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2003 Research and Extension Beef Report

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Contents

Effects of Oral Chlortetracycline and Steroidal Implant on Growth Performance and Carcass Merit of Finishing Beef Steers

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Summary

Rate of BW gain and efficiency of gain were increased in finishing beef steers receiving growth implants over a 110-day finishing period. These increases were especially apparent during the 28-day periods immediately following growth implantation at day 0 and 56. The usual recommendation for reimplantation is 60 to 90 days; however, based on the data from this experiment, Synovex-S is only effective in altering apparent growth performance for 28 days following implantation. We also demonstrated that there was a tendency for marbling to increase in steers fed CTC, indicating a propensity for intramuscular fat deposition to increase, despite the presence of growth implants. Moreover, CTC numerically increased marbling score in steers not implanted, despite a significant reduction in fat cover. This suggests that in the presence of a growth implant that promotes lean tissue gain, CTC may promote marbling independent of implant effects. However, additional research is needed to further delineate these effects and interactions.

Introduction

Feeding subtherapeutic levels of chlortetracycline (CTC) has been reported to have a growth-promoting effect for ruminants, swine, and poultry, but the mechanism for this effect is not known. Most hypotheses for growth promotion by antibiotics in ruminants relate to effects on digestive tract microorganisms or gut wall thinning. Based on carcass composition of calves, it has been suggested that CTC may influence growth via an endocrine axis. However, there is a paucity of information on effects of antibiotics on endocrine regulation of growth in ruminants, as well as their possible effects when fed in conjunction with estrogenic growth implants.

It has been demonstrated that the growth hormone (GH), thyroid-stimulating hormone, and thyroxine response to a challenge injection of thyrotropin-releasing hormone (TRH) plus GH-releasing hormone is reduced in steers chronically fed CTC. These findings are consistent with the antithyroid effect of CTC and reduced maintenance requirements demonstrated in rats and chicks. Recent research has also indicated that a sustained effect of subtherapeutic feeding of CTC to growing cattle is increased subcutaneous and intramuscular fat deposition, consistent with a reduced GH and thyroid status under marginal or adequate protein conditions. Chlortetracycline binds Ca^{2+}, which is involved in cytoplasmic release of hormones by TRH. Chlortetracycline also reduces hypothalamic deiodinase activity. These effects may be factors that attenuate pituitary response to releasing hormones and, in turn, influence growth and tissue deposition.

The purpose of the present study was to determine whether the practical measures of performance and carcass merit characteristics are detectably different between control steers and steers with reduced sensitivity to pituitary-releasing hormones (TRH-releasing hormone and GH-releasing hormone) in response to a subtherapeutic feeding of CTC (350 mg CTC/day fed one hour before morning feed). In addition, the effect of growth implant was tested to determine if there are possible interactions between the lipogenic effects of CTC and anabolic effects of estrogenic growth implants.

Materials and Methods

Animals and Treatments

Twenty-four Simmental-Angus crossbred steers were purchased from a single farm in central Kentucky. Steers were initially housed on pasture for 30 days upon arrival at the University of Kentucky Animal Research Center, during which time they were dewormed using ivermectin (Merial, Duluth, GA) and vaccinated using Bovi-Shield™ 4 and Ultrabac® 7 (Pfizer Animal Health, Exton, PA). After 30 days, steers were moved to group pens (four steers/pen) for a 30-day backgrounding period. During this time, a corn silage-based growing diet was fed until a body weight (BW) of approximately 340 kg was achieved. The group pens measured 14.6 x 2.4 m and were located on a concrete pad partially covered with a roof. The steers had continuous access to automatic waterers.

After the 30-day backgrounding period, steers were limit-fed two step-up diets for 30 days at 2.25% BW for adaptation to *ad libitum* intake of the experimental diet (Table 1). These steers were separated into three blocks based on initial BW (340 to 360 kg). The start day of block 2 was staggered one week after block 1, while block 3 was started three weeks after block 1. Ten days before each block was started on the experiment, steers were moved into individual pens measuring 2.4 x 1.8 m and covered by a roof. Each pen had an individual feed bunk and waterer. During the experiment, steers were exercised by turning them out in groups of four from 0730 to 0900 each day.

Across treatments, steers were stratified by body weight and frame size and assigned randomly to a 2 x 2 factorial arrangement of treatments. Treatments included a corn meal + molasses carrier containing either 0 or 350 mg CTC (Aureomycin, Alpharma Animal Health, Paramus, NJ) and steroidal implant or no implant on days 0 and 56. The experimental diet was formulated using two protein supplements: protein supplement 1 was formulated to provide 105% of the metabolizable protein requirement for large-frame steers (350 kg BW) gaining 1.60 kg/day and was fed until day 56 of the experiment; Protein supplement 2 was formulated to provide 105% of the metabolizable protein requirement for large-frame steers (450 kg BW) gaining 1.60 kg/day and was fed from day 57 to 112. The carrier or carrier plus CTC (500 g) was supplied daily at 0900. Steers were returned to the individual pens from the exercise lot and allowed one hour to consume the treatments before feeding at 1000. Orts were measured daily immediately after the steers were turned out for exercise, and throughout the study feed offered was adjusted to maintain approximately 20% orts.

Table 1. Step-up and experimental diets.

Ingredient, % DM	Step-Up Diet #1	Step-Up Diet #2	Experimental Diet (day -10-56)	Experimental Diet (day 57-112)
Corn silage	20.00	5.00	-----	-----
Alfalfa haylage	20.00	20.00	20.00	20.00
Cracked corn	50.00	65.00	70.00	70.00
Corn gluten meal	2.97	2.97	2.97	-----
Ground corn	4.78	4.78	4.78	7.75
Urea	0.36	0.36	0.36	0.35
Limestone	1.07	1.07	1.07	1.07
Trace mineral-salt[1]	0.51	0.51	0.51	0.51
Vitamins A, D, E[2]	0.02	0.02	0.02	0.02
Choice white grease	0.31	0.31	0.31	0.30

[1] 98.5% NaCl, 0.35% Zn, 0.34% Fe, 0.20% Mn, 330 ppm Cu, 70 ppm I, 50 ppm Co, 90 ppm Se.
[2] 8,800 IU/g vitamin A, 1,760 IU/g vitamin D, 1.1 IU/g vitamin E.

Steers were implanted or not implanted with Synovex-S® on day 0, after which steers initially implanted were re-implanted on day 56. Before feeding, body weights were determined biweekly for each block of steers; however, initial (day –2 and –1) and final (day 111 and 112) body weights were determined by weighing steers on two consecutive days.

After day 111 for each block was reached, the four heaviest steers from each treatment were chosen for slaughter on day 112. The four remaining steers from the block were slaughtered on day 114. Steers were slaughtered at the University of Kentucky abattoir. Carcass merit evaluation was done according to USDA standards and performed by a qualified meat scientist.

Results and Discussion

Growth Performance

BW gain (calculated as the slope of the weekly body weight data over time), dry matter intake (DMI), and efficiency of gain (BW gain per unit of DMI) are summarized in Table 2. Regardless of period, there were no treatment effects (P > 0.1) on DMI throughout the experiment. For period 1, growth implant increased BW gain (P = 0.01) by 21% and feed efficiency (P = 0.005) by 23%. This would be expected since the positive effects of growth implants are most apparent in the period immediately following implantation. Overall, BW gain was greater than expected for this period. Steers were targeted to gain 1.6 kg/day throughout the experiment; however, in period 1 steers averaged almost 2.3 kg/day. Likewise, BW gain for steers not receiving implants was also greater than expected, with a rate of almost 1.9 kg/day. It is possible that the higher rate of gain during this period can be attributed to adaptation to the *ad libitum* level of intake during period 1 or to compensatory gain.

There were no treatment effects (P > 0.1) on growth performance during period 2. However, during period 3, implant increased BW gain (P = 0.03) by 35% and feed efficiency (P = 0.03) by 34%. This was expected as steers were reimplanted with Synovex-S on day 56. During period 4, initial body weights were greater (P = 0.002) for all implanted steers; this is reflective of the greater BW gain throughout the previous periods. BW gain and efficiency of gain were similar for all treatments during this period.

Over the entire experiment (days 0 to 110), implant increased rate of gain by 21%, efficiency of gain by 19%, and final BW (P ≤ 0.01). It is important to note that the periods of greatest response to the growth implants were immediately following implantation on days 0 and 56. The increases in BW gain and feed efficiency illustrate the effectiveness of the implants with and without the addition of CTC.

Recent research has demonstrated that CTC tends to improve efficiency of BW gain when nutrition is adequate. However, responses to CTC in growing and finishing cattle have been variable, with some research showing increased BW gain and efficiency in growing but not finishing steers, while some data suggest improvements in weight gain for feedlot steers. Our research did not show effects of CTC on growth performance; however, we did show that growth implant increases weight gain and feed efficiency.

Carcass Merit

Carcass merit data are summarized in Table 3. Slaughter weight was greater (P = 0.006) for implanted steers, while there was an interaction (P = 0.03) between CTC and implant for carcass weight. In the absence of implant, steers fed CTC had heavier carcasses (P = 0.05) compared with steers not receiving CTC. However, in the presence of implant, CTC had no effect on carcass weight (P = 0.3). Implant and CTC tended to interact (P = 0.08) for longissimus area. In the absence of implant, area was lower (P = 0.04) in steers not receiving CTC compared with those receiving CTC. Concurrently, longissimus fat cover was lower (P = 0.02), and yield grade tended to be lower (P = 0.06) in steers fed CTC in the absence of implant, but CTC had no effect when steers were implanted (interaction, P ≤ 0.06). This interaction between CTC and implant on longissimus muscle area and fat cover is unclear; however, longissimus area and fat cover were 17% less and 45% greater, respectively, in control (-CTC,

-implant) steers compared to all other treatments. There was no effect of treatment on kidney, pelvic, or heart fat. In the current experiment, marbling score was only numerically (P = 0.18) greater in steers fed CTC. However, this numerical increase was similar to that previously reported with a greater number of animals. Bone maturity was lower (P = 0.01) for implanted steers, which is in agreement with other studies using growth implants.

Table 2. Effects of oral chlortetracycline[a] (CTC) and growth implant on body weight (BW) gain, feed intake, and efficiency of gain.

	-Implant		+Implant			P <		
Item	**-CTC**	**+CTC**	**-CTC**	**+CTC**	**SEM[b]**	**CTC**	**Implant**	**X[c]**
Period 1, 0-26 d								
Initial BW, kg	363	366	369	363	21.03	0.90	0.85	0.62
DMI, kg/day	9.60	9.13	9.13	9.04	0.98	0.50	0.51	0.66
BW gain, kg/day	1.88	1.89	2.21	2.34	0.33	0.60	0.01	0.70
Gain:DMI, g/kg	86.92	91.29	106.93	112.41	7.01	0.46	0.005	0.93
Period 2, 27-54 d								
Initial BW, kg	411	415	427	424	18.37	0.94	0.15	0.66
DMI, kg/day	10.21	9.72	10.33	9.32	1.24	0.17	0.79	0.62
BW gain, kg/day	1.49	1.61	1.91	1.58	0.33	0.45	0.19	0.12
Gain:DMI, g/kg	69.22	72.06	84.29	78.30	6.93	0.81	0.12	0.50
Period 3, 55-82 d								
Initial BW, kg	453	461	480	468	20.04	0.78	0.06	0.26
DMI, kg/day	9.27	9.66	10.15	9.11	1.46	0.61	0.79	0.26
BW gain, kg/day	1.07	1.43	1.78	1.59	0.45	0.66	0.03	0.16
Gain:DMI, g/kg	53.64	66.14	80.67	80.13	9.65	0.52	0.03	0.48
Period 4, 83-110 d								
Initial BW, kg	483	501	530	512	19.49	0.99	0.002	0.05
DMI, kg/day	9.83	9.84	10.42	9.75	1.21	0.52	0.63	0.52
BW gain, kg/day	1.36	1.40	1.55	1.49	0.36	0.94	0.37	0.72
Gain:DMI, g/kg	63.65	65.40	68.32	71.06	5.53	0.67	0.33	0.92
0-110 d								
Initial BW, kg	363	366	369	363	21.03	0.90	0.85	0.62
Final BW, kg	522	540	574	555	26.88	0.99	0.01	0.12
DMI, kg/day	9.73	9.59	10.02	9.31	1.05	0.35	0.99	0.53
BW gain, kg/day	1.42	1.57	1.87	1.74	0.24	0.93	0.01	0.17
Gain:DMI, g/kg	67.45	74.17	84.14	84.48	3.76	0.33	0.001	0.37

[a] Chlortetracycline was fed at 350 mg of CTC per day per steer.
[b] Standard error of the mean calculated from analysis of variance using n = 5.
[c] Interaction of CTC x implant.

Table 3. The effects of oral chlortetracycline[a] (CTC) and growth implant on carcass evaluation measures of finishing beef steers.

	-Implant		+Implant			P <		
Item	**-CTC**	**+CTC**	**-CTC**	**+CTC**	**SEM[b]**	**CTC**	**Implant**	**X[c]**
Slaughter weight, kg	522	544	575	556	24.87	0.88	0.006	0.07
Carcass weight, kg	301	322	337	327	15.83	0.48	0.007	0.03
Dressing percentage	57.70	59.06	58.61	58.67	0.51	0.15	0.60	0.19
Longissimus area, cm^2	71.74	82.96	84.84	83.17	0.58	0.19	0.07	0.08
Longissimus fat cover slaughter, cm[d]	0.86	0.55	0.57	0.66	0.04	0.19	0.29	0.03
KPH fat, %	1.80	1.67	1.42	1.58	0.18	0.92	0.18	0.38
Marbling[e]	2.58	2.83	2.45	2.87	0.25	0.18	0.84	0.74
Bone maturity[f]	1.38	1.33	1.27	1.23	0.04	0.32	0.01	0.87
Yield grade	2.68	1.95	1.96	2.07	0.22	0.16	0.17	0.06

[a] Chlortetracycline was fed at 350 mg of CTC per day per steer.
[b] Standard error of the mean calculated from analysis of variance using n = 5.
[c] Interaction of CTC x implant.
[d] Slaughtered at day 112 or 114.
[e] Scores: 1.00 = $trace^{00}$, 2.00 = $slight^{00}$, 3.00 = $small^{00}$, 4.00 = $modest^{00}$.
[f] Scores: 1.00 = A^{00}.

Effect of Supplemental Energy Source on Performance of Growing Beef Heifers Fed Drought-Damaged Corn Silage

K.C. Hanson, K.R. McLeod, and D.L. Harmon

Summary

Ninety-six Angus or crossbred heifers (275 kg) were fed growing diets based on corn silage for 84 days to evaluate the effects of supplemental energy source on animal performance. Over the 84-day growing period, heifers fed an energy supplement consumed more feed ($P < 0.01$; 8.99 kg/day) than non-supplemented controls (7.66 kg/day) and gained faster ($P < 0.01$; 1.23 versus 1.04 kg/day). The performance of heifers in this study was equal whether the supplemental energy source was high fiber or high starch. This suggests that producers should choose the most economical source in their area.

Introduction

During the summer of 2002, the weather was extremely dry in central Kentucky, resulting in very poor yields of corn and extremely low quality of corn silage because of the low corn content. This results in a very high-fiber, low-energy feed, requiring a source of additional energy to support adequate gains of growing beef cattle. Supplementation of feeds such as this with an energy source high in starch may result in poor utilization of dietary fiber because of negative associative effects from the starch. We hypothesized that high-energy fiber sources such as corn gluten feed or soybean hulls may be advantageous because they would avoid these negative associative effects. Therefore, the objective of the present study was to determine the effects of supplemental energy source on the growth performance of beef heifers fed low-quality corn silage.

Materials and Methods

Ninety-six Angus or crossbred heifers (275 kg) were fed growing diets based on corn silage for 84 days to evaluate the effects of supplemental energy source on animal performance. Animals were blocked by weight, source, and breed and randomly assigned to one of four treatments (four heifers per pen, six pens per treatment) in a completely randomized design. Treatments included: 1) no supplemental energy, control diet; 2) 25% cracked corn diet; 3) 25% corn gluten feed diet; and 4) 25% soyhulls diet (Table 1). All diets contained 10% supplement. Diets were formulated to be isonitrogenous (13.5% CP) and fed once daily (~3.0% BW) as a completely mixed ration to achieve *ad libitum* intakes.

Approximately half of the animals used were from the University of Kentucky beef herd, and the remainder were purchased through local auctions. Upon arrival, purchased heifers were vaccinated with ViraShield 5 + Somnus (Novartis Animal Vaccines Inc., Overland Park, KS). Heifers were fed a receiving diet and adjusted to corn silage for approximately two weeks after arrival. Body temperatures were monitored and animals dosed with Nuflor and Banamine (Schering-Plough Animal Health, Union, NJ) when body temperatures exceeded 40°C upon arrival. Animals with persistent fevers (> 39.4°C) were later dosed with Micotil (Elanco Animal Health, Greenfield, IN). One day prior to initiation of the trial, all animals were weighed, dewormed with Safegard (medicated feed) for the control of internal parasites, and assigned randomly to treatments.

Animals were weighed in the morning prior to feeding on days 1, 2, 28, and 56 and at completion of the experiment (days 83 and 84). Initial and final weights were taken on consecutive days and averaged.

Total feed offered was measured daily. Feed refusals were collected from feed bunks every Tuesday before animals were fed. Feed refusals from each bunk were weighed, and a sample was collected and composited within each treatment and analyzed for DM. Feed ingredients were analyzed for DM content and diets adjusted accordingly every Tuesday, to correspond with weigh days and collection of feed refusals. Data were analyzed as a randomized complete block design.

Table 1. Composition of diets (%) fed to growing heifers to determine influence of supplemental energy from corn, corn gluten feed (CGF), or soybean hulls.

Item	Control	Corn	CGF	Soybean Hulls
Corn silage[1]	90.00	65.00	65.00	65.00
Cracked corn	-	25.00	-	-
Corn gluten feed	-	-	25.00	-
Soybean hulls	-	-	-	25.00
Soybean meal	6.29	6.04	-	3.71
Ground corn	1.65	1.81	8.11	4.49
Urea	0.46	0.43	0.13	0.33
Dicalcium phosphate	0.16	0.04	-	0.26
Limestone	0.79	1.04	1.105	0.55
Trace mineral-salt[2]	0.30	0.30	0.30	0.30
Vitamins A, D, E[3]	0.02	0.02	0.02	0.02
Choice white grease	0.30	0.30	0.30	0.30
Rumensin 80®[4]	0.0125	0.0125	0.0125	0.0125
Tylan 40®[5]	0.0075	0.0075	0.0075	0.0075
Melengesterol acetate	0.01	0.01	0.01	0.01
Diet crude protein, % dry matter	12.3	12.5	12.8	11.8

1 Corn silage was 8.7% crude protein, 53.6% NDF, and 11.7% starch on a dry matter basis.
2 98.5% NaCl, 0.35% Zn, 0.34% Fe, 0.20% Mn, 330 ppm Cu, 70 ppm I, 50 ppm Co, and 90 ppm Se.
3 8,800 IU/g vitamin A, 1,760 IU/g vitamin D, and 1.1 IU/g vitamin E.
4 Added to supply 22 mg/kg of feed dry matter.
5 Added to supply 6.6 mg/kg of feed dry matter.

Results

Results of dry matter intake, average daily gain, and feed efficiency are shown in Table 2. There were no differences (P > 0.05) in feed efficiency among treatment groups for the entire trial. During the first 28-day period, supplemented heifers gained faster (P < 0.02) and consumed more feed (P < 0.01) than those on the control diet, regardless of energy source. During the second 28-day period, supplemented heifers again consumed more feed (P > 0.001), but gains were not affected by treatment (P > 0.05). From day 57 to the end of the trial, heifers supplemented with corn gluten feed or soyhulls gained faster (P < 0.03) than the control heifers, with those supplemented with corn being intermediate. Heifers supplemented with an energy source consumed more (P < 0.02) feed than those not supplemented.

Over the 84-day growing period, heifers fed an energy supplement consumed more feed (P < 0.01; 8.99 kg/day) than those not supplemented (7.66 kg/day) and gained faster (P < 0.01; 1.23 kg/day) than control heifers (1.04 kg/day). Although the supplemented heifers consumed more feed, because they gained faster than the heifers on the control diet, feed efficiency was not affected.

Based on the findings of this experiment, animal gains may be improved by supplementing poor-quality corn silage with an energy source without a corresponding decrease in feed efficiency. Producers can choose from several energy sources based on economics and achieve the same improvements in animal performance.

Table 2. Dry matter intake (DMI), average daily gain (ADG), and feed efficiency of growing heifers fed low-quality corn silage and supplemented with different energy sources.

	Control	Corn	CGF	Soyhulls	SEM	P-value
DMI, kg/day						
days 1-28	7.29[a]	8.49[b]	8.87[b]	8.76[b]	0.288	0.0036
days 29-56	7.77[a]	9.30[b]	9.35[b]	9.21[b]	0.250	0.0006
days 57-84	7.92[a]	8.95[b]	8.97[b]	9.06[b]	0.245	0.0118
Total	7.66[a]	8.91[b]	9.09[b]	8.98[b]	0.242	0.0015
ADG, kg						
days 1-28	1.09[a]	1.40[b]	1.36[b]	1.53[b]	0.087	0.0168
days 29-56	1.29	1.35	1.30	1.27	0.076	0.9050
days 57-84	0.73[a]	0.88[ab]	0.95[b]	1.02[b]	0.061	0.0241
Total	1.04[a]	1.21[b]	1.20[b]	1.27[b]	0.044	0.0090
Gain:Feed						
days 1-28	0.150	0.164	0.152	0.175	0.0080	0.1380
days 29-56	0.167	0.147	0.140	0.139	0.0090	0.1293
days 57-84	0.094	0.099	0.106	0.113	0.0076	0.3247
Total	0.137	0.137	0.133	0.142	0.0048	0.6031

[ab] Means within rows without a common superscript differ significantly.

Implications

This study shows that the energy value of low-quality corn silage can be improved by providing additional energy. The performance of heifers in this study was equal whether the energy source was high fiber or high starch. Since high-energy fiber sources like soybean hulls and corn gluten feed are typically lower in energy than corn, this study demonstrates the benefits of feeding a highly digestible fiber in diets such as these.

Effects of Corn Type and Forage Level on Growth Performance and *E. coli* Shedding in Finishing Beef Steers

S.E. Kitts, K.C. Hanson, N.A. Elam, M.C. Newman, D.L. Harmon, and K.R. McLeod

Summary

As expected, DMI was greater for steers fed a high level of forage during an 84-day finishing period. Average daily gain was greater for steers fed HM corn, which likely reflects its greater availability. Dietary forage level did not affect feed efficiency in steers fed HM corn; however, a negative relationship was observed between dietary forage level and feed efficiency in steers fed CC. Additionally, feeding a high level of forage in conjunction with CC had a negative impact on average daily gain early in the feeding period (29 to 56 days) when compared to feeding CC plus a low level of forage. Lower average daily gains possibly were caused by decreased availability of the corn and increased passage rate of the diet; together, these factors resulted in less nutrients and energy to support the level of gain seen with either lower forage or HM corn. When fecal pH and microbial shedding were measured, CC induced a lower pH in the feces. However, there were no differences in total coliforms or total *E. coli* between corn types or forage level, suggesting that at the levels of forage included in this experiment, there is no decrease in microbial shedding.

Introduction

Corn grain is the primary source of energy supplied to finishing beef cattle. A substantial amount of information is available concerning the effects of mechanical processing (dry-rolled) or early harvesting (high moisture) on the utilization and subsequent performance of feedlot cattle fed corn. Typically, processing has been shown to decrease dry matter intake with little effect on average daily gain, thus increasing feed efficiency.

Due to processing, high-moisture corn is rapidly fermented in the rumen; presumably, very little starch escapes to the intestines undigested. Conversely, dry-rolled and cracked corn are not as fermentable in the rumen due to physical limitations of the kernels, and consequently much starch escapes to the intestines. Depending on the amount of starch digested in the small intestine or fermented in the large intestine, full utilization of the feed may not be realized; thus, average daily gain and feed efficiency may be negatively affected. Research has shown that including forage in high-concentrate diets for finishing cattle has beneficial effects on rumen health. These effects are largely due to increased rumination and salivation, which buffer the rumen and prevent the low pH generally associated with high-concentrate diets. However, these beneficial effects could be diminished at different forage inclusion rates due to increased passage; thus, because organic matter degradation rate is dependent on grain type and processing method, as well as passage rate, it is important to delineate the effects of these factors on growth performance in finishing cattle.

In addition to the effects of forage level and corn type on finishing performance, research has suggested these same factors influence fecal shedding of pathogenic bacteria such as *Escherichia coli*. Cattle have been implicated as a reservoir for pathogenic *E. coli*, and fecal shedding of these bacteria can serve as a source of contamination in beef and dairy products. Two factors have been suggested to contribute to increased fecal shedding of *E. coli* and the subsequent contamination of food products. Shipping stress and increasing holding time of cattle before slaughter are associated with increased numbers of *Salmonella* sp. and *E. coli* in the rumen at slaughter. Also, high-concentrate diets such as those typically fed to finishing cattle induce a lower colonic pH due to starch fermentation and thus more acid-resistant *E. coli*. Acid resistance lends to the transmission of *E. coli* from cattle to humans. At slaughter, it is virtually impossible to prevent some fecal contamination of meat; however, cooking or irradiation of the meat usually destroys harmful bacteria. In addition to these postharvest ameliorations, another effective strategy would be to reduce fecal shedding of *E. coli*.

Some research has suggested that certain management factors, including diet, affect changes in *E. coli* shedding. Specifically, feeding higher levels of forage for a period immediately prior to slaughter could reduce *E. coli* shedding and reduce the risk of carcass contamination and transmission to humans.

The purpose of this study was to determine the effects of type of corn (cracked versus high-moisture) and level of forage (5% versus 15% alfalfa haylage) on growth performance and fecal shedding of *E. coli* in finishing beef steers.

Materials and Methods

Experimental Protocol

Ninety-six crossbred steers were purchased from a commercial stockyard in central Kentucky. Steers were housed in group pens (four steers/pen) measuring 14.6 x 2.4 m and located on a concrete pad partially covered with a roof. The steers had continuous access to automatic waterers.

For 30 days prior to initiation of the experiment, steers were adapted to *ad libitum* intake of the high-concentrate diets using two step-up diets containing increasing levels of concentrate. Steers were stratified by weight and assigned randomly to one of four treatments (four steers/pen, six pens/treatment) in a completely randomized design with a 2 x 2 factorial arrangement of treatments. Factors were corn type (cracked versus high moisture) and level of forage (5% versus 15% alfalfa haylage). Dietary treatments included: 1) 85% cracked corn (CC), 5% alfalfa haylage (AH); 2) 85% high-moisture corn (HM), 5% AH; 3) 75% CC, 15% AH; 4) 75% HM, 15% AH (Table 1). Diets were formulated to be isonitrogenous (12% crude protein); this was achieved using separate supplements for treatments 1 and 2 versus treatments 3 and 4 (Table 1). Diets were fed once daily as a total mixed ration at an *ad libitum* level of intake, and orts were measured weekly.

On day 1, steers were weighed, implanted with Revalor-S®, and assigned to treatments. Steers were subsequently weighed on days 28 and 56 and the day prior to slaughter. Groups of 24 steers were slaughtered over a 30-day period, beginning at day 71. The heaviest steer from each pen was slaughtered on each of four slaughter days. Each group of steers was transported 1.5 hours to a slaughter facility and held overnight until slaughter the next morning.

Microbial Analyses

Immediately after slaughter, fecal grab samples were collected from each steer for total coliform and *E. coli* determination. Approximately 100 g of feces were placed in a whirlpak bag and stored on dry ice until microbial analysis the same day. Concurrently, approximately 50 g of feces were collected into a foil pack and snap frozen in liquid nitrogen for dry matter (DM) and pH determination. For microbial analysis, 25 g of feces were blended with an enrichment buffer (1:10) and plated on Petrifilm™ plates at dilution rates of 10^4, 10^5, and 10^6. Total coliform and *E. coli* enumeration was determined, and all microbial enumerations are expressed as $\log_{10}$ colony-forming

Table 1. Composition of experimental diets.

	Cracked Corn		High-Moisture Corn	
Ingredient, % DM	**5% AH**	**15% AH**	**5% AH**	**15% AH**
Alfalfa haylage (AH)	5.00	15.00	5.00	15.00
Cracked corn (CC)	85.00	75.00	------	------
High-moisture (HM) corn	------	------	85.00	75.00
Urea	0.85	0.35	0.85	0.35
Ground corn	7.20	8.06	7.20	8.06
Dicalcium phosphate	------	0.01	------	0.01
Limestone	1.32	0.94	1.32	0.94
Trace-mineralized salt[1]	0.30	0.30	0.30	0.30
Vitamins A, D, E[2]	0.03	0.03	0.03	0.03
Choice white grease	0.30	0.30	0.30	0.30
Rumensin 80®[3]	0.013	0.013	0.013	0.013
Tylan 40®[4]	0.008	0.008	0.008	0.008

1 98.5% NaCl, 0.35% Zn, 0.34% Fe, 0.20% Mn, 330 ppm Cu, 70 ppm I, 50 ppm Co, and 90 ppm Se.
2 8,800 IU/g vitamin A, 1,760 IU/g vitamin D, and 1.1 IU/g vitamin E.
3 Added to supply 22 mg/kg of feed dry matter.
4 Added to supply 6.6 mg/kg of feed dry matter.

units (CFU) per gram of dry feces. Fecal pH was measured using equal proportions of feces and deionized water (25 g feces + 25 mL water).

Results and Discussion

Growth Performance

Body weight (BW) gain (calculated as average daily gain), dry matter intake (DMI), and efficiency of gain (BW gain per unit of DMI) are summarized in Table 2. Across the entire feeding period, DMI was greater (P = 0.0001) for steers receiving 15% AH compared to those receiving 5% AH. This observation is not surprising because higher inclusion levels of forage would decrease dietary energy density and steers would consume more dry matter in an attempt to meet metabolizable energy (ME) requirements. Similarly, DMI tended (P = 0.11) to increase for steers fed HM corn compared to those fed CC, and this effect was significant during the period from 29 to 56 days (P = 0.03). Other data suggest that early in the feeding period, DMI is greater for steers receiving HM corn than for those receiving dry-rolled corn when fed to slaughter at 84 or 111 days.

Table 2. Effects of corn type and forage level on body weight gain, feed intake, and efficiency of gain in finishing beef steers.

	Cracked Corn		High-Moisture Corn			P <		
Item	5% AH	15% AH	5% AH	15% AH	SEM[a]	Corn	Forage	X[b]
Period 1, 0-28 days								
Initial BW, kg	456	463	462	463	4.01	0.57	0.32	0.44
DMI, kg/day	9.58	11.46	10.01	11.43	0.34	0.57	0.0001	0.50
BW gain, kg/day	1.78	1.74	1.91	2.06	0.10	0.04	0.59	0.38
Gain:DMI, g/kg	186.11	152.21	191.79	181.00	12.24	0.17	0.08	0.36
Period 2, 29-56 days								
Initial BW, kg	506	529	515	520	4.73	0.07	0.24	0.92
DMI, kg/day	9.48	11.00	10.05	11.99	0.33	0.03	0.0001	0.53
BW gain, kg/day	1.59	1.34	1.41	1.61	0.08	0.59	0.71	0.01
Gain:DMI, g/kg	168.05	121.92	140.60	134.84	7.25	0.33	0.002	0.01
Period 3, 57-84 days								
Initial BW, kg	551	550	555	565	5.56	0.08	0.39	0.30
DMI, kg/day	9.43	10.83	9.88	11.75	0.42	0.12	0.001	0.58
BW gain, kg/day	1.48	1.46	1.66	1.94	0.18	0.08	0.47	0.43
Gain:DMI, g/kg	154.92	134.49	167.75	164.58	15.13	0.17	0.44	0.57
0-56 days								
Initial BW, kg	456	463	462	463	4.01	0.57	0.32	0.44
DMI, kg/day	9.53	11.23	10.03	11.71	0.31	0.13	0.0001	0.97
BW gain, kg/day	1.68	1.54	1.66	1.83	0.06	0.04	0.82	0.02
Gain:DMI, g/kg	176.91	137.10	166.23	157.33	6.60	0.47	0.002	0.03
0-84 days								
Initial BW, kg	456	463	462	463	4.01	0.57	0.32	0.44
Final BW, kg	588	586	596	609	6.30	0.02	0.39	0.23
DMI, kg/day	9.50	11.12	9.99	11.72	0.32	0.11	0.0001	0.85
BW gain, kg/day	1.61	1.51	1.68	1.83	0.06	0.006	0.67	0.07
Gain:DMI, g/kg	169.44	136.15	168.48	156.81	4.82	0.05	0.0002	0.04

[a] Standard error of the mean calculated from analysis of variance using n = 6.
[b] Interaction of corn type x forage level.

Over the entire feeding period, average daily gain was greater (P = 0.006) for steers receiving HM corn when compared to those receiving CC. Additionally, there was an interaction (P = 0.04) for feed efficiency during this period. There was no difference (P > 0.1) in feed efficiency for steers fed HM corn, but feed efficiency decreased (P < 0.0001) for steers receiving CC + 15% AH compared to those receiving CC + 5% AH. From 0 to 56 days, there was an interaction (P ≤ 0.03) between corn type and forage level for average daily gain and feed efficiency. Specifically, this interaction (P = 0.01) was observed at days 29 to 56. Average daily gain (P = 0.04) and feed efficiency (P = 0.0002) were lower for steers fed CC + 15% AH compared to those fed CC + 5% AH; however, both average daily gain and feed efficiency were unaffected by dietary forage level for steers fed HM corn. These decreases in average daily gain and feed efficiency for steers fed this diet are likely reflective of two compounding factors: 1) increased passage rate due to the higher inclusion level of forage and 2) physical limitations for the digestion of CC; i.e., decreased susceptibility to digestive enzymes. If the ruminal digestion of CC is lower and passage rate of the diet is increased, decreased average daily gains would be expected compared to steers fed CC plus a lower level of forage. Conversely, because HM corn is rapidly degraded, increased passage rate would have less of an impact on digestion. Because of the decrease in average daily gain and increase in dry matter intake, feed efficiency was lower as well. Other than the increase in DMI due to forage in the 57- to 84-day period, there were no effects on growth performance during this time. However, there was a tendency (P = 0.08) for average daily gain to be greater for steers fed HM corn compared to those fed CC.

Microbial Shedding

Fecal pH and microbial enumeration data are summarized in Table 3. Fecal pH was lower (P = 0.04) when steers received either of the CC diets compared to those receiving the high-moisture diets. Because HM corn is highly fermentable in the rumen, a significant amount of starch would not be expected to reach the large intestine for fermentation. However, research shows that CC is not as fermentable in the rumen, and a large amount of starch escapes to the intestines intact. Of the starch presented to the small intestine, about 82% is digested. Therefore, of the starch escaping the rumen, about 20% has the potential to be fermented in the large intestine. This fermentation would reduce the pH in the large intestine, conceivably creating an environment for acid-resistant bacteria to proliferate. When total coliforms and total *E. coli* were enumerated, no differences between diets were seen. These results are consistent with previous research showing no differences in total coliform and *E. coli* shedding with postruminal carbohydrate infusions. Our findings that increased dietary forage levels did not affect microbial shedding are inconsistent with other reports in the literature that have demonstrated that higher forage levels decrease microbial shedding. However, the forage levels used in this experiment are considerably lower than those that have been shown to alter microbial shedding.

Table 3. Effects of corn type and forage level on fecal pH, total coliforms, and total *E. coli* in finishing beef steers.

	Cracked Corn		High-Moisture Corn			P <		
Item	**5% AH**	**15% AH**	**5% AH**	**15% AH**	**SEM[a]**	**Corn**	**Forage**	**X[b]**
Day of slaughter								
Fecal pH	6.35	6.50	6.57	6.71	0.10	0.04	0.14	0.94
Total coliforms, $\log_{10}$ CFU/g dry feces	33.08	32.93	34.11	31.43	2.06	0.91	0.47	0.52
Total *E. coli*, $\log_{10}$ CFU/g dry feces	32.79	32.66	33.69	31.20	2.02	0.88	0.50	0.54

[a] Standard error of the mean calculated from analysis of variance using n = 6.
[b] Interaction of corn type x forage level.

Effect of Brahman Influence on Cattle Grazing Fescue Pastures

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Summary

Cows in this trial did not have markedly different (P < 0.10) pregnancy rates when grazing either low or high endophyte fescue pastures. Cows with 3/8 Brahman breeding calved later on high endophyte fescue than those with no Brahman breeding. However, when weaning weights were adjusted for age, calves from 3/8 Brahman cows on high endophyte fescue were heavier (P < 0.10) than those from 0 Brahman cows on high endophyte fescue. Overall, calves from cows on low endophyte pasture weaned heavier (P < 0.01) calves than those on high endophyte pasture.

Carcass traits were similar and acceptable for all steer calves regardless of Brahman breeding, with 3/16 Brahman calves tending to have greater (P < 0.10) carcass quality grades. Net income was greatest for 3/16 Brahman steers due to their lower valuation as feeder calves, indicating that retaining ownership can be a viable option for producers of calves with some Brahman breeding.

Introduction

Fescue pastures are the predominant source of grazing for beef cattle in Kentucky and the southeastern United States. Although tall fescue has many desirable agronomic traits, endophyte-infected fescue has been shown to reduce cow reproductive performance and weaning weight of calves. The endophyte also causes the production of several alkaloids that are considered to be causative factors in "fescue toxicosis." The symptoms of fescue toxicosis in livestock include heat intolerance, rough hair coats, elevated body temperature, reduced performance, and altered hormone concentrations. Since the majority of fescue pastures are endophyte-infected, tolerance to the effects of the endophyte would be a desirable trait in beef cattle. Brahman cattle have more heat tolerance and, therefore, might be more tolerant to the negative effects of high-endophyte fescue.

The objective of this study was to evaluate the effects of Brahman breeding on performance of cows and calves grazing high or low endophyte fescue pastures. Steer calves with varying percentages of Brahman breeding were finished in a commercial Midwestern feedlot to study their performance and carcass traits.

Procedures

Forty-five Angus-based beef cows with varying amounts of Brahman-breeding (0, 3/16, or 3/8) were randomly assigned to either high (> 95%) or low (< 5%) endophyte-infected tall fescue pastures in a three-year study at the University of Kentucky West Kentucky Research and Education Center at Princeton. These cows were bred to one of two Hereford bulls that were rotated between pastures at weekly intervals during a 70-day (May 15 to July 25) breeding season.

Pregnancy rates and calving dates of cows were obtained. Birth weight, body weight in mid-July, actual weaning weight, and adjusted 205-day weaning weight of calves were measured. Feedlot performance, carcass traits, and economic returns of steer calves from this study were also studied. The study was conducted between 1998 and 2001.

Results and Discussion

Pregnancy rate of cows and growth data for suckling calves are shown in Table 1. Although pregnancy rates were not different (P < 0.10) among treatments, cows on low endophyte fescue pastures tended to have more favorable pregnancy rates. Cows that were 3/8 Brahman calved about two weeks later (P < 0.01) than those with no Brahman breeding. Calves with no Brahman breeding and grazing on low endophyte fescue were heaviest (P < 0.05) in mid-July. Endophyte level had a significant (P < 0.01) effect on both actual and adjusted weaning weight, with calves on high endophyte pastures having depressed weaning

Table 1. Least square means for effects of Brahman influence on performance of Angus-based cows and their Hereford-sired calves grazing high or low endophyte fescue (three years).

	Endophyte Level:	Low			High			
Item	**Brahman Level:**	**0**	**3/16**	**3/8**	**0**	**3/16**	**3/8**	**Effect**
Observations (cow-calf pairs x yrs.)		23	23	20	19	14	17	
Average cow weight, lb (at start of breeding)		1243	1299	1322	1261	1294	1306	
Pregnancy rate, %		92.6	91.5	100	90.5	85.7	89.7	Endophyte N.S.; Breed N.S.
Calf Data								
Average birthdate:	Julian	65.8^{a}	71.0^{ab}	71.8^{ab}	63.6^{a}	69.7^{ab}	78.6^{b}	
	(calendar)	(Mar. 7)	(Mar. 12)	(Mar. 13)	(Mar. 5)	(Mar. 11)	(Mar. 20)	
Mid-July weight, lb		428.3^{c}	403.2^{cd}	395.2^{d}	383.3^{d}	378.0^{d}	364.2^{d}	Year P < 0.01
Actual weaning weight, lb		568.1^{a}	552.2^{ab}	546.4^{ab}	489.1^{b}	487.6^{b}	499.3^{b}	Endophyte P < 0.01
Adjusted 205-day weight, lb		577.1^{a}	574.4^{a}	569.2^{a}	499.2^{b*}	512.5^{b}	533.9^{b*}	Endophyte P < 0.01

^{a,b} Means on the same line with different superscripts differ (P < 0.01).
^{c,d} Means on the same line with different superscripts differ (P < 0.05).
* Means on the same line are different (P < 0.10).

weights. However, among calves from cows grazing high endophyte, heavier (P < 0.10) adjusted 205-day weaning weights were observed when their dams were of 3/8 Brahman breeding versus no Brahman breeding. This difference was not apparent in actual weaning weights since those calves were two weeks younger at weaning time.

Feedlot performance and carcass traits of steers produced in this trial are shown in Table 2. Steers were sent to a Kansas feedlot (FACTS program) for finishing and marketing. Calves were of 0, 3/32, or 3/16 Brahman breeding and produced acceptable carcasses with favorable performance. Calves with Brahman breeding tended to be heavier at slaughter and tended to have greater carcass weights when slaughtered at 0.4 inches of backfat. Calves of 3/16 Brahman breeding had higher (P < 0.10) carcass quality grades with a significant (P < 0.05) year effect that accounted for this difference. Cost of gain was similar for all treatment groups, but calves with 3/16 Brahman breeding netted about $15 per head more due mainly to being valued lower as feeder calves in Kentucky.

Table 2. Least square means for feedlot performance and carcass traits of Hereford-sired steers (three years).

	Brahman Breeding			
Item	**0**	**3/32**	**3/16**	**Effect**
Steers, no.	16	13	16	
Days on feed	144	166	158	
Average daily gain, lb	3.32	3.29	3.33	
Feed efficiency	5.5	5.5	5.4	
Live harvest weight, lb	1071.6	1140.6	1108.9	
Hot carcass weight, lb	679.3	714.3	700.8	
Dressing percentage	63.5	62.6	63.1	
Fat thickness, inches	0.44	0.43	0.39	
Ribeye area, in^2	12.4	12.5	12.5	
Yield grade	2.78	2.80	2.67	
Quality grade[a]	2.30[bc]	2.27[b]	2.56[c]	Year effect P < 0.05)
Total cost of gain, ¢/lb	44.7	44.6	43.1	
Net income, $/hd[d]	80.77	79.91	94.87	

[a] 1 = Standard; 2 = Select; 3 = Choice; 4 = Prime.
[b,c] Means on the same line with different superscripts are different (P < 0.10).
[d] Slaughter value minus feeder calf value and all feedlot costs.

Effect of Increasing Level of Soybean Hulls on Intake and Utilization of Endophyte-Infected Fescue Hay by Beef Steers

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Summary

Twenty ruminally cannulated crossbred steers were used in an experiment to determine effects of increasing levels of supplemental soybean hulls on intake and utilization of a moderate-quality endophyte-infected fescue hay. Steers received either no supplement or soybean hulls fed at 0.32, 0.64, 0.96, or 1.28% of body weight (dry matter [DM] basis). Increasing levels of supplemental soybean hulls led to increases in organic matter digestibility, liquid dilution rate, and digestible organic matter intake, with very modest shifts in ruminal fermentation. Results suggest that increasing the amount of soybean hulls offered to growing stocker cattle would result in linear increases in growth. Additionally, estimates based on this data suggest that partial conversion efficiencies of 6 kg supplement per kg additional gain are possible with soybean hulls. Furthermore, the effects of supplementation on forage intake were accurately predicted by previously published models based on forage and supplement composition.

Introduction

High-fiber energy supplements, such as soybean hulls, may provide a means of supplementing forages without incurring depressions in forage digestibility that occur when low-fiber, highly fermentable concentrates like corn are added to forage diets. Previous research from our group has demonstrated that when soybean hulls were used as a supplement for tall fescue hay, digestible organic matter intake (including that from the forage and the supplement) was greater than when corn was used as a supplement, regardless of forage quality. However, most previous work with soybean hulls as a forage supplement has been conducted using single levels of soybean hulls. The few previous studies that have evaluated effects of increasing levels of soybean hulls on forage utilization either have increased soybean hulls at the expense of other supplemented feeds or been conducted at restricted levels of intake, which eliminates effects of supplements on forage intake, and this is not applicable under grazing conditions. Thus, the effects of increasing the level of soybean hulls, as the sole supplemental energy/protein source, on intake and digestibility in cattle allowed *ad libitum* access to forage, remain unclear. Previous studies with grain-based supplements have shown little effect on forage intake with low levels of supplementation, whereas increasing levels of supplement generally substitute for forage intake.

The objectives of this study were to quantify changes in intake and digestibility with increasing levels of supplemental soybean hulls and to measure associated changes in ruminal fermentation and kinetics.

Materials and Methods

Twenty ruminally cannulated crossbred steers initially averaging 476 kg body weight (BW) were used in a randomized complete block design. Steers received tall fescue (*Festuca arundinacea*) hay on an *ad libitum* basis and were randomly assigned within weight blocks to receive either no supplement or one of four levels of soybean hulls (SH). Treatments included the control (0 SH), and soybean hulls fed at 0.32% (0.32 SH), 0.64% (0.64 SH), 0.96% (0.96 SH), and 1.28% (1.28 SH) of BW (DM basis). Endophyte-infected tall fescue hay was offered at 130% of the previous five-day average intake. Chemical composition of the hay and soybean hulls is presented in Table 1. The steers were fed once daily at 0600, and all steers had continuous access to fresh water and consumed 40 g of a commercial mineral mix daily. The experiment consisted of 23 days: days 1 to 14 were an adaptation period to the experimental diets; days 15 to 21, total intake and fecal measurements; day 22, ruminal fluid sampling; and day 23, ruminal evacuations. Steers were housed in individual pens (3.0 x 3.7 m), and an average temperature of 20°C and a 16-hour light and 8-hour dark cycle were maintained throughout the experiment.

Table 1. Chemical composition of hay and soybean hulls, % of DM.

	Tall Fescue Hay	Soybean Hulls
Organic matter	91.8	94.6
Crude protein	14.1	18.8
Neutral detergent fiber	68.0	56.7
Acid detergent fiber	34.9	40.5
Acid detergent lignin	5.6	1.6
Ergovaline, ppb	193	-

Daily hay, soybean hull, ort, and fecal samples were dried at 55°C in a forced-air oven before being ground in a Wiley mill to pass through a 1-mm screen and then composited within period. The supplement and hay samples were analyzed for dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF); the ort samples for DM, OM, CP, and NDF; and the fecal samples for DM, OM, and NDF.

For measurement of liquid dilution rate, each steer was dosed intraruminally with a liquid phase marker (Cr: EDTA) prior to feeding on day 22. Using a suction strainer, ruminal fluid samples were taken from the ventral rumen prior to dosing and at 5, 8, 11, 14, and 24 hours after dosing. Ruminal fluid samples were analyzed for pH, as well as NH_3, volatile fatty acids (VFA), and Cr concentrations. Ruminal contents were manually removed, weighed, and sampled on day 23, prior to (0 hour) and 6 hours after feeding, to correspond with estimated (based on consumption patterns) times of minimal (0 hour) and maximal (6 hours) ruminal fill.

Statistical Analysis

Statistical analysis was performed using the MIXED procedure of SAS. The design was a randomized complete block, with block specified as a random effect and treatment as a fixed effect. Fermentation characteristics were analyzed as repeated measures. The error covariance of repeated measures was modeled with an autoregressive correlation structure. Treatment means were separated by using linear, quadratic, and cubic contrasts.

Results and Discussion

The tall fescue hay used in this experiment was a moderate quality hay (14.1% CP; 68.0% NDF; Table 1). Previous studies from our tall fescue research pastures indicate that fertilized, summer-grazed tall fescue selected by grazing cattle will typically contain at least 14% CP. However, compared with our previous studies, the hay fed in the current study also contained relatively high concentrations of ergovaline, a compound produced by the endophytic fungus *Neotyphodium coenophialum*, which is generally associated with fescue toxicosis. The CP content of the soybean hulls used in this experiment was higher than expected and atypical from most literature reports. High CP concentrations occasionally occur with soybean hulls as a result of soybean meal "contamination" arising from the soybean-crushing facility. However, because the forage contained more than 14% CP, it is unlikely that this excess CP had substantial effects on the primary response criteria in this study.

Voluntary intake of the forage (without supplement) was lower than we have seen previously with similar quality forage. However, this hay also contained relatively high concentrations of ergovaline, which is often associated with decreased forage intake. Additionally, it appears that the relative effects of supplementation measured in this experiment were not biased by the presence of ergovaline, as the effects on intake and digestion are in agreement with previous studies.

Total OM intake increased linearly ($P < 0.01$), whereas voluntary forage OM intake decreased linearly ($P < 0.01$) with increasing levels of soybean hull supplementation (Table 2), resulting in a substitution coefficient (change in hay intake per unit change in supplement intake) of -0.48. These results agree with previous studies in which we fed soybean hulls at 0.67% of BW (DM basis). Using input values for basal forage intake and composition from the present study, a prediction model

Table 2. Effect of increasing level of soybean hulls on intake and digestibility.

	Soybean Hulls, % of BW (DM Basis)						Probability[a]		
Item	0.00	0.32	0.64	0.96	1.28	SEM[b]	L	Q	C
Organic matter intake									
Total	1.55	1.75	1.94	2.01	2.22	0.13	< 0.01	0.81	0.69
Soybean hulls	0.00	0.30	0.60	0.90	1.20	-	-	-	-
Forage	1.55	1.45	1.33	1.11	1.02	0.13	< 0.01	0.83	0.67
Digestible OM	0.98	1.14	1.31	1.40	1.54	0.08	< 0.01	0.67	0.89
OM digestibility, %	63.8	65.0	67.8	69.5	69.3	0.09	< 0.01	0.24	0.22
NDF digestibility, %	67.6	66.7	69.2	69.6	69.0	1.13	0.14	0.71	0.24

[a] Probability of linear (L), quadratic (Q), and cubic (C) responses to increasing level of soybean hulls.
[b] SEM = standard error of the mean (n = 4).

published by J. E. Moore and co-workers at the University of Florida predicted decreases in forage intake of 0.19, 0.26, 0.38, and 0.58% of BW with each of the incremental levels of SH, compared with observed values of 0.10, 0.22, 0.44, and 0.53% of BW. Thus, this prediction model appeared to provide reasonable estimates of the effect of supplementation on forage intake, with the difference between actual and predicted values falling between 3 and 7% of the average forage intake.

There was a linear increase ($P < 0.01$) in OM digestibility with increasing level of supplementation. Consequently, digestible OM intake (DOMI) increased linearly ($P < 0.01$) with increasing levels of soybean hull supplementation. In our earlier work, we found a significant increase in DOMI with supplementation of soybean hulls when compared to no supplementation (control) and supplementation with corn (both supplements were fed at 0.67% of BW on a DM basis). Digestible OM intakes serve as a reliable estimate of digestible energy (DE) intake with these diets. Thus, we would expect cattle consuming greater levels of soybean hulls to have proportional increases in DE intake, and, ultimately, in growth. No effects were observed for NDF digestibility. We can infer from this that the digestibility of the fiber in the soybean hulls was similar to that of the fiber from the forage in this study.

Using the intakes and digestibilities from this experiment, we used the NRC Nutrient Requirements of Beef Cattle software to estimate effects on gains of 300 kg steers. Results from this analysis suggested that, with the relatively low intakes in this study, presumably a result of ergovaline effects, gains would be anticipated to increase linearly from 0.21 kg/day with no supplement to 0.89 kg/day with the highest level of supplement. The highest level of supplement, when expressed on an as-fed basis, would correspond to about 4.3 kg soybean hulls/day for a 300 kg steer. These calculations suggest that partial conversion efficiencies (kg of supplement required for each kg of additional gain) would be on the order of 6.0. Previous studies at the University of Kentucky have demonstrated that partial conversion efficiencies of this magnitude do occur with soybean hull supplementation, although typically we have observed less efficient conversions, averaging between 8 and 10 kg supplement per kg additional gain.

Liquid dilution rate increased linearly (Table 3) with increasing level of soybean hull supplementation. This is in agreement with the increased voluntary intakes with higher levels of supplementation. Generally, there is a positive correlation between the rate of liquid escape from the rumen and the rate of escape of unfermented particles. Also, increasing the rate at which digesta move through the gastrointestinal tract is typically associated with increased intake.

There was a significant treatment x sampling time interaction for ruminal pH (Figure 1). The 1.28 SH treatment resulted in the lowest pH (pH 6) at 11 hours after feeding. However, ruminal pH did not drop below 6.0 for any of the treatments. Typically, decreases below pH 6.0 can result in a reduction of fiber degradation. Thus, we would not expect that acid production in the rumen was sufficient for large depressions in digestion of the basal forage.

There was also a treatment x time ($P < 0.01$) interaction for ruminal ammonia concentration (Figure 2). Maximal ruminal ammonia concentrations for 0 SH, 0.32 SH, 0.64 SH, and 0.96 SH were detected at 5 hours after feeding. Ruminal ammonia concentration for the 1.28 SH peaked 24 hours after feeding. Across sampling times, ruminal ammonia concentrations averaged 4.9 m*M* for 0 SH, 5.4 m*M* for 0.32 SH, 5.0 m*M* for 0.64 SH, 5.9 m*M* for 0.96 SH, and 5.1 m*M* for 1.28 SH. Others have found lower ruminal ammonia concentrations with increasing level of soybean hulls in the diet. The effect on ruminal NH_3-N concentrations is partly a function of the degradable protein:energy ratio in the supplement relative to that in the basal forage. Since our soybean hulls were unusually high in CP (18.8%), excess protein was available for deamination by ruminal microorganisms. Based on studies evaluating the effects of ruminal NH_3 on fiber digestion, it is possible that NH_3 concentrations limited fiber digestion, at

Figure 1. Ruminal pH of steers fed 0 SH, 0.32 SH, 0.64 SH, 0.96 SH, and 1.28 SH. Sampling time x treatment ($P < 0.01$). L = linear ($P < 0.01$) effect of increasing level of soybean hulls within a given sampling time.

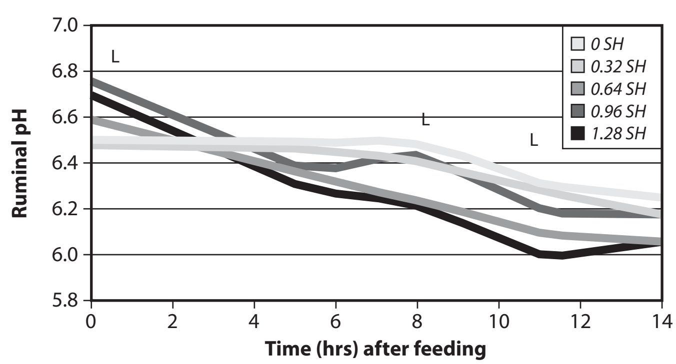
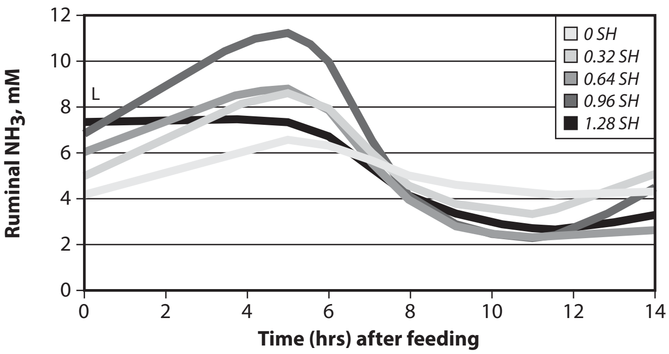


Table 3. Ruminal fermentation characteristics and liquid dilution rates of steers fed increasing levels of soybean hulls.

	Soybean Hulls, DM Basis (% of BW)						Probability[a]		
Item	**0.00**	**0.32**	**0.64**	**0.96**	**1.28**	**SE[b]**	**L**	**Q**	**C**
Liquid dilution rate, %/h	9.40	9.96	10.60	11.71	12.28	0.88	0.02	0.87	0.83
Ruminal pH	6.40	6.36	6.26	6.38	6.25	0.07	0.23	0.87	0.37
Total VFA, mM	109.09	117.23	123.57	116.37	128.40	5.13	0.03	0.77	0.21
Acetate:Propionate	3.87	3.94	3.88	3.72	3.62	0.08	0.01	0.15	0.42
				mol/100 mol					
Acetate	71.19	70.29	70.55	69.33	69.00	0.44	< 0.01	0.84	0.85
Propionate	18.42	17.87	18.25	18.67	19.12	0.32	0.04	0.10	0.39
Butyrate	8.10	9.20	8.80	9.00	9.00	0.46	0.23	0.38	0.39
Isobutyrate	0.74	0.81	0.73	0.94	0.82	0.06	0.12	0.68	0.29
Valerate	0.81	0.85	0.86	0.96	0.96	0.03	< 0.01	0.95	0.39
Isovalerate	0.79	1.00	0.84	1.10	1.10	0.07	0.01	0.79	0.54

[a] Probability of linear (L), quadratic (Q), and cubic (C) responses to increasing level of soybean hulls.
[b] SEM = Standard error of the mean (n = 4).

Figure 2. Ruminal ammonia concentration of steers fed 0 SH, 0.32 SH, 0.64 SH, 0.96 SH, and 1.28 SH. Sampling time x treatment interaction ($P < 0.01$). L = linear ($P < 0.01$) effect of increasing level of soybean hulls within a given sampling time. Q = quadratic ($P < 0.01$) effect of increasing level of soybean hulls within a given sampling time.



least during part of each day, despite the comparatively high protein content of our soybean hulls.

There was an increase in total VFA production with increasing levels of soybean hulls, in agreement with the observed increases in OMD and DOMI. Molar proportions of acetate decreased (linear; $P < 0.01$) and molar proportions of propionate increased ($P < 0.06$) with increasing soybean hulls resulting in a linear ($P = 0.01$) decrease in acetate:propionate ratio. Although statistically significant, these changes were very subtle, as were shifts in proportions of the minor VFA, valerate and isovalerate.

Implications

Supplementation with soybean hulls at levels up to 1.28% of body weight (DM basis) led to increases in organic matter digestibility, liquid dilution rate, and digestible organic matter intake, with very modest shifts in ruminal fermentation. This suggests that increasing the amount of soybean hulls offered to growing stocker cattle would result in linear increases in growth. Estimates based on data generated in the present study suggest that partial conversion efficiencies of 6 kg supplement per kg additional gain are possible with soybean hulls. Additionally, the effects of supplementation on forage intake were accurately predicted by previously published models based on forage and supplement composition.

Soyhull-Based Supplements for Weaned Calves on Hay Diets

Roy Burris, Jim Randolph, Darrh Bullock, Les Anderson, and John Johns

Summary

Two trials were conducted with 108 weaned calves to compare various soyhulls-based supplements with conventional corn-based supplements (home-mixed or commercial) under conditions of restricted or *ad libitum* intake.

Soyhull-based supplements supported better rates of gain than the corn-based home-mixed supplements used in these trials. The soyhull supplements yielded more favorable feed costs per pound of gain than the commercial supplements.

Introduction

Retaining ownership of calves for a short, postweaning feeding period and participating in special programs like the Kentucky CPH45 feeder calf sales can provide an additional source of revenue for cattle producers. Weaned calves can make rapid gains during a 45-day postweaning feeding period. However, gains should be as economical as possible for maximum net returns.

By-product feeds can sometimes provide a cheaper source of nutrients than conventional feeds. Some by-product feeds may even elicit more desirable performance than traditional grain-based supplements. By-product commodities have potential as supplements for beef cattle on forage-based diets due to their lower starch content, moderate protein content, and/or lower costs.

Two trials were conducted to evaluate different supplements for postweaning beef calves with restricted or *ad libitum* intake. Supplements containing soyhulls with soybean meal, corn gluten feed, or MIX 30™ were compared to traditional corn/soybean meal supplements or a commercially available supplement.

Procedures

Trial 1

Forty-five steer calves averaging 517 pounds at weaning were used in a completely randomized design. Calves were allotted to one of three treatment groups, with each group consisting of three pens of five calves. Treatments were: (1) corn and soybean meal (C/SBM), (2) soyhulls and corn gluten feed (SH/CGF), or (3) a commercial pre-conditioning feed fed for 45 days. Supplements were formulated to be isonitrogenous to the commercial supplement (14% crude protein on a dry matter basis). Intake was kept equal across treatments by restricting intake of the SH/CGF and commercial treatments to that of calves consuming the C/SBM supplement.

Trial 2

Sixty-three calves (31 steers and 32 heifers) averaging 541 pounds were used in a complete randomized design. Calves were allotted to one of four treatment groups, with each group consisting of one pen of eight steers and one pen of eight heifers. Treatments were: (1) corn and soybean meal (C/SBM), (2) soyhulls and soybean meal (SH/SBM), (3) soyhulls and MIX 30™ (SH/MX30), or a commercial supplement (COMM) fed for 48 days. The C/SBM supplement was a 9:1 mixture; SH/SBM was a 9:1 mixture; SH/MX30 was fed separately with MIX 30™ provided in a tank with *ad libitum* intake. Large round bales of hay were also provided for all calves.

Statistical analyses of both trials was by the GLM procedure of SAS. Means were separated by LSD test.

Results and Discussion

Trial 1

Performance of weaned calves receiving three different supplements in equal amounts for 45 days is shown in Table 1. Supplemental feed intake was restricted to 10.4 lb/day for all treatments. Calves on all treatments had acceptable rates of gain. However, those on treatments SH/CGF or COMM had higher ($P < 0.05$) average daily gain (ADG) than those receiving C/SBM (3.08, 3.15, and 2.48 lb, respectively).

Calves fed SH/CGF consumed more hay, which was offered free-choice, than the other two corn-(starch-)based treatments. This indicates that these two highly digestible fiber-type feeds have a less negative effect on fiber intake than starch-based supplements, like corn.

Feed cost per pound of gain was 33, 27, and 45 cents for C/SBM, SH/CGF, and COMM, respectively, based on prices listed in Table 1. Prices for commercial supplements and commodity feeds can vary considerably, so price and availability in your area must be taken into account.

Table 1. Different feeding regimes for conditioning weaned calves (45 days postweaning).

	Feed		
	Corn/ SBM[1]	Soyhulls/Corn Gluten Feed[2]	Commercial[3]
Steer calves, no.	15	15	15
Pens	3	3	3
Calves/Pen	5	5	5
Suppl. intake, lb/day	10.4	10.4	10.4
Initial (weaning) weight, lb	517.4	515.9	516.5
Final weight, lb	628.1[a]	655.3[b]	658.3 [b]
Postweaning gain, lb	111.5 [a]	138.7 [b]	141.7 [b]
Postweaning ADG, lb	2.48 [a]	3.08 [b]	3.15 [b]
Hay intake, lb/day	11.8	15.1	11.5
Feed cost per lb of gain, ¢[4]	33	27	45

[1] Diet consisted of 88% corn and 12% soybean meal with hay *ad lib.*
[2] Diet consisted of 67% soyhulls and 33% corn gluten fed with hay *ad lib.*
[3] Diet consisted of a commercial pre-conditioning feed (14.6% CP) with hay *ad lib.*
[4] Feed costs based on corn—$2.50/bu; soybean meal—$200/T; soyhulls—$70/T; corn gluten feed—$120/T; commercial feed—$220/T; and hay—2.5 ¢/lb.
[a,b] Means on the same line with different superscripts differ ($P < 0.05$).

Trial 2

Performance of weaned calves receiving four different supplements *ad libitum* for 48 days postweaning is shown in Table 2. Supplemental feed intake was lowest for the C/SBM treatment and similar for the other three treatments.

Table 2. Different feeding regimes with *ad libitum* supplement intake for weaned calves (48 days).

	Feed			
Item	Corn/Soybean Meal (9:1)	Soyhulls/ Soybean Meal (9:1)	Soyhulls/ MIX 30™	Commercial
Calves, no.	16	15	16	16
Initial (weaning) weight, lb	558	527	549	531
Final weight, lb	674	693	699	694
Average daily gain, lb				
Days 1-20	1.75	4.60	3.68	3.96
Days 21-48	2.94	2.64	2.68	2.99
Overall	2.42	3.46	3.13	3.39
Average daily intake (supplement), lb				
Days 1-20	9.3	12.1	13.3	12.0
Days 21-48	15.0	20.9	20.6	22.1
Overall	12.8	17.4	17.8	18.1
Feed cost per lb of gain, ¢[a]	31.4	25.4	26.0	56.9

[a] Based on corn—$2.50/bu; soybean meal—$195/T; soyhulls—$75/T; commercial feed—$200/T; hay—$60/T and MIX 30™—$120/T (with 1.2 lb daily intake).

Average daily gain for calves on the C/SBM treatment tended to be lower than for those on the other three treatments, with most of that difference occurring in the first 20 days postweaning. These differences, although large in magnitude, were not significantly different ($P > 0.10$), probably due to the variation in the observed gain in the C/SBM group, which might indicate that some calves in this group had acidosis because of the high starch content of corn.

Feed costs per pound of gain were highest for calves fed the commercial supplement based on prices shown in Table 2. Feed costs for the C/SBM, SH/SBM, and SH/MX30 were lower and very favorable for retaining ownership.

Increasing Level of Soybean Hulls for Stocker Steers Grazing Endophyte-Infected Fescue

E.S. Vanzant

Summary

Growth studies were conducted across two grazing seasons with 250 kg stocker steers to evaluate the influence of increasing the level of soybean hull supplementation from 0 to 2.72 kg/day. Despite extreme differences in environmental conditions and subsequent effects on forage and cattle growth between the two years, the response to increasing level of soybean hulls was very consistent. On average, when fed up to 2.72 kg/day, each kg of additional soybean hulls resulted in 0.126 kg additional gain with stocker steers grazing endophyte-infected fescue pastures.

Introduction

Soybean hulls are commonly used to provide supplemental energy to cattle grazing summer forages. Previous work from our group has demonstrated that soybean hulls are slightly more efficient at promoting gain in grazing stocker cattle than corn, when supplemented at around 0.75% of body weight (equivalent of 1.9 kg of supplement for a 250 kg calf). However, little information exists to suggest whether the efficiency of supplement use is affected by the level of supplement fed. These experiments were conducted to evaluate the influence of increasing amounts of soybean hulls on growth of stocker steers grazing endophyte-infected fescue across two summer grazing seasons.

Procedures

Grazing studies were conducted on eight 3.04-ha (7.5-ac) endophyte-infected, tall fescue pastures at the University of Kentucky Woodford County Animal Research Center from May through September 2002 and from April through October 2003. In both experiments, 176 crossbred beef steers (average initial weight = 260 and 240 kg in years 1 and 2, respectively) were stratified by weight and randomly assigned to each of the eight experimental pastures. At the beginning of the study, steers were vaccinated against respiratory disease and clostridia, with booster vaccinations administered 28 days later. All steers were dewormed with Safeguard® on days 0, 28, and 56 of the grazing study. No implants were administered in the first year of the study. In 2003, all steers were implanted with a TBA/estradiol implant (Revalor G®) at the beginning of the grazing season .

Two pasture groups were randomly assigned to receive each of four supplement treatments for the entire grazing season. Treatments were different amounts of soybean hulls: 1) control, no supplement (0 SH); 2) 0.91 kg soybean hulls per steer daily (0.91 SH); 3) 1.81 kg soybean hulls per steer daily (1.81 SH); and 4) 2.72 kg soybean hulls per steer daily (2.72 SH). These treatments corresponded to supplement levels of approximately 0, 0.33, 0.67, and 1.00% of initial body weight, or 0, 0.28, 0.55, and 0.83% of average body weight (across entire grazing season). Supplements were group-fed in feed bunks each day at approximately 0700 to 0900.

Pastures were fertilized with 56 kg N/ha in March and were clipped once in June of each year at a height of approximately 20 cm to remove seed heads. Initial stocking densities were set at 1,940 and 1,830 kg live weight/ha (1,730 and 1,640 lb/ac) in each of the two years of the study. In order to match stocking rates with forage growth profiles across the summer, steers were removed part-way through the grazing season in each year. In the first year, the heaviest eight steers (averaging 347 kg) were removed from each pasture on July 23. At this time, each pasture was opened to allow steers access to an additional 3.04 ha, resulting in a late-season stocking rate of 725 kg live weight/ha (stocking rates represent steer weights at the beginning of each stocking phase). In the second year, steers were not allowed access to additional pasture, but the heaviest 11 steers (averaging 347 kg) were removed from each group, resulting in late-season stocking densities of 1,120 kg live weight/ha.

Steers had free-choice access to water and mineral supplement throughout the grazing seasons. Steers were weighed every 28 days, following an overnight stand without access to feed or water. Groups of steers were rotated, in a random order, among the eight pastures every 28 days.

Data were analyzed separately for each year using the MIXED procedure of SAS with a model appropriate for repeated measures within a completely randomized design. Pasture groups were designated as the experimental unit on which repeated measures were made. Treatment means were separated using orthogonal contrasts for linear, quadratic, and cubic effects of increasing level of soybean hulls.

Results and Discussion

Gains of grazing animals are heavily influenced by climatic conditions. Average monthly maximum and minimum temperatures and monthly rainfall totals for the duration of the two experiments are shown in Figure 1. The 2002 grazing season was particularly hot and dry. During the period of the experiment in 2002, rainfall measured at a weather station adjacent to the research pastures recorded rainfall of about 67% of the long-term central Kentucky average. Likewise, average temperatures in central Kentucky were about 2% over the long-term average in 2002. Conversely, 2003 was an exceptional year for forage production with adequate, timely rainfall across the growing season. These environmental conditions are reflected in the performance of the steers in the two years of the experiment (Figure 2). In 2002, steers that received no supplement averaged only 0.25 kg/day gain, whereas gains by unsupplemented steers averaged nearly 0.6 kg/day in 2003. Although forage availability was likely the predominant factor affecting these differences, another factor that likely contributed to the higher gains in 2003 was the fact that steers had received growth-promoting implants.

A time x treatment interaction was detected (P = 0.06) during the first year of the study (Figure 2), indicating that the response to increasing level of supplement was different among the various 28-day experimental periods. However, soybean hulls generally increased gains in all periods, with the differences occurring because of differences in the magnitude of the responses. No time x treatment interactions were detected (P = 0.13) in the second year. Additionally, short-term gains (i.e., 28-day period gains in this study) must be viewed with caution because small differences in gut fill can have substantial influence on these measures. Thus, despite the interaction in year 1, average responses across each year of the experiment (Figure 3) are a more meaningful, integrated measure of the response to supplementation. The gain response to supplement was very consistent between the two years of the study, despite large differences in the gain of the unsupplemented groups between years. Thus, despite the level of gain supported by the basal forage, we would expect that soybean hulls would provide a partial efficiency of about 12.6%, equivalent to about 7.9 kg of soybean hulls per kg of additional gain. This is a slightly more efficient conversion efficiency than we previously reported (9.5:1) with soybean hulls and slightly less efficient than predictions based on intake and digestibility responses (6.0:1) in another report in this publication. To meet the objectives of the previous growth studies, however, cattle were redistributed among treatment groups in each period of the study. Therefore, cattle did not receive the same supplement treatment across the entire grazing season. This would be expected to result in less efficient conversion because of the need for ruminal microorganisms to adapt to new dietary conditions with each diet shift. Thus, we would anticipate that partial conversion efficiencies of about 8:1 would be more typical for soybean hull supplementation up to 2.72 kg/day for 250 kg stocker steers grazing endophyte-infected fescue.

Figure 1. Precipitation and average monthly maximum and minimum temperatures at the University of Kentucky Animal Research Center in Woodford County, Kentucky, during each period of the experiment.

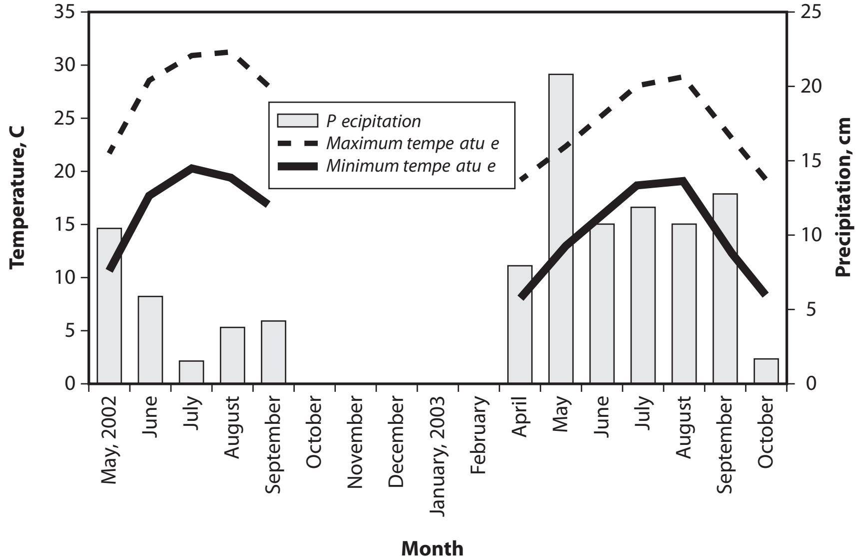
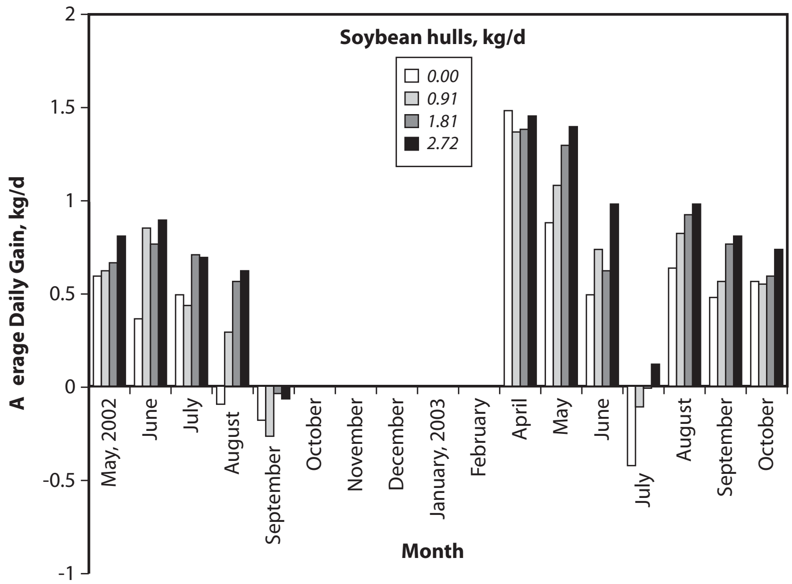


Figure 2. Average daily gain response to increasing level of soybean hulls within each experimental period across both years of the experiment.

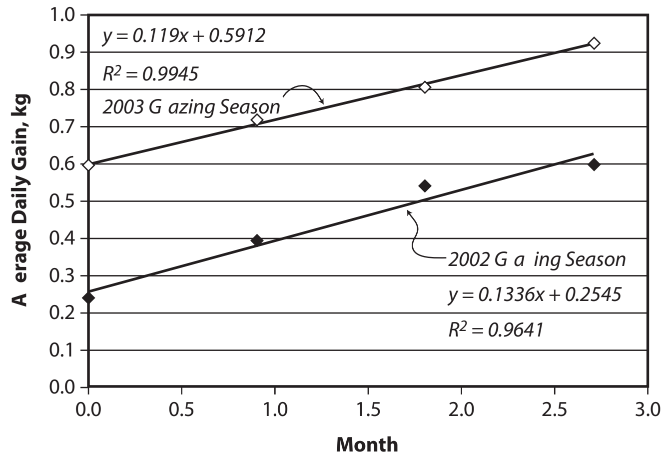


Because of the presence of time x treatment interactions, we conducted a more detailed analysis to determine if the response to increasing level of soybean hulls was related to the level of gain supported by the pastures within each period of the experiment. During each period of the experiment, we calculated the partial efficiency of soybean hull supplementation (i.e., slope of the response of average daily gain to increasing level of soybean hulls). This value was then regressed against the average gain of the control groups (unsupplemented) to identify relationships between unsupplemented gain and response to soybean hulls. A significant (P = 0.06) relationship was detected, although the relationship was weak; unsupplemented gain explained only 30% of the variation in partial efficiencies. Furthermore, this relationship appeared to be heavily influenced by a lack of response to supplement in April 2003 when unsupplemented gains were greater than at any other time during the study. Indeed, when this period was excluded from the analysis, partial efficiency was not related (P = 0.42) to unsupplemented gain. With very high forage quality, as would be observed with early spring grazing of fescue, less opportunity exists for response to supplemental feed. However, throughout most of the grazing season, the degree of response to increasing levels of soybean hulls appears to be independent of forage quality.

Implications

Results from this study suggest that up to 2.72 kg/day of soybean hulls, supplemented to stocker cattle grazing endophyte-infected fescue during the summer, should result in approximately 0.13 kg gain per kg of supplement. This linear response to supplement was consistent across two grazing seasons with very different climatic conditions and thus very different baseline steer growth rates. This partial conversion efficiency can be used by producers to calculate expected returns and determine practicality of soybean hull supplementation under a variety of economic conditions.

Figure 3. Average daily gain response to increasing level of soybean hulls within each year of the experiment.



Effect of Exogenous Amylase and Corn Type on Performance and Carcass Characteristics of Finishing Beef Heifers

K.C. Hanson, K.R. McLeod, Juan Tricario, and D.L. Harmon

Summary

Two experiments were conducted to evaluate the efficacy of feeding a fungal amylase preparation on the performance and metabolism of beef cattle fed high grain diets. Experiment 1 used 12 ruminally cannulated steers divided into one of three dietary treatments: 1) control, no enzyme; 2) 5 g/day amylase; or 3) 10 g/day amylase enzyme preparation. The diet consisted of a 50% concentrate (corn-based), 50% corn silage. There was no effect of exogenous amylase on daily dry matter intake (DMI), volatile fatty acids (VFA) proportions, total VFA concentrations, acetate:propionate, or ruminal pH. *In situ* starch disappearance was also unaffected by treatment. In Experiment 2, 96 crossbred heifers were fed finishing diets until slaughter to evaluate the effects of corn type and inclusion of an exogenous amylase preparation on animal performance and carcass characteristics. Animals were assigned randomly to one of six treatments in a completely randomized design with a 2 x 3 factorial arrangement of treatments. Factors were corn type (dry versus high moisture) and amount of exogenous amylase preparation (0, 7.5, or 15 g amylase/(heifer•d). During the first 28 days, supplementation of amylase resulted in a linear increase in average daily gain. However, this increase in gain was not observed during the remainder of the trial. The increased average daily gain during the first 28 days was largely the result of increased intake, as feed efficiency was not affected. The greatest longissimus area and lowest yield grades were observed in heifers receiving amylase at 7.5 g/(hd•d). These studies suggest that the amylase preparation used may be beneficial for starting calves on feed, but we saw no effects on fermentation or starch degradation that would suggest long-term benefits with addition to finishing diets.

Introduction

Most feed grains require some form of processing to break the seed coat and provide microbial access to stored starch granules. More extensive processing, such as steam flaking, can actually disrupt the starch granule and improve starch degradability. All processing methods are capital and energy intensive and increase production costs. If starch utilization could be maintained with minimal grain processing, it would represent a substantial savings in energy and equipment to beef producers. We hypothesized that by feeding additional starch-degrading enzymes in the diet, ruminal starch digestion could be improved, particularly for diets in which starch degradation is less extensive, like dry-rolled corn. Therefore, the objective of the following experiments was to determine the effects of adding exogenous amylase to the diet on ruminal fermentation, performance, and carcass characteristics in finishing beef cattle.

Materials and Methods

Experiment 1

Twelve ruminally cannulated steers (500 kg) were equally divided into one of three dietary treatments: 1) control, no enzyme; 2) 5 g/day amylase; or 3) 10 g/day amylase enzyme preparation. The diet consisted of a 50% concentrate (corn-based), 50% corn silage (Table 1). All animals were fed once daily at 0700 at a rate of 2.0% body weight/day. All enzyme preparations were weighed into capsules and dosed directly into the rumen at each feeding. Animals were adapted to their dietary treatments for seven days.

On day 8, blood samples were collected via jugular venipuncture two hours post-feeding and stored at -20°C until analyzed for nonesterified fatty acids (NEFA), ß-hydroxybutyrate, and glucose content. On day 9, ruminal fluid samples were collected at 0600 and every two hours

Table 1. Composition of diets (dry basis) fed to heifers evaluating effects of feeding amylase as a dietary supplement.

	Experiment 1	Experiment 2	
Ingredient	50:50 Diet	Cracked Corn[1]	High-Moisture Corn
Corn silage	50.00	15.00	15.00
Cracked corn	40.00	75.00	-
High-moisture corn	-	-	75.00
Ground corn	0.37	6.80	7.22
Soybean meal	7.83	-	-
Urea	-	0.66	0.24
Dyna-K	-	0.43	0.43
Limestone	1.17	1.46	1.46
Trace mineral salt[2]	0.30	0.30	0.30
Vitamin A, D, E[3]	0.02	0.02	0.02
Fat	0.30	0.30	0.30
Rumensin 80®[4]	-	0.01	0.01
Tylan 40®[5]	-	0.01	0.01
Melengesterol acetate	-	0.01	0.01

[1] Diets were 11.9, 11.4, and 11.6% crude protein on a dry matter basis for 50:50, cracked, and high-moisture corn diets, respectively.
[2] 98.5% NaCl, 0.35% Zn, 0.20% Fe, 0.20% Mn, 300 ppm Cu, 70 ppm I, 50 ppm Co, and 90 ppm Se.
[3] 8,800 IU/g vitamin A, 1,760 IU/g vitamin D, and 1.1 IU/g vitamin E.
[4] Added to supply 22 mg/kg of feed dry matter.
[5] Added to supply 6.6 mg/kg of feed dry matter.

thereafter for 12 hours. Samples were immediately analyzed for pH, and an aliquot was deproteinized with 25% *m*-phosphoric acid (1:5 acid:fluid) and frozen for further analysis of VFA concentrations. On day 11, *in situ* starch disappearance was determined. Corn samples ground to pass 2- and 4-mm screens were weighed into Dacron bags. Each steer received duplicate bags for each particle size and a blank bag (for a total of five bags) for each incubation time. Each set of five bags in each steer was incubated for 0, 1, 2, 4, 6, 9, and 12 hours. Bags were placed into each steer at the time of feeding. After removal from the rumen, bags were rinsed and dried at 60°C for 12 hours. Each bag was then analyzed enzymatically for starch content to determine starch disappearance.

Experiment 2

Ninety-six crossbred heifers (320 kg) were fed finishing diets based on corn, high-moisture corn, and corn silage until slaughter to evaluate the effects of corn type and inclusion of an exogenous amylase preparation on animal performance and carcass characteristics. Animals were stratified by weight and assigned randomly to one of six treatments (four heifers per pen, four pens per treatment) in a completely randomized design with a 2 x 3 factorial arrangement of treatments. Factors were corn type (dry versus high-moisture) and amount of exogenous amylase preparation (0, 7.5, or 15 g amylase/(heifer•day). This provided 0, 4500, and 9000 fungal α-amylase units per head per day, respectively. The final diets contained 15% corn silage, 75% corn, and 10% supplement (Table 1). Diets were formulated to be isonitrogenous (12.0% crude protein) and fed once daily as a completely mixed ration to achieve *ad libitum* intakes. Heifers were adjusted to the final diet over three weeks by varying the proportion of corn and corn silage in the diet. During week 1, they were fed 60% corn silage, 30% corn; during week 2, 45% corn silage 45% corn; and during week 3, 30% corn silage 60% corn (all on dry matter basis). All diets contained 10% supplement, and all experimental treatments started on day 1. From day 21 until the end of the trial, heifers consumed their respective experimental diets, containing 15% silage.

The exogenous amylase preparation was mixed with ground corn as a carrier, 5% wet molasses, and 5% dry molasses to make three premixes. The concentration of amylase in each premix was formulated to deliver 0, 7.5, or 15 g amylase preparation/(heifer•d) when 500 g of the premix was topdressed per pen. The premix was topdressed immediately after feed was delivered to the feed bunk.

Upon arrival, heifers were vaccinated with ViraShield 5 + Somnus (Novartis Animal Vaccines Inc., Overland Park, KS). Heifers were fed a receiving diet and adjusted to corn silage for approximately four weeks after arrival. Body temperatures were monitored and animals dosed with Nuflor and Banamine (Schering-Plough Animal Health, Union, NJ) when body temperatures exceeded 40°C upon arrival. Animals with persistent fevers (> 39.4°C) were later dosed with Micotil (Elanco Animal Health, Greenfield, IN). Starting one day prior to initiation of the trial, animals were weighed, dewormed with Safegard (medicated feed) for the control of internal parasites, implanted with a growth promotant (Revalor-IH, Intervet, Millsboro, DE), and randomly assigned to treatments.

Animals were weighed on days 1, 28, 56, and the day before slaughter. Initial weights were taken over two days and averaged, while final weights were based on hot carcass weight adjusted for a 62% dressing percentage. Based on animal weights, four groups of 24 heifers each were selected to be shipped to Cincinnati, Ohio, for slaughter on days 63, 70, 91, and 98 and held overnight prior to being slaughtered. Backfat measurements at the 12th rib were collected via ultrasound each day animals were weighed and used to estimate backfat accretion rate.

Total feed offered was measured daily. Supplement samples were collected for analysis after each new batch was mixed and composited. Feed refusals were collected from feed bunks every Tuesday before animals were fed. Orts from each bunk were weighed and a sample collected and composited within each treatment combination and analyzed for DM. Feed ingredients were analyzed for DM content and diets adjusted accordingly every Tuesday, to correspond with weigh days and collection of orts.

Data were analyzed as a completely randomized design using initial body weight as a covariant and with pen as the experimental unit. Treatment effects were partitioned into effects of amylase, corn type, and their interaction. Contrasts were used to determine linear and quadratic effects of amylase level.

Results and Discussion

Experiment 1

There was no effect of exogenous amylase on daily dry matter intake (Table 2). Treatment with exogenous amylase tended ($P < 0.07$) to have a quadratic effect on plasma nonesterified fatty acids and glucose concentrations, as concentrations of both were lowest for the 5 g/day treatment and highest for the 10 g/day treatment. There tended ($P < 0.09$) to be a linear effect on plasma ß-hydroxybutyrate concentrations as lowest concentrations were seen with the 10 g/day treatment (Table 2). Intraruminal dosing with exogenous amylase did not affect VFA proportions, total concentrations, acetate: propionate, or ruminal pH (Table 2). Additionally, *in situ* starch disappearance (Table 3) was also unaffected by treatment; however, there were differences between corn particle sizes (Table 4). The 2-mm screen size (finer grind) produced a faster rate of disappearance ($P < 0.05$), greater 12-hour disappearance ($P < 0.01$), and greater extent of disappearance ($P < 0.01$).

Experiment 2

There were no diet x amylase interactions for any variable measured. Additionally, corn type (dry versus high-moisture) had no effect on performance or carcass characteristics. Because of this, means were pooled across diets (Table 5), and the main effects of amylase are presented.

During the first 28 days, intake tended to be greater for both the 7.5 and 15 g/(hd•d) treatments (linear; $P < 0.07$) but was greatest for the 7.5 g/(hd•d) treatment (quadratic; $P < 0.06$). This increased intake during the first 28 days resulted in a linear ($P < 0.05$) increase in average daily gain (Table 5). This increased average daily gain tended to be quadratic ($P < 0.07$), as gain for heifers receiving 7.5 g/(hd•d) tended to be higher. Feed efficiency during the first 28 days was not affected by treatment.

During days 29 to 56, intake again tended to increase with 7.5 g/(hd•d) amylase supplementation (quadratic; $P < 0.10$). There was no effect of amylase supplementation on gain; however, there tended to be a quadratic decrease in gain:feed for the 7.5 g/(hd•d) treatment ($P < 0.09$).

Throughout the entire trial, heifers receiving 7.5 g/(hd•d) tended ($P < 0.07$) to consume more feed than those receiving either 0 or 15 g/(hd•d) of the amylase preparation. Gain was not affected by treatment, resulting in a tendency ($P < 0.08$) for lower gain:feed with the 7.5 g/(hd•d) amylase supplementation.

Dressing percentage, kidney-pelvic-heart (KPH) fat, and degree of marbling were not affected by treatment. Fat thickness at the 12th rib tended ($P < 0.10$) to increase linearly with amylase concentration. Amylase treatment resulted in a quadratic effect ($P < 0.05$) on longissimus area and yield grade. The greatest longissimus area and lowest yield grades were observed in heifers receiving amylase at 7.5 g/(hd•d). The rate of backfat accretion based on ultrasound measurements tended ($P < 0.10$) to have a quadratic effect with amylase supplementation. Heifers receiving 7.5 g/(hd•d) accrued backfat slowest, while those receiving 15 g/(hd•d) accrued backfat fastest. Heifers receiving 7.5 g/(hd•d) had the slowest accretion of backfat, while those receiving 15 g/(hd•d) had the fastest accretion of backfat.

Table 2. Effect of supplemental fungal amylase on intake, blood, and ruminal metabolites in steers.

Item	0 g/day	7.5 g/day	15 g/day	SEM	Linear	Quadratic
Dry matter intake, kg/day	8.45	8.81	8.34	0.41		
Nonesterified fatty acids, µM	140.8	108.6	194.9	23.8	0.142	0.072
Glucose, mg/dL	73.1	67.8	80.9	3.65	0.166	0.069
ß-hydroxybutyrate, mM	0.601	0.621	0.397	0.075	0.087	0.217
		mol/100 mol				
Acetate	60.74	64.42	59.77	2.64	0.802	0.230
Propionate	22.18	17.70	22.10	2.83	0.984	0.232
Isobutyrate	1.07	0.92	1.13	0.10	0.646	0.161
Butyrate	12.36	14.06	13.33	1.66	0.691	0.566
Isovalerate	2.39	1.74	2.21	0.31	0.694	0.177
Valerate	1.27	1.17	1.46	0.10	0.214	0.158
Total VFA, mM	109.85	120.27	116.17	5.29	0.420	0.292
Acetate:Propionate	2.96	3.98	3.06	0.62	0.912	0.238
Ruminal pH	6.11	5.97	5.93	0.14	0.384	0.773

Table 3. *In situ* starch disappearance in steers fed exogenous amylase.

	Amylase, g/day					
Item	**0**	**5**	**10**	**SEM**	**Linear**	**Quadratic**
Rate of disappearance, %/h	4.10	4.25	3.83	0.349	0.593	0.511
12-hour extent of disappearance, %	46.81	48.29	47.35	1.983	0.851	0.623
Extent of disappearance, %	56.31	58.19	55.30	1.791	0.697	0.291

Table 4. Effect of grind size on *in situ* starch disappearance in steers fed exogenous amylase.

Item	2 mm	4 mm	SEM	P-value
Rate of disappearance, %/h	4.59	3.54	0.285	0.0183
12-hour extent of disappearance, %	52.06	42.91	1.619	0.0008
Extent of disappearance, %	60.11	53.09	1.463	0.0033

Implications

Based on the results of this trial, inclusion of an exogenous amylase preparation at 0, 7.5, or 15 g/(hd•d) in the diet of finishing beef heifers elicited a quadratic response in several performance and carcass characteristics. The animals supplemented with 7.5 g/(hd•d) consumed more feed, particularly early in the feeding period. The increased feed intake was associated with less desirable feed efficiencies. No response was seen in ruminal fermentation that would support an advantage to an amylase preparation on diets such as these. However, increased feed intake could be beneficial for newly received or stressed cattle.

Table 5. Growth performance and carcass characteristics of finishing heifers fed three concentrations of an amylase preparation.

	Amylase Treatment				P <	
Item	0 g/day	7.5 g/day	15 g/day	SEM	Linear	Quadratic
Days 1-28						
DMI, kg/day	8.05	9.03	8.73	0.254	0.074	0.054
ADG, kg/day	1.98	2.30	2.23	0.08	0.047	0.066
Gain:Feed	0.247	0.254	0.255	0.007	0.417	0.730
Days 29-56						
DMI, kg/day	9.67	10.61	9.85	0.385	0.748	0.091
ADG, kg/day	2.02	1.93	1.94	0.092	0.552	0.629
Gain:Feed	0.211	0.183	0.199	0.010	0.404	0.083
Days 1-80$_{average}$						
DMI, kg/day	9.15	10.06	9.55	0.301	0.357	0.070
ADG, kg/day	1.95	1.98	2.01	0.043	0.341	0.981
Gain:Feed	0.213	0.198	0.211	0.006	0.852	0.077
Carcass Characteristics						
Dressing %	57.18	58.10	57.83	0.523	0.392	0.364
Fat thickness, cm	0.77	0.73	0.88	0.035	0.096	0.125
Kidney, pelvic, heart fat, %	2.58	2.50	2.64	0.128	0.792	0.490
Longissimus area, cm^2	80.04	85.06	78.94	2.151	0.728	0.049
Marbling score[a]	2.95	2.92	2.99	0.153	0.869	0.809
Yield grade	2.28	2.06	2.51	0.118	0.184	0.032
Rate of backfat accretion, mm/day	0.046	0.044	0.052	0.003	0.101	0.094

[a] 1.00 = trace^{00}, 2.00 = slight^{00}, 3.00 = small^{00}, 4.00 = modest^{00}.

Influence of Bufferfos® on the Ruminal Environment of Steers Fed High-Grain Diets

K.C. Hanson, S.E. Kitts, D.L. Harmon, and D.E. Axe

Summary

Bufferfos® is a new mineral aggregate that could be used to improve the ruminal environment in animals fed large amounts of grain. To determine its efficacy, 12 ruminally cannulated steers were fed a high concentrate diet for 14 days with and without Bufferfos. On day 14, the dry-rolled corn was replaced by high-moisture corn to challenge the ruminal environment. Bufferfos did elevate ruminal pH throughout the study; however, it tended to depress intake, particularly early in the feeding period. Patterns of volatile fatty acids were largely unaffected, suggesting little or no effect on fermentation. Bufferfos may be beneficial in situations where intake moderation is needed, such as adapting cattle to high-concentrate diets or with the use of self feeders.

Introduction

Bufferfos is a new mineral aggregate developed (IMC Global, Lake Forest, IL) for potential use as a feed additive for livestock. Ruminants fed high quantities of starch produce tremendous quantities of acid in the rumen. Buffering compounds are often added to the diet to aid in dealing with this acid load and thereby improve feed intake and overall production. Because of its high phosphate content, Bufferfos should possess the ability to positively influence the ruminal environment while supplying needed phosphorus in the diet. Therefore, the objective of the present study was to determine the biological efficacy of Bufferfos for improving the ruminal environment of grain-fed cattle.

Procedures

Twelve ruminally cannulated steers (400 kg) were housed in individual stalls in an environmentally controlled room and adapted to a high-concentrate diet for two weeks. The diet was 50% dry-rolled corn, 50% corn silage (dry matter basis). All supplemental nitrogen was from soybean meal. Six steers received the control diet, and six received the control diet with 1% (dry basis) added Bufferfos (Table 1). Bufferfos was added immediately prior to feeding and mixed to prevent segregation at feeding. Feed was offered *ad libitum*. A single sample of rumen fluid was collected daily, four hours post-feeding, during this 14-day adaptation period. On day 14 of the study, rumen samples were collected throughout the day to monitor the ruminal environment. On the morning of the sampling day, the dry-rolled corn was replaced by high-moisture corn. This was done to represent a greater challenge to the control of the ruminal environment. High-moisture corn is more fermentable, and an abrupt switch such as this should result in an increased acid load. Samples of ruminal fluid were then collected two hours pre-feeding (prior to the switch) and at 0, 2, 4, 6, 8, 10, and 12 hours post-feeding on day 14 for analysis of pH and ruminal VFA concentrations.

Results

Dry matter intake tended to be lower ($P < 0.10$) for steers fed Bufferfos over the entire two-week feeding period (Table 2). However, on the day of the high-moisture corn challenge, intakes were equal for the two treatments. Ruminal pH in steers fed Bufferfos was higher ($P < 0.06$) for the once-daily samples, higher for the final seven days of the pre-feeding period ($P < 0.08$) and tended ($P < 0.20$) to be higher for the high-moisture corn challenge day. Data in Tables 3 and 4 contain means from the samples collected daily (Table 3) or means from ruminal fluid collected bi-hourly during the high-moisture corn challenge day. While there were time effects, there were no time-by-treatment interactions, with two minor exceptions. Therefore, treatment means are presented. Ruminal VFA proportions or concentrations were not affected by treatment. Valerate had time-by-treatment interactions, and these are presented in Figures 1 and 2. When animals were first introduced to Bufferfos (days 1 to 5), the molar proportions of valerate were reduced (Figure 1); however, from days 6 to 13 molar proportions of valerate were similar for Bufferfos and control steers. Following the high-moisture corn challenge, bufferfos tended to elevate the molar percentage of valerate one to three hours post-feeding; however, it was lower than control 9 to 11 hours post-feeding (Figure 2).

Table 1. Composition of experimental diets (dry basis).

Ingredient	Control	Bufferfos
Corn silage	50.00	49.50
Dry-rolled corn	40.00	39.60
Soybean meal	7.83	7.75
Ground corn	0.37	0.37
Limestone	1.17	1.16
Trace mineral-salt[1]	0.30	0.30
Vitamins A, D, E premix[2]	0.02	0.02
Fat	0.30	0.30
Bufferfos	0.00	1.00

[1] Composition was 96 to 98.5% NaCl, 3,500 mg/kg Zn, 2,000 mg/kg Fe, 1,800 mg/kg Mn, 370 mg/kg Mg, 350 mg/kg Cu, 100 mg/kg I, 90 mg/kg Se, and 60 mg/kg Co.
[2] Composition was 1.8 million IU/kg vitamin A, 3.6 million IU/kg vitamin D and 227 IU/kg vitamin E.

Implications

Bufferfos does increase ruminal pH in steers fed diets composed of predominantly grain. Over the entire study, there was a tendency for slightly lower intakes for steers fed Bufferfos. This could be advantageous for animals fed large amounts of grain.

Table 2. Intakes and ruminal pH for steers fed Bufferfos daily and when abruptly switched to high-moisture corn (challenge day).

Item	Control	Bufferfos	SEM[a]	P-value
Dry matter intake days 1 to 13, kg/day	12.24	11.09	0.45	0.0998
Dry matter intake days 7 to 13, kg/day	12.22	11.26	0.48	0.1865
Dry matter intake challenge day, kg/day	10.28	9.95	0.88	0.7951
Ruminal pH days 1 to 13[b]	5.84	6.08	0.076	0.0523
Ruminal pH days 7 to 13[b]	5.90	6.09	0.068	0.0772
Ruminal pH challenge day[c]	5.78	5.90	0.060	0.1806

[a] Standard error of the mean, n = 6.
[b] Based on one rumen sample taken daily.
[c] Based on rumen samples taken bi-hourly for 12 hours following switch to high-moisture corn.

Table 3. Effect of Bufferfos on once-daily ruminal VFA concentrations throughout the study.[a]

	mol/100 mol			
Item	Bufferfos	Control	SEM[b]	P-value
Acetate	62.53	61.59	0.906	0.4817
Propionate	20.87	20.72	1.035	0.9251
Isobutyrate	1.19	1.19	0.044	0.9794
Butyrate	11.68	12.62	0.598	0.2920
Isovalerate	2.27	2.28	0.128	0.9900
Valerate	treatment x day interaction			
Total VFA, mM	112.84	118.94	4.160	0.3242
Ac:Pr	3.09	3.11	0.186	0.9500

[a] Based on one rumen sample taken daily.
[b] Standard error of the mean, n = 6.

Table 4. Effect of Bufferfos on ruminal VFA concentrations from samples collected every two hours following high-moisture corn switch.[a]

	mol/100 mol			
Item	Bufferfos	Control	SEM[b]	P-value
Acetate	64.29	64.27	1.379	0.9934
Propionate	17.97	17.83	1.701	0.9535
Isobutyrate	1.26	1.16	0.087	0.4049
Butyrate	13.01	13.47	1.056	0.7670
Isovalerate	2.22	1.96	0.172	0.3216
Valerate	treatment x time interaction			
Total VFA, mM	113.59	118.36	3.113	0.3040

[a] Based on rumen samples taken bi-hourly for 12 hours following switch to high-moisture corn.
[b] Standard error of the mean, n = 6.

Figure 1. Effect of Bufferfos on daily ruminal fluid valerate concentration.

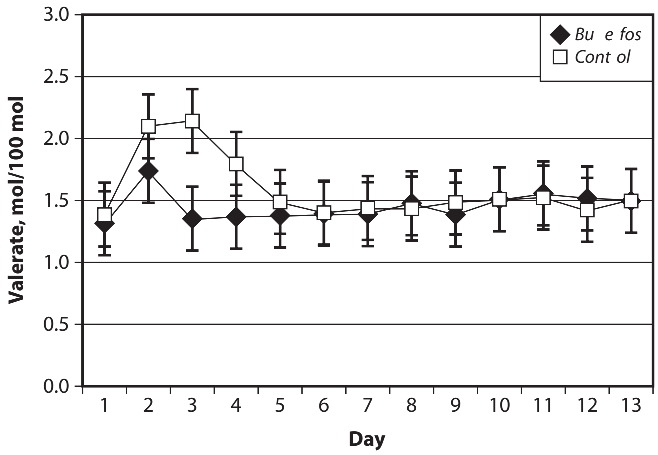
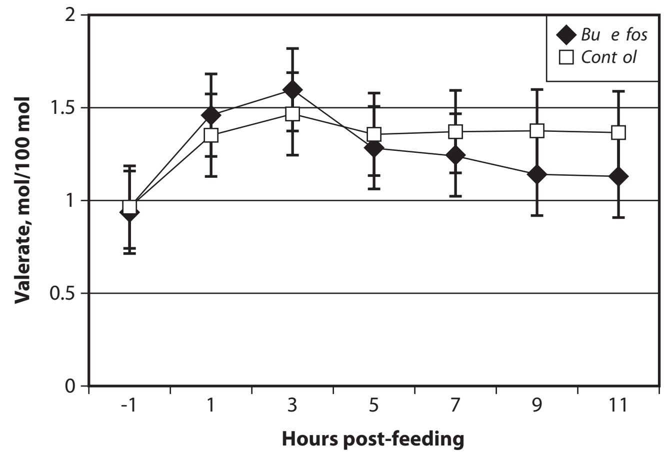


Figure 2. Effect of Bufferfos on ruminal fluid valerate concentration.



Metabolism of Volatile Fatty Acids Absorbed from the Washed Rumen of Steers

N.B. Kristensen and D.L. Harmon

Summary

Six Holstein steers fitted with a rumen cannula and permanent indwelling catheters in the mesenteric artery, portal vein, hepatic vein, mesenteric vein, as well as in the right ruminal vein, were used to study the relationship between volatile fatty acid (VFA) absorption from the washed rumen and the portal appearance of VFA. The absorption of VFA from the rumen was manipulated by incubating bicarbonate buffers in the rumen with or without VFA. The portal appearance of VFA was strongly affected by the presence or absence of VFA in the rumen buffer, and the portal recovery of acetate, propionate, butyrate, isovalerate, and valerate absorbed from the rumen was 71 ± 6, 91 ± 5, 27 ± 2, 54 ± 3, and 30 ± 3%, respectively. These estimates are of importance to our understanding of VFA metabolism in ruminants and the ability to measure the actual microbial production of VFA in fed ruminants.

Introduction

The unique digestive system of ruminants implies that most nutrients absorbed and metabolized are not identifiable in the feed before ingestion. Ruminants will get most of their nutrients from microbial cells and end-products of microbial fermentation. The major energy source of ruminants is volatile fatty acids (VFA) produced from fermentation of carbohydrates. However, not only is it difficult to predict and measure the microbial production of VFA, the subsequent metabolism of VFA by the ruminant animal has also been a matter of much debate. A large proportion of VFA is apparently metabolized before entering the bloodstream and only partly accounted for. Therefore, even though VFA absorption probably accounts for around 50% of digestible energy (DE) in ruminants, no feed evaluation system is capable of describing VFA production and metabolism. This means that current feeding models are largely unable to account for dietary effects associated with changes in VFA pattern and production. The present study was undertaken to investigate how the rumen epithelium of steers metabolizes VFA absorbed from the rumen. The washed rumen technique was used to investigate animal metabolism without interference from microbial metabolism in the rumen.

Materials and Methods

Six Holstein bull calves were placed under general anesthesia and fitted with a rumen cannula, castrated, and fitted with permanent indwelling catheters in the mesenteric artery, mesenteric vein, hepatic portal vein, hepatic vein, and the right ruminal vein.

Beginning before surgery and throughout the study, the steers were fed 2.1 kg DM/day of mixed grass hay and 3.3 kg DM/day of corn-based concentrate (composition of ration, in percentage of DM: 13% crude protein, 34% NDF). The steers had access to a mineral mix (composition of DM: Ca, 13 to 15%; P, 6%; NaCl, 17 to 20%; Mg, 3%; S, 1%; K, 1%; Zn, 2300 ppm; Mn, 2200 ppm; Cu, 1050 ppm; I, 45 ppm; Co, 15 ppm; Se, 29 ppm). The mineral mix contained Vitamin A (66,000 IU/100 g) and Vitamin E (28 IU/100 g).

The steers were housed individually in pens (3 x 3 m) at 18 to 24°C, with light from 0530 to 2130. Samplings were done 21 and 35 ± 2 days after surgery with an average body weight of 251 and 260 ± 6 kg at the two samplings, respectively.

The steers were prepared for sampling by removing the rumen contents by hand and washing the rumen in warm water and saline. The sampling period was divided into three periods: 1) incubation of a bicarbonate buffer in the rumen without VFA for 40 minutes (0-buffer; Table 1); 2) incubation of a bicarbonate buffer with VFA at normophysiological levels combined with continuous infusion of VFA into the rumen for 240 minutes (VFA-buffer, Rumen infusate; Table 1); and 3) incubation of 0-buffer for 40 minutes equivalent to the first incubation.

Blood was sampled from arterial and portal catheters along with infusion of p-aminohippurate (250 mM, pH 7.4, 1.0 mL/minute) into the mesenteric vein to measure blood flow and infusion of isobutyrate into the ruminal vein as an internal calibrator. VFA concentration in rumen buffers and blood samples were analyzed by gas chromatography. Data were analyzed statistically by ANOVA in a balanced block design with animals as blocks.

Results and Discussion

With the 0-buffer incubations in the rumen, no VFA was absorbed from the rumen; however, stable and apparently normal physiological conditions were maintained in the rumen with VFA-buffer incubations. With VFA-buffer incubations, the rumen pH was 6.5 ± 0.1, and the concentrations of acetate, propionate, butyrate, isovalerate, and valerate were 64 ± 3, 25 ± 1, 11 ± 0.2, 1.7 ± 0.03, and 1.2 ± 0.02 mmol/kg, respectively. The absorption rates (disappearance from the buffer) of acetate, propionate, butyrate, isovalerate, and valerate were 592 ± 16, 257 ± 5, 127 ± 2, 17 ± 0.3, and 20 ± 0.3 mmol/hour, respectively. The 0-buffer incubation allowed for measuring the VFA appearance in the portal blood originating from the hindgut, and values for portal appearance obtained with VFA-buffer incubations could be corrected for VFA appearance of nonruminal origin.

The net portal appearance of VFA was calculated as the portal blood flow x (portal concentration - arterial concentration). Figure 1 shows the arterial and portal concentrations of acetate with 0-buffer and VFA-buffer incubation. The figure illustrates that blood acetate concentration and portal-arterial difference is lower with the 0-buffer compared with the VFA-buffer, and that the system is in quasi-steady-state during VFA-incubation. Similar patterns were found for the other VFA. This illustrates that the ruminal absorption of VFA is the major source of VFA in the animals and that adequate experimental conditions were obtained. The net portal appearance of acetate, propionate, butyrate, isovalerate, and valerate were higher ($P < 0.01$) with the VFA-buffer compared with the 0-buffer (Table 2). The increase in net portal appearance of VFA compared with the amount of VFA absorbed from the rumen is the portal recovery of VFA and was found to differ for the individual VFA (Table 2). The highest portal recovery was found for propionate (91 ± 5%) and the lowest for butyrate (27 ± 2%). The recovery of acetate was 71 ± 6%; however, acetate posed a special problem due to its high arterial concentration and the uptake of arterial acetate by the portal-drained viscera. Final estimates for acetate recovery can therefore only be obtained after correction for portal-drained visceral uptake. It can, however, be concluded that the portal recovery of acetate is at least 71 ± 6%. The values for portal recovery of ruminally absorbed acetate and propionate are higher in the present study compared with most studies where a separation of animal and microbial factors has not been possible. For butyrate and valerate, the present study confirmed that the rumen epithelium is the primary tissue for metabolism of these compounds.

Implications

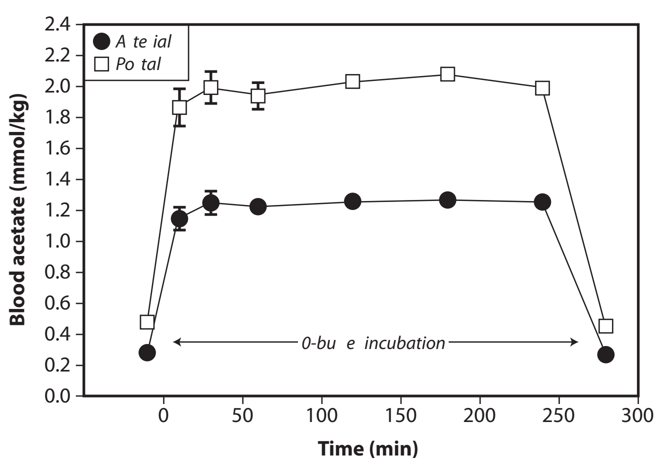
The present study has shown that the portal recovery of acetate and propionate absorbed from the rumen is higher when applying the washed rumen technique compared with most

Table 1. Amount (kg) and composition (mmol/kg) of rumen buffers and rumen infusate.

Item	0-buffer[1]	VFA-buffer[1]	Rumen Infusate
Amount incubated/ infused	15 kg	15 kg	1 kg/h
NaCl	96	0	0
$NaHCO_3$	24	24	0
NaOH	0	95	0
$KHCO_3$	30	30	0
K_2HPO_4	2	2	0
$CaCl_2$	1.5	1.5	0
$MgCl_2$	1.5	1.5	0
Acetic acid	0	72	600
Propionic acid	0	30	250
Butyric acid	0	12	125
Isovaleric acid	0	1.8	15
Valeric acid	0	1.2	15

[1] Rumen buffers were gassed with a 75% CO_2/25% N_2 gas mixture.

Figure 1. Arterial and portal blood concentrations of acetate in steers incubated with 0-buffer (buffer without VFA) and VFA-buffer under temporarily washed rumen conditions. Blood was sampled from permanent indwelling catheters implanted under general anesthesia. Each point is the mean ± SE of six steers sampled twice.



studies using intact/fermenting ruminants. This implies that the microbes in the rumen utilize some of the VFA produced, resulting in low estimates of production; therefore, measurement of portal appearance of acetate and propionate is probably the most reliable way to assess net microbial production of acetate and propionate in ruminants.

Butyrate and valerate are extensively metabolized in the rumen epithelium. The present study adds to our knowledge of this important property of the epithelium by showing that this phenomenon is not related to rumen microbes, i.e., because the metabolism of butyrate and valerate persisted even though the rumen was washed.

Table 2. Net portal appearance of VFA in steers incubated with bicarbonate buffer in the washed rumen with (VFA-buffer) or without VFA (0-buffer) and the portal recovery of VFA absorbed from the rumen.

	Net Portal Appearance, mmol/h Treatment				Portal Recovery, % of Absorbed	
	0-buffer	VFA-buffer	SEM	P-value	Mean	SEM
Acetate	98.9	477.3	25.1	< 0.01	71	6
Propionate	25.2	235.4	8.3	< 0.01	91	5
Butyrate	14.4	44.9	3.2	< 0.01	27	2
Isovalerate	0.9	9.3	0.6	< 0.01	54	3
Valerate	1.5	6.8	0.5	< 0.01	30	3

Influence of Slow-Release Urea on Digestion and Metabolism of Ruminants

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Summary

Two experiments were conducted to study the behavior of a slow-release urea (SRU) in beef cattle. Experiment 1 used ruminally cannulated steers to monitor the behavior of SRU within the ruminal environment. Ruminal ammonia was lower (P < 0.02) and ruminal urease activity tended to be higher (P < 0.06) in steers consuming SRU. Animals did not appear to adapt to SRU feeding in that the degradation of SRU was the same in animals fed SRU for 35 days as it was in those fed urea for 35 days. Ruminal volatile fatty acid (VFA) molar proportions (Table 2) or concentrations (not shown) were not affected by treatment. In Experiment 2, SRU or urea was dosed intraruminally immediately post-feeding, and blood samples were collected for 10 hours. Dosing the steers intraruminally with urea produced greater (P < 0.03) ruminal ammonia concentrations. Net portal flux of ammonia tended to be greater (P < 0.08) for urea than SRU. Hepatic ammonia uptake increased rapidly following dosing with urea. These results demonstrate that SRU possesses the ability to release N slowly in the ruminant. There is no apparent adaptation to this protection, at least within 35 days of feeding. Further research is needed to determine if this process is efficacious in ruminant feeding systems.

Introduction

For many years, researchers have sought means to synchronize ruminal urea degradation with carbohydrate availability. Dietary urea is rapidly hydrolyzed upon entry into the rumen, resulting in a rapid peak in rumen ammonia concentrations within the first hour after feed is consumed. Carbohydrate degradation and subsequent microbial growth is a much slower process with peak activities occurring four to six hours post-feeding. A greater synchrony of these processes may improve the efficiency of incorporation of nonprotein nitrogen into microbial protein and thereby improve the overall efficiency of nitrogen use and reduce nitrogen excretion into the environment. Therefore, the objective of the following experiments was to determine the behavior of a slow-release urea (SRU) for ruminants. Specifically, the objective for Experiment 1 was to ascertain if the ruminant microflora adapt to SRU with extended feeding and to characterize the behavior of SRU in the rumen. Experiment 2 sought to further the observations on ruminal behavior as well as assess the net absorption of ammonia and the effects on nitrogen metabolism when SRU was added to the rumen.

Procedures

Experiment 1

Twelve ruminally cannulated steers were used to study the effects of SRU on ruminal nitrogen metabolism. The diet was corn silage plus 10% supplement (Table 1). All supplemental nitrogen was from urea or SRU. Experimental treatments were control (feed-grade urea) and slow-release urea (SRU). The diet was offered at 1.25% of body weight once daily for the 35-day feeding period. Animals (six per treatment) received either SRU or feed-grade urea as the sole source of supplemental nitrogen in a corn-silage-based diet. A single supplement was prepared, and then the two different urea sources were weighed individually for each day's feeding. Animals received 50% of the calculated amounts of urea for the first three days of feeding. On day 33, blood (20 mL) was collected four hours post-feeding by jugular venipuncture, and plasma was harvested and frozen for analyses of urea, glucose, glutamate, and glutamine. On day 34, ruminal fluid (100 mL) was collected at 0, 2, 4, 6, 8, and 10 hours post-feeding and analyzed for ammonia, volatile fatty acids (VFA), and pH. Samples taken four hours post-feeding were analyzed for urease activity. On day 35, an *in situ* study determined the release of SRU from nylon bags suspended in the rumen. Nylon bags containing 0.5 g SRU (two bags plus a blank at each time) were suspended for 0, 2, 4, 6, 8, 12, and 24 hours. The bags were removed, rinsed lightly to remove rumen debris, dried at 55°C and analyzed for N. Zero bags (six) were rinsed and dried without placing them in the rumen. In addition, we had two bags labeled 24 hours and two labeled 48 hours in each animal. This initial experiment sought to ascertain the integrity of SRU for ruminants. Our hypothesis was that by feeding the materials for over 30 days and determining the rate of hydrolysis of SRU using *in situ* incubations, we would be able to demonstrate that SRU will maintain its characteristic rates of hydrolysis and that the rumen microflora will not adapt to hasten its degradation. The experiment was analyzed as a completely random design experiment. For samples collected over time (ruminal pH, ammonia, VFA), the data were analyzed as a randomized complete block, split plot in time. Animals were considered blocks, and the animal (treatment) term was used as the error term for treatment. No variable showed a time x treatment interaction; thus, only treatment means are presented.

Experiment 2

Four steers (319 ± 5 kg body weight) surgically prepared with permanent vascular catheters to study nutrient absorption from the gut and subsequent metabolism by the liver were used to study the effects of ruminal dosing of feed-grade urea or SRU on nitrogen absorption and metabolism. The steers had been surgically fitted with hepatic portal, hepatic venous, and mesenteric venous catheters and a mesenteric arterial catheter as well as ruminal cannula approximately six months prior to this experiment. The diet was the same as Experiment 1 above, corn silage plus 10% supplement (Table 1) and was offered (dry matter basis) at 1.5% body weight once daily. All supplemental nitrogen was from urea or SRU (averaged 92 g urea/head daily). Throughout a three-week pre-feeding period, steers were fed their respective urea treatments topdressed on their corn silage. However, on the day of sampling, steers were offered only corn silage and supplement containing no urea and a set of time zero samples were collected. Starting one hour prior to this zero time sample and throughout the sampling period, p-aminohippuric acid (250 mM, pH 7.4) was infused continuously into the mesenteric vein catheter (approximately 1.3 mL/minute). The steers were then dosed intraruminally with their daily aliquot of urea or SRU. Additional sets of samples were then collected at 0.5, 1, 2, 4, 6, 8, and 10 hours post-dosing. Each sample set consisted of simultaneously collecting arterial, portal, and hepatic blood samples (10 mL each) into heparinized syringes. These were then transferred to centrifuge tubes and placed on ice. Following the blood sample collection, ruminal fluid was sampled (100 mL) using a suction strainer, pH was measured directly, and an aliquot was acidified with 25% metaphosphoric acid and stored frozen for ammonia analysis. Blood samples were then centrifuged to harvest plasma that was stored frozen for analyses.

Table 1. Composition of supplement for steers fed corn silage with control or slow-release urea in Experiments 1 and 2.[a]

Ingredient	% of DM
Ground corn	73.99
Fat	3
Dicalcium phosphate	10.21
Limestone	9.5
TM-salt[b]	3
Vitamin A[c]	0.3

[a] Diet was composed of 90% corn silage + 10% supplement. Urea or SRU was added to increase crude protein intake to 12.5% crude protein.

[b] Composition was 96 to 98.5% NaCl, 3,500 mg/kg Zn, 2,000 mg/kg Fe, 1,800 mg/kg Mn, 370 mg/kg Mg, 350 mg/kg Cu, 100 mg/kg I, 90 mg/kg Se, and 60 mg/kg Co.

[c] Composition was 1.8 million IU/kg vitamin A, 3.6 million IU/kg vitamin D, and 227 IU/kg vitamin E.

Results

Experiment 1

Results are presented in Table 2. Body weights and dry matter intakes were similar for both treatments. Intakes were low and averaged 1.29% body weight for both treatments. This was done to ensure complete and equal consumption. There appeared to be some adaptation to the supplements that were topdressed and mixed by hand in that early on, steers avoided them but consumed them readily at the end. Ruminal pH was not affected by treatment, but ruminal ammonia was lower ($P < 0.02$) and ruminal urease activity tended to be higher ($P < 0.06$) in steers consuming SRU. Figure 1 shows the ammonia concentrations over time, and SRU consistently had lower ruminal ammonia concentrations indicative of a slower rate of urea hydrolysis. The *in situ* rates of SRU degradation were not affected by treatment. This demonstrates that animals did not adapt to SRU feeding in that the degradation of SRU was the same in animals fed SRU for 35 days as it was in those fed urea for 35 days. The plasma concentration of glucose was lower ($P < 0.02$) in steers fed SRU, a result that is difficult to explain. Plasma urea concentration was not statistically affected as were glutamate and glutamine concentrations, although plasma glutamate concentrations in SRU-fed animals were 50% of control. Ruminal VFA molar proportions (Table 2) or concentrations (not shown) were not affected by treatment.

Experiment 2

Results from Experiment 2 are listed in Table 3. Dosing the steers intraruminally with SRU did not affect ruminal pH; however, there was a tendency ($P < 0.7$) for a time x treatment interaction. The tendency for a difference in ruminal pH was largely the result of much greater ($P < 0.03$) ruminal ammonia concentrations for the urea treatment giving higher ruminal pH. Figure 2 shows the changes in ruminal ammonia over time. There was a time x treatment interaction ($P < 0.01$), as dosing with urea resulted in a rapid and substantial increase in ruminal ammonia concentrations, whereas dosing with SRU produced little change in concentrations.

There were no differences in portal blood flow or net portal flux of glucose or lactate with treatment. Net portal urea flux was not affected by treatment, but there was a tendency for a time x treatment interaction ($P < 0.06$), as net portal urea flux, which is usually negative because of the extensive transfer of nitrogen to the lumen of the gastrointestinal tract, rose sharply and was positive at 0.5 hours post-dosing (Figure 3a). Net portal flux of ammonia tended to be greater ($P < 0.08$) for

Table 2. Rumen pH, ammonia, and VFA in steers consuming corn silage with control or slow-release urea (SRU).

Item	Control	SRU	SEM	P <
Body weight, kg	534	523	16	0.62
Intake, kg DM/day	6.87	6.73	0.21	0.64
	Rumen Variables			
Rumen pH	6.54	6.47	0.06	0.36
Rumen NH_3, mM	14.08	8.94	1.25	0.02
Ruminal urease, mmol/(min•mL)	88.93	148.85	19.88	0.06
In situ SRU degradation, %/h	6.83	5.73	1.08	0.48
	Plasma Concentrations			
Glucose, mg/dL	59.8	50.45	2.31	0.02
Urea, mM	4.98	5.24	0.32	0.58
Glutamate, μM	232.5	114.5	68.2	0.25
Glutamine, μM	272	234.3	16.4	0.13
	Rumen VFA, mol/100 mol			
Acetate	61.99	63.60	2.70	0.39
Propionate	19.95	21.35	0.73	0.47
Isobutyrate	0.8	0.85	0.04	0.98
Valerate	1.39	1.49	0.08	0.50
Total VFA, mM	99.72	103.19	4.22	0.57

Table 3. Metabolite fluxes in steers dosed intraruminally with urea or slow-release urea (SRU).

	Treatments			Probability, P <	
Item	Control	SRU	SEM	Treat-ment	Time*Treatment
Rumen pH	6.66	6.46	0.07	0.15	0.07
Rumen ammonia, mM	12.9	3.6	1.6	0.03	0.01
Net Portal Flux, mmol/h					
Portal blood flow, L/h	557	570	74	0.90	0.46
Glucose	-26	-27	10	0.95	0.75
Lactate	61	60	4	0.80	0.84
Urea	-10	-33	13	0.29	0.01
Ammonia	300	179	34	0.08	0.01
Glutamate	-2	-4.0	1.5	0.43	0.89
Glutamine	-12.9	-13.0	2.0	0.96	0.92
Net Hepatic Flux, mmol/h					
Hepatic blood flow, L/h	691	716	90	0.85	0.45
Glucose	175	150	11	0.22	0.97
Lactate	-90	-64	11	0.20	0.02
Urea	134	90	22	0.25	0.8
Ammonia	-261	-182	28	0.13	0.02
Glutamate	32.3	37.2	5.1	0.41	0.65
Glutamine	20.8	21.4	4.6	0.93	0.35

Figure 1. Ruminal ammonia in steers fed urea or slow-release urea (SRU).

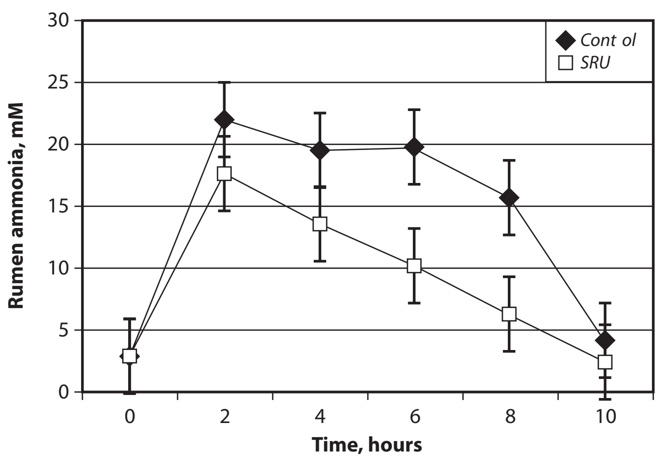
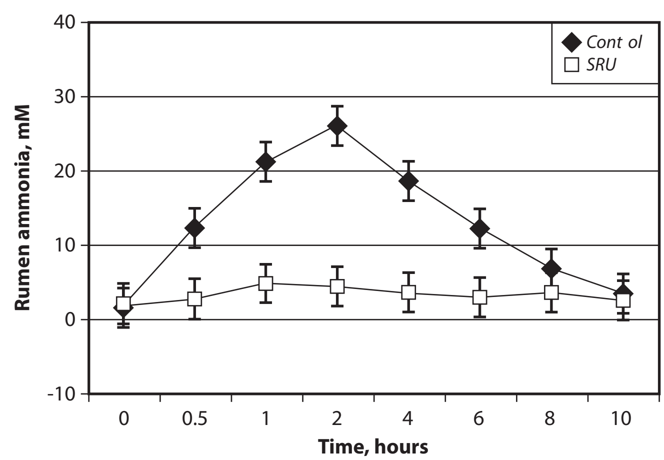


Figure 2. Ruminal ammonia in steers dosed with urea and slow-release urea (SRU).



urea than SRU; however, there was a time x treatment interaction (P < 0.01), as the net portal flux of ammonia rose rapidly following the dosing of urea, whereas the flux of ammonia for SRU was fairly constant (Figure 3b). The net portal fluxes of glutamate and glutamine were not affected by treatment.

There were no differences in hepatic blood flow or hepatic glucose flux with treatment (Table 3). Net hepatic lactate flux was negative, indicating the liver was taking up or metabolizing more lactate than it was producing. Hepatic lactate flux was not affected by treatment, but there was a time x treatment interaction (P < 0.02). Hepatic lactate uptake was greater following dosing urea than it was for SRU where lactate uptake was fairly steady (Figure 4a). Net hepatic fluxes of urea and ammonia were not affected by treatment; however, ammonia did exhibit a time x treatment interaction (P < 0.02). Hepatic ammonia uptake increased (more negative) rapidly following dosing with urea. The SRU produced a much more gradual increase in hepatic ammonia uptake following dosing (Figure 4a).

Implications

These results demonstrate that SRU possesses the ability to release N slowly in the ruminant. There is no apparent adaptation to this protection, at least within 35 days of feeding. Further research describing nitrogen utilization is needed to determine if this protection process is efficacious in ruminant feeding systems.

Figure 3. Net portal flux of ammonia and urea in steers dosed with urea and slow-release urea (SRU).

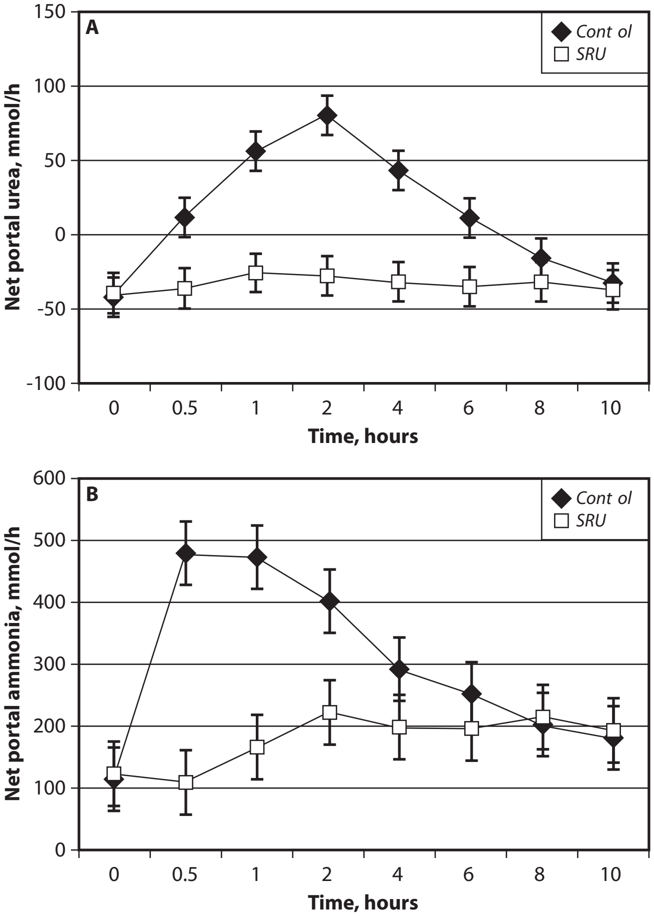
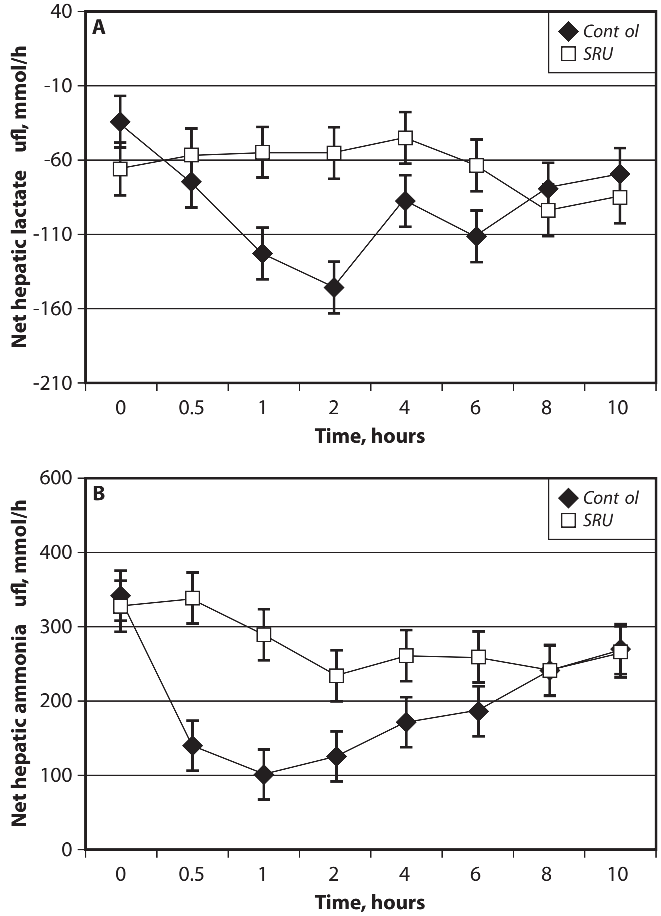


Figure 4. Net hepatic lactate and ammonia flux in steers dosed with urea and slow-release urea (SRU).



Improving Reproductive Performance of Beef Cattle through Fat Supplementation

E. Myers, E. Vanzant, L. Anderson, R. Burris, B. Hightshoe, J. Johns, and K. Schillo

Summary

To assess the effect of a high-fat liquid supplement on heat-stressed lactating beef cows grazing endophyte-infected tall fescue, 130 predominantly Angus cows were allotted to a total of 12 pastures at two locations, balanced within each location for calf birth date, calf sex, cow age, cow body condition score (BCS), and cow weight. Within location, groups were randomly assigned to receive either a commercial liquid supplement containing approximately 23% fat (MIX 30™) or a corn/soybean meal supplement (CON) fed as a control to provide similar amounts of energy and crude protein. Supplements were fed from 30 days before, through the last day of, breeding. Cows receiving MIX 30 were offered supplement twice weekly on a free-choice basis up to 2.72 kg/hd/day; CON pastures were fed supplement daily with intakes adjusted twice weekly to match MIX 30 intakes. All cows were estrus synchronized and bred by artificial insemination (AI) or embryo transfer (ET) once, followed by 42-day pasture breeding. No treatment x location interactions were detected. Cows receiving MIX 30 gained more weight and body condition, had higher pregnancy rates, lower final rectal temperatures, and lower serum thyroxine concentrations than cows receiving CON. Calf performance was unaffected by treatment. Compared with corn/soybean meal supplementation, supplementing heat-stressed cows from 30 days before, through the end of, the breeding season with a liquid, fat-containing supplement improved pregnancy rates and body temperatures and lowered serum thyroxine concentrations.

Introduction

Previous studies have shown that adding supplemental fat to the diet of beef cows can enhance reproductive efficiency. Although simply increasing the energy content of the diet can have a beneficial effect, especially for thin cows, fat supplementation has been shown to improve reproduction independent of increased energy intake. However, results of research studies have not been consistent; while some studies have shown improved pregnancy rates, other studies have not. This discrepancy may be due to the different types of fat used, the timing of supplementation relative to breeding, or other factors that may affect the chemical form of the fat absorbed by the cow.

In Kentucky and the rest of the southeastern United States, one of the primary factors limiting pregnancy rates in beef cows is the presence of endophyte in the majority of tall fescue pastures. The mechanisms through which the toxins produced by the endophyte affect reproduction are not completely understood. However, previous research has demonstrated that some of the hormonal effects of the endophyte are opposite those seen when adding supplemental fat to the diet. Thus, dietary fat supplementation may be particularly beneficial for beef cows grazing endophyte-infected tall fescue pastures.

One approach to providing supplemental dietary fat is to use a commercial liquid supplement. Although some specialized handling equipment is required, these types of supplements can be provided on an infrequent basis, thus decreasing labor requirements compared with daily, hand supplementation. This experiment was conducted to assess the effect of a high-fat liquid supplement on pregnancy rates and associated physiological responses in heat-stressed, spring-calving, lactating beef cows grazing endophyte-infected tall fescue.

Experimental Procedures

Animals

One hundred thirty Angus cows (initial body weight = 567 kg; initial body condition score = 5.6 on a 1 to 9 scale) at two locations (80 cows at the University of Kentucky Animal Research Center [ARC], 50 cows at the University of Kentucky Research and Education Center at Princeton [PTN]) were allotted to eight (ARC) and four (PTN) endophyte-infected tall fescue pastures. Pasture groups were balanced for calf birth date, calf sex, cow age, cow body condition score, and cow weight. At ARC, all cows were multiparous; at PTN, 16 cows were primiparous.

Diets and Feeding

Within each location, half of the groups were randomly assigned to receive either a commercial liquid supplement containing, on a dry matter (DM) basis, approximately 23% fat (MIX 30™, AgriDyne Inc.; composition shown in Table 1) or a corn/soybean meal supplement fed to provide similar amounts of digestible energy and crude protein. Supplementation started 30 days before breeding and lasted through the last day of the breeding season. At PTN, supplementation was started April 26, 2002, and continued through July 12, 2002; at ARC, supplementation was started May 1, 2002, and continued through July 30, 2002. Feeding was discontinued 13 days earlier at PTN due to severe drought conditions, which required the removal of cattle from pastures. Cows were offered MIX 30 twice weekly on a free-choice basis up to approximately 2.72 kg/hd/day. In order to maintain similar supplement intakes between control and MIX 30 groups, each MIX 30 pasture was paired with one control pasture. Within pairs, the control group of each pair was fed supplement daily at a rate adjusted twice weekly to match protein and energy consumption observed with the respective

Table 1. Nutrient composition of MIX 30™.

	% of As Fed	% of DM
Moisture	58.6	-
Dry Matter	41.4	100
Crude Protein	17.1	41.3
Crude Fat	9.7	23.4
Urea, protein equivalents	0.3	0.7
Ammonia, protein equivalents	9.6	23.2

Table 2. Average supplement dry matter (DM), crude protein (CP), digestible energy (DE), and fatty acid consumption by treatment groups at each location.[a]

Intake from Supplement, per Cow Daily	Location			
	ARC		PTN	
	Control	MIX 30™	Control	MIX 30™
Supplement DM, kg	1.13	0.99	0.93	0.85
CP, kg	0.48	0.44	0.34	0.38
DE, Mcal	4.94	4.61	4.06	3.98
Fatty acids, g				
C 16	2.9	40.9	2.5	37.1
C 18:0	0.8	11.2	0.7	10.1
C 18:1	2.2	52.5	1.9	47.6
C 18:2	7.1	103.1	6.1	93.6
C 18:3	0.9	6.1	0.8	5.5

[a] Nutrient intakes were calculated from supplement composition data and measured supplement disappearance from feed bunks.

MIX 30 group. The dry supplement was formulated to target similar daily consumption of digestible energy and crude protein as observed with the MIX 30 groups (Table 2).

Breeding

To synchronize estrus, all cows received 0.91 kg/cow/day of a mixture containing 75% cracked corn and 25% commercial premix containing melengesterol acetate (MGA) (0.5 mg MGA/cow/day) for seven days. On the first day of MGA feeding, cows were injected with 1 mg estradiol cypionate, and on the last day of MGA feeding, they received an injection of 25 mg prostaglandin. Following synchronization, cows received either timed insemination or embryo transfer (balanced across pasture groups) and were then exposed to a single Angus bull per pasture for 45 days.

Environment

Several factors contributed to heat stress during the trial: the presence of endophyte-infected fescue, high temperature and humidity, and lack of cooling opportunities. Pastures utilized during this experiment were deliberately established with fescue seed from stands known to be heavily infected with the endophytic fungus *Neotyphodium coenophialum*. Additionally, although some shade was available from trees at PTN, pastures at ARC had minimal shade, and the only water source in any pasture at either location was an automatic waterer.

Environmental conditions present during the trial period were conducive to heat stress. At ARC, average daytime temperature over the trial period was 27.2°C (81°F) with an average relative humidity of 70% resulting in a temperature humidity index (THI) of 76, which falls within the alert category (THI values of 75 to 78) of the livestock safety index. In the alert category, heat stress appears, and precautionary measures to prevent heat stress are recommended for confined animals. At PTN, the average daytime temperature was 28.3°C (83°F) with an average relative humidity of 82% resulting in a THI of 83.2, which falls at the upper range of the livestock safety index danger category (THI 79 to 83) indicating severe heat stress and possible death with inadequate management. Signs of heat stress such as increased respiratory rate, open-mouth breathing, sweating, cessation of voluntary activity, and preferentially choosing damp ground around waterers for resting were regularly observed.

Statistical Analysis

Data were analyzed with the GLM procedure of SAS as a completely randomized design with a 2 x 2 factorial treatment structure using pasture groups as the experimental units. The model included terms for supplement type, location, and their interaction. Location x treatment interactions were not detected for any response variable. Thus, only the main effects of treatment are shown. Serum thyroxine levels were only determined at ARC. Thus, these data were analyzed as above, but with a one-way treatment structure.

Results and Discussion

The nutrient composition of the liquid supplement used in this study is shown in Table 1. Although this product contains only small quantities of urea, it contains a substantial amount of nonprotein nitrogen (NPN) in the form of ammonium salts. This source of nitrogen accounted for 56% of the crude protein equivalents in the supplement. Supplement intakes and consumption of supplemental energy and protein are detailed in Table 2.

Dry matter intakes were intentionally greater with the dry supplement in order to target similar consumption of digestible energy and crude protein from the supplements. At both locations, slightly greater amounts of digestible energy were provided from the dry supplement, as compared with the liquid supplement. At ARC, the dry supplement provided about 9% more crude protein, whereas at PTN, cows receiving the liquid supplement consumed about 10% more crude protein equivalents than those receiving the dry supplement.

There are two important considerations regarding these nutrient intake values. First, these data reflect only nutrient consumption in the supplement and not nutrients from the grazed forage. It is known that different supplements can have different effects on forage intake and possibly on forage selection. Thus, the effects of the supplements on total nutrient intake in this study are unknown. Based on previous research with cattle grazing similar pastures, it is unlikely that protein was limiting in the diet. Thus, small differences in protein consumption from the supplements are unlikely to have had substantial effect on the performance of these cattle. Second, the form of the nutrients provided by the two supplement types was different. In the case of energy, a substantial amount of the digestible energy (DE) in the liquid supplement was in the form of fat, whereas most of the DE in the dry supplement was in the form of carbohydrate. We hypothesized that provision of energy in the form of fat would result in enhanced performance compared to energy in the form of carbohydrate, so this difference was integral to the design of the study.

With respect to protein, much of the protein in the liquid supplement was present as nonprotein nitrogen, whereas most of the protein in the dry supplement was in the form of true protein. As indicated above, since it was unlikely that protein was limiting in the grazed forage, it is unlikely that these differences affected cattle performance. However, some studies have indicated that high levels of NPN can be detrimental to reproductive performance of cattle. The primary dietary fatty acids provided by the liquid supplement were linoleic acid (C 18:2), oleic acid (C 18:1), and the 16-carbon fatty acids palmitic acid (C 16:0), and palmitoleic acid (C 16:1). Because of biohydrogenation by the microbial population in the rumen, most of the unsaturated fatty acids (C 18:2, C 18:1, C 16:1) are absorbed as saturated fatty acids (C 18:0 and C 16:0).

The effects of the supplementation treatments were similar at the two locations (Table 3; treatment x location interactions $P > 0.10$). Cows receiving MIX 30 gained more weight ($P = 0.06$) and body condition ($P < 0.01$) than cows receiving the control supplement. Cows receiving MIX 30 had higher pregnancy rates ($P = 0.02$) than cows receiving the control supplement as determined by ultrasound 35 days after the end of the breeding season. Cows receiving MIX 30 had lower final body temperatures ($P < 0.01$) and a greater body temperature decrease ($P < 0.01$) compared to cows receiving the control supplement. At ARC, cows receiving MIX 30 had lower serum thyroxine concentrations ($P < 0.01$) than cows receiving the control supplement. Final calf weights and calf average daily gains were unaffected ($P > 0.10$) by treatment.

Table 3. Effect of fat-containing, liquid supplement vs. control supplement on cow and calf response variables.

	Supplement			
	Control	MIX 30™	SEM[a]	P-value[b]
Cow weight, kg				
Initial	573.3	557.9	9.8	0.25
Final	578.8	572.4	10	0.66
Change	5	14.5	3.6	0.06
Cow body condition, 1-9 scale				
Initial	5.75	5.39	0.12	0.04
Final	5.59	5.62	0.13	0.88
Change	-0.18	0.22	0.08	< 0.01
Calf weight, kg				
Initial	107.5	106.6	2.9	0.8
Final	171	169.6	3.5	0.77
Change	63.5	63	1.4	0.98
Cow body temp, °C				
Initial	39.2	39.1	0.05	0.31
Final	39.3	38.8	0.07	< 0.01
Change	0.08	-0.28	0.07	< 0.01
Pregnancy rate, %	56.4	75.3	6	0.03
Serum thyroxine, ng/mL[c]	40.2	35.1	1	< 0.01

[a] Standard error of the mean.
[b] Probability of a greater F-value for the treatment comparison.
[c] Thyroxine concentrations for cows at ARC location only.

Implications

This experiment showed that, when compared with a corn/soybean meal supplement, provision of a commercial liquid feed supplement with 23% fat from 30 days prior through the last day of a controlled breeding season improved pregnancy rates of cows grazing endophyte-infected pasture in the presence of severe heat stress. Cows receiving the high-fat supplement gained a slight amount of body condition, whereas cows receiving the control supplement lost a small amount of body condition. Although differential effects on forage consumption or digestion cannot be precluded, the lower body temperatures and serum thyroid hormone levels in the fat-supplemented cows suggest an underlying metabolic effect and could be related to decreases in heat stress. Based on other work, it appears that this underlying metabolic effect may directly affect early embryo survival. Additional research is necessary to determine the mechanisms whereby fat supplementation affects reproductive performance and heat stress in beef cattle. This knowledge will allow us to accurately target fat supplementation to situations in which there is a high probability of obtaining economical responses.

Beef Performance and Financial Record Keeping Programs

D. Bullock, A. Smith, J. Hunter, and L. van Rensburg

Summary

Good record keeping is a critical component of any beef enterprise. Having knowledge of production levels and costs can assist producers in making informed management decisions to improve profitability. The Kentucky Beef Integrated Resource Management Committee has developed a records keeping program to assist Kentucky beef producers in this important activity.

Introduction

In any business, good record keeping is extremely important, and the beef industry is no exception. Knowing the level of production and costs associated with that production is critical in making any business profitable. Unfortunately, in the beef industry, keeping good production and financial records is a low priority. Common reasons for the lack of proper record keeping are that it is complicated, time consuming, and boring. To try to assist producers in this important activity, the University of Kentucky Integrated Resource Management Committee has committed one full-time Extension Associate and resources to coordinate record keeping and beef financial record keeping.

Program Description

The software used to record performance records is the Cow Herd Appraisal Performance Software (CHAPS) developed by North Dakota State University. This is a Microsoft® Windows-based software that allows producers to record production information for each beef enterprise from cow/calf to feedyard. Additional information can be generated on the reproductive performance and individual cow lifetime productivity. The program can easily generate reports based on sorting that fits the individual producer's needs. The program can be useful with a minimal amount of information that includes individual identification (with calves matched with cows), bull turnout date, birth date, weaning date, and weaning weight. There are opportunities to include additional information, but this is the minimum to get useful reports.

The CHAPS computer software can be used in one of two ways. Producers can purchase the software for a minimal fee and do all of their record keeping themselves. This is the least expensive and most flexible option; the producer can manipulate data and generate new reports with a few clicks of a button. The other option is for producers to keep records in a pocket record book and send those records to our office for entry. There is a per head fee for this service, and reports are mailed back to participants.

To record and interpret financial records, the Beef Cow/Backgrounding Business Records program is being utilized. Standardized Performance Analysis (SPA) can be used to assist Kentucky beef producers in analyzing herd economic and production records. It allows producers to identify ways to lower their cost of production in three enterprises: cow/calf or backgrounding, harvested forages, and pasture. Producers will be able to calculate their rate of return on assets, pounds weaned per cow exposed, feeding and grazing costs per cow, forage production costs on a per acre and ton basis, and much more.

Impact

The number of producers who are now participating in the program has greatly increased over the past three years. We currently have approximately 340 producers who have purchased the software or are using the data-entry service. Prior to implementing this program, we had approximately 50 producers per year participating.

In addition to directly benefiting the producers, a state database is being generated that will provide benchmarks on beef production statewide. Table 1 shows the averages of the 3,137 cow records that were collected in 2002. The $357.61 total receipts figure is based on $80/cwt. for weaned calves, not actual values (currently we do not have enough information to generate averages for financial information). This gives all Kentucky producers an indication of average production levels for comparison to their performance.

Table 1. State averages for performance traits based on 3,137 cow records for calves born in 2002.

Performance Measure		Performance Measure	
Total cows exposed	44	% mature cows calving within 42 days	71.5
Number of cows calving	42	Average age of cows in herd	6.1
Number of cows sold due to age	0.50	Number of replacements retained	6.7
Number sold due to physical defects	0.24	Pregnancy percentage	94.9
Number sold as open	0.24	Calving percentage	94.5
Number sold for other reasons	0.89	Weaning percentage	84.0
Total cows culled	1.88	Calf death loss percentage	3.6
Calf weight per day of age	2.42	Calves born in first 42 days	71.4
Average adjusted 205 day weight	522	Calves born in first 63 days	79.5
Calf average daily gain	2.04	Average age at weaning, days	219.2
% heifers calving within 42 days	34.5	Pounds weaned per exposed female	447
		Total Receipts per Cow Exposed ($80/cwt. average price)	$357.61

Pre-Conditioning of Feeder Calves: A Kentucky CPH-45 Case Study

Kenneth H. Burdine and John T. Johns

Summary

This producer was able to add an additional net value of $80.96 to each calf above its value at weaning time. This is an example of how the CPH-45 program can add value to feeder cattle for Kentucky producers. The CPH-45 sales program is designed to allow producers who are unable to market uniform load lots of cattle to receive the benefits that come from marketing in larger groups. The program can be profitable for any producer, regardless of the size of the operation. Kentucky's average beef cow herd size is 28 head. If the average herd weans and pre-conditions 25 calves each year and experiences net returns similar to this example, an additional return of more than $2,000 per year would be experienced. The CPH-45 program represents a real opportunity to increase farm income.

Introduction

For many years, Kentucky has promoted its CPH-45 (Certified Pre-Conditioned for Health) program to producers as a way to add value to their feeder calves. Many studies have shown considerable increases in producers' income resulting from weight gain during the pre-conditioning period and price premiums at the time of sale. However, most of these studies have used state average prices as the baseline and made assumptions about rates of gain, feed and medical costs, and length of time in the pre-conditioning program. The intent of this project was to profile a single producer who participated in the Kentucky CPH-45 program for the first time in the spring of 2003. Actual cost and return data were collected by the producer and made available for use in this analysis. Actual production data were collected on calves at multiple points throughout the period. Although the producer wishes to remain anonymous, his cooperation and willingness to share information are deeply appreciated.

Program Description

This case study is of a commercial partnership, consisting of 130 cows, located in central Kentucky. The cowherd is primarily Angus-Simmental cross, bred to registered Angus bulls. Until the time of this project, calves were sold at weaning through the stockyards. Calf management practices prior to weaning were similar to previous years. Current requirements for managing and marketing calves under Kentucky's CPH-45 program are: 1) owned by the seller for a minimum of 60 days, 2) weaned a minimum of 45 days, 3) trained to eat feed from a bunk and drink water from a trough, 4) dehorned and healed, 5) males castrated and healed, 6) treated for grubs and lice according to label directions for the time of year, 7) dewormed with an endectocide no more than 60 days prior to sale, 8) vaccinated for Clostridia (seven way) subcutaneously in the neck according to product label, 9) vaccinated and boostered for IBR, PI_3, BVD, and BRSV with the booster vaccine required to be a modified live product, 10) during the conditioning period, calves have access to a free choice mineral containing a minimum of 1,000 ppm of copper with no copper oxide, 26 ppm selenium, 2,000 ppm zinc, 1,000 ppm manganese, and a salt content of 18 to 25%. In addition, all females come with a $100 guarantee of being open, and all males come with the same guarantee that they are steers.

During the spring and early summer of 2003, this central Kentucky producer pre-conditioned 124 fall-born calves for a total of 81 days. Following the pre-conditioning period, 58 steers and 45 heifers were sold in the June 27 CPH sale at Bluegrass Stockyards in Lexington, Kentucky. Twenty-one heifers were retained for herd replacements. For the purposes of this case study, all associated costs are allocated across all calves in the group. Profitability analysis is only included for the 103 calves that were sold in the CPH sale. Every effort has been made to make this analysis as realistic as possible.

To understand the value that was added to these calves through the CPH-45 program, the returns after pre-conditioning are compared to returns that would have been received had the animals been sold at weaning. Weaning is the point where the cow-calf enterprise ends and the pre-conditioning enterprise begins.

The average weaning weight was 413 pounds for the heifers and 462 pounds for the steers. In order to best estimate sale weight at weaning time, weaning weights have been shrunk by 5% to account for weight loss incurred in loading and hauling to the stockyards. Thus, pay weight at weaning becomes 392.4 pounds for the heifers and 438.9 pounds for steers.

Price estimates for weanlings were determined from market price reports for Bluegrass Stockyards for the week including April 1. During that week, 3- to 4-cwt. heifers sold between $94 and $104/cwt., and 4- to 5-cwt. steers sold between $90 and $107/cwt. Adjusting prices to reflect the estimated sale weight of the cattle gives a sale price of $94.67 for the heifers and $100.39 for the steers. Therefore, value at weaning would have been $371.49 for heifers and $440.61 for steers.

Pre-conditioning began on April 8. Calves were fed a ration of 40% distillers grain and 60% soyhulls during this time. Calves were fed 9.25 pounds per head daily of the concentrate mixture in addition to good pasture throughout the entire period. Concentrate cost was $76.60 per ton, or $43.91 per day for the entire group. This equates to $28.68 per head for the period. One ton of high magnesium mineral was purchased for the period at a cost of $436 per ton, or $3.52 per head.

In addition to feed and mineral costs, medicine represents a substantial cost in a pre-conditioning enterprise. Initial viral and bacterial vaccines were administered one week after weaning at a cost $1.59 per head. Calves were dewormed and implanted at this time. Dewormer costs $2.18 per head, while implants cost $0.37 per head. A modified live vaccine was given as a booster on April 24 at a cost of $2.27 per head. Miscellaneous costs included ear tagger pins, syringes, and needles and amounted to just under $0.07 per head.

Total labor, which included feeding and working calves during the pre-conditioning period, was 118 hours. Calves were worked four times after weaning in order to collect data on gain. Under ordinary circumstances, calves would be worked only twice: once to administer initial vaccines and then a second time to administer booster vaccines and apply electronic identification and CPH ear tags. Therefore, labor used during the last two workings (21 hours) has been excluded from the analysis. Most of these hours were from a laborer hired at $7.00 per hour. Some operator labor is also included and valued at the same rate for simplicity purposes. Therefore, for this analysis, total labor costs are $679, or $5.48 per head.

A pasture rental rate is included in the analysis, although one was not actually paid by the producer. This cost is included to cover the opportunity cost of grazing pasture. In other words, if the producer had decided not to pre-condition his feeder calves during 2003, he could have rented pasture out to a backgrounder. The rate used in our analysis is $0.20 per head per day, or $16.20 per head for the 81-day pre-conditioning period. Table 1 summarizes all cash costs associated with the pre-conditioning enterprise.

Impact

On June 27, 58 steers and 45 heifers were delivered to Bluegrass Stockyards for inclusion in a CPH sale. These calves were weighed on arrival and commingled into pens with other cattle of similar genetics, frame, and weight. Sale weight was the in-weight reduced by a 2% pencil shrink. Pens were broken into 100-pound body weight increments.

These calves were grouped into five pens of predominantly Angus cattle, which were steers 450 to 550 pounds, 550 to 650 pounds, and 650 to 750 pounds and heifers 450 to 550 pounds and 550 to 650 pounds. Prices received for these five groups are shown in Table 2.

The average sale weight of the 58 steers was 634 pounds. Average sale price was $94.94, or an average value of $601.92 per head. Heifers averaged 556 pounds and sold for an average of $92.92 per cwt., or a per head value of $512.91. Table 3 provides a profitability analysis of the pre-conditioning program. A weighted average of steers and heifers is used to simplify the analysis. Marketing and transportation costs are not included because they would have been the same regardless of marketing method. Calves sold in this CPH sale were required to have both an electronic identification tag and a CPH visual tag. Tag costs have been included in the budget below. Also included in the budget is interest expense during the pre-conditioning period for the value of the weaned calves and all cash expenses.

Profitability of the CPH-45 program comes from two sources. First is weight gain of the calves during the pre-conditioning period. In this case study, calves gained 1.97 pounds per day from weaning to pay weight (including hauling and pencil shrink). This weight gain was achieved through an economical feeding program and forage utilization. The revenues associated with these additional pounds exceeded the cost of adding them. The producer would have made some profit even without selling in a CPH-45 feeder calf sale.

This point is illustrated in Table 4. Using the same pay weight from the CPH sale, the calves are valued at market price for the same week of the Bluegrass Stockyards CPH sale. Based on the market price report for the week including June 27 at Bluegrass

Table 1. Cost summary for the pre-conditioning program (81 days).

Expense Item	Herd Cost	Cost per Head
Feed	$3556.80	$28.68
Pasture rental	2008.80	16.20
Labor	679.00	5.48
Mineral	436.00	3.52
Initial vaccine	196.73	1.59
Booster vaccine	281.87	2.27
Dewormer	270.39	2.18
Implants	45.98	0.37
Miscellaneous	8.17	0.07
Total	$7,483.74	$60.36

Table 2. CPH sale results.

Group Specification	Sale Price in $/cwt.
Angus steers 450-550 lb	$105.90
Angus steers 550-650 lb	96.70
Angus steers 650-750 lb	90.90
Angus heifers 450-550 lb	94.20
Angus heifers 550-650 lb	93.00

Table 3. Profitability analysis (using weighted average of steers and heifers) on a per head basis.

Revenues	
Sale of CPH-45 calves	$563.04
Expenses	
Purchase of weaned calves from cow-calf enterprise	($410.40)
Feed costs	(28.68)
Pasture rental	(16.20)
Labor	(5.48)
Mineral	(3.52)
Initial vaccine	(1.59)
Calf dewormer	(2.18)
Implants	(0.37)
Booster vaccine	(2.27)
Electronic ID and CPH tags	(3.00)
Interest expense	(8.32)
Miscellaneous	(0.07)
Net Return per Head	**$80.96**

Stockyards, steers would have sold for $89.91 per cwt., or a value of $570.03 per head. Heifers would have sold for $86.47 per cwt., or a value of $480.77 per head. The weighted average value of steers and heifers would have been $531.03 per head. Therefore, the program would have been profitable even if the calves had been sold at the regular weekly auction rather than in the CPH sale.

A second source of income for producers participating in a CPH-45 sale is the premium above-market prices received for their calves. On average, the CPH calves brought $5.34 per hundredweight above the Lexington market for that week. This premium totaled $32.01 per head. Although the majority of the net returns to CPH-45 came from weight gain of the calves, more than one-third came from sale price premiums associated with the CPH-45 sale program.

Table 4. Examination of CPH profitability (weight gain vs. CPH premium).

Revenues	
Sale of calves at regular weekly sale (no CPH premium)	$531.03
Expenses	
Purchase of weaned calves from cow-calf enterprise	($410.40)
Other expenses (feed, labor, medical, interest, etc.)	(71.68)
Net Return per Head (no CPH premium)	**$48.95**
Plus CPH-45 premium	32.01
Net Return per Head for CPH-45 Program	**$80.96**

2003 Summary of the Five State Beef Initiative in Kentucky

K.H. Burdine, J.T. Johns, A.L. Meyer, P. Scharko, P. Deaton, and J. Akers

Summary

Cow-calf operators and backgrounders who sell feeder calves should know what type of cattle they have. Imagine how much different this grid analysis would have been if the bottom 25% had been excluded. Individual producers have the ability to do this for their operation. Programs such as the Five State Beef Initiative allow producers to receive detailed feedlot and carcass data on their cattle so that, over time, this information can be used to cull cows and/or bulls that cost the beef industry large sums of money each year. By removing these outliers and documenting calf performance, cow-calf producers may be able to command superior prices for their cattle and target them toward markets that were not previously attainable.

Introduction

The Five State Beef Initiative (FSBI) continues to be a successful program among Kentucky producers. A large number of calves born in 2001 were tagged with electronic identification tags and tracked through the feedlot and packing plant. Carcass data obtained show that Kentucky feeder cattle perform quite well and in most situations are above industry average, as reported in the 2000 Fed Cattle Audit. This information can be beneficial to cow-calf producers, allowing them to make necessary genetic or management changes when called for and/or to target specific markets for their cattle. Additionally, the project has provided a unique opportunity to develop a large database of feedlot and carcass performance on Kentucky feeder calves that has proven useful in marketing efforts.

Program Description

Over the course of late 2002 and early 2003, carcass data were received on 1,598 feeder calves born in 2001 and marketed to feedlots in fall 2001 and spring 2002. The majority of calves (68%) came from five CPH sales in two locations. Another 17% came from independent producers able to market uniform load lots of cattle. The remaining 15% came from two small producer groups that commingle their calves and market directly to feedlots. Of the 1,598 sets of carcass data received, 58% were steers and 42% were heifers.

These calves represent a broad sample of Kentucky feeder cattle from various geographic, genetic, and pre-weaning management backgrounds. However, all calves were managed postweaning according to Kentucky's CPH-45 program guidelines.

The average, minimum, and maximum values for carcass data are shown in Table 1. The average carcass had a marbling

Table 1. 2003 carcass data summary.

	Hot Carcass Wt.	Backfat	Ribeye Area	Yield Grade	Quality Grade	Marbling Score
Average	827	0.57	13.6	3.22	Choice-	SM 60
High	1173	1.60	24.8	6.44	Prime	MDA 20
Low	536	0.08	8.3	0.08	Standard	TR 0

Figure 1. Carcass quality grade summary.

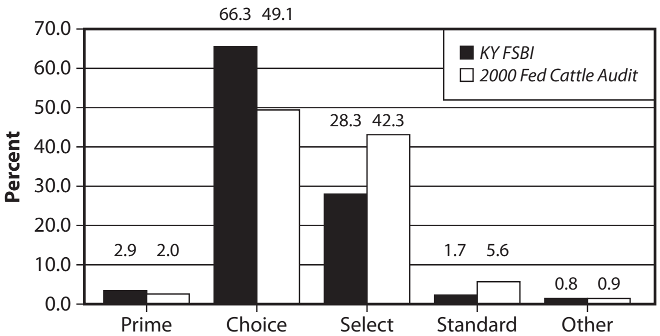
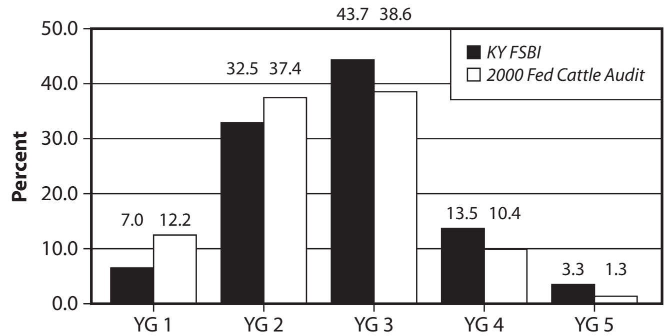


Figure 2. Yield grade summary.



score of Small 60 indicating a quality grade of low Choice. The average ribeye area of 13.6 square inches was right on target for the average hot carcass weight of 827 pounds. Average backfat of 0.57 inches is slightly greater than the average of 0.51 inches for similar cattle from the NBQA-2000 survey and is within standards for the industry. The average carcass had a yield grade of 3.2. These average values indicate high market acceptability for Kentucky cattle; however, the need to remove carcasses that will receive discounts and that have reduced value is also apparent.

Carcass quality and yield grades for Kentucky Five State Beef Initiative (KY FSBI) cattle are compared to data from the 2000 National Fed Cattle Audit in Figures 1 and 2, respectively. Kentucky FSBI cattle produced more Prime and Choice carcasses and fewer Select and Standard grade carcasses (Figure 1) compared to the audit cattle. The "other" category is used to describe undesirable quality grades such as Commercial or Utility, dark cutters, blood splash, or an animal being graded a "C" maturity.

More than 69% of the Kentucky cattle graded Choice or better compared to 51% for the fed cattle audit. Only 1.7% of Kentucky calves produced Standard grade carcasses, while 5.6% of carcasses in the fed cattle audit graded Standard.

On average, Kentucky calves produced carcasses with higher yield grades. Kentucky FSBI cattle produced fewer yield grade 1 and 2 carcasses while producing more yield grade 4 and 5 carcasses (Figure 2) than cattle in the fed cattle audit. Cattle were fed to heavier weights than in previous years, resulting in both higher quality and yield grades. However, 85% of the Kentucky carcasses yield graded 3 or better.

Finally, it is interesting to examine how many calves would have qualified for premiums such as CAB or Sterling Silver. To qualify for these programs and earn the associated premiums, a carcass must grade in the upper two-thirds of the Choice grade and receive a yield grade no higher than 3. In 2002, greater than 19% of Kentucky FSBI calves would have qualified for such a program.

Quality and yield grade distributions for Kentucky FSBI steers are shown in Figures 3 and 4 and for heifers in Figures 5 and 6. Steers graded 68.9% Prime and Choice, with only 1.3% falling into the Standard grade. Data in Figure 4 reveal an undesirable number of steer carcasses (18.8%) falling into yield grades 4 and 5. Heifers were similar to steers in the percentage of carcasses grading Prime and Choice (69.8%) but had a higher percentage of carcasses grading Standard or Other (4.2%) compared to steers. Heifer carcasses had a greater percentage of yield grades 1 and 2 (45.4% versus 35.2%) and lower percentage of yield grades 4 and 5 (14.4% versus 18.8%) compared to steer carcasses.

Carcasses given a yield grade of 4 or 5 receive a significant discount in price. Producers need to understand why cattle receive these undesirable yield grades to determine if farm-level management can change this problem. Genetic factors as well as overfeeding on the part of the feedlot impact the percentage of high yield grade cattle. Understanding the

Figure 3. KY FSBI steers—quality grades.

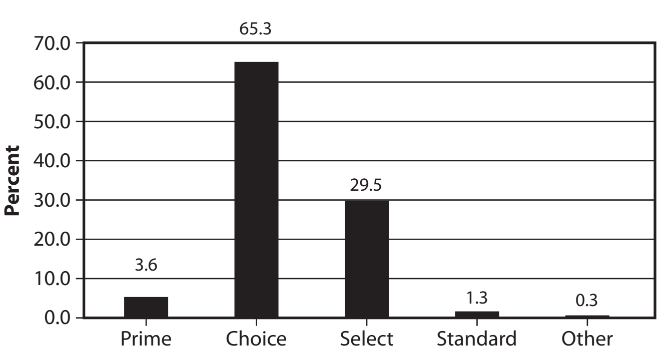


Figure 4. KY FSBI steers—yield grades.

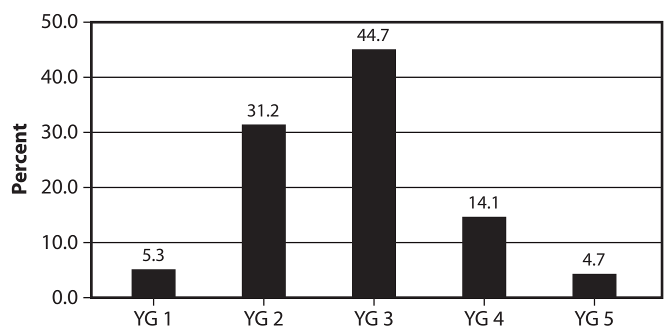


Figure 5. KY FSBI heifers—quality grades.

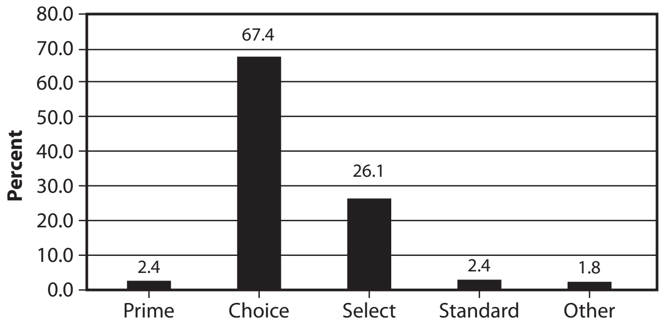
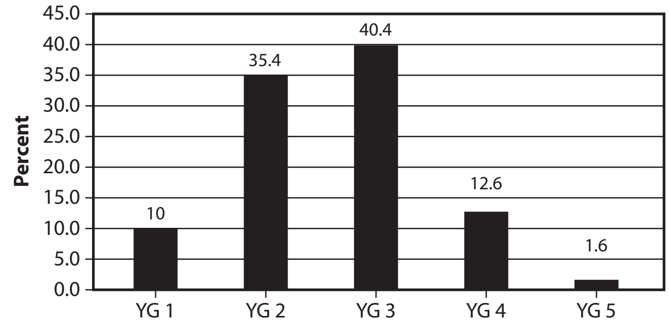


Figure 6. KY FSBI heifers—yield grades.



USDA yield grade equation will help determine responsibility for the problem.

The USDA yield grade equation has three components. The first component is the amount of backfat at the 12th rib at slaughter. A carcass with no backfat receives a preliminary yield grade of 2.0. Each additional tenth of an inch of backfat increases the preliminary yield grade by 0.25. For example, a carcass with 0.6 inches of backfat would receive a preliminary yield grade of 3.5.

The second component of the equation is the relationship between hot carcass weight and ribeye area in square inches. A carcass that weighs 500 pounds has a required ribeye area of 9.8 inches. For each 100-pound increase of hot carcass weight, the required ribeye area increases by 1.2 square inches, i.e., a 700-pound carcass would require a 12.2-square-inch ribeye. For every square inch that the measured ribeye area is less than the required ribeye area, 0.3 is added to the preliminary yield grade. For every square inch that the measured ribeye area is greater than the required ribeye area, 0.3 is subtracted from the preliminary yield grade.

The third component of the equation is determined by the amount of internal or kidney, pelvic, and heart (KPH) fat present within the carcass. An average carcass has a KPH value of 3.5%. For each percent greater than 3.5%, 0.2 is added to the preliminary yield grade. For each percent lower than 3.5%, 0.2 is subtracted from the preliminary yield grade. Most cattle, including the Kentucky FSBI cattle, have KPH measurements less than 3.5%. Most yield grade 4 and 5 carcasses are the result of excessive backfat. A contributor to undesirable yield grade is also having a ribeye smaller than the required size for carcass weight. Internal fat deposition, while a part of the yield grade equation, has little practical significance in causing a carcass to have an undesirable yield grade.

Forty-one steers and 11 heifers had a yield grade of 5 (Table 2). Overfeeding is the normal cause of a yield grade 5. The best indicator of overfeeding is the amount of backfat present on the carcass at the time of slaughter. Animals are usually slaughtered with backfat ranging from 0.3 inches to 0.7 inches. The average amount of backfat on all 2003 Kentucky FSBI calves was 0.57 inches.

The average amount of backfat on the 11 heifers was 1.17 inches and 1.18 inches for the 41 steers. The least amount of backfat any of the yield grade 5 carcasses had was 0.8 inches, with the majority having greater than 1 inch of backfat. This is an excessive amount of backfat and shows that these animals were fed too long, creating the high number of yield grade 5 carcasses (see Table 2).

In this data set, 127 steers and 80 heifers received a yield grade of 4 (Tables 3 and 4). Fifty-nine of the 80 heifers had 0.8 inches or greater of backfat, indicating overfeeding. However, a majority of the heifers also had a smaller ribeye area than the amount required for their hot carcass weight to avoid an upward adjustment in yield grade. Average hot carcass weight of the heifers was 837 pounds, requiring a ribeye area of 13.84 square inches. The average ribeye area for the 80 heifers was 12.69 inches, or greater than 1 square inch less than the required amount. Fourteen of the 80 heifers had ribeye areas more than 2 square inches less than required for their hot carcass weight (see Table 3).

Seventy-eight of the 127 steers receiving a yield grade 4 had 0.8 inches or greater of backfat. Similar to the heifers, however, many also had a smaller than required ribeye area. The average hot carcass weight for these 127 steers was 928 pounds, requiring a 15-square-inch ribeye. The average ribeye for the 127 steers was 13.25 square inches, 1.75 square inches less than the amount required. Forty-eight of the 127 steers had a ribeye area greater than 2 square inches smaller than the amount required, while an additional 12 had a ribeye area greater than 3 inches smaller than the amount required for hot carcass weight (see Table 4). These steers and heifers

Table 2. Yield grade 5 carcasses (steers and heifers).

	Yield Grade	Backfat	Hot Carcass Wt.	Ribeye Area	KPH
Average	5.40	1.17	984	13.3	2.47
High	6.44	1.6	1172	15.9	4.0
Low	5.00	0.8	713	8.3	1.5

Table 3. Yield grade 4 carcasses (heifers only).

	Yield Grade	Backfat	Hot Carcass Wt.	Ribeye Area	KPH
Average	4.41	0.88	837	12.69	2.74
High	4.97	1.2	996	15.4	4.0
Low	4.00	0.52	659	8.7	2.0

received high yield grades primarily due to two factors. The majority were overfed, resulting in excessive backfat. In addition, several had a much smaller ribeye area than the amount required for the hot carcass weight. Both factors contributed to significant discounts in value for these yield grade 4 and 5 carcasses.

Impact

Currently, greater than 50% of all finished cattle in the United States are marketed on some type of grid. The grid analysis that follows is only intended to help place economic values on the carcass data received. It is not meant to imply that these figures are actual returns and/or premium and discount levels for Kentucky calves in the Five State Beef Initiative.

The USDA Direct Slaughter Cattle Premiums and Discounts report was used as the value-based system for these cattle. This report is published on a weekly basis by the USDA Market News Service and is considered to provide an average of all grids. The report for the week of July 7, 2003, was used in conducting this analysis. Value adjustments in this report are shown in Table 5.

This premium and discount schedule was used to determine a value for all 1,598 Kentucky FSBI cattle. As expected, there was great variation in the value of the cattle. The carcass earning the greatest premium level per hundredweight was a heifer with a quality grade of Prime and a yield grade of 2.96. This carcass earned a premium of $7.45 per hundredweight, or $54 total. The carcass with the greatest discount had a quality grade of Select, a yield grade of 4, and a carcass weight greater than 1,000 pounds. This carcass was discounted $47.38 per hundredweight, or more than $500 total.

A comparison of the top 25% and the bottom 25% of the cattle is shown in Table 6. The top 25% received a $2.37 average premium per hundredweight, or an average total premium of $18.66 per head. The bottom 25% received an average discount of $20.40 per hundredweight, or $191.49 per head.

There is only a small difference in quality grade, less than one marbling score between the top 25% and the bottom 25%. Both groups were in the Choice quality grade. There were Choice and Prime carcasses in the bottom 25%. This suggests that quality grade may not be the primary factor in determining the value of animals sold on a grid. Factors accounting for carcass discounts as discussed below may be more important.

Hot carcass weight was quite different for the two groups. Average hot carcass weight for the bottom 25% was 130 pounds heavier than the top 25%. Of the 400 carcasses in the bottom 25%, 236 received discounts due to excessive hot carcass weight. One hundred and thirty of these carcasses were over 1,000 pounds and received sizable discounts.

An additional factor was the amount of yield grade 4 and 5 discounts received among the bottom 25% of the carcasses. On average, there was an entire yield grade difference between the top 25% and the bottom 25%. Within the bottom 25%, 242 carcasses out of 400 received discounts for being a yield grade 4 or 5.

This grid exercise was not intended to downplay the quality of cattle in the data set. It was discussed earlier that Kentucky cattle exceeded industry averages in many areas. Rather, the intent is to show the wide variation existing among the cattle. This variation in premium and discount levels drives home the importance of knowing something about the cattle being fed.

This grid exercise also makes clear the importance of marketing cattle through the appropriate channels. If the upper 25% of these cattle had been sold on a live weight basis, which would be similar to the grid price levels drawing no premium or discount, the feedlot operator would have been losing significant premiums (Table 6, $18.66 per head) that could have been obtained. However, if the feedlot operator had sold the bottom 25% on a grid such as the one used in this analysis, a large dollar loss (Table 6, $191.49 per head) would have been the result.

Of the 1,598 calves that were included in this hypothetical grid-pricing analysis, 859 received discounts, while 489 received premiums. If those cattle receiving premiums had been sold on a grid like the one used in the analysis, they would have returned $16.67 per head above the base price of the grid. On the other hand, if those cattle receiving discounts had been sold on a grid, they would have lost an average of $124.37 per head below the base price of the grid (Table 7). This clearly shows how valuable carcass data can be to those feeding cattle. If there is historic data of how cattle would grade, they could be marketed in the most appropriate way to greatly increase returns per head.

Given the large range of values shown in this simple analysis, it is clear that cattle feeders should be willing to pay more

Table 4. Yield grade 4 carcasses (steers only).

	Yield Grade	Backfat	Hot Carcass Wt.	Ribeye Area	KPH
Average	4.39	0.84	927	13.25	2.44
High	4.97	1.40	1114	18.4	4.0
Low	4.00	0.42	647	8.8	1.5

Table 5. National direct slaughter cattle—premiums and discounts, June 7, 2003.

Quality Grade	Premium/ Discount	Yield Grade	Premium/ Discount	Hot Carcass Wt.	Premium/ Discount
Prime	$6.07	1.0-2.0	$2.92	400-500	($24.08)
Avg. Choice	2.08	2.0-2.5	1.79	500-550	(16.17)
Choice	0.00	2.5-3.0	1.38	550-600	(4.08)
Select	(10.40)	3.0-3.5	0.00	600-900	0.00
Standard	(18.73)	3.5-4.0	0.00	900-950	(1.25)
Hard bone	(23.92)	4.0-5.0	(13.18)	950-1000	(7.83)
Dark cutter	(28.13)	5.0 and up	(18.31)	Over 1000	(18.67)

Table 6. Grid pricing analysis of 1,598 KY FSBI calves.

	Carcass Wt.	Marbling Score	Yield Grade	Premium/ Discount/ Cwt.	Premium/ Discount/ Head
Top 25%	792.3	MT23	2.90	$2.37	$18.66
Average	827.2	SM56	3.22	(6.87)	(61.75)
Bottom 25%	921.4	SM55	3.92	(20.40)	(191.49)

Table 7. Cattle earning premiums vs. cattle earning discounts.

	Premium/ Discount per Cwt.	Premium/ Discount per Head
Cattle earning premiums	$2.11	$16.67
Cattle earning discounts	(13.98)	(124.37)

for the right type of cattle. It is hoped that this work has also shown the value of having carcass data. Even if the quality of the Kentucky FSBI cattle were unchanged, knowing something about how they would perform on the rail could have eliminated costly marketing mistakes. The higher quality cattle could have been targeted to a quality-based grid, and the poorer quality cattle could have been sold through other means.

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