusted and actual carcass data of control (CON) and treatment (TRT) steers adjusted to 28% empty body fat using year as a random variable.

	Adjusted			Actual		
Item	CON	TRT	SEM	CON	TRT	SEM
Number of Steers	127	132		127	132	
Hot Carcass Weight, lbs	668[b]	810[c]	21	752[b]	860[c]	21
Ribeye Area, in[2]	10.78[b]	12.68[c]	0.24	11.59[b]	13.05[c]	0.23
Fat, in	0.538	0.502	0.015	0.638[b]	0.548[c]	0.018
Yield Grade	2.8	2.8	0.1	3.2[b]	2.9[c]	0.1
Marbling Score[a]	530[b]	467[c]	16	588[b]	493[c]	16

[a]Marbling score: 500 = Small[00] (low Choice).
[bc]Means within a row with unlike superscripts differ (P < 0.05).

Results

The amount of grain left in the stalk fields after harvest was less than a bushel per acre in each of the three years that TRT cows grazed corn residue. The TRT cows grazed corn residues for an average 91 days each year.

Cow weights and BCS were similar at weaning and before corn stalk grazing in all three years. In years 1 and 3, weights after corn stalk grazing were greater (P < 0.01) for CON cows (yr 1 = 1242 lb; yr 3 = 1291 lb) than for TRT cows (yr 1 = 1165 lb; yr 3 = 1199 lb).

BCS was also greater (P < 0.01) in years one and three for CON cows (yr 1 = 5.7; yr 3 = 5.3) than for TRT cows (yr 1 = 5.3; yr 3 = 4.7). Despite differences in cow weight and BCS after corn stalk grazing, pregnancy rates were not different (CON = 91%; TRT = 93%).

The wintering period for TRT steers averaged 197 days, and steers gained an average of 1.16 lb/day during this period (Table 1). ADG for the summering period was considerably higher and averaged 2.20 lb/day in year 1, 1.97 lb/day in year 2, and 2.01 lb/day in year 3. The average spring/summer grazing period was 118 days. The higher gains realized during the summering period were likely due to compensatory growth, as observed previously (*2002 Beef Cattle Report,* pp. 25-29).

Actual and adjusted feedlot performance data are summarized in Table 2. Steer post-weaning weights were similar between treatments (CON = 496 lb; TRT = 503 lb). During the finishing phase, CON steers averaged 211 DOF and TRT steers averaged 90 DOF. When DOF were adjusted so that carcasses were 28% empty body fat, DOF was 171 days and 72 days for CON and TRT steers respectively. CON steers had lower (P < 0.05) ADG compared to TRT steers. DMI and F/G were also different (P < 0.01). F/G averaged 5.78 for CON steers and 7.29 for TRT steers. Previous researchers also observed lower feed intake and lower feed conversions in calf-feds when compared with yearlings (*2000 Nebraska Beef Cattle Report* pp. 20-22). Adjusted final weights were greater (P < 0.05) for TRT steers, and averaged 1286 lb compared to 1061 lb for CON steers.

Adjusted carcass data are summarized in Table 3. CON (668 lb) steers had lighter (P < 0.05) HCW compared to TRT (810 lb) steers. REA were also smaller (P < 0.05) for CON than TRT steers. FAT was similar for CON compared to TRT steers. CON (YG = 2.8; MARB = 530) steers had similar YG and higher (P < 0.05) MARB compared to TRT (YG = 2.8; MARB = 467) steers.

The results of the current study indicate differences in cow weight and condition after corn stalk grazing did not affect pregnancy rates. Growing steers for a longer period of time on forage before a short finishing period resulted in poorer feed conversion, leaner, heavier carcasses and more carcass weight marketed per cow. Because more product is marketed in the TRT compared to the CON system, there is greater potential for profit if costs are equal to or less than the costs incurred in the CON system. If costs are less in the TRT system, then value is added to the steer before the finishing phase using owned or locally owned grazing opportunities. The next step in this research is to compare the CON and TRT systems economically.

[1]Rosemary Anderson, graduate student; Rick Rasby, professor, Animal Science, Lincoln; Terry Klopfenstein, professor, Animal Science, Lincoln; Casey Macken, research technician.

Comparison of Two Heifer Development Systems on a Commercial Nebraska Ranch

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A system of developing bred heifers on native winter range and supplement resulted in improved body condition, with similar weight change and reproductive performance as a hay-fed control system.

Summary

A trial was conducted at a commercial Nebraska ranch to evaluate the effectiveness of a bred heifer development program that minimized the use of harvested feed. Two management systems were imposed on 505 March-calving bred heifers during the winter before the calving season, one including the use of hay (CON), and one relying solely on winter range and supplementation (TRT). During the winter period, heifers in the TRT system lost less condition and had similar weight gains to CON. Two-year-old pregnancy rates did not differ between systems. A partial budget analysis of the two development programs indicated that the TRT system could decrease costs relative to the CON system.

Introduction

Reported values of the cost of providing winter feed to beef cows vary (*2002 Nebraska Beef Report, pp. 17-19*), though it is clear that these costs are a significant portion of the annual cow cost. Reducing winter feed costs without sacrificing performance would improve ranch profitability. Decreasing dependency on harvested feeds and increasing use of winter grazing with supplementation may lower winter feed costs.

Supplementing to meet the relatively high nutritional requirements of bred heifers presents unique challenges. Pregnant heifers grazing native winter range have been shown to be deficient in metabolizable protein (MP; *2000 Nebraska Beef Report, pp. 7-10*). Heifer supplementation programs must not only meet these MP demands but meet heifers' higher energy requirements as well. Byproducts of the grain milling industry

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are becoming increasingly available to Nebraska producers (*2001 Nebraska Beef Report, pp. 45-47*). Because of the amount and form of protein and energy in dry corn gluten feed (DCGF), it may fit well as a supplement to pregnant heifers grazing native winter range.

The objective of this trial was to design a program for developing bred heifers that would maintain the high levels of production already present in the herd, and do so relying solely on winter range and supplementation, without using harvested feeds.

Procedure

The study was conducted at the Rex Ranch (Abbot Unit) near Ashby, Nebraska. On Sept. 15, 2000, approximately 700 yearling heifers (841 + 3.1 lb) were weighed and assigned a body condition score (BCS; 1 = emaciated, 9 = obese) by two technicians. Heifers that met a minimum weight requirement as determined by the ranch, that were not previously marked for culling, and were determined pregnant by rectal palpation were assigned to one of two pre-calving treatments. Treatments included the ranch's standard heifer management program (CON; n = 249) and an alternative system (TRT; n = 256).

The CON system included access to native range with heifers being rotated to new pastures regularly, and included supplementation of a high undegradable intake protein (UIP) supplement (Table 1), formulated to meet MP requirements (*2000 Nebraska Beef Report,* pp. 7-10). Hay feeding began in December and was gradually increased until calving. Levels of hay fed were at the discretion of the ranch manager, and increased from about 7 to 18 lb per heifer per day. As the amount of hay increased, rotation to ungrazed winter pastures declined until little grazed forage was made available to the CON heifers.

As in the CON system, TRT heifers were given access to native winter range. In contrast to CON, the TRT system was designed under the assumption that heifers would not be limited in the amount of standing forage available to them at any time, and the rotation schedule was maintained throughout the winter. Heifers allocated to the TRT system were fed no hay before calving season began. The TRT supplement (Table 1) was based on dry corn gluten feed (DCGF). Mineral and vitamin premixes were included in the supplement, and sunflower meal and fat were added to improve pellet quality. The supplementation schedule was set up such that predicted forage intake and DCGF supplement delivered approximately the same amount of TDN intake as the hay, control supplement, and grazed forage intake of the CON heifers. Metabolizable protein requirements were met at all times.

The feeding schedule for each treatment was designed to begin October 1, and continue through March 1 (estimated start of calving). The amount of supplement fed was changed at the beginning of the month from October through Jaunary (0.7 to 1.1 and 0.7 to 4.0 lb for CON and TRT), and at two-week intervals during February (1.2 to 1.8 and 5.7 to 7.5 lb for CON and TRT).

These changes were made to account for predicted changes in forage quality and intake, as well as to meet the demands of advancing gesta-

Table 1. Composition of supplements.

	Composition, %DM	
Ingredient	CON	TRT
Dry gluten feed	—	72.00
Feather meal	40.00	—
Sunflower meal	30.00	22.40
Wheat middlings	26.25	—
Molasses	2.50	2.50
Bentonite	—	2.50
Salt	1.00	—
Starch	—	0.25
Fat	—	0.25
Vitamin premix	0.26	0.05
Trace mineral premix	—	0.05

Table 2. Weight, body condition, and reproductive performance of two heifer development systems.

Item	CON	TRT	*P*-value
Initial weight, lb	840.5 + 3.1	842.3 + 3.1	0.67
Final weight, lb	937.9 + 3.7	939.5 + 3.8	0.77
Weight change, lb	99.9 + 2.4	98.3 + 2.5	0.62
Initial BCS[a]	5.2 + .02	5.2 + .02	0.49
Final BCS[a]	5.0 + .02	5.1 + .02	0.02
BCS change[a]	-0.2 + .02	-0.1 + .02	0.01
Pregnancy rate, %[b]	96.4	98.0	0.26

[a]BCS = body condition score; 1 = emaciated, 9 = obese
[b]Percentage pregnant with second calf; *P*-value reflects chi-square analysis

Table 3. Feed and labor costs associated with two heifer development systems.

	CON		TRT	
Item	$/animal	% total	$/animal	% total
Feed costs				
Supplement[a]	13.58	21.4	23.49	46.0
Grazing[b]	17.64	27.7	24.30	47.8
Hay[c]	24.78	39.0	0.00	0.0
Labor costs				
Supplement[d]	0.76	1.2	3.22	6.3
Hay[d]	6.84	10.8	0.00	0.0
Total	63.59	100.0	51.02	100.0

[a]Includes delivered price to the ranch
[b]Standing winter forage valued at $6/AUM
[c]Hay valued at $0.025 per lb DM, or $55 per ton as-fed
[d]Includes ranch values of costs associated with feed delivery

tion. The actual dates supplementation and hay feeding began were at the discretion of the ranch manager, and were dependent upon weather, forage availability, etc. The first hay was fed to the CON group in late November. Supplementation for both groups began Oct. 20.

To help alleviate differences in gut fill that may have resulted from the treatments, groups were commingled March 1, 2001 and fed a common diet. On March 2, heifers were weighed and BCS were determined independently by two evaluators. Winter weight and BCS change were calculated. Heifers were managed as a single group during the calving period and summer grazing season.

To examine carryover effects of the pre-calving treatments, heifers were weighed, assigned BCS, and rectally palpated to determine pregnancy on Oct. 22, 2001. Weight and BCS change, and reproductive performance were calculated.

A partial budget analysis was used to compare the costs associated with implementing the two systems. Costs of the supplements were obtained through personal communication and amounts fed from ranch records. Intake predictions were used to calculate grazing costs, with a value of $6 per AUM used for standing winter range. This value is 25% the recommended value of $24 per growing season AUM in the Sandhills. The amount of hay fed was obtained from ranch records, and valued at $0.025 per pound DM, or about $55 per ton as-fed.

Results

Initial body weight was 841 lb, final weight was 939 lb, and neither differed ($P > 0.67$) between systems (Table 2). Control and TRT heifers gained 100 and 98 lb, respectively ($P = 0.62$) over the course of the trial. Gestational weight gain (fetus, fluids, uterus and placenta) can be approximated by multiplying calf birth weight by 1.7. Average calf birth weight from heifers used in this study was 81.4 lb. Using the 1.7 estimate, gestational weight gain would be 138 lb, suggesting that the heifers actually lost body weight from September to March.

Body condition at the beginning of the trial was 5.2 (Table 2), and was similar ($P = 0.49$) between systems. Final BCS of CON heifers was 5.0, which was lower ($P = 0.02$) than TRT heifers (5.1). Previous research has demonstrated the importance of pre-calving energy reserves to subsequent reproduction. Although the TRT heifers lost less ($P = 0.01$) condition than CON, it is difficult to say whether 0.1 BCS units is of biological significance. Two-year-old pregnancy rates were 96.4 and 98.0% for CON and TRT, respectively ($P = 0.26$). These values are high, particularly for second-parity cows. Because reproductive rates had been high previously (*2000 Nebraska Beef Report, pp. 7-10*), it was not an objective to increase the percentage of pregnant two-year-olds, only to maintain productivity at a lower cost.

A partial budget analysis of cost differences of the two treatments showed that implementing the TRT system would reduce costs by $12.58 per heifer (Table 3). The unit cost of the TRT supplement was lower than the CON supplement, but higher levels of feeding led to higher supplement costs for TRT heifers. A higher grazing cost was charged to the TRT system, which relied more heavily on grazed forage. However, the cost of the hay fed to CON heifers was nearly $25 per animal. This caused feed costs in the CON system to be $8.21 more per heifer. Due to the high levels of supplement fed, there was a greater cost associated with feeding the TRT supplement, particularly in February when two trips per day were necessary to deliver the needed level of supplement. In spite of this, the cost of feeding hay ($6.84/heifer) lead to higher total labor costs for the CON system, and this cost comprised the balance of the $12.58 difference. Hay comprised the largest single cost of the CON system, at about 39% of the total cost (Table 3). Labor costs totaled nearly 12% of the total cost for CON heifers. Supplement and grazing costs were nearly equal for TRT heifers, with labor costs representing around 6% of the total (Table 3).

Accurate values for a winter AUM are difficult to establish, particularly when pastures may have been grazed multiple times, both during the summer and winter as was the case in this study. Because the TRT system relies more heavily on grazed forage, changes in this value have a larger impact on the cost associated with the TRT system. However, using our partial budget, the value would have to reach $17.25 per AUM (or about 72% of summer AUM) before the systems would be equal in cost. Because hay and supplement represent the largest feed costs for CON and TRT, respectively, changes in the values of those feedstuffs could alter the outcome of the comparison. However, fluctuating the prices within likely ranges may change the magnitude of the difference, but would not change the ranking. The value of hay would have to decline to $28 per ton as-fed before costs become equal. Likewise, the cost of the TRT supplement would have to increase to nearly the same value of the CON supplement (an increase of more than 50%) before costs equalized.

In conclusion, it is possible to design a bred heifer development program that relies exclusively on grazed winter forage and supplementation. Heifers in the TRT system lost less condition and did not differ in weight change relative to CON heifers. Pregnancy rates were quite high for 2-year old cows, and no difference was observed between the two systems. Additionally, costs associated with implementing the TRT system were slightly less than the cost of the CON program.

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[1]Tim Loy, research technician; Don Adams, professor, animal science; Terry Klopfenstein, professor, animal science; Dillon Feuz, professor, agricultural economics; Jacki Musgrave, research technician; Burke Teichert, Rex Ranch, Ashby NE. Appreciation is expressed to Harry and Jean Younkin and the rest of the Rex Ranch crew for assistance with this project.

Value of Dry Distillers Grains in High-Forage Diets and Effect of Supplementation Frequency

Tim Loy
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Casey Macken[1]

Dry distillers grains improved gain and efficienicy relative to corn. Heifers supplemented daily consumed more hay and gained faster, but were not more efficient than those supplemented three times weekly.

Summary

An experiment was conducted with 120 crossbred heifers to determine the value of dry distillers grains (DDG) in high-forage diets, and to evaluate the effect of supplementing daily compared to three times weekly. Heifers were fed to consume grass hay ad libitum and supplemented with DDG, dry rolled corn (DRC), or DRC with corn gluten meal (DRC+CGM). Supplements were fed at two levels and offered either daily or three times per week in equal proportions. Heifers supplemented daily ate more hay, gained faster (1.37 vs. 1.24 lb per day), but were not more efficient than those supplemented on alternate days. At the low level of gain, DDG heifers gained more and were more efficient than DRC or DRC+CGM. At the high level of gain, DDG and DRC+CGM were not different, although both resulted in improved gain and efficiency relative to DRC.

Introduction

Because the energy supplied from wet corn gluten feed (WCGF) and wet distillers grains (WDG) is largely in the form of digestible fiber (and fat in the case of WDG), they fit well as energy supplements in high-forage diets (*1996 Nebraska Beef Report, pp. 65-66)*. However, use of the wet products has been somewhat localized around corn milling plants due to the expense of shipping. Drying these products makes them more accessible to forage-dependent cow-calf and stocker operations. Although drying has been shown to decrease the energy value of distillers grains in finishing diets (*1994 Nebraska Beef Report, pp. 38-40)*, the energy value of DDG in high-forage diets is unknown.

Due to the costs associated with supplementation, there has been considerable interest in decreasing the frequency with which supplement is delivered. Researchers have reported success in decreasing the frequency of delivery of high-protein supplements, due largely to animals' ability to recycle N to the rumen. Irregular feeding of energy supplements has been less successful. However, feeding less frequently generally requires more supplement to be offered at each feeding. Because energy supplements are often grain-based, feeding these higher levels that are necessary with infrequent supplementation may lead to negative associative effects and impaired forage utilization. Byproducts may provide an opportunity to provide a high-energy supplement less frequently without negatively impacting forage utilization, as well as reducing the risk of digestive problems associated with feeding grain.

The objectives of this study were to determine the energy value of DDG in a high-forage diet, and to evaluate the impact of supplementation frequency on intake and performance.

Procedure

One hundred and twenty crossbred heifers (584 + 4.5 lb) were used in a randomized complete block design to compare DDG to DRC in a high-forage diet and to evaluate the impact of providing an energy supplement daily or three times weekly. Treatments were arranged in a 3 x 2 x 2 factorial, with three supplements, two levels and two supplementation frequencies. Heifers were limit-fed (1.75% BW) for five days before and at the end of the 84-day experimental period. Heifer weights were recorded on three consecutive days following each limit-feeding period.

Heifers were individually fed in Calan electronic headgates. Chopped native grass hay (8.7% CP) was fed for ad libitum consumption, with dry matter intakes (DMI) determined weekly. All heifers were fed a dehydrated alfalfa-based supplement at 0.5 lb per day as an MGA carrier (0.5 mg/day). The DDG and DRC supplements (Tables 1 and 2) were formulated to meet NRC-predicted energy and metabolizable protein (MP) requirements at two targeted levels of gain. An energy value equal to corn was used for DDG. Urea was included where degradable intake protein deficiencies were calculated. The DRC+CGM supplements were designed to supply a similar level of undegradable intake protein (UIP) as the DDG supplements.

The two levels were designed to attain ADG of 1.00 (LOW) and 1.75 (HIGH) lb/day, with LOW supplements fed at 0.21% of BW and HIGH fed at 0.81% of BW, in addition to ad libitum hay and the MGA supplement. Heifers were weighed every 28 days with supplement levels adjusted accordingly. Heifers were supplemented every day (DAILY), or in equal portions on Monday, Wednesday, and Friday (ALT), such that seven-day supplement intakes were similar between DAILY and ALT heifers.

The NRC (1996) model uses net energy content of the diet in conjunction with feed intake to predict animal performance. Therefore, if intake and performance are known, energy content of the feed can be predicted. Individual intakes, diet compositions, weights and weight gains were used to calculate an energy value of DDG in the treatment diets. The energy value of corn was determined similarly so that DDG could be expressed relative to corn.

Table 1. Composition of low-gain supplements.

	Composition, %DM		
Ingredient	DDG	DRC	DRC+CGM
Dry distillers grains	90.33	—	—
Dry rolled corn	—	88.47	60.53
Corn gluten meal	—	—	30.73
Urea	2.79	4.66	1.86
Molasses	2.42	2.42	2.42
Salt	3.73	3.73	3.73
Vitamin premix	0.17	0.17	0.17
Trace mineral premix	0.56	0.56	0.56

Table 2.Composition of high-gain supplements.

	Composition, %DM		
Ingredient	DDG	DRC	DRC+CGM
Dry distillers grains	94.88	—	—
Dry rolled corn	—	84.28	62.35
Corn gluten meal	—	8.63	32.53
Urea	—	1.97	—
Molasses	2.46	2.46	2.46
Limestone	1.48	1.48	1.48
Salt	0.99	0.99	0.99
Vitamin premix	0.04	0.04	0.04
Trace mineral premix	0.15	0.15	0.15

Data were analyzed using the GLM procedure of SAS. Initial weight was included as a covariate. Interactions between supplement type, level and frequency were tested. When interactions were not significant, main effects were reported.

Results

Heifers supplemented DAILY consumed more hay ($P < 0.01$) and more total DM ($P < 0.01$) than those in ALT treatments. Gains were higher ($P < 0.01$) when supplement was provided daily (1.37 and 1.24 lb / day for DAILY and ALT, respectively). However, efficiency did not differ ($P = 0.97$) with frequency of supplementation. Heifers fed for the high level of gain consumed an average of 5.2 lb of supplement per day. This translates to an average of 12.1 lb per feeding for those in ALT treatments. We had hypothesized that providing energy in the form of highly digestible fiber (DDG), rather than starch (DRC), might be beneficial in alternate-day feeding, particularly at these high levels. This was not the case, however, as no supplement by frequency interactions were observed for any intake or performance criteria.

Hay DMI were higher ($P < 0.01$) for LOW heifers than HIGH (1.78 vs 1.50% BW, respectively). However, HIGH heifers had greater ($P < 0.01$) supplement intakes, which led to greater ($P < 0.01$) total DM intakes (1.99 and 2.28% BW for LOW and HIGH, respectively). The lower hay intakes observed for HIGH heifers reflects the substitution effect high levels of supplementation can have. At the high level of supplementation, hay represented only about two thirds of total DMI, whereas the diet of LOW heifers was nearly 90% hay.

Heifers in DDG treatments ate less hay ($P = 0.03$) and less total DM ($P = 0.03$) than DRC+CGM heifers, and tended to eat less hay ($P = 0.10$) and total DM ($P = 0.08$) than DRC heifers at the high level of supplementation (Table 4). This was not the case, however, at the low level, where intakes did not differ ($P > 0.54$) with supplement type.

A supplement by level interaction was detected for ADG ($P < 0.01$) and feed efficiency ($P = 0.01$). At the low level of gain, heifers in DDG treatments gained more ($P < 0.03$) and were more efficient ($P < 0.01$) than those in DRC+CGM or DRC treatments (Table 3). No difference was observed ($P = 0.20$) between DRC and DRC+CGM for either parameter at the low level of supplementation. At the high level of gain, DDG and DRC+CGM produced higher gains ($P < 0.01$) and improved efficiencies ($P < 0.01$) compared to DRC (Table 3). However, there was no difference ($P > 0.20$) in gain or efficiency between DDG and DRC+CGM at the higher level of gain. Because intakes did not differ between DDG and DRC, but ADG and efficiency were improved by DDG, we can conclude that DDG has a higher energy value than DRC in this diet. Calculated values indicated that DDG had a net energy value 27% higher than DRC. This compares to an improvement in efficiency of 25% and an increase in gain of 21% of DDG heifers compared to those in DRC treatments.

Heifers at the high level of gain would logically have higher MP requirements than those at the low level. Because DDG and DRC+CGM were formulated to supply an equal amount of UIP, it may appear that the response in the HIGH treatments was to UIP. However, all treatments were designed to meet MP requirements, suggesting the difference in response between HIGH and LOW was not due to UIP.

An alternative explanation of the different responses observed in the two levels of gain may be a negative associative effect elicited by the amount of starch present in the DRC supplement. When fed at the high level, the DRC supplement could have altered the rumen environment such that maximum forage utilization was not achieved. This may not have been the case, however, as hay and total DM intake did not differ between DRC and DRC+CGM. Another potential explanation may be differences in forage utilization brought on by differences in the amount of fat in the three supplements. Using NRC (1996) values of fat content and applying them to observed intakes shows total dietary fat amounts of 3.2% for DDG and 2.6% for DRC and DRC+CGM in the low-gain treatments. Heifers in the HIGH treatments had 5.0%, 2.9%, and 2.8% dietary fat for DDG, DRC and DRC+CGM, respectively. The level of fat in the HIGH DDG treatment may not be high enough to affect forage utilization, but hay

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Table 3. Effect of supplement type on gain and efficiency within level of supplementation.

Treatment	Level of Gain	
	LOW[a]	HIGH[a]
ADG + SEM, lb		
DDG[b]	0.99[d] + .05	1.89[d] + .05
DRC[b]	0.81[e] + .06	1.57[e] + .05
DRC+CGM[b]	0.71[e] + .05	1.88[d] + .05
Feed efficiency + SEM, feed:gain[c]		
DDG[b]	12.8[d] + .5	8.0[d] + .5
DRC[b]	15.9[e] + .5	9.8[e] + .5
DRC+CGM[b]	17.9[e] + .5	8.4[d] + .5

[a]LOW = supplement fed at 0.21% BW, HIGH = supplement fed at 0.81% BW
[b]DDG = dry distillers grains; DRC = dry rolled corn; DRC+CGM = DRC with corn gluten meal
[c]Feed:gain calculated as gain:feed
[d,e]Unlike superscripts within a column differ ($P < 0.01$)

Table 4.Effect of supplement type on hay and total dry matter intake within level of supplementation.

Treatment	Level of Gain	
	LOW[a]	HIGH[a]
Hay DMI + SEM, %BW		
DDG[b]	1.76 + .04	1.42[c] + .04
DRC[b]	1.77 + .04	1.51[d] + .04
DRC+CGM[b]	1.80 + .04	1.55[d] + .04
Total DMI + SEM, % BW		
DDG[b]	2.05 + .04	2.28[c] + .04
DRC[b]	2.06 + .04	2.38[d] + .04
DRC+CGM[b]	2.08 + .04	2.40[d] + .04

[a]LOW = supplement fed at 0.21% BW, HIGH = supplement fed at 0.81% BW
[b]DDG = dry distillers grains; DRC = dry rolled corn; DRC+CGM = DRC with corn gluten meal
[c,d]Unlike superscripts within a column differ ($P < 0.10$)

intake by DDG heifers was significantly lower than DRC+CGM, and tended to be lower than DRC at the high level of supplementation.

In conclusion, providing high-energy supplements to growing heifers on a forage-based diet three times per week resulted in lower intakes and gains relative to heifers supplemented daily. However, feed efficiency was not affected by supplementation frequency. These results were not affected by the form of energy being supplied. Heifers consuming DDG supplements generally ate less forage than those eating corn-based supplements at the high level of feeding. At both levels of gain, DDG heifers gained more and were more efficient than DRC heifers. At the low level of gain, ADG and efficiency were better for DDG than DRC+CGM. However, no difference between the two supplements was observed at the high level of gain. Dry distillers grains appear to have a higher energy value than DRC in high-forage diets.

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Microbial Protein Production in Gestating Cows Supplemented with Different Sources of Rumen Degradable Protein Grazing Dormant Range

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Don Adams
Jacki Musgrave
Galen Erickson[1]

Synthesis of microbial protein increased as amount of digestible organic matter consumed increased, but efficiency of microbial protein synthesis did not change and averaged 8.5% of digestible organic matter intake.

Summary

Twenty-four gestating spring calving cows grazing dormant native range were used to determine the effect of two different sources of DIP supplementation in the winter. Supplementation treatments were: 1) supplement containing urea as a source of non-protein nitrogen, 2) corn gluten feed (CGF) as a source of true protein, and 3) no supplement . Forage intake was greater for cows supplemented with urea compared to no supplement, and forage intake tended be greater for cows supplemented with urea than CGF. Microbial protein (MCP) synthesis estimated from urinary excretion of allantoin was greater for cows receiving urea than CGF or no supplement. However, efficiency of MCP synthesis did not differ among treatments and was approximately 8.5% of digestible organic matter intake.

Introduction

University of Nebraska research showed the first limiting nutrient for beef cows grazing dormant native range during the winter was rumen degradable protein (DIP;*1996 Nebraska Beef Cattle Report,* pp. 14-16). Furthermore, cows can meet their metabolizable protein (MP) requirements through synthesis of microbial protein, if DIP is supplemented. There are different sources of DIP available for supplementation. Urea is the least expensive source of DIP, but it does not provide true protein. In vitro studies indicate microbes respond positively to dietary addition of amino acids suggesting supplementing true protein instead of non-protein N (NPN) would increase microbial protein production. Enhanced animal performance was observed when sources of natural protein instead of urea were supplemented to cows grazing winter range (*1998 Nebraska Beef Cattle Report,* pp. 11-14). In addition, the slower rate of degradation of natural protein compared to urea more closely matches the rate of fiber degradation. Corn gluten feed provides high DIP in the form of amino acids and small peptides. Therefore, we compared effects of supplementing NPN as well as true protein on MCP synthesis and efficiency in cows grazing dormant native range in December.

Procedure

The experiment was conducted at the University of Nebraska's Gudmundsen Sandhills Laboratory near Whitman, Neb., in December, 2000. Twenty-four pregnant cows were randomly assigned to three DIP supplemental treatments. Treatments were: 1) supplement containing urea as a source of non-protein N (UREA), 2) corn gluten feed as a source of true protein (CGF), and 3) no supplement (CONTROL).

Cows grazed in a pasture located on a sands range site which was dominated by little bluestem, prairie sandreed, sand bluestem, and switchgrass. Cows were individually supplemented during three weeks from Nov. 27 to Dec. 14. Cows were offered approximately 3.5 lb DM three times weekly for the first week. Following the first week, cows received approximately 2 lb/day for the rest of the trial. Supplements were formulated to provide the same amount of DIP (180 g/day). Table 1 shows the composition of the supplements.

Table 1. Composition of supplements (% of DM) offered to cows grazing dormant range in December

Item	CGF[a]	Urea[b]
Steep liquor	41.3	—
Corn bran	58.7	55.8
Molases	—	22.8
Starch	—	10.1
Urea	—	6
Dicalcium phosphate	—	5.3

[a]Corn gluten feed.
[b]Supplement containing urea.

Intake was determined from fecal output and feed indigestibility over a five-day collection period (December 11 to 15). Forage intake was estimated as: forage organic matter intake (FOMI) = (total fecal OM output – estimated fecal OM from supplement) / (1 – forage IVOMD). Fecal output was measured using intra-ruminal slow releasing chromium devices. Four steers were used to calibrate Chromium payout from the time-release capsules to total fecal collection. Forage diets were collected with four esophageally fistulated cows, and samples were freeze dried, ground and analyzed for DM, OM, IVOMD, CP and UIP.

Approximately 50 ml of urine were taken daily the last five days of the experiment as a spot sample from each cow. Samples were frozen for further analysis of allantoin and creatinine. Creatinine was used as a marker for estimation of urine output. Urine volumes used to calculate daily excretion of allantoin from spot urine samples were estimated as: BW(lb)* 12.1/creatinine concentration (mg/L), where 12.1 represents the mean daily creatinine excretion rate in mg/lb BW/day. Allantoin concentration was measured colorimetrically by using a spectrophotometer. The ratio of allantoin to creatinine in spot urine samples was used to determine MCP supply. Cows were individually weighed in the second week of the trial. Data were analyzed as a complete randomized design using the MIXED procedure of SAS with supplement as treatment factor.

Results

Chemical composition of native range and the two supplements are shown in Table 2. Supplements did not differ in digestibility or CP content.

Despite numerical differences, there were no overall significant differences in forage organic matter intake expressed either as lb/day or percentage of BW among the three treatments ($P > 0.05$; Table 3). Still, cows receiving the urea supplement tended to consume more, and this tendency was more marked between the urea and control group (24.4 and 17.8 lb/day; 2.3 and 1.6% BW respectively). When comparing total intake (forage + concentrate), it was higher for cows in the urea treatment than the control (26.5 versus 17.8 lb/day; $P < 0.05$), but there was no significant difference between the two supplemented groups. Based on the creatinine analysis, urine output was significantly higher for the urea sup-

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Table 2. Chemical composition of forage and supplements offered to cows grazing dormant native range in December.

Item	Range	CGF[a]	Urea[b]
DM, %	—	86.3	86.5
OM, %	85.9	91.2	91.9
IVDMD, %	52.0	88.7	88.8
IVOMD, %	56.3	90.9	90.1
CP, % DM	7.5	25.8	26.7
UIP, % DM	1.6	—	—
DIP, % CP	78.6	—	—

[a]Corn gluten feed.
[b]Supplement containing urea.

Table 3. Intake, urinary parameters and MCP synthesis and efficiency of cows grazing dormant range and receiving different DIP supplemental treatments in December.

Item	Control	CGF	Urea	SE
BW, lb	1,096	1,056	1,076	31
FOMI, lb/day	17.8 [b]	19.4 [bc]	24.4[c]	2.53
FOMI, %BW	1.6 [b]	1.8 [bc]	2.3[c]	0.24
Suppl. OMI, lb/day	0	2.0	2.1	—
Total OM, lb/day	17.8[a]	21.4[ab]	26.5[b]	2.55
Allantoin, mmol/L	28.8[a]	17.7[b]	16.2[b]	2.9
Urine Volume, L	3.9[a]	9.5[ac]	18.7[b]	3.5
Allantoin:Creatinine	0.99[a]	1.12[ac]	1.55[b]	0.11
DOMI, lb/day	10.1[a]	12.8[a]	15.6[b]	2.0
MCP, g/day[d]	405[a]	465[a]	607[b]	66.7
MCP Eff, %	8.9	8.1	8.5	1.5

[a,b]Means with unlike superscripts differ within a row ($P < 0.05$)
[b,c]Means with unlike superscripts differ within a row ($P < 0.1$)
[d]Estimated from allantoin excretion.

plemented cows compared to the control unsupplemented cows (Table 3). Allantoin concentration decreased with supplementation indicating a dilution of the allantoin (and creatinine) by the greater urine volume. The allantoin to creatinine ratio increased with supplementation resulting in more allantoin being excreted, further resulting in prediction of more microbial protein being produced with supplementation.

The greater total intake of the urea treatment compared to the other two treatments was also seen for MCP production ($P = 0.11$; Table 3), with cows fed the urea supplement producing more MCP than those without supplementation ($P < 0.05$) and those supplemented with CGF ($P = 0.14$). However, the higher MCP supply when urea supplement was fed did not reflect better MCP efficiency, given total digestible organic matter intake was also increased by feeding the urea supplement ($P < 0.05$). As a result, MCP efficiency did not differ among treatments and averaged 8.5% of DOMI ($P = 0.96$).

We hypothesized that supplementing DIP would produce a positive response in MCP, and providing amino acids with CGF instead of non-protein nitrogen (urea) would cause a greater response. However, the response to CGF was not greater than supplementation with urea, as a source of DIP. Both supplements provided similar amounts of DIP and phosphorous. Corn gluten feed contains corn bran and steep liquor. The urea supplement contained corn bran, starch and molasses as energy sources. Research conducted (K. Karges, M.S. Thesis, 1990) at the University of Nebraska indicated MCP production in vitro from corn starch and molasses was greater than from steep liquor. The response occurred because more energy was available to the microbes from the corn starch mixture than the steep liquor. In the current experiment, both supplements were formulated to contain similar amounts of corn bran; therefore, the higher energy availability from the corn starch-molasses (urea supplement) than from the steep liquor (CGF supplement) may have enhanced microbial growth and flow of microbial protein to the small intestine.

Forage in this trial supplied approximately 26.4 g of DIP/lb of DM which is higher than expected for dormant range. Forage intake was 20.7 lb of DM for the control group resulting in a DIP supply of 545 g/day. Using the forage intake (20.7 lb DM) and MCP efficiency (8.9%) as inputs in the NRC model, control cows required 471 g DIP/day; therefore DIP was not deficient. If DIP was not deficient, even for the control diet, adding DIP as NPN or protein would give no response because energy was first limiting. If more energy is available to rumen bacteria from corn starch and molasses, the response observed with urea supplement could have been mainly due to the supplemental energy and not to the DIP source in itself. Given our experiment was designed to compare DIP sources, we cannot prove this hypothesis as carbohydrate source and nitrogen source are confounded.

Microbial crude protein synthesis was related to total digestible organic matter intake and MCP efficiencies were similar indicating the amount of energy available for microbes was the important factor. This supports the NRC model that if DIP requirements are met, it is energy supply (TDN) that drives MCP yield. In conclusion, a CP content of 7.5% in the forage was sufficient to meet microbes' requirements for N or amino acids. When DIP is not deficient, supplying energy enhances MCP synthesis; however, the efficiency of use of that energy to synthesize MCP seems to be constant at approximately 8.5% of DOMI.

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Microbial Protein Synthesis and Efficiency in Nursing Calves

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Synthesis of microbial protein in nursing calves increased as forage intake increased while efficiency of microbial protein synthesis remained constant at approximately 19% of forage digestible organic matter intake.

Summary

Microbial protein synthesis and efficiency were estimated in spring-born nursing calves grazing native range and subirrigated meadow. Forage intake increased from 1.5 lb/day (0.6% BW) in June to 5.9 lb/day (1.2% BW) in September while milk intake decreased over the same period. Microbial protein (MCP) synthesis increased from 67 g/day in May to 278 g/day right before weaning in September. Urinary allantoin was used as a marker. Efficiency of MCP synthesis was approximately 19% of forage digestible organic matter (OM) intake.

Introduction

The diet of nursing calves is mainly milk and widely believed adequate to meet their nutrient requirements until weaning. However, research conducted at the University of Nebraska (*1994 Beef Cattle Report,* pp 3-5) showed forage intake of nursing calves is the major component of the diet 2 to 3 months before weaning when calves are 4 to 5 months old. Compensation for reduction in milk consumption by increasing forage intake should result in more OM fermented in the rumen and, consequently, enhanced microbial activity. In addition, UIP is the first limiting nutrient in nursing calves grazing native sandhills range, and UIP supplementation increased weight gains of nursing calves grazing subirrigated meadow (*1998 Beef Cattle Report*, pp. 14-16). However, MCP yield was not measured in any of these studies. Having an estimate of MCP supply is important for estimation of amount of UIP necessary to meet MP requirements. Therefore, the objective of this study was to estimate MCP synthesis and efficiency of MCP synthesis in nursing calves grazing native range and subirrigated meadow in the Nebraska Sandhills.

Procedure

The trial was conducted at the Gudmunsen Sandhills Laboratory of the University of Nebraska, near Whitman, Neb. Sixteen cow/calf pairs were assigned to either upland native range or subirrigated meadow. Dams and their calves were allowed to graze their respective sites for two-week periods from May to September. The first week was for adaptation and the second week for sample collection. Urine samples were collected daily on May 22-26, June 19-23, July 17-21, Aug. 14-18, and Sept. 18-22.

Milk intake of calves was estimated by the 16-hour weigh-suckle-weigh technique. The afternoon before estimating milk intake, calves were separated from their dams for 3 hours, then allowed to nurse and again removed for 16 hours. The following morning, calves were weighed, allowed to nurse and weighed immediately when they finished suckling. Daily milk intake was calculated as the difference between the two weights divided by 16 and multiplied by 24. Fecal output of calves was determined by total fecal collection in June, July, August and September. Each calf was fitted with a fecal collection bag. Feces collected were weighed, mixed and subsampled for DM and OM determination. Bags were emptied daily in the morning. Forage diets were collected with four esophageally fistulated cows, and samples were freeze dried, ground and analyzed for DM, OM, IVOMD, CP and UIP. Forage intake was estimated by dividing total fecal output by the indigestibility of the diet.

Approximately 50 ml of urine were taken daily as a spot sample from each calf. Samples were frozen for further analysis of allantoin and creatinine. Creatinine was used as a marker for the estimation of urine output. Urine volumes used to calculate daily excretion of allantoin from spot urine samples were estimated as: BW(lb) 12.1/creatinine concentration (mg/L), where 12.1 represents the mean daily creatinine excretion rate in mg/lb BW/day. Allantoin concentration was measured colorimetrically using a spectrophotometer. The

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ratio of allantoin to creatinine was used to determine MCP supply. Several assumptions were based on the literature for the conversion of allantoin to MCP:

- Endogenous purine derivative excretion = 0.175 mmol/lb $BW^{.75}$
- Proportion of allantoin in total purine derivatives = 90%
- Proportion of absorbed purines excreted in urine = 85%
- Digestibility of purines in the small intestine = 83%
- Ratio purine-N:microbial-N = 0.134

Calf body weights were individually measured one week prior to the collection for each monthly collection period. Data were analyzed as repeated measures using the MIXED procedures of SAS.

Results

Table 1 shows the changes in forage chemical composition by month. There was a decline in both digestibility and protein content of the forage from May to September. Calves' body weight (BW) increased from 189 + 7 lb in May to 486 + 11 lb in September and weights did not differ for calves grazing range or meadow. (P > 0.05; Table 2).

Daily consumption of forage increased while fluid milk consumed decreased (Table 2) from May to September. Forage intake of nursing calves grazing meadow or range was not different in June and September; therefore, average forage OM intake was 1.54 lb/day (0.6% BW) and 5.87 lb/day (1.2% of BW) respectively. Calves consumed about 1.32 lb/day more forage when grazing range than meadow in July and August (P < 0.05). A similar trend was observed for digestible forage OM intake. Fluid milk intake was similar for calves grazing meadow and range (P > 0.05) and it decreased linearly from 16.3 lb/day (6.5% BW) in June to 8.1 lb/day (1.7% BW) in September (P <0.001). Therefore, forage already was consumed in a higher percentage on a DM basis, when calves were 3 to 4 months old (1.12

Table 1. Chemical composition of native range and subirrigated meadow diets during the grazing season.

Item	Ash %[a]	IVOMD %[bc]	CP % of DM[d]	UIP % of DM
Range				
May	7.9[ef]	70.5	12.0[e]	2.76[e]
June	8.0[ef]	66.2	9.7[f]	2.59[e]
July	8.1[ef]	64.0	9.6[f]	2.08[f]
August	7.9[e]	59.5	9.3[f]	2.30[ef]
September	9.2[f]	56.9	9.3[f]	2.45[ef]
Meadow				
May	8.9[e]	73.2	13.7[e]	2.53[f]
June	10.3[e]	70.8	12.1[f]	3.18[e]
July	12.1[f]	63.5	12.7[f]	2.47[f]
August	12.5[f]	61.5	12.3[f]	2.39[f]
September	14.9[g]	56.8	8.5[g]	1.61[g]

[a]Meadow higher than range in July, August and September (P < 0.05).
[b]Meadow higher than range in May and June (P < 0.05).
[c]Linear effect within a column and forage (P < 0.05).
[d]Meadow higher than range in June, July and August (P <0.05).
[e,f,g]Means with unlike superscripts differ within a column and forage (P < 0.05).

Table 2. Fluid milk and forage intake for nursing calves grazing meadow and range during the summer

Item	Body weight lb[a]	Forage OM intake lb/day[b]	Forage OM intake % BW[b]	Fluid milk intake lb/day[a]	Fluid milk intake % BW[a]
Range					
May	189	—	—	—	—
June	249	1.67[c]	0.68[c]	15.8	6.4
July	319	3.54[d]	1.12[d]	14.3	4.5
August	400	4.90[e]	1.24[d]	10.1	2.4
September	486	5.85[f]	1.21[d]	8.8	1.8
Meadow					
May	189	—	—	—	—
June	257	1.41[c]	0.54[d]	16.5	6.6
July	323	2.24[d]	0.69[cd]	16.1	5.0
August	394	3.61[e]	0.91[d]	15.2	3.9
September	486	5.87[f]	1.21[e]	7.3	1.5

[a]Time linear effect (P < 0.001)
[b]Range higher than meadow in July and August (P < 0.05)
[c,d,e,f]Means with unlike superscripts differ within a column and forage (P < 0.05)

Table 3. Urine volume and urinary purine derivatives for nursing calves grazing meadow and range during the summer

Item	Allantoin mmol/L[a]	Urine volume L/day[b]	Allantoin:Creatinine ratio[c]
Range			
May	5.9	8.5	1.22
June	5.7	9.5	1.24
July	6.8	12.4	1.45
August	7.3	12.5	1.30
September	16.0	10.3	1.58
Meadow			
May	2.5	12.7	0.99
June	3.5	14.9	1.06
July	3.0	23.9	1.18
August	5.3	22.1	1.32
September	9.5	16.0	1.51

[a]Range higher than meadow (P < 0.01); Time quadratic effect (P < 0.001).
[b]Meadow higher than Range (P < 0.01); Time quadratic effect (P < 0.01).
[c]Time linear effect (P < 0.001).

Table 4. Digestible forage OM intake (FOMI), microbial protein (MCP) synthesis and efficiency for nursing calves grazing range and meadow during the summer.

Item	Digestible FOMI lb/day[a]	MCP g/day[b]	MCP Efficiency %
Range			
May	—	73	—
June	1.10[c]	99	20.1
July	2.27[d]	179	18.7
August	2.93[e]	189	14.2
September	3.32[f]	290	19.3
Meadow			
May	—	60	—
June	0.99[c]	85	20.5
July	1.43[c]	133	21.1
August	2.22[d]	189	19.5
September	3.34[e]	265	17.6

[a]Range higher than meadow in July and August ($P < 0.05$).
[b]Time quadratic effect ($P < 0.05$).
[c,d,e,f]Means with unlike superscripts differ within a column and forage ($P < 0.05$).

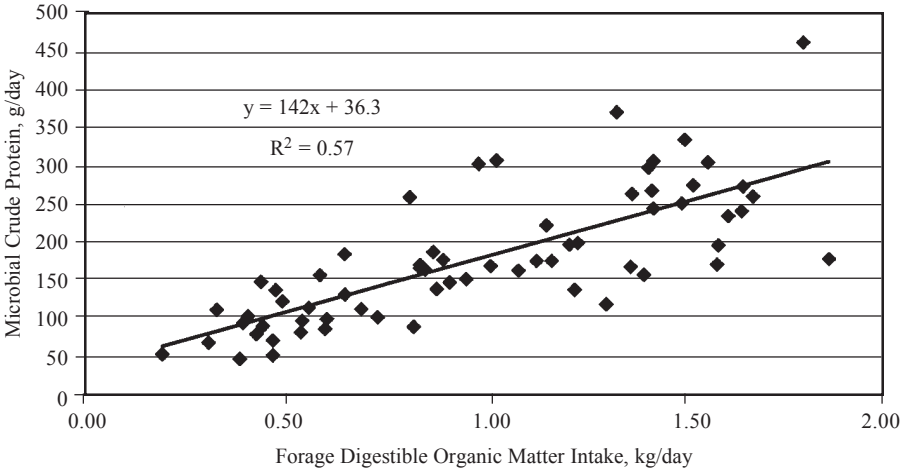

Figure 1. Relationship of forage digestible organic matter intake of nursing calves to microbial crude protein production.

and 0.69% of BW for July range and meadow respectively than milk, 0.57% BW. The increasing contribution of forage in the diet brings along a higher rumen microbial activity indicated by increasing allantoin output (Table 3) and MCP synthesis (Table 4). MCP yield did not differ between meadow and range forage ($P > 0.05$), and it increased from 67 g/day in May to 278 g/day before weaning in September ($P < 0.001$).

The increase in both forage intake and MCP yield resulted in a fairly constant MCP efficiency, being approximately 19% of digestible forage OM intake ($P > 0.05$; Table 4). Previous studies suggest calves select forage of higher digestibility and CP content than cows (*1994 Beef Cattle Report,* pp. 3-5). Because diets were collected with mature cows, MCP efficiency might be slightly overestimated in this trial.

Another way to analyze microbial efficiency is to regress microbial crude protein synthesized against the intake of forage digestible organic matter. This was accomplished by using observations from all 16 calves across the four monthly collection periods (Figure 1). Both MCP and FDOMI increased as the season progressed. The relationship ($r^2 = .57$) between MCP and FDOMI was quite good and would be expected because the FDOMI is the source of energy for the microorganisms. Because of esphogeal groove closure milk bypasses the rumen.

The slope of the regression of MCP on FDOMI was 142 grams MCP per kilogram of FDOMI. This would be a microbial efficiency of 14.2% which is closer to NRC estimates. The intercept was 36.3 (not zero) indicating that there may be a systematic error in the assumptions used in calculating MCP from allantoin in spot urine samples.

An estimate of the amount of MCP or efficiency of MCP production helps to predict DIP requirements more accurately as well as the contribution of MCP to total MP supply. In this trial, MCP represented approximately 21% of total MP in June increasing to 55.5% ,while milk represented 30% of MP, in September. This has implications when formulating supplements or forage strategies to meet MP requirements.

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Amino Acid Supplementation to Growing Heifers Fed Soypass®

Jim MacDonald
Terry Klopfenstein
Casey Macken[1]

Growing heifers fed Soypass® do not benefit from additional supplementation of amino acids.

Summary

Sixty individually fed heifers were used in an 84-day growing trial to determine effects of adding rumen protected methionine and/or bloodmeal on performance of growing heifers supplemented with Soypass®. Treatments were designed to be a 2x2 factorial with diets supplemented with or without rumen protected methionine and bloodmeal (0.3% of DM) to provide 0.72 g per day of additional histidine as factors. The rumen protected methionine source, Smartamine M®, provided 1.85 g per day of additional methionine. No statistical differences in performance among treatments were observed, suggesting growing animals fed Soypass® do not benefit from addition of supplemental rumen protected methionine or bloodmeal.

Introduction

Soypass® is a commercially available protein supplement produced by nonenzymatic browning of soybean meal. The treatment results in a product with similar CP content to soybean meal, but 80% of the protein bypasses the rumen compared to 30% undegraded intake protein (UIP) in soybean meal *(1999 Nebraska Beef Report* pp. 65-66). Thus, total metabolizable protein supplied to the animal is increased by feeding Soypass® rather than soybean meal and gain and protein efficiency (*1988 Nebraska Beef Report,* pp. 48-51) are improved.

Growing cattle may be limited by specific amino acids such as lysine, methionine, cysteine, and histidine (*1999 Nebraska Beef Report,* pp. 14-15). To determine which of these amino acids might be limiting and the severity of their deficiency, a review of literature was conducted. Using assumed intakes and gain from similar previous research trials, the amino acid compositions of soybean meal and omasal samples from animals on similar diets were compared to the amino acid requirements for growing animals to achieve maximum gain. A summary of the results of these calculations is provided in Table 1. Based on these analyses, it was determined that methionine and histidine might be limiting gain. Bloodmeal is an excellent source of UIP (89% of CP), and is relatively high in histidine (6.45% of UIP). The objective of this trial was to determine if growing cattle supplemented with Soypass® could benefit from additional supplementation of methionine and histidine from bloodmeal.

Procedure

An 84-day calf growing trial was conducted to determine the effect of additional supplementation of methionine and bloodmeal to calves supplemented with Soypass as a protein source. Sixty heifer calves (466+ 42 lb) were blocked by weight and assigned randomly to one of four protein supplementation treatments in a 2x2 factorial design. Treatments were: 1) Soypass® (SP); 2) Soypass® + methionine (SP+MET); 3)Soypass® + bloodmeal (SP+BM); and 4) Soypass® + methionine + bloodmeal (SP+MET+BM). There were 15 heifers per treatment. Heifers were individually fed a diet containing 40% sorghum silage, 30% corn bran, 20% ground corn cobs, and 10% supplement (Table 2). Supplements were formulated to contain equal amounts of UIP based on NRC requirements. Supplements containing bloodmeal were formulated to provide 0.72 grams per day of additional histidine. Supplements containing supplemental methionine were formulated to provide 1.85 grams per day of rumen protected methionine from Smartamine

Table 1. Balance of amino acids for growing animals fed a high forage diet and soybean meal.

Amino acid (g/day)	Supply[a]	Requirement[b]	Balance[c]
Lysine	36.4	33.0	+3.4
Methionine	13.4	15.4	-2.0
Cysteine	12.9	11.8	+1.1
Histidine	11.8	12.9	-1.1

[a]Calculated from amino acid composition of metabolizable protein from diet and soybean meal.
[b]Calculated from amino acids required for maximal gain as % of metabolizable protein supply.
[c]Calculated as supply - requirement.

Table 2. Composition of supplements (percentage of DM) fed to growing heifers.

Ingredient	Treatment			
	SoyPass Control[a]	SoyPass + Bloodmeal[ab]	SoyPass + Smartamine M[ac]	SoyPass + Bloodmeal + Smartamine M[abc]
Soypass	37.5	31.6	37.5	31.6
Fine ground milo	26.4	29.3	25.8	28.8
Urea	12.6	12.6	12.6	12.6
Limestone	7.1	7.1	7.1	7.1
Dicalcium phosphate	6.5	6.5	6.5	6.5
Salt	3.0	3.0	3.0	3.0
Bloodmeal	—	3.0	—	3.0
Smartamine M	—	—	0.6	0.5
Potassium Choride	2.8	2.8	2.8	2.8
Tallow	2.0	2.0	2.0	2.0
Ammonium sulfate	0.8	0.8	0.8	0.8
Selenium premix[d]	0.5	0.5	0.5	0.5
Trace mineral premix[e]	0.5	0.5	0.5	0.5
MGA[f]	0.2	0.2	0.2	0.2
Vitamin premix[g]	0.1	0.1	0.1	0.1

[a]Supplements were formulated to provide equal amounts of undegradable intake protein.
[b]Supplements were formulated to provide 0.72 g/day histidine from bloodmeal.
[c]Supplements were formulated to provide 1.85 g/day methionine from Smartamine M.
[d]Premix contained .06% Se.
[e]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, .5% Cu, .3% I, and .05% Co.
[f]Supplements were formulated to provide 0.5 mg per head per day MGA.
[g]Premix contained 5,000 IU vitamin A, 3000 IU vitamin D, 3.75 IU vitamin E per gram of premix.

Table 3. Performance data.

Item	Treatments[a]				SEM	P-Value		
	SP	SP + SM	SP + BM	SP + BM + SM		BM[b]	SM[c]	Inter[d]
ADG, lb	1.88	1.85	1.99	1.94	0.06	0.12	0.59	0.87
Intake, lb	12.55	12.36	12.65	12.48	0.21	0.59	0.38	0.97
Feed:gain	6.71	6.78	6.47	6.47	0.19	0.15	0.84	0.85

[a]Treatments: SP = Soypass control; SP + SM = Soypass + Smartamine M.; SP + BM = Soypass + bloodmeal; SP + BM + SM = Soypass + Smartamine M + bloodmeal.
[b]Main effect of bloodmeal.
[c]Main effect of Smartamine M.
[d]Bloodmeal*Smartamine interaction.

M® (Aventis Animal Nutrition, Inc.). Supplements containing both bloodmeal and Smartamine M® supplied a total of 1.85 grams per day of supplemental methionine and 0.72 grams per day of supplemental histidine. Level of methionine and histidine supplementation were based on the deficiencies presented in Table 1 and accounting for additional protein provided by feeding Soypass® in place of soybean meal. The level of bloodmeal closely agreed with the amount suggested previously (*1990 Nebraska Beef Report, pp. 65-67*) to achieve maximum gain.

Heifers were individually fed, once daily, at equal percentage of body weight with Calan electronic gates. The DM fed as a percentage of body weight was adjusted as needed to minimize orts while maintaining intakes near ad libitum consumption. Average DMI was 2.43 % of body weight. Body weights were measured on three consecutive days on days 0, 56 and 84. Heifers were also weighed once on day 28. Intakes were recalculated following each weighing.

Results

Performance data are shown in Table 3. No statistical differences among treatments for ADG, feed intake, or feed conversions were observed. Main effect P-values are provided because no bloodmeal by Smartamine M® interaction occurred. Methionine supplementation did not improve performance indicating growing animals supplemented with Soypass® are not limited by methionine. There was a trend for bloodmeal supplementation to increase ADG (P = 0.12) and improve feed conversion (P = 0.15). While we assume that the trend is due to increased histidine availability, it is not possible from this trial to determine if this is the true cause for the trend, or if it is a result of a different characteristic of bloodmeal. While further investigation into this trend is warranted, we conclude from these data, growing animals supplemented with Soypass® are not deficient in undegradable methionine or histidine.

[1]Jim MacDonald, graduate student; Terry Klopfenstein, professor, Animal Science, Lincoln; Casey Macken, research technician.

Utilization of Genetically Enhanced Corn Residue on Grazing Steer Performance

Casey Wilson
Casey Macken
Galen Erickson
Terry Klopfenstein
Edward Stanisiewski[1]

The feeding value of corn residue is not different between transgenic hybrids (Bt Corn Rootworm Protected and Roundup Ready®) compared to non-transgenic corn.

Summary

Two studies were conducted to evaluate the efficacy of transgenic corn hybrids for residue grazing. In Experiment 1 two irrigated corn fields were used after grain harvest, one Roundup Ready® and it's non-transgenic control line to evaluate grazing performance. This experiment was terminated after 35 days due to excessive snow cover. There was no significant difference in performance in Experiment 1. Experiment 2 was conducted the following year using dryland corn. In Experiment 2 corn root worm protected variety (Bt), Roundup Ready®, and their non-transgenic control line were evaluated. No differences in animal performance were observed between either genetically enhanced hybrid and their non-transgenic control.

Introduction

Genetic enhancement has been performed for centuries in plants and animals beginning with the selection of seed from superior plants and livestock with desirable traits and reproducing these through selection and breeding. These methods have significantly increased productivity, with corn yields approximately doubling over the past 40 to 50 years. The most recent innovation is the ability to introduce DNA directly into crop plants. This genetic enhancement enables a selective plant improvement process that promises to continue to improve agricultural productivity. The use of direct DNA introduction allows for more specific selection of traits, rather than the imprecise process of conventional plant breeding. Corn root worm (Bt) protected and Roundup Ready® hybrids are two hybrids of interest. These corn hybrids have been designed to reduce pesticide and herbicide use in cropping systems. Recent concerns include the possibility that genetic enhancements may affect performance when residue is used as a feedstuff for cattle. The objectives of this research were to 1) compare corn residue from a corn root worm (Bt) protected and conventional non-transgenic (nonBt) hybrid on growth performance, and 2) compare corn residue from a Roundup Ready® hybrid (RR) and the parental non-transgenic (nonRR) hybrid on growth performance.

Procedure

Experiment 1

Sixty-four crossbred steer calves (530 1b) were used in a completely randomized design in the fall of 2000. Twenty-eight acres of irrigated Roundup Ready® and 28 acres of irrigated nonRR corn residue were divided into eight equally sized pastures (4 RR and 4 nonRR). Steers were stratified by weight and assigned randomly to one of eight pastures. Each pasture was stocked with 8 steers to achieve equal stocking rates (.875 acre/steer/60days). Before grazing, residual corn (bu/acre) was estimated by counting full and partial ears in each of the eight pastures. Steer weights were taken for two consecutive days at the start and finish of the trial after a five-day period of limit-feeding (2% of BW; DM basis) to equalize gut fill. All steers were supplied a protein supplement (1 lb/head/day; Table 1) to ensure protein did not limit performance. When snow covered the residue, a storm ration (47% ground corn cobs, 47% soybean hulls, 4% molasses, and 2% pellet binder) was fed.

Experiment 2

One hundred twenty-eight crossbred steer calves (576 lb) were used in a completely randomized design in the fall of 2001. Four 34 acre fields (Bt corn root worm protected, nonBt, RR and nonRR corn residue; all corn seed provided by Monsanto Company, St. Louis, MO) were divided into 16 equal pastures (4 pastures per hybrid). Steers were stratified by weight and assigned randomly to one of sixteen pastures for 60 days. Steer weights were taken as in Experiment 1. Each pasture was stocked with 8 steers to achieve equal stocking density (1.06 acre/steer/60 days). All steers were supplemented with an equal amount of protein supplement (1 lb/head/day; Table 1) to ensure protein intake did not limit performance. Steer performance data were analyzed using the GLM procedure of SAS.

Corn residues were sampled in every pasture before and after grazing to measure residue remaining (lb/acre) and initial stalk strength. Residue was collected from ten feet of row within each pasture,

Table 1. Composition of protein supplement in Experiment 1 and 2.

Ingredients (DM%)	Experiment 1	Experiment 2
Soybean meal	78.1	78.1
Urea	8.8	8.8
Dicalcium Phosphate	5.0	5.0
Salt	4.0	4.0
Molasses	2.7	2.7
Trace mineral[a]	.7	.7
Vitamin A-D-E[b]	.4	.4
Rumensin-80[c]	.23	—
Bovatec[d]	—	.27
Selenium premix[e]	.2	.2

[a]Trace mineral composition;10% Mg, 6% Zn, 4.5% Fe, 2% Mn, .5% Cu, .3% I, and .05% Co.
[b]Vitamin A-D-E; 15,000 IU of vitamin A, 3,000 IU of vitamin D, and 3.75 IU of vitamin E/g of premix.
[c]Rumensin-80; 367 g of Rumensin per ton of supplement.
[d]Bovatec; 340 g of Bovatec per ton of supplement.
[e]1 g Se per ton of premix.

Table 2. Performance of growing steers grazing Roundup Ready and nonRoundup Ready corn residue in Exp. 1.

Item[a]	RR	nonRR	SEM	P-Value
Initial weight, lb	531	529	1.43	.41
End weight, lb	576	566	3.53	.09
ADG, lb/day	1.28	1.05	.07	.07

[a]Roundup Ready (RR), non-Roundup Ready (nonRR).

Table 3. Corn residue measurements in Experiment 2[a].

	Residue type (lb/acre)								
	Husk			Leaf			Stem		
Hybrid[b]	Before	After	P-value[c]	Before	After	P-value[c]	Before	After	P-value[c]
RR	562.4	0	.0001	1427.8	982.9	.581	2583.3	2261.7	.36
nonRR	383.0	0	.0001	1289.4	738.7	.009	2320.8	1907.0	.27
Bt CRW	322.5	0	.0001	1650.9	1138.3	.343	2481.4	2036.1	.19
nonBt	454.3	0	.0001	1903.1	1649.5	.179	1799.3	1705.7	.48

[a]Time designates when the stalk samples were taken before or after grazing.
[b]Roundup Ready (RR), non-Roundup Ready (nonRR), Corn Root Worm protected (Bt CRW), and non-Corn Root Worm protected (nonBt).
[c]P-value comparison for residue before and after grazing within hybrid.

Table 4. Corn stalk characteristics in Experiment 2[a].

Item[b]	RR	nonRR	SEM	P-Value	Bt CRW	nonBt	SEM	P-Value
Diameter, mm	22.5	22.8	1.34	.89	23.1	27.5	1.34	.04
Total force, mJ	4132.9	3428.7	304.4	.128	2482.1	3300.1	304.4	.082
Force/Diameter, mJ/mm	183.1	149.7	10.7	.047	107.7	119.6	10.6	.44

[a]Measurements taken on corn stalks following harvest or prior to grazing.
[b]Roundup Ready (RR), non-Roundup Ready (nonRR), Corn Root Worm protected (Bt CRW), and non-Corn Root Worm protected (nonBt).

Table 5.Steer performance in Experiment 2.

Item[a]	RR	nonRR	SEM	P-Value	Bt CRW	nonBt	SEM	P-Value
Initial wt, lb	577	577	1.01	.60	574	576	1.83	.33
End wt, lb	631	627	2.00	.22	618	628	5.65	.25
ADG lb/day	.86	.79	.04	.23	.75	.87	.08	.31
Residual corn bu/acre	0	.13	—	—	.29	.58	—	—

[a]Roundup Ready (RR), non-Roundup Ready (nonRR), Corn Root Worm protected (Bt CRW), and non-Corn Root Worm protected (nonBt).

dried (48 hour @ 60°C), and separated into husk, leaf and stem fractions. Stalk diameter was measured with calipers. Stalks then were tested for breaking strength using a Instron 5500R compression tester (Canton, MA). Residue weights, stalk diameter and strength were analyzed using the GLM procedure of SAS.

Results

Experiment 1

Grain yield for RR was 137 bu/ac and 147 bu/ac for nonRR. Trial 1 grazing was terminated at 35 days due to inclement weather and snow cover. In the last eight days of this experiment 10 inches of snow accumulated, completely covering corn stalk residue. This made it necessary to provide additional feed in the form of storm ration (7 lb/head/day). There was no significant difference ($P > 0.01$) in steer performance (Table 2). Previous Nebraska research has demonstrated a high correlation (r=.79) between residual corn and daily gain of steers grazing corn residue (*1997 Nebraska Beef Report, pp 27-29*). In Experiment 1 steer gain was numerically different with RR and nonRR ADG of 1.28 lb/day and 1.05 lb/day respectfully. The differences in residual corn (2.3 and 1.6 bu/acre, RR and nonRR respectively) are our explanation for differences in ADG. Due to the termination of Experiment 1 at 35 days, Experiment 2 was conducted to further the understanding of genetic enhancements on residue value.

Experiment 2

Grazing residue weights were reduced with larger reductions in husks and leaves than in stalks as would be expected under normal grazing selection (Table 3). Significant reductions were accounted for in husks in all hybrids. Numerical reductions were noticed in all leaf and stem residue with a significant reduction in only nonRR leaves. Corn stalk analysis shows significant differences in stalk diameter and total breaking strength (Table 4). Differences in breaking strength may be a function of stalk diameter. When total breaking strength is adjusted for diameter, RR stalks are significantly stronger than nonRR stalks ($P < 0.05$). Corn root worm protected (Bt) show a significant difference in diameter and total force ($P < 0.10$) when compared to nonBt stalks. When total force is adjusted for diameter however, no differences in stalk strength were observed.

Steer performance was not different between Bt corn root worm protected or RR hybrids and their parental control (Table 5) following the 60 day grazing period. Steer ADG for the Bt and nonBt were .87 and .75 lb/day, respectfully. Roundup Ready® and nonRR were similar with ADG of .86 and .79 lb/day, respectfully. The animal performance data demonstrates feeding value of corn residue does not differ between genetically enhanced corn hybrids and their non-genetically enhanced parent hybrid.

The data from these experiments suggest genetic enhancement has no effect on corn residue utilization by grazing beef steers. Producers can take advantage of increased yields and reduced herbicide/pesticide use with Bt corn root worm protected or RR hybrids without adverse effects on corn residue grazing performance.

[1]Casey Wilson, research technician, Casey Macken, research technician, Galen Erickson, assistant professor, Terry Klopfenstein, professor, Animal Science, Lincoln; Edward Stanisiewski, Monsanto Company, St. Louis, MO.

Effects of Grazing Corn Stalks in the Spring on Subsequent Crop Yields

Casey Wilson
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Walker Luedtke [1]

Grazing corn residue in spring improves soybean yields. Subsequent corn yields may be reduced at stocking rates of .32 acres per calf (2.5 times normal) for 60 days.

Summary

Two studies evaluated impact of grazing corn residue during the spring on subsequent soybean yields in a corn-soybean rotation. Each study was conducted for two consecutive years. Tillage treatments consisting of ridge-till, fall-till, spring-till, and no-till were also evaluated to determine if yields could be maintained by alleviating compaction from grazing in the spring. No significant differences in yield with tillage treatment and grazing were observed. Grazing treatments overall increased soybean yields in both studies. In the second study only a depression in subsequent corn yield was noted with spring grazing at stocking rate of .32 acres/calf for 60 days.

Introduction

In Nebraska, corn residue grazing generally occurs from November to February. Previous research has shown that grazing corn residue during this time does not impact subsequent crop yields of corn or soybeans (*2001 Nebraska Beef Report, pp. 43-45*). Presumably no effect is observed, because cattle are maintained in crop fields when the ground is frozen.

Producers require both holding areas and feed sources for cattle from February until pastures are available in late April. Some producers may use spring grazing areas as holding or calving pens where stocking rates are greater than .8 acres per calf. Fields generally are wet and not frozen from February to April. Therefore, compaction from cattle may cause yield losses in subsequent crops. The hypothesis was spring grazing will interact with tillage. When grazing caused surface compaction, we hypothesized that tillage would offset the compaction and maintain yield. The objective of this research was to evaluate the impact of grazing corn residue from late February until late April on subsequent crop yields in a corn-soybean rotation with ridge-till, fall-till, spring-till and no-till cropping systems.

Procedure

In 1997, a 90-acre field (silty clay loam, 2 to 2.5% OM) was identified. The field was split into quarters with ungrazed check strips replicated across each quarter. Crop production was based on an annual corn-soybean rotation with one-half of the field planted to each crop. The field was irrigated by a linear-move (2425 feet width) irrigation system (Valmont, Valley, Neb.) and the grazing areas replicated within each half grown to corn for grazing experiments. The first grazing trial was conducted from Feb. 25 until April 14, 1998 (48 days) and from March 1 until April 26, 1999 (56 days). Animals were fed supplement daily at 1.5 lb per calf per day. Calf stocking rate was .8 acres per calf for 60 days. The stocking rate was based on average stocking rates to optimize animal performance. With this in mind the second two-year grazing trial was conducted from Feb. 4 until April 19 in 2000 (75 days) and from Feb. 21 until May 1, 2001 (68 days). Stocking rate was increased 2.5 times to .32 acres per calf for 60 days. Animals were fed supplement daily consisting of 1 lb protein supplement and 5 lb dry rolled corn per calf per day, to maintain calf gain throughout the grazing period.

Tillage treatments included ridge-tilling during the summer, no-tillage, fall tillage with a chisel followed by conventional tillage (disk) in the spring, or spring conventional tillage alone. All tillage treatments were conducted during the corn rotation with no tillage following the soybean crop. Grazed and ungrazed treatments were superimposed on tillage treatments. The no-till, ridge-till and spring-till treatments each contained a grazed and ungrazed section. Treatments were applied to an eight-row strip and grazing treatments managed with electric wires.

At soybean harvest, the middle six rows were harvested out of the 8-row strip to maintain one border row on each side and eliminate effects from grazing pressure and fences. After each individual replication (eight replications per treatment; seven treatments) was harvested, total grain weight was recorded using a weigh wagon. Samples were collected following the grain weight measurement to determine DM and DM yield. Corn harvest (1999, 2000, and 2001) was conducted on all eight rows included in the replication. Weighing and sampling was performed similar to soybeans except a 550 bu grain cart with load cells was used for weighing.

Results

Trial 1

Calf performance was variable across years (Table 1). In 1998, calves gained 2.12 lb per day. In 1999, ADG was significantly less and calves just maintained weight during the 56 days (ADG = -0.1 lb per day). Gain differences across years may be explained by residual corn grain in fields. In 1998, residual grain estimation from surrounding fields suggested an average of 15 bu of corn grain per acre was available to calves. In 1999, no corn grain was available based on residual grain measurements.

Soybean yields the following fall after spring grazing showed a trend for main effect of treatments ($P = 0.14$). Soybean yields showed no difference

Table 1. Performance of calves grazing corn residue in the spring (Trial 1).[a]

	Year[b]		
Item	1998	1999	SE
Initial weight, lb	611	688	17.4
Final weight, lb	714	683	18.0
ADG, lb	2.1	-.1	.13

[a]Stocking rates were .8 acre per calf for 60 days
[b]Significant year effect was observed for initial weight and ADG (P < 0.05).

Table 2. Grazing and tillage impacts on soybean and corn yields in Trial 1.

		Soybean yield (bu/acre)		Corn yield (bu/acre)[a]	
Contrast	Treatment[b]	P-value	Means	P-value	Means
Grazed vs Ungrazed	1,2,7 vs 3,4,5,6	.40	45.7 vs 45.0	.45	212.4 vs 214.3
Ridge vs No-till	6,7 vs 1,5	.39	46.4 vs 45.7	.61	213.5 vs 211.8
Spring-till vs No-till	2,3 vs 1,5	.15	44.6 vs 45.7	.41	214.6 vs 211.8
Fall-till vs No-till	4 vs 1,5	.38	44.9 vs 45.7	.49	214.6 vs 211.8
Ridge GR vs Ridge UG	7 vs 6	.14	47.2 vs 45.6	.64	212.4 vs 214.5
No-till GR vs No-till UG	1 vs 5	.55	46.0 vs 45.4	.57	210.5 vs 213.1

[a]Corn yield the second year post grazing.
[b] Treatment numbers are: 1=No-till grazed (GR), 2=Spring till grazed, 3=Spring till ungrazed, 4=Fall/ Spring ungrazed, 5=No-till ungrazed (UG), 6=Ridge-till ungrazed (UG), and 7=Ridge-till grazed (GR).

Table 3.Performance of calves grazing corn residue in the spring (Trial 2).[a]

	Year		
Item	2000	2001	SE
Initial weight, lb	677	671	4.4
Final weight, lb	775	746	10.1
ADG, lb	1.3	1.1	.11

[a]Stocking rates were .32 acre per calf for 60 days

Table 4.Grazing and tillage impacts on soybean and corn yields in Trial 2.

		Soybean yield (bu/acre)		Corn yield (bu/acre)[a]	
Contrast	Treatment[b]	P-value	Means	P-value	Means
Grazed vs Ungrazed	1,2,7 vs 3,4,5,6	.01	65.3 vs 63.8	.11	210.0 vs 212.3
Ridge vs No-till	6,7 vs 1,5	.01	65.9 vs 63.3	.36	213.8 vs 211.5
Spring-till vs No-till	2,3 vs 1,5	.45	64.0 vs 63.3	.32	208.9 vs 211.5
Fall-till vs No-till	4 vs 1,5	.69	63.7 vs 63.3	.34	214.5 vs 211.5
Ridge GR vs Ridge UG	7 vs 6	.15	66.9 vs 65.0	.79	213.3 vs 214.3
No-till GR vs No-till UG	1 vs 5	.07	64.5 vs 62.0	.05	207.9 vs 215.1

[a]Corn yield the second year post grazing.
[b] Treatment numbers are: 1=No-till grazed (GR), 2=Spring till grazed, 3=Spring till ungrazed, 4=Fall/ Spring ungrazed, 5=No-till ungrazed (UG), 6=Ridge-till ungrazed (UG), and 7=Ridge-till grazed (GR).

between grazed and ungrazed treatments. Spring and fall tillage treatments had no effect on soybean yield when compared to the no-till treatments. Yield on the ridge-till grazed treatment tended to be greater than the ridge-till ungrazed treatment (P < 0.15). Table 2 illustrates contrasts used and statistics for soybean and corn yields. Spring grazing did not depress soybean yields the following season as was our original hypothesis. Our hypothesis was that yields would potentially be depressed, but tillage treatments might help alleviate yield depressions due to soil compaction from spring grazing. Based on the results of Trial 1, spring and fall tillage caused a depression in yield relative to ridge-till and no-till grazed treatments. Corn yields two years post grazing showed no significant differences in treatments.

Trial 2

Calf performance was not different across year in Trial 2. In 2000 calves gained 1.3 lb/day and in 2001, calves gained 1.1 lb/day (Table 3). The more uniform performance with increased stocking rate may have been the result of the additional corn fed to maintain performance.

Soybean yields showed a significant effect of treatment (P = 0.028). Overall grazing improved soybean yields over ungrazed treatments (P = 0.015) and included significant improvement in yield in no-till grazed over no-till ungrazed treatments. Spring and fall tillage had no effect on soybean yield when compared to no-till treatments. Table 4 illustrates contrasts used and statistics for soybeans and corn.

Corn yields the second year after grazing in Trial 2 showed a depression in yield with the 2.5 times normal grazing treatment. There was a trend (P =0 .11) for grazing to reduce corn yields when compared to the ungrazed treatments. The no-tillage grazed treatment showed a significant depression in yield compared to no-tillage ungrazed treatment (P = 0.05). The ridge-till grazed treatment showed no difference when compared to ridge-till ungrazed treatment (P = 0.79). This suggests that grazing of ridge-till stalks in the spring is not detrimental to subsequent corn yields. Also, tillage treatments may alleviate any effects on corn yields two years following grazing.

In summary, spring corn residue grazing appears to have no detrimental impacts on subsequent soybean yields. With 2.5 times normal stocking rate soybean yields actually improved with grazing. The corn yields two years post grazing showed a depression in yield. However, this yield depression was related to the tillage system. Any depression in corn yields with higher stocking rates may be eliminated with a deep tillage treatment following soybeans and prior to corn planting. Because the carryover effect of grazing to the subsequent corn crop following soybeans was unexpected, there was no additional tillage treatment imposed between the soybeans and corn in this research.

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Intervention Strategies for Reduction of *E. coli* O157:H7 in Feedlot Steers

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Beef producers may be able to reduce shedding of *E. coli* O157:H7 in feedlot cattle with intervention strategies.

Summary

Two experiments were conducted to evaluate the effects of three intervention strategies on the prevalence of E. coli O157:H7 in feedlot steers. In both experiments, 432 steers were assigned to one of 54 pens. Intervention strategies were two competitive exclusion products, monthly pen cleaning. In Experiment 2 a diet change treatment was imposed prior to slaughter. No differences in performance or carcass yield were observed for the competitive exclusion products or the pen cleaning treatments, compared to the control. However, changing the finishing diet prior to slaughter decreased steer performance. We also observed a non-significant decrease in the prevalence of E. coli O157:H7 with inclusion of the competitive exclusion products.

Introduction

E. coli O157:H7 has been implicated in many outbreaks of food-borne illnesses and deaths. Many of these outbreaks have been traced back to beef products or manure from bovine animals spread on crops consumed by humans. Preliminary Nebraska research has indicated that inclusion of competitive exclusion products (*Lactobacillus acidophilus* organisms that out compete other microorganisms) fed in the diet of beef animals, may reduce the numbers of *E. coli* O157:H7 shed in the feces (Moxley, unpublished data). Also, previous research has indicated increased mud and manure in feedlot pens is associated with a higher prevalence of cattle shedding *E. coli* O157:H7. In addition, removal of starch from the diet by either hay feeding or elimination of starch feedstuffs has been found to increase fecal pH, decrease fecal VFA and decrease acid-resistant *E. coli*, and *E. coli* O157:H7 (*2001 Nebraska Beef Report pp 86-88*). Therefore, an experiment was conducted to evaluate the effect of inclusion of competitive exclusion products, pen cleaning, and diet change intervention strategies on the prevalence and shedding of *E. coli* O157:H7.

Procedure

Experiment 1

Four hundred thirty-two medium framed steer calves (737 lb) were used in two experiments covering a 140-day feedlot finishing period. Experiment 1 steers were blocked into three weight groups and stratified within block and assigned randomly to one of 54 pens (8 steers/pen). Pens were assigned randomly to a 3 x 2 factorial treatment design; either one of two *Lactobacillus acidophilus* competitive exclusion products (NPC 747), or (NPC 750), or a negative control; and monthly pen cleaning or pen cleaning at the end of the experiment. Competitive exclusion products were mixed with water and applied to the feed truck mixing box and fed at a rate of $1x10^9$ colony forming units/steer/day. Steers were fed once daily with the control steers fed first and a load of non-experiment feed was fed between loads of experiment feed to minimize cross contamination of competitive exclusion products. Steer weights were taken for two consecutive days at the start of the experiment after a 3-day period of limit-feeding to equalize gut fill. In Experiment 1, four rectal fecal samples were obtained from each steer over a period of 3 months. Also, weekly water and composite fecal samples were collected from each pen throughout the experiment.

Experiment 2

Experiment 2 was initiated immediately after the end of Experiment 1 using the same pens and animals. Again, a 3 x 2 factorial treatment design was used continuing the competitive exclusion product treatments, and implementing a 14-day diet change versus no diet change treatments at the end of the feeding period. Rectal fecal samples were collected on days 0, 7 and 14 of Experiment 2. Concentrate type and finishing diet formulation was changed from a 33% high moisture corn, 15% dry rolled corn, 40% wet corn gluten feed diet to a 44% corn bran and 44% wet corn gluten feed diet in a two-day change period (Table 1). Alfalfa hay and supplement were included in both diets at rates of 7% and 5% respectively. Steers were slaughtered on day 14 after rectal fecal sampling.

All samples were taken immediately to the UNL *E. coli* lab and analyzed for presence of *E. coli* O157:H7. A pen was considered positive if at least one animal in the pen was positive during the period of the study. Performance

Table 1. *E. coli* O157:H7 intervention experiment finishing diets.

Ingredients (DM %)	Finishing Diet	Experimental Diet
Wet Corn Gluten Feed	40.0	44.0
High Moisture Corn	33.0	—
Dry Rolled Corn	15.0	—
Corn Bran	—	44.0
Alfalfa Hay	7.0	7.0
Supplement[a]	5.0	5.0
Nutrient Composition, % DM		
Crude Protein	14.1	15.9
Calcium	0.82	0.82
Phosphorus	0.51	0.43

[a]Supplement formulated to deliver 30g/ton Rumensin® and 10g/ton Tylan® and meet NRC requirements for trace minerals and vitamins.

Table 2. *E. coli* O157:H7 results for competitive exclusion products.

Item	NPC 747	NPC 750	Control	P-Value[a]
Experiment 1				
Positive Pens[b]	3/18	1/18	4/18	.3
Period Prevalence[c]	16.7	5.6	22.2	.3
Odds[d]	0.20	0.06	0.28	
Experiment 2				
Positive Pens[b]	3/18	3/18	8/18	.1
Period Prevalence[c]	16.7	16.7	44.4	.1
Odds[d]	0.20	0.20	0.80	

[a]Model = -2 log likelihood X^2
[b]Indicates number of positive pens out of eighteen possible.
[c]Indicates the prevalence over the experimental period.
[d]Odds = number of pens positive for *E. coli* O157:H7 divided by the number of negative pens.

Table 3. *E. coli* O157:H7 entire feeding period finishing and carcass performance.

Item	NPC 747	NPC 750	Control	No Diet[a]	Diet[b]	Diet P[c]	Diet * Product[d]
Daily Gain, lb	3.83	3.85	3.84	3.95	3.73	<0.01	0.04
Feed/Gain	6.61	6.49	6.56	6.40	6.73	<0.01	0.21
14-day DMI, lb/day[e]	27.0	26.4	27.0	28.2	25.4	<0.01	0.31
HCW[f], lb	802	802	803	812	793	<0.01	0.03
Marbling[g]	503	513	507	513	502	=0.07	0.20

[a]No Diet = main effect of no diet change.
[b]Diet = main effect of diet change.
[c]Diet P = P-value for main effect of diet change in Experiment 2.
[d]Diet by Product interaction.
[e]14-day DMI = dry matter intake for the diet change period.
[f]HCW = Hot carcass weight.
[g]Mabling = Marbling score = 400 = $Slight^0$, 450 = $Slight^{50}$, 500 = $Small^0$, etc.

data were statistically analyzed with the mixed procedures of SAS. *E. coli* O157:H7 data were analyzed on a pen basis using the Proc Logistic procedure of SAS.

Results

E. coli

In Experiment 1 there were no significant (P = 0.3) effects of pen cleaning or competitive exclusion product feeding on the prevalence of *E. coli* O157:H7 (Table 2). However, *E. coli* O157:H7 was detected in 3 of 18 (16.7%) pens treated with NPC 747, 1 of 18 (5.6%) pens treated with NPC 750, and 4 of 18 (22.2%) of the control pens.

In Experiment 2 there were no significant effects of diet change on the prevalence of *E. coli* O157:H7. On marketing day we observed fewer (P = 0.1) pens fed the competitive exclusion products shedding *E. coli* O157:H7 (Table 2). The organism was detected in 3 of 18 (16.7%) pens treated with NPC 747, 3 of 18 (16.7%) pens treated with NPC 750, and 8 of 18 (44.4%) of the control pens. The odds ratio for each competitive exclusion product compared to the control was 0.25 (P = 0.1). Therefore, we observed that the odds for detecting *E. coli* O157:H7 in control pens at marketing time was four times greater than in the treated pens (P = 0.1).

Finishing Performance

Finishing performance is summarized in Table 3. There were no effects of competitive exclusion product or pen cleaning on any aspect of steer finishing performance or carcass merit. However, changing the concentrate in our finishing diet from 33% high moisture corn, 15% dry rolled corn, 40% wet corn gluten feed diet to 44% corn bran, and 44% wet corn gluten feed had large negative effects on steer performance. The 14-day diet change at the end of the feeding period significantly (P < 0.01) decreased average daily gain by 5.6% from 3.95 to 3.73 lb/day, decreased hot carcass weight by 2.3% from 812 to 793 lb, decreased feed conversion by 5.1% from 6.4 to 6.7 lb of feed /lb of gain, and decreased diet change period dry matter intake by 10% from 28.2 to 25.4 lb./day. Also, the diet change tended (P =0.07) to decrease marbling score from 513 to 502.

Addition of a competitive exclusion product tended to decrease the prevalence of E. coli O157:H7 in cattle feces. Even though no significant effects were noted, we did observe a lower *E. coli* O157:H7 recovery from pens treated with the competitive exclusion products and especially from NPC 750. Also, the magnitude of response we observed was large enough to be important and thus deserve further investigation. Manipulation of finishing diets and pen cleaning had no effect on prevalence of *E. coli* O157:H7. Finally, changing the finishing diet had a large negative effect on steer performance.

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Wet Corn Gluten Feed Levels for Steam-flaked Corn Based Finishing Diets

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Replacing steam-flaked corn with wet corn gluten feed in finishing diets had no effect on animal performance up to a level of 35%.

Summary

A finishing trial was conducted to evaluate level of wet corn gluten feed in steam-flaked corn based finishing diets. Feed efficiency and daily gain were similar among all levels (10, 20, 25, 30, and 35%, DM basis) of inclusion of Sweet Bran® wet corn gluten feed evaluated in this trial. These data indicate wet corn gluten feed is similar in energy content to steam-flaked corn based on animal performance.

Introduction

Feeding wet corn gluten feed (WCGF) in dry-rolled corn based diets to finishing cattle improves daily gain and feed intake while maintaining or improving feed efficiency. Based on previous work in commercial feedlots, the response when WCGF is used in steam-flaked corn diets has been different than when WCGF is fed in dry-rolled corn diets. Based on previous work at University of Nebraska (*2002 Nebraska Beef Report,* pp.68-71), the optimum level of WCGF is 20 to 30% (DM basis) for feed conversion in steam-flaked corn based finishing diets. The response to WCGF in commercial feedlot studies, suggested the optimum level may be lower, but few levels have been tested.

Defining the level of inclusion of WCGF in steam-flaked corn diets is important to optimizing animal performance. The objective of this research was to determine the optimum level of WCGF in steam-flaked corn finishing diets.

Table 1. Finishing diet ingredient composition.

Ingredient[a], % DM	0%	10%	20%	25%	30%	35%
Steam-flaked corn	81.5	71.5	61.5	56.5	51.5	46.5
Wet corn gluten feed	—	10.0	20.0	25.0	30.0	35.0
Corn silage	10.0	10.0	10.0	10.0	10.0	10.0
Tallow	3.5	3.5	3.5	3.5	3.5	3.5
Dry meal supplement	5.0	5.0	5.0	5.0	5.0	5.0

Procedure

One hundred ninety-two crossbred steer calves (658 lb) were stratified by weight and assigned randomly to 1 of 24 pens (8 steers/pen). Pens were assigned randomly to 1 of 6 treatments. Treatments were assigned based on six levels of Sweet Bran® wet corn gluten feed. Levels were 0, 10, 20, 25, 30, and 35% (DM basis) of wet corn gluten feed. All diets were formulated to contain a minimum of 14.0% crude protein, 0.70% calcium, 0.28% phosphorus, 0.60% potassium, 31 g/ton Rumensin, and 10 g/ton Tylan (DM basis; Table 1). Supplements were fed in two phases to supply UIP early in the finishing stage when calves may be deficient in MP. Phase 1, UIP was supplemented to calves using feather and blood meal (50:50) at 1% of the dietary DM. Phase 2, UIP was

Table 2. Effect of WCGF level in steam-flaked corn based diets on animal performance and carcass characteristics.

	Treatments							
Item	0%	10%	20%	25%	30%	35%	SEM	P-Value
Days on feed	151	151	151	151	151	151		
Initial wt., lb	657	659	659	656	661	658	1	0.22
Final wt., lb[a]	1312	1321	1352	1329	1317	1326	14	0.47
DMI, lb/day	20.0[b]	20.8[bc]	21.3[c]	20.8[c]	20.7[bc]	21.4[c]	0.3	0.07
ADG, lb	4.33	4.39	4.59	4.46	4.35	4.43	0.10	0.47
Feed:gain	4.62	4.73	4.65	4.68	4.76	4.83		0.25
Carcass weight, lb	826	832	852	837	830	836	9	0.47
Marbling score[d]	524	526	514	517	528	534	14	0.92
Choice or above, %	79.9	67.4	61.1	53.1	73.2	81.2	9.1	0.25
Fat thickness, in	0.54	0.54	0.58	0.56	0.56	0.58	0.03	0.87
Yield grade	2.8	2.7	2.7	2.8	2.9	2.8	0.1	0.81

[a]Final weight calculated as hot carcass weight divided by 0.63.
[b,c]Means within a row with unlike superscripts differ (P < 0.10).
[d]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.

replaced with urea when the cattle were estimated to weigh 875 lb. Corn silage was included in all diets, including step-up diets, at 10% (DM basis). Step-up diets contained 35, 25, 15 and 5% alfalfa hay (DM basis) replacing the corn in each treatment diet and fed for 7, 8, 7 and 7 days, respectively.

Initial weights were determined as the average of two consecutive early morning weights before feeding at the initiation of the trial. Steers were fed once daily and allowed ad libitum access to feed and water. Steers were implanted with Synovex-C on day 1 and reimplanted with Revalor-S on day 53. Cattle were fed for 151 days and harvested at a commercial packing plant where carcass data were collected. Hot carcass weight was collected the day of harvest with fat, marbling score, and yield grade data collected following a 24-hour chill.

Results

Overall cattle performance was exceptional for this experiment, presumably due to a mild winter/spring with no mud. Final weights, ADG and feed conversion were similar among treatments (Table 2). Dry matter intake was lower ($P < 0.10$) for 0% WCGF compared to levels of 20, 25, and 35% WCGF. Dry matter intake was not statistically different for treatments containing WCGF. Hot carcass weight, marbling, fat thickness and YG were similar among treatments. These data would suggest levels up to 35% WCGF can be fed with steam-flaked corn based diets though there would be a tendency for a decrease in efficiency at 35% WCGF level. These data suggest Sweet Bran® WCGF has the feeding value similar to steam-flaked corn.

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Effects of Corn Processing Method and Crude Protein Level with the Inclusion of Wet Corn Gluten Feed on Finishing Steer Performance

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More intensively processed corn, such as dry fine-grinding, early ensiling of high-moisture, or steam-flaking corn improved feed conversion by 3.7, 7.8, or 11.7%, respectively, compared to dry-rolling in finishing diets that contained wet corn gluten feed.

Summary

Three hundred twenty crossbred steer calves were used to evaluate corn processing method and crude protein level in finishing diets that included wet corn gluten feed. There was no response due to crude protein level (14 vs 15%) observed in this trial. As corn processing method became more intensive (fine-grinding, high-moisture ensiling, and steam-flaking corn) compared to dry-rolling, daily intake was reduced. Daily gain was similar across corn processing methods. Feed efficiency and cost of gain improved as corn processing method intensity increased.

Introduction

Using products such as wet corn gluten feed (WCGF) to replace corn in finishing diets has been shown to improve feed intake and daily gain while maintaining or improving feed efficiency. Most of this work has been done with dry-rolled corn replacement, although it has been shown that there are improvements in feed efficiency when corn is more intensely processed and WCGF is included in finishing diets (*2001 Nebraska Beef Report, pp. 59-63*) fed to yearlings or calves.

Research at Nebraska has shown that steam-flaked corn and high-moisture corn have similar ruminal starch digestion, with both being greater than dry-rolled corn (Cooper et al., 2002 JAS). However, postruminal starch digestion was higher for steam-flaked corn than high-moisture or dry-rolled corn. High-moisture corn used in the previous trial was rolled and stored in a bunker at 29% moisture. Harvesting high-moisture corn at an earlier stage and grinding to a smaller particle size may provide some opportunity to increase starch digestion postruminally. However, when fed to cattle, decreasing particle size raises some concerns about acidosis and separation in the feedbunk. Inclusion of WCGF alleviates these concerns (*1995 Nebraska Beef Report, pp. 34-36*).

By controlling acidosis (the increasing ruminal pH) with the inclusion of WCGF, microbial efficiency presumably increases. An increase in microbial efficiency will increase degradable intake protein (DIP) requirements in finishing diets. Previous work (*2001 Nebraska Beef Report, pp. 54-57*) illustrated more intensive corn processing methods (high-moisture and steam-flaked corn), compared to DRC, increased DIP requirements. Finishing diets that contain WCGF and have

(Continued on next page)

intensely processed corn may have a higher DIP requirement than when that grain is fed alone. Therefore, the objectives of this research were to determine: 1) if more intensive processing of HMC can improve animal performance in diets containing WCGF, 2) energy values of corn processed by different methods with the inclusion of WCGF, and 3) DIP requirement in finishing diets with different methods of corn processing in finishing diets containing WCGF.

Procedure

Three hundred twenty crossbred steer calves (677 lb) were stratified by weight and assigned randomly to 1 of 40 pens (8 steers/pen). Pens were assigned randomly to 1 of 10 treatments. Treatments were assigned based on a 2 × 5 factorial design with factors of crude protein level and grain processing method. Crude protein levels were formulated to be 13 or 14% with the additional CP supplemented by urea. However, actual CP analyses were 13.9 and 14.9% (Table 1). Grain processing methods were dry-rolled (DRC), fine-ground (FGC), high-moisture rolled (RHMC), high-moisture ground (GHMC), and steam-flaked corn (SFC). *Sweet Bran*® wet corn gluten feed (WCGF) was fed at 25% of the diet dry matter. High-moisture corn was harvested all in one day at 30% moisture, processed, and stored in silo bags. All diets were formulated to contain a minimum of 0.70% calcium, 0.51% phosphorus, 0.65% potassium, 31 g/ton Rumensin, and 10 g/ton Tylan (Table 1, DM basis). Feed ingredients were sampled weekly and then composited by month for crude protein analysis. Supplements were fed in two phases. Phase 1, UIP was supplemented to calves using feather and blood meal (50:50) at 1% of the dietary DM. Phase 2, UIP was replaced with urea when the cattle were estimated to weigh 875 lb. Corn silage was included in all diets, including step-up diets, at 10% of the DM. Cattle were adapted to grain by feeding 35%, 25%, 15% and 5% alfalfa hay (DM basis) replace with the respective corn treatment and fed for 3, 4, 7 and 7 days, respectively.

Table 1. Finishing diet ingredient and nutrient composition.

Ingredient[a], %	DRC	FGC	RHMC	GHMC	SFC
DRC	60.0	—	—	—	—
FGC	—	60.0	—	—	—
RHMC	—	—	60.0	—	—
GHMC	—	—	—	60.0	—
SFC	—	—	—	—	60.0
Wet corn gluten feed	25.0	25.0	25.0	25.0	25.0
Corn silage	10.0	10.0	10.0	10.0	10.0
Dry meal supplement	5.0	5.0	5.0	5.0	5.0
Nutrient[b], %					
High Protein					
CP	15.1	15.1	14.8	14.8	14.8
DIP	9.6	9.6	10.6	10.6	9.5
Low Protein					
CP	14.2	14.1	13.8	13.8	13.8
DIP	8.6	8.6	9.6	9.6	8.5

[a]DRC = dry-rolled corn, FGC = fine-ground corn, RHMC = rolled high-moisture corn, GHMC = ground high-moisture corn, and SFC = steam-flaked corn.
[b]High Protein = high protein diet and Low Protein = low protein diet.

Initial weights were determined as the average of two consecutive early morning weights before feeding at the initiation of the trial. Steers were fed once daily and allowed ad libitum access to feed and water. Steers were implanted with Synovex-S on day 1 and reimplanted with Revalor-S on day 51. At reimplant, fecal samples from individual animals were taken and composited by pen. One half tablespoon of as-is feces was used to composite fecal samples by pen. Composites were stored frozen, freeze-dried, ground to pass through a 1 mm screen and starch analysis was completed. Net energy was calculated for the different corn processing methods, according to methods outlined by Owens, et al. (2002 Proc. ASAS, abst. 1089). Cattle were fed for 152 days (November 21, 2001 to April 22, 2002) and harvested at a commercial packing plant where carcass data were collected. Hot carcass weight was collected the day of harvest with fat, marbling score, and yield grade data collected following a 24-hour chill.

Cost of gain was calculated for each treatment by using ration cost adjusted for processing method. Adjustments for processing were used from previous published *2001 Nebraska Beef Report, pp. 51-54*. Dry-rolling corn was given no adjustment and used as the control. Fine-ground corn was calculated with a 10% increase in energy cost compared to dry-rolling which related to $0.09/ton more than dry-rolling. Rolled high-moisture corn was calculated at a cost of $0.74/ton more than dry-rolling. Ground high-moisture corn was calculated with the additional $0.09/ton for grinding plus $0.74/ton as high-moisture corn compared to the dry-rolling. Steam-flaking corn was calculated at $5.56/ton more than dry-rolling. Ten-year average prices in Nebraska (1992-2001) for alfalfa hay (baled) and corn were used. Ingredient costs were ground alfalfa hay ($73.75/ton), corn ($97.00/ton), corn silage ($67.00/ton), dry supplement ($95.00/ton) and WCGF priced equal to corn.

Results

Overall cattle performance was exceptional for this experiment, presumably due to a mild winter/spring with no mud. No significant protein x grain processing interactions occurred for any of the variables observed, therefore only main effects are presented. Protein level had no effect on any of the variables measured. Based on analysis of ingredients, finishing diets contained approximately 1% unit higher CP levels than formulated concentrations. For this reason, the low protein diets met the DIP require-

Table 2. Effects of grain processing and protein level on animal performance and carcass characteristics.

	Treatments[a]						P-values[b]		
Item	DRC	FGC	RHMC	GHMC	SFC	SEM	Protein	Process	Inter
Days on feed	152	152	152	152	152				
Initial wt., lb	677	678	678	677	677	1	0.07	0.94	0.78
Final wt., lb[c]	1320	1339	1318	1321	1335	7	0.70	0.15	0.36
DMI, lb/day	23.2[d]	23.0[d]	21.6[e]	21.4[e]	21.3[e]	0.2	0.18	<0.01	0.89
ADG, lb	4.23	4.35	4.21	4.24	4.33	0.05	0.86	0.16	0.39
Feed:gain	5.49[d]	5.29[e]	5.13[f]	5.05[f]	4.91[g]		0.31	<0.01	0.39
NEg, Mcal/cwt[h]	70.0[d]	73.4[e]	76.4[f]	77.7[f]	80.4[g]	0.9	0.31	<0.01	0.37
Hot carcass, lb	831	843	830	829	838	5	0.75	0.20	0.17
Marbling score[i]	492	497	508	483	505	9	0.93	0.31	0.48
Choice or above, %	47.3	47.8	57.8	42.2	52.5	6.6	0.16	0.54	0.54
Fat thickness, in	0.47[d]	0.56[e]	0.54[f]	0.52[d]	0.53[e]	0.02	0.89	0.05	0.37
Yield grade	2.3[d]	2.7[e]	2.6[ef]	2.4[df]	2.5[de]	0.1	0.90	0.02	0.29
Cost of gain, $/cwt[j]	35.34[d]	34.12[e]	33.59[f]	33.21[f]	33.09[f]	0.31	0.36	<0.01	0.36
Fecal starch, %	19.2[d]	11.8[e]	10.6[ef]	8.4[f]	4.1[g]	1.3	0.40	<0.01	0.59

[a]DRC = dry-rolled corn, FGC = fine-ground corn, RHMC = rolled high-moisture corn, GHMC = ground high-moisture corn, SFC = steam-flaked corn.
[b]Protein= main effect of protein level, Process= main effect of processing method, Inter = interaction between protein level and processing method.
[c]Final weight calculated as hot carcass weight divided by 0.63.
[d,e,f,g]Means within a row with unlike superscripts differ (P < 0.10).
[h]Calculated net energy values of the processed corn.
[i]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.
[j]Values used in calculation: Ration prices: DRC = $97.91/ton, FGC = $97.98/ton, RHMC = $98.35/ton, GHMC = $98.46/ton, SFC = $101.39/ton; Yardage = 0.30/day; and interest on half the feed = 10%. Cattle interest is not include.

ments of the animals and the additional DIP had no effect. Because no difference was observed for the main effect of protein level (P > 0.15), these data are not shown. The low protein diets supplied DIP levels that would be similar to requirements stated in previous research (*2001 Nebraska Beef Report, pp. 54-67*, and *2002 Nebraska Beef Report, pp. 68-71*).

Grain processing methods did have an effect on cattle performance. Dry matter intake decreased as the degree of processing increased (Table 2). Dry-rolled corn and FGC had similar daily intakes but had higher (P < 0.05) intakes than RHMC, GHMC, or SFC. Rolled high-moisture corn, GHMC, and SFC had similar intakes. Gains were similar across all treatments. Steam-flaked corn had the lowest feed conversion compared to all other treatments. Steam-flaking corn improved (P < 0.05) feed conversion by 11.7, 7.7, and 3.6% compared with dry-rolling, dry fine-grinding, or early ensiling of high-moisture corn, respectively. Fine-grinding dry corn improved (P = 0.01) feed conversion by 3.7% compared to dry-rolling corn. Feed conversion was similar between the two processing methods for early ensiled high-moisture corn, and feeding high-moisture corn improved feed conversion by 7.8% compared with dry-rolling corn. Calculations of net energy values for the processed corns were improved by 4.8, 9.1, 11.0, and 14.8% for fine-grinding dry, rolling high-moisture, fine-grinding high-moisture, and steam-flaking corn, respectively, compared to dry-rolling corn. Acidosis and diet separation due to fine particles appeared to be controlled using WCGF.

Hot carcass weight and marbling score were similar among treatments. Fat thickness was greater (P < 0.05) for RHMC, FGC, and SFC compared to DRC and GHMC. Dry-rolled corn, GHMC, and SFC had similar USDA yield grades. Dry-rolled corn had lower USDA yield grades compared to FGC and RHMC. Fine-ground corn, RHMC, and SFC had similar USDA yield grades.

Cost of gain was highest for DRC. Cost of gain was decreased (P < 0.01) by $1.22/cwt when corn was fine-ground compared to dry-rolling. Cost of gain was similar for RHMC, GHMC, and SFC though feed cost of gain was decreased (P < 0.01) by $1.75, 2.13, and 2.25/cwt, respectively, compared to DRC. Fine-ground corn had a similar cost of gain compared to RHMC but higher than GHMC or SFC.

Fecal starch content may indicate how much starch is used. Fecal starch was the highest for DRC and the lowest for SFC among treatments (Table 2). Fine-grinding corn reduced fecal starch by 7.4 percentage units compared to DRC. Fine-ground corn had similar fecal starch content compared with RHMC, but higher than GHMC or SFC. Ground high moisture corn had similar fecal starch content compared to RHMC. Both GHMC and RHMC had higher fecal starch compared to SFC. Fecal starch content supports the difference in feed conversions among treatments ($R^2 = 0.95$; feed conversion = 0.0394 * % fecal starch + 4.7454).

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Corn Steep and Bran:Germ Meal Ratio in Steam-flaked Corn Based Finishing Diets

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Rick Stock[1]

Based on feedlot performance, corn steep has a higher energy value than corn bran:germ meal in steam-flaked based finishing diets.

Summary

A finishing trial was conducted to evaluate corn steep:bran/germ meal combinations in steam-flaked based diets. Feed efficiency improved in a linear fashion as steep level increased. Feed efficiency was similar between cattle that received no byproducts compared with cattle fed 25% corn byproducts that contained 50% steep. Feed efficiency was decreased for levels of 37.5, 41.7, and 45.8% steep compared to no byproduct or 50% steep. Daily gain was similar among treatments.

Introduction

Corn steep is a blend of steep liquor and distillers solubles and is a component in the manufacturing of corn gluten feed. Based on data published in the Nebraska Beef Cattle Research Report (Scott et al., 1997), steep has more energy than corn bran and germ meal (GM); but high levels of steep without corn bran and GM may cause handling problems and mineral imbalances.

Corn bran is a highly digestible fiber source that is a component of corn gluten feed. In the manufacturing of corn gluten feed, wet corn bran is pressed and may be dried before steep is added. Germ meal is a medium protein, highly digestible fiber source that remains after oil is extracted from the germ. Germ meal contains more energy than corn bran, but less energy than steep.

When WCGF is included in steam-flaked corn based diets, feed conversion has been variable. Perhaps the ingredients comprising wet corn gluten feed interact with the type of grain fed in the diet. Therefore, the objective of this research was to determine the interaction of steep and bran/GM level when fed in steam-flaked corn diets.

Procedure

One hundred sixty crossbred steer calves (693 lb) were stratified by weight and assigned randomly to 1 of 20 pens (8 steers/pen). Pens were assigned randomly to 1 of 5 treatments. Treatments were assigned based on four ratios of steep to bran/GM mix plus a negative control (CON). Wet corn gluten feed (WCGF) was fed at 25% of dietary DM. Wet corn gluten feed was made by mixing the different components into the diet. Bran/GM was mixed weekly and added to the diet as one ingredient. Bran/GM mix was of 60% bran, 24% GM, and 16% fine-cracked corn (DM basis). Bran/GM was mixed with steep into the diet to produce four levels of steep in the WCGF: 37.5% steep; 41.7% steep; 45.8% steep and 50.0% steep (DM, Table 1). Tallow was added at 3.5% (DM basis) to all diets. All diets were formulated to contain a minimum of 14.0% crude protein, 0.70% calcium, 0.28% phosphorus, 0.60% potassium, 31 g/ton Rumensin and 10 g/ton Tylan (DM basis; Table 1). Supplements were fed in two phases to supply UIP early in the finishing stage when calves may be deficient in MP. Phase 1, UIP was supplemented to calves using feather and blood meal (50:50) at 1% of the dietary DM. Phase 2, UIP was replaced with urea when the cattle were estimated to weigh 875 lb. Corn silage was included in all

Table 1. Finishing diet ingredients.

	Treatments[a]				
Ingredient, % DM	CON	37.5% steep	41.7% steep	45.8% steep	50.0% steep
Steam-flaked corn	81.5	56.5	56.5	56.5	56.5
Corn silage	10.0	10.0	10.0	10.0	10.0
Dry supplement	5.0	5.0	5.0	5.0	5.0
Tallow	3.5	3.5	3.5	3.5	3.5
Steep	—	9.4	10.4	11.5	12.5
Bran/SEM mix					
Bran	—	9.4	8.8	8.1	7.5
Germ meal	—	3.8	3.5	3.3	3.0
Fine-cracked corn	—	2.5	2.3	2.2	2.0

[a]CON = 0% WCGF, 37.5% steep = 25% WCGF made with 37.5% steep, 41.7% steep = 25% WCGF made with 41.7% steep, 45.8% steep = 25% WCGF made with 45.8% steep, and 50.0% steep = 25% WCGF made with 50.0% steep.

Table 2. Animal performance and carcass characteristics with different steep to bran/GM ratios in WCGF added to steam-flaked corn based diets.

	Treatments[a]						
Item	CON	37.5% steep	41.7% steep	45.8% steep	50.0% steep	SEM	P-value
Days on feed	132	132	132	132	132		
Initial wt., lb	694	692	696	691	693	1	0.12
Final wt., lb[b]	1322	1315	1345	1342	1343	10	0.19
DMI, lb/day[c]	21.1[d]	22.7[ef]	23.0[f]	23.1[f]	22.4[de]	0.2	<0.01
ADG, lb[g]	4.76	4.72	4.93	4.94	4.93	0.08	0.18
Feed:gain[g]	4.44[d]	4.80[e]	4.68[ef]	4.67[ef]	4.56[df]		0.02
Hot carcass, lb	833	829	848	846	846	7	0.18
Marbling score[h]	516	533	531	538	528	9	0.55
Choice or above, %	71.9	81.3	78.1	75.0	74.6	6.9	0.89
Fat thickness, in	0.49[d]	0.56[e]	0.58[ef]	0.63[f]	0.57[ef]	0.03	0.03
Yield grade	2.4[d]	2.8[e]	2.8[e]	2.8[e]	2.8[e]	0.1	0.04

[a]CON = 0% WCGF, 37.5 = 25% WCGF made with 37.5% steep, 41.7 = 25% WCGF made with 41.7% steep, 45.8 = 25% WCGF made with 45.8% steep, and 50.0 = 25% WCGF made with 50.0% steep.
[b]Final weight calculated as hot carcass weight divided by 0.63.
[c]Quadratic effect of steep % of WCGF ($P < 0.10$).
[d,e,f]Means within a row with unlike superscripts differ ($P < 0.10$).
[g]Linear effect of steep % of WCGF ($P < 0.10$).
[h]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.

diets, including step-up diets, at 10% of diet DM. Step-up diets contained 35, 25, 15 and 5% alfalfa hay (DM basis) replacing the corn in each treatment diet and fed for 3, 4, 7 and 7 days, respectively.

Initial weights were determined as the average of two consecutive early morning weights before feeding at the initiation of the trial. Steers were fed once daily and allowed ad libitum access to feed and water. Steers were implanted with Synovex-C on day 1 and reimplanted with Revalor-S on day 46. Cattle were fed for 132 days (Jan. 17 to May 29, 2002) and harvested at a commercial packing plant where carcass data were collected. Hot carcass weight was collected the day of harvest and fat, marbling score and yield grade following a 24-hour chill.

Results

Dry matter intake was similar for CON and 50.0% steep. However 37.5, 41.7 and 45.8% steep had higher ($P < 0.10$) DMI than CON (Table 2). Cattle fed 50.0% steep had similar DMI compared to those fed 37.5% steep. Therefore, DMI responded in a quadratic ($P = 0.03$) fashion for ratio of steep to bran/GM. Daily gain was statistically similar among treatments though there was a linear trend for ADG to increase as steep level increased in byproduct inclusion. Feed conversion was similar between CON and 50.0% steep. A linear decrease for improvement of feed conversion was detected as the percentage of steep in the WCGF increased, suggesting steep has a higher energy value than corn bran/GM meal in steam-flaked corn based diets.

Hot carcass weight and marbling score were similar among treatments. Cattle that were fed CON had less ($P < 0.05$) fat and lower YG than those fed WGCF, suggesting that the CON cattle composition of gain was different than cattle fed WCGF. Presumably feed conversion for the CON cattle would increase if they were fed to the same fat thickness as the cattle fed WCGF. Therefore, the feed conversion data are unclear on whether CON cattle were more efficient due to diet energy or composition of gain. It is unclear how to correct for composition of gain effects on feed conversion. Marbling scores were not different among the treatments.

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Feeding Transgenic (*Bt* Corn Rootworm Protected and Roundup-Ready®) Corn to Feedlot Cattle

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Feeding two transgenic corn hybrids (*Bt* corn rootworm protected and Roundup Ready®) had no effect on feedlot performance or carcass characteristics when compared with non-transgenic reference and control hybrids.

Summary

Two finishing trials were conducted to evaluate the effect of feeding corn root worm protected (Bt) and Roundup Ready® (RR) corn hybrids on animal performance and carcass characteristics in the feedlot. Two commercially available non-genetically engineered reference hybrids, and the non-transgenic control hybrid were compared to the two genetically enhanced hybrids. No significant differences were observed on animal performance or carcass characteristics for either trial as a result of corn source in feed.

Introduction

The introduction of transgenic plants into modern agriculture has had a significant effect on management plans for a variety of agronomic crops grown in the United States. The use of genetically enhanced corn, cotton and soybeans has allowed producers to reduce their use of chemicals and minimize tillage. This technology has also led to the development of new herbicides and insecticides that have zero or minimal residue in the soil. These factors have led modern agriculture to become more efficient and more environmentally conscious.

According to National Ag Statistic Service (NASS, 2000) the livestock industry uses 60% of the corn that is grown in the United States annually, with the beef feedlots using the highest percentage among all livestock. Therefore, if 60% of the corn grown in the United States is fed to livestock, and 33% of the corn is genetically enhanced, this results in tremendous number of feedlot cattle that use transgenic corn. It is important for livestock producers to know if cattle fed biotech corn will perform similar to animals fed non-transgenic corn.

The objectives of these research studies were to compare the performance and carcass characteristics of finishing steers fed corn root worm protected corn (event MON863), or Roundup Ready® corn (event nk603) with their genetically related non-transgenic hybrid, or to the average of two non-transgenic commercial reference hybrids.

Procedure

Animals

Two-hundred crossbred steer calves (706 lb) were used in the Roundup Ready® (RR) trial, which was conducted during the winter and early spring of 2001. Two hundred crossbred yearling steers (805 lb) were used in the corn root worm protected corn (*Bt*) trial which was conducted during the fall and early winter of 2001 and 2002. The cattle were purchased in the fall of 2000, received and backgrounded on stockpiled smooth bromegrass pastures (45 days), with RR steers then entering the feedlot, and *Bt* steers managed in a conventional yearling production system (corn stalk grazing, limit fed drylot, summer pasture grazing). Prior to the initiation of the feeding period both groups were limit fed at 2% of body weight for five days. Steers on the RR trial were implanted with Ralgro® on day one of the trial, and were reimplanted with Revelor-S® on day 56. Steers on the *Bt* trial were implanted with Revelor-S® on day 28.

Limit fed weights were taken for steers on both trials two days before the initiation of the feeding period. Both trials were analyzed as a completely randomized design, therefore animals were stratified by weight, and assigned randomly to one of 20 pens (10 steers/pen). Pens were then assigned randomly to treatment (5 pens/treatment).

Diets

Treatments for the RR trial consisted of the two reference hybrids, DK647 (Ref1), RX740 (Ref2), the genetically related non-transgenic hybrid RX670 (PAR) and the Roundup Ready® hybrid nk603 (RR). Treatments for the *Bt* trial were similar to the treatments on the RR trial. However, the Roundup Ready® hybrid was substituted with the corn root protected hybrid MON863 (*Bt*). All corn was grown at the Agricultural Research and Development Center near Mead, Neb. After harvest, all corn hybrids were stored separately on site to minimize any cross contamination. Samples of all hybrids were taken and sent to Monsanto Company, where the presence/absence of the genes were verified.

Diets for the RR and *Bt* trials are presented in Table 1. Steers on the RR trial were adapted to the final diet for 28 days, while steers on the *Bt* trial were adapted to the final diet for 21 days. Adjustments to the diet for adaptation

Table 1. Finishing diet composition (% of DM) for Roundup Ready® and *Bt* trials.

Ingredient	Roundup Ready® Trial (% of Diet DM)	*Bt* Trial (% of Diet DM)
Dry rolled hybrid[a]	79.5	77.5
Steep liquor	10.0	10.0
Alfalfa hay	7.5	7.5
Dry supplement[b]	3.0	5.0
Fine ground milo	0.85	2.50
Limestone	1.39	1.60
Urea	0.29	0.45
Salt	0.30	0.30
Tallow	0.10	0.10
Trace mineral premix[c]	0.03	0.05
Rumensin premix[d]	0.016	0.017
Tylan premix[e]	0.013	0.012
Vitamin A, D, E premix[f]	0.010	0.010

[a]Reference hybrid DK647, Reference hybrid NK740, Near isogenic parental hybrid RX670, or Roundup Ready® hybrid nk603 (Roundup Ready® trial) or hybrid MON863 (*Bt* trial).
[b]Supplement formulated to be fed at 3% (Roundup Ready® trial) or 5% (*Bt* trial) of diet DM.
[c]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, 0.05% Co.
[d]Premix contained 80 g/lb monensin.
[e]Premix contained 40 g/lb tylosin.
[f]Premix contained 1500 IU vitamin A, 3000 IU vitamin D, 3.7 IU vitamin E per g.

Table 2. Roundup Ready® finishing trial animal performance[a].

	REF1	REF2	PAR	RR®	SE	F-test[b]
Initial wt, lb	706	707	705	707	0.83	0.24
Final wt, lb[c]	1288	1270	1296	1270	13.38	0.33
Carcass wt, lb	811	800	817	800	8.37	0.42
DMI, lb/day	24.4	23.9	23.9	23.9	0.27	0.42
ADG, lb/day	4.04	3.91	4.11	3.91	0.09	0.39
Feed:gain[d]	6.10	6.13	5.82	6.12		0.22
Marbling[e]	533	544	539	541	9.16	0.85
12th rib fat, in	0.62	0.62	0.58	0.56	0.02	0.20
REA, in^2	13.59	13.37	13.91	13.30	0.24	0.30

[a]REF1= reference hybrid DK647, REF2=reference hybrid NK740, PAR=near isogenic parental hybrid RX670, and RR®=Roundup Ready® hybrid hK603.
[b]F-test p-value for treatment effect due to corn hybrid.
[c]Based on hot carcass weight adjusted to a 63% common yield.
[d]Statistically analyzed as gain:feed, which is the reciprocal of feed:gain.
[e]500=Small 0, 600=Modest 0.

Table 3.*Bt* corn finishing trial animal performance[a].

	REF1	REF2	PAR	*Bt*	SE	F-test[b]
Initial wt, lb	804	807	805	808	1	0.09
Final wt, lb[c]	1331	1351	1333	1362	12	0.24
Carcass wt, lb	838	851	840	858	8	0.24
DMI, lb/day	28.0[fg]	28.8[f]	27.3[g]	28.1[fg]	0.3	0.03
ADG, lb	4.66	4.86	4.71	4.95	0.11	0.27
Feed:gain[d]	6.02	5.92	5.82	5.68		0.15
Marbling[e]	568	558	551	551	12	0.72
12th rib fat, in	0.49	0.50	0.50	0.48	0.02	0.86
REA, in^2	13.0	13.1	13.0	13.4	0.2	0.39

[a]REF1= reference hybrid DK647, REF2=reference hybrid NK740, PAR=near isogenic parental hybrid RX670, and Bt=corn root worm protected hybrid MON863.
[b]F-test p-value for treatment effect due to corn hybrid.
[c]Based on hot carcass weight adjusted to a 63% common yield.
[d]Statistically analyzed as gain:feed, which is the reciprocal of feed:gain.
[e]500=Small 0, 600=Modest 0.
[f, g]Means with unlike superscripts differ P<0.05.

were similar for both trials, with ground alfalfa hay replacing corn. Alfalfa hay levels were decreased from 45, 35, 25 and 15% of diet DM, for either 7 days each (RR trial) or 3, 4, 7, and 7 days (*Bt* trial). The diets were formulated to meet or exceed NRC (1996) recommendations for DIP, UIP, calcium, phosphorus and potassium. The dry supplement was formulated to be fed at 3 and 5% of the diet DM for the RR and *Bt* trials respectively, with diets containing 27 g/ton of Rumensin® and 9 g/ton of Tylan® (DM basis).

The average dry matter content of the corn hybrids was 90.2 + 0.5 %. Because the corn was low in moisture, steep liquor was added to the diet at 10% of DM to reduce dust, and potential acidosis problems, from fines separating in the feedbunk, created when corn was dry rolled.

This was a blind study for feedlot personnel. Each hybrid was assigned a letter before the initiation of the trial. Study treatments, feed sheets, commodity bays, and pen assignments were designated by letter only to minimize any treatment bias. A non-study load was mixed and fed between each load of feed to minimize the possibility of cross-contamination of the transgenic corn.

Measurements

Animals on both trials were weighed every 28 days. Feed refusals were collected every 28 days and at the discretion of the feedlot manager. Diets and feed ingredients were sampled weekly, composited monthly and sent to a commercial laboratory (DHIA Forage Laboratory, Ithaca, NY) for subsequent analysis.

Cattle were harvested at a commercial packing plant (IBP, West Point, Neb.) on day 144 for the RR trial and day 112 for the *Bt* trial. Hot carcass weight, and liver scores were taken on the day of slaughter, while REA, and 12th rib fat thickness measurements were taken after a 24 hour chill. Marbling score and yield grade were assigned to each carcass by a certified USDA grader 24 hours post harvest.

(Continued on next page)

Final weight and performance calculations are based on the hot carcass weights adjusted to a common 63% yield.

Data were analyzed as a completely randomized design using the General Linear Model procedure of SAS. A protected F-test was used to test treatment effect due to corn hybrid. If significant, a Bonferroni t-test was used to separate means.

Results

Animal performance and carcass data for the RR trial are shown in Table 2. No significant differences were observed in terms of performance or carcass characteristics for cattle on the RR trial. The average across all treatments for ADG and feed conversion were 3.99 lb/day and 6.05 respectively. The overall average across treatments for 12th rib fat thickness was .60 in, which may be an explanation for the average USDA marbling score of 539 (low choice). Overall, source of corn in the feed had little impact on any performance parameter measured in this experiment based on F-test statistics.

Animal performance and carcass data for the *Bt* trial are shown in Table 3. Based upon the F-test statistics, no significant differences were observed for initial weight, final weight, ADG, feed efficiency, hot carcass weight, 12th rib fat thickness, or marbling score between all hybrids. Dry matter intakes were significantly different ($P<0.05$). Cattle fed the REF2 hybrid had the highest DMI, followed by the *Bt*, REF1, and PAR hybrids respectively.

Cattle fed corn genetically enhanced for agronomic traits had similar performance and carcass characteristics compared to cattle fed non-transgenic corn. These data suggest feeding attributes of Roundup-Ready® and corn root worm protected corn hybrids are similar to non-transgenic corn hybrids.

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[1]Kyle Vander Pol, graduate student; Jon Simon, former graduate student; Galen Erickson, assistant professor; Terry Klopfenstein, professor; Animal Science, Lincoln; Edward Stanisiewski and Gary Hartnell, Monsanto Company, St. Louis, MO.

Effects of Starch Endosperm Type and Corn Processing Method on Feedlot Performance, Nutrient Digestibility and Ruminal Fermentation of High-Grain Diets

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Floury corn endosperm type improves feed efficiency when fed as dry-rolled corn but not when fed as high-moisture corn compared to a more vitreous corn endosperm type.

Summary

A feedlot finishing and metabolism trial were conducted to evaluate two starch types and two corn processing methods. The floury endosperm variety improved daily gain and feed efficiency when corn was fed as dry-rolled versus an endosperm that was more vitreous in type. However, when fed as ensiled high-moisture corn, endosperm type did not affect ADG or feed efficiency. Feeding high-moisture corn in finishing feedlot diets improved feed efficiency by 6.5% compared to feeding dry-rolled corn. When vitreous type endosperm was fed as high-moisture corn feed efficiency was improved by 9.5% over dry-rolled corn. Floury type endosperm fed as high-moisture corn improved feed efficiency by 3.5% over dry-rolled corn. These data suggest an important interaction between starch type and processing method.

Introduction

Corn endosperm type is synonymous with starch type, not to be confused with starch composition (amylose and amylopectin). Endosperm type is a primary reason for differences in corn hybrid effects on starch utilization by feedlot cattle. Endosperm that is more vitreous is "harder" with more densely packed starch molecules compared to floury endosperm which is "softer." Corn with a floury type endosperm has been shown to have increased ruminal starch degradablity compared to a corn hybrid that has more vitreous type endosperm in previous studies (Philippeau et al., 1999 JAS).

Another approach to improve corn use is processing the corn to increase starch digestion and improve feed efficiency. Processing corn increases feed costs. For example, steam-flaking corn increases feed cost $5 to $15 a ton.

In cattle, intense processing of corn may increase incidence and severity of acidosis leading to decreased DMI, ADG and feed efficiency. Likewise, corn hybrids that are naturally more digestible in the rumen may increase the challenge of managing acidosis. Therefore, corn hybrid may interact with processing method in rations.

Our objective was to compare corn hybrids differing in endosperm type as either dry-rolled or high-moisture grain on finishing performance, total tract nutrient digestion, and rumen pH.

Table 1. Effects of corn hybrid and processing method on performance and carcass characteristics of finishing steers.

	floury		flinty			P-value[a]		
Item	HMC	DRC	HMC	DRC	SEM	Process	Hybrid	Inter
Days on feed	191	191	191	191				
Initial wt., lb	641	642	642	643	1	0.31	0.59	0.78
Final wt., lb[b]	1337[c]	1333[c]	1332[c]	1281[d]	13	0.05	0.04	0.09
DMI, lb/day	19.5	20.1	19.4	19.6	0.3	0.16	0.23	0.55
ADG, lb	3.65[c]	3.61[c]	3.61[c]	3.34[d]	0.06	0.03	0.03	0.08
Feed:gain	5.36[c]	5.55[d]	5.37[c]	5.88[e]		<0.01	<0.01	0.01
Hot carcass wt, lb	843[c]	840[c]	839[c]	807[d]	7.9	0.05	0.04	0.09
Marbling score[f]	447	439	459	419	9	0.03	0.69	0.11
Fat thickness, in	0.43[c]	0.41[c]	0.45[c]	0.33[d]	0.02	0.01	0.22	0.07
Yield grade	2.31	2.25	2.23	1.90	0.13	0.17	0.13	0.35

[a]Process = main effects of high-moisture ensiling versus dry-rolling corn; Hybrid = main effect of hybrid floury versus hybrid flinty; Inter = interaction of processing method and hybrid type.
[b]Final weight calculated as hot carcass weight divided by 0.63.
[c,d,e]Means within a row bearing unlike superscripts differ (P < 0.10).
[f]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.

Procedure

Corn Grain Production, Hybrids, Harvest, and Processing

Two dent type hybrids representing differences in endosperm type were planted and grown under irrigation in similar fields at the Agricultural Research and Development Center. One hybrid was used that primarily contained vitreous endosperm (flinty) and the other hybrid had primarily floury endosperm (floury). The two hybrids that were used were chosen based on their endosperm characteristics. Both hybrids were commercially available but represented extremes in endosperm type. Grain was harvested as high-moisture corn or dry corn. High-moisture harvest was conducted when the corn grain reached 28-30% moisture. The high-moisture corn was coarsely rolled and stored in silo bags until feeding. Dry grain was harvested at approximately 18% moisture and dried to 15% moisture for storage.

Feedlot Experiment

One hundred sixty crossbred steer calves (642 lb) were stratified by weight and allotted randomly to one of 16 pens (10 head/pen). Treatments were arranged as a 2 X 2 factorial design with factors being corn hybrid (flinty or floury) and processing method (high-moisture; HMC or dry-rolled corn; DRC). The finishing diets were formulated to contain equal amounts of forage, crude protein, vitamins, minerals, and feed additives (Rumensin at 30 g/ton; Tylan at 10 g/ton). Because floury contained less CP than flinty (8.7 versus 10.1%, respectively), corn gluten meal was supplemented to floury diets so all diets contained similar amounts of protein from corn grain. Finishing diet composition was 81% of the respective corn, 8% alfalfa hay, 3% cane molasses, and 8% milled supplement (DM basis). Steers were implanted with Synovex C on day 1 and reimplanted on day 72 with Revalor-S. Steers were fed 191 days, and adapted to the final diet in 28 days using diets containing 45, 35, 25 and 15% alfalfa hay (dry-matter basis) fed for 7 days each.

Initial weights were determined by the average of two consecutive early morning weights prior to feeding at the initiation of the trial. Steers were fed once daily and allowed ad libitum access to feed and water. Final weights were calculated by using common dressing percentage (63). Hot carcass weight was collected the day of harvest. Fat depth, USDA called marbling score, and yield grade data were collected following a 24-hour chill.

Ruminal Metabolism Trial

A 4 X 4 Latin square experiment was conducted using ruminally fistulated steers (1194 lb) to measure effects of endosperm type fed as either high-moisture or dry-rolled corn on nutrient digestibility and ruminal fermentation characteristics. The metabolism trial was conducted during the feedlot performance trial, allowing the same diets to be evaluated. Each of the four experimental periods consisted of 21 days: 14-day diet adaptation and 7-day continuous ruminal pH measurements. Feed intake was measured continuously throughout each period by feedbunks suspended from weigh cells. Ruminal pH was monitored with a submersible pH electrode suspended through the plug of the rumen cannula of each steer. Weigh cells and pH electrodes were linked directly to a computer allowing data acquisition software to record both feed weight and ruminal pH every 6 seconds and averaged for each minute for each steer during collection.

Ruminal fluid samples were collected on days 20 and 21 of each period at 0, 3, 6, 9, 12, 18 and 24 hours post feeding and analyzed for ruminal ammonia concentrations. Fecal grab samples were taken on days 18 through 21 four times daily at 6-hour intervals, with collection time advanced 1.5 hour each day, such that samples were obtained over each 1.5-hour interval of a 24-hour cycle. Feed ingredient and fecal samples were dried in a 60 degree C oven and analyzed for dry matter, organic matter and starch to calculate total tract digestibility.

Chromic oxide was used as an indigestible marker for estimating fecal output. Chromic oxide was dosed twice daily at 0800 and 1600 via rumen cannula. Each dose contained 7.5 g of chromic oxide (15 g/day of chromic oxide).

Results

Feedlot Experiment

Dry matter intake was similar between hybrids and grain processing treatments (Table 1). Interactions were

(Continued on next page)

Table 2. Effect of corn hybrid and processing method on total tract digestibility in metabolism steers.

	floury		flinty			P-value[a]		
Item	HMC	DRC	HMC	DRC	SEM	Process	Hybrid	Inter
Dry Matter								
Intake, lb/day	20.3	20.5	19.5	18.7	0.6	0.66	0.09	0.50
Digestibility, %	85.0	86.1	83.3	83.8	1.0	0.50	0.12	0.80
Organic Matter								
Intake, lb/day	19.4	19.6	18.7	18.0	0.6	0.66	0.10	0.51
Digestibility, %	86.4	87.3	84.7	85.2	1.1	0.55	0.15	0.87
Starch								
Intake, lb/day	12.1	11.9	11.6	11.6	0.4	0.70	0.36	0.86
Digestibility, %	98.1	97.6	95.3	95.6	0.9	0.92	0.06	0.70

[a]Process = main effects of high-moisture ensiling versus dry-rolling corn; Hybrid = main effect of hybrid floury versus hybrid flinty; Inter = interaction of processing method and hybrid type.

Table 3. Effect of corn hybrid and processing method on ruminal pH and ammonia concentrations in metabolism steers.

	floury		flinty			P-value[a]		
Item	HMC	DRC	HMC	DRC	SEM	Process	Hybrid	Inter
Average pH	5.34	5.55	5.56	5.49	0.22	0.77	0.75	0.59
Maximum pH	6.12	6.07	6.44	6.15	0.24	0.53	0.46	0.65
Minimum pH	4.83	5.15	5.02	5.07	0.16	0.34	0.79	0.49
pH change	1.28	0.92	1.42	1.09	0.14	0.07	0.34	0.93
pH variance	0.102	0.046	0.133	0.049	0.029	0.08	0.62	0.68
Area < 5.6	507	428	273	310	146	0.89	0.31	0.72
Ruminal ammonia, mg/dl	2.90	3.46	2.57	3.17	0.33	0.07	0.28	0.93

[a]Process = main effects of high-moisture ensiling versus dry-rolling corn; Hybrid = main effect of hybrid floury versus hybrid flinty; Inter = interaction of processing method and hybrid type.

observed between hybrids and grain processing method for daily gain (P = 0.08), feed efficiency (P = 0.01), hot carcass weight (P = 0.09), and fat thickness (P = 0.07). Daily gain was similar between hybrids when fed as high-moisture corn. However, when fed as DRC, floury resulted in a 0.27 lb/day increase (P = 0.01) in daily gain or a total of 52 lb of gain for the feeding period over flinty. Daily gain was similar for processing method when floury hybrid was fed. But when flinty was fed HMC increased (P = 0.01) daily gain by 8.1% compared to DRC.

The interaction observed between hybrid and processing method for feed efficiency was a result of magnitude of change between feeding each hybrid as either HMC or DRC. When floury was fed as HMC, it improved (P = 0.01) feed efficiency by 3.5% compared to processing as DRC. When flinty was fed as HMC, feed efficiency was improved (P < 0.01) by 9.5% compared to feeding DRC.

Differences among treatments in hot carcass weight are a reflection of daily gain (Table 1). Fat thickness was similar between hybrids when fed as HMC though fat thickness was decreased (P < 0.05) for steers that were fed flinty DRC compared to flinty HMC or floury DRC. Marbling scores were higher (P = 0.02) for steers fed HMC compared with DRC. Other carcass characteristics were similar among treatments.

Metabolism Trial

Dry matter, organic matter, and starch intake were similar between grain processing method. Dry matter (P = 0.10) and organic matter (P = 0.10) digestibility were higher for floury compared to flinty (Table 2). Total tract dry matter and organic matter digestibility tended (P < 0.15) to be higher for steers fed floury compared with flinty. Total tract starch digestibility was higher for the steers fed floury compared to steers fed flinty. The differences observed with total tract nutrient digestibility support the improved animal performance observed with floury hybrid versus flinty hybrid in the feedlot experiment. However, total tract nutrient digestibility did not support the data for corn processing method observed in the finishing study. Nutrient digestibility was not different for HMC compared to DRC though there was a marked difference in animal performance. Differences could be related to intake observed in the metabolism steers. Intakes were lower as a percentage of body weight for the metabolism steers (1.6% BW) compared to the finishing steers (2.0% BW).

Ruminal pH measurements were not influenced by grain hybrid (Table 3). Feeding HMC resulted in larger (P = 0.07) changes (maximum-minimum) and greater (P = 0.08) variance in daily ruminal pH. The results support a greater rate and extent of ruminal starch digestion for HMC compared to DRC. Lower ruminal ammonia concentrations suggest that more starch was being ruminally digested with HMC compared with DRC. Ruminal ammonia concentrations were similar between grain hybrids.

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Evaluation of Buffering Agents in Feedlot Diets for Cattle

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Galen Erickson
Terry Klopfenstein[1]

Feeding Acid Buf and sodium bicarbonate resulted in increased ruminal pH through rumen buffering and/or mediation of dry matter intake.

Summary

Six ruminally cannulated heifers were used in a 6 x 6 Latin square to determine effects of Acid Buf, sodium bicarbonate and Rumensin on severity of acidosis and feeding behavior when fed to cattle consuming high grain finishing diets. Heifers received diets containing no added buffer, Acid Buf at 0.75% or 1.25% DM, sodium bicarbonate at 1.25% DM, 28 grams/ton Rumensin, or 28 grams/ton Rumensin + 0.75% DM Acid Buf. Heifers were adapted to dietary treatments 9 days before a 5-day data collection period. Animals fed Acid Buf and sodium bicarbonate had a higher average ruminal pH. Feeding Rumensin and Acid Buf alone or in combination resulted in a lower DMI than no added dietary buffer. Ruminal VFA analysis yielded similar results among treatments.

Introduction

Ruminal acidosis is a major challenge when large amounts of rapidly fermentable starch is fed to beef cattle. Decreased DMI, decreased feed efficiencies and animal death (during acute acidosis) may result if acidosis is not properly managed. Animals experiencing acidosis can translate into severe economic loss. Methods of alleviating and/or reducing the incidence and severity of acidosis should be beneficial to the beef feedlot industry. Rumensin in high grain diets helps reduce acidosis (*1997 Nebraska Beef Report, pp. 49-52; 1999 Nebraska Beef Report, pp. 41-44*) presumably by mediating intake. Another option to reduce acidosis potential is adding buffer to the diet. One common buffering agent is sodium bicarbonate, but its use is variable due to its cost-benefit ratio. Another buffer, Acid Buf, has shown value in *in vitro* systems, *in situ* and sheep and dairy metabolism studies. However, continuous pH monitoring with associated feed intake in beef feedlot animals fed rapidly fermentable diets and fed buffers is limited and can offer insight into the potential of buffers to alleviate acidosis.

Our objective was to evaluate rumen buffer addition to the diet of grain fed animals based on ruminal pH, feeding behavior, rumen VFA concentrations, and water intake.

Table 1. Composition of diets (% DM basis)

Ingredient	CON	LOWBUF	HIBUF	RUM	RUM+BUF	BICARB
High-moisture corn	65.2	65.2	65.2	65.2	65.2	65.2
Dry-rolled corn	16.3	16.3	16.3	16.3	16.3	16.3
Alfalfa hay	7.5	7.5	7.5	7.5	7.5	7.5
Molasses, cane	5.0	5.0	5.0	5.0	5.0	5.0
Ground milo	2.57	2.43	2.33	2.55	2.41	1.59
Urea	1.13	1.14	1.14	1.13	1.14	1.16
Limestone	1.66	1.05	0.65	1.66	1.05	1.66
Salt	0.3	0.3	0.3	0.3	0.3	—
Tallow	0.24	0.24	0.24	0.24	0.24	0.24
Mineral premix[a]	0.05	0.05	0.05	0.05	0.05	0.05
KCl	0.04	0.04	0.04	0.04	0.04	0.04
Vitamin premix	0.01	0.01	0.01	0.01	0.01	0.01
Acid Buf®	—	0.75	1.25	—	0.75	—
Na-bicarbonate	—	—	—	—	—	1.25
Rumensin-80®	—	—	—	0.0194	0.0194	—

[a]Provided 70 mg Ca, 60 mg Zn, 40 mg Mn, 50 mg Fe, 7.5 mg Cu, 1 mg I, and 0.5 mg Co per kg diet DM.

Procedure

Six ruminally cannulated yearling crossbred beef heifers (avg. BW = 1094 lb) were used in a 6 × 6 Latin square to determine effects of sodium bicarbonate, Rumensin, and Acid Buf on rumen parameters and feed intake behavior. Dietary treatments were assigned randomly to animals and periods with six observations per treatment. Heifers were adapted over a 21-day period to the final finishing ration using four step-up diets (roughage level 45, 35, 25, 15% DM). The finishing diet (Table 1) was high moisture and dry-rolled corn based and contained 7.5% ground alfalfa hay (DM basis). Inclusion of Rumensin, Acid Buf, or sodium bicarbonate was achieved via the supplement (6% of diet DM). Dietary treatments were 1) 0 inclusion of Rumensin or buffers (CON); 2) Acid Buf at 0.75% DM (LOWBUF); 3) Acid Buf at 1.25% DM (HIBUF); 4) sodium bicabonate at 1.25% DM (BICARB); 5) Rumensin at 28 grams/ton (RUM);

(Continued on next page)

and 6) Acid Buf at 0.75% DM + Rumensin at 28 grams/ton (RUM+BUF).

Periods were 14 days in length (9-day diet adaptation and 5-day data collection) and all animals were fed to achieve ad libitum intake continuously throughout each period. Heifers were fed in individual free-stalls on days 1-8 of each period. On day 9, cattle were moved and tethered to individual metabolism stalls for a 1-day acclimation period before data collection (days 10 to 14). Bunks were read once daily throughout each period at 0730 hour and feed offerings were adjusted accordingly just prior to the once daily feeding at 0800 hour. Any feed refusals were removed, quantified and sampled. Heifers were fed individually while individual feed bunks were suspended from load cells connected to a computer equipped with software allowing continuous data acquisition. The feed weight in each bunk was recorded every minute and continuously stored for each heifer over the entire data collection period (days 10 to 14).

On day 10 of each period, submersible pH electrodes were placed into the rumen of each heifer through the ruminal cannula plug and remained until the end of the period (day 14). Each pH electrode was encased in a weighted, four-wire metal shroud to keep the electrode in a stationary suspended position approximately 5-10 inches above the ventral floor of the rumen. This allowed rumen contents to flow freely around the pH electrode. Electrodes were linked directly to a computer allowing data acquisition software to record a ruminal pH every 6 seconds and averaged for each minute throughout the days of collection for each heifer. A representative rumen fluid sample from each animal was also taken every 3 hours for a 24-hour period beginning on day 13 of each period. Rumen fluid samples were individually labeled and stored frozen until VFA analyses were conducted.

Water intake of each heifer also was quantified on days 10 to 14 of each period. This was obtained by suspending six individual water containers overhead. Water containers were monitored and filled when necessary to continuously supply water at all times. Water disappearance was recorded and water intake was calculated on a daily basis for each individual heifer assuming disappearance equates to consumption and no wastage. Our hypothesis was that cattle experiencing ruminal acidosis may consume water differently than those that are not, thus we wanted to measure the effect that rumen buffers would have on water intake.

Feed intake measurements (day 10 to 14) included DM intake, rate of intake, number of meals per day, average meal size, total time spent eating and average meal length. Rate of intake was calculated as a 1st order reaction following log transformation of DM disappearance from bunks. Meals were calculated from DM disappearance data and designated a meal when bunks did not change weight for a 10 minute interval. Ruminal pH measurements (day 10 to 14) included average, maximum and minimum pH, area of pH below 5.6 and 5.3 (time below x magnitude below), pH variance and magnitude of pH change.

Feed intake, water intake and ruminal pH data (days 10 to 14) were analyzed using the Mixed procedure of SAS for a Latin Square design. Model effects were period and treatment while animal was termed a random effect, thus placed into the random statement. Least squares means were separated using the PDIFF statement of SAS (Bonferonni t-test statistic) when protected by a significant ($P < 0.10$) *F*-test.

Results

Ruminal pH

Results for rumen pH data are reported in Table 2. Average pH, minimum pH and maximum pH for a 24-hour period all were influenced by diet treatment based on F-test statistic. Feeding Acid Buf at either level or BICARB increased average pH relative to control. On average, pH increased from 5.95 to 6.12 by feeding Acid Buf. Subsequently, minimum pH and maximum pH were also higher when buffers were fed as would be expected with higher average pH. Interestingly, magnitude of pH change and pH variance were not influenced by dietary treatment. Some of the common measurements to assess acidosis using our continuous data acquisition system are time and area of ruminal pH below 5.6 and 5.3. Area of ruminal pH below these points is related to both magnitude and time (minutes) spent below either 5.6 or 5.3. While these numbers are an average value, they tend to give insight into when cattle go "off feed." In this experiment, time (in minutes) was influenced by treatment. Rumen pH from cattle fed HIBUF and BICARB was below 5.6 for less time than CON fed heifers. Feeding LOWBUF was intermediate to HIBUF and CON but decreased time below 5.6. Data on area below 5.6, time below 5.3, and area below 5.3 support the observation that feeding buffers prevented both magnitude and time below pH of either 5.6 or 5.3.

Intake Behavior

Intake behavior and meal consumption data are presented in Table 3. A significant treatment effect was observed for DMI ($P = 0.02$). Feeding either Acidbuf or Rumensin alone or in combination resulted in lower DMI compared to CON fed heifers. Heifers consuming BICARB were intermediate in DMI compared to CON and Acid Buf treatments. There appeared to be an effect of level of Acid Buf on feed intake. As Acid Buf inclusion into the diet increased, there was a depression in consumption relative to CON fed heifers. The other intake behavior variables including rate of intake (% per hour), number of meals or meal size and time spent eating during the day or a meal were not influenced by dietary treatment. All variables had trends consistent with Rumensin and Acid Buf decreasing meal size and the average size of the largest meal. Perhaps the benefit of feeding Acid Buf is that meal size decreases and time spent eating increases. While not statistically significant, the consistent response across treatments for these variables may be "biologically significant," because of the effects that ruminal acidosis has on feed intake and subsequently animal performance.

Table 2. Effects of added Rumensin or dietary buffers on ruminal pH of heifers fed a high concentrate finishing diet.

	Dietary Treatment[1]							
Parameter	CON	LOWBUF	HIBUF	BICARB	RUM	RUM+BUF	SEM	*F*-Test
Average pH	5.95^{ab}	6.13^{cde}	6.11^{cd}	6.25^{e}	5.91^{a}	6.06^{bc}	0.14	<0.01
Minimum pH	5.34^{a}	5.51^{bcd}	5.53^{cd}	5.63^{d}	5.37^{ab}	5.42^{abc}	0.12	0.02
Maximum pH	6.65^{ab}	6.79^{cde}	6.75^{bcd}	6.88^{e}	6.59^{a}	6.74^{bc}	0.09	<0.01
pH change	1.31	1.28	1.23	1.25	1.22	1.32	0.07	0.75
pH Variance	0.120	0.110	0.108	0.113	0.118	0.135	0.02	0.76
Time < 5.6	406^{cd}	268^{abc}	237^{ab}	156^{a}	449^{d}	305^{abcd}	139	0.06
Area < 5.6	106	57	48	26	100	53	38	0.28
Time < 5.3	163	65	51	20	123	35	64	0.45
Area < 5.3	19.3	7.0	5.3	2.1	8.8	1.7	7.4	0.50

[1]CON= no added Rumensin or dietary buffer, LOWBUF= 0.75% DM Acid Buf, HIBUF= 1.25% DM Acid Buf, BICARB= 1.25% DM sodium bicarbonate, RUM= 28 grams/ton Rumensin, RUM+BUF= 28 grams/ton Rumensin and 0.75% DM Acid Buf.
[abcde]Means in a row with unlike superscripts differ ($P < 0.10$).

Table 3.Effects of added Rumensin or dietary buffers on feed intake and water consumption of heifers fed a high concentrate finishing diet.

	Dietary Treatment[1]							
Parameter	CON	LOWBUF	HIBUF	BICARB	RUM	RUM+BUF	SEM	*F*-Test
Intake								
DMI, lb/day	23.5^{e}	21.2^{abc}	20.0^{a}	22.0^{bcde}	20.9^{abcd}	21.0^{ab}	1.3	0.02
Rate, %/hour	25.3	25.2	22.7	27.7	25.2	25.0	2.3	0.75
Meals								
No./day	5.6	5.8	5.7	5.5	5.6	5.5	0.5	0.99
Avg., lb	6.65	5.87	4.90	5.60	5.52	5.95	0.9	0.65
Largest, lb	16.5	15.2	12.3	14.7	14.2	15.1	1.4	0.18
Time spent eating								
Total, min./day	806	823	849	821	808	796	52.7	0.98
Avg. meal, min.	180	166	154	160	153	172	20.4	0.91
Water intake, L/day	28.6	28.0	26.5	27.2	30.7	29.6	2.6	0.65

[1]CON= no added Rumensin or dietary buffer, LOWBUF= 0.75% DM Acid Buf, HIBUF= 1.25% DM Acid Buf, BICARB= 1.25% DM sodium bicarbonate, RUM= 28 grams/ton Rumensin, RUM+BUF= 28 grams/ton Rumensin and 0.75% DM Acid Buf.
[abcde]Means in a row with unlike superscripts differ ($P < 0.10$).

Differences in water intake between dietary treatments were not observed (Table 3). This may indicate that cattle experiencing acidosis do not consume water differently, or that animals in our experiment were not experiencing enough acidosis to cause changes in water intake patterns.

VFA Analysis

Analyses of volatile fatty acids yielded similar results among dietary treatments. Total VFA was not different across treatments, averaging 105 m*M* (data not shown). Individual VFA was not influenced by diet treatment, suggesting little effect of buffer on VFA composition being produced in the rumen. Surprisingly, Rumensin did not decrease the acetate:proprionate (A:P) ratio as expected. As a general rule, feeding Rumensin will increase propionate production resulting in A:P ratios of 1.6 to 2.0. In previous experiments evaluating Rumensin, the control-type diets containing no Rumensin would have A:P ratios in the range of 2.0 to 2.4. It appears that CON fed cattle did not respond in this experiment. The periods in this experiment were 14 days, with only 9 days of adaptation. Our design did not include inoculation of cattle with rumen fluid from cattle fed no Rumensin or buffer. Both of these issues may have had an impact on the heifers fed CON in this experiment. The concern is any carryover effect of either Rumensin or buffers when heifers are switched to CON diet, particularly for VFA production data which is dependent on the microbial population. These populations are dynamic and 9 days of adaptation should be adequate, but this may have been an issue given the data for heifers when fed CON.

Because no interactions were observed between dietary treatment and time of day, main effect of time data are illustrated in Figure 1. Heifers were fed once daily at 0800 hour. As expected, total VFA production increased during the day with peak production between 5.5 and 8.5 hours post feeding. Composition as well as amount produced changed over time. Molar percentages

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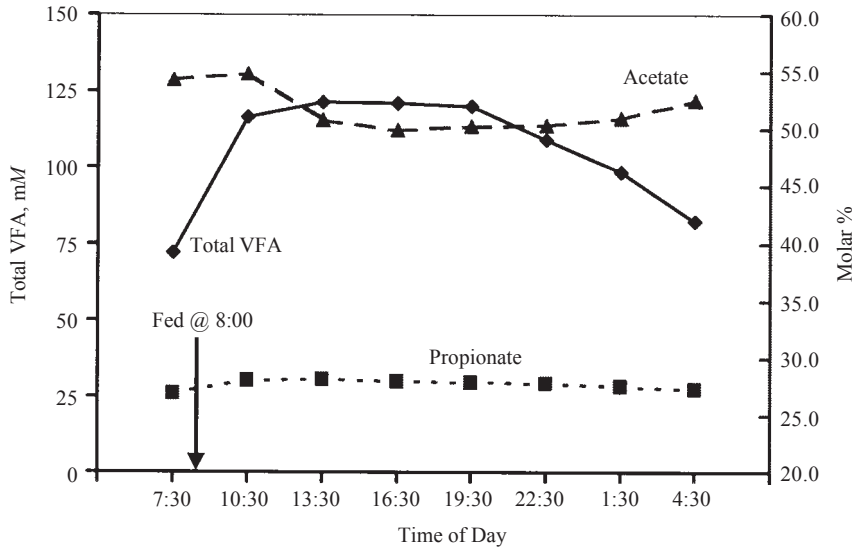

Figure 1. Schematic representing change over time across all treatments for total VFA concentration (m*M*) and molar percentages of acetate and propionate. Heifers were fed at 8:00 daily.

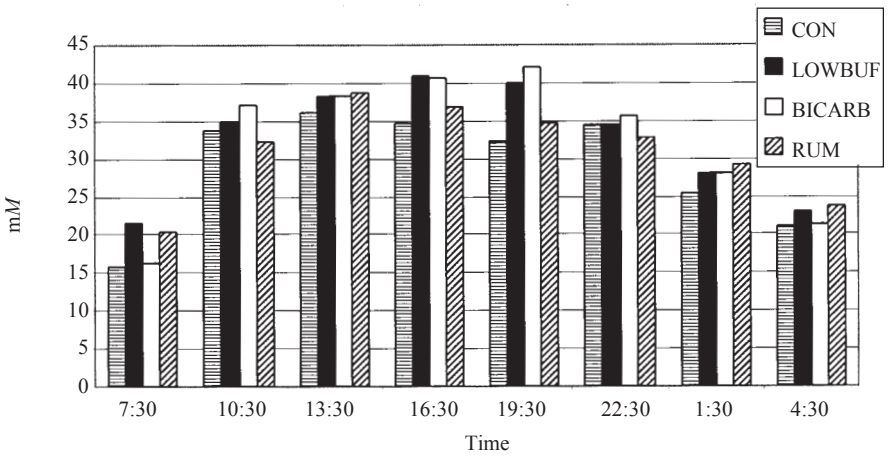

Figure 2. Propionate concentration (m*M*) for CON= no added Rumensin or dietary buffer, LOWBUF= 0.75% DM Acid Buf, BICARB= 1.25% DM sodium bicarbonate, and RUM= 28 grams/ton Rumensin across time of day. Time of feeding was 8:00.

of acetate were highest (54.3%) before feeding (measured at 0730 hour) and lowest 8.5 hours post feeding at 49.9% of total VFA. Propionate production responded similar to total VFA; however, molar percentage was the inverse of acetate with highest percentages 5.5 to 8.5 hours post feeding (30.6%) and lowest prior to feeding at 0730 hour. Figure 1 demonstrates the change in total VFA (m*M* concentration) and molar percentages of acetate and propionate over time of day. Presumably, total VFA and propionate responses indicate that starch utilization is greatest at 5.5 to 8.5 hours following feeding, which would be expected. Then, less substrate and certainly less starch are available over the night and early morning as indicated by total VFA and acetate. During this time, rumen pH increases, total VFA decreases and acetate increases as a percentage of total VFA. Because of these changes in acetate and propionate production, the A:P ratio is lowest 5.5 to 8.5 hours post feeding at 1.78 and highest just prior to feeding at 2.24. However, feeding Rumensin or Acid Buf increased propionate prior to feeding, during times of high A:P ratios (Figure 2).

In summary, feeding Acid Buf and bicarbonate increased rumen pH when heifers were fed a finishing diet containing an 80:20 mixture of high-moisture corn:dry rolled corn. However, DMI was decreased by feeding Acid Buf. Therefore, the higher pH observed with heifers fed Acid Buf may be due to lower DMI, or presumably a combination of buffering and lower intakes. Based on rumen fluid samples over a 24-hour period, it is unclear whether Acid Buf will result in similar performance in production situations. Given the positive attributes of Rumensin in mediating DMI in the feedlot, lower intakes or intake control may be a benefit of feeding Acid Buf if gain is maintained. As for level of Acid Buf, there appeared to be little change between the 0.75 (LOWBUF) and 1.25 % (HIBUF) Acid Buf treatments, except for intake. With the observed DMI in this experiment, feeding LOWBUF resulted in 72.1 grams per day consumption of Acid Buf; whereas the HIBUF led to 113.4 grams per day of consumption. Further evaluation of Acid Buf with concentrations up to 0.75% in production settings would be beneficial.

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Feeding Kelp Meal in Feedlot Diets

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Benefits of supplemental kelp meal for receiving cattle or cattle under heat stress were inconclusive.

Summary

Three trials were conducted to assess the effects of feeding kelp meal to feedlot cattle. In Trial 1, two commercial feedlots were utilized to determine the effects of kelp meal fed to finishing steers exposed to heat stress. Trial 2 was conducted to evaluate the effects of feeding kelp meal in receiving feedlot steer diets. Trial 3 assessed the effects of kelp meal on performance and carcass characteristics when finishing feedlot heifers were exposed to heat stress. Panting scores were reduced in commercial pens of cattle fed kelp meal while dry matter intakes were maintained. Water intake and dry matter intake were not altered when receiving feedlot steers were fed kelp meal. Physiological responses to heat stress were not altered when finishing heifers were fed kelp meal.

Introduction

Kelp meal has been incorporated into supplements for cattle and swine. Benefits of feeding kelp meal have been hypothesized due to its high mineral and electrolyte content. Research conducted in Missouri and Texas indicated beef cattle grazing infected tall fescue pastures and supplemented with kelp meal had improved immune status and performance, while shelf life of meat products from supplemented steers was increased.

The objectives of these trials were to determine the effects of feeding kelp meal to receiving feedlot steers and finishing steers and heifers on water intake, performance, carcass characteristics and the animal's physiological response to heat stress.

Procedure

Trial 1

Steers in two commercial feedlots (1277 steers, 3 pens/treatment) were used to evaluate effects of feeding finishing steers kelp meal (KM) on heat stress. Kelp meal (Tasco™ -14), *Ascophyllum Nodosum,* is a pure source of seaweed meal harvested off the North Atlantic Coast of Canada and Europe. Tasco™ -14 is approximately 22% ash on a dry matter basis. Feedlots were located in Northeast Nebraska, approximately 20 miles apart. Treatments were control (no KM; CTRL) or KM at 2.5 % of diet DM (2.5KM). Feedlot operators applied treatments to pens. Trial monitors were unaware of treatment allocation until the trial was complete. Trial days were grouped into 3 periods: pre-treatment (July 3 through July 9), treatment (July 10 through July 19) and post-treatment (8 days after KM was removed). Daily feed intake was recorded and weather data were downloaded from the Northeast Research and Extension Center weather station near Concord, Neb. Behavior data were collected between 1400 and 1600 hour on July 6, July 13 and July 22. Behavior data consisted of panting scores (PS), 0 = no panting; 1 = slightly elevated respiration rate; 2 = moderate respiration rate accompanied by drool or saliva present around mouth; 3 = elevated respiration rate accompanied by moderate amounts of saliva present and/or open mouth; 4 = elevated respiration rate accompanied by open mouth and/or protruding tongue. Infared surface body temperature and PS were recorded on equal number of black, white and red hided cattle per pen. Bunching scores were assigned to pens, 0 = not bunched, 1 = < 10%, 2 = 11 to 25%, 3 = 26 to 50%, 4 = 51 to 75%, and 5 = 76 to 100% bunched.

Table 1. Composition of the control (CTRL) and 1% kelp meal (1KM) in trial 2 receiving study.

	CTRL	1KM
Ingredients		
Alfalfa hay	18	18
Corn silage	15	15
Corn	42	41
Corn bran	20	20
Liquid supplement	4	4
Kelp meal[a]	—	1
Composition		
NE_m, Mcal/lb	.93	.92
NE_g,Mcal/lb	.54	.54
Crude protein, %	13	13

[a]Farmland Industries, Tasco - 14

Trial 2

Two hundred and forty crossbred steer calves were used in a receiving trial at the University of Nebraska Northeast Research and Extension Center, Concord, Neb. Steers arriving on Oct. 24, 2001 were weighed, processed and assigned randomly to pens, (10 head/pen) on Oct. 25. Pens (n=12) were assigned randomly to either 1) CTRL or 2) KM for four days at 1.0% of diet DM (1KM) with the intent to supplement levels needed to replenish electrolytes depleted due to shipping stress. Receiving diets and composition are shown in Table 1. Supplementation began on Oct. 28, 2001. Data were collected Oct. 26, 2001 through Nov. 15, 2001 and consisted of initial weight and final weight, DMI and water intake.

(Continued on next page)

Trial 3

Ninety-six black hided Angus crossbred yearling heifers were received at the University of Nebraska Northeast Research and Extension Center, Concord, Neb on June 26, 2001. Heifers were weighed, processed and assigned randomly to pens (8 head/pen). Pens (n = 12) were allocated randomly to treatment. Treatments were CTRL, kelp meal fed at 1.0% diet DM for two weeks (1KM) and kelp meal fed at 0.17% diet DM (.17KM) throughout the feeding period. The two different levels of KM were designed with the intent of 1KM steers consuming the same amount of KM as .17KM steers for the trial. The 1KM treatment was applied from July 1 through July 14. Kelp meal was hand mixed into the ration at the bunk. Stowaway XTI data loggers were used to record tympanic temperature during heat stress periods. Tympanic temperatures were obtained from two heifers/pen. Behavior data were recorded between 1500 and 1700 hour and consisted of PS, fly agitation score and bunching score. Bunk scores were recorded at 1100 and 1500 hour. Feed intake was recorded daily and body weights were obtained on days 0, 20, 47 and 69. Heifers were commercially slaughtered on day 70. Hot carcass weight, liver abscess scores, 12th rib fat thickness, USDA yield grade and USDA marbling scores were obtained. Average daily gain and feed efficiency were calculated based on 63% dress.

Performance, carcass characteristics and physiological data were analyzed using General Linear Models procedures of SAS. Least square means were used to separate pen means. Behavior data and liver abscess scores were analyzed using Chi-Square analysis.

Table 2. Climatic Conditions during Trial 1.

Period	Temperature, °F	Relative humidity, %	Wind speed miles/hour	THI[a]
Pre-treatment				
Average	74.8	80.1	8.5	72.3
Maximum	82.8	96.1	11.8	78.0
Minimum	66.8	64.1	5.1	66.5
Treatment				
Average	78.8	67.1	7.7	73.0
Maximum	91.9	93.3	13.5	80.7
Minimum	65.6	40.8	1.8	65.4
Post-treatment				
Average	64.9	77.6	5.4	62.9
Maximum	74.9	99.6	7.6	70.8
Minimum	54.9	53.6	3.2	54.9

[a]Temperature humidity index = T_a - (0.55 - (0.55*(RH/100))) * T_a - 58)

Table 3. Effect of kelp meal supplementation fed at 1% of diet DM (1KM) in receiving steer diets, Trial 2.

	Control	1KM	SE	P-value
Performance, lb				
Initial weight	621	619	7.1	NS
Final weight	726	725	6.8	NS
ADG	4.46	4.47	0.1	NS
DMI, lb				
Treatment	13.85	13.78	0.17	NS
Post-treatment	21.32	21.12	0.23	NS
Average	18.06	18.38	0.26	NS
Water intake, gal/head				
Treatment	3.28	3.37	0.15	NS
Post-treatment	4.98	4.75	0.19	NS
Average	3.67	3.53	0.07	NS

Table 4. Effects of kelp meal supplementation on performance and carcass traits of finishing beef heifers in Trial 3.

	Control	1KM[a]	.17KM[b]	SE	P-value
Performance, lb					
Initial weight	958	958	955	2.3	NS
Final weight[c]	1217	1191	1192	12.1	NS
ADG	3.75	3.38	3.43	0.18	NS
DMI	21.01	21.33	20.66	0.33	NS
Feed:gain	5.66	6.39	6.01	0.32	NS
Carcass Characteristics					
HCW, lb	767	751	751	7.76	NS
Rib fat, in	0.43	0.43	0.40	0.03	NS
Marbling[d]	547	561	572	21.7	NS
Yield grade	2.13	2.19	2.17	0.11	NS

[a]1KM, heifers were fed kelp meal at 1.0% of diet DM for two weeks.
[b].17KM heifers were fed kelp meal throughout the trial at 0.17% diet DM.
[c]Final weight was calculated by adjusting hot carcass weight to a common dressing percentage = 63%.
[d]Marbling score: 500 = small (low choice), 600 = modest (average choice).

Results

Trial 1

Climatic data, recorded from the weather station at Concord, indicate during the pre-treatment and treatment periods steers were exposed to *Danger* conditions based on the Livestock Conservation Institute-temperature humidity index (THI; Table 2). According to Mader and Davis (2002 Plains Nutrition Council Spring Conference, pp 113-114) implementation of emergency heat stress strategies are advised when THI was> 79. Behavior data were collected during the hottest part of the day (1400-1600 hour). The THI were: pre-treatment = 78.0 (alert); treatment = 80.7(danger) and post-treatment 70.8 (normal). During the treatment period, PS based on individual steer observations differed (P = 0.08) with 54% of

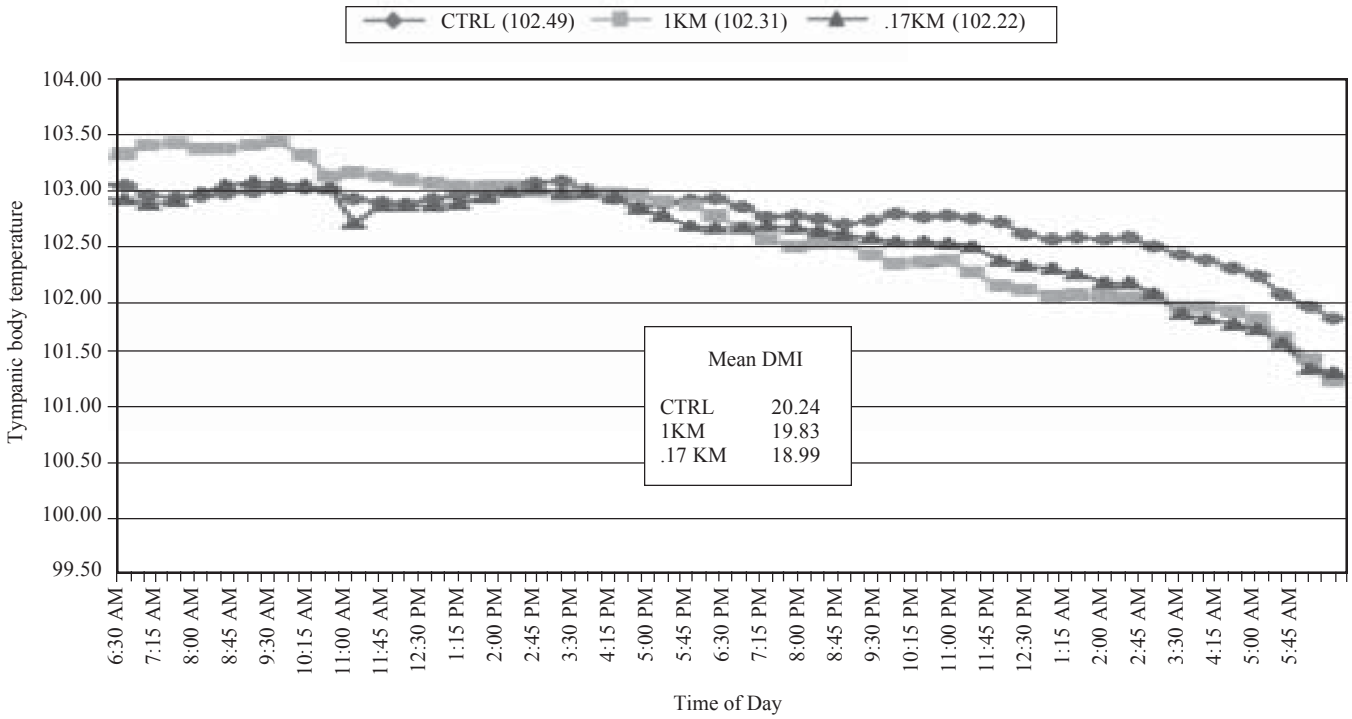

Figure 1. Effects of feeding kelp meal on tympanic body temperature, ºF (P > 0.05) and mean DMI for the period body temperature was obtained.

CTRL steers and 33% of 2.5KM steers had PS > 2. Panting scores based on an estimated average for the pen differed (P = 0.001) with 84% CTRL and 68% 2.5KM steers had PS > 2. Bunching scores were not different (P > 0.05). Surface body temperatures were 103.8, 102.4 and 93.9° F, respectively, for the periods with no treatment effect or treatment x period interactions (P > 0.05) found. Body weight was different among the pens. Therefore, intake was analyzed with pre-treatment weight as the covariate (Table 2). During the treatment (19.69 and 19.82 lb) or six-weeks post treatment period (22.87 and 23.06 lb) no difference (P > 0.05) in DMI was observed between steers fed CTRL and 2.5KM, respectively. Feeding kelp meal during periods of heat stress reduced the percentage of steers with panting scores greater than PS1 but did not alter DMI.

Trial 2 and Trial 3

In Trial 2, performance, DMI or water intake (Table 3) in receiving steers fed KM or CTRL diets were not affected (P > 0.05).

In Trial 3, heifer performance, DMI and feed efficiency were not different (P > 0.05) among treatments (Table 4). Numerically, heifers fed CTRL diets had the greatest gains and were the most efficient compared to heifers supplemented with KM. Dry matter intake was greatest for 1KM heifers. There were no differences (P > 0.05) in HCW, 12th rib fat thickness, marbling score, liver abscess score or USDA yield grade among treatments. Bunk score, PS and degree of fly agitation were not different (P > 0.05) among treatments. Heifers fed CTRL diets were (P < 0.06) not bunched before noon, while heifers fed .17KM diets were not (P < 0.05) bunched in the afternoon. During the heat of the day, feeding a low level of kelp meal was beneficial in keeping heifers from bunching indicating they were more comfortable than heifers not receiving kelp meal. Tympanic body temperature did not differ (P > 0.05) among treatment groups (Figure 1).

Performance and carcass characteristics were not enhanced by feeding kelp meal. In commercial feedlots, feeding kelp meal at 2.5% of diet DM reduced panting scores during periods of heat stress without suppressing performance. However, in Trial 3 panting score was not altered by feeding kelp meal. Benefits of feeding receiving cattle or cattle under heat stress kelp meal was inconclusive in regards to enhancing performance or alleviating physiological responses due to heat stress.

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Summer vs. Winter Growth Promotant Strategies for Intact Yearling Heifers

Wanda Kreikemeier
Terry Mader[1]

Growth promotant strategy by season interactions were not found for gain, efficiency of gain or carcass traits.

Summary

A winter and a summer trial were conducted to evaluate growth promoting strategies among season for yearling heifers fed feedlot finishing diets. Two hundred seventy Angus crossbred intact yearling heifers were used for each trial. Daily dry matter intake and daily water intake were recorded and average daily gain and feed efficiency were calculated. A growth promotant by season interaction was found for dry matter intake only. Performance was improved in both summer and winter when a growth promoting system was used. In the summer, adding melengestrol acetate to estrogenic and androgenic implants strategies tended to stimulate DMI, while in the winter DMI was suppressed by the addition of melengestrol acetate. Heifers had higher gains and intakes in the winter but more efficient gain in the summer.

Introduction

Growth promoting systems have been implemented by beef cattle producers for over 30 years. Approximately 96% of the finished beef cattle in the United States have received a growth promoting implant at least once in their lifetime. Estrogenic and androgenic implants have been reported to increase average daily gain 5 to 15% and improve feed efficiency 5 to 10%. Growth promoting strategies involving melengestrol acetate (MGA) and anabolic implants for both feedlot heifers and steers have been studied extensively by industry and university researchers. However, there is minimal research evaluating the efficiency of growth promoting systems across seasons.

The objective of this study was to evaluate the effect of growth promotant implant strategies with and without MGA on performance and carcass characteristics for intact yearling feedlot heifers in summer compared to winter.

Procedure

Winter Experiment

Two hundred seventy Angus crossbred, intact yearling heifers (mean BW = 745 lb) were purchased from western South Dakota in early November. Heifers were pregnancy checked prior to arrival at the University of Nebraska Northeast Research and Extension Center, Concord, Neb. Upon arrival, November, 1999, heifers were given free choice water and a receiving diet. The receiving diet contained chlortetracycline (CTC) administered at 2 g/head/day for 7 days. Heifers were processed two weeks after arrival and included: weighing, palpating for existing implants, vaccinating with Bar-Vac-7/Somnus® for clostridial organisms and Elite 4® (Boehringer Ingelheim Animal Health, Inc., St. Joseph, MO), deworming and treating for external parasites (Cydectin®; Fort Dodge Animal Health, Overland Park, KS).

On Dec. 8, 1999, all heifers were weighed and sorted into their respective blocks. This weight was used to assign heifers randomly to pens (9 head/pen) within block. Blocks 1, 2 and 3 were different alleys in the feedlot and are designed with different airflow patterns. Block 1 consisted of 6 pens and blocks 2 and 3 consisted of 12 pens. Pens within blocks were assigned randomly to treatments; block 1 consisted of 1 pen/treatment and blocks 2 and 3 had 2 pens/treatment/block. Treatments were: control, estrogenic implant, E; (Compudose®; 24 mg Estradiol - 17β; Vetlife, West Des Moines, IA), androgenic implant, TBA (Finaplix-H®; 200 mg TBA; Intervet, Inc., Millsboro, DE), E + TBA; ET, (Compudose® in one ear and a Finaplix-H® implant in the other ear), MGA (MGA®200 Premix; Pharmacia Animal Health, Kalamazoo,

Table 1. Step-up and Finishing Diets for Winter and Summer Trials and Diet Composition.

	Dry Matter Basis				
	1	2	3	4	5[a]
Ingredients, %					
Alfalfa Hay	40.0	28.0	15.5	10.0	5.0
Corn Silage	12.0	12.0	15.0	10.0	5.0
Dry Rolled Corn	42.5	54.5	61.0	77.5	81.5
Soybean Meal	—	—	—	2.0	2.0
Dry Supplement	1.0	1.0	2.0	2.0	2.0
Liquid Supplement	4.5	4.5	4.5	4.5	4.5
Composition					
Dry Matter, %	69.3	70.0	67.8	72.8	78.5
Crude Protein, %	14.6	13.6	13.6	13.2	12.8
Calcium, %	1.15	0.99	0.84	0.76	0.67
Phosphorus, %	0.29	0.31	0.33	0.33	0.34
NE_m, Mcal/lb	0.75	0.80	0.85	0.88	0.91
NE_g, Mcal/lb	0.50	0.55	0.59	0.62	0.65[a]

[a]5 was the finishing ration.

MI) and ET implant and fed MGA, ETM. Heifers were adapted to grain diets using 5 step-up rations (Table 1) with step 5 as the finishing ration. All heifers were on the finishing ration at the start of the trial and were fed once a day at 0800 throughout the experiment. Two dry supplements, in pellet form, were used in the trial one with MGA formulated to be fed at .45 mg/head/day and one supplement without. The dry supplements contained Rumensin 80® at 25 g/T and Tylan 40® at 8.33 g/T (Elanco Animal Health, Indianapolis, IN). On Dec. 9 heifers in blocks 1 and 2 were weighed, implanted and sorted to their respective trial pens. Heifers assigned to Block 3 were weighed, implanted, bled (4 heifers/pen) and sorted on Dec. 10. Heifer non-shrunk initial weights were obtained by averaging the Dec. 8 and Dec. 9 individual weight for Blocks 1 and 2, and by averaging the Dec. 8 and Dec. 10 individual weight for Block 3. Individual full weights were obtained at day 35, 70 and 104, the day before harvest.

Water intake was recorded daily when bunks were read, prior to feeding. On the day of harvest, hot carcass weight (HCW), and liver scores were recorded. USDA quality grade, marbling score, USDA yield grade, 12th – rib fat thickness, kidney, pelvic and heart fat percentage (KPH) were recorded after a 24-hour chill. Fill differences among treatment groups were corrected by adjusting final weights and corresponding performance to a common dressing percentage, 63%.

Summer Experiment

In early spring, 270 Angus crossbred, intact yearling heifers (mean BW = 745 lb) were received from western South Dakota and were of similar type and kind as used in the winter trial and managed similar to heifers described in the winter experiment. On June 13, 2001 heifers were allotted randomly to 30 pens (five pens/treatment; nine heifers/pen) and pens were assigned randomly to treatments, as described in the winter experiment. Non-shrunk initial weights were the average of consecutive weights taken over a two-day period. Individual full weights were taken on day 34, 68 and 104 (day prior to harvest). Heifers were stepped up on feed as explained in the winter trial (Table 1). All heifers were fed monensin and tylosin throughout the trial.

During the summer experiment one heifer died on day 74 and was not included in statistical analysis. On the day of harvest, HCW and liver scores were recorded as described in the winter trial. Carcass data were collected after a 24-hour chill using procedures outlined in the winter experiment.

Statistical Analysis

Performance, and carcass characteristics were analyzed using Mixed Models procedures of SAS. Means were separated using least square means. Quality grade and liver abscess scores were analyzed using Chi-Square analysis.

Table 2. Main effects of season on feedlot heifer performance and water intake.

	Winter	Summer	SE
Weight, lb.			
Initial	845	846	1.26
Day 35	990[c]	953[b]	2.72
Day 69	1111[c]	1053[b]	3.91
Final[a]	1168[e]	1138[d]	3.94
Average daily gain, lb/day			
0 - 35	4.13[c]	3.14[b]	0.08
0 - 69	3.80[c]	3.05[b]	0.06
0 - 104	3.11[c]	2.81[b]	0.04
Feed:gain			
0 - 35	5.80[b]	6.38[c]	0.14
0 - 69	6.30	6.40	0.07
0 - 104	7.60[c]	7.29[b]	0.08
Water intake, gal/day			
0-35	5.01[b]	8.48[c]	0.24
0-69	4.76[b]	8.33[c]	0.25
0-104	4.74[b]	8.24[c]	0.27

[a]Adjusted to a common dressing percent of 63%.
[b,c]Means are different P < 0.01
[d, e]Means are different P < 0.05

Table 3. Main effects of season on feedlot heifer dry matter intake, lbs.

	Winter	Summer	SE
0 - 35	23.68[b]	19.55[a]	0.17
35 - 69	24.00[b]	19.20[a]	0.17
0 - 69	23.84[b]	19.36[a]	0.16
69 - 104	22.86[d]	22.33[c]	0.16
0 - 104	23.57[b]	20.41[a]	0.15

[a,b]Means are different P < 0.01
[c,d]Means are different P < 0.05

Results

There were no (P > 0.05) growth promotant by season interactions for performance and water intake of yearling heifers. Initial weights were not different (P > 0.05) for winter and summer-fed heifers (Table 2). Heifers fed during the winter trial finished 29 lb heavier (P < 0.05) than summer-fed heifers (Table 2). When compared to summer-fed heifers, average daily gain was greater (P < 0.01) for winter-fed heifers for each period, with the exception of the final 35 days on feed (Table 2). The last 35 days on feed summer-fed heifers gained 0.68 lb/day more than winter-fed heifers. During both seasons, feed efficiency declined for the last 35 days on feed. During this period heifers fed in the summer were more efficient (P < 0.01) than winter-fed heifers. Water intake by period was consistently 3.50 gal/day greater (P < 0.01) for summer-fed heifers than for winter-fed heifers (Table 2). Heifers fed in the

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winter had higher (P < 0.01) DMI than summer-fed heifers (Table 3). Even so, during the last 35 days on feed summer-fed heifers increased DMI (19.36 to 22.33) while winter-fed heifers decreased DMI (23.84 to 22.86; Table 3).

Initial weights were the same (P > 0.05) across all growth promotants treatment groups (GP) (Table 4). Heifers not receiving GP had comparable final weights to E and TBA implanted heifers and lower (P < 0.05) final weights than all other GP (Table 4). Estrogen and TBA combination treated heifers had the same (P > 0.05) final weight as ETM heifers and a higher (P < 0.05) final weight than all other GP (Table 4). Control heifers had the lowest (P < 0.05) ADG and ET and ETM had the highest (P < 0.05; Table 4). Overall, control heifers were the least (P < 0.05) efficient in feed converstion (Table 4). Estrogen and TBA combination, MGA and ETM had the most (P < 0.05) efficient gains while E and TBA were intermediate (Table 4).

Mean water intake was 6.49 gal/day and was not different (P > 0.05) across GP (Table 4). Dry matter intake 0 to 104 was not different (P > 0.05) across GP (Table 5). However, during the last 35 days on feed ET and ETM had greater DMI (P < 0.05) than control and MGA groups (Table 5). There were a GP by season interactions (P = 0.12) for DMI from 0 to 104 days (Table 5).In the summer, adding MGA to ET tended to stimulate DMI while, in the winter DMI was suppressed by the addition of MGA (Table 5).

There were no GP by season inter–actions for carcass characteristics. Both hot carcass weight, and marbling score were greater (P < 0.01) in the winter when compared to summer (Table 7). However, winter-fed heifers had 0.04 in. less (P < 0.05) rib fat than summer fed heifers(Table 7). There was no difference (P > 0.05) in liver abscess score across growth promotant strategy or season. Percentage kidney, pelvic and heart fat were not different (P > 0.05) between seasons (Table 7) or among GP (Table 8). Marbling score was least (P <0.01) for ET heifers and feeding MGA to ET implanted heifers (ETM) improved marbling score when compared to marbling

Table 4. Effects of growth promotants on feedlot heifer performance and water intake.

	Control	E	TBA	ET	MGA	ETM	SE
Weight, lb.							
Initial	845	846	848	844	845	845	2.18
0 - 35	958[b]	964[bc]	974[cde]	979[de]	966[bcd]	986[e]	4.71
0 - 69	1065[b]	1075[bc]	1086[cd]	1093[cd]	1080[bcd]	1096[d]	6.77
0 - 104[a]	1130[b]	1150[bd]	1148[bc]	1172[e]	1151[cd]	1169[de]	6.82
Average daily gain, lb/day							
0 - 35	3.28[b]	3.43[b]	3.65[bc]	3.89[c]	3.50[b]	4.07[d]	0.15
0 - 69	3.19[b]	3.32[b]	3.45[bc]	3.60[c]	3.39[b]	3.62[b]	0.10
0 - 104	2.74[b]	2.93[c]	2.89[cd]	3.15[e]	2.94[cd]	3.12[de]	0.06
Feed : gain							
0 - 35	6.84[d]	6.59[cd]	5.98[bc]	5.59[b]	6.14[cb]	5.41[b]	0.24
0 - 69	6.88[d]	6.58[cd]	6.26[bc]	6.09[b]	6.28[cb]	6.00[b]	0.13
0 - 104	8.00[e]	7.55[c]	7.59[c]	7.09[b]	7.34[bc]	7.12[b]	0.14
Water intake, gal/day							
0-35	6.72	7.01	6.74	6.97	6.44	6.60	0.42
0-69	6.36	6.96	6.72	6.56	6.23	6.45	0.44
0-104	6.22	6.84	6.71	6.66	6.18	6.32	0.46

[a]adjusted to a common dressing percentage of 63%.
[b,c,d,e]Means are different P < 0.05.

Table 5. Effects of growth promotants on feedlot heifer dry matter intake, lb.

	Control	E	TBA	ET	MGA	ETM	SE
0 - 35	21.86	21.85	21.54	21.66	21.09	21.68	0.30
35 - 69	21.66	21.68	21.42	22.07	21.20	21.59	0.30
0 - 69	21.75	21.77	21.48	21.86	21.13	21.62	0.28
69 - 104	22.08[a]	22.59[ab]	22.60[ab]	23.13[b]	22.12[a]	23.06[b]	0.28
0 - 104	21.91	22.09	21.92	22.34	21.51	22.16	0.26

[ab]Means are different P < 0.05.

Table 6. Growth promotant x season interaction on feedlot heifer dry matter intake, lb.

	Control	E	TBA	ET	MGA	ETM	SE
Summer	20.04[a]	20.35[a]	20.12[a]	20.65[ab]	20.10[a]	21.23[b]	0.52
Winter	23.78[abc]	23.94[bc]	23.71[abc]	24.03[c]	22.92[a]	23.10[ab]	

Interaction P = 0.12
[abc]Means are different P < 0.10.

Table 7. Main effects of season on carcass characteristics in feedlot heifers.

	Winter	Summer	SE
HCW, lb	736[b]	717[a]	2.42
KPH, %	2.31	2.34	0.02
Rib fat, in	0.46[a]	0.51[b]	0.01
Marbling[e]	588[b]	561[a]	5.3
Yield Grade	2.30[c]	2.42[d]	0.04
Choice >, %[f]	86	81	

[a,b]Means are different P < 0.01.
[c,d]Means are different P < 0.05.
[e]400 = slight 0, 500 = small 0.
[f]Chi Square analysis.

Table 8. Effects of growth promotants on carcass characteristics in feedlot heifers.

	C	E	T	ET	MGA	ETM	SE
HCW	712[a]	724[b]	723[ab]	738[c]	725[b]	737[c]	4.19
KPH, %	2.32	2.34	2.31	2.34	2.38	2.25	0.04
Rib fat, in	0.489	0.489	0.477	0.494	0.479	0.482	0.02
Marbling [f]	579[e]	580[e]	594[e]	535[d]	581[e]	578[e]	9.1
Yield grade	2.36	2.39	2.29	2.30	2.46	2.39	0.07
Choice >, %[g]	83.3	84.3	81.1	73.0	86.7	86.4	

[a,b,c]Means are different P < 0.05.
[d,e]Means are different P < 0.01.
[f]400 = slight 0, 500 = small 0.
[g] Chi Square analysis (P = 0.07).

score of ET heifers (Table 8). Growth promoting strategies with both estrogenic and androgenic (ET and ETM) activity had the heaviest ($P < 0.05$) HCW (Table 8). Rib fat, USDA yield grade and percentage USDA choice were not different ($P > 0.05$) among GP (Table 8).

Yearling heifers fed in the winter had heavier final weights and higher ADG and DMI. However, summer-fed heifers were more efficient in feed conversions. Growth promoting systems for yearling fed heifers improved ADG, DMI and overall efficiency. Feeding MGA to heifers implanted with estrogenic and androgenic combinations was found to be beneficial in preventing marbling score depletion. Feeding MGA in combination with implant strategies using estrogenic implants and TBA implants enhance DMI in summer fed yearling heifers but not in winter-fed yearling heifers.

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Body Temperature Changes Associated with Moving Feedlot Cattle

Terry L. Mader[1]

Moving cattle through working facilities requires an expenditure of energy, causing an elevation of average body temperature between 0.5 and 1.4°F.

Summary

In two winter and two summer studies, tympanic temperatures (TT), an indicator of body temperature, were obtained in unrestrained feedlot cattle moved through working facilities. Moving yearling cattle elevated TT between 0.5 and 1.4°F. Effects of cattle movement and handling on body temperature needs to be taken into account when evaluating animal health studies. Furthermore, minimal handling of cattle during hot days is recommended for promoting animal well-being and comfort.

Introduction

In general, cattle are processed (vaccinated, treated for parasites, receive a growth implant, and provided an eartag for identification) within a few days of arriving at the feedlot. In addition, a significant number of cattle are returned to the processing facilities to receive health care or to be re-implanted with a growth promotant. The effect of activity on body temperature is particularly important when it is used as an indicator of health status or when environmental conditions exist which could contribute to heat stress. The objective of these studies was to evaluate effects of cattle movement in the feedyard and quantitate body temperature of animals moved various distances and at different times during the year.

Procedure

Two winter and two summer studies were conducted using yearling feedlot cattle fed a high-energy finishing diet. Studies were conducted in the following order January, February, August and June. In January, five animals from one pen were moved from the pen through the working facilities and back into the pen. Cattle were moved around 0800 and 1500 hour. Total distance moved each time was about 500 feet (250 feet each way). Animals were moved two days and allowed a day of rest (baseline days) before and between the days moved. In February, six animals from one pen were moved from the pen through the working facilities and back into the pen. Cattle were moved only once at approximately 0945 hour. Total distance moved was about 1,000 feet (500 feet each way). Animals were moved two days in a row and allowed a rest (baseline days) the day before and after the days that they were moved. They were moved to the facilities briefly delayed in the working facilities, and returned to the pens. Total moving time was approximately 15 minutes, but varied between 5 and 25 minutes.

In August, eight animals were placed in two pens (four head/pen). On days one and two, one pen of cattle was moved through the working facilities a short distance of about 500 feet and the other pen was moved a longer distance, about 2,000 feet, through the working facilities and back to their pens. Cattle were allowed two days of rest and moved again over the next two days. Moving distance (short vs long) assignments were reversed for each pen of cattle on the second set of moving days. All moves began at approximately 0900 hour.

In June, 18 animals were placed in three pens (six head/pen). On days one and two, cattle from respective pens

(Continued on next page)

were moved through the working facilities a total distance of about 1,000, 2,000 and 3,000 feet, respectively. Cattle were moved only once/day at approximately 0900 hour. Cattle were allowed a day of rest after the second day of moving. In all handling studies, tympanic temperatures were obtained throughout the study period using procedures described below. In all four studies, average animal weight was about 1,050 pounds. In all studies, cattle were not pushed and were allowed to move at a pace they chose. Cattle tended to move at a faster pace (run or trot) versus a slower pace (walk).

In all studies, individual animals were randomly selected from each pen to assess the effect of the imposed treatment on tympanic temperature (TT). In the two winter handling studies, TT were obtained from three animals in the pen. In the summer handling studies, two and four animals/pen were selected in the first and second study, respectively. Tympanic temperature loggers (Stowaway XTI®, Onset Computer Corporation, Pocasset, MA) were placed in the left ear of the selected animal. Placement of the logger into the ear consisted of attachment of a thermistor to the data logger and inserting the thermistor approximately four to five inches down the ear canal until the tip was located near the tympanic membrane of the animal. The datalogger was wrapped in gauze and secured to the ear using self-adhesive bandages (Vet-Wrap and athletic tape). Tympanic temperature was obtained once every 15 minutes in the January and February studies, and every two and 1.5 minutes in the August and June summer studies, respectively. After loggers were secured to the ear, all steers were returned to their respective pens. The handling studies were initiated the day following placement of the data loggers. Data loggers were removed the day following the last time cattle were moved or rested, depending on study design.

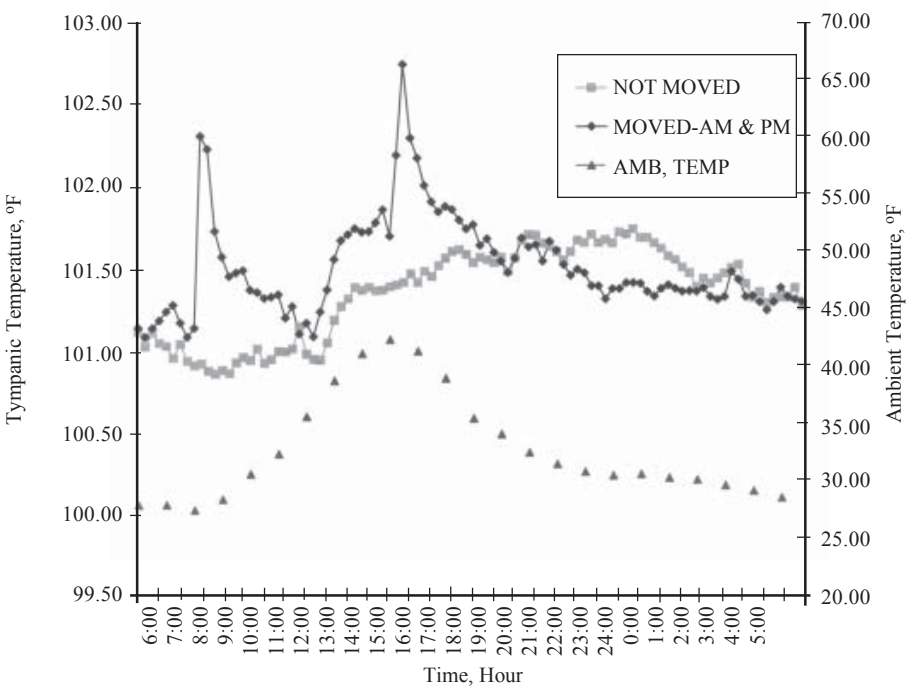
Ambient temperature for each study was obtained from the High Plains Climate Center automated weather station about 1 mile northwest of the feedlot facilities.

Tympanic temperature data were analyzed using analysis of variance proce-

Table 1. Effects of moving cattle through working facilities on tympanic temperature.

	Tympanic temperature (TT), °F			
	Baseline	Initial peak	Post-peak low[a]	Post-low high[b]
January study				
Morning move				
Distance, feet				
0[c]	100.9	100.9	101.2	101.4
500	101.1	102.3	101.1	101.9
SE	0.1	0.1*	0.1	0.1*
Time, hour[c]	0800	0815	1145	1445
Afternoon move				
Distance, feet				
0[c]	101.4	101.4	101.6	101.7
500	101.7	102.7	101.6	101.7
SE	0.1	0.1*	0.1	0.1
Time, hour[c]	1500	1530	1900	1945
February study				
Distance, feet				
0[c]	102.0	102.0	102.4	102.9
1,000	102.0	102.5	102.4	102.7
SE	0.3	0.3	0.2	0.2
Time, hour[c]	0945	1015	1400	1715
August study				
Distance, feet				
0 (for 500 foot move)[c]	101.4	101.4	101.5	102.5
0 (for 2,000 foot move)[c]	101.4	101.4	101.8	102.5
500	101.4	102.0	101.5	102.6
2,000	101.4	102.7	101.8	102.5
Pooled SE	0.1	0.1*	0.2	0.3
Time, hour (for 500 foot move)[d]	0906	0922	1002	1814
Time, hour (for 2,000 foot move)[d]	0906	0928	1136	1812

*Means between moved and non-moved cattle, within a column for respective trial or moving time, differ ($P < .05$).
[a]Low point and/or point at which moved cattle TT becomes to that of cattle not moved (see figures).
[b]Time and TT corresponding to highest TT obtained by moved cattle following post-peak low TT.
[c]Corresponds to time moved cattle TT were recorded.
[e]Time TT was recorded for characteristic associated with moved cattle.



Fgure 1. Tympanic temperatures of cattle moved through working facility in January. Cattle were moved about 500 feet around 0800 hour and 1500 hour.

Table 2. Effects of moving cattle through working facilities (June study)

	Distance moved, feet				
	0	1,000	2,000	3,000	Chi-square *P*-value
Tympanic temperature,°F					
Baseline, 0900 hour	101.4	101.3	101.5	101.5	—
Initial peak[ab]	—	102.6 (.2)	102.8 (.2)	102.9 (.1)	—
Time initial peak occurred, hour	—	0942	0931	0934	—
Post-peak low[b]	—	101.7 (.1)	101.8 (.1)	101.8 (.1)	—
Time post-peak low recorded, hour	—	1052	1112	1137	—
Time cattle returned to pens	—	0934	0937	0945	—
Behavior, % of observations					
Time					
1000					
Standing	19.4	83.3	75.0	83.3	0.01
Lying	36.1	5.6	0.0	0.0	0.02
Head in or over waterer	2.8	5.6	8.3	2.8	0.87
Head in bunk	41.7	5.6	16.7	13.9	0.20
1100					
Standing	55.6	38.9	44.4	55.6	0.91
Lying	2.8	47.2	41.7	38.9	0.13
Head in or over waterer	16.7	11.1	5.6	0.0	0.06
Head in bunk	25.0	2.8	8.3	5.6	0.10
1200					
Standing	80.5	61.1	41.7	58.3	0.13
Lying	2.8	16.7	30.6	22.2	0.20
Head in or over waterer	13.9	13.9	13.9	0.0	0.15
Head in bunk	2.8	8.3	13.9	19.4	0.23
1300					
Standing	77.8	38.9	66.7	72.2	0.85
Lying	11.1	47.2	22.2	22.2	0.89
Head in or over waterer	11.1	13.9	11.1	5.6	0.89
Head in bunk	0.0	0.0	0.0	0.0	—
1400					
Standing	0.0	38.9	44.4	52.8	0.01
Lying	100.0	33.3	44.4	36.1	0.02
Head in or over waterer	0.0	2.8	8.3	8.3	0.11
Head in bunk	0.0	25.0	2.8	2.8	0.72

[a]Means differ from control (0 feet moved) at respective times TT were recorded (P< 0.05).
[b]Parenthetical numbers represent standard error of the mean.

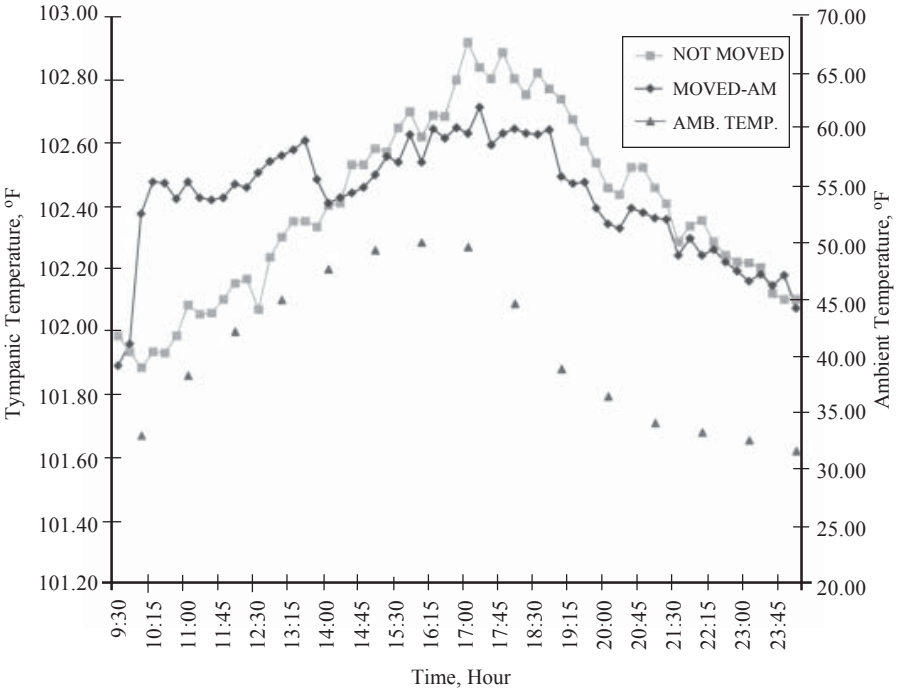


Figure 2. Tympanic temperatures of cattle moved through working facility February. Cattle were moved about 1,000 feet at 0945 hour.

dures for repeated measures (SAS; SAS Inst. Inc., Cary, N.C.). The model included treatment, animal, day and time. Data from the days cattle were rested were used for determining moving treatment TT changes, which occur over time relative to cattle that are not moved. Prestudy TT were used as a covariant in studies is which initial TT were found to be different. Differences among treatments were determined using Fisher's Protected LSD and the PDIFF option. Behavior data were analyzed using Chi-square. Significance was determined based on the Mantel-Haenszel Chi-square test.

Results

In general, mild climatic conditions existed for the time of year these studies were conducted. Tympanic temperatures were increased by moving cattle in the winter both in the morning and afternoon (Figure 1, Figure 2 and Table 1). The process of moving cattle obviously elevates TT and body temperature immediately, most likely through muscle activity. The rate of decline in TT can be very rapid as found in the January study, but may remain constant as shown in the February study. In the first study, non-moved cattle TT remained very low, while in the second study, non-moved cattle TT was rising during the day-time hours. Feeding pattern, cattle disposition, and in-pen activity, as well as ambient climatic conditions, would most likely influence the rate of TT decline.

In the summer studies, the rise in TT was similar to that found in the winter for cattle moved a short distance (Figure 3 and Table 1). In the August study, the rise in TT was nearly doubled for cattle moved longer distances when compared with cattle moved shorter distances. In the June study, TT rises were similar regardless of distance moved. The rise was significant in all cases (Figure 4 and Table 2). In every study, TT of cattle that were moved returns (declines) to points near (below or equal) that of the TT of non-moved cattle before the moved cattle TT begins to rise again. Cattle apparently need to reach a TT level comparable to what would be normal under

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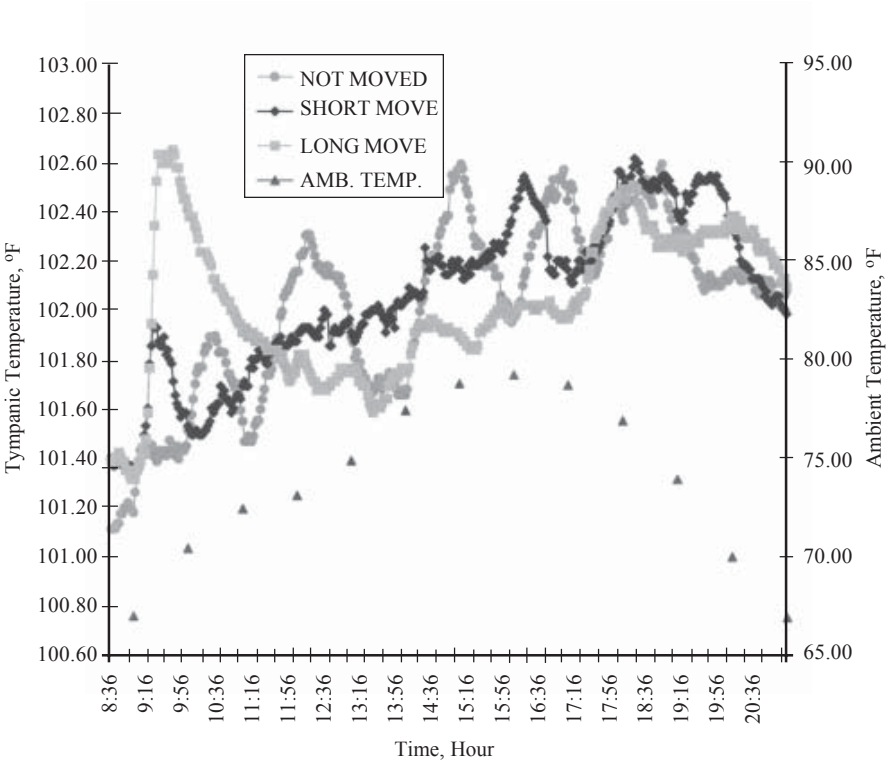

Figure 3. Tympanic temperatures of cattle moved through working facility in August. Cattle were moved about 500 feet (short) or 2,000 feet (long) around 0900 hour.

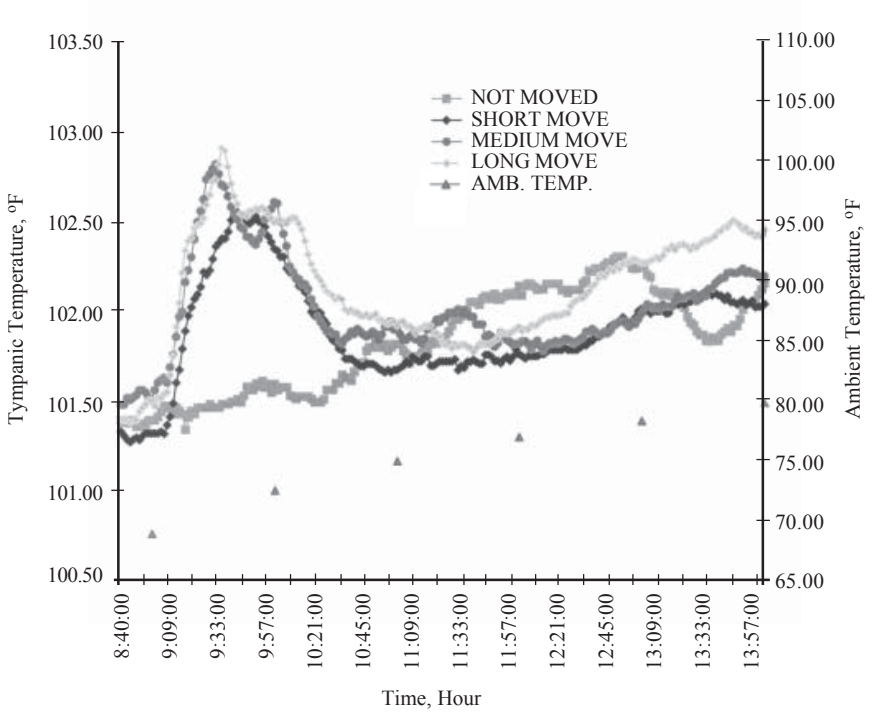

Figure 4. Tympanic temperatures of cattle moved through working facility in June. Cattle were moved approximate distances of 1,000 feet (short), 2,000 feet (medium) or 3,000 feet (long) around 0900 hour.

prevailing conditions before they resume normal eating and other behavior patterns. Also, during short moves, peak TT may occur after cattle are returned to the pen. During longer moves peak TT occurs while the cattle are being moved or possibly in the working facilities (Table 2). In addition, moving affects other post-move activities, which is dependent on distance cattle were previously moved. Particularly the percentage of cattle lying, standing, or at water varied with time of day and previous distance moved. Eating activity (head in bunk) tended to be reduced at 1000 and 1100 hour but increased by noon for cattle moved the farthest distance (Table 2). Interestingly, non-moved cattle were all resting (lying) by 1400 hour while only 33 to 36% of the moved cattle were resting.

Strategies are needed to reduce the detrimental effects of heat stress while maintaining animal productivity. In order to derive maximum benefit, livestock producers must be proactive in their decision-making and must be able to accurately assess the level of stress to which their animals are subjected. Minimal handling of cattle during hot days is a justifiable means to promote animal well-being and comfort. Adjustments for potential rise in body temperature, due to handling, may be needed when assessing animal health status.

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Adjustments for Wind Speed and Solar Radiation to the Temperature-Humidity Index

Shane Davis
Terry Mader[1]

Adjustments to the temperature-humidity index for wind and solar heat can provide a more accurate estimation of heat stress in cattle.

Summary

Data from three separate feedlot finishing trials were combined into one data set to determine wind speed and solar radiation adjustments to the temperature-humidity index equation based on degree of panting and ambient environmental conditions. Regression equations were used to determine the relationship between observed panting and current temperature-humidity index, wind speed and solar radiation for developing correction factors. Based on these calculations, for each 1 mile/hour increase in wind speed, THI should be decreased approximately 1 unit, and for each 3 Langley increase in solar radiation or 10% increase in cloud cover, THI should be decreased approximately 1 unit.

Temperature Humidity Index (THI)

Relative Humidity, %

Temperature, °F	30	35	40	45	50	55	60	65	70	75	80	85
100	84	85	86	87	88	90	91	92	93	94	95	97
98	83	84	85	86	87	88	89	90	91	93	94	95
96	81	82	83	85	86	87	88	89	90	91	92	93
94	80	81	82	83	84	85	86	87	88	89	90	91
92	79	80	81	82	83	84	85	85	86	87	88	89
90	78	79	79	80	81	82	83	84	85	86	86	87
88	76	77	78	79	80	81	81	82	83	84	85	86
86	75	76	77	78	78	79	80	81	81	82	83	84
84	74	75	75	76	77	78	78	79	80	80	81	82
82	73	73	74	75	75	76	77	77	78	79	79	80
80	82	72	73	73	74	75	75	76	76	77	78	78
78	70	71	71	72	73	73	74	74	75	75	76	76
76	69	70	70	71	71	72	72	73	73	74	74	75

THI = Temp – (.55 – (.55 x (RH/100))) x (Temp – 58)

Normal < 74 | Alert 75 - 78 | Danger 79 - 83 | Emergency > 84

Figure 1. Temperature Humidity Index (NOAA, 1976, Operations Manual Letter C-31-76. NOAA Kansas City, MO).

Introduction

The Livestock Weather Safety Index (LWSI) is commonly used as a benchmark to determine the susceptibility of cattle to heat stress, by assigning potentially heat stressed animals into normal, alert, danger and emergency categories. The LWSI is based on the temperature-humidity index (THI), which quantitates environmental conditions using a combination of temperature and relative humidity (Figure 1). Although THI has been effectively used as a heat stress indicator, correction for wind speed and solar radiation are needed.

Solar radiation can greatly influence heat load, while changes in wind speed result in altered convective cooling. Both solar radiation and wind speed alter the ability of the animal to maintain thermal balance. Accounting for these two environmental variables in the temperature-humidity index would greatly improve the applicability of the LWSI under varying environmental conditions.

Procedure

Three hundred sixty feedlot steers were used as the database for this trial. These steers originated from three trials previously reported (Nebraska Beef Reports 2000 and 2001) involving management strategies designed to reduce the effect of heat stress on summertime feedlot performance of cattle. Experiments 1 (84 head) and 2 (96 head) were conducted from June 23 to Sept. 13, 1999 (82 days), while Exp. 3 (192 head) was conducted from June 8 to Aug. 30, 2000 (83 days). Panting scores were assigned to individual animals at 1700 hour by visual observation using the scoring system presented in Table 1. These observations were made on days 9 to 15, 20 to 22, 29 to 31 of Exp. 1 and 2,

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and additionally on days 36 to 37 of Exp. 1 and days 54 to 55, and 68 to 69 of Exp. 2. During Exp. 3, observations were made on days 18 to 19, 29 to 33, 40 to 41, 54 to 55, 58, 61 to 62, and 78 to 79. The combination of these observation times resulted in a total of 5,520 individual panting score assessments.

Weather variables used during this trial are presented in Table 2. All variables (except solar radiation) were collected continuously and compiled hourly using a weather station located in the center of the feedlot facility. Solar radiation was obtained from the High Plains Climate Center automated weather station located .5 mile west and 1 mile north of the feedlot facilities. In order to determine temperature-humidity index (THI), ambient temperature (Ta) and relative humidity (RH) readings were combined using the equation:

$$THI = Ta - (.55 - (.55 \times (RH/100)))*(Ta - 58)$$

A regression equation was developed to determine the relationship between panting score and weather variables at the time of panting score assignment. To develop correction factors for THI based on wind speed (WSPD) and radiation (RAD) mean climatological data were used to predict a panting score. The ratio of WSPD and RAD parameter estimates to THI were used to determine correction factors. For graphical purposes, wind speed was altered by + one standard deviation from the mean and a new panting score was calculated. The resulting THIs were plotted against WSPD and RAD, with the slope of the lines being the adjustment factor for WPSD and RAD.

National Oceanic and Atmospheric Administration (NOAA) weather reports were used to develop a relationship between RAD and cloud cover (CCVR). These reports were compilations of CCVR data observed during mid-afternoon in Sioux City, IA during the months of July and August. Once this relationship was determined, an adjustment factor for CCVR could be determined using identical procedures to those for WSPD and RAD.

Table 1. Panting scores assigned to steers.

Score	Description
0	Normal respiration, ~60 or less breaths/min
1	Slightly elevated respiration, ~ 60 - 90 breaths/min
2	Moderate panting and/or drooling mouth, ~ 90 - 120 breaths/min
3	Heavy open-mouthed panting and drooling mouth, ~ 120 - 150 breaths/min
4	Severe open-mouthed panting accompanied by protruding tongue and excessive salivation

Table 2. Mean, maximum and minimum values for temperature (Ta), relative humidity (RH), temperature-humidity index (THI), wind speed and solar radiation at 1700 hours on the days panting scores were assigned.

Item	Mean + SE	Maximum	Minimum
Temperature, °F	86.5 + 7.2	97.7	65.1
Relative humidity, %	58.3 + 12.4	92.0	37.5
THI	79.7 + 5.2	86.2	63.9
Wind speed, mi/h	8.3 + 3.4	16.1	2.5
Solar radiation, Langley's	29.9 + 9.5	42.4	1.3

Table 3. Parameter estimates for the regression equation describing the relationship between panting score at 1700 hours and temperature-humidity index (THI), wind speed, and solar radiation at 1700 hours (R^2 = .47).

Variable	Parameter estimate + SE	P - value
Intercept	- 6.3173 + .2876	< .0001
THI	.0972 + .0040	< .0001
Wind speed, mph	- .1042 + .0054	< .0001
Solar radiation, Langley's	.0302 + .0019	< .0001

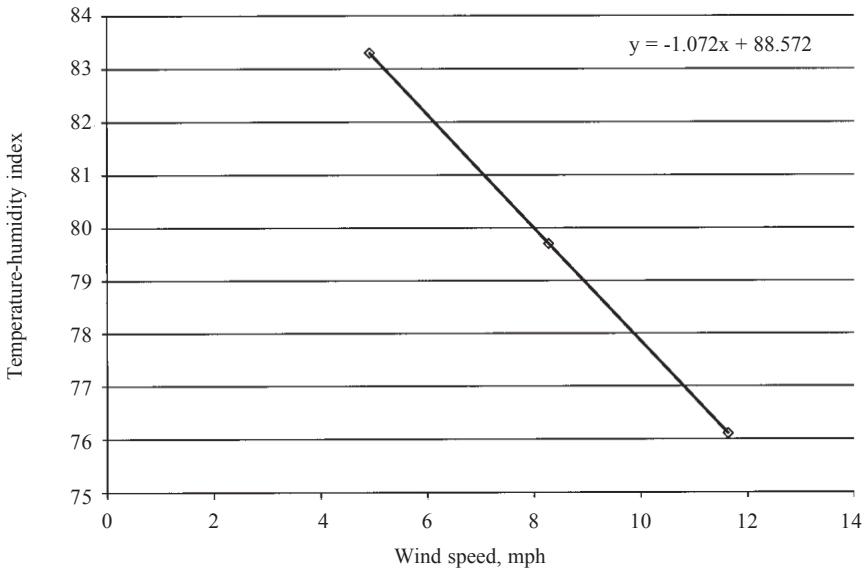

Figure 2. Effect of wind speed on temperature-humidity index. Based on the slope of the line, for every 1 mile/hour increase in wind speed, THI should be decreased 1.072 units.

Results

Mean, maximum and minimum values for THI, wind speed and solar radiation for the days that panting scores were assigned are presented in Table 2. Temperature during panting score assessment averaged 86.5 + 7.2 °F, while relative humidity averaged 58.3 + 12.4 %. This resulted in average THI being 79.7 + 5.2 units. The LWSI classifications for heat stress are as follows: Normal (< 74),

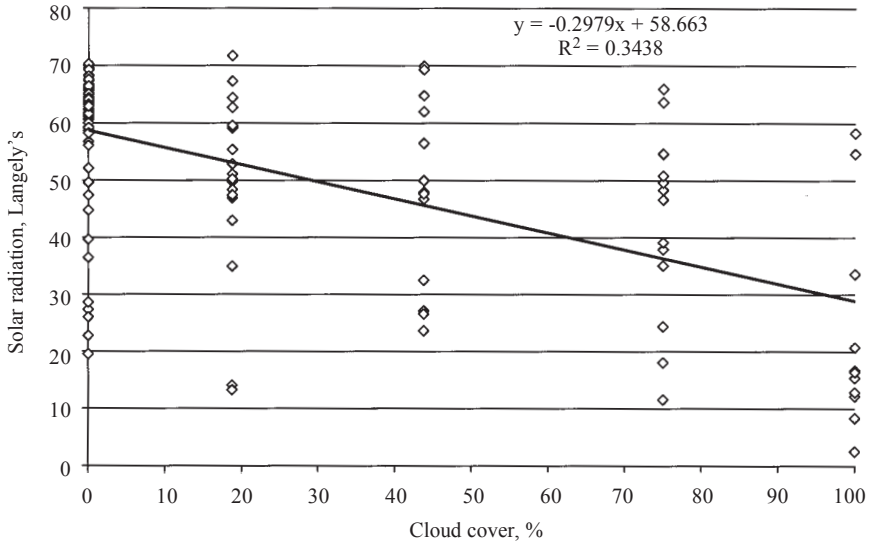

Figure 3. Effect of cloud cover on solar radiation. Based on the slope of the line, for every 25% increase in cloud cover, solar radiation should be decreased 7.45 Langely's. Average solar radiation at 0% cloud cover was 58.62 Laygley's.

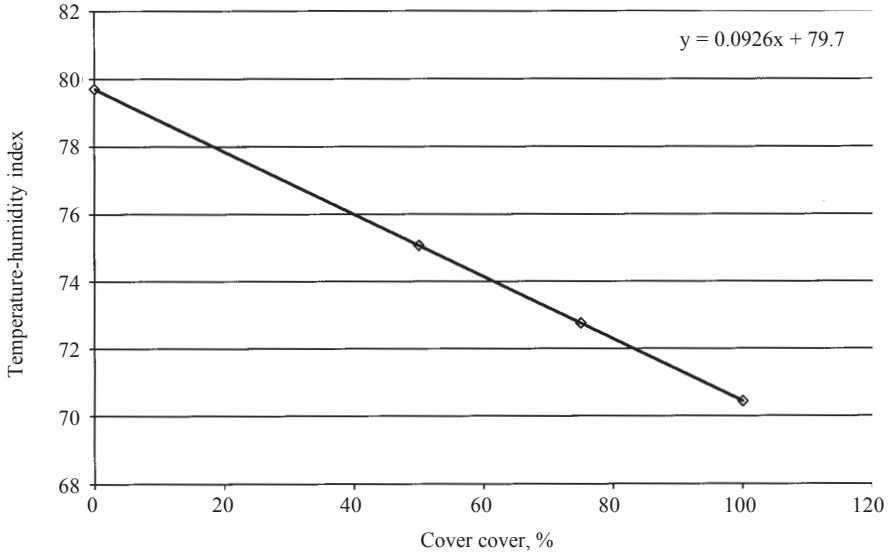

Figure 4. Effect of cloud cover on temperature-humidity index. Based on the slope of the line, for ever 25% increase in cloud cover, THI should be decreased 2.315 units.

Alert (74 < THI < 79), Danger (79< THI < 84), and Emergency (THI > 84). The range of THI for the days in which panting score was determined on the animals represented all categories of the LWSI.

Measurements of wind speed and solar radiation also were composed of a wide range of conditions (2.5 to 16.1 mph and 1.3 to 42.4 Langley's, respectively). Inferences made regarding application of this model must remain within the bounds of the ranges of environmental variables measured.

The parameter estimates for the effects of THI, WSPD and RAD on panting score of the steers are presented in Table 3. The ratio of the coefficients for WSPD and THI is -1.072. Figure 2 describes the relationship with each point representing the THI, based on the prediction equation, that would be needed to produce an equivalent panting score when WSPD was average and + 1 standard deviation. The slope of this line also represents the adjustment for THI based on WSPD. Thus, for every 1 mph increase in WSPD, THI should be adjusted down 1.072 units.

Identical procedures were used for RAD adjustment as were used to develop the WSPD adjustment. The ratio of the coefficients for RAD and THI and the slope of the line suggests for each Langley increase in RAD, THI should be increased 0.311 units. Information regarding the amount of RAD present is not always available. Certain on-site weather stations may have capabilities to supply this information to producers, since local weather reports do not routinely supply RAD levels. One measure that may be visually assessed is the amount of cloud cover (CCVR) present. A more precise relationship is not present between CCVR and RAD because factors other than CCVR affect the amount of RAD (Figure 3). Such factors include dust, pollution levels, incidence of the sun, type of cloud cover (thin, cirrus clouds vs. thick, cumulonimbus clouds) and altitude. While the amount of incoming RAD is not proportionally related to CCVR, a reasonable relationship does exist (Figure 4). Based on this relationship, every 25% increase in CCVR reduces RAD by 7.45 Langley's. By using this relationship it was determined that for every 25% increase in CCVR, THI should be decreased 2.315 units (Figure 4).

Close monitoring of weather variables is essential in determining the potential for heat stress related complications in livestock operations. The LWSI long has been used as an indicator for potential heat stress related losses, however its precision is questioned under conditions of varying wind speed and radiative heat load. Adjustments proposed in this report should allow producers to more accurately predict the potential for heat stress within the bounds of the environmental variables measured.

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Impact of Manure Application on Phosphorus in Surface Runoff and Soil Erosion

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Reducing P in feedlot diets has long-term impacts in reducing P contamination of surface water from runoff and erosion on manure amended soil.

Summary

Effects of method of manure management and dietary P were compared on 21 natural runoff plots to monitor the long-term impact of dietary P to P losses in runoff and erosion. Reducing feed P resulted in a 33% reduction in manure P content and soil test P buildup and runoff losses of P also were directly proportional to feed P inputs. The timing and management of manure are also important considerations for controlling P losses in runoff in the year of application. However, residual effects of timing and management are probably small. Management criteria designed to assess the potential for landscape P-loading (i.e. "P-index") correctly weight winter applications as more detrimental than planting time applications.

Introduction

Phosphorus (P) losses from agricultural land is a serious environmental issue because of the impact of P on freshwater eutrophication. The movement of P from soil to surface water is impacted by P input to soil and manure management practices that impact P transport processes. Previous research has shown that the nutritional requirement for P is quite low and added inorganic P to corn-based feedlot diets has no value (*1998 Nebraska Beef Report,* pp. 78-80; *2002 Nebraska Beef Report,* pp. 45-48). Our study was designed to monitor the long-term effects of dietary P inputs and manure management on P losses to the environment.

Procedure

Twenty-one natural runoff plots (0.01 acre ea.) were established on an irrigated Sharpsburg silty clay loam soil in 1998 to monitor the effects of manure application time as well as the long-term impact of reducing P in beef feedlot rations on P losses in runoff and sediment. Average soil slope was 6.2%. Compost was generated from feedlot manure and nutrition studies conducted at the Agricultural Research and Development Center research feedlot. Compost from 1998 and 1999 was from the same study, evaluating conventional dietary P levels (0.35% of diet DM) compared to diets without supplemental mineral P (0.25%P). Performance data and nutrient balance in the feedlot were published previously (*2000 Nebraska Beef Report* pp. 65-67). Decreasing dietary P decreased the amount that was removed in manure.

Annual compost applications were made at a rate to meet the N needs of the corn crop (178 lb N/acre) assuming 30 % mineralization of organic N each year. Compost was applied with three method/time treatments in a randomized complete block design with 3 replications to evaluate the effect of management on P losses in runoff. A replicated control consisting of 178 lb N/acre applied as NH_4NO_3 broadcast incorporated prior to spring planting was also included (Table 1). Plots were disked once so that

Table 1. Treatment schematic outlining composted manure treatments applied from June 1998 to January of 2001.

Treatment	P level	Application method	Application time	Dates of application
H-Sp-I	High-P	Incorporated	Spring-preplant	April 1998, 1999, 2000
H-Sp-S	High-P	Surface applied	Spring-postplant	May 1998, 1999, 2000
H-W	High-P	Surface applied	Winter	January 1999, 2000, 2001
L-Sp-I	Low-P	Incorporated	Spring-preplant	April 1998, 1999, 2000
L-Sp-S	Low-P	Surface applied	Spring-postplant	May 1998, 1999, 2000
L-W	Low-P	Surface applied	Winter	January 1999, 2000, 2001
N fertilizer	none	Incorporated	Spring-preplant	April 1998, 1999, 2000

Table 2. Compost characteristics and application rates.

Compost Type	Year	Total N %	Total P %	N:P	Compost rate[a] ton/acre		Applied P lb/acre
High - P	1998	0.81	0.36	2.3:1	37		266
	1999	0.80	0.43	1.9:1	37		319
	2000	0.64	0.46	1.4:1	46		435
						Total:	1020
Low - P	1998	0.81	0.28	2.9:1	37		207
	1999	0.79	0.36	2.2:1	37		270
	2000	0.60	0.20	3.0:1	50		198
						Total	675

[a]Compost rate to deliver 178 lb N/acre assuming 30% mineralization rate of organic N.

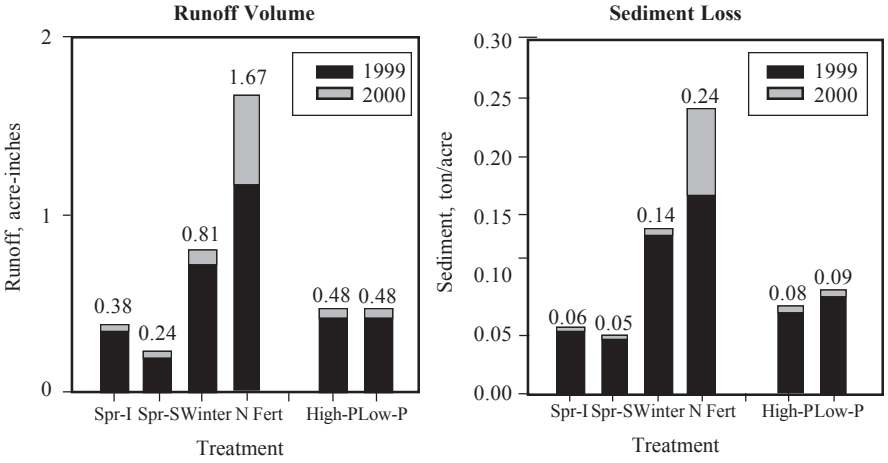

Figure 1. Annual runoff and sediment losses by treatment during compost application years.

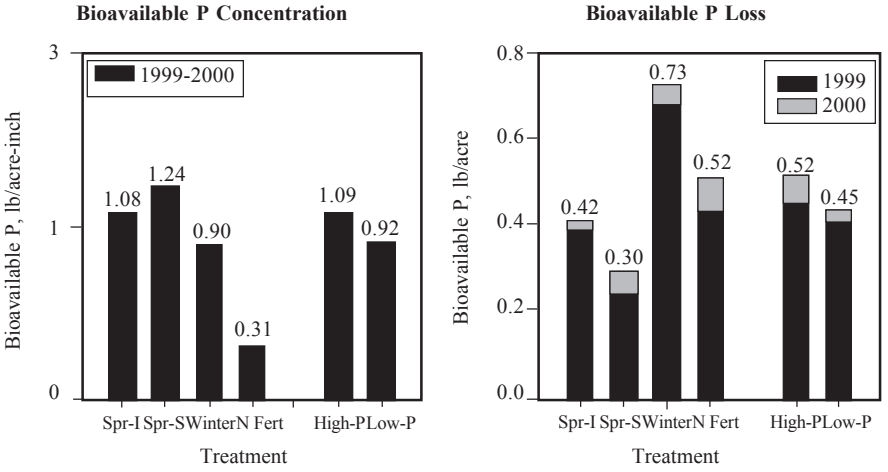

Figure 2. Average bioavailable P (BAP) concentration and annual BAP losses, by treatment, during compost application years.

the winter (W) and spring incorporated (Sp-I) treatments were incorporated prior to planting.

Three consecutive annual applications of composted manure were made beginning in 1998 through 2000. The first winter application was made in January of 1999 and the last in January of 2001. Corn was planted at 26,000 plants/acre in 1999-2000. Soybean was planted at 137,000 plants/acre in 2001. No compost or fertilizer applications were made after January, 2001. Table 2 lists the compost N and P characteristics by year. Runoff collection was initiated in 1999 following natural precipitation events and analyzed in duplicate for volume, sediment concentration and bioavailable P (BAP).

Results

Animal Performance

Reducing dietary P from conventional levels (0.35% or greater) to diets with no supplemental P (0.25%) improved animal P use efficiency, decreased P excreted and did not affect animal performance. Erickson et al. (*1998 Nebraska Beef Report,* pp. 78-80; *2002 Nebraska Beef Report,* pp 45-48) concluded that typical grain finishing diets contain enough P for optimal gains.

Runoff, Sediment and P Losses

In this eastern Nebraska environment, runoff occurred only during the spring months (March–June) and only trace amounts of runoff were experienced in the fall. Results are shown for two distinct periods: a) compost application years (1999-2000), and b) residual year (2001) following three years of compost application.

In the years of compost application (1999-2000), time of application effect on compost weathering had a significant effect on runoff volume loss. We observed that a longer time interval between compost application date and spring runoff season resulted in a diminished effect on water retention. Runoff volume was not affected by compost type as rate of application did not differ between High-P and Low-P manures. Spring applications had the effect of decreasing runoff volume compared to winter application (Figure 1). In the residual year (2001), when no compost had been applied, runoff volume was about 2/3 of the no-compost control. Note that 2001 runoff volume from the 2001 winter application was lower than that from the spring 2000 application, because of the difference in the time of compost weathering between these treatments. The winter application in Figure 2 was applied almost eight months after the spring application.

Sediment losses in the years of application (1999-2000) were directly proportional to runoff volume. Although sediment concentrations were higher in the surface-applied treatments, decreased runoff volume reduced the total sediment load (Figure 1). In the residual year (2001) winter application of compost resulted in very high sediment concentration in runoff following a substantial winter runoff event when the soil surface soil was frozen. Sediment load was not impacted by compost type in 2001 (Figure 2).

Bioavailable P (BAP) losses in runoff were nearly proportional to P loading rates by compost type in both application and residual years of study. Phosphorus loading to soil as compost was 1.5 times greater for the High-P vs. the Low-P manure and BAP losses (total of all years) were 1.6 times greater from High-P vs. Low-P amended plots. More phosphorus as BAP was lost during the application years of 1999-2000 from the

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winter treatment compared to the spring-applied compost treatments (Figure 3). Most "P-indices" place a greater penalty on winter manure applications than those made at planting time. Our results confirm that the diminished runoff protection from winter applications because of weathering and the danger of runoff from frozen soil increases P loss to surface water. In the residual year (2001) compost application no longer had the effect of reducing runoff and so BAP losses were more than double that from the control. Application time no longer had the effect of reducing BAP losses in the residual year (2001) (Figure 4).

In summary, reduction in supplementary P inputs had a direct effect on P losses to surface water in runoff and sediment. We will be maintaining these runoff plots for the next several years to monitor the long-term residual effect of soil P loading on runoff, sediment and P losses to surface water.

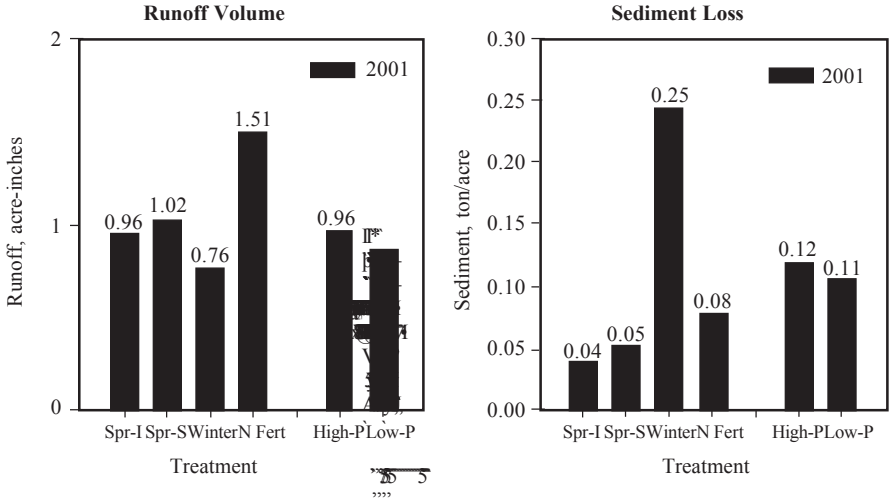

Figure 3. Annual runoff and sediment losses by treatment during residual post-application year.

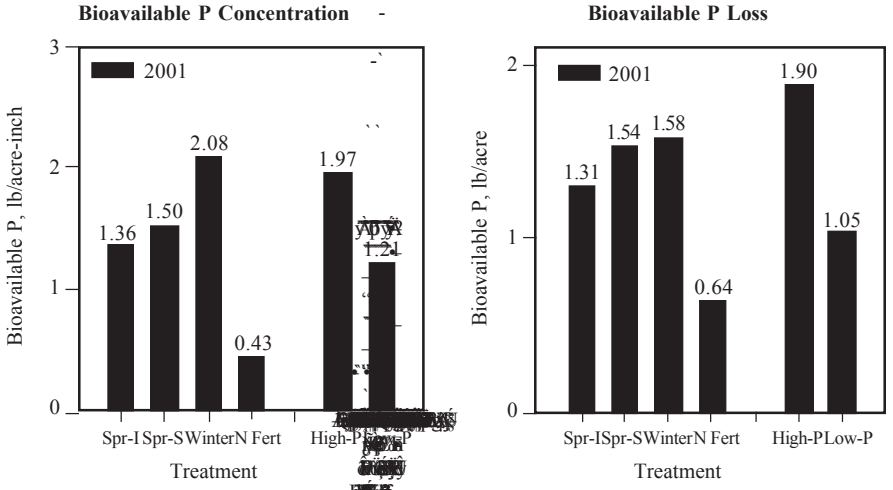

Figure 4. Average BAP concentration and annual BAP losses, by treatment, during residual post-application year.

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[2]Acknowledgments: This research is funded by the Nebraska Department of Environmental Quality and the US EPA.

Effect of Organic Matter Addition to the Pen Surface on Feedlot Nitrogen Balance

Julie Adams
Galen Erickson
Terry Klopfenstein
Casey Macken
Casey Wilson[1]

Feeding corn bran reduced nitrogen losses in winter and in summer but increased feed conversion. Sawdust application reduced nitrogen loss in winter but was ineffective during summer.

Summary

Two experiments, calves fed November to May (WINTER) and yearlings fed May to September (SUMMER), were conducted to evaluate effects of replacing dry-rolled corn with 30% corn bran or applying sawdust to the pen surface on feedlot nitrogen balance. Bran increased feed conversion during both experiments but reduced nitrogen losses in the WINTER. Sawdust application to the feedlot pen surface reduced nitrogen losses during the WINTER. Bran and sawdust treatments increased nitrogen recovered in manure during the WINTER. Adding OM to the pen surface did not impact nitrogen losses during the SUMMER.

Introduction

Nitrogen loss from feedlot manure occurs mostly through gaseous emissions, primarily ammonia (NH_3). One

potential option to reduce N loss is the manipulation of the carbon:nitrogen (C:N) ratio of feedlot manure. Adding C to manure increases microbial N immobilization, which reduces N losses. Previous research has shown that byproducts from wood manufacturing (*2002 Nebraska Beef Cattle Report* pp. 52-53) and corn wet milling (*2002 Nebraska Beef Cattle Report* pp. 54-57) industries increase manure C:N ratio and result in reduced N loss from feedlots. However these methods have not been compared to one another.

Corn bran has a lower digestibility than corn, causing animals to excrete additional C to the pen surface. Therefore, bran serves as C source for microbial N immobilization. However, cattle performance may be depressed by feeding corn bran due to the lower digestibility, which may limit the usefulness of this alternative.

Sawdust application to the pen surface provides an undigested C source for microbes. Sawdust applied to the pen surface does not affect diet characteristics and subsequent animal performance. The use of this alternative may increase labor and machinery costs required for delivery and application to the pen surface. One potential negative effect of adding C to the pens is the associated expense of increased manure removal. However, decreasing N loss may overcome any negatives.

The objective of these experiments was to compare the effects of adding organic matter (OM) to the pen surface through decreased diet digestibility or direct application of C as sawdust on N losses in open feedlots.

Procedure

Feedlot Experiment

Two experiments were conducted using 96 steers each, calves (716 + 29 lb BW) fed 180 days from November to May (WINTER) and yearlings (829 + 31 lb BW) fed 132 days from May to September (SUMMER), to evaluate impacts of applying additional organic matter (OM) to the pen surface on N balance in open feedlots. Steers were stratified by weight and assigned randomly to treatment (8 head/pen, 4 pens/treatment).

Design of each experiment led to 2 treatments and a control. The control (CONTROL) was designed to provide a typical feedlot diet and environmental management. A dietary treatment (BRAN) was devised to increase OM excretion to the pen surface by decreasing the OM digestibility of the diet. This diet contained 30% corn bran, replacing dry-rolled corn. Cattle assigned to the sawdust (SAWDUST) treatment were fed the CONTROL diet and sawdust was applied weekly to the pen surface (14 lb/steer/week). The SAWDUST application rate was formulated to match the amount of OM excreted by cattle on the BRAN treatment above CONTROL.

On day 1, WINTER steer calves were initially implanted with Synovex-S® followed by Revalor-S® on day 90. SUMMER yearling steers were implanted on day 1 with Synovex-C® and reimplanted on day 35 with Revalor-S®. Finishing diets for each trial were formulated to meet animal metabolizable protein requirements using NRC (1996) recommendations. Within each experiment, CONTROL and SAWDUST diets were identical (Table 1).

Carcass data were collected upon completion of experiments at a commercial abattoir. At harvest, hot carcass weights were recorded. Final weights were calculated using a common dressing percentage (63). Following a 24 hour chill, fat thickness at the 12th rib and *longissimus* area were collected. Yield and marbling score, determined by a USDA grader, were recorded.

Nutrient Balance

These nutrient balance experiments were conducted in 12 open feedlot pens with a stocking density of 332 ft^2 per steer. Six retention ponds constructed of soil collected runoff from the 12 pens. In the case of a runoff event, effluent was collected in the retention ponds, drained, quantified with an air-bubble flow meter (ISCO, Lincoln, NE) and sampled. Drymatter, OM, total P and total N were analyzed on all samples.

Each week throughout the feeding period, pens assigned to SAWDUST received a sawdust application to the pen surface just behind the feed bunk on the cement apron. Cattle spend most of their time and presumably excrete the most N in this area.

Throughout the feeding period, feed refusals were collected when necessary. Fecal samples were collected every 2 weeks. After cattle were removed from the pens upon completion of the feeding period, manure was piled on the cement apron. As the manure was being loaded out of the pens, manure samples were taken. Manure was weighed on an as-is basis and hauled to the University of Nebraska compost yard. The manure then was composted.

Before initiation and upon completion of both experiments, soil core samples from each pen (6 inch depth) were taken from 16 designated locations evenly spaced throughout the pen and

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Table 1. Composition of diet (% DM) fed to steers during WINTER and SUMMER trials.

	TREATMENT					
	WINTER			SUMMER		
Item	CONTROL	BRAN	SAWDUST	CONTROL	BRAN	SAWDUST
Dry-rolled corn	74	44	74	75	45	75
Corn silage	15	15	15	15	15	15
Corn bran	—	30	—	—	30	—
Molasses	5	5	5	5	5	5
Supplement	6	6	6	5	5	5
Composition						
CP[a]	12.9	13.1	12.9	13.8	13.8	13.8
DIP[b]	7.2	8.0	7.2	6.6	8.9	6.6
P[c]	0.26	0.20	0.26	0.27	0.27	0.27

[a]Dietary crude protein content, on a DM basis.
[b]Degradable intake protein, expressed as a percent of diet DM.
[c]Phosphorus content of the diet, on a DM basis.

six samples from each retention pond. The same core pattern, or grid, was used for both experiments. Soil samples were used to correct for manure/soil mixing by cattle activity throughout the experiment and pen cleaning variation. All manure, soil, compost, refusal and feed samples were analyzed for DM, OM, total P and total N.

Nitrogen intake was calculated using analyzed dietary N concentration multiplied by DMI, corrected for N content of feed refusals. Retained energy and protein equations established by the NRC (1996) were used to calculate steer N retention. Nitrogen excreted (urine plus feces) was determined by subtracting N retention from N intake. Fecal N was determined by multiplying the total N concentration of fecal samples collected by the amount of feces excreted. Fecal excretion was determined by multiplying DMI throughout the feeding period, adjusted for refusals, by the DM digestibility of the diet (75.8% CONTROL/SAWDUST, 71.7% BRAN), (*2002 Nebraska Beef Cattle Report,* pp. 66-68). The digestibility (*2002 Nebraska Beef Cattle Report*, pp. 66-68) seem to over-predict the actual digestibility value for the BRAN treatment. Bierman et al. (1999), calculated the difference in DM digestibility between a 7.5% roughage diet to be 9.1 units higher than a wet corn gluten feed diet (41.5% diet DM). Therefore, the BRAN DM digestibility of 66.7% (75.8 minus 9.1) was also examined.

Total N lost (lb/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion. All N values were converted to a lb/steer basis. Statistical analysis was conducted using the General Linear Models procedure of SAS.

Table 2. Performance of steer calves fed during WINTER.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
Initial BW, lb	714	716	717	2	0.62
Final BW, lb	1350[f]	1301[g]	1345[f]	18	0.14
DM intake, lb	22.7	23.2	23.0	0.4	0.61
Average daily gain, lb	3.53[f]	3.25[g]	3.49[f]	0.09	0.11
Gain:feed	0.156[h]	0.140[i]	0.152[h]	0.003	0.01
Feed:gain[c]	6.43[h]	7.14[i]	6.59[h]	—	—
Hot carcass weight., lb	851[f]	819[g]	847[f]	11	0.14
Marb. Score[d]	5.28[fg]	4.95[g]	5.44[f]	0.15	0.11
Fat thick, in[e]	0.48[f]	0.38[g]	0.46[f]	0.03	0.10

[a]Standard error of the means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Analyzed as gain:feed.
[d]Marbling score: 4.5 = Slight[50]; 5.0 = Small[00]; 5.5 = Small[50].
[e]12th rib fat thickness.
[f,g]Means within a row with different superscripts differ (P < 0.10).
[h,i]Means within a row with different superscripts differ (P < 0.01).

Table 3. Performance of yearling steers fed during SUMMER.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
Initial BW, lb	829	829	829	2.0	1.0
Final BW, lb	1265	1254	1279	8.8	0.19
DM intake, lb	23.6[f]	25.1[g]	23.6[f]	0.3	0.01
Average daily gain, lb	3.29	3.22	3.40	0.07	0.24
Gain:feed	0.139[f]	0.128[g]	0.144[f]	0.002	<0.01
Feed:gain[c]	7.18[f]	7.79[g]	6.94[f]	—	—
Hot carcass weight., lb	793[hi]	790[h]	805[i]	5	0.13
Marb. Score[d]	5.05	4.70	4.83	0.14	0.27
Fat thick, in[e]	0.45	0.46	0.43	0.03	0.70

[a]Standard error of the means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Analyzed as gain:feed.
[d]Marbling score: 4.5 = Slight[50]; 5.0 = Small[00]; 5.5 = Small[50].
[e]12th rib fat thickness.
[f,g]Means within a row with different superscripts differ (P < 0.01).
[h,i]Means within a row with different superscripts differ (P < 0.10).

Results

Feedlot Performance

Performance of steers assigned to CONTROL and SAWDUST treatments for either experiment was not different between treatments, because diets were identical (Tables 2 and 3). Steers consuming the BRAN had lower average daily gain (ADG) than the steers fed the CONTROL/SAWDUST diet in WINTER (P < 0.10), whereas the yearlings fed BRAN were not different from CONTROL or SAWDUST. The BRAN steers had higher feed conversion compared to CONTROL or SAWDUST during WINTER and SUMMER (P < 0.02). During WINTER, calves on the BRAN diet had similar DMI but lower gains causing the increase in feed:gain. The yearlings fed BRAN, however, had higher DMI and similar gains, resulting in increased feed conversion. This would indicate that calves and yearlings did not respond alike. Hot carcass weights tended to be lighter for BRAN cattle than CONTROL, whereas SAWDUST was intermediate during the WINTER feeding period (P = 0.14). During SUMMER, BRAN hot carcass weights tended to be lower than SAWDUST, whereas CONTROL was intermediate (P = 0.13). Marbling score and 12th rib fat thickness were also lower for BRAN cattle than CONTROL or SAWDUST (P < 0.10) during WINTER, but not during SUMMER (P > 0.10). Feeding BRAN for 14 additional days during WINTER would have allowed for final weights and carcass characteristics equivalent to CONTROL. Additional days on feed were not required for SUMMER steers because carcass characteristics and gains were similar to CONTROL.

Table 4. Nitrogen mass balance during WINTER expressed in lb/steer.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
N intake	83.5	87.5	84.5	1.3	0.15
N retention[c]	10.4[j]	9.6[k]	10.3[j]	0.2	0.09
N excretion[d]	73.2[j]	78.1[k]	74.3[j]	1.1	0.03
Fecal N[e]	23.6[l]	27.6[m] (32.8[m])[n]	22.5[l]	0.7	<0.01
Manure N[f]	36.0[l]	54.9[m]	53.9[m]	3.6	0.01
Runoff N	0.9[j]	0.6[k]	0.6[k]	0.1	0.10
N lost[g]	36.2[j]	22.7[k]	19.8[k]	3.7	0.03
Adjusted N lost[h]	36.2[j]	24.5[k]	19.8[k]	4.1	0.05
N loss, %[i]	49.4[l]	29.1[m]	26.8[m]	5.1	0.01
Manure C:N ratio	9.3[l]	11.3[m]	12.5[m]	0.3	<0.01

[a] Standard error of means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Calculated using NRC (1996) net protein and net energy equations.
[d]Calculated as N intake minus N retention.
[e] Calculated as fecal N concentration multiplied by lb of excreted feces.
[f]Corrected for N concentration before and after trial.
[g]Calculated as N excretion minus manure N (corrected for soil), and runoff N.
[h]N lost includes 14 additional days for WINTER.
[l]Calculated as N lost divided by N excretion.
[j,k]Means within a row with different superscripts differ (P < 0.10).
[l,m]Means within a row with different superscripts differ (P < 0.01).
[n]Values in parenthesis represent fecal excretion values calculated using 66.7% DM digestibility.

Table 5. Nitrogen mass balance during SUMMER expressed in lb/steer.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
N intake	68.8	69.4	68.9	2.3	0.98
N retention[c]	7.9	7.8	8.2	0.2	0.28
N excretion[d]	60.9	61.6	60.7	2.2	0.96
Fecal N[e]	18.9[k]	22.9[l](26.9[l])[m]	19.4[k]	0.6	<0.01
Manure N[f]	23.0	26.5	21.3	2.8	0.45
Runoff N	0.004[i]	0.004[i]	0.003[j]	0.002	0.10
N lost[g]	37.9	35.1	39.4	3.8	0.73
N loss, %[h]	62.2	56.4	64.8	5.3	0.54
Manure C:N ratio	8.1[k]	8.2[k]	11.3[l]	0.5	<0.01

[a]Standard error of means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Calculated using NRC (1996) net protein and net energy equations.
[d]Calculated as N intake minus N retention.
[e]Calculated as fecal N concentration multiplied by lb of excreted feces.
[f]Corrected for pen soil concentration and soil N concentration before and after trial.
[g]Calculated as N excretion minus manure N (corrected for soil), and runoff N.
[h]Calculated as N lost divided by N excretion.
[i,j]Means within a row with different superscripts differ (P < 0.10).
[k,l]Means within a row with different superscripts differ (P < 0.01).
[m]Values in parenthesis represent fecal excretion values calculated using 66.7% DM digestibility.

Nutrient Balance

All N mass balance results are reported on a per-steer basis (Tables 4 and 5). Nitrogen intake (lb DM) for BRAN cattle was higher (numerically) than CONTROL or SAWDUST in WINTER (P = 0.15) and similar across treatments in the yearling trial (P > 0.90). Nitrogen retention was based on gains and final weights. Therefore BRAN calves retained less N than CONTROL and SAWDUST calves (P < 0.10) due to lower ADG, but yearling N retention was similar (P > 0.25). Differences in N retained are subtle and calculated N retentions are often quiet low (10-13% of N intake). Reduced N retention caused BRAN calves to excrete more N during WINTER than CONTROL or SAWDUST (P < 0.10). Nitrogen excretion was similar across treatments for SUMMER (P > 0.95). Fecal N content was greater for the BRAN steers than the other two treatments for both experiments, using both 71.2 and 66.7% digestibility values.

Precipitation during WINTER totaled 12.76 inches, while SUMMER precipitation totaled 16.7 inches. Runoff is not a large contributor to N loss. Runoff N from pens assigned to CONTROL treatment was higher (P < 0.10) than pens designated to other treatments during WINTER. During SUMMER, BRAN and CONTROL lost equal amounts of N via runoff, and more than SAWDUST (P < 0.10). Runoff accounted for less than 1% of all N excreted across all treatments.

Pens receiving OM had higher amounts of manure removed from the pen surface than the CONTROL in both experiments (Table 6 and 7). Logically, hauling more OM into the pen would require more material to be hauled from the pen. Manure (corrected for soil contamination) from the BRAN and SAWDUST treatments contained more N during WINTER than CONTROL (P < 0.01). During SUMMER, manure N content did not differ among treatments; however, numerically, BRAN was highest. Preserving excreted N in manure by increasing the C:N ratio prevented volatile N losses.

All N unaccounted for is presumed to be N volatilized as ammonia. Adding OM to the pen surface reduced N losses during WINTER (P < 0.05). Nitrogen lost (lb/steer) from the BRAN and SAWDUST treatments were 13.5 and 16.4 lb, respectively, lower than CONTROL. There were no differences in N lost (lb/steer) during the SUMMER. BRAN reduced lb of N lost by 38% and 8% during WINTER and SUMMER, respectively, while SAWDUST reduced N lost by 45% in WINTER and had no impact during SUMMER, when compared to the CONTROL.

As previously stated, the cattle assigned to the BRAN treatment required 14 additional days to achieve a similar carcass end point as cattle assigned to CONTROL or SAWDUST. Therefore, to account for the additional N lost during the extended feeding period, adjusted N lost was calculated. The amount of N lost by CONTROL and SAWDUST were held constant. The additional 14 days on feed for the BRAN steers would increase N lost by 1.8 lb.

Reducing diet digestibility by substituting dry-rolled corn with corn bran and applying SAWDUST during WINTER

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lowered percentage of N loss compared to CONTROL (P < 0.10). BRAN had the lowest percentage of N lost during SUMMER (numerically), while SAWDUST treatment lost the largest percentage (numerically). When compared to previously cited research (*2002 Nebraska Beef Cattle Report,* pp. 54-57), BRAN volatile N losses in this study were lower during winter months (59.8 vs 29.1%, respectively) and summer months (57.6 vs 56.4%, respectively). These differences may be due to year-to-year climatic variation. The average temperature during WINTER of the present study was 33°F with 12.76 inches of precipitation, while the average temperature during the winter (*2002 Nebraska Beef Cattle Report,* pp. 54-57) study was conducted was 43°F with 8.21 inches of precipitation. However, SUMMER temperatures were similar for the present study (71°F) (*2002 Nebraska Beef Cattle Report,* pp. 54-57; 73°F). The present study received an additional 6 inches of precipitation compared to Erickson et al. Warmer conditions cause volatile N losses to increase. Volatile N losses from the present SAWDUST treatment are comparable to losses reported by Lory et al. (*2002 Nebraska Beef Cattle Report,* pp. 52-53) during the summer months (60.6 vs 66.1%, respectively).

Table 6. Manure removed from the pen surface during WINTER expressed in lb/steer.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
As-is weight removed	4639[c]	6401[d]	6429[d]	529	0.06
% DM	72.4[e]	65.7[f]	65.5[f]	1.3	0.01
DM weight removed	3351	4199	4230	364	0.21
% OM	18.8[e]	26.2[f]	28.6[f]	1.1	<0.01
OM weight removed	626[e]	1098[f]	1192[f]	77	<0.01
C:N ratio	9.3[e]	11.3[f]	12.5[f]	0.3	<0.01

[a]Standard error of means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c,d]Means within row with different superscripts differ (P < 0.10).
[e,f]Means within row with different superscripts differ (P < 0.01).

Table 7.Manure removed from the pen surface during SUMMER expressed in lb/steer.

Item	CONTROL	BRAN	SAWDUST	SE[a]	F-test[b]
As-is wt removed	1706[c]	2253[d]	2026[d]	88	0.01
% DM	61.0[e]	56.2[f]	54.4[f]	2	0.05
DM wt removed	1040[e]	1268[f]	1102[e]	68	0.10
% OM	23.5[e]	25.5[e]	31.9[f]	3	0.09
OM wt removed	245[c]	322[d]	344[d]	18	0.01
C:N ratio	8.1[c]	8.2[c]	11.3[d]	0.5	<0.01

[a]Standard error of means.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c,d]Means within row with different superscripts differ (P < 0.01).
[e,f]Means within row with different superscripts differ (P < 0.10).

Nitrogen volatilization may be enhanced by warm, moist conditions, such as those experienced during the summer months. These conditions cause the N pool to be lost at a much faster rate. Therefore, increasing the C:N ratio was not as effective during the SUMMER as WINTER. However, adding more OM to the pen surface will increase the amount of material removed from the pen, potentially increasing production costs. However, reducing N losses may overcome any additional economic costs.

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Carbon Sequestration Following Beef Cattle Feedlot Manure, Compost, and Fertilizer Applications

Bahman Eghball
Daniel Ginting[1]

Application of feedlot manure or composted manure resulted in significant carbon sequestation in the soil while chemical fertilizer application had no effect.

Summary

Manure or compost application can increase carbon (C) sequestration in the soil since these organic sources contain significant amounts of C, which is a major constituent of soil organic matter. An experiment was conducted from 1992 to 1996 to evaluate the effects of annual or biennial N- and P-based manure or composted manure application on soil C sequestration. Fertilized and unfertilized checks were also included. About 25% of applied manure C and 36% of applied compost C remained in the surface (0-6 inch) soil after four years of application, indicating greater C sequestration with composted than noncomposted manure. Soil C in the 6 to 12 inch soil was unaffected by the applied manure, compost, and fertilizer.

Table 1. Characteristics of beef cattle feedlot manure and composted feedlot manure applied in 4 years at Mead, Neb. Nutrients, C and ash contents are on dry weight basis.

Year and Source	Total C	Total N	Total P	Ash	Water content	NO_3-N	NH_4-N	EC[a]	pH[a]
	%					ppm		mmho/ cm	
1992									
Manure	7.8	0.8	0.23	84.4	19.5	30	1263	4.6	7.3
Compost	9.5	1.1	0.42	80.8	33.2	117	169	7.4	7.7
1993									
Manure	13.3	1.0	0.50	71.5	53.9	17	480	5.2	8.8
Compost	8.7	0.8	0.31	79.6	40.3	38	33	2.2	8.3
1994									
Manure	23.7	1.6	0.33	59.1	20.0	11	365	5.4	8.2
Compost	7.4	0.8	0.41	84.9	34.0	383	55	6.1	7.2
1995									
Manure	17.3	1.3	0.32	67.7	25.1	130	898	3.8	7.3
Compost	6.8	0.8	0.31	79.8	15.0	294	97	6.0	7.7

[a]EC and pH were determined on 2:1 water to dry manure or compost ratio.

Table 2. Composted and non-composted manure dry weight application in 4 years at Mead, Neb.

Treatment	Dry weight			
	1992	1993	1994	1995
	tons/acre			
Manure for N	20.9	8.3	5.4	6.5
Manure for P	12.6	2.9	2.9	1.2
Manure for N/2 yr	41.9	—	16.2	—
Manure for P/2 yr	25.2	—	8.8	—
Compost for N	15.4	22.1	11.2	16.3
Compost for P	6.9	4.6	2.4	1.3
Compost for N/2 yr	31.0	—	33.6	—
Compost for P/2 yr	13.8	—	7.1	—
Fertilizer	—	—	—	—

Introduction

Soil carbon level usually increases with manure application since manure contains not only nutrients that are essential for plant growth but also contains carbon. Carbon is the major component of any organic matter and constitutes about 58% of the organic matter in the surface soil. Carbon in manure may be more valuable than the nutrients it contains when manure is applied to less productive or degraded soils. These soils are usually low in carbon and subsequently organic matter and that reduces their productivity. Carbon increases soil water holding capacity, aggregation, nutrient mineralization and aeration and improves the physical environment for the plants to grow.

Increased carbon dioxide in the atmosphere has been implicated in the global warming. To reduce the adverse effects of the increased carbon dioxide in the atmosphere, C sequestration in agricultural soil has been proposed. By storing C in the soil, not only does the soil become more productive, but also the negative effect of increased C in the atmosphere is reduced.

Procedure

The experiment was initiated in 1992 on a Sharpsburg silty clay loam soil under dryland conditions at the University of Nebraska Agricultural Research Center near Mead, Neb. Growing season rainfall (May 1 to October 15) was 30.4, 22.0, 12.1, and 16.7 inches in 1993,1994, 1995, and 1996, respectively. The study area had a Bray and Kurtz No.1 soil P test of 69 ppm, a pH of 6.2, and a soil organic matter content of 3.1% in the top 6 inches.

The experimental design was a randomized complete block with four replications. The 10 treatments applied included annual or biennial manure or compost application based on N or P removal by corn (135 lb N/acre and 53 lb P_2O_5/acre for an expected corn yield level of 150 bu/acre and fertilized and unfertilized checks. Fertilizer application was made in the spring each year. The inorganic fertilizer plots received N as ammonium nitrate and P as superphosphate (0-46-0) in 1993 and diammonium phosphate (18-46-0) in 1994, 1995 and 1996. If necessary, the P-based treatments (annual or biennial application) also received N fertilizer as ammonium nitrate in the spring so that a total of 135 lb N/acre was available to the corn crop.

Beef cattle manure was collected from the feedlot pens in late spring each year and composted for about four months using active composting with turning. Beef cattle feedlot manure (collected in the autumn) and composted feedlot manure were applied in the autumn of 1992 based on the assumption that 40, 20, 10 and 5% of the total N in manure or compost would become plant available in the first, second, third and fourth year after application, respectively. The first year N availability assumption from compost was found to be too high, based on N uptake in 1993, and were changed to 20, 20, 10 and 5% in the first, second, third and fourth year after compost applications in 1993, 1994 and 1995.

Manure or compost application was made in late autumn after corn harvest. Manure and compost were applied by hand to plots 40 ft long and 15 ft wide (6 corn rows) and incorporated by disking within one or two days. Manure and compost characteristics are given in Table 1 and the amounts applied are given in Table 2. Soil samples to a depth of 12 inches were collected from all

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plots each year after corn harvest. The soil samples were divided into 0-6 and 6-12 inch depth increments. The soil samples were air-dried and analyzed for C.

Results

Total C quantities in the surface (0-6 inch) soil were significantly influenced by year of sampling (Table 3). Soil C increased with increasing years of manure and compost applications. Total C concentration in the surface soil was generally greater for N- than P-based manure and compost applications and the differences became greater with years of application (Figure 1) indicating the cumulative effects of manure and compost applications. Following four years of application (in 1996), biennial N-based compost treatment resulted in greater soil surface (0 to 6 inch) C concentration than annual N-based even though similar total amounts of compost were applied for both treatments. This indicates that heavy application of compost every other year may protect the C from mineralization as compared with smaller annual rates.

Following four years of applications in 1996, total C content in the 0 to 6 inch soil was 19.9 tons/acre for manure applied to provide for corn N needs, 17.0 for manure applied to provide for corn P needs, 19.5 for manure for N for two years, 20.0 for manure for P for two years, 19.5 for compost for N, 18.6 for compost for P, 21.1 for compost for N for two years, 17.6 for compost for P for two years, 17.9 for fertilizer and 17.2 for the check treatment with a $LSD_{0.05}$ value of 1.5 ton/acre. This pointed out that significant C sequestration occurred for plots receiving manure or compost but not for the plots receiving commercial fertilizer. Based on the 1996 soil C values and the amount of C applied from 1992 to 1995 (Tables 1 and 2) , about 25% of applied manure C and 36% of applied compost C remained in the soil after four years of application (soil C increase above the fertilizer treatment), indicating more stable C compounds in compost than in manure. A greater fraction of applied C remained in the soil from compost application even though cumulative C application rate from 1992 to 1995 was less for compost (3.47 tons/acre) than for manure (4.65 tons/acre) when averaged across treatments. Soil C concentrations and quantities in the 6-12 inch soil depth increment were unaffected by the manure, compost and fertilizer treatments.

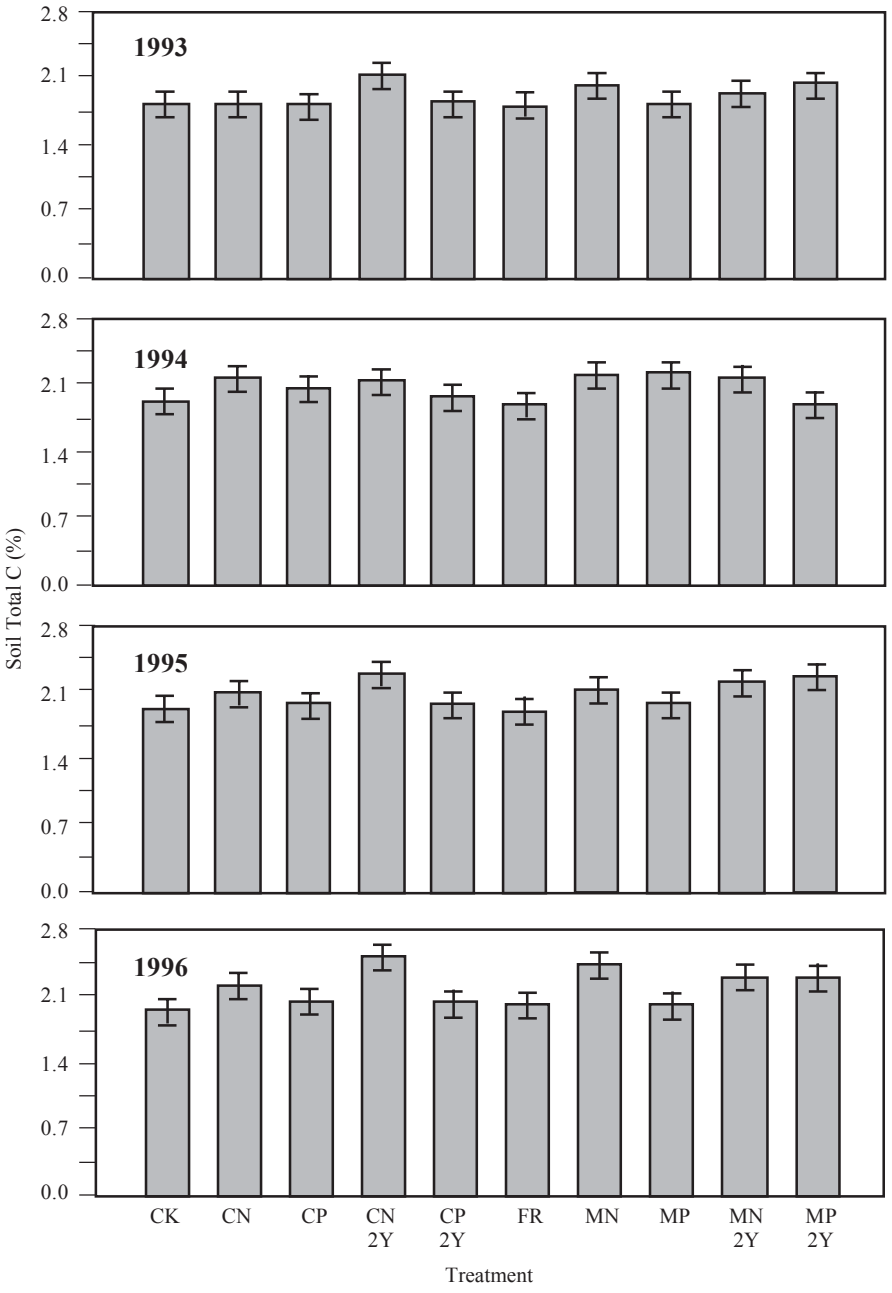

Figure 1. Surface soil (0-6 inch) total carbon concentration for ten treatments in four years. The vertical bars are standard errors, CN is compost for N, CP is compost for P, MN is manure for N, MP is manure for P, FR is inorganic fertilizer, CK is check, and 2Y is biennial application. Manure and compost applications started in the autumn of 1992.

Table 3. Effects of year (across treatments) and treatment (across years) on surface (0-6 inch) soil carbon.

Variables	Total C Concentration	Total C Quantity
	%	tons/acre
Year		
1993	1.95	16.9
1994	2.07	18.0
1995	2.07	17.9
1996	2.18	18.8
$LSD_{0.05}$	0.08	1.0
Treatment		
Manure for N	2.21	19.1
Manure for P	2.02	17.2
Manure for N for two years	2.17	19.2
Manure for P for two years	2.13	18.2
Compost for N	2.09	18.0
Compost for P	1.99	17.5
Compost for N for two years	2.29	19.4
Compost for P for two years	1.97	17.1
Fertilizer	1.91	16.9
Check	1.93	16.8
$LSD_{0.05}$	0.28	2.5

Conclusions

After four years of application, greater C sequestration occurred in the soil receiving N- based manure or compost application as compared with P-based reflecting the greater amounts of organic materials applied in the N-based application strategy. Fertilizer application did not result in a significant C sequestration, as the soil C amount was similar to that of the check plots. Annual or biennial N-based manure or compost application rates can be made to improve soil quality and increase C sequestration in the soil.

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Relationships of Chute-Side Measurements to Carcass Measurements

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Live body weight is the most valuable indicator of carcass weight at all times in the production system.

Summary

Three data sets were compiled to determine the relationship of weight, performance, hip height and ultrasound-measured fat thickness to hot carcass weight and fat thickness. Weight is generally the best predictor of relative differences in carcass weight at any time in the production system. Hip heights do not predict relative differences in carcass weight. Although the combination of hip height and weight is a more precise indicator of carcass weight than is hip height alone, generally this combination is inferior to weight alone. Only ultrasound-measured fat thickness predicted relative differences in fat thickness. Prediction of relative differences in carcass weight from body weight and fat thickness from ultrasound scans improved as marketing date approached.

Introduction

Previous research conducted at the University of Nebraska suggests relationship of live body weight to final market weight increases from 0.223 at the beginning of the wintering period (weaning) to 0.758 at the beginning of the grazing period, to 0.834 at the beginning of the finishing period (*2002 Nebraska Beef Report,* pp. 37-39). Additional observations are needed to further establish these relationships and to compare the relative value of live body weight to other measurements that may be taken during processing.

The objective of this research was to determine the relationship of weight, performance, hip height, and ultrasound-measured fat thickness at different times in the production system to carcass weight and carcass fat thickness.

Procedure

Three data sets were compiled. Whenever possible, weights were taken following a period of limited intake to equilibrate gut fill differences. If limit-fed weights were not possible, cattle were shrunk 4% and all weights assumed to be on an equal shrunk-weight basis. Hip heights were taken in a restraining chute and every attempt was made to take measurements when the animals were standing with all four legs squarely beneath them. A weight to hip height ratio was calculated for individuals by

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dividing the individual's weight by their hip height at a given point in time. Fat thickness was measured between the 12th and 13th rib with an Aloka 500V model ultrasound machine attached to an eight-inch linear array transducer. Animal hide was curried to remove dirt if necessary and mineral oil was applied to the region to ensure maximal acoustical contact.

Data Set 1

Data set 1 was used to determine the relationships of hip height, fat thickness, weight and average daily gain at times prior to entering the feedlot to carcass weight and carcass measured fat thickness in a long yearling production system. Comparisons also were made to carcass weights adjusted to a constant percentage body fat (28) to illustrate how relationships might change if all cattle were marketed at equal fatness. The data set includes cattle from a long term yearling-calf-fed comparison study. Calves' dams were randomly assigned to calf or yearling treatments. Cows assigned to calf or yearling treatment are managed as two separate herds. Only calves from the yearling system are included in the data set. Thus the data set is unique, because every steer calf (n = 43) from a herd is included. Weaning weights for calves assigned to the yearling treatment were 541 + 66 lb.

Data Set 2

Data set 2 was developed to determine if the relationship of measurements to carcass traits improved with time on feed. Cattle in this data set were yearling steers on a 112 day feeding trial to test differences in corn hybrids. Cattle assigned to this trial were received in the fall and were part of a group of approximately 1500 calves. The 600 heaviest steers were sorted off in the fall and placed on calf-fed trials. The remaining 900 steers were wintered together on corn stalks and placed in a dry lot where they received ammoniated wheat straw. They were sorted again in mid-April and the lightest 250 steers were placed on grass, where they consumed a combination of cool season, warm season or legume grasses. In September, when the trial started, the lightest 25 steers and the heaviest 25 steers were removed, leaving 200 steers for the study. Steers on this trial weighed 444 + 55 lb at the beginning of the wintering period, 620+ 31 lb at the beginning of the grazing period, and 805+ 42 lb upon entering the feedlot. No treatment differences were expected or found for performance or carcass characteristics. The trial protocol required the steers be weighed every 28 days. Ultrasound fat thickness and hip height measurements were taken at the same time. As with Data set 1, carcass weights were adjusted to a constant percentage body fat (28) to illustrate how the relationship might change if each individual animal were marketed at equal fatness.

Data Set 3

Data set 3 was compiled to determine the relationship of initial weight and reimplant weight to final weight in calf-fed steers. The data set includes steers from three calf-fed trials conducted in 1997. Steers were included in the data set if their treatment final weight was not different from the control in their trial. Cattle were sorted into each trial from a large group to meet specific weight range specifications and to reduce the standard deviation of weight as much as possible. When trials were pooled, cattle included in this data set had initial weights averaging 628 + 48 lb. Simple correlation coefficients were used to determine the relationship of initial weight and reimplant weight to final weight. There were 352 head in this data set.

Table 1. Correlation coefficients of pre-finishing measurements to carcass characteristics (Data Set 1).

Item	HCW[ab]	HCW[b]	Fat thickness[c]
Weight			
Birth	NS	NS	NS
Winter initial	0.66	0.74	NS
Grass initial	0.68	0.82	0.30
Feedlot intial	0.69	0.81	0.29
Hip height			
Winter initial	0.31	0.32	NS
Grass initial	NS	NS	NS
Feedlot initial	0.49	0.50	NS
Weight/hip height ratio			
Winter initial	0.61	0.69	NS
Grass initial	0.68	0.84	0.37
Feedlot initial	0.62	0.77	0.29
Fat thickness[d]			
Grass initial	NS	0.55	0.51
Feedlot initial	NS	NS	0.53
Fat-Weight Equation[e]			
Grass initial	0.70	0.83	0.52
Feedlot initial	0.75	0.81	0.55
ADG			
Winter	0.28	0.43	0.33
Summer	NS	NS	NS
Feedlot	0.52	0.68	0.35

[a]Adjusted to 28% body fat.
[b]Hot carcass weight.
[c]12th rib fat thickness.
[d]12th rib fat thickness measured via ultrasound.
[e]Multiple regression equation based on weight and fat measurements.
NS = Non-significant relationship (P<0.05).

Results

Data Set 1

Table 1 shows results from analysis of Data set 1. Ultrasound measured fat thickness was the best indicator of relative differences in carcass fat thickness prior to entering the feedlot. It was thought that the ratio of a steers' weight and hip height would give indication of its fattening potential. This is clearly not the case since the correlation coefficient between ratio of hip height to weight and carcass measured fat thickness are not significant or poor (r = 0.29 to 0.37).

With the exception of birth weight, weights collected at different times in the production system provide insight into relative differences in carcass weight. The relationships improved as cattle

Table 2. Correlation coefficients of finishing measurements to carcass characteristics (Data Set 2).

Item	HCW[ab]	HCW[b]	Fat thickness[c]
Weight			
Day 0	0.38	0.51	NS
Day 28	0.55	0.72	NS
Day 56	0.64	0.80	NS
Day 84	0.62	0.81	NS
Day 112[d]	0.64	0.90	0.15
Hip height			
Day 28	0.34	0.43	NS
Day 56	0.36	0.48	NS
Day 84	0.42	0.50	NS
Day 112[d]	0.42	0.47	NS
Weight/hip height ratio			
Day 28	0.33	0.46	NS
Day 56	0.49	0.61	NS
Day 84	0.42	0.61	0.17
Day 112[d]	0.49	0.77	0.27
Fat thickness[e]			
Day 56	-0.29	NS	0.48
Day 84	-0.17	0.15	0.47
Day 112[d]	-0.19	0.15	0.50
Fat-weight equation[f]			
Day 56	0.71	0.80	0.40
Day 84	0.66	0.82	0.36
Day 112[d]	0.71	0.90	0.41

[a]Adjusted to 28% body fat.
[b]Hot carcass weight.
[c]12th rib fat thickness.
[d]Slaughter date.
[e]12th rib fat thickness measured via ultrasound.
[f]Multiple regression equation based on weight and fat measurements.
NS = Non-significant relationship (P<0.05).

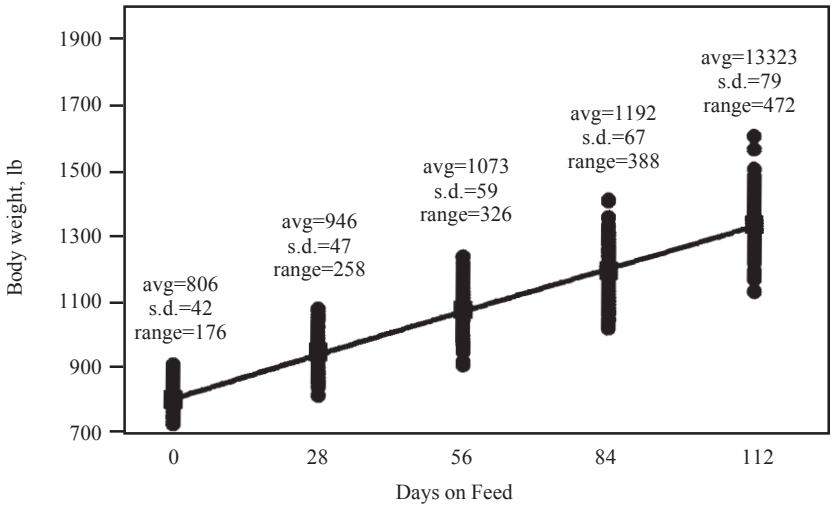

Figure 1. Distribution of interim weights for cattle on a 112day feeding trial (Data Set 2). s.d.=one standard deviation from the mean (lb), range=actual difference between maximum and minimum weights (lb). Correlation coefficients among weights ranged from 0.51 to 0.86.

grew. The relationship of weights taken at the beginning of the winter phase, beginning of the summer phase and beginning of the finishing phase were 0.74, 0.82 and 0.81, respectively. Previous data suggests these relationships are 0.22, 0.75 and 0.83, respectively (*2002 Nebraska Beef Report,* pp. 37-39). Perhaps the difference in the relationships at the beginning of the winter period is related to the fact that every calf from the herd was included in this data set. Inclusion of every calf may increase variation thereby increasing correlation coefficients in relation to data sets where the heaviest or lightest steers are removed. These data confirm that weight entering the feedlot should give good insight into relative differences in carcass weight.

When carcass weights were adjusted to a constant percentage body fat, correlation coefficients generally decreased indicating that if cattle were sold at equal fatness, it is more difficult to predict relative differences in carcass weight. When weight and fat were combined in a multiple regression equation, the relationships to fat-adjusted carcass weights improved when steers entered the feedlot, (r = 0.75 vs. r = 0.69).

Hip heights taken at the beginning of the wintering period and the beginning of the finishing period were significantly related to carcass weight but were always inferior to the live body weight taken at the same time point. The weight/hip height ratio was generally intermediate to live body weight or hip height alone.

Hip heights are difficult and time consuming to accurately measure. When hip heights were taken on the same group of cattle for two consecutive days, the correlation coefficient between days was 0.81. This repeatability is less than that of either ultrasound (r = 0.93) or live body weight (r = 0.99).

Although ADG for the winter period was significantly related to carcass weight and fat thickness, the relationships were poor and would not predict relative differences in these carcass characteristics. ADG for the feeding period also was significantly related to carcass weight and fat thickness. This is not useful, since gain is calculated at the end of the feeding period.

Data Set 2

Relationships from Data set two are shown in Table 2. Similar to Data set 1, only ultrasound-measured fat thickness was consistently related to carcass fat thickness. This relationship improved as the marketing date approached. The same trend could be seen with live body weight measurements. Also, live body weight was always superior to hip heights taken at the same time point while weight/hip height ratios were intermediate. As before, adjusting carcass weights to a consistent percentage body fat decreased

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correlation coefficients. Combining weight and fat in a multiple regression equation improved these correlation coefficients.

Figure 1 shows the distributions of weight with days on feed for Data set 2. As a group, cattle tend to gain weight at a linear rate and variation in weight increases as cattle get heavier. Correlation coefficients among weights taken at different times through the finishing period ranged from 0.51 to 0.86 suggesting heavier cattle generally remain heavier through the feeding period if marketed as one group. The variability in weight also increased with time on feed causing a larger range in weights at the end of feeding period compared to that found at beginning of the feeding period. Therefore, delaying sorting to late in the finishing period should increase the accuracy in identifying marketing groups based on carcass weight.

Figure 2 shows the distribution of ADG for each of the four 28-day periods. ADG tends to remain constant through the feeding period for a group of cattle. Any variation from the constant ADG is probably due to differences in gut fill, error associated with measuring weight, or environmental factors. Comparing the small variability of gain calculated from hot carcass weight for the entire trial to the large variability for any one of the measured periods, demonstrates that ADG calculated from non-shrunk weights gives way to false variability due to differences in gut fill.

When sorting cattle into marketing groups, it would be useful to know what an individual can be expected to gain during a future period of time. It was thought that relative differences in rates of gain could be predicted from previous rates of gain. However, correlation coefficients for ADG among periods ranged from -0.11 to 0.18 and suggest while a group of cattle gain at a constant rate, an individual does not. Therefore, it is difficult to predict gain for a period of time for an individual animal based on that animal's previous performance. Also, the variation in and poor correlations of ADG through the feeding period is likely the reason that the correlation coefficient of weight to final weight improves as marketing draws nearer, but never reaches 1.0. Finally, while sorting on weight may improve uniformity of a group of cattle with large differences in weight, the advantage of sorting decreases as variation in weight decreases.

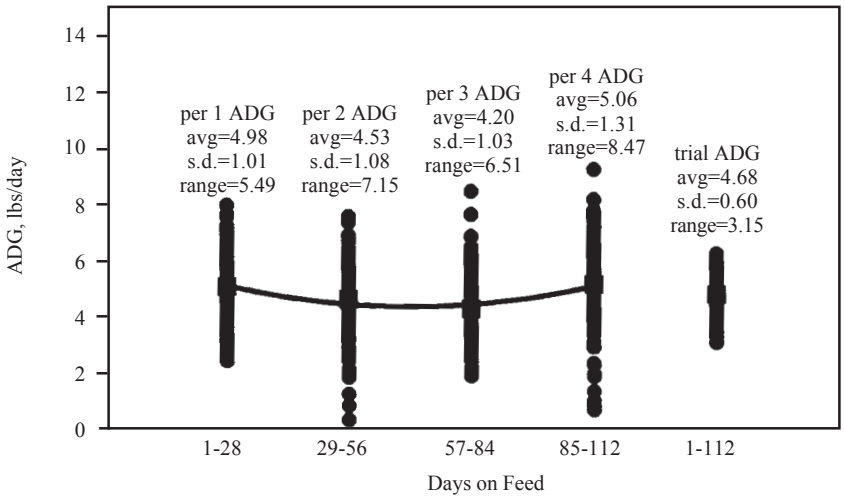

Figure 2. Interim ADG for cattle on a 112 day feeding trial (Data Set 2). s.d.=one standard deviation from the mean (lb/day), range=actual difference between minimum and maximum ADG (lb/day). Correlation coefficients among periods ranged from -0.11 to 0.18.

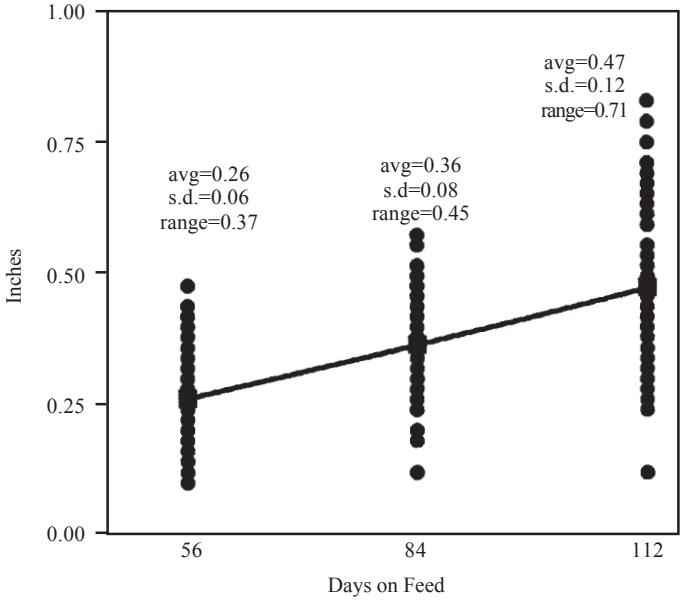

Figure 3. Distribution of 12th rib fat measurements taken via ultrasound (Data Set 2). s.d.=one standard deviation from the mean (in), range=actual difference between maximum and minimum fat thicness (in).

Figure 3 shows the distribution of 12th rib fat measurements taken over the last 56 days on feed. Similar to weight, cattle appear to fatten at a linear rate and variation in fat thickness increases with time on feed. Since only three ultrasound measurements were taken, average fattening rate (AFR) can be calculated for only two periods. Cattle fattened at a rate of 0.0037 inch/day between the first and second measurements and 0.0038 inch/day between the second and third ultrasound measurements. The correlation coefficient relating the AFR of individuals from the first period to the AFR from the second period was -0.35. Like ADG, on average, cattle fatten at a constant

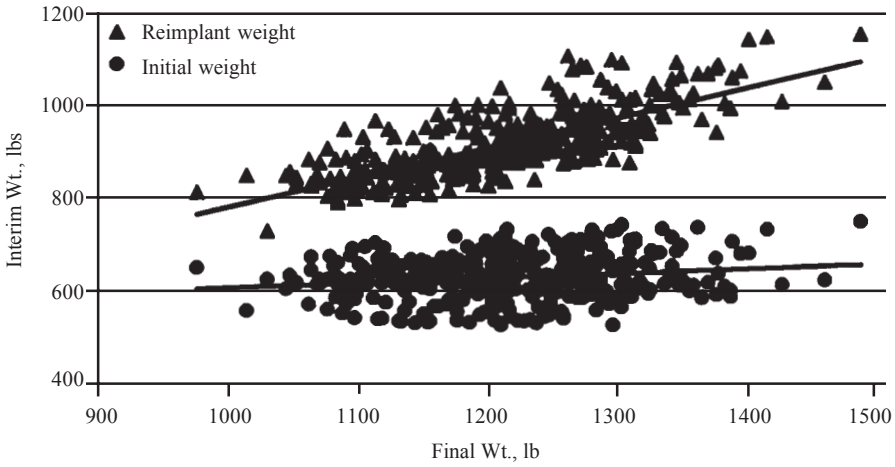

Figure 4. Relationship of initial weight and reimplant weight to final weight for calf-fed research trials (~350 head).

rate, but individuals do not. This may be due to actual variation in individual fattening rate, or because the ultrasound scans did not precisely detect small differences in fatness. Also, the variation in AFR is large. Therefore, using a constant fattening rate for a group of cattle may be appropriate, assigning a constant rate of fattening for individuals is probably not. The poor relationship of fattening rate from one period to another suggests that future fattening rates for an individual cannot be predicted by taking two ultrasound measurements and calculating a fattening rate for an individual. Thus sorting systems that predict fattening rate or relative differences in fatness at a future time likely will realize poor success in identifying animals for different marketing groups based on fatness. Rates of weight gain and fat accretion respond similarly over the feeding period, although unrelated to one another (r = -0.08 to 0.08). We suggest that both may be related to dry matter intake.

Data Set 3

The results of the analysis of Data set 3 are presented in Figure 4. For calf-fed steers, the relationship of weight to final weight greatly improves at reimplant time (r = 0.76) compared to the relationship to final weight at the time they enter the feedlot (r = 0.18) Calf-fed steers are normally reimplanted 90 to 120 days prior to slaughter. The preceeding relationships suggest while sorting calf-feds by weight upon entry into the feedlot will probably realize limited success in identifying relative differences in carcass weight, sorting at reimplant time shows promise. Cooper et al. (*1999 Nebraska Beef Report,* pp. 57-59) reported correlation coefficients for weights at reimplant time vs. carcass weight ranging from 0.46 to 0.86. These data agree with those findings and suggest that sorting by weight at reimplant time may be a viable option for producers feeding calves.

These data reaffirm that measuring live body weight is a powerful tool for producers to predict relative differences in carcass weight. While accuracy in predicting these differences is generally increased by delaying sorting until late in the feeding period, producers should realize success by sorting yearlings upon entry into the feedlot and sorting calf-feds at reimplant time.

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Sorting Strategies for Yearlings

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Sorting yearling cattle may reduce variation in carcass weights but does not increase carcass weight or profitability.

Summary

One hundred sixty medium-framed English-cross steers were used in each year of a two-year study to determine effects of three sorting strategies on performance, carcass characteristics and profitability in an extensive beef production system. Sorting by weight before the grazing period or entering the feedlot decreased variation in carcass weight. Sorting by weight before the grazing period increased marbling scores and resulted in significantly higher premiums. However, no sorting strategy significantly increased carcass weight or improved profitability.

Introduction

As the beef industry continues to move from a commodity-based marketing system to a value-based system, efforts are under way to find methods to reduce variability in carcass characteristics and

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improve consumer satisfaction. Also, economists have suggested that carcass weight is an important factor of profitability in beef productions systems (*2002 Nebraska Beef Report,* pp. 39-41). Therefore, adding carcass weight is also important to producers. Sorting methods have shown promise in accomplishing these goals by feeding cattle more closely to their ideal market endpoint. Marketing individuals that otherwise would be overweight or overfat early and feeding individuals that otherwise would be underfat longer should avoid discounts for overweight and overfat carcasses while marketing more total pounds of carcass weight. However, many of the data available do not compare the tested sorting strategy to an unsorted control.

The objective of this research was to test possible sorting strategies in a production system extensively using forage to produce long yearlings. A long yearling can be defined as a beef animal who was weaned and has gone through a period of backgrounding in the winter and grazing in the summer prior to entering the feedlot Analysis of previous data suggests logical sorting times for this type of production system include sorting at beginning of the grazing period, at the beginning of the feeding period, and at the end of the feeding period (*2002 Nebraska Beef Report,* pp. 36-39). The hypothesis for this research was that sorting would increase carcass weight, reduce variation in carcass weight and carcass fat thickness, reduce discounts received for overweight and overfat carcasses and improve profitability.

Procedure

One hundred sixty medium-framed English-cross steers (537 lb) were used in each year of a two-year study conducted from November 1999 to December 2001 to determine effects of three sorting strategies on performance, carcass characteristics, variation in weight and profitability. A preliminary analysis of the first year's results were reported previously (*2002 Nebraska Beef Report,* pp. 36-39). This report includes compete analysis of both years of the trial. Treatments were:1) 40 head sorted by weight prior to the grazing period (PASTURE), 2) 40 head sorted by weight entering the feedlot (FEEDLOT), 3) 60 head sorted by weight and 12th rib fat thickness at the end of the feeding period (PEN), and 4) 20 head that were not sorted and served as a control (CON). Each treatment consisted of two replicates. Each replicate in the PASTURE and FEEDLOT treatments were sorted into heavy and light halves. The light half of each replicate was marketed together and the heavy half of each replicate was marketed together. Cattle in the PEN treatment were marketed as individuals from their pens, whereas the CON were marketed together at one time.

Winter Period

Steers grazed corn residue from Nov. 30 to Feb. 8 in year 1 and from Nov. 28 to Feb 14 in year 2. Following removal from corn residue, they were fed ammoniated wheat straw ad-libitum in a dry lot until April 21 and 20 in years 1 and 2, respectively. A mineral supplement was provided. Steers were supplemented with 5 lb per head per day of wet corn gluten feed (DM basis) for the entire winter period

Summer Period

On April 21 and 20 for year 1 and 2, respectively, cattle were implanted with Revlor-G® and placed on smooth bromegrass pastures near Mead, Neb. until May 15 in year 1 (25 days) and May 19 in year 2 (28 days). They were then fly tagged and transported to native warm-season pastures near Ainsworth, Neb. The heavy half of the PASTURE treatment was removed from grass approximately half way through the grazing season [July 4 (50 days) and 3 (45 days) for year 1 and 2, respectively]. The remaining cattle were removed from native range on Aug. 18 in year 1 (95 days) and Aug. 29 in year 2 (102 days). In year 1, cattle returned to smooth bromegrass pastures to graze regrowth until Sept. 13 (26 days). In year 2, conditions did not allow for grazing of smooth bromegrass regrowth so cattle were placed directly into the feedlot. In year 1 the light half of the pasture sort was on grass for 75 days while the remaining cattle were on grass for 146 days. In year 2, the light half of the pasture sort was on grass for 73 days while the remaining cattle were on grass for 130 days. While grazing, steers were managed as one group and every effort was made to rotate cattle so forage never became limiting to steer performance.

Finishing Period

Upon entry into the feedlot, all steers were implanted with Revlor-S® and placed into pens. All cattle were in 10-head pens except for the PEN treatment which had 30 head per pen. Steers were stepped up on feed in 21 days using four step-up diets containing 45, 35, 25 and 15% roughage fed for 3, 4, 7 and 7 days, respectively. The final diet contained 7% roughage and was formulated to contain 12% CP, 0.7% Ca, 0.35% P, 0.6% K, 30 g/ton monensin and 10 g/ton tylosin (DM basis). The finishing diet contained 40% wet corn gluten feed, 48% high moisture corn, 7% alfalfa and 5% supplement. Initial weights for the winter, summer and finishing periods were an average of two weights taken on consecutive days following a four-day limit feeding at 2% of the average estimated BW. The limit fed diet consisted of 47.5% wet corn gluten feed, 47.5% alfalfa hay and 5% supplement. This was done to equalize gut fill so that weights taken were a true reflection of relative differences in weight rather than differences in gut fill.

Each treatment had an individual marketing strategy based on fat thickness or a combination of fat thickness and weight. Ultrasound was used to estimate fat thickness. The PASTURE treatment was marketed in two groups (light and heavy halves at the initiation of grazing) when the average of each group averaged 0.45 in 12th rib fat thickness. The FEEDLOT treatment also was marketed in two groups (light and heavy halves at entry to the feedlot). The light half was marketed when the group averaged 0.50 in 12th rib fat thickness to allow them to gain additional carcass weight. The heavy half was marketed when the group averaged 0.40 in 12th rib fat thickness to avoid overweight car-

Table 1. Performance data.

	Treatment[a]				
Item	Control	Pasture	Feedlot	Pen	SEM
Winter					
Days	143	143	143	143	—
Initial weight, lb	537	537	540	535	13
Daily gain, lb	1.41	1.41	1.43	1.47	0.29
Summer					
Days	138	106	138	138	—
Initial weight, lb	740	740	744	747	29
Daily gain, lb	1.67	1.76	1.72	1.74	0.04
Finishing					
Days	82	99	90	86	—
Initial weight, lb	973[b]	927[c]	982[b]	985[b]	22
Daily gain, lb	4.73[b]	4.38[c]	4.58[b]	4.63[b]	0.11
Dry matter intake, lb	31.3[b]	29.1[c]	30.8[b]	30.8[b]	0.22
Feed/gain	6.62	6.64	6.72	6.65	0.17

[a]Treatments: control=no sorting, pasture=sorted based on weight going to grass, feedlot=sorted based on weight entering the feedlot, pen=sorted by weight and fat thickness at the end of the feeding period.
[bc]Means within row with unlike superscripts differ (P < 0.05).

Table 2. Carcass, economic, and variance data.

	Treatment[a]				
Item	Control	Pasture	Feedlot	Pen	SEM
Carcass data					
Weight, lb	852	848	870	863	11
Yield grade	2.60[bc]	2.65[b]	2.48[cd]	2.43[d]	0.08
12th rib fat, in.	0.457	0.460	0.457	0.444	0.012
Marbling score[e]	495[f]	539[g]	502[f]	509[f]	7.93
% overweight	8.00	0.00	5.00	8.00	4.00
Economic analysis					
Break even, $/cwt	66.31	67.12	65.92	66.41	1.60
Premium/discount, $/cwt	-0.28[f]	2.75[g]	0.05[f]	-0.01[f]	0.64
Profit/loss, $/head	28.01	37.31	36.22	28.08	22.66
Standard deviation[h]					
Winter initial weight, lb	55	46	48	48	2
Summer initial weight, lb	70	62	62	62	2
Feedlot initial weight, lb	70[b]	37[c]	62[d]	66[bd]	2
Carcass weight, lb	55[f]	42[g]	46[g]	59[f]	0.03
Fat thickness, in.	0.075	0.118	0.122	0.091	0.520

[a]Treatments: control=no sorting, pasture=sorted based on weight going to grass, feedlot=sorted based on weight entering the feedlot, pen=sorted by weight and fat thickness at the end of the feeding period.
[bcd]Means within row with unlike superscripts differ (P < 0.05).
[e]Marbling score: 400 = slight 0; 450 = slight 50; 500 = small 0; 550 = small 50; etc.
[fg]Means within row with unlike superscripts differ (P < 0.05).
[h]Statistical analysis and SEM based on log base 10 of standard deviation.

casses. The average market fatness of the FEEDLOT treatment was intended to be 0.45 in 12th rib fat thickness. The PEN treatment was marketed as individuals in four kill dates in year 1 and five kill dates in year 2. Back fat thickness was measured by ultrasound and weights were taken every two weeks once the cattle were on feed for approximately 50 days. Cattle were marketed when they reached about 0.45 in 12th rib fat thickness or 1500 lb shrunk body weight (4% shrink). As estimated marketing time neared, ultrasound was also used to determine fat thickness of cattle in other treatments but was not collected at regular intervals as was the case with the PEN treatment.

Economic Analysis

Profit was calculated by selling the cattle on the rail in a value-based market that rewards high marbling cattle. The grid used is based on the work of Feuz (*2002 Nebraska Beef Report,* pp. 39-41). The grid was changed so that premiums and discounts received for marbling were based on marbling scores rather than percentage choice, because of small and varying numbers of cattle in each replicate. A few differences in individuals grading choice can have large impacts on the percentage choice of the replicate. Thus using the average marbling score for each replicate is a more realistic comparison. Premiums and discounts for marbling were based on the choice/select spread for the months of October ($9.19/cwt), November ($9.80/cwt) and December ($8.00/cwt) from 1992-2002. The actual choice/select spread for each replicate was calculated using a weighted average based on the number of cattle marketed in each of the three months. A marbling score of small[00] received no premium or discount. Premiums and discounts were calculated by multiplying the choice/select spread by 100 units above or below small[00] (premiums for marbling scores above small[00] and discounts for marbling scores below small[00]). The base price used was the average Nebraska dressed fed cattle price for October ($107.43/cwt), November ($109.57/cwt), and December ($109.58/cwt) from 1992-2001. Actual base price paid for each replicate was calculated using a weighted average of the number of cattle sold in each of the three months for each replicate. No treatments were charged for the use of ultrasound.

Results

Performance data are shown in Table 1. Treatments performed similarly during the winter and summer periods. However, because the PASTURE treatment grazed fewer days, cattle on this treatment were lighter entering the feedlot. While on feed, the PASTURE treatment consumed less feed and exhibited reduced ADG compared to other treatments. The reduction in gain is likely due to intake, since they exhibited feed conversions similar to other treatments. The reduced intake may be related to the PASTURE treatment cattle entering the feedlot at lighter weights, or that they entered the feedlot in early July and endured warmer temperatures for a longer period of time compared to other treatments.

Carcass data are shown in Table 2. All treatments were successfully marketed at similar fat depths. There were

(Continued on next page)

no significant differences in carcass weight. This was unexpected since increasing carcass weight was a main objective of the trial. The PEN treatment resulted in a reduction of USDA called yield grades indicating that this sorting strategy may reduce excess fat. The PASTURE treatment had significantly higher marbling scores compared to other treatments. This is presumably due to half the cattle on PASTURE being on feed for more days. There were no statistical differences in percentage of overweight cattle in any treatment. However, the PASTURE treatment was the only sorting strategy that successfully avoided any overweight carcasses.

Results of the economic analysis are also shown in Table 2. There were no differences in break-even costs for any treatments. The PASTURE treatment had significantly higher premiums compared to other treatments. This is related to the increased marbling scores of this treatment. There were no differences in profitability for any of the treatments. This was also unexpected but is not surprising considering there were no differences in carcass weight. Producers who want to sort cattle should use caution to not implement a sorting strategy that adds cost, because there is no opportunity to recapture the expense.

Table 2 also provides data on the variation in weight and carcass fat thickness among treatments. There were no differences in variability in weight among treatments until cattle entered the feedlot. Upon entry into the feedlot, the PASTURE treatments had significantly less variation in weight compared to other treatments, resulting in reduced variation in carcass weight. The FEEDLOT treatment also had reduced variability in carcass weight suggesting that these two sorting strategies may result in more uniform carcass weights. There were no differences in variation in carcass measured fat thickness. It was expected that the PEN treatment might have the best chance of reducing variability in carcass fat thickness, since cattle were measured individually. This was not the case, possibly because fat thickness and weight were used as sorting criteria. These results may differ if fat thickness was the only sorting criteria used.

Producers considering a sorting strategy should have specific goals in mind when implementing sorting techniques. None of the strategies investigated improved profitability. To reduce variability in carcass weight, producers may consider sorting cattle by weight upon entry into the feedlot, because it can be implemented easily into most feedlots at little to no cost. Producers using a long yearling production system wanting to increase marbling scores and reduce variability in carcass weight may consider sorting the cattle by weight before the grazing period begins and then removing the heavy cattle mid-way through the grazing season. This strategy can also be implemented with low input costs and may allow for more options in range management.

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Carcass and Palatability Characteristics of Calf-fed and Yearling Finished Steers

Perry Brewer
Chris Calkins
Rosemary Anderson
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Rick Rasby[1]

Steers finished as yearlings produce less tender beef than calf-fed steers. However, fewer "tough" steaks occurred with extended aging times.

Summary

Steers finished in two management systems were used to compare carcass and palatability characteristics. Calves (n=34) were finished on a high concentrate diet for 203 days. Yearlings (n=42) grazed forages followed by 93 days on a high concentrate diet. Calves had higher marbling scores, lower shear force values and higher sensory ratings for tenderness, flavor and overall acceptability. Compared at equal marbling scores, calves had lower shear force values and higher sensory ratings for tenderness and overall acceptability. The risk of steaks being classified as "tough" was higher in yearlings, but relatively low, especially at extended aging times.

Introduction

An intensive method of finishing cattle consists of calves entering a feedlot post-weaning, where cattle are fed a high-concentrate diet ad libitum, to optimize time on feed. These calves commonly are finished and slaughtered at 12-15 months of age and are termed calf-feds. Some extensive management systems include finishing cattle solely on grass or forage, while others include both forage and grain feeding. Cattle which are backgrounded before entering the drylot are slightly older and commonly finished as yearlings. However, meat becomes less tender as the chronological age of an animal increases. Implementing grazing into a beef production system increases utilization of forage, thus decreasing costs associated with drylot feeding and possibly the length of time necessary in the feedlot. Literature suggests cattle on feed, for as little as 90 days, may have similar palatability traits as cattle fed for longer periods of time.

Cooler aging is a common method used to produce a more tender beef product. Aging beef allows naturally occurring enzymes in the muscle to function, thus producing a more tender cut of meat.

Table 1. Carcass characteristics and longissimus muscle proximate composition from calf-fed and yearling steers.

	Calf-feds		Yearlings	
Trait	Mean	SE	Mean	SE
Carcass wt, lb.	718[b]	10.59	843[c]	9.53
Fat thickness, in.	0.60	0.03	0.56	0.03
Adj. fat thickness, in.	0.65	0.03	0.60	0.02
Longissimus muscle area, in.^{2}	11.3[b]	0.16	12.7[c]	0.14
Kidney, pelvic, heart fat, %	2.1	0.07	1.95	0.07
Yield grade	3.7	0.08	3.5	0.07
Marbling score[a]	511[b]	13.18	353[c]	11.86
Moisture, %	66.44[b]	0.37	72.29[c]	0.33
Fat, %	11.85[b]	0.48	6.82[c]	0.44
Ash, %	1.54[b]	0.03	1.32[c]	0.03

[a]Marbling score: modest = 500-599; small = 400-499; slight 300-399.
[b,c]Means on the same row without a common superscript are different (P < 0.05)

Table 2. Palatability traits and shear force values for loin steaks aged 7, 14, and 21 days from calf-fed and yearling steers.

		Calf-feds		Yearlings	
Aging Time	Trait[a]	Mean	SE	Mean	SE
7 day	Juiciness	5.18	0.08	4.99	0.08
	Tenderness	5.61[b]	0.09	4.84[c]	0.08
	Flavor	4.93[b]	0.06	4.70[c]	0.05
	Overall acceptability	5.07[b]	0.08	4.62[c]	0.07
	Shear force, lb.	6.02[b]	0.23	8.49[c]	0.20
14 day	Juiciness	4.93	0.08	4.72	0.08
	Tenderness	5.64[b]	0.09	4.90[c]	0.08
	Flavor	4.98[b]	0.06	4.74[c]	0.05
	Overall acceptability	5.03[b]	0.08	4.62[c]	0.07
	Shear force, lb.	5.58[b]	0.23	7.85[c]	0.20
21 day	Shear force, lb.	5.32[b]	0.23	7.28[c]	0.20

[a]Means based on an eight-point scale (8 = extremely desirable, 7 = very desirable, 6 = moderately desirable, 5 = slightly desirable, 4 = slightly undesirable, 3 = moderately undesirable, 2 = very undesirable, 1 = extremely undesirable).
[b,c]Means on the same row without a common superscript are different (P < 0.05).

The objective of this study was to compare differences in carcass traits and palatability characteristics in calf-fed versus yearling steers.

Procedure

Seventy-six crossbred steers were evaluated in two management systems. All calves were weaned and the steers were separated into the two treatments at the same time. Thirty-four steers were finished as calf-feds and 42 as yearlings. Calf-fed steers entered the feedlot with a 28-day receiving period, followed by a 5-week period of increasing concentrate formula up to 90% concentrate (12% CP). These steers were given ad libitum access for 203 days. Yearling steers were drylotted for 60 days until corn stalks were available for grazing. Corn stalks were grazed for 78 days, followed by a 64-day period in the drylot. Spring and summer grasses then were grazed for 96 days before a 93-day finishing period in the feedlot with the same feeding formula received by calf-fed steers. Calf-fed and yearling steers were fed to a target fat thickness endpoint of 0.5 inch at the 12th rib.

The cattle were harvested in a commercial packing plant and the carcasses were chilled. At 48 hours post-mortem, carcass data for yield and USDA quality grades were collected. Wholesale loins from the left side of each carcass were collected and transported to the University of Nebraska Meat Laboratory.

At 7 days post-mortem one steak was removed from the 13th rib area and frozen for proximate analysis. The remaining portion of each loin then was fabricated into one-inch thick steaks for Warner-Bratzler shear force determinations and consumer sensory taste panel. Steaks for shear force were classified into aging treatments of 7, 14 and 21 days. Steaks for consumer sensory taste panel were aged for 7 and 14 days. All steaks were vacuum-packaged and frozen until used for further testing.

For consumer taste panel determination, 3-4 steaks were thawed and broiled on Farberware Open-Hearth Broilers to a final internal temperature of 158°F. Immediately after cooking, each steak was sectioned into 1/2" x 1/2" x 1" portions and kept warm in double-boiler units. A consumer sensory taste panel, averaging 29 members (range: 21-42), evaluated eight samples, two for each of the four treatments, for 19 consecutive sessions. Juiciness, tenderness, flavor and overall acceptability were rated using an 8-point descriptive scale (8 = extremely desirable, 1 = extremely undesirable). Steaks for Warner-Bratzler shear force measurement were cooked using the same method as for the taste panel. After cooling to room temperature, a minimum of six 1/2 inch cores were removed and sheared in the center with the Warner-Bratzler shear attachment to an Instron Universal Testing Machine.

Shear force values were used to classify steaks as being "tough", "intermediate" or "tender." "Tough" steaks were distinguished as having greater than 10 lbs. of shear force; "intermediate" steaks having from 8.5 to 10 lb., and "tender" steaks having less than 8.5 lb. of shear force.

Results

Carcass Characteristics

Carcass characteristics and chemical analyses means of calf-fed and yearling steers are summarized in Table 1. Yearling steers produced much heavier carcasses with larger longissimus muscle areas (P < 0.01). Calf-fed steers, however, showed substantially higher marbling scores (P < 0.01) and USDA quality grades.

Chemical analyses showed significant differences (P < 0.01) between calf-fed and yearling steers. Fat and ash percentages were higher in calf-fed carcasses, while moisture percentage was higher in yearling carcasses.

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Palatability Traits

Palatability traits for steaks aged 7 and 14 days, and shear force means for steaks aged 7, 14 and 21 days are summarized in Table 2, comparing calf-fed and yearling steers. Tenderness, flavor and overall acceptability ratings were significantly higher ($P < 0.05$) in calf-fed steaks aged 7 and 14 days. In addition, shear force means were significantly lower ($P < 0.01$) for steaks from calf-fed cattle compared at 7, 14 and 21 days of post-mortem aging.

Palatability and shear force values also were analyzed using marbling score as a covariant (Table 3). This enabled us to compare calf-fed and yearling steers at an equivalent marbling score. Sensory tenderness remained significantly higher ($P < 0.01$) for calf-fed steers at 7 and 14 days aging. Overall acceptability ratings were also higher for calf-fed steers at 7 ($P < 0.05$) and 14 ($P < 0.10$) days of post-mortem aging. Flavor differences were no longer significant at equal marbling scores. Shear force means also remained significantly lower ($P < 0.01$) for calf-fed steers at 7, 14 and 21 days of aging.

Figure 1 illustrates the percentage of the calf-fed and yearling steers within each range of shear force at 7, 14 and 21 days of aging. The percentage of animals being classified into the "tough" category was determined using the shear force values at these aging times. No calf-fed steers were classified as "tough" in this study. However, 19%, 11.9% and 4.8% of yearling steers were classified as "tough" at 7, 14 and 21 days of aging, respectively. Post-mortem aging showed a more significant effect on yearling cattle. However, steaks from calf-fed steers were unusually tender in this study.

Although the risk of finding a "tough" loin steak was higher for yearling finished steers than for calf-feds, the frequency was relatively low, especially with extended aging times.

Table 3. Palatability traits and shear force values for loin steaks aged 7, 14, and 21 days from calf-fed and yearling steers adjusted to a constant marbling score.

Aging Time	Trait[a]	Calf-feds		Yearlings	
		Mean	SE	Mean	SE
7 day	Juiciness	5.07	0.09	5.07	0.08
	Tenderness	5.50[b]	0.10	4.92[c]	0.09
	Flavor	4.84	0.07	4.77	0.06
	Overall acceptability	4.97[b]	0.08	4.71[c]	0.07
	Shear force, lb.	6.37[b]	0.24	8.20[c]	0.21
14 day	Juiciness	4.82	0.09	4.80	0.08
	Tenderness	5.53[b]	0.09	4.99[c]	0.09
	Flavor	4.89	0.06	4.81	0.06
	Overall acceptability	4.92[d]	0.08	4.71[e]	0.07
	Shear force, lb.	5.93[b]	0.23	7.56[c]	0.21
21 day	Shear force, lb.	5.67[b]	0.23	6.99[c]	0.21

[a]Means based on an eight-point scale (8 = extremely desirable, 7 = very desirable, 6 = moderately desirable, 5 = slightly desirable, 4 = slightly undesirable, 3 = moderately undesirable, 2 = very undesirable, 1 = extremely undesirable).
[b,c]Means on the same row without a common superscript are different ($P < 0.05$)
[d,e]Means on the same row without a common superscript are different ($P < 0.10$)

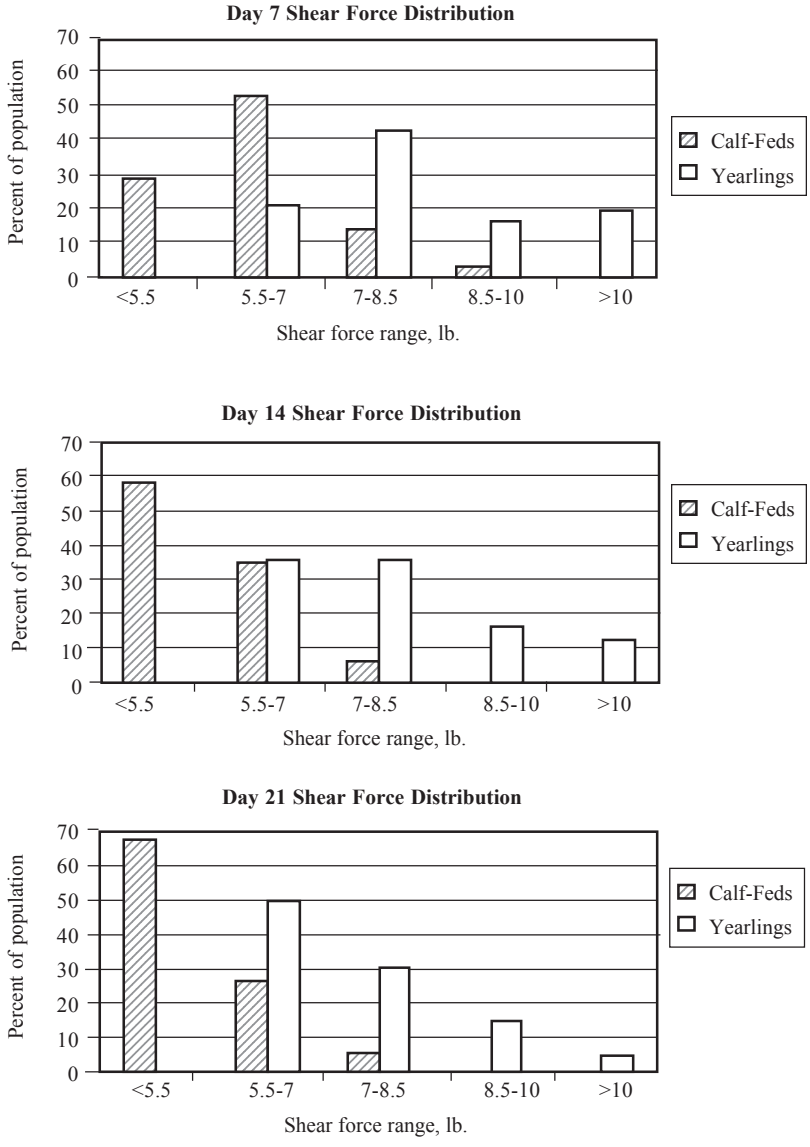

Figure 1. Shear force distribution by aging time.

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Cow Muscle Profiling: Processing Traits of 21 Muscles from Beef and Dairy Cow Carcasses

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Beef and dairy cow carcasses exhibited considerable variation in muscle processing traits. These results suggest opportunities may exist to enhance the value of selected muscles.

Summary

Twenty-one muscles from beef and dairy cow carcasses were analyzed for objective color, shear force, pH, expressible moisture, total collagen, total heme-iron and proximate composition. Results of this analysis showed large variation in processing traits from muscle to muscle. Muscle traits were most often influenced by fat thickness in both beef and dairy carcasses. These results will aid in selecting muscles that are well suited for enhancement.

Introduction

Previous research has revealed 43% of the cow carcass is sold as boxed beef. Much of the remaining 57% is merchandised as beef trim for grinding and processing. To increase the overall value of the cow carcasses it is necessary to characterize the muscles harvested from these animals. Cows of advanced maturities will yield meat with differing chemical and physical properties that directly influence its processing potential. Information about muscles from these animals was not readily available before this study. The lack of information has lead to the underuse of muscles from dairy and beef cows. Therefore, the objectives of this study were to create a database of information, to include processing traits of 21 muscles from beef and dairy cow carcasses and to determine effects of carcass weight, fatness, muscling level and skeletal maturity on these traits.

Procedure

One hundred and forty-five cow carcasses (74 beef and 71 dairy) were selected over a 5-month period in four geographic locations (Green Bay, Wis., Gering, Neb., Phoenix, Ariz., and Gainesville, Fla.). Carcasses were selected based on estimated 12th rib fat thickness (< .10 in > .10 in), carcass weight (< or > 550 lb for beef and < or > 750 lb for dairy), muscling level (heavy/medium or light) and skeletal maturity (USDA C/D or E score). Approximately five carcasses were selected within each cell, from which 21 muscles per carcass were harvested for analysis. Muscles from two carcasses were evaluated for objective color using a Hunter Lab® Mini Scan XE plus colorimeter with a 1-inch port, and for Warner-Bratzler shear force (dry heat cooked to 71°C, 0.5-inch cores). Chemical analyses were performed on muscles from three carcasses per cell. A pH meter with a glass tip electrode was used to determine muscle pH. Water holding capacity was determined as expressible moisture and was measured as the percentage of moisture loss due to centrifugation. Total muscle collagen content was calculated from hydroxyproline, measured with a spectrophotometer. Total heme-iron was extracted using an acetone extraction procedure and quantified using a spectrophotometer. Proximate composition consisted of fat, moisture and ash determination and was measured by Soxhlet ether extraction (fat) and a LEC Thermogravimetric Analyzer (moisture and ash). Data were analyzed using the General Linear Model procedure of Statistical Analysis System (SAS). Comparisons between dairy and beef body types were not analyzed due to differences in carcass weight ranges.

Results

The results of this project are given in Tables 1-4. The most intriguing aspect of these data was the large variation present in all measured characteristics, found in all 21 muscles. Variation was seen within a given muscle, as well as among muscles for a given characteristic. Objective color was represented by three quantitative values, L*, a* and b*, representing lightness (0 = black to 100 = white), redness (-60 = green to +60 = red), and yellowness (-60 = blue to +60 = yellow), respectively. Muscle lightness ranged from 24.8 (*Rectus femoris*) to 38.3 (*Semitendinosis*) in beef and 33.1 (*Vastus medialis*) to 38.8 (*Semitendinosis*) in dairy. *Tensor fascia latae* exhibited the lowest mean redness values in both beef and dairy (26.9 and 27.9 respectively) muscles, while *Serratus ventralis* (29.8, beef and 30.6, dairy) measured the highest. Muscle yellowness ranged from 20.1 (*Tensor fascia latae*) to 23.2 (*Infraspinatus*) for beef and 20.4 to 24.1 for dairy represented by the same muscles, respectively.

Warner-Bratzler shear force has become an industry standard for measurement of cooked meat tenderness. Tenderness is a major factor influencing palatability of meat and a main determinant of consumer acceptance. The *Multifidus/Spinalis dorsi* (3.4 lb) had the lowest shear force measurement of the muscles from beef carcasses, while the *Psoas major* (3.1 lb) was the lowest of dairy muscles. The least tender (highest shear force measurement) muscle was the *Biceps femoris* for both beef and dairy (9.5 lb and 8.5 lb, respectively) muscles.

Moisture retention in meat products will have a significant effect on processing yield. Increased water holding capacity, measured as moisture loss

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Table 1. Properties of beef muscles.

Muscles	L* value		a* value		b* value		Warner-Bratzler shear force (lb)		Expressible moisture (%)	
	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d)	Mean	(s.d)
Adductor	34.9	(4.2)	29.7	(2.4)	22.9	(2.9)	4.5	(1.0)	47.0	(4.3)
Biceps femoris	34.8	(4.8)	29.2	(2.4)	22.7	(2.6)	9.5	(2.7)	44.2	(4.6)
Complexus	33.4	(3.3)	28.5	(2.3)	21.2	(3.0)	5.3	(1.4)	41.1	(4.9)
Deep pectoral	33.6	(4.8)	27.7	(2.5)	21.1	(2.6)	8.7	(2.6)	42.1	(5.8)
Gluteus medius	32.6	(3.7)	28.3	(2.3)	21.7	(2.6)	5.7	(1.5)	45.7	(4.1)
Infraspinatus	31.4	(4.4)	29.7	(2.1)	23.2	(4.5)	4.9	(1.1)	38.1	(4.2)
Latissimus dorsi	33.1	(4.2)	27.5	(2.9)	20.3	(3.5)	6.0	(1.5)	41.1	(6.1)
Longissimus dorsi	33.9	(4.3)	28.1	(2.5)	21.7	(2.6)	7.0	(1.5)	44.5	(3.6)
Multifidus/Spinalis dorsi	31.8	(3.7)	28.7	(3.1)	21.8	(3.7)	3.4	(1.2)	36.1	(6.7)
Psoas major	34.1	(3.6)	27.2	(3.0)	20.9	(2.9)	3.5	(0.6)	43.9	(3.5)
Rectus femoris	24.8	(4.0)	28.9	(2.8)	22.4	(3.0)	5.9	(1.6)	43.1	(5.3)
Semimembranosis	33.2	(4.7)	29.5	(2.3)	23.0	(2.7)	6.0	(1.3)	46.1	(4.7)
Semitendinosis	38.3	(4.6)	28.0	(2.2)	21.8	(1.9)	7.6	(1.5)	44.3	(4.6)
Serratus ventralis	33.4	(2.6)	29.8	(1.9)	23.1	(2.4)	5.3	(1.0)	39.9	(5.8)
Supraspinatus	34.2	(3.9)	28.9	(2.6)	21.9	(3.2)	4.5	(1.4)	41.8	(4.0)
Teres major	35.8	(3.3)	27.5	(2.6)	20.7	(2.9)	3.7	(0.8)	45.8	(5.2)
Tensor fascia latae	33.1	(4.5)	26.9	(2.6)	20.1	(2.8)	5.3	(1.3)	42.0	(5.5)
Triceps brachii	32.2	(4.4)	28.5	(2.5)	22.1	(2.8)	5.2	(1.0)	43.2	(5.0)
Vastus lateralis	33.3	(5.0)	28.0	(2.1)	21.3	(2.4)	5.8	(1.9)	45.0	(5.2)
Vastus medialis	32.5	(4.4)	27.4	(2.6)	20.6	(3.2)	3.8	(1.1)	43.9	(4.9)
Vastus intermedius	35.7	(4.3)	29.0	(2.7)	22.8	(3.1)	3.8	(0.8)	43.0	(4.1)

Table 2. Properties of beef muscles.

Muscles	pH		Total collagen (mg/g)		Heme-Iron (ppm)		Fat (%)		Moisture (%)		Ash (%)	
	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d)	Mean	(s.d.)	Mean	(s.d.)
Adductor	5.6	(.22)	7.4	(3.4)	35.5	(10.6)	3.5	(1.7)	75.1	(1.4)	1.6	(.26)
Biceps femoris	5.7	(.20)	10.9	(4.7)	32.5	(10.4)	4.3	(1.9)	75.0	(1.7)	1.6	(.28)
Complexus	5.9	(.21)	10.9	(3.3)	34.9	(7.2)	4.0	(2.0)	76.0	(1.9)	1.3	(.25)
Deep pectoral	5.7	(.22)	10.3	(4.0)	30.1	(8.3)	3.4	(1.8)	76.4	(1.6)	1.5	(.37)
Gluteus medius	5.7	(.17)	9.2	(5.6)	34.5	(9.5)	4.7	(1.8)	74.4	(1.7)	1.6	(.29)
Infraspinatus	6.1	(.18)	9.4	(6.2)	35.0	(6.2)	5.6	(2.7)	74.3	(2.2)	1.2	(.33)
Latissimus dorsi	5.9	(.27)	18.3	(2.2)	30.6	(8.3)	3.0	(1.6)	76.4	(1.4)	1.5	(.25)
Longissimus dorsi	5.6	(.19)	9.4	(3.1)	31.0	(8.9)	4.4	(2.2)	74.4	(2.1)	1.5	(.27)
Mutifidus/Spinalis dorsi	3.1	(.18)	6.3	(3.5)	37.1	(8.2)	7.5	(2.8)	76.1	(2.6)	1.2	(.27)
Psoas major	5.7	(.26)	13.3	(2.4)	31.6	(9.0)	5.7	(2.3)	74.5	(2.2)	1.6	(.24)
Rectus femoris	5.9	(.26)	4.7	(3.3)	31.2	(9.5)	3.1	(1.2)	76.1	(1.1)	1.4	(.28)
Semimembranosis	5.6	(.23)	7.8	(2.6)	32.9	(9.0)	3.4	(1.5)	75.3	(1.4)	1.5	(.33)
Semitendinosis	5.7	(.25)	6.8	(3.7)	25.2	(8.7)	2.8	(1.3)	76.1	(1.3)	1.4	(.25)
Serratus ventralis	6.0	(.21)	8.2	(2.6)	35.4	(7.7)	5.0	(2.8)	75.1	(2.4)	1.3	(.33)
Supraspinatus	6.0	(.23)	10.0	(3.6)	34.0	(7.4)	3.6	(1.6)	74.5	(1.3)	1.5	(.28)
Teres major	5.9	(.26)	8.8	(6.3)	28.9	(8.9)	3.0	(1.4)	76.7	(1.6)	1.5	(.35)
Tensor fascia latae	5.8	(.25)	7.9	(2.9)	29.1	(8.9)	3.6	(2.0)	75.7	(2.1)	1.4	(.27)
Triceps brachii	5.8	(.25)	10.5	(5.1)	36.4	(10.6)	3.5	(1.6)	75.7	(1.4)	1.5	(.29)
Vastus lateralis	5.8	(.24)	6.1	(2.7)	34.3	(8.6)	2.6	(1.2)	76.2	(1.1)	1.5	(.23)
Vastus medialis	5.9	(.27)	6.7	(4.6)	34.9	(8.4)	2.6	(1.2)	77.3	(1.0)	1.4	(.22)
Vastus intermedius	6.3	(.27)	8.9	(4.5)	36.7	(8.7)	4.7	(1.9)	76.2	(1.2)	1.4	(.28)

due to centrifugation, will decrease cooking loss and improve consumer satisfaction. *Multifidus/Spinalis dorsi* exhibited the lowest percentage weight loss due to centrifugation, 36.1% and 39.3%, for both beef and dairy muscles, respectively. *Adductor* (47.0%) muscles from beef carcasses and *Semimembranosis* (46.8%) muscles from dairy carcasses produced the largest percentage weight loss due to centrifugation of the 21 muscles (lowest water holding capacity).

Muscle pH has a large effect on muscle color, protein functionality and water-holding capacity. All of these factors play important roles in the stability and acceptability of meat products. Higher pH indicates improved water holding capacity, as well as darker color, with the side effect of shorter shelf life. Muscle pH ranged from 5.6 (*Longissimus dorsi, Adductor,* and *Semimembranosis*) to 6.3 (*Vastus intermedius*) for both beef and dairy muscles.

Muscle total collagen content is an indicator of connective tissue found in a meat sample. Connective tissue has been shown to affect the tenderness and palatability of meat. Of the 21 beef muscles, the *Psoas major* (4.7 mg/g) exhibited the lowest total collagen content while the *Vastus medialis* (6.4 mg/g) was lowest of dairy muscles. The *Infraspinatus* muscle was found to have the highest mean total collagen content for both beef and dairy (18.3 mg/g and 22.9mg/g, respectively) muscles.

Heme-iron content is a measure of

Table 3. Properties of dairy muscles.

	L* value		a* value		b* value		Warner-Bratzler shear force (lb)		Expressible moisture (%)	
Muscles	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d)	Mean	(s.d)
Adductor	35.2	(3.2)	30.4	(2.5)	23.0	(3.2)	4.3	(0.8)	46.3	(3.4)
Biceps femoris	35.9	(3.4)	29.4	(2.0)	22.4	(2.2)	8.5	(1.7)	43.4	(4.6)
Complexus	35.1	(2.5)	29.8	(1.6)	22.7	(2.2)	4.5	(1.3)	42.7	(4.0)
Deep pectoral	35.7	(2.5)	28.9	(2.0)	22.1	(2.5)	7.8	(4.1)	42.7	(4.8)
Gluteus medius	33.3	(2.3)	28.9	(2.4)	22.0	(2.7)	5.6	(1.4)	45.7	(4.3)
Infraspinatus	35.2	(2.1)	30.6	(1.3)	24.1	(2.1)	4.8	(1.2)	41.4	(3.4)
Latissimus dorsi	33.5	(2.2)	28.3	(1.9)	20.9	(2.8)	5.4	(1.6)	42.1	(4.7)
Longissimus dorsi	35.0	(3.6)	29.7	(2.3)	23.1	(2.8)	5.4	(1.4)	44.3	(4.0)
Multifidus/Spinalis dorsi	33.5	(3.3)	29.5	(3.0)	22.5	(3.5)	3.9	(1.5)	39.3	(5.9)
Psoas major	36.6	(2.3)	28.0	(2.5)	21.1	(2.6)	3.1	(0.6)	44.9	(3.7)
Rectus femoris	35.6	(2.6)	29.8	(2.0)	22.8	(2.2)	4.8	(1.2)	43.7	(4.2)
Semimembranosis	33.3	(2.0)	28.8	(2.6)	21.7	(2.9)	5.3	(0.9)	46.8	(4.0)
Semitendinosis	38.8	(3.3)	29.0	(2.5)	22.5	(2.3)	6.7	(1.2)	45.6	(3.9)
Serratus ventralis	34.4	(2.5)	30.6	(2.0)	24.0	(2.7)	4.4	(0.9)	41.9	(4.2)
Supraspinatus	33.8	(2.9)	29.1	(2.4)	21.9	(3.2)	4.7	(1.1)	43.1	(4.4)
Teres major	36.2	(3.2)	29.1	(2.7)	22.1	(3.2)	4.0	(0.6)	46.7	(4.7)
Tensor fascia latae	34.3	(3.5)	27.9	(1.9)	20.4	(2.0)	4.7	(1.1)	40.9	(5.1)
Triceps brachii	33.3	(2.3)	29.8	(2.2)	23.3	(3.3)	4.8	(0.7)	44.3	(3.2)
Vastus lateralis	34.1	(2.7)	29.1	(2.5)	22.2	(2.8)	6.2	(1.6)	45.5	(4.2)
Vastus medialis	33.1	(2.8)	28.3	(1.8)	21.6	(2.1)	4.4	(1.1)	43.2	(4.4)
Vastus intermedius	34.9	(3.6)	29.3	(1.3)	22.2	(1.5)	4.3	(0.9)	43.9	(5.5)

Table 4. Properties of dairy muscles.

	pH		Total collagen (mg/g)		Heme-Iron (ppm)		Fat (%)		Moisture (%)		Ash (%)	
Muscles	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d.)	Mean	(s.d)	Mean	(s.d.)	Mean	(s.d.)
Adductor	5.6	(.17)	6.7	(2.0)	36.7	(10.2)	3.8	(1.6)	74.2	(1.2)	1.5	(.30)
Biceps femoris	5.7	(.17)	12.4	(4.4)	33.2	(8.1)	5.4	(2.3)	73.6	(1.9)	1.5	(.34)
Complexus	5.9	(.14)	11.2	(2.1)	36.7	(8.7)	6.1	(3.1)	73.4	(2.6)	1.3	(.28)
Deep pectoral	5.7	(.14)	10.3	(2.2)	31.0	(9.6)	4.4	(1.7)	74.7	(1.7)	1.5	(.35)
Gluteus medius	5.7	(.14)	12.1	(4.8)	35.3	(7.5)	5.8	(2.0)	72.9	(1.5)	1.5	(.32)
Infraspinatus	6.0	(.15)	22.9	(5.7)	38.8	(9.4)	6.6	(2.8)	73.0	(2.3)	1.3	(.27)
Latissimus dorsi	5.8	(.20)	8.6	(2.1)	30.7	(9.6)	3.4	(1.5)	75.6	(1.4)	1.4	(.34)
Longissimus dorsi	5.6	(.15)	6.7	(2.8)	31.4	(8.4)	6.3	(2.7)	72.0	(2.1)	1.4	(.34)
Mutifidus/Spinalis dorsi	6.0	(.17)	15.9	(2.9)	39.0	(9.6)	9.9	(3.6)	70.8	(3.1)	1.2	(.30)
Psoas major	5.8	(.24)	7.2	(4.3)	32.8	(8.1)	7.4	(2.6)	72.4	(2.5)	1.5	(.32)
Rectus femoris	5.9	(.24)	7.9	(1.9)	33.5	(9.4)	3.7	(2.0)	74.8	(1.5)	1.4	(.29)
Semimembranosis	5.6	(.15)	7.1	(2.9)	33.2	(10.4)	4.3	(1.6)	73.9	(1.4)	1.5	(.34)
Semitendinosis	5.7	(.19)	9.3	(3.0)	29.6	(10.0)	3.3	(1.8)	75.0	(1.5)	1.3	(.28)
Serratus ventralis	6.0	(.18)	8.8	(3.9)	36.5	(6.7)	8.4	(3.9)	71.7	(3.1)	1.3	(.32)
Supraspinatus	6.0	(.19)	10.7	(3.8)	34.5	(7.4)	3.6	(1.7)	75.7	(1.3)	1.4	(.39)
Teres major	5.9	(.24)	9.1	(3.6)	33.3	(10.9)	3.9	(1.6)	75.2	(1.4)	1.4	(.41)
Tensor fascia latae	5.8	(.27)	8.0	(1.6)	31.7	(9.3)	6.8	(3.5)	72.9	(3.1)	1.3	(.31)
Triceps brachii	5.8	(.17)	10.1	(2.6)	37.0	(10.4)	4.4	(2.1)	74.5	(1.5)	1.5	(.30)
Vastus lateralis	5.8	(.23)	7.2	(2.1)	34.7	(8.4)	3.2	(1.4)	75.2	(0.9)	1.5	(.30)
Vastus medialis	5.9	(.26)	6.4	(2.6)	38.5	(9.0)	2.7	(1.3)	76.6	(1.1)	1.4	(.26)
Vastus intermedius	6.3	(.27)	9.6	(3.3)	37.1	(7.9)	5.0	(1.8)	75.2	(1.7)	1.3	(.27)

the total pigment in a muscle sample. Heme-iron has an influence on the visual appearance (color) of meat and therefore on its acceptability by consumers. Heme-iron ranged from 25.2 ppm (*Semitendinosis*) for beef muscles and 29.6 ppm (*Semitendinosis*) for dairy muscles to 37.1 ppm (*Multifidus/Spinalis dorsi*) for beef and 39.0 ppm (*Multifidus/Spinalis dorsi*) for dairy muscles.

Proximate composition is an analysis to determine fat, moisture and ash. The *Vastus lateralis* (2.6%) and *Vastus medialis* (2.7%) had the low mean for fat in both beef and dairy muscles, respectively. The *Multifidus/Spinalis dorsi* from both beef (7.5%) and dairy (9.9%) carcasses exhibited the highest percentage fat. Percentage moisture ranged from 74.3% (*Infraspinatus*) to 77.3% (*Vastus medialis*) for beef muscles and 70.8% (*Multifidus/Spinalis dorsi*) to 76.6% (*Vastus medialis*) for dairy muscles. Percentage ash ranged from 1.2% (*Multifidus/Spinalis dorsi*) for both beef and dairy muscles to 1.6% (*Psoas major* and 3 other muscles) for beef muscles and 1.5% (*Psoas major* and 7 other muscles) for dairy muscles.

The effects of the carcass selection criteria (12th rib fat thickness, carcass weight, skeletal maturity and muscling level) were evaluated for significance. Muscle color (L*, a*, and b*) was rarely influenced by carcass selection criteria in beef and dairy (< 5 of 21 muscles, depending on the criteria) muscles. Most selection criteria had low relationships

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to tenderness in beef (1 or 2 muscles, depending on selection criteria) and dairy (< 5 of 21 muscles, depending on selection criteria). Muscle pH was influenced by fat thickness and carcass muscling in beef (9 and 10 muscles, respectively) muscles, while few dairy (1 or 2 depending on criteria) muscles exhibited a relationship with any selection criteria. All selection criteria had low relationships to expressible moisture in beef and dairy (< 5 of 21 muscles) muscles. Total collagen was most frequently affected by maturity in beef (4 of 21 muscles), while weight had the greatest influence on dairy (6 of 21 muscles) muscles. Fat thickness most often influenced total heme-iron content in beef (12 of 21 muscles) muscles, while all selection criteria had little effect on dairy (< 5 of 21 muscles) muscles. Carcass fatness was the most common carcass selection trait related to muscle fat (16 beef and 14 dairy muscles) and moisture (21 beef and 19 dairy muscles) content. Muscle ash content was seldom influenced by any selection criteria for beef and dairy (< 5 of 21 muscles depending on criteria) muscles.

This research was performed as a follow-up to the muscle profile research of chuck and round muscles from fed cattle (*2001 Nebraska Beef Report,* pp 99-103). Muscles from cow carcasses exhibited a larger expressible moisture value than did muscles from the fed cattle study, probably because of differences in methodologies. In this study ground samples were collected while in the previous study a whole muscle cube was used. Values for pH and Warner-Bratzler shear force were higher in cow muscles as compared with the previous study. Muscles from cow carcasses were shown to have lower L* and a* values indicating cow muscles were darker and less red than those from fed cattle. As expected, the cow muscles were leaner than those of fed cattle, indicated by lower percentage fat. Variation in trait values were detected in both studies. As a general rule cow muscles exhibited higher variability than muscles from fed cattle for the majority of traits measured.

These data indicate a vast range of values of measured characteristics for both beef and dairy cow muscles. Of the four selection criteria, estimated 12th rib fat thickness influenced the most muscle characteristics, particularly percentage fat and moisture. However, in general there was a lack of significant effects by the carcass characteristics on muscle characteristics measured. This variation indicates muscles exist that can be better utilized as value added products to increase the value of cow carcasses.

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Quality Traits of Grain- and Grass-Fed Beef: A Review

Perry Brewer
Chris Calkins[1]

Grass-fed beef is less tender and lower in flavor and acceptability than grain-fed beef.

Summary

Carcasses from grass-fed beef have lower fat thickness and lighter carcass weights, which increases the risk for cold shortening and reduces muscle proteolysis, both of which would reduce beef tenderness. A review of nine research papers indicates grass-fed beef is lower in tenderness (both from shear force and by taste panel), flavor and overall acceptability/desirability ratings.

Introduction

Recently, interest in production of grass-fed beef has increased. Proponents identify advantages of sustainability, low inputs, a more "natural" process than grain feeding, reduced use of antibiotics, leaner/healthier meat and better flavor. Opponents caution that increased production time, cost of production, seasonality of forage resources, absence of evidence demonstrating that forage finished beef is healthier, economic risk, and limited marketing potential do not support finishing cattle on grass. Although each of these points (and many others) merit a detailed discussion, this review focuses on the characteristics of the end product — beef for human consumption. The tenderness and flavor of beef finished under either system has been studied in the past and this brief review of the literature is intended to provide concrete information on this particular aspect of the issue.

Procedure

This review includes data from nine publications that compared grain-fed to grass-fed beef. There are a variety of treatments among papers and within each study. For clarity, only all-forage treatments were compared to grain feeding, except the 2000 paper by French et al. This particular publication compared a number of treatments containing forages with several that included concentrates so the means of all-forage treatments versus those containing concentrates are presented. Different taste panel rating scales were used in the studies so the data are presented as a percentage of the rating scale to facilitate direct comparisons among studies. Of course, this is not a complete list of the grain versus grass-fed beef literature. We have attempted to summarize papers where animal age appeared to be controlled and where grain feeding lasted 85 days or more.

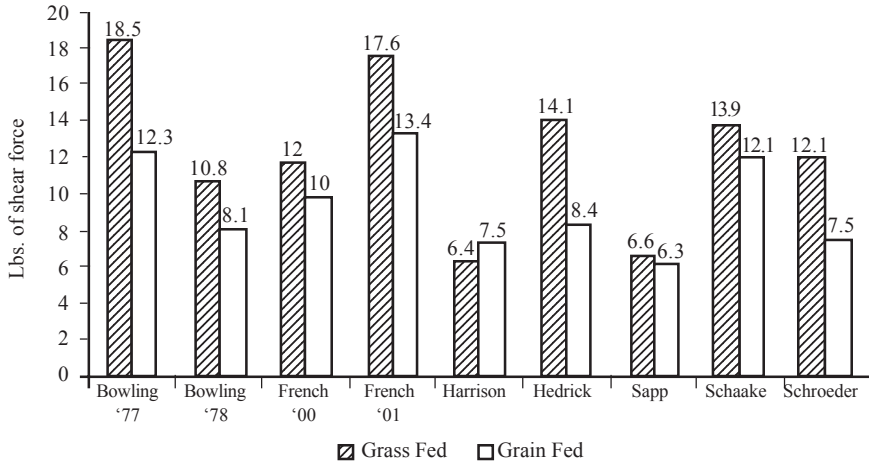

Figure 1. Warner-Bratzler shear force of grass- and grain-fed beef.

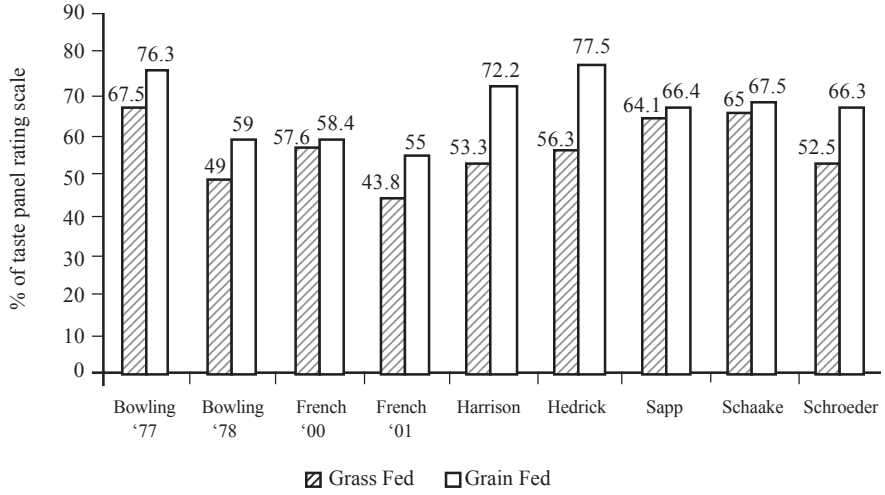

Figure 2. Taste panel tenderness ratings of grass- and grain-fed beef.

Results

Tenderness Issues

Figure 1 indicates a distinct advantage in tenderness (shear force) for grain-fed cattle versus grass-fed cattle. The only time the mean shear force for beef from grass-fed cattle was lower than for corresponding grain-fed cattle (in the Harrison et al., 1978 paper), the taste panel produced conflicting results (Figure 2). In that particular study, the taste panel ratings for tenderness were almost 2 full taste panel units lower (less tender) for the grass-fed treatment. Taken together, these data indicate that grass-fed cattle produce beef that is less tender than beef from grain-fed cattle.

Tenderness is one of the most important palatability traits influencing consumer satisfaction with beef. This complex trait can be influenced by a number of factors. These factors may be categorized as those influencing connective tissue and those influencing the muscle fiber itself.

Muscles containing more connective tissue are less tender. Connective tissue from older animals is less heat soluble than connective tissue from younger animals. So both amount and solubility of connective tissue can influence tenderness. This can best be visualized by comparing a ribeye steak to a round steak from the same animal. The later has a much greater connective tissue content and of course is less tender. A steak from a mature animal is usually less tender than one from a younger animal because the connective tissue is less heat soluble. It's possible to detect differences in tenderness among animals that have been finished as calves compared to those finished in yearling programs (see paper in this issue by Brewer et al.). Hence, anything that increases the time of production is likely to adversely affect tenderness.

A second aspect of connective tissue exists. Animals on a sub-optimal plane of nutrition frequently exhibit greater amounts of connective tissue. The hypothesis is that these animals have smaller muscle fibers. Given that each muscle fiber is covered with a layer of connective tissue, it's easy to understand that muscles with smaller fibers have proportionally more connective tissue. In effect, existing connective tissue is "diluted" by larger muscle fibers. As these fibers become smaller, the connective tissue becomes concentrated and exerts a greater influence on tenderness. This has been offered as an explanation as to why forage finished cattle have less tender meat.

Numerous factors influence the tenderness of the muscle fibers. Generally, they may be grouped into those that affect muscle fiber shortening and those that affect fragility of the muscle fibers. Implicitly, those muscles with longer fibers and those with more fragile fibers will be more tender.

A phenomenon of pre-rigor muscle is shortening in response to cold temperatures. Rapid chilling of beef carcasses, which occurs in carcasses with minimal subcutaneous fat, can increase muscle shortening. Carcasses with smaller muscle mass also chill more quickly and thus exhibit more muscle shortening. Although more gentle chilling conditions would minimize this condition, it is not recommended because of the benefits to food safety provided by rapid chilling of beef.

Fragility of the muscle fiber occurs as a result of post-mortem enzyme activity. Extended storage of beef under refrigerated conditions allows time for the natural, endogenous enzymes to function. This is the foundation of cooler aging and has been used for many years to enhance meat tenderness. More recent research clearly demonstrates that a significant increase in tenderization can occur during the hours immediately after harvest. The temperature of the meat

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Table 1. Carcass traits of grain and grass fed beef.

	Animal/	Carcass weight, lb		Fat thickness, in.		REA, in^2		KPH, %		YG		Marbling Score[a]	
	treatment	grass	grain	grass	grain	grass	grain	grass	grain	grass	grain	grass	grain
Bowling '77	30	483	476	.16	.33	9.5	11.0	2.3	3.5	2.1	2.4	8.9	9.4
Bowling '78	10	412	679	.06	.57	8.9	10.4	na	na	na	na	2.4	13.3
French '00	na												
French '01	na												
Harrison	8	573	728	.23	.26	10.3	12.1	2.7	3.3	2.7	3.3	9.5	15.4
Hedrick	27	346	646	.08	.43	7.5	10.9	1.8	2.3	1.8	3.0	5.9	13.9
Sapp	20	655	637	.32	.47	11.3	10.9	1.4	2.0	1.4	2.0	11.0	13.0
Schaake	36	621	769	.20	.51	11.6	12.9	2.4	3.2	2.2	3.2	11.0	16.3
Schroeder	7	403	690	.10	.50	8.6	11.6	2.0	2.9	1.9	3.2	5.0	12.3

[a]Small + = 15, Small 0 = 14, Small - = 13 and so on.

during chilling not only influences shortening, described in the paragraph above, but also alters the extent of muscle proteolysis. More enzyme activity occurs at warmer temperatures. Thus, muscle chilled too quickly will be less tender not only because of cold shortening, but also because the lower temperature has minimized enzyme activity. Carcasses with more subcutaneous fat chill less quickly.

None of the studies reviewed made specific measures of muscle shortening, muscle fiber fragility, or connective tissue amount. However, almost every study revealed carcasses from grass-fed cattle to be lighter in weight, with less fat, smaller ribeye areas, and lower marbling scores than carcasses from grain-fed cattle. These conditions would be expected to allow greater muscle shortening and reduce proteolysis, together with possibly smaller muscle fibers (which would generate proportionally more connective tissue).

Flavor Issues

Flavor scores from trained taste panels support the contention that flavor of beef from grain-fed cattle is more desirable than beef from grass-fed steers (Figure 3). In the seven studies that included an assessment of overall acceptability/palatability, grain-fed beef was more highly rated every time.

Although some important flavor compounds in meat reside in the lean, compounds within the fat also contribute to the flavor profile — especially in the differences among species. Implicitly, the diet of the animal will influence these flavor contributors. Recent data reported in the *2001 Beef Cattle Report*, pp. 96-98, indicate there are significant flavor differences between grain-fed and grass-fed beef and U.S. consumers strongly discriminate against the flavor of grass-fed beef. This later research was conducted with beef loins matched in tenderness, so there was no bias among the samples on the basis of texture. There were some differences in aging time between the grain-fed and grass-fed samples, but the longer aging period (which would be expected to

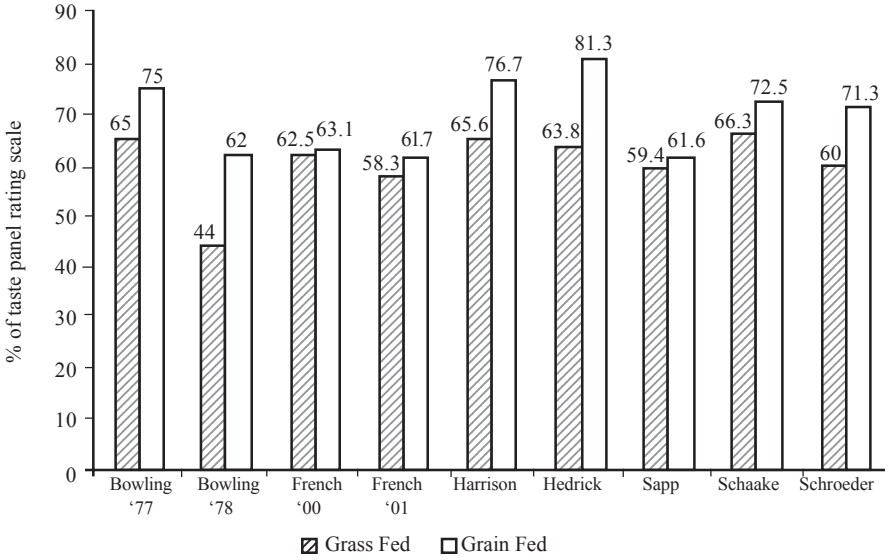

Figure 3. Taste panel flavor ratings of grass- and grain-fed beef.

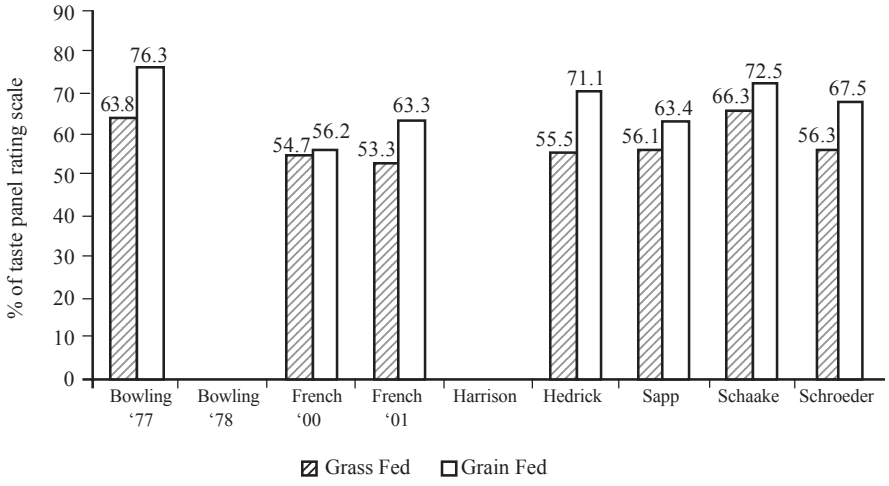

Figure 4. Taste panel overall acceptability/palatability ratings of grass- and grain-fed beef.

improve consumer acceptance of flavor) was for the grass-fed beef.

Although the preponderance of data indicate grass-fed beef is less desirable than grain-fed beef, a small niche market for grass-fed beef may exist. For those intent upon producing grass-fed beef, it would be imperative to identify a market for the meat before undertaking such a production system.

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The Effects of Tumbler Volume on Roasted Beef Quality

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Jesús Velazco[1]

Tumbling is a mechanical method of extracting myofibrillar protein and dispersing marinade throughout meat. One-third free space in the tumbler appears to be essential in achieving optimum quality.

Summary

Semitendinosus beef muscles (n = 108) were used to determine optimum tumbler volume with regards to meat quality. Fill capacity of 2/3 meat had lower shear force values than capacities of 1/2 (P = 0.02) and 1/3 (P < 0.01). Texture profile analysis showed favorable results among treatments. Hardness was lower with 2/3 capacity than 1/2 (P = 0.02) and 1/3 (P = 0.06). Gumminess favored 2/3 capacity over 1/2 (P = 0.02). Springiness favored 1/2 capacity over 1/3 capacity (P < 0.01) and 2/3 capacity (P=0.04). Purge, absorption rate during tumbling, absorption rate after rest, cooking loss and yield had no effect between treatments.

Introduction

Value-added meats are becoming increasingly popular in today's marketplace. Low value and less desirable meats are improved in flavor, texture and consistency. This is accomplished with the use of marinades coupled with a mechanical action of massaging or tumbling. The ingredients of the marinades have well known effects. However, optimum times and volumes of the massaging method of tumbling are still unknown. The objective of this project was to study the effects of the fill/free space in the tumbler to optimize flavor, texture and consistency of muscle. This will allow processors to understand the implications on textural properties as associated with tumbler fill capacity.

Procedure

Semitendinosus, NAMP 171C Beef Round, Eye of Round were purchased from ConAgra Meat Company and were delivered to the University of Nebraska Loeffel Meat Lab. Muscles were removed from the bag and fat and heavy external connective tissue was trimmed. Each muscle then was cut to a weight of 5.6 lbs. Muscles were sorted into three different batches. The first batch contained eight muscles, a second batch contained 12 muscles and a third batch contained 16 muscles. The study was replicated three times. Total batch weights were taken. A marinade was formulated containing 0.9 lb salt, 1.4 lb phosphates and 85.7 lb of water. This allowed for 0.25% salt and 0.40% phosphates in the meat. Using a hand-held stitch pump, muscles were pumped with the marinade to 115% green weight evenly throughout the batch. An additional 10% of the fresh meat weight was added directly into the tumbler. It was determined that the capacity of the tumbler was 39.6 gallons. Using water displacement, the amount of meat needed for each treatment was determined. To reduce the amount of meat needed to fill the tumbler to a desired capacity, dummy bags, approximating the meat weight were filled with 1 liter of water were used to achieve desired fill capacity since the density of water and meat are similar. Twenty bags were added to 8 *semitendinosus* to allow for 1/3 fill, 32 bags were added to 12 *semitendinosus* for 1/2 fill and 44

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bags were added to 16 *semitendinosus* for 2/3 fill. Each batch was tumbled for 45 minutes under a vacuum of 0.8 torr. After tumbling was complete, the vacuum was released, the meat was removed, weighed to determine solution pickup and a sample of the exudate was taken for protein analysis. The muscles then were allowed to rest for 18 hours. A second sample of the exudate was taken prior to cooking.

The cooking process took place in a Alkar smokehouse (Alkar, Lodi, WI) with 180°F set point on the dry bulb and 155°F on the wet bulb. The muscles were cooked for approximately 7 hours to an internal temperature of 158°F. The meat was allowed to cool for 14 hours before analysis.

The muscles were removed and cut in half . A slice 1-inch thick was removed from the center, perpendicular to the muscle fibers for Warner-Bratzler Shear force analysis. An additional slice measuring 0.5 inches was removed for Texture Profile Analysis (TPA), a tenderness measure.

Results

Significant differences in tenderness were determined by the Warner-Bratzler shear force test on treatment levels of 1/3, 1/2, and 2/3 tumbler capacity (Table 1). Tumbler capacity of 2/3 full had significantly lower shear force values than 1/2 ($P = 0.02$) and 1/3 ($P < 0.01$) capacities. Likewise, hardness (Table 2), using TPA, determined that 2/3 fill capacity had significantly lower values than 1/2 ($P = 0.02$) and 1/3 ($P = 0.06$). Hardness can be defined as the peak force during the first bite or compression of a sample. It was also determined in the TPA that 2/3 tumbler fill capacity had lower gumminess values than that of 1/2 fill ($P = 0.02$) but was not significantly lower than 1/3 fill capacity. Springiness can be defined as the time in which the sample recovers from the end of the first compression to the start of the second compression. It was determined that the tumbler fill of 1/2 had lower springiness than 1/3 fill ($P = 0.01$) and 2/3 fill ($P = 0.04$). The data also determined no significant differences among treatments for cohesiveness. Cohesiveness is described as ratio of positive force area during the second compression over that of the first (A_2/A_1). Chewiness, described as the product of gumminess times springiness also showed no significant differences. There were no significant interactions between the treatments in regards to percentage purge, rate of absorption immediately after tumbling, absorption after 18-hour rest, cooking loss and yield. Though the interactions were not significant, adjusted purge in the 2/3 fill capacity was 51% higher than that of 1/3 capacity. Also cooking losses tended to be less with 2/3 fill over both 1/3 and 1/2 fill.

The implication of this data can help processors understand the effects of the fill capacity of tumblers and its results on the texture of beef. These data show that the majority of significant textural properties exists at 2/3 fill capacity; processors should target this in order to optimize product quality. The common practice of many processors is to make a batch and fill the capacity to what ever the batch is or to fill it with allows for best time management. The data shows that with management of tumbler fill, processors can make a more tender and consistent product.

Table 1. Warner-Bratzler mean shear force values.

	Force (lb)	
Fill space	Mean	SE[a]
1/3	8.93[b]	0.07
1/2	8.78[b]	0.05
2/3	8.43[c]	0.05

[a]Standard error of the means.
[b,c]Similar letters within column indicate significance ($P > 0.05$).

Table 2. Mean texture profile analysis.

	Fill Space		
Parameters	1/3	1/2	2/3
Hardness, N[a]	839.74[f]	846.75[f]	776.51[g]
Cohesiveness[b]	0.336	0.340	0.343
Gumminess, N[c]	282.94[fg]	289.52[f]	264.97[g]
Springiness, mm[d]	3.06[f]	2.90[g]	3.00[f]
Chewiness, N*mm[e]	863.54	838.77	794.84

[a]Peak force during first compression cycle; measured in Newtons.
[b]Ratio of the positive force area during the second compression to the first (A_2/A_1).
[c]Product of hardness times cohesiveness; measured in Newtons.
[d]Height of recovery during the time lapse from end of first compression to start of second compression.
[e]Product of gumminess times springiness.
[fg]Similar letters within row indicate significance ($P > 0.10$).

Table 3. Mean marination results.

	Fill Space		
Parameters	1/3	1/2	2/3
Purge, %[a]	2.67	3.08	5.40
Tumbling absorption, %[b]	12.60	11.07	11.24
Rest absorption, %[c]	9.61	7.63	5.24
Cooking loss, %[d]	34.71	34.28	31.75
Yield, %[e]	71.55	70.75	71.72

[a]Determined by weight after tumble minus weight after rest.
[b]Weight determined immediately after tumbling completed.
[c]Post-tumbling 18 hour rest absorption percentage.
[d]Cooked meat weight/ weight after rest.

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Ingredient Opportunities for Case-Ready Beef

Mike Baczwaski
Roger Mandigo[1]

Case-ready fresh meat is the fastest growth product category in the supermarkets. Understanding the phenomenon and the role that ingredients play in the success of these products is important with respect to meat quality and consistency.

Summary

Case-ready beef products have grown at a tremendous rate since the early large scale introductions in the mid 1990's. Estimates exceed 9 billion pieces in the near future, up from 500 million in 1997 and 1.2 billion in 2000. The key producers of case-ready beef products are fresh-meat processors and retailer co-packers and the list continues to grow rapidly. Justification for producers and consumers includes better-in-stock at retail or less out-of-stock on a 24-hour basis, labor availability at retail level, less shrink, greater cost savings, and most importantly consumer satisfaction, consistency, tenderness, juiciness and improved food safety.

Discussion

There are several technologies that case-ready meats can use to improve product consistency and extend shelf life. Consistency is a goal that all producers strive for regardless of the industry segment. Case-ready beef allows consumers to experience more consistent fresh beef in regards to color, texture and eating quality. Case-ready meat allows a shelf life of 2-5 weeks following enhancement/ fabrication, compared to a 5-12 day shelf life seen with conventional shrink wrapped fresh packaging. Extending case-ready meats allows for improved processing at large, efficient, central fabrication plants close to the beef supply and fabrication. Case-ready beef is consumer ready to use with fat and bones removed. Fat and bone utilization is greater at central processing locations. Case-ready products are shipped to distribution centers for retail outlet consumer demands. Extended shelf life may be accomplished with modified atmospheres containing gases such as carbon dioxide, nitrogen and oxygen in different combinations. Marinated or enhanced products can be vacuum packaged to extend refrigerated product life. Case-ready beef also reduces in-store meat cutting, preparation and packaging which also has a huge effect on food safety due to reduced handling and improved temperature control. Anti-microbial impact results from the carbon dioxide and/or nitrogen gasses.

Case-ready beef concepts will reduce the amount of out-of-stocks at retail levels and store availability of complete product lines. Product management and inventory control is much more efficient without in-store meat cutting and packaging. There are new thrusts for case-ready beef that include enhanced or marinated products.

Enhancement can be defined as fresh beef that is injected with a solution of water, salt, sodium phosphates and a potentially large range of natural flavors such as rosemary extract and lemon juice. The beef is usually pumped to 8-12% of original weight. A marinade typically contains the same ingredients as the enhancement solution plus flavor components such as caramel colorings and top dressings with whole and/or cracked spices and other flavors. Thus, there are a number of non-meat ingredients that have increased the opportunity for fresh and processed beef in the retail marketplace.

The functionality of the non-meat ingredient varies depending on application and contribution to flavor and appearance ranges greatly. The ingredients functionality include the role in water-holding capacity, binding through salt bridges, swelling by phosphates, and impact on overall juiciness and texture properties of the finished product. While increasing yields with the use of non-meat ingredients is economically important to the processor, maximizing their functional impact on tenderness, juiciness, textural properties and flavor is the most important factor.

The biggest non-meat ingredient used in processed beef is water. Water quality, with respect to hardness and possible

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contaminates, influences potential benefits of water. Hard water reduces the ability of certain non-meat ingredients to dissolve and reduces the solubility of phosphates, salt and other ingredients. Without proper dissolving in water, phosphates and other ingredients will precipitate and thus not go into solution. If these ingredients precipitate out, poor binding in meat proteins will occur, resulting in poor water retention during distribution and cooking. Contaminates in water, such as iron and copper, increase oxidation. Oxidation of color and flavor proteins causes a negative effect on flavor and appearance. High chlorine levels in water have been shown to have an oxidative effect on finished product by increasing lipid rancidity and loss of color stability. Water retention can be effectively controlled through adjusting pH. The isoelectric point (pI) of meat is the pH of the meat at which the net ionic charge is equal to zero. The pI for fresh post-mortem beef generally occurs about pH 5.3. At the pI, there are no free charges and the meat fibers are attracted to one another, resulting in minimal space between the fibers for water to be held. As the pH of the meat is altered away from the pI, with the use of an enhancement solution or a marinade, charges begin to free themselves causing repulsion of the meat fibers, and the free charges begin to attract water. To accomplish this alteration of pH, alkaline phosphates are generally used. The use of phosphates increases water retention in beef during processing, distribution and final cooking or reheating.

Salt is a major non-meat component of any marinade or enhancement solution. Salt is needed for the solubilization of beef myofibrillar proteins. It is also an important flavor component. Through this process small pieces of meat are bound to one another. Salt also can create a negative effect by causing a rubber-like texture when excessive protein solubilization has taken place.

In addition, subjecting beef to too much mechanical action in the presence of high salt and phosphate can be detrimental to desired texture. Typically, sodium chloride is the processor's salt of choice but in the cases where excess salt content may cause problems, alternatives can be used. Potassium salts can be used but they tend to produce bitter or metallic aftertaste. In the case where there is a masking flavor such as with marination, these potassium salts can work well.

Other non-meat ingredients that are common in case-ready and marinated meats include the broad category of hydrocolloid gums. These gums include carageenan, konjac flour, xanthan and gellan gums. Their function is to increase water holding capacity and aid in retaining water throughout the cooking process. Gums are primarily used in beef products that are low-fat or fat-free. Lactates and acetates are antimicrobial agents that extend shelf life.

Lactates, usually sodium or potassium, are ingredients that are derived from corn or beet sugar. Lactates act as a bacteriostat by interfering with bacterial metabolism and increasing the lag phase of growth. Lactates inhibit growth of *Listeria monocytogenes, Staphylococcus, Salmonella and Clostridium botulinum.* By doing this, lactates decrease microbial growth and spoilage, therefore increasing shelf life. Research has shown that with the addition of lactate, fresh beef sausage shelf life can be increased from 30 to 70% and roast beef shelf life can be increased 50 to 100%. The addition of lactate in beef products acts to protect against refrigeration challenges during transportation, retail storage and handling. In case-ready beef products, temperature abuse comes in the form of retail refrigeration inconsistencies, consumer abuse after the product is purchased before home refrigeration and increased temperatures of home refrigeration units.

Sodium diacetate, a salt of acetic acid, is a biocide that reduces the initial microbial load, but has the potential for unwanted flavors and odors. Commonly a combination of lactate and diacetate allows for lower levels in the product while obtaining a combination of both bactericidal and bacteriostatic actions.

Reducing agents play a key role in case-ready meats. Such ingredients are sodium erythorbate and sodium ascorbate. While these ingredients are important in flavor, improving shelf life and keeping quality, the most important role of reducing agents is to reduce the tendency of fresh meat color to darken and turn more brown.

Another important non-meat ingredients are the acidulation agents. Acid encapsulation has been used in products such as low-fat beef patties. Encapsulation is used because the melting temperature of the specific fat that encapsulates the acid, protects beef's color proteins from discoloration due to oxidation. These acids then are released during final cooking and preparation.

Lactic acid starter cultures, which ferment dextrose, also provide excellent acidification of products such as beef summer sausage and snack sticks but use in enhanced beef products is very limited. The most significant problems with lactic acid are the limited times and temperature at which they are effective. Tenderizers are usually proteases that are derived from plants. These tenderizers degrade muscle protein. The challenge of using plant or fungal enzymes for enhanced products is controlling the activity. Consumer uncertainty of cooking procedures will limit the use of papain, bromelin, ficin and fungal enzymes. If the tenderizer is applied and a protein denaturant level of heat is applied too early, the tenderizer is rendered ineffective and if it is applied too late, the tenderizer will cause the beef to be too soft in texture. In addition, enzymes are hard to distribute uniformly throughout beef.

Traditionally, food processors have used synthetic antioxidants developed from fats and oils such as BHA and BHT. Since it is required to declare this on the product ingredient label, they are not often used in enhanced beef products. Instead, the use of natural antioxidants in the form of herbs, spice extracts and fruit pastes have become widely adapted. Lemon juice is also being used for subtle flavor changes.

The popularity of case-ready beef products is increasing. Benefits include product convenience, consistency, and food safety.

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Estimation of Rumen Undegradable Protein in Forages by Using Neutral Detergent Insoluble Nitrogen at a Single In Situ Incubation Time Point

Mariela Lamothe
Terry Klopfenstein[1]

In situ incubation of forages for a single time point, equivalent to 75% of the mean retention time, accurately estimated UIP using NDIN

Summary

Neutral detergent insoluble nitrogen (NDIN) was used as a direct estimate of UIP. Forage samples collected from upland range and subirrigated meadow sites over the summer were incubated in situ for a time equivalent to a mean retention time estimated from the digestibility of the forage plus 10 hour to account for a lag in passage of particles from the rumen. Samples also were incubated for 75% of the estimated total mean retention time. The UIP values obtained from the fractional rates of degradation and passage were highly correlated with those estimated from samples incubated for 75% of total mean retention time while incubating the samples longer tended to underestimate the UIP fraction.

Introduction

Previous research at the University of Nebraska demonstrated that neutral detergent insoluble nitrogen (NDIN) can be used as a direct estimate of UIP in forages (*1997 Beef Cattle Report,* pp.38-39). The standard method uses a first order disappearance model to estimate the potentially digestible fraction that escapes rumen degradation.

The first order disappearance model assumes ingested particles are capable of passing immediately out of the rumen. This may not be the case of particles that are too large or buoyant to reach the reticulo-omasal orifice and escape the rumen. The consequence of not accounting for a lag in passage, time during which particles may be digested but cannot escape, is that UIP may be overestimated. It has been suggested that this lag in passage is relatively constant, and it is approximately 10 hour.

Using a data set from the University of Nebraska, we compared the results obtained by using the fractional rates of passage and digestion and accounting for passage lag time of 10 hours with those obtained from a single incubation time equivalent to total mean retention time (TMRT). The UIP values were lower when a single time point was used than when using fractional rates of passage and degradation. We also observed that values obtained by the two methods approached similarity if a TMRT analogous to 75% of TMRT was used. The objective of this study was to compare UIP results and rates of NDIN degradation obtained from forage samples incubated for the estimated TMRT and for a time equivalent to 75% of TMRT.

Procedure

Forage Samples

Two types of forage were evaluated in this study: upland native range (Range) and subirrigated meadow (Meadow). Forages were grown at the Gudmunsen Sandhills Laboratory (GSL) of the University of Nebraska, near Whitman, Neb. The dominant grass species in Range were: little bluestem, prairie sandreed, sand bluestem, switchgrass, sand lovegrass, indiangrass, and grasslike plants. Dominant species in Meadow were: Kentucky bluegrass, slender wheatgrass, smooth bromegrass, timothy, reed canarygrass, redtop, several species of sedges and clover. Samples were collected from two pastures on each site (Meadow and Range) with three esophageally fistulated cows. Collections were carried out on May 25, June 22, July 20, Aug. 17 and Sept. 21. Esophageal masticate samples were frozen immediately, later freeze-dried and ground to pass through a 2-mm screen, and a subsample was ground through a 1-mm screen for further determination of in vitro digestibility. Samples from the same pasture and period were composited on a DM basis.

In Situ Procedures

Two ruminally cannulated steers were housed in individual pens and offered a total mixed ration of 70% brome hay and 30% concentrate. Rumen degradability of protein in the experimental forages was determined by incubating duplicate 5 x 10 cm dacron bags filled with 1.25 g of forage in the rumen of each steer. Experimental incubation times were determined from IVDMD. First, using the following equation rate of passage (Kp) was estimated:

$$kp\ (\%/h) = 0.07\ IVDMD\ (\%) - 0.20.$$

Then mean retention time was calculated as the inverse of kp. A 10-hour lag time was added to the estimated mean retention time and designated total mean retention time (TMRT), the total time particles would be subjected to

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degradation. Samples were incubated for 10 hours, the calculated TMRT, a period equivalent to 75% of the TMRT, and 96 hours. The estimated mean retention time for forages collected in May and Meadow in June was about 31 hours. For Range samples collected in June and all samples collected in July and August, the estimated mean retention time was 35 hours and 40 hours for those Range samples collected in September.

After incubation, sample residues were refluxed with neutral detergent solution in an Ankon Fiber Analyzer and analyzed for N content by the combustion method using a nitrogen analyzer.

Calculations

The NDIN content was calculated for the original forage sample and for each in situ forage residue, thus allowing the establishment of a degradation curve for NDIN. The UIP as a % DM of the original sample was calculated as NDIN (% of DM) in the residue of samples incubated for the estimated TMRT multiplied by 6.25 to convert N to crude protein equivalents.

The original NDIN pool was measured on 0-hour samples. The portion of NDIN remaining in bags incubated for 96 hours was considered to be the ruminally unavailable fraction. Potentially degradable NDIN was determined as total NDIN – NDIN content of the unavailable portion. Rates of ruminal degradation (k_d) for each in situ CP fraction were calculated by using a first order disappearance model. The k_d was calculated as the slope of the regression of the natural logarithm of NDIN remaining (after NDIN content of the unavailable fraction was subtracted) against time.

Data were analyzed using the MIXED procedure of SAS. Type of forage (Meadow and Range), collection period (May through September) and incubation time (10 hour, 0.75 TMRT and TMRT) were included in the model as fixed effects, and pasture, nested within forage type, as random effect. Average rates of protein degradation were calculated from the two duplicate samples and the two steers.

Table 1. Original CP content and undegraded protein as a percentage of DM of range and meadow samples collected from May to September.

Item	Original CP[a]	Incubation time (hour) 0[b]	10[b]	.75 TMRT[b]	TMRT[b]	96
Range						
May	12.0	5.27	3.90	2.02	1.83	0.95
June	9.7	3.69	2.94	1.71	1.21	1.40
July	9.5	3.15	2.56	1.35	1.08	0.98
August	9.3	3.08	2.10	0.91	0.91	1.62
September	9.4	2.18	1.67	0.76	0.48	2.18
Meadow						
May	13.7	7.81	5.11	1.79	1.77	0.74
June	12.2	5.55	4.03	1.98	2.27	0.93
July	12.8	5.40	2.83	0.99	1.08	1.39
August	12.4	3.87	2.30	1.00	0.90	1.47
September	8.4	2.54	1.63	0.76	0.28	1.33

[a]Percentage of DM.
[b]Undegraded protein as a percentage of DM corrected for 96 hour values.

Table 2. Rates of degradation (%/hour) of protein of summer range and meadow incubated from 0 to 10 hour, 10 to a time equivalent to 75% of TMRT and 75% of TMRT to TMRT.

Item	0-10[a]	10-.75 TMRT[b]	.75 TMRT-TMRT[c]
Range			
May	3.03	5.15	1.18
June	2.23	3.24	4.19
July	1.86	3.74	2.68
August	3.93	4.86	0.18
September	2.69	3.75	9.02
Meadow			
May	4.33	8.38	0.19
June	3.18	5.41	-1.60
July	6.36	5.66	0.57
August	5.21	4.91	1.73
September	4.27	3.64	11.06

[a]Rate of protein degradation from 0 to 10 hours inubation.
[b]Rate of protein degradation from 10 to .75 TMRT.
[c]Rate of protein degradation from .75 TMRT to TMRT.

Results

The protein undegraded at the various times is shown in Table 1. Protein degradability was greater for Meadow than Range ($P < 0.05$). Protein degradability decreased from May to September.

Table 2 shows rates of protein degradation for the first 10 hours of incubation (lag time) and the period following the lag time through a time point equivalent to 75% of the estimated TMRT. Two significant interactions: month x incubation time ($P < 0.05$) and month x forage type ($P = 0.09$) were observed. The protein of forages collected in May and June was degraded more slowly from 0 to 10 hours than from 10 hours to 0.75 TMRT ($P < 0.05$), but rates of degradation were not significantly different for the rest of the collection periods ($P > 0.1$). This trend for protein of samples collected early in the season to be more resistant to initial degradation may be indicative of some lag in NDIN digestion. Since NDIN is the protein fraction associated with the cell wall, a lag in fiber digestion when the microbes attach to the fiber but no digestion occurs, might affect the initial availability of protein.

Regardless of the length of the incubation, meadow protein degraded more rapidly than range early in the season (May to July; $P < 0.1$). This tendency for meadow to degrade more rapidly than range during this phase of incubation may be indicative of the differences across these types of grass that affect the availability of protein to microbial degradation. Warm-season grasses

Table 3. UIP content (% DM) of summer upland range and meadow estimated by three different approaches.

Item	Equation[a]	.75 TMRT[b]	TMRT[b]
Range			
May	2.87	3.02	2.76
June	3.07	3.11	2.59
July	2.35	2.33	2.08
August	2.52	2.54	2.30
September	2.97	2.94	2.45
Meadow			
May	2.63	2.53	2.53
June	2.74	2.90	3.18
July	2.54	2.48	2.47
August	2.46	2.47	2.39
September	2.11	2.08	1.61

[a]UIP = 0 hour value (Table 1) * (kp/kp + kd) + 96 hour value (Table 1), corrected for passage lag time.
[b]In situ incubation for 75 % of TMRT or TMRT.

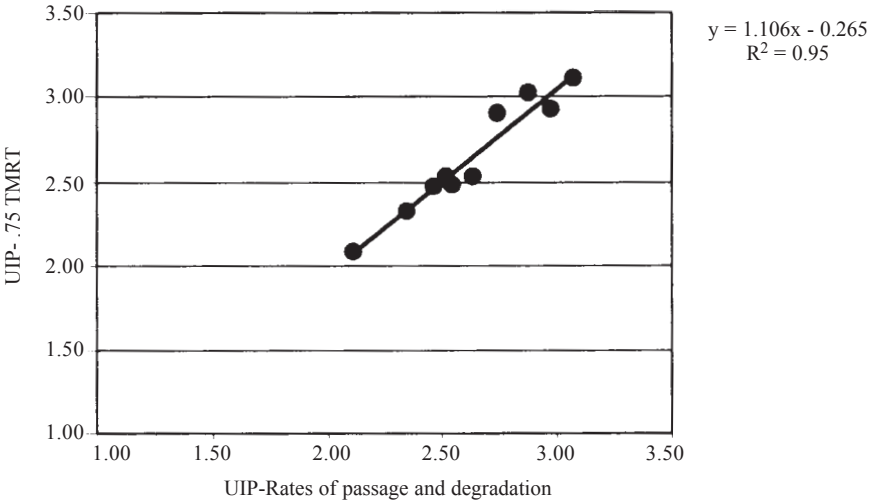

Figure 1. Relationship between forage UIP content calculated either by a single in situ incubation time point equivalent to 75% of the total ruminal mean retention time or by the fractional rates of digestion and passage.

dominating the range site contain a rigid, thick-walled parenchyma bundle sheath that degrades more slowly than the fiber in cool-season species (meadow) which may protect protein from microbial degradation. In addition, lignification of the parenchyma bundle sheath with increasing maturity would make protein within this structure potentially less digestible.

When comparing rates of protein degradation for 10 hours to 0.75 TMRT and 0.75 TMRT-TMRT, rates were significantly slower for the last part of the incubation for forages collected from May through August ($P < 0.05$); however, a dramatic increase in the 0.75 TMRT-TMRT rate of degradation was observed for the September forages (10 versus 1.15%/hour for September and May through August average respectively for average of Range and Meadow). When comparing the values for the two last points of the degradation curve, 0.75 TMRT and TMRT, values for the two times did not differ from May through August ($P > 0.1$), but the potentially degradable fraction remaining was significantly higher at 0.75 TMRT than at TMRT in September ($P < 0.001$); Table 1). The similar contents of NDIN in the residues when forages were incubated for 0.75 TMRT and TMRT as well as lower rates of digestion of NDIN during 0.75 TMRT-TMRT than 10-0.75 TMRT indicate that most of the potentially digestible NDIN was already degraded at the 0.75 TMRT point. September forages were the exception. Degradation appeared to continue from 0.75 TMRT to TMRT. This could have been due to forages becoming dormant and, consequently, more resistant to digestion. However, in our experiment the potentially degradable NDIN fraction at 0.75 TMRT was already very small for the September forages.

Undegraded intake values obtained from the competition of the fractional rates of digestion and passage from the rumen as used in many models may be a more accurate estimate than a single time point incubation. Therefore, values obtained from such a model of the competition of kp and kd with the addition of a passage lag were regressed linearly on corresponding estimates obtained from a single incubation time point, either TMRT or 0.75 TMRT.

The UIP values obtained from the three approaches are shown in Table 3. UIP estimates from samples incubated for 0.75 TMRT were highly correlated with those calculated from fractional rates of digestion and passage ($R^2 = .95$; Figure 1). The slope of the regression line was 1.1064 (SE = 0.09), and was not different from 1 ($P < 0.05$). The intercept was equal to –0.2652, and it was not different from 0 ($P = 0.32$); therefore, assuming an intercept equal to 0, the slope is 1.0066 and the R^2 of the regression is 0.999. This clearly indicates that the two methods yielded similar estimates of UIP. On the contrary, incubating samples longer (TMRT) tended to underestimate UIP ($R^2 = 0.53$).

The overall results of this trial suggest using a single incubation time point equivalent to 75% of the TMRT estimated from IVDMD and accounting for a passage lag time would give accurate UIP estimates as well as rates of NDIN degradation.

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Estimating Rumen Undegradable Protein in Smooth Bromegrass and Legumes

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Undegradable protein values for birdsfoot trefoil were higher than for alfalfa or kura clover.

Summary

An in situ trial was conducted to compare estimates of rumen undegradable protein (UIP) using a single incubation time point and rates of degradation. Four forage samples (three legumes and one grass) were incubated in situ for their mean retention time estimated from in vitro dry matter disappearance plus a 10-hour lag time as well as for a time point equal to 75% of the total mean retention time (mean retention time plus lag). The UIP values obtained from the fractional rates of degradation and passage were more highly correlated with those estimated from 75% of the total mean retention time (R^2 = 0.99) than those estimated from the total mean retention time (R^2 = 0. 62). The UIP of birdsfoot trefoil was higher than that in the other forages.

Introduction

The standard method for estimating the potentially digestible fraction of protein that escapes rumen degradation uses a first-order disappearance model which assumes that ingested particles can pass out of the rumen immediately. Some particles may not escape out of the rumen for some time, however, and may undergo digestion during this time. Accounting for a lag in passage by adding 10 hours (suggested by previous research) to the mean retention time (MRT) represents the total MRT (TMRT) in which particles may be degraded. Neutral detergent insoluble nitrogen (NDIN) was used to directly estimate the UIP of forages in this experiment (Lamothe et al., this report).

Diet and clip samples previously were collected from smooth bromegrass pastures interseeded with birdsfoot trefoil, alfalfa, or kura clover (*2002 Nebraska Beef Report,* pp. 20-21). The legumes supplied fixed nitrogen for grass production and supplied additional protein for the yearlings grazing the forage. The UIP of the legumes is important because degradable protein is in excess of cattle needs and UIP is usually limiting for yearlings. The objective of this study was to compare UIP single incubation estimates obtained from forage samples at 75% TMRT and TMRT in addition to rates of NDIN degradation for three legumes and smooth bromegrass.

Procedure

Forage Samples

Four forage samples were included in the in situ trial: alfalfa, birdsfoot trefoil, kura clover and smooth bromegrass. The source of the forages were smooth bromegrass pastures interseeded with legumes at the Research and Development Center of the University of Nebraska, near Ithaca, Neb. There were two sample types for each forage: diet 23 and clip 1. Diet 23 samples were collected using four ruminally fistulated steers grazing the following: smooth bromegrass (BROME), alfalfa and bromegrass (ALF), birdsfoot trefoil and bromegrass (BFT), or kura clover and bromegrass (KURA). Diet 23 samples are a composite of diet 2 and diet 3 samples and represent the midpoint of a grazing period (*2002 Nebraska Beef Report,* pp. 20-21). There were four periods (May through September) in which diet 23 forage samples were collected. The clip samples are from one collection period (May) and are composed of only the single forage: smooth bromegrass (cBROME), alfalfa (cALF), birdsfoot trefoil (cBFT), or kura clover (cKURA). Masticate (diet) and clip samples were freeze-dried and ground to pass through a 2-mm screen. A subsample was ground through a 1-mm screen for IVDMD analysis.

In Situ Procedure

The experimental procedure used in this experiment was similar to that described by Lamothe (this report). Incubation time points included 10 hours, 75% TMRT, TMRT, and 96 hours and were estimated using the following equation:

$$\text{kp (\%/hour)} = 0.07\ \text{IVDMD (\%)} - 0.20$$

The inverse of the kp was used to determine the MRT, and a 10-hour lag time was added to the estimated MRT to yield the TMRT.

Calculations

NDIN was measured on each in situ residue as well as on the original sample allowing for the construction of a degradation curve for NDIN. A first-order

Table 1. Original CP of diet and clip samples, potentially digestible NDIP (% DM) remaining from 0 hour, 10 hour, 75% TMRT, and TMRT incubations, and the indigestible fraction (96 hour).

		Incubation Time				
Item	Original CP[a]	0[b]	10[b]	75% TMRT[b]	TMRT[b]	96
Diet 23[c]						
ALF	14.05	3.83	1.80	.56	.18	1.23
BFT	15.66	3.60	1.63	.60	.31	1.05
KURA	17.74	3.581	.21	.30	.34	.88
BROME	11.34	3.59	1.63	.54	.32	1.01
Clip 1[d]						
cALF	13.40	2.50	.99	.34	.20	1.24
cBFT	15.03	2.74	1.19	.53	.37	1.48
cKURA	15.48	2.23	.67	.24	-.06	.64
cBROME	13.22	4.17	2.14	.66	.18	1.01

[a]Percentage of DM.
[b]96 hour values have been subtracted.
[c]Alfalfa and smooth bromegrass (ALF), birdsfoot trefoil and smooth bromegrass (BFT), kura clover and smooth bromegrass (KURA), and smooth bromegrass (BROME).
[d]Alfalfa (cALF), birdsfoot trefoil (cBFT), kura clover (cKURA), and smooth bromegrass (cBROME).

Table 2. Rate of degradation (%/hour) of NDIP of diet and clip samples from 0 to 10 hours, 10 hours to 75% TMRT, and 75% TMRT to TMRT.

Item	0 - 10[ac]	10 - 75% TMRT[abc]	75% TMRT - TMRT[b]
Diet 23[d]			
ALF	7.72	8.24	10.08
BFT	8.40	7.98	8.23
KURA	11.53	15.73	3.35
BROME	7.59	8.26	9.36
Clip 1[e]			
cALF	9.41	8.05	2.86
cBFT	8.85	8.21	3.61
cKURA	13.91	12.05	13.43
cBROME	6.70	9.44	5.52

[a]0 - 10 not different from 10 - 75% TMRT (P = 0.3253 and P = 0.8690) for Diet 23 and Clip 1, respectively.
[b]10 - 75% TMRT not different from 75% TMRT - TMRT (P = 0.2442 and P = 0.3027) for Diet 23 and Clip 1, respectively.
[c]Forage effect (P = 0.0202).
[d]Alfalfa and smooth bromegrass (ALF), birdsfoot trefoil and smooth bromegrass (BFT), kura clover and smooth bromegrass (KURA), and smooth bromegras.s (BROME)
[e]Alfalfa (cALF), birdsfoot trefoil (cBFT), kura clover (cKURA), and smooth bromegrass (cBROME).

Table 3. Estimated UIP (% DM) of diet samples using three different approaches.

Item	Equation[a]	75% TMRT[bc]	TMRT[bc]
Diet 23[df]			
ALF	1.96	1.80	1.41
BFT	1.73	1.65	1.35
KURA	1.14	1.18	1.21
BROME	1.65	1.56	1.33
Clip 1[eg]			
cALF	1.75	1.59	1.44
cBFT	2.14	2.01	1.84
cKURA	.84	.88	.58
cBROME1	.81	1.67	1.19

[a]UIP = pot dig NDIN * [kp/(kp + kd)] + undig NDIN; corrected for passage lag time.
[b]In situ incubation at 75% TMRT and TMRT.
[c]75% TMRT UIP value different from TMRT UIP value for Diet 23 (P = 0.0009) and Clip 1 (P = 0.0105).
[d]Forage (P = 0.0007) and time (P < 0.0001) effect.
[e]Forage effect (P < 0.001).
[f]Alfalfa and smooth bromegrass (ALF), birdsfoot trefoil and smooth bromegrass (BFT), kura clover and smooth bromegrass (KURA), and smooth bromegrass (BROME).
[g]Alfalfa (cALF), birdsfoot trefoil (cBFT), kura clover (cKURA), and smooth bromegrass (cBROME).

disappearance model was used to calculate the rates of ruminal degradation (kd) for each in situ CP fraction. The natural logarithm of the percentage of NDIN remaining (corrected for the 96-hour indigestible fraction) was regressed against time to calculate kd (slope of the regression line).

Data were analyzed using the MIXED procedure of SAS. Fixed effects in the model included: forage (alfalfa, birdsfoot trefoil, kura clover, and brome), time (period 1, period 2, period 3, and period 4), and incubation time (10 hour, 75% TMRT, and TMRT).

Results

The initial, undegraded protein remaining, and indigestible fraction are shown in Table 1 for diet 23 and clip 1 samples. These values then were used to calculate rates of degradation and UIP values. There were no differences between rates of degradation for the three time periods–0 to 10 hours, 10 to 75% TMRT, and 75% TMRT to TMRT (Table 2). This was the case for both sample sets, clip samples and diet samples (diet 23). This suggests a constant rate of degradation for these forages from zero to TMRT.

Rates of degradation are shown in Table 2. There was a significant treatment x forage interaction (P = 0.0255) for diet 23 samples. From 10 to 75% TMRT (diet 23), the rate of degradation for KURA was significantly higher than ALF, BFT, or BROME (P < 0.05). The rates of degradation among forages from 0 to 10 hours or 75% TMRT to TMRT were not different for diet 23 samples (P > 0.05). Rates of degradation for clip samples were not different for the four forages (P > 0.05) with the exception of the rate from 0 to 10 hours for KURA being higher than BROME (P = 0.0421).

Values of UIP obtained from the competition of kp and kd represent mechanisms in the rumen and may be the most accurate estimates; therefore, the UIP values using kp and kd plus accounting for a lag were regressed linearly on the estimates from a single incubation time point, either 75% TMRT or TMRT. Table 3 shows the UIP values obtained

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for the diet and clip samples obtained from these three different approaches. There were two significant interactions for diet 23 samples: treatment (75% TMRT and TMRT) x forage (P = 0.0433) and forage x sampling month (P = 0.0139).

Estimates of UIP from 75% TMRT incubations were more highly correlated with those calculated from an equation using fractional rates of digestion and passage (R^2 = 0.99) than estimates of UIP from TMRT incubations (R^2 = 0.62). The relationship observed was consistent with Lamothe's single incubation UIP estimates for meadow and range pastures (R^2 = 0.95 and R^2 = 0.53 for 75% TMRT and TMRT, respectively) when compared to the equation values for UIP.

The diet samples likely contain variable amounts of legume. Alfalfa, birdsfoot trefoil and kura clover pastures contained 40, 20 and 50 % legume, respectively. Therefore, the clip samples were evaluated to determine the protein degradability of the actual legumes. The UIP values for both the diet samples (legume and grass) as well as the clip samples (legume or grass) were consistent with the use of the equation or 75% TMRT (Table 3). The UIP values were higher for the birdsfoot trefoil than for the alfalfa or kura clover (P < 0.05). Kura clover values were consistently low. The UIP values for birdsfoot trefoil may be higher than smooth bromegrass, but the UIP may not be sufficiently high to increase the UIP content of the diet selected from the bromegrass pasture interseeded with birdsfoot trefoil.

[1]Heather Haugen, graduate student; Terry Klopfenstein, professor, Animal Science, Lincoln; Mark Ullerich, former graduate student; Casey Macken, Kimberly Whittet, and Tim Loy, research technicians.

Influence of Rinsing Technique and Sample Size on *In situ* Protein Degradation

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Use of machine rinsing or increasing sample size does not change *in situ* dry matter disappearance or undegradable intake protein values of soybean meal or Soypass.

Summary

Four experiments were conducted to evaluate effects of in situ *bag rinsing technique and sample size on the variation of undegradable intake protein (UIP) and dry matter disappearance (DMD) of soybean meal (SBM) and Soypass, a heat-treated soybean meal. Five rinsing techniques and five sample sizes were used to test effects. Soybean meal had higher DMD, lower UIP and higher variance for UIP than Soypass. A steer difference was noted for experiments with steer as a replication and also contributed a larger effect than day and run within day. Rinsing technique and sample size were not significant in concentrate fed steers but were in mixed diet steers. There was a rinsing difference with highest machine rinses having higher DMD and lower UIP values. A size difference was noted with largest sample size having lowest DMD and highest UIP. No difference was found between hand and machine rinsing and no evidence was found to eliminate the use of an increased sample size.*

Introduction

Over the past twenty-five years, *in situ* digestion techniques have been used extensively for measuring ruminal degradation of feedstuffs. Moreover, *in situ* digestion techniques are commonly used to predict undegradable intake protein (UIP) value of protein sources. However, *in situ* techniques suffer from variation involving rinsing techniques and sample sizes. If incubated samples are washed too thoroughly, undigested sample may be lost. If sample size is increased too much, dry matter disappearance (DMD) may be inhibited. Assays of rapidly degradable protein sources are influenced both by variation in DMD and UIP. Also, rapidly degradable feedstuffs incubated with small initial sample sizes leave minimal residue for further analysis. If the initial sample size can be increased, more residue will be remaining for subsequent analysis. Error across technicians may further contribute to the variation of *in situ* digestion techniques. Therefore, the objectives of this study were to evaluate the effect of *in situ* bag rinsing techniques and sample size on the variation of UIP and DMD of soybean meal (SBM) and Soypass, a heat-treated soybean meal.

Procedure

Four experiments were conducted to evaluate effects of *in situ* bag rinsing technique and sample size on UIP and DMD of SBM and Soypass. All four experiments were conducted under similar conditions. Samples were weighed as

received (unground) into 10 x 20 cm dacron bags with 50-µm pore size (Ankom Technology, Inc., Fairport, NY). Steer, day and run were used as replications: Exp. 1 day and run; Exp. 2 steer and run; Exp. 3 steer and day; and Exp. 4 day and run. Run was a duplicated rinse within day or steer. Three replicate bags within steer within day within run were used. Twenty *in situ* bags were placed in a larger mesh bag. All mesh bags were incubated for one 16-hour incubation period in a ruminally fistulated steer fed either a concentrate or mixed diet. Experiments 1 and 3 used a feedlot diet with 7.5% roughage, while Exp. 2 and 4 used a mixed diet (70% forage:30% concentrate). After bags were rinsed, all bags were dried overnight at 60°C and allowed to air equilibrate for two hours before the bag and residue were weighed. Protein analysis was conducted on the residue contained in each bag by weighing a sub-sample for nitrogen analysis using the combustion method (LECO, Inc., St. Joseph, MI). The UIP (% of CP) and DMD then were calculated. Each experiment was analyzed separately as a 2x2x2x5 factorial design.

Bag Rinsing

Experiments 1 and 2 evaluated the effect of five rinsing techniques. Experiment 1 used the concentrate diet, while Exp. 2 used the mixed diet. Two hand-rinsing techniques and three machine-rinsing techniques were tested. The first hand-rinsing technique consisted of rinsing the mesh bags containing the *in situ* bags in 39°C water until color could not be distinguished in the rinse water. Bags then were rinsed individually to remove any particles from the outsides of the bags. The second hand-rinsing technique consisted of removing all the *in situ* bags from the mesh bags and rinsing in a five-gallon bucket in 39°C water. Bags were agitated for one minute, water was drained and the procedure was repeated two additional times. The three machine rinses used a commercial clothes washing machine with 3, 5 or 8 rinses. A rinse consisted of a one-minute agitation in 45 liters (250 mL/bag) of 39°C water and a two-minute spin. All bags contained 5 g of sample per bag.

Table 1. Undegradable intake protein values and their corresponding coefficients of variation for Experiments 1 and 2.

	Treatment					
Item	Hand 1[a]	Hand 2[b]	Machine 3[c]	Machine 5[d]	Machine 8[e]	SEM
Experiment 1 – Concentrate Diet						
Soybean meal						
UIP[f], %CP	70.7	71.0	74.1	68.8	68.9	2.0
CV	8.1	14.3	4.1	12.5	13.6	3.9
Soypass						
UIP, %CP	92.3	93.2	93.6	93.5	92.7	2.0
CV	1.9	1.8	1.5	1.4	1.5	3.9
Experiment 2 – Mixed Diet						
Soybean Meal						
UIP, %CP	19.4[g]	22.9[g]	21.8[g]	23.5[g]	4.3[h]	2.1
CV	30.2	68.7	39.6	38.3	44.1	9.1
Soypass						
UIP, %CP	73.4[g]	71.1[g]	72.9[g]	70.2[g]	55.5[h]	2.1
CV	9.6	4.9	10.2	5.8	4.3	9.1

[a]Hand 1 rinse consisted of multiple rinses with an individual rinse.
[b]Hand 2 rinse consisted of multiple rinses without an individual rinse.
[c]Machine 3 consisted of 3 machine rinses (rinse = 1 min agitation, 2 min spin).
[d]Machine 5 consisted of 5 machine rinses.
[e]Machine 8 consisted of 8 machine rinses.
[f]UIP = undegradable intake protein.
[gh]Means within row with unlike superscripts differ ($P < 0.05$).

Sample Sizes

Experiments 3 and 4 evaluated the effect of five sample sizes. Experiment 3 utilized the concentrate diet, while Exp. 4 made use of the mixed diet. Bags contained 5, 10, 20, 30 or 50 g of sample per bag. After incubation, bags were machine rinsed with five machine rinses.

Results

There was a sample effect across all experiments ($P < 0.01$). Soybean meal had higher DMD and lower UIP values than Soypass and higher variance for UIP. Variance for DMD was also higher ($P < 0.01$) for SBM compared to the Soypass in concentrate fed steers (Exp. 1 and 3). Heat treatment of the Soypass condenses sugar residues with amino acids rendering the protein undegradable in the rumen. The heat treatment is stopped before the product becomes indigestible in the small intestine. Consequently, DMD is reduced, increasing the UIP value of the product. Previous research has shown depressed *in situ* degradabilities of protein sources when dietary forage is decreased. Slime produced in the rumen of animals fed concentrate diets could block pores of the dacron bag, thus reducing DMD. The inconsistent flow through the bag then increases the variation in DMD values.

A steer effect was noted for experiments with steer as a replication ($P < 0.01$). Steer had a larger effect than day with F-statistics of 243.5 and 8.6, respectively. In Exp. 3, the F-statistic for steer was 146.2 and day in Exp. 4 was 4.4. Additionally, steer contributed more variation than run with a F-statistic of 146.18 for steer and 10.61 for run. It was hypothesized that steer, day, and run would contribute similar amounts of variation when evaluating DMD and UIP. Since steer contributed the most variation, it is suggested that it be included in replications in *in situ* incubation.

Rinsing technique and sample size were not significant ($P = 0.85$) in concentrate fed steers (Exp. 1 and 3) but were ($P < 0.01$) in steers fed a mixed diet. There was a rinsing effect ($P < 0.01$) in Exp. 2, with 8 machine rinses having

(Continued on next page)

higher DMD and lower UIP values (Table 1). It was hypothesized that machine rinsing would eliminate technician-induced variation involved with hand-rinsing *in situ* bags. However, with increased rinsing, washout was expected to occur with over rinsing of bags. No difference was detected between hand and machine rinsing, suggesting machine rinsing is a suitable technique for rinsing bags. Reduction in time spent rinsing bags by hand makes the machine method more efficient and will likely reduce error between technicians. Five machine rinses is suggested to ensure proper rinsing and reduced washout. A sample size effect ($P < 0.01$) was noted for Exp. 4, with 50 g having the lowest DMD and highest UIP values (Table 2). The ratio of sample size to bag surface area is important in *in situ* studies. With excessive inclusion of sample in the bags, DMD can be inhibited. Previous research has shown that effective digestion of soybean meal protein is greatest at a lower sample size to bag surface area. A sample size range from 10-30 g is suggested ensure DMD is not inhibited and to also increase residue amount remaining after ruminal incubation

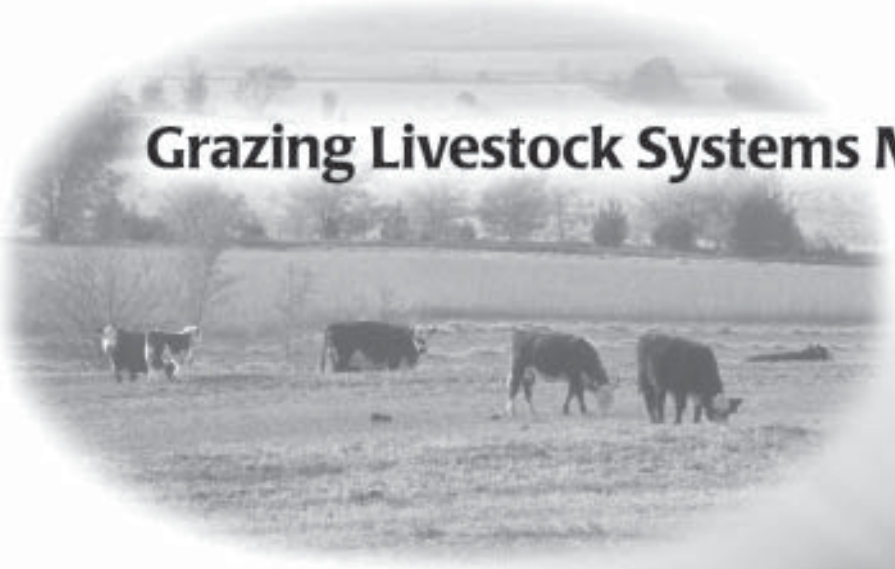
In summary, steer contributed more variation than both day and run. There is no difference between hand and machine rinsing, but with increased rinsing, washout can occur. Sample size can be increased, yet the sample size to bag surface area should be monitored due to depressed DMD at higher ratios. Based on the lack of effects and very high UIP values produced in a concentrate fed steer, a mixed diet is a better model for *in situ* incubation.

Table 2. Undegradable intake protein values and their corresponding coefficients of variation for Experiments 3 and 4.

	Treatment					
Item	5g	10g	20g	30g	50g	SEM
Experiment 3 – Concentrate Diet						
Soybean meal						
UIP[a], %CP	49.3	51.9	52.7	49.4	53.7	1.6
CV	12.6	12.0	8.2	12.9	8.2	3.9
Soypass						
UIP, %CP	89.8	88.2	88.6	89.3	88.9	1.6
CV	1.1	2.2	2.0	1.3	1.6	3.9
Experiment 4 – Mixed Diet						
Soybean Meal						
UIP, %CP	41.3[b]	44.5[bc]	47.6[cd]	49.7[d]	55.9[e]	2.1
CV	21.9	12.3	17.3	13.0	6.4	4.8
Soypass						
UIP, %CP	88.8[bc]	88.3[bc]	88.1[bc]	86.2[b]	91.5[c]	2.1
CV	2.3	3.6	2.7	3.9	4.1	4.8

[a]UIP = undegradable intake protein.
[bcde]Means within row with unlike superscripts differ ($P < 0.05$).

[1]Kimberly Whittet, research technician; Kelly Creighton, Kyle Vander Pol, graduate students; Galen Erickson, assistant professor; Terry Klopfenstein, professor, Animal Science, Lincoln.



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