Beef Cattle Research — 2008

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ANTIMICROBIAL INGREDIENTS AFFECT BEEF SNACK STICK QUALITY

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Introduction

The Centers for Disease Control and Prevention estimate that 2,500 people become infected with listerosis each year by consuming food containing *Listeria monocytogenes*. Certain ready-to-eat meat and poultry products, particularly deli meats and hot dogs, are considered high risk products based on a *Listeria* risk assessment performed by the Centers for Disease Control and Prevention, the U.S. Food and Drug Administration, and the U.S. Department of Agriculture Food Safety and Inspection Service.

Meat and poultry processors use various strategies to minimize *L. monocytogenes* contamination in ready-to-eat products; one strategy is inclusion of antimicrobial ingredients. Meat snacks, including snack sticks, are popular items in the United States; $3 million of meat snacks were sold in the United States during 2007. However, these snacks typically are not produced with antimicrobial ingredients. Ional[2], Ional LC, and PURSAL Opti.Form PD4[3] are three organic acid salts that can be added to product formulations to limit *L. monocytogenes* growth. Ional contains buffered sodium citrate, and Ional LC is a combination of buffered sodium citrate and sodium diacetate that is optimized for *L. monocytogenes* control. Opti.Form contains sodium lactate and sodium diacetate. Inclusion of buffered sodium citrate is limited by the USDA Food Safety and Inspection Service to 1.3% in a formulation, but higher levels might be needed for effective *L. monocytogenes* control. Our objective was to evaluate quality characteristics and consumer preference of beef snack sticks formulated with these three antimicrobial ingredients.

Experimental Procedures

Fresh beef trimmings and beef fat obtained from the Kansas State University (KSU) Meat Lab were ground and then blended with a snack stick seasoning and cure salt (6.25% sodium nitrite). Eight treatments were formulated using 2.5% Opti.Form; 1.3, 2.5, or 3.5% Ional; 1.3, 2.5, or 3.5% Ional LC, or no antimicrobial addition (control) based on meat block weight. Meat batter was stuffed into 0.67-inch diameter collagen casings and thermally processed in a commercial smokehouse until the internal product temperature reached 155°F. After cooking, beef sticks were chilled overnight in a cooler and vacuum packaged (day 0). Smokehouse yield for each treatment was calculated (100 × Weight of thermally processed sticks/Weight of raw sticks). Treatments were replicated on three separate production days.

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[1]Department of Statistics.
[2]Ional and Ional LC are registered trademarks of World Technology Ingredients, Inc., Jefferson, GA.
[3]PURSAL Opti.Form PD4 is a registered trademark of PURAC America, Inc., Lincolnshire, IL.

Vacuum packaged beef snack sticks were stored up to 112 days in a 34°F walk-in cooler. Moisture, fat, and protein content were analyzed from samples collected on day 0 for each treatment. Water activity and pH levels for each of the eight treatments were determined on days 0, 28, 56, 84, and 112 of storage. Sensory analysis was conducted at the KSU Meat Sensory Lab on day 28 using a trained panel. Twelve panelists rated each treatment for sensory attributes on an eight-point scale: 1 = not at all salty/biter/sour/spicy, abundant off flavor, extremely soft/undesirable; 8 = extremely salty/bitter/sour/spicy, no off flavor, extremely firm/desirable. Warner-Bratzler Shear Force (WBSF) was measured on day 28. On day 30 of storage, 180 consumer panelists ranked snack stick samples for saltiness (1 = lacking saltiness extremely; 7 = extremely too salty) and overall acceptability (1 = dislike extremely; 7 = like extremely).

Results and Discussion

Smokehouse yield and WBSF averaged 76.34% and 13.16 lbs., respectively, and were not affected by addition of antimicrobial ingredients (Table 1). Fat, moisture, and protein, were also unaffected by antimicrobial ingredient additional and averaged 23.82%, 44.45%, and 22.94%, respectively.

Use of any of these antimicrobials reduced beef snack stick water activity to 0.923 or less compared with 0.928 for the control. Some strains of *L. monocytogenes* are capable of growing at a water activity of 0.90 under ideal conditions, but most are inhibited from growing at a water activity of 0.92. Reducing water activity in beef snack sticks closer to the minimum for growth in combination with other hurdles makes it more challenging for the organism to grow. Compared with the control, pH level of beef snack sticks declined with addition of all levels of Ional or Ional LC but not with 2.5% Opti.Form. For both water activity and pH, significant differences ($P<0.05$) were found for days of storage, but no treatment by day interaction was observed. During storage, overall pH declined from 5.72 on day 0 to 5.48 on day 84. Water activity decreased from 0.917 on day 0 to 0.912 on day 84.

Trained sensory panelists found beef snack sticks containing a higher percentage of antimicrobial ingredients to be softer and lower in overall acceptability than those containing a lower percentage or no antimicrobial at all. As antimicrobial level increased, perception of snack stick sourness and saltiness also increased. Panelists tended to score snack sticks with a higher percentage of antimicrobial ingredients higher in spice intensity. Bitterness and off-flavor scores of snack sticks containing antimicrobials were similar to the control.

Consumer panelists found the control beef snack sticks to be less salty than those with added ingredients, and perceptions of saltiness increased as antimicrobial level increased. Beef snack sticks containing 2.5 and 3.5% Ional were perceived to be the most salty. Snack sticks containing 3.5% Ional and Ional LC were ranked lowest in overall consumer acceptability, while sticks formulated with 1.3% Ional were the most acceptable. Consumers' perceptions of saltiness and overall acceptability had an inverse relationship.

Implications

Incorporating currently approved levels (1.3% Ional and Ional LC) of some antimicrobial ingredients into beef snack sticks can enhance consumer acceptability of beef snack sticks without reducing yield and impart a slightly tangier flavor to the product**.**

Table 1. Quality Traits of Beef Snack Sticks Formulated with Three Antimicrobial Ingredients

	Treatments							
Trait	Control	Ional 1.3%	Ional 2.5%	Ional 3.5%	Ional LC 1.3%	Ional LC 2.5%	Ional LC 3.5%	Opti.Form 2.5%
Fat, %	24.58	23.79	24.24	23.73	23.12	23.22	23.40	24.49
Moisture, %	44.38	45.37	43.19	42.48	44.98	44.29	43.46	47.44
Protein, %	23.49	22.61	22.91	22.78	23.49	22.92	22.54	22.82
pH	5.75[e]	5.59[cd]	5.49[ab]	5.41[a]	5.63[d]	5.56[bcd]	5.53[bc]	5.76[e]
Water activity, a_w	0.928[e]	0.923[d]	0.911[b]	0.903[a]	0.920[d]	0.909[b]	0.902[a]	0.917[c]
Smokehouse yield, %	76.93	75.81	76.26	76.63	75.55	76.21	76.57	76.75
Warner-Bratzler shear force, lb	13.38	13.45	13.62	13.23	12.72	12.83	12.32	13.76
Sensory traits[1]								
Texture	6.16[e]	5.08[c]	4.43[b]	3.36[a]	5.41[cd]	4.51[b]	3.73[a]	5.88[de]
Saltiness	4.68[a]	5.04[ab]	5.76[d]	5.80[d]	5.08[ac]	5.41[bcd]	5.78[d]	4.82[a]
Bitterness	1.13	1.10	1.15	1.24	1.20	1.18	1.26	1.18
Sourness	2.31[a]	2.80[b]	3.57[c]	4.04[d]	2.53[a]	3.34[c]	4.15[d]	2.47[a]
Spice	4.97[a]	5.16[ab]	5.54[c]	5.45[bc]	4.90[a]	5.25[abc]	5.37[bc]	5.00[a]
Off flavor	7.81	7.84	7.87	7.88	7.82	7.84	7.84	7.67
Overall	5.80[c]	5.46[b]	5.21[b]	4.55[a]	5.78[c]	5.29[b]	4.77[a]	5.82[c]
Consumer traits[2]								
Overall acceptability	4.84[c]	5.11[d]	4.81[c]	4.22[a]	5.06[cd]	4.96[cd]	4.48[b]	4.97[cd]
Saltiness	3.67[a]	3.98[b]	4.65[de]	4.78[e]	3.87[b]	4.37[c]	4.56[cd]	3.96[b]

[abcde]Means within a row without a common superscript letter differ ($P<0.05$).
[1]1 = not at all salty/bitter/sour/spicy, abundant off flavor, extremely soft/undesirable; 8 = extremely salty/bitter/sour/spicy, no off flavor, extremely firm/desirable.
[2]Overall acceptability (1=dislike extremely; 7=like extremely); Saltiness (1=lacking saltiness extremely; 7=extremely too salty).

BLADE TENDERIZATION IN COMBINATION WITH INJECTION ENHANCEMENT CONTAINING AN ENZYME INCREASES TENDERNESS OF STRIP STEAKS FROM FED CULL COWS

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Introduction

Cow meat is tougher than meat from young steers and heifers and typically has a less desirable, darker color. It is generally assumed that cow meat will need to be ground or have some form of post-mortem tenderization applied to be merchandized as a whole muscle product. Most cow steaks are fabricated by food service providers for their customers with different specifications for aging and post-mortem tenderization application. Aging, blade tenderization, and injection enhancement are commonly used on cow meat to increase tenderness. It is unknown if an extended aging period is needed in addition to a combination of tenderization and injection enhancement to improve tenderness. If shorter aging periods can be used without compromising tenderness, then aging costs would be greatly reduced. Our objective was to determine the effects of days of aging and an enhancement protocol on tenderness of strip loin steaks from fed cull cows.

Experimental Procedures

This study used strip loins from 31 cull cows fed a high-concentrate diet for 60 days. The strip loin from both the right and left sides were removed, vacuum packaged, and randomly assigned to 7 or 28 days of aging. Following aging, the loins were divided in half, vacuum packaged, and frozen until further processing. Strip loin halves that were to be enhanced were subsequently thawed for 36 hours, blade tenderized using one pass through a blade tenderizer, and injected at 10% of their weight with a solution containing 0.35% phosphate, 0.5% salt, and 0.023% bromelin. After pumping, strip halves were allowed 5 minutes to drip before they were vacuum packaged and refrozen. Using a band saw, all strip halves were cut frozen into three 1-inch-thick steaks. Steaks were randomly assigned for Warner-Bratzler shear force (WBSF), sensory panel, and further laboratory analysis.

Frozen steaks for WBSF were thawed overnight, weighed in the package, removed from the package, and re-weighed to determine package loss percentages. Vacuum package loss was calculated by 100 × (thawed steak in package weight – thawed steak weight)/thawed steak in package weight. Steaks were cooked to an internal temperature of 158°F, cooled for 30 minutes, and re-weighed to determine cooking loss percentages. Cooking loss was calculated by 100 × (thawed steak weight – cooked steak weight)/thawed steak weight. Steaks were chilled overnight, and six 0.5-inch cores were removed and sheared once perpendicular to the direction of the muscle fibers using the

[1]Department of Statistics.

WBSF attachment on the Instron Universal Testing Machine.

Sensory panel steaks were cooked to an internal temperature of 158°F and served warm to a trained sensory panel. Myofibrillar and overall tenderness, connective tissue amount, firmness, juiciness, beef flavor, and off flavor were scored on a scale of 1 to 8 with 1 = extremely tough, abundant, extremely soft, dry, extremely bland, and none; and 8 = extremely tender, none, extremely firm, extremely juicy, extremely intense, and none, respectively.

Warner-Bratzler Shear Force and moisture losses were analyzed as a split plot. Aging served as the whole plot in a completely randomized block with animal serving as the blocking factor and enhancement as the subplot. Sensory data were analyzed as a split plot in a randomized complete block design. Panel session was used as the block to account for the potential variation due to session.

Results and Discussion

Sensory panelists found steaks aged for 7 days were more juicy, had more detectable connective tissue (lower scores), and were firmer than steaks aged for 28 days (Table 1). Steaks aged for 7 days also tended to have more beef flavor than steaks aged 28 days. Steaks aged for 7 days were less tender and had lower pH values than steaks aged for 28 days. No differences were noted in vacuum package losses between steaks aged 7 or 28 days.

Enhanced and non-enhanced steaks had similar sensory panel juiciness scores and vacuum package moisture losses (Table 2). Sensory panelists found enhanced steaks to have less beef flavor (lower score), be less firm, and have less detectable connective tissue than non-enhanced steaks. Enhanced steaks were more tender according to WBSF values and had a higher pH than non-enhanced steaks.

Aging ×enhancement interactions ($P<0.05$) were observed for sensory panel myofibrillar tenderness, overall tenderness, and off flavor scores and percentage of cooking loss (Table 3). After 7 days of aging, enhanced steaks had more myofibrillar tenderness than non-enhanced steaks. Enhanced steaks aged for 28 days had the most myofibrillar tenderness compared with the other three treatments. In addition, non-enhanced steaks aged 28 days had more myofibrillar tenderness than the non-enhanced steaks aged for 7 days. Enhancement of steaks resulted in the highest overall tenderness scores compared with non-enhanced steaks. However, non-enhanced steaks aged 28 days had higher overall tenderness scores than non-enhanced steaks aged for 7 days. Sensory panelists noted that enhanced steaks had more off-flavors than non-enhanced steaks. In addition, enhanced steaks aged for 7 days had more off-flavor than enhanced steaks aged for 28 days. Non-enhanced steaks had more cooking loss than enhanced steaks, and enhanced steaks aged for 7 days had less cooking loss than enhanced steaks aged for 28 days.

As expected, enhancement increased pH due to the enhancement solution. While vacuum package loss did not differ due to the enhancement, enhanced steaks had higher initial moisture due to water added in the enhancement process and retained a higher percentage of moisture during the cooking process. However, enhancement slightly reduced beef flavor intensity and increased off-flavors. Overall, enhancement improved tenderness as indicated by both a sensory panel and WBSF. Aging improved tenderness as indicated by WBSF, but the sensory panel indicated improved tenderness for the non-enhanced steaks only.

Implications

Aging cow strip loins for 28 days to achieve maximum tenderness is not necessary when a combination of injection enhancement containing an enzyme and blade tenderization are used. Shorter aging periods can be used without compromising tenderness, resulting in reduced costs associated with aging.

Table 1. Sensory Panel and Warner-Bratzler Shear Force (WBSF) Values for Strip Steaks Aged for 7 or 28 Days

	Aging Time			
Trait	7 days	28 days	SE	P-value
Juiciness	5.5	5.2	0.07	0.0002
Beef flavor	5.1	5.0	0.04	0.06
Connective tissue	6.3	6.7	0.07	<0.0001
Firmness	5.0	4.6	0.08	0.0004
WBSF, lb	8.2	6.5	0.23	<0.0001
Vacuum package loss, %	2.6	2.7	0.08	0.43
pH	5.7	5.8	0.01	<0.0001

Connective tissue amount, firmness, juiciness, and beef flavor scale: 1 = abundant, extremely soft, dry, extremely bland; and 8 = none, extremely firm, extremely juicy, extremely intense, respectively.

Table 2. Sensory Panel and Warner-Bratzler Shear Force (WBSF) Values for Enhanced and Non-enhanced Strip Steaks

Trait	Non-enhanced	Enhanced	SE	P-value
Juiciness	5.4	5.3	0.07	0.10
Beef flavor	5.4	4.6	0.04	<0.0001
Connective tissue	5.6	7.3	0.07	<0.0001
Firmness	6.2	3.5	0.08	<0.0001
WBSF, lb	10.4	4.2	0.23	<0.0001
Vacuum package loss, %	2.6	2.7	0.08	0.48
pH	5.7	5.9	0.01	<0.0001

Connective tissue amount, firmness, juiciness, and beef flavor scale: 1 = abundant, extremely soft, dry, extremely bland; and 8 = none, extremely firm, extremely juicy, extremely intense, respectively.

Table 3. Sensory Panel Mean Values for Enhanced and Non-enhanced Strip Steaks Aged for 7 or 28 Days

	Cow				
	Non-enhanced		Enhanced		
Trait	7 days	28 days	7 days	28 days	SE
Myofibrillar tenderness	4.2[a]	4.9[b]	7.3[c]	7.6[d]	0.11
Overall tenderness	4.4[a]	5.0[b]	7.6[c]	7.6[c]	0.15
Off flavor	6.9[c]	6.6[c]	5.7[a]	5.9[b]	0.07
Cooking loss, %	29.4[c]	29.4[c]	26.3[a]	28.4[b]	0.62

[abcd]Means within a row without a common superscript letter differ (P<0.05).
Myofibrillar and overall tenderness, and off flavor scale: 1 = extremely tough, and extreme off flavor; and 8 = extremely tender, and none, respectively.

OPTIMIZING GROUND BEEF LEAN SOURCES TO MAXIMIZE DISPLAY COLOR LIFE[1]

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Introduction

It is widely accepted that meat color is the most important influencer of consumers' meat purchasing decisions. Understanding how ground cow meat discolors is, and will continue to be, very important as a large influx of cull dairy cows in the U.S. meat supply is predicted. Optimal management and more timely marketing of cows should result in increased revenue for the beef industry. However, many valuable by-products from cows have been labeled as specified risk materials accompanied by a lost value. Thus, there is an unprecedented need to add value to cow meat. Research characterizing cow muscles and how to optimally use them for ground beef production could increase the value of cull cows and result in improved management and use of meat from cull cows.

Our objectives were to evaluate the display color life of ground beef from different muscle combinations that vary in pre-established color stability values and determine if using beef or dairy cow meat affects color dynamics and stability of ground beef.

Experimental Procedures

Sampling. For the first objective, six ground beef combinations were formulated using three cow muscles of predetermined color stability: *M. longissimus thoracis* (high stability), *M. semimembranosus* (intermediate stability), and *M. triceps brachii* (low stability). While ground *M. supraspinatus* exhibited slightly poorer color stability than ground *M. triceps brachii*, sufficient product was not available for *M. supraspinatus* muscle due to its small size. The ground beef formulation combinations were: 50% high + 50% intermediate; 50% high + 50% low; 50% intermediate + 50% low; 33.3% high + 33.3% intermediate + 33.3% low; 75% high + 25% low; and 25% high + 75% low muscles. Each mixture was formulated at both 90% and 80% lean points for a total of 12 treatment combinations. Beef trim, approximately 50% fat and 50% lean, from A-maturity carcasses was obtained 2 days postmortem and used to achieve the desired lean percentage for each treatment. Lean and fat were coarse-ground and then fine-ground. Two 0.25-lb patties from each batch were formed by hand using a mold.

To accomplish the second objective (beef cow vs. dairy cow ground beef), inside rounds from beef cows (n = 4) and dairy cows (n = 4) were obtained 5 days postmortem from a commercial abattoir. Inside round muscle (*M. semimembranosus*) was used because it was identified as an intermediate color stability muscle. All muscles were trimmed of visible

[1]This research was funded by beef and veal producers and importers through their $1-per-head checkoff and was produced for the Cattlemen's Beef Board by the National Cattlemen's Beef Association. The authors extend appreciation to Cargill Meat Solutions, Wichita, KS, for product, use of equipment, and personnel support.

fat. The lean was then blended to obtain three different lean-source combinations: 100% beef cow lean, 50% beef cow lean and 50% dairy cow lean, and 100% dairy cow lean. For each lean-source combination, the ground beef was formulated to both 90% and 80% lean points using 50% lean/50% fat young beef trim and also 50% lean/50% mature cow trim, for a total of 12 (3 blends x 2 lean points x 2 fat sources) treatment combinations.

Packaging and Storage. Ground beef patties were placed in rigid plastic trays and covered with oxygen-barrier film, and patties were packaged in high-oxygen (80% O_2, 20% CO_2) modified atmosphere packaging (MAP). Because measuring instrumental color in MAP requires opening a package, two extra packages of each treatment were made for day 0 and day 2 of display only, and those for use on day 4 were also evaluated by the visual panel. Packages were stored in dark conditions for 5 days at 34-36°F and then displayed under continuous fluorescent lighting for 4 days.

Color Analyses. Instrumental color (L*, a*, and b*) was measured using a HunterLab MiniScan™ at 0, 0.5, 1, 2, 3, and 4 days of display. Instrumental color was scanned in triplicate and averaged. Initial visual color was evaluated on an 8-point scale, and panelists were instructed to score patties to the nearest 0.5 visual color unit. The scale used for initial color was: 1 = bleached, pale red, 2 = slightly cherry red, 3 = moderately light cherry red, 4 = cherry red, 5 = slightly dark red, 6 = moderately dark red, 7 = dark red, and 8 = very dark red. Display visual color was scored for 5 days on an 8-point scale to the nearest 0.5 unit according to the following scale: 1 = very bright red or pinkish red, 2 = bright red or pinkish red, 3 = dull red or pinkish red, 4 = slightly dark red or pinkish red, 5 = reddish tan or pinkish tan, 6 = moderately dark red or reddish tan or moderately dark pinkish red or pinkish tan, 7 = tannish red or tannish pink, and 8 = tan to brown. Panelists considered a score of 5.5 to be borderline acceptable color.

Results

There was a three-way interaction (treatment x lean point x day of display) for visual color and instrumental color. The a* (redness) instrumental color value has precedence of being a good indicator of color stability; a* values are reported in Tables 1 and 2. Visual score data is presented in Tables 3 and 4.

The combination of 75% high + 25% low (80/20 and 90/10 lean points) and 50% high + 50% intermediate (80/20 lean point) yielded the most desirable a* value by day 4 of display (Table 1). Combinations containing 50% or more low color stability muscles had the least desirable a* values by day 4 of display. Thus, the inclusion of low color stability muscles at greater than 25% had negative effects on the overall a* value during display. Visual data (Table 3) supports these results.

Ground dairy cow inside round, fattened with either beef 50/50 trim or cow 50/50 trim, had higher a* values throughout display than ground beef cow inside round (Table 2). By day 4, a* values of ground diary cow inside round were clearly superior (P<0.001) to ground beef cow inside round. Visual data (Table 4) supports these results.

Implications:

The inclusion of muscles low in color stability at levels greater than 25% will cause negative effects on color life of ground beef. Moreover, the use of muscles with high color stability can be optimally managed to lengthen the display life of ground beef. Ground beef made from dairy cow muscle has superior color display life properties compared with ground beef from beef cows.

Results of this study offer much-needed information on how to better manage ground beef from cows by including or excluding certain muscles as needed and also by including ground beef from dairy cows. The potential for adding value to cull cows is clearly evident, provided that lean is managed in the most optimal way.

Table 1. a*(redness) Least Squares Means for Ground Beef Patties Sourced From Muscles of High, Intermediate, and Low Color Stability, Formulated to 80% and 90% Lean Points, and Displayed for 4 Days

	Day 0		Day 2		Day 4	
Treatment	80/20	90/10	80/20	90/10	80/20	90/10
75% high + 25% low	30.46^{a}	27.34^{b}	26.61^{b}	25.20^{b}	23.41^{b}	19.85^{c}
50% high + 50% int.	30.52^{a}	30.98^{a}	17.46^{d}	20.12^{c}	16.47^{d}	14.87^{e}
50% high + 50% low	30.10^{ab}	30.87^{a}	14.44^{e}	14.55^{e}	10.70^{h}	13.73^{eg}
50% int. + 50% low	31.48^{a}	33.09^{a}	11.70^{g}	13.49^{f}	12.50^{g}	12.08^{g}
33% high + 33% int. + 33% low	30.02^{ab}	26.45^{b}	18.12^{d}	20.50^{c}	12.45^{g}	13.49^{eg}
25% high + 75% low	32.20^{a}	31.79^{a}	19.46^{cd}	18.00^{d}	10.05^{h}	12.95^{eg}

$^{a-h}$Means within a row or column without a common superscript letter differ (P<0.05).

Table 2. a* Least Squares Means for Ground Beef Patties Sourced from Dairy Cows and Beef Cows, Formulated to 80% and 90% Lean Points with Young or Mature Beef Fat, and Displayed for 4 Days

Treatment		Day 0		Day 2		Day 4	
Lean Source	Fat Source	80/20	90/10	80/20	90/10	80/20	90/10
Beef	Beef trim	27.29^{b}	25.36^{bc}	13.62^{g}	11.79^{h}	10.46^{i}	10.22^{i}
Beef	Cow trim	27.95^{b}	27.67^{b}	17.65^{f}	16.71^{f}	12.06^{g}	13.28^{g}
Dairy	Beef trim	29.60^{a}	29.37^{a}	23.40^{d}	25.37^{c}	18.26^{ef}	20.01^{e}
Dairy	Cow trim	30.34^{a}	29.88^{a}	27.30^{b}	26.26^{bc}	24.64^{cd}	26.28^{c}
Beef + Dairy	Beef trim	29.43^{a}	28.24^{ab}	18.62	20.20^{e}	14.77^{g}	17.83^{f}
Beef + Dairy	Cow trim	29.09^{a}	29.18^{a}	22.03^{d}	23.82^{d}	18.93^{ef}	20.22^{e}

$^{a-i}$Means within a row or column without a common superscript letter differ (P<0.05).

Table 3. Display Color Score[a] for Ground Beef Patties Sourced from Muscles of High, Intermediate, and Low Color Stability, Formulated to 80% and 90% Lean Points, and Displayed for 4 Days

	Day 0		Day 1		Day 2		Day 3		Day 4	
Treatment	80/20	90/10	80/20	90/10	80/20	90/10	80/20	90/10	80/20	90/10
75% high + 25% low	1.8^{b}	2.1^{b}	2.2^{b}	2.4^{c}	2.8^{cd}	3.1^{d}	3.2^{d}	3.3^{d}	6.3^{i}	6.7^{ij}
50% high + 50% int.	2.0^{b}	2.1^{b}	2.6^{c}	2.7^{cd}	3.7^{e}	4.4^{ef}	3.5^{d}	4.6^{f}	7.2^{j}	7.0^{ij}
50% high + 50% low	2.4^{c}	2.5^{c}	3.2^{d}	3.4^{d}	5.4^{g}	5.8^{h}	3.8^{e}	3.9^{e}	8.0^{k}	8.0^{k}
50% int. + 50% low	3.4^{d}	3.4^{d}	3.8^{e}	3.9^{e}	5.1^{f}	5.9^{h}	5.9^{h}	6.0^{h}	8.0^{k}	7.9^{k}
33% high + 33% int. + 33% low	3.1^{d}	3.3^{d}	3.3^{d}	3.6^{de}	4.7^{f}	5.0^{f}	4.6^{f}	5.5^{g}	8.0^{k}	8.0^{k}
25% high + 75% low	3.8^{e}	4.1^{e}	4.0^{e}	4.2^{e}	6.7^{i}	6.5^{i}	7.6^{jk}	7.5^{j}	8.0^{k}	8.0^{k}

[a]1 = very bright red or pinkish red, 2 = bright red or pinkish red, 3 = dull red or pinkish red, 4 = slightly dark red or pinkish red, 5 = reddish tan or pinkish tan, 6 = moderately dark red or reddish tan or moderately dark pinkish red or pinkish tan, 7 = tannish red or tannish pink, and 8 = tan to brown.
[b-k]Means within a row or column without a common superscript letter differ ($P<0.05$).

Table 4. Display Color Score[a] Means for Ground Beef Patties Sourced from Dairy Cows and Beef Cows, Formulated to 80% and 90% Lean Points, and Displayed for 4 Days

Treatment		Day 0		Day 1		Day 2		Day 3		Day 4	
Lean Source	Fat Source	80/20	90/10	80/20	90/10	80/20	90/10	80/20	90/10	80/20	90/10
Beef	Beef trim	1.8^{b}	2.2^{b}	3.8^{de}	3.6^{d}	5.8^{g}	6.0^{g}	6.6^{h}	6.3^{gh}	7.7^{ii}	7.2^{hi}
Beef	Cow trim	2.1^{b}	2.0^{b}	3.5^{d}	3.7^{d}	5.1^{f}	5.0^{f}	5.3^{f}	5.5^{fg}	6.8^{h}	6.7^{h}
Dairy	Beef trim	3.2^{c}	3.4^{cd}	3.3^{c}	3.5^{d}	3.2^{c}	3.4^{cd}	5.4^{f}	4.9^{f}	5.3^{f}	5.0^{f}
Dairy	Cow trim	3.6^{d}	3.3^{cd}	3.0^{c}	3.3^{c}	3.0^{c}	3.1^{c}	3.7^{d}	3.7^{d}	4.6^{e}	4.4^{e}
Beef + Dairy	Beef trim	2.9^{c}	3.0^{c}	3.6^{d}	3.8^{de}	4.2^{e}	4.4^{e}	5.8	5.7^{g}	6.2^{gh}	6.3^{gh}
Beef + Dairy	Cow trim	3.3^{cd}	3.5^{d}	3.4^{cd}	3.2^{c}	3.6^{d}	3.6^{d}	4.0^{e}	4.2^{e}	5.5^{fg}	5.7^{g}

[a]1 = very bright red or pinkish red, 2 = bright red or pinkish red, 3 = dull red or pinkish red, 4 = slightly dark red or pinkish red, 5 = reddish tan or pinkish tan, 6 = moderately dark red or reddish tan or moderately dark pinkish red or pinkish tan, 7 = tannish red or tannish pink, and 8 = tan to brown.
[b-i]Means within a row or column without a common superscript letter differ ($P<0.05$).

PACKAGING ATMOSPHERES ALTER BEEF TENDERNESS, FRESH COLOR STABILITY, AND INTERNAL COOKED COLOR[1]

J. P. Grobbel, M. E. Dikeman, M. C. Hunt, and G. A. Milliken[2]

Introduction

Several meat quality traits affect consumers' overall purchase decisions and satisfaction with meat products, but color is the major factor affecting purchasing decisions. According to some researchers, tenderness is the most important palatability attribute in consumers' overall eating experience. Case-ready packaging in the meat industry is growing at a rapid rate and generally includes modified atmosphere packaging (MAP) with specific gases. Advantages of MAP include use of a centralized location, improved sanitation control, more consistent products, and increased marketing flexibility. Packaging beef in high-oxygen (HiO_2) MAP results in a desirable bright red lean color but can have detrimental effects on other quality traits, including increased off-flavors and decreased tenderness. Use of carbon monoxide (CO) has been approved by USDA and the Food and Drug Administration for use at levels up to 0.4% in retail MAP. Products in MAP that include CO have improved beef color stability and extended display time.

Premature browning, originally discovered in ground beef, results when meat is cooked to temperatures lower than what is necessary to kill harmful pathogens but appears well done internally. This phenomenon is also found in whole muscle steaks and can be attributed to packaging environments, including HiO_2 MAP. Therefore, objectives of our study were to evaluate the effects of different gas compositions in different MAP systems vs. vacuum packaging on grain finished beef tenderness, display color stability, and internal cooked color.

Experimental Procedures

Strip loins (n=14 pairs) from USDA Select, A-maturity carcasses were assigned to either 14 day tenderness measurement or to display and then 18 or 28 day tenderness measurement. Loins were fabricated on day 7 postmortem into 1-inch-thick steaks. Seven steaks from the anterior end of the strip loin were cut and assigned to one of six packaging treatments or to initial tenderness measurement. Steaks 8-10 were cut posterior to the first seven steaks, cut in half and assigned to a packaging treatment, and used for internal cooked color determination. One full steak was used for initial tenderness. Packaging treatments were: vacuum packaging (VP); 80% O_2/20% CO_2 (HiO_2); 0.4% CO/35% CO_2/64.6%N_2 (ULO_2CO); 0.4% CO/99.6% CO_2 (ULO_2COCO_2); 0.4% CO/99.6% N_2 (ULO_2CON_2); or 0.4% CO/99.6% Ar (ULO_2COAr). Steaks packaged in HiO_2 MAP were held in dark storage at 35.6°F for 4 days,

[1]This project was funded by The Beef Checkoff and the Kansas Beef Council. The authors express appreciation to Cargill Meat Solutions, Wichita, KS, for the use of their facilities and equipment.

[2]Department of Statistics.

and all other steaks were held in the dark at 35.6°F for 14 days. Steaks were then displayed under fluorescent lighting for 7 days with instrumental color measured on day 0 and 7 of display. Ten trained color panelists assigned color scores. Instrumental tenderness was measured using Warner-Bratzler shear force (WBSF). Steaks for WBSF and cooked color were cooked to 158°F.

Results and Discussion

There was a packaging treatment × day interaction (P<0.01) for WBSF (Figure 1). Warner-Bratzler shear force values from strip loin steaks indicate that, as a system, HiO_2 MAP at day 18 postmortem resulted in steaks being less tender than those packaged in ULO_2 with CO MAP or VP at day 28 postmortem. On day 14 postmortem, WBSF was similar (P>0.05), and all treatments were more tender (*P*<0.01) on day 14 postmortem than on day 7 postmortem. Conversely, steaks packaged in HiO_2 MAP were less tender (*P*<0.05) than other treatments at the end of display, likely due to 10 days less aging time (18 vs. 28 days postmortem) resulting from a shorter dark storage period (4 days) for HiO_2 MAP than for ULO_2CO MAP and VP treatments (14 days). Steaks packaged in all packaging treatments used for 14 days postmortem WBSF were held for 7 days in the dark and then cooked for WBSF measurement. Dark storage times for HiO_2 and ULO_2 atmospheres were designed to replicate industry practice.

There was a packaging treatment × day interaction (P<0.001) for display visual color (Figure 2). Display color scores indicated that steaks from all treatments became darker (P<0.05) as day of display increased, as was expected. Steaks packaged in HiO_2 MAP were slightly brighter (*P*<0.05) according to display color scores than steaks packaged in ULO_2COAr or ULO_2CO MAP on day 0 of display. Vacuum-packaged steaks had the most consistent display color throughout the 7 days of display and changed only from bright purplish red or pink to dull purplish red or pink during the entire display period. Steaks in VP were expected to be stable in color and not change much throughout the 7 days of display; however, many consumers find the purplish red color of VP meat undesirable regardless of the consistent display color. Steaks packaged in HiO_2 MAP were an undesirable reddish tan by day 7 of display, whereas steaks packaged in the ULO_2CO MAP treatments were either dull red or slightly dark red by day 7 of display.

There was a packaging treatment × day interaction (P<0.001) for discoloration scores (Figure 3). Steaks packaged in VP or the four ULO_2 MAP blends with CO had little or no surface discoloration over the 7 days of display. Steaks packaged in HiO_2 MAP discolored faster (P<0.05) and to a greater extent (P<0.05) than those packaged in any of the ULO_2 MAP or VP treatments. Steaks packaged in HiO_2 MAP discolored (P<0.05) by day 4 of display and had 56% more (P<0.05) metmyoglobin discoloration than steaks packaged in any other packaging treatment. Including O_2 in the package allowed for oxidation of myoglobin and thus resulted in a reddish tan color by day 7 of display. Excluding O_2 from the package, as with VP or ULO_2CO MAP treatments, allows myoglobin to remain in a more stable form (red) longer and delays the onset of metmyoglobin (tan/brown) color formed through oxidation of myoglobin.

There was a packaging treatment main effect (P<0.001) for internal cooked color as assessed by a* value and saturation index (Figure 4). Steaks packaged in HiO_2 had the lowest (P<0.05) a* values (brownest) for internal cooked color of all packaging treatments. Steaks packaged in ULO_2COCO_2 and in VP had intermediate a* values, and those packaged in ULO_2COAr, ULO_2CO, and ULO_2CON_2 had the highest (P<0.05) a* values (reddest). Premature browning is defined by internal cooked color of meat that is brown at temperatures where it should still appear red in color and is related to the oxidative state of meat prior to cooking. Results indicated that steaks packaged in ULO_2COAr, ULO_2CO, and ULO_2CON_2 MAP had a redder ($P<0.05$) internal cooked color than steaks packaged in VP. Steaks were cooked to a medium degree of doneness (158°F), which should result in a pinkish internal color. Steaks packaged in HiO_2 MAP were brown inside at this temperature. This could pose a definite safety risk, especially if consumers cook intact steaks to an internal color and do not use a meat thermometer to determine a safe endpoint cook temperature.

In conclusion, results from this study indicated that steaks packaged in HiO_2 MAP have less display color stability than all other packaging treatments evaluated because they discolor faster and to a greater extent. Ultra-low oxygen + CO MAP and VP steaks had better fresh color stability and equal or better tenderness than steaks packaged in HiO_2 MAP. Packaging atmospheres altered internal cooked color, with steaks packaged in HiO_2 MAP exhibiting premature browning. Strip loin steaks packaged in the HiO_2 MAP system were less tender at the end of display than other packaging treatments, perhaps due to the shorter aging time associated with the HiO_2 MAP system.

Implications

Packaging beef in ULO_2CO MAP provides a bright red color with extended display color stability, allows for a longer aging time and increased tenderness, and results in an internal cooked color that is expected for a medium degree of doneness, all of which would are beneficial to the meat industry.

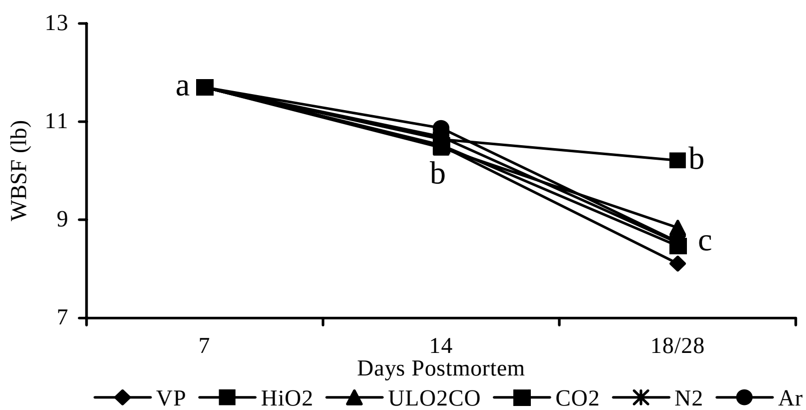


Figure 1. Packaging Treatment × Day Warner-Bratzler Shear Force Means for Strip Loin Steaks Packaged in Different Atmospheres.

[abc]Means without a common superscript letter differ ($P<0.05$).

VP = vacuum packaging; HiO_2 = 80%/O_2, 20%CO_2; ULO_2CO = 64% N_2, 35% CO_2, 0.4% CO; CO_2 = 99.6% CO_2, 0.4% CO; N_2 = 99.6% N_2, 0.4% CO; Ar = 99.6% Ar, 0.4% CO.

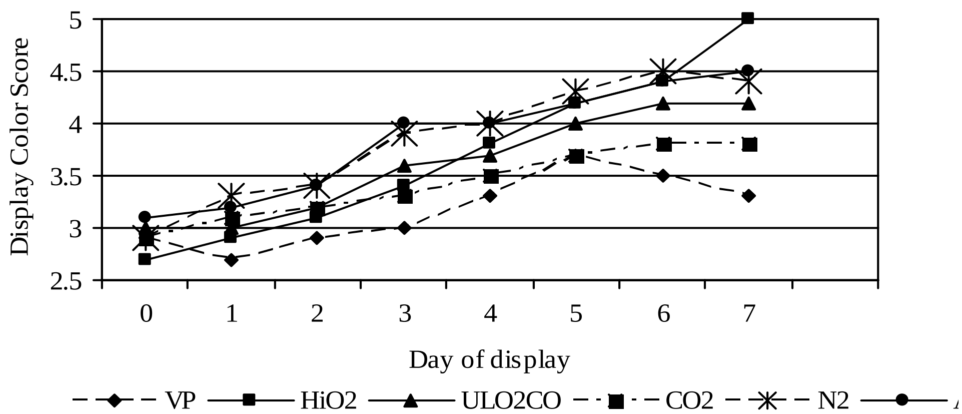


Figure 2. Display Color Score Means for Strip Loin Steaks Packaged in Different Atmospheres.

VP = vacuum packaging; HiO_2 = 80%/O_2, 20%CO_2; ULO_2CO = 64% N_2, 35% CO_2, 0.4% CO; CO_2 = 99.6% CO_2, 0.4% CO; N_2 = 99.6% N_2, 0.4% CO; Ar = 99.6% Ar, 0.4% CO.

Color score scale: 2 = bright red or pinkish red; 5 = reddish tan or pinkish tan.

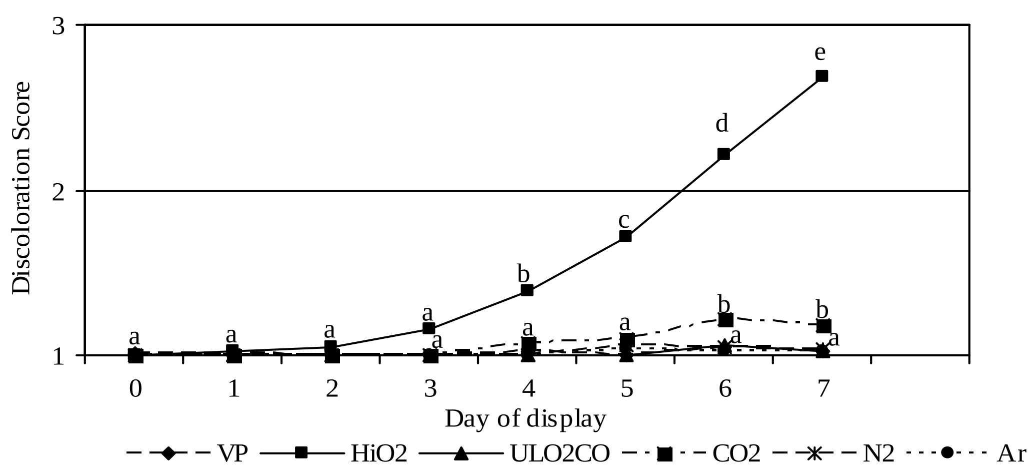


Figure 3. Display Discoloration Score Means for Strip Loin Steaks Packaged in Different Atmospheres.

[abc]Means without a common superscript letter differ ($P<0.05$).

VP = vacuum packaging; HiO_2 = 80%/O_2, 20%CO_2; ULO_2CO = 64% N_2, 35% CO_2, 0.4% CO; CO_2 = 99.6% CO_2, 0.4% CO; N_2 = 99.6% N_2, 0.4% CO; Ar = 99.6% Ar, 0.4% CO.

Discoloration score: 1= 0%, 2=1-19%, 3=20-39% metmyoglobin.

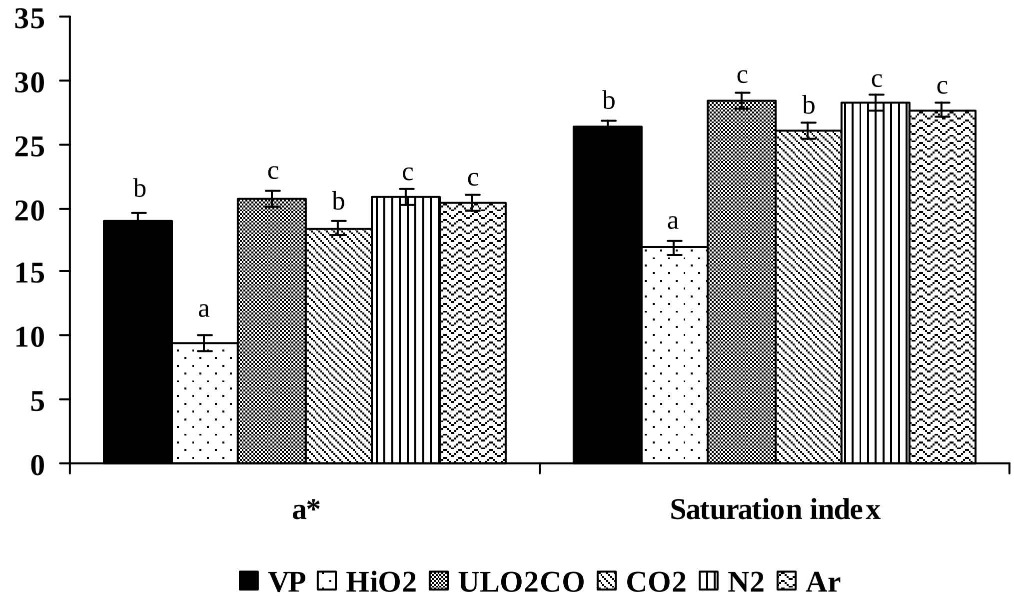


Figure 4. Instrumental Internal Cooked Color Means for Strip Loin Steaks Packaged in Different Atmospheres.

[abc]Means without a common superscript letter differ ($P<0.05$).

VP = vacuum packaging; HiO_2 = 80%/O_2, 20%CO_2; ULO_2CO = 64% N_2, 35% CO_2, 0.4% CO; CO_2 = 99.6% CO_2, 0.4% CO; N_2 = 99.6% N_2, 0.4% CO; Ar = 99.6% Ar, 0.4% CO.

PACKAGING ATMOSPHERES AND INJECTION ENHANCEMENT AFFECT BEEF TENDERNESS AND SENSORY TRAITS[1]

J. P. Grobbel, M. E. Dikeman, M. C. Hunt, and G. A. Milliken[2]

Introduction

Case-ready meat provides many benefits, including quality and safety. Meat packaged in high-oxygen (HiO_2) modified atmosphere packaging (MAP) has a desirable bright red display color but may have increased off-flavors and decreased tenderness. According to several international research reports, steaks aged and packaged in HiO_2 MAP had more off-flavor, including warmed-over flavor, and were less tender and juicy than steaks aged in vacuum packaging (VP). Research at Kansas State University found that injection-enhanced beef quadriceps muscles packaged in HiO_2 MAP were less tender and had more off-flavors than those in ultra-low oxygen MAP. Detrimental effects of O_2 on tenderness might be caused by protein oxidation. Oxidation of beef muscle proteins early postmortem inactivates the primary enzyme (μ-calpain) necessary to break down proteins postmortem, which results in decreased myofibrillar proteolysis and limited tenderization.

Injection-enhancement improves tenderness and juiciness while decreasing variation and often is used in conjunction with MAP. Several studies have reported that enhanced steaks were more tender and juicy than non-enhanced steaks. Several researchers found an increase in beef flavor associated with enhanced steaks, but others have reported a decreased or no change in beef flavor. Off-flavors associated with enhanced beef include salty and oxidative. Objectives of our study were to determine the effects of packaging atmosphere and injection-enhancement on beef strip loin, eye of round, and chuck clod tenderness, sensory traits, and desmin degradation.

Experimental Procedures

Strip loins (SL; n=12 pairs); eye of rounds (ER; n=12 pairs); and clods (CC; 12 pairs from the same carcasses as the SL and ER plus 12 additional pairs) were obtained from the same USDA Select A-maturity carcasses. On day 7 postmortem, each muscle from one side of the carcass was injection-enhanced with a commercial solution (beef broth, potassium lactate, sodium phosphate, salt, and rosemary), and each muscle from the other side was non-enhanced. One-inch-thick steaks were cut from the muscles and packaged in VP; ultra-low oxygen with CO (ULO_2CO) (0.4% CO/35% CO_2/69.6% N_2) MAP; or high-oxygen MAP (HiO_2) (80% O_2/20% CO_2) and assigned to 7 or 14 day tenderness measurement postmortem or display followed by 18 or 28 day tenderness measurement post-

[1]This project was funded by The Beef Checkoff and the Kansas Beef Council. The authors express appreciation to Dr. Tommy L. Wheeler, USDA, ARS, U.S. Meat Animal Research Center, Clay Center, NE, for assistance with measurement of desmin degradation, and Cargill Meat Solutions, Wichita, KS, for the use of their facilities and equipment.

[2]Department of Statistics.

mortem. Steaks packaged in HiO_2 MAP were held in dark storage at 36°F for 4 days while all other steaks were stored for 14 days in the dark at 36°F before display under fluorescent lighting. Steaks for Warner-Bratzler shear force (WBSF), sensory panel evaluation (1 = extremely tough, dry or bland; 8 = extremely tender, juicy and intense; n=8 trained panelists) at 18 (HiO_2) or 28 days (ULO_2CO and VP) postmortem, and desmin degradation were cooked to 158°F before analysis.

Results and Discussion

Targeted injection-enhancement pump levels were 10%. After approximately 30 minutes of initial injection and just prior to fabrication, pump level was 10.7% for the SL, 8.2% for the ER, and 13.0% for the CC.

Tenderness, according to WBSF, resulted in a packaging treatment × day interaction (P<0.01, Figure 1). Steaks packaged in HiO_2 MAP were less tender at the end of display (day 18 postmortem) than steaks packaged in VP or ULO_2CO MAP (day 28 postmortem). Because there was no difference on day 14 postmortem, we attributed the difference in tenderness primarily to the fewer days postmortem associated with HiO_2 MAP at the end of display. The different storage times used for the two MAP treatments are similar to current industry procedures.

There was a muscle × enhancement treatment × day interaction (P<0.05) in which steaks from enhanced muscles were more tender (P<0.05) than non-enhanced steaks (Figure 2). Tenderness increased with time postmortem (day 14 to 18/28) in enhanced SL and CC steaks but not in ER steaks. Non-enhanced steaks were similar in tenderness on day 7 and 14 postmortem but were more tender on day 18/28 postmortem for all muscles. Enhanced SL steaks were more tender (P<0.05) than non-enhanced steaks on day 7 postmortem, which was day 0 of packaging. This indicates that injection-enhancement has an immediate effect on tenderness. Injection-enhancement might increase tenderness through water binding, a dilution effect, or through physically altering the muscle structure with the injection needling process; however, the exact method of action is currently unknown.

There was an enhancement treatment × packaging treatment interaction for myofibrillar tenderness (P<0.05), beef flavor and off-flavor (P<0.01), and overall tenderness (P<0.05) (Figures 3 and 4). According to sensory panelists, non-enhanced steaks packaged in HiO_2 MAP were less tender and had less beef flavor and more off-flavors (*P*<0.05) than those packaged in ULO_2CO MAP and VP. The SL (5.9 ± 0.1) and CC (6.0 ± 0.1) were more tender according to myofibrillar tenderness (P<0.05) than the ER (5.1 ± 0.1). Enhanced steaks packaged in VP had more (P<0.05) beef flavor than those packaged in HiO_2 MAP.

The main effect (P<0.01) for juiciness revealed that enhanced steaks (5.7 ± 0.1) were juicier (P<0.05) than non-enhanced steaks (5.1 ± 0.1). The muscle main effect (P<0.01) for juiciness resulted in steaks from SL (5.5 ± 0.2) and CC (5.9 ± 0.1) muscles being juicier (P<0.05) than steaks from ER (5.0 ± 0.2) muscles. There was a packaging treatment main effect (P<0.01) for juiciness. Steaks packaged in HiO_2 MAP (5.3 ± 0.1) were less juicy (P<0.05) than steaks packaged in ULO_2CO MAP (5.6 ± 0.1), whereas steaks packaged in VP (5.4 ± 0.1) were intermediate and not different in juiciness from steaks packaged in HiO_2 and ULO_2CO MAP.

There was a main effect (P<0.01) for perceptible connective tissue for the enhancement treatment and muscle. Enhanced (6.6 ± 0.1) steaks had less (P<0.05) perceptible connective tissue than non-enhanced (6.1 ± 0.1) steaks (lower score = more connective tissue). The ER (5.9 ± 0.1) had more (P<0.05) perceptible connective tissue than the CC (6.4 ± 0.1), which had more (*P*<0.05) perceptible connective tissue than the SL (6.7 ± 0.1). There was also a main effect (*P*<0.01) for packaging treatment for connective tissue in which steaks packaged in HiO_2 MAP (6.2 ± 0.1) had more (P<0.05) perceptible connective tissue than steaks packaged in ULO_2CO MAP (6.4 ± 0.1) and VP (6.4 ± 0.1).

The most common off-flavors associated with steaks packaged in HiO_2 MAP were oxidative or rancid. Enhanced steaks had more (P<0.05) off-flavors than non-enhanced steaks, with typical descriptors of salty and metallic or chemical. Comments on many of the enhanced steaks indicated an undesirable mushy texture.

There was a muscle × enhancement treatment interaction for beef flavor (P<0.05) and off-flavor (P<0.05) (Figure 5). Enhanced CC steaks had more (*P*<0.05) beef flavor than enhanced ER steaks. Oxidative off-flavors associated with steaks packaged in HiO_2 MAP were expected because the O_2 present in the package atmosphere allows for more rapid and a greater extent of oxidation of proteins and lipids found in meat. Eliminating O_2 from the package environment, as done with VP or ULO_2CO MAP, drastically decreases the rate and extent of oxidation, resulting in fewer off-flavors and increased beef flavor.

There was a muscle × enhancement (day) interaction (P<0.001) for desmin degradation (data not shown). Desmin degradation in non-enhanced and enhanced steaks was similar (P>0.05). There was a day postmortem main effect (P<0.001) for desmin degradation, with day 14 postmortem (36.09% ± 2.9) having more (P<0.05) degradation than day 7 (23.67% ± 3.3). The SL desmin degradation increase (P<0.05) from day 7 to day 14 was independent of enhancement treatment. Strip loin steaks had more (P<0.05) degradation of desmin at day 14 than the ER or CC, regardless of enhancement treatment. Desmin degradation was not affected (P>0.05) by packaging type (data not presented) but was affected (P<0.05) by time postmortem.

In summary, more off-flavors were associated with enhanced steaks than non-enhanced steaks. Enhanced steaks were juicier and had less perceptible connective tissue than non-enhanced steaks. Steaks packaged in HiO_2 MAP were less tender according to sensory panelists and had more off-flavors than those packaged in either ULO_2CO MAP or VP. Sensory panelists found steaks packaged in HiO_2 MAP to be less tender than steaks packaged in VP or ULO_2CO MAP on day 18 postmortem, but WBSF results from steaks on day 14 postmortem were not different. Packaging treatment did not affect desmin degradation, which is a measure of tenderization during aging. Desmin degradation differed between SL and CC muscles, but these two muscles were similar in tenderness. Desmin degradation did not differ between control and enhanced muscles, yet enhanced steaks were much more tender than control steaks.

Implications

Differences in desmin degradation of different muscles might not be related to tenderness differences across muscles. Injection enhancement is expected to improve tenderness, but not because of increased desmin degradation. Packaging steaks in ULO_2CO MAP and VP would likely result in optimum tenderness and minimal off flavors compared with HiO_2MAP, but the purplish-red color of VP steaks generally is not acceptable to consumers.

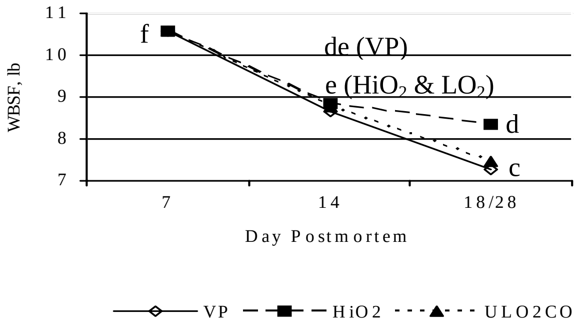


Figure 1. Packaging Treatment[a] x Day[b] Warner-Bratzler Shear Force Means for Strip Loin (SL), Eye of Round (ER), and Clod (CC) Steaks Packaged in Different Atmospheres

[a]HiO_2 = 80% O_2, 20% CO_2; ULO_2CO = 0.4% CO/35% CO_2/64.6%N_2; VP = vacuum packaging.
[b]Day 18 postmortem for the HiO_2 treatment and day 28 postmortem for the ULO_2CO and VP treatments
[cdef]Means without a common superscript letters differ (P<0.05).

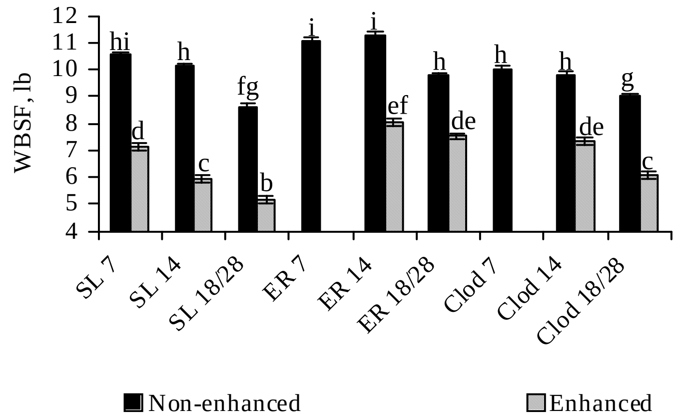


Figure 2. Muscle x Enhancement x Day[a] Warner-Bratzler Shear Force Means for Strip Loin (SL), Eye of Round (ER), and Clod (CC) Steaks.

[a]Days postmortem = 7, 14, or 18/28 (18 days postmortem for the HiO_2 treatment and 28 days postmortem for the ULO_2CO and VP treatments).
[bcdefghi]Means without a common superscript letter differ (P<0.05).

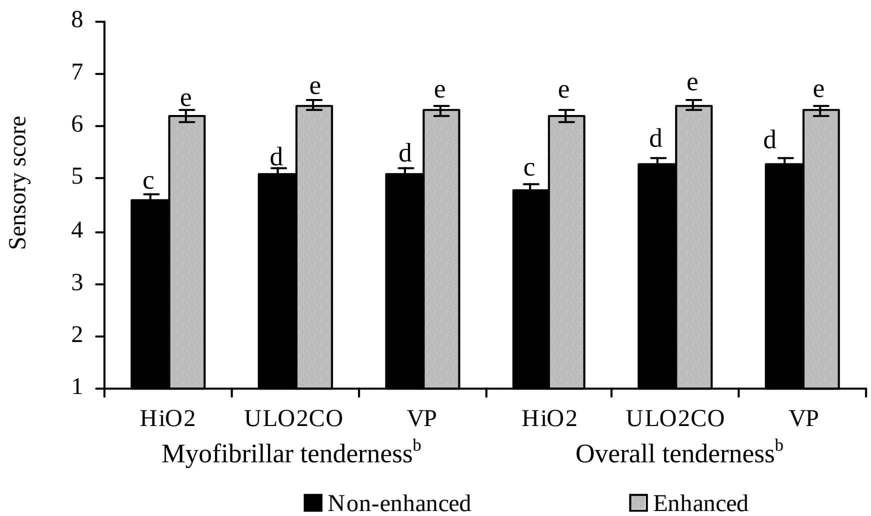


Figure 3. Enhancement x Packaging Treatment[a] Myofibrillar Tenderness and Overall Tenderness Means for Strip loin (SL), Eye of Round (ER), and Clod (CC) Steaks.

[a]HiO_2=80% O_2, 20% CO_2; ULO_2CO=0.4% CO/35% CO_2/64.6%N_2; VP=vacuum packaging.
[b]Tenderness: 1=extremely tough, 4=slightly tough, 6=moderately tender, 8=extremely tender.
[cde]Means within sensory traits without a common superscript letter differ (P<0.05).

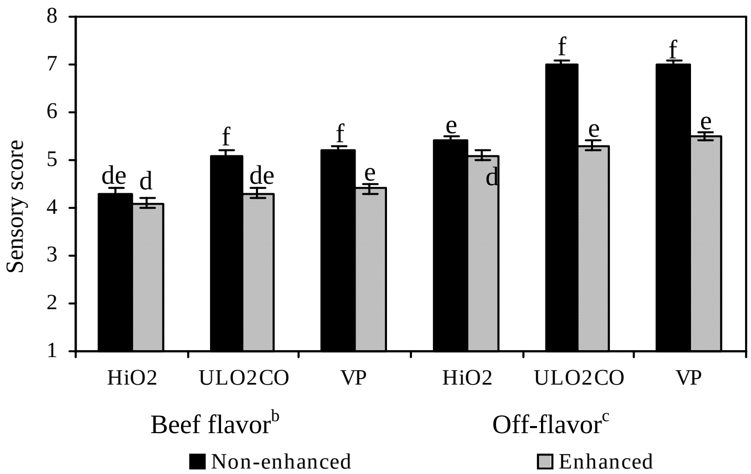


Figure 4. Enhancement x Packaging Treatment[a] Beef Flavor and Off-flavor Means for Strip Loin (SL), Eye of Round (ER), and Clod (CC) Steaks.

[a]HiO_2=80% O_2, 20% CO_2; ULO_2CO=0.4% CO/35% CO_2/64.6%N_2; VP=vacuum packaging.
[b]Beef Flavor: 1=extremely bland, 4=slightly bland, 6=moderately intense, 8=abundant
[c]Off-flavor:1=abundant, 5=slight, 6=traces, 7=practically none, 8=none.
[def]Means within sensory traits without a common superscript letter differ (P<0.05).

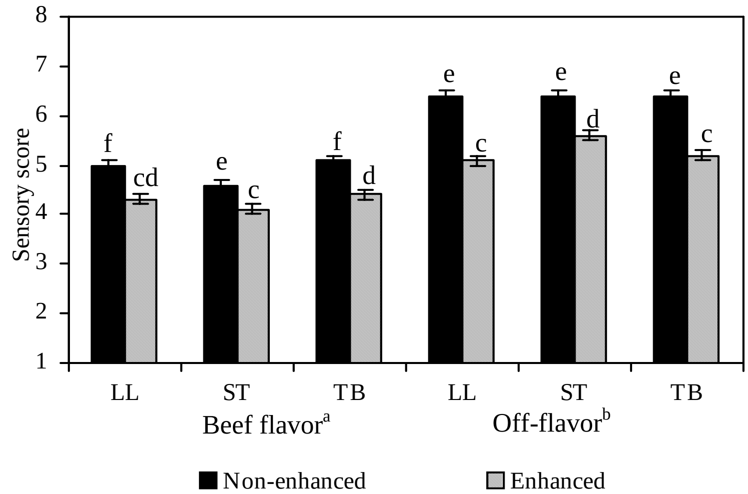


Figure 5. Muscle x Enhancement Beef Flavor and Off-Flavor Means for Strip Loin (SL), Eye of Round (ER), and Clod (CC) Steaks.

[a]Beef Flavor: 1=extremely bland, 4=slightly bland, 6=moderately intense, 8=abundant.
[b]Off-flavor: 1=abundant, 5=slight, 6=traces, 7=practically none, 8=none.
[cdef]Means within sensory traits without a common superscript letter differ (P<0.05).

RESTRICTING VITAMIN A IN CATTLE DIETS IMPROVES BEEF CARCASS MARBLING AND USDA QUALITY AND YIELD GRADES

A. M. Arnett, M. J. Daniel, and M. E. Dikeman

Introduction

Marbling continues to be a major factor affecting profitability for beef producers, processors, retailers, and restaurateurs. However, feeding animals to 'fatten' is quite inefficient, requiring about 2.25 times more energy than is needed for producing lean muscle. For the cattle feeding industry to be sustainable in the future, increases in marbling must be accomplished without increasing days on feed, slaughter age carcass weight, and fatness and without sacrificing feed efficiency and carcass cutability.

A 2002 survey of feedlot nutritionists revealed that most recommended supplementation of vitamin A to feedlot cattle at levels exceeding the guidelines of the National Research Council (NRC) by three to five times. Because vitamin A fortification of cattle diets is an inexpensive method used to improve the immune response of receiving cattle, it is likely that few have considered the negative consequences of over-supplementing vitamin A on marbling and carcass quality grades of feedlot cattle. The objective of our research was to evaluate the effects of supplementing vitamin A at either zero (NA) or seven times (HA) the NRC-recommended level in feedlot diets and age at weaning on carcass marbling development and USDA quality grade of crossbred beef steers.

Experimental Procedures

Genetically uniform Angus crossbred steers (n = 48) were either early-weaned (EW) at 137 ± 26 days of age or traditionally-weaned (TW) at 199 ± 26 days of age. The experimental feeding period consisted of a growing and a finishing phase for EW calves and finishing only for TW calves. The HA diet provided 42,180 IU vitamin A per head per day and was initiated upon arrival at the Kansas State University Agricultural Research Center located at Hays, KS, following a 14-day preconditioning period in Manhattan, KS. The finishing diet consisted of sorghum silage, ground sorghum, and supplement (Table 1). The vitamin A treatments were fed until steers were harvested. Steers were weighed, and blood was sampled every 60 days throughout the finishing period to monitor growth performance and level of vitamin A in circulation. No animals exhibited symptoms of vitamin A deficiency during our study.

Table 1. Average Composition (Dry matter basis) of the Finishing Diet

Ingredient	Percent (DM basis)
Ground sorghum grain	48.2
Corn gluten feed	24.2
Tallgrass prairie hay (chopped)	14.8
Whole soybeans (raw)	9.6
Supplement[1]	3.2
Total	100.0

[1]Provided NRC (1996) recommended levels of salt, trace minerals, and vitamin A. Bovatec 91 (Alpharma, Fort Lee, NJ) was included at 1.2% (DM) of the diet.

Steers were harvested at Tyson Fresh Meats® at Emporia, KS, when average 12th-rib fat thickness, determined by periodic ultrasound, reached 0.40 inches. To minimize variation in body composition, steers were harvested in two groups, 35 days apart. Detailed carcass data were collected along with liver, muscle, and fat samples.

Results and Discussion

Concentrations of serum retinol on three sampling days are presented in Figure 1. Serum levels were initially similar (P>0.10). On the second sampling day, steers had consumed vitamin A treatments for either 105 (EW) or 45 (TW) days. On the last sampling day, steers had consumed treatment diets for either 210 (EW) or 150 (TW) days and serum retinol levels had diverged significantly (P<0.05). Weaning age did not affect serum retinol content on the last sampling day (P>0.10).

Weights at the beginning of the finishing period were similar for EW and TW steers (Table 2). The TW steers tended (P = 0.11) to have higher ADG than EW steers during the finishing period. This can most likely be attributed to compensatory gain early in the finishing period in TW steers.

There were no differences (P>0.10) in mean dressing percent (62.5 ± 1.28%) or hot carcass weight due to either dietary vitamin A level or weaning age.

Feeding NA increased (P<0.05) marbling scores compared with feeding HA, suggesting that feeding NA for at least 150 days increases marbling scores. This difference seemed to be enhanced with EW; the EW-NA steers produced carcasses that tended to have higher marbling scores (480) than the other treatments (430, 440, and 450), but this difference was not statistically different. This research confirms that high degrees of marbling can be attained in cattle 12 to 13 months of age without sacrificing cutability when steers of relatively high genetic potential for marbling are managed on a high plane of nutrition. The percentage of intramuscular fat (IMF), determined by gas chromatography, supported the marbling scores (Table 3). Steers fed NA had 17% more (P<0.05) IMF than HA steers. Carcasses from EW-NA steers tended to have 30% more IMF than TW-HA-steers, but the interaction was not statistically significant. The percentage of carcasses that qualified for "Premium Choice" brands (cattle with marbling scores of Modest^{00} or higher) was doubled in carcasses from steers fed NA, regardless of age at weaning. Based on current market premiums, the effect of reduced dietary vitamin A might have important economic benefits for producers.

Carcass yield grades ranged from 1.6 to 3.7 and were excellent relative to the carcass marbling scores. Although not statistically significant (P>0.10), the combination of smaller ribeyes in the fattest carcasses caused yield grades to be numerically higher (less desirable) in EW-HA carcasses (Table 3).

The ratio of marbling deposition per USDA Yield Grade is a very useful measure of overall efficiency of marbling deposition (Figure 2). Based on traditional logic, the EW-NA steers might have been expected to produce fatter, lower yielding carcasses associated with higher amounts of marbling. However, EW-NA steers were the most efficient producers of marbling per yield grade (Figure 2) and per day in the feedlot (data not shown). The EW-NA steers also produced the most (P<0.05) marbling relative to carcass weight, and EW-HA steers produced the least (data not presented). The TW steers were intermediate in marbling deposited per USDA Yield Grade, regardless of vitamin A level.

Implications

Feeding diets with no supplemental vitamin A to market cattle for at least 150 days is a safe and effective method of improving carcass marbling and USDA quality grades without increasing external fat. These benefits appear to be enhanced with EW and(or) restricting vitamin A for up to 210 days.

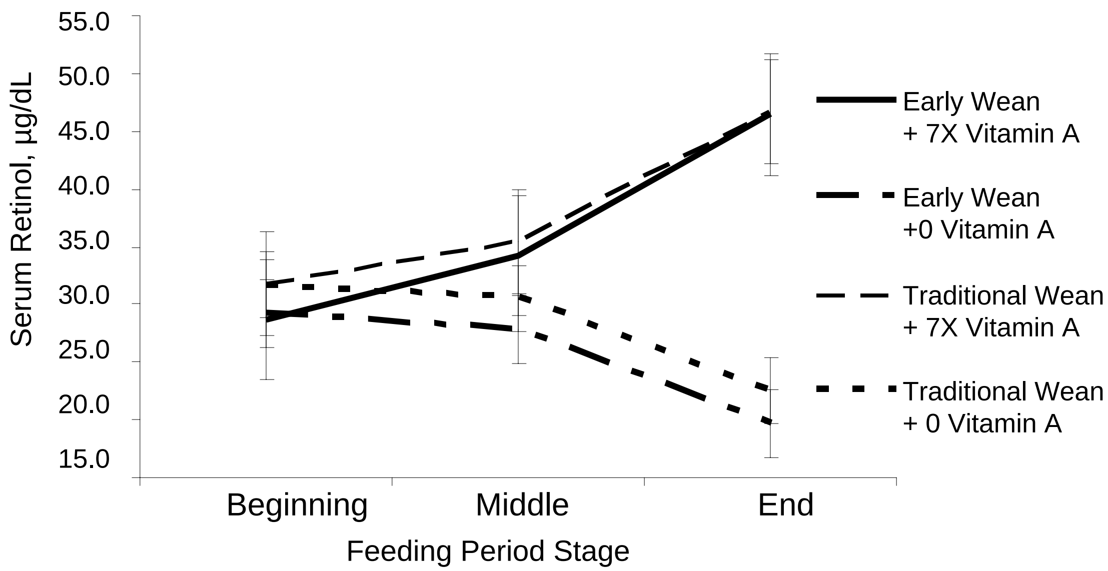


Figure 1. Serum Retinol (vitamin A) Concentration on Three Sampling Days Representing the Beginning, Middle, and End of the Feeding Period. Beginning = before vitamin A supplementation for early- and traditionally-weaned steers; middle = after 105 days for early-weaned and 45 days for traditionally-weaned steers; and end = after 210 days for early-weaned and 150 days for traditionally-weaned steers.

Table 2. Growth Performance of Steers Weaned at Either Early or Traditional Ages Fed Diets with Either Very High or No Supplemental Vitamin A

	High Vitamin A		No Vitamin A					
	Weaning age		Weaning age			P value		
Item	Early	Traditional	Early	Traditional	SEM	Vit. A	Wean	Vit. A × Wean
Grower								
Initial weight, lbs	425.0	NA	414.0	NA				
Final weight, lbs	566.5	NA	573.5	NA				
Weight gain, lbs/day	2.42	NA	2.62	NA				
Finishing								
Initial weight, lbs	566.5	521.4	573.5	506.4	70.2	0.96	0.43	0.87
Final weight, lbs	1078	1074	1061	1055	79.6	0.83	0.96	0.97
Weight gain, lbs/day	2.97	3.26	2.77	3.23	0.24	0.63	0.11	0.67

Table 3. Carcass Traits of Steers Weaned at Either Early or Traditional Ages Fed Diets with Either Very High or No Supplemental Vitamin A

	High vitamin A		No vitamin A					
	Weaning age		Weaning age			P value		
Item	Early	Traditional	Early	Traditional	SEM	Vit. A	Wean	Vit. A × Wean
Hot carcass weight, lbs	700	700	691	686	16.1	0.84	0.96	0.97
Ribeye area, sq. in.	11.3	12.1	11.9	11.7	0.8	0.88	0.69	0.50
12th rib fat, in.	0.46	0.43	0.36	0.33	0.08	0.33	0.74	0.98
KPH, %	2.3	2.2	2.2	2.2	0.2	0.79	0.79	0.62
USDA Yield Grade	3.2	2.8	2.7	2.7	0.4	0.40	0.57	0.64
Marbling score[1]	430	440	480	450	34.9	0.03	0.04	0.77
Intramuscular fat, %	4.8	4.8	6.2	5.3	0.8	0.01	0.03	0.73
Premium Choice and Prime, %	17	18	36	36	NA	NA	NA	NA

[1]Marbling score: 400 = Small^{00}, 410 = Small^{10}, 500=Modest^{00}, etc.

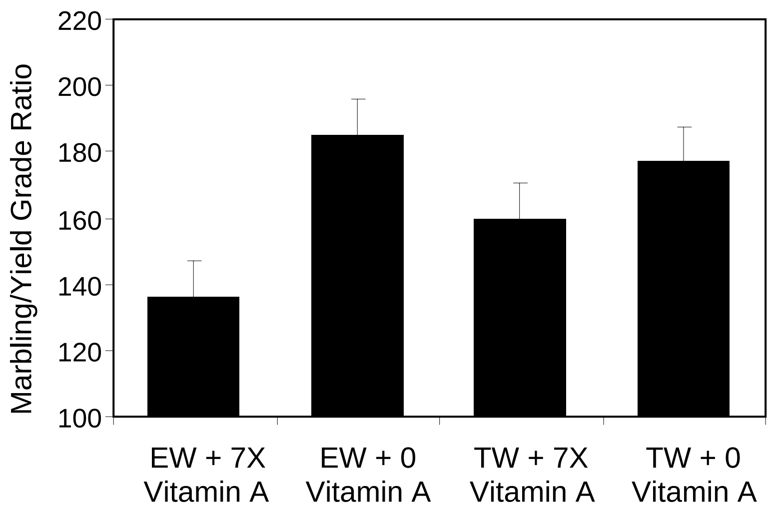


Figure 2. Ratio of Marbling produced per USDA Yield Grade in Steers Weaned at Either Early (EW) or Traditional (TW) Ages Fed Diets with Either Very High or No Supplemental Vitamin A.

0 = No vitamin A supplementation.
7x = 7 times the NRC recommended vitamin A level.
Bars indicate standard error.

VITAMIN A RESTRICTION DURING FINISHING BENEFITS BEEF RETAIL COLOR DISPLAY LIFE

M. J. Daniel, M. E. Dikeman, and A. M. Arnett

Introduction

Because the beef industry commonly uses marbling as an indicator of meat palatability, determining the most cost effective methods of increasing quality grade in cattle is a high priority. Previous research showed that weaning calves at around 90 instead of 200 days of age can be beneficial in reducing cow production costs and increasing marbling in feedlot steers. Other studies demonstrated that high levels of vitamin A inhibit development of intramuscular fat. Vitamin A restriction is used commonly in Japanese cattle to increase marbling scores; this stimulated interest in applying this restriction in U.S. beef production systems. However, little research has been conducted to determine the effect that vitamin A restriction might have on other meat quality components. Therefore, our objective was to determine the effects of feeding high and restricted levels of vitamin A to early and traditionally weaned calves during finishing on color display life, lipid oxidation, and sensory attributes of two beef muscles.

Materials and Methods

Angus crossbred calves (n=46) were weaned at either 137 ± 26 days or 199 ± 26 days of age, placed in the feedlot, and either supplemented with seven times the NRC recommended level of vitamin A (6911.6 IU/lb) or restricted to no supplemental vitamin A. Calves were harvested in two kill groups when they reached approximately 0.40 inches of backfat. After chilling and grading, strip loins and shoulder clods were retrieved from carcasses. Three 1.0-inch *Longissimus lumborum* and *Triceps brachii* steaks were cut after 14 days of aging. One steak was packaged immediately in PVC overwrap and placed in a retail display case for 7 days. Visual color scores and instrumental color values were evaluated on each day of display. Thiobarbituric acid reactive substances (TBARS) were analyzed on display steaks on day seven to quantify the amount of lipid oxidation. The other two steaks were vacuum packaged and frozen for Warner-Bratzler shear force (WBSF) determinations and trained sensory panel analysis. Steaks were thawed at 36˚F overnight, cooked to an internal temperature of 158˚F, and chilled overnight at 32˚F. Eight 0.5-inch cores were removed parallel to the muscle fibers for WBSF. Each core was sheared perpendicular to the direction of the muscle fibers using the WBSF attachment on the Instron Universal Testing Machine with a 50-kg compression load cell and a cross head speed of 250 mm/min. Sensory steaks were cut into 0.5 by 0.5 by 1 inch cubes and evaluated by six to eight trained panelists on an 8-point scale for tenderness, flavor, juiciness, connective tissue, firmness, and off-flavor intensity with 8 = extremely desirable and 1 = extremely undesirable.

Results and Discussion

Display color scores are presented in Figures 1 and 2. Steaks from calves supplemented with high vitamin A had less desirable color scores ($P<0.05$) than steaks from calves restricted in vitamin A on all days of display for the *Longissimus lumborum* steaks and on days 2 throught 6 for *Triceps brachii* steaks. Discoloration scores (data not shown) were less desirable ($p<0.05$) for high vitamin A steaks on days 3 through 6 in the *Longissimus lumborum* muscle and on days 4 and 5 in the *Triceps brachii* muscle. Also, a*, b* and saturation index values were numerically lower (less desirable) in the high vitamin A steaks on all days of display for the *Longissimus lumborum* muscle but were statistically significant only on days 3, 2, and 3, respectively (data not shown).

Lipid oxidation (Figure 3), measured by TBARS values, was higher ($P<0.05$) for both muscles after 7 days of display in steaks from calves supplemented with high vitamin A. There were no differences ($P>0.05$) in WBSF values between the treatments for either muscle. Also, there were no differences ($P>0.05$) in sensory panel traits for the *Triceps brachii* muscle. However, *Longissimus lumborum* steaks from steers supplemented with high vitamin A had lower ($p<0.05$) scores for myofibrillar tenderness and connective tissue amount (data not shown).

Implications

Vitamin A restriction during finishing has potential to increase retail color display life and reduce lipid oxidation of beef *Longissimus lumborum* and *Triceps brachii* steaks without negatively affecting cooked meat sensory attributes.

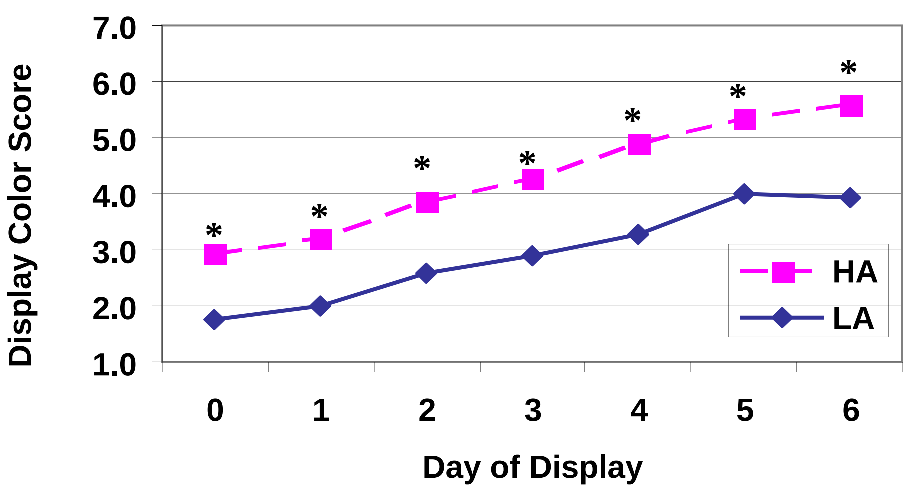


Figure 1. Display Color Scores for *Longissimus lumborum* Steaks.

Display Color Score: 1 = most desirable; 8 = least desirable.
*Means differ ($P<0.05$).
HA = Supplemented with 6911.6 IU/lb vitamin A; LA = No supplemental vitamin A.

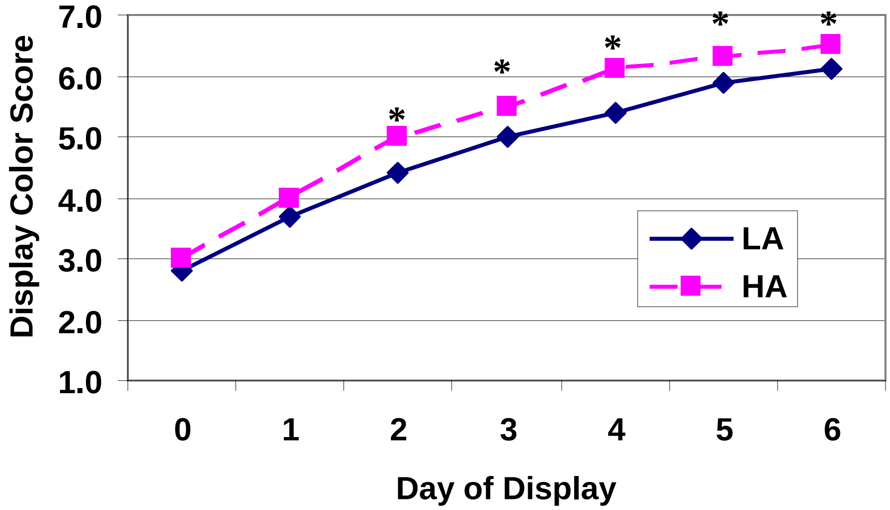


Figure 2. Display Color Scores for *Triceps brachii* Steaks.

Display Color Score: 1 = most desirable; 8 = least desirable.
*Means differ (P<0.05).
HA = Supplemented with 6911.6 IU/lb vitamin A; LA = No supplemental vitamin A.

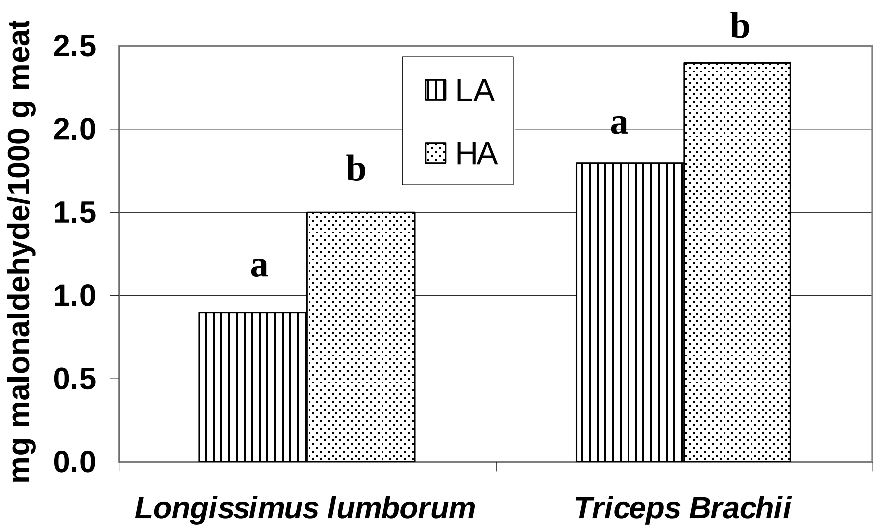


Figure 3. Lipid Oxidation of *Longissimus lumborum* and *Triceps Brachii* Steaks.

[ab]Means with different superscripts differ (P<0.05).
HA = Supplemented with 6911.6 IU/lb vitamin A; LA = No supplemental vitamin A.

PREPARTUM SUPPLEMENTATION INFLUENCES RESPONSE TO TIMED ARTIFICIAL INSEMINATION BY SUCKLED MATURE BEEF COWS

M. D. Thomas, K. C. Olson, J. S. Stevenson, and J. R. Jaeger,
J. W. Bolte, N. A. Sproul, and D. A. Linden

Introduction

Fat supplementation before calving (i.e., prepartum) can alter reproductive performance of beef cows. These effects do not seem to be related to energy or protein content of the supplement. Chemical structures of some plant fats are similar to chemical structures of certain reproductive hormones; moreover, some fats are precursors to prostaglandin production. Prepartum vegetable fat supplementation has been associated with improved reproductive performance by cows and heifers managed for artificial insemination (AI) breeding. The biological basis for this effect is not clearly understood but is believed to reflect the influence of fat supplements on cyclicity, body weight, body condition, and other factors. Our objective was to evaluate the effects of supplementing whole fuzzy cottonseed or whole raw soybeans on pregnancy rates following ovulation synchronization and timed AI of mature beef cows.

Experimental Procedures

Cows (n = 188; average initial body weight = 1239 ± 84 lb) at the Kansas State University Commercial Cow-Calf Unit were stratified by body condition score and body weight and assigned randomly to one of three supplementation treatments: 1) whole raw soybeans, 2) whole fuzzy cottonseed, or 3) a mixture of 50% ground corn and 50% soybean meal (control). Cows were weighed, assigned a body condition score, and assigned to one of four similar pastures in mid-January 2007. Each pasture contained 47 cows (15 or 16 per treatment).

Supplements were fed to cows beginning 45 days before the first projected calving date (April 1). Cows were gathered from pastures four times weekly at 6:00 am and sorted by treatments into feeding pens. Supplements were hand fed to individual treatment groups at approximately 7 lbs per cow (dry matter basis) at each feeding episode. The daily equivalent was approximately 4 lbs per cow. Supplements supplied similar protein and energy to cows at prescribed feeding rates. At calving, cows were weighed and assigned a body condition score. Calves also were weighed at that time. Thereafter, all cows were fed the control supplement until May 15.

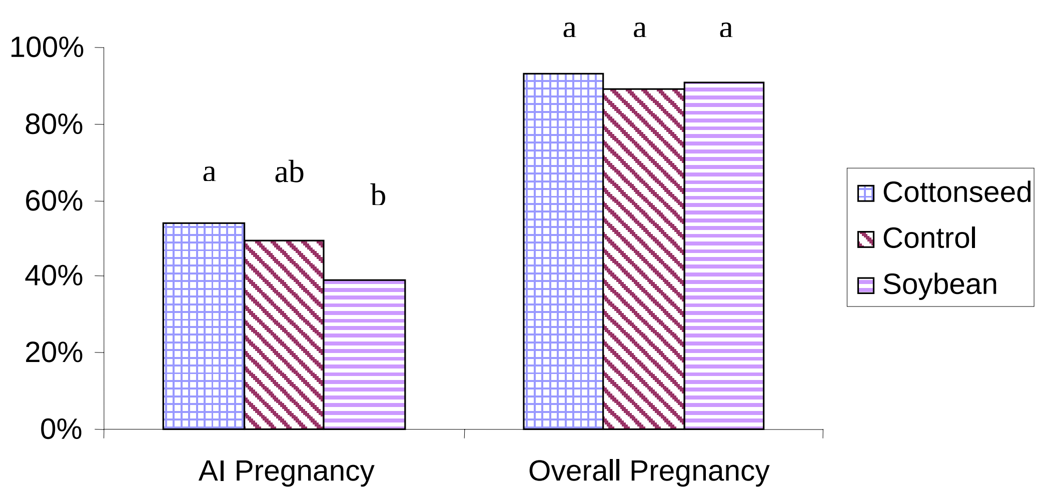
Ovulation was synchronized using the Co-synch + controlled internal drug release (CIDR) protocol and then inseminated by appointment on June 21. Blood was collected 21 and 10 days before initiating the Cosynch + CIDR protocol. Blood samples were assessed for serum concentrations of progesterone to assess estrous cyclicity and prior ovulation. Beginning 10 days after AI, cows were exposed for natural service breeding for 50 more days. Conception to AI and overall pregnancy rates were assessed 33 and 66 days after AI, respectively. Cows were again weighed and assigned a body condition score at the beginning and end of the breeding season. Calf weights were measured at the end of the breeding season.

Results and Discussion

Body weight and body condition score of cows at calving was similar (P>0.5) across treatments; however, cows feed whole fuzzy cottonseed lost more body weight and more body condition from the beginning of the trial to calving (P<0.03) than cows fed whole raw soybeans. The proportion of cows that had previous estrous cycle activity (i.e., increased serum concentrations of progesterone) did not differ (P = 0.85) among treatments. Conversely, supplementation with whole fuzzy cottonseed was associated with increased AI conception compared with whole raw soybeans (P = 0.05) but not compared with the control treatment (Figure 1; P = 0.58; 49, 39, and 54% for control, whole raw soybeans, and whole fuzzy cottonseed, respectively). Final pregnancy rates at the end of the breeding season were similar (P = 0.74) among treatments; moreover, no treatment differences (P>0.28) were detected in cow body weight or body condition score by the end of the natural-service breeding season. Calf birth weights and calf weights at the end of the breeding season also were similar (P>0.37) among treatments.

Implications

Source of prepartum supplemental fat fed to mature beef cows can affect conception response to timed AI.



[ab]Means within a bar cluster without a common superscript letter differ (P<0.05).

Figure 1. The Effect of Supplement Type on Conception to AI and Overall Pregnancy Rate.

INFORMATION NEEDS REGARDING THE NATIONAL ANIMAL IDENTIFICATION SYSTEM IN THE LIVESTOCK AUCTION MARKET INDUSTRY

K. Bolte[1], K. Dhuyvetter[1], and T. Schroeder[1]

Introduction

The National Animal Identification System (NAIS) is a federal-level voluntary program that uses a streamlined information system designed to help animal health officials and producers respond to animal health threats in a timely manner.[2] Electronic individual animal identification systems likely will be the popular choice among cattle producers who adopt individual animal identification systems. Because auction markets are the first market for many cattle, livestock markets are a natural place to implement animal identification scanning and recording. Therefore, it is important to understand livestock market operators' knowledge, concerns, views, and adoption of the NAIS and electronic animal identification systems. If livestock market operators do not understand the NAIS or animal identification systems they might misconstrue or misunderstand information on these systems. In addition, it is important to identify livestock market operators' concerns about electronic animal identification systems so issues can be addressed.

Experimental Procedures

A national survey of livestock markets was conducted to determine operators' knowledge and concerns about the NAIS and its anticipated effect on their businesses. The survey questioned managers regarding their knowledge of the NAIS program standards, understanding of how to adopt and costs of adoption, views of the program, and concerns about the NAIS.

Livestock market operators were asked to rank their knowledge of the NAIS program standards, understanding of how to adopt the NAIS practices, and understanding of costs of the NAIS. Livestock market operators were asked whether they viewed the NAIS as a *threat*, *neither a threat or opportunity*, or *opportunity* to their businesses. The level of concern each livestock market had about an adverse change in speed of sale due to the NAIS adoption was investigated. Livestock market operators also were asked whether they have adopted electronic reader systems.

Survey results reveal livestock market operators moderately understand NAIS program standards, costs associated with adopting NAIS, and how to adopt NAIS practices. Forty-two percent of survey respondents indicated intermediate or less understanding of the NAIS program standards, 51% indicated they did not fully understand what would need to be done to adopt NAIS practices, and 56% did

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[1]Department of Agricultural Economics.
[2]NAIS Home Page. USDA APHIS. Accessed May 2007. http://animalid.aphis.usda.gov/nais/index.shtml

not understand costs involved with adopting NAIS. More importantly, 50% of livestock market operators indicated that they view the NAIS as a *threat* to their businesses; only 20% view it as an *opportunity*. Only 14% of livestock market survey respondents had adopted radio frequency identification (RFID) reader systems.

To determine how individual characteristics of livestock markets relate to levels of NAIS knowledge, views, and concern, statistical analysis was conducted on the survey responses. This analysis determined whether systematic characteristics of auction markets were related to survey respondents' answers to particular questions. Knowledge of how certain factors relate to responses to specific questions can be used to better target information dissemination programs to market operators.

Results and Discussion

Livestock market operators who currently have or plan to add a RFID tagging service in the future are likely to have more knowledge of NAIS program standards, more knowledge of how to adopt NAIS practices, and a greater understanding of probable costs involved with adoption of the NAIS. Managers of facilities that sell a large volume of livestock annually tend to have a higher level of understanding of how to adopt NAIS practices and are more knowledgeable about NAIS program standards than operators of small-volume facilities (Figures 1 and 2). Furthermore, managers of facilities that have operating RFID reader systems tend to be more informed about how to adopt NAIS practices and of costs associated with adopting the NAIS. This suggests that smaller auction market operators, facilities that do not plan to add a RFID tagging service in the future, and facilities that do not currently have operating RFID reader systems are important targets for information dissemination.

As expected, given that NAIS is currently a voluntary program, livestock market operators that have operating RFID reader systems and those who have registered operators who have their premises are more likely to perceive the NAIS as an *opportunity* to their businesses compared with operators who have not completed these activities. Auction markets that see having electronic animal identification systems as an opportunity have been early adopters of the system. Markets that have not adopted electronic animal identification information technology likely will not adopt such technology without a change in perception.

Livestock market managers tend to be highly concerned about adoption of individual electronic animal identification systems adversely impacting sale speed. The more volume the auction sells, the greater the manager's concern about animal identification systems slowing speed of commerce (Figure 3). However, the effect on the sale speed in livestock markets that have already adopted electronic animal identification and tracking systems is generally less than what those who have not adopted this technology perceive it to be.

Facilities where premises are registered are more likely to adopt RFID technology than facilities that have not registered premises. Large-volume markets are more likely to adopt RFID technology than small-volume markets (Figure 4). Also, livestock markets that plan to provide a RFID tagging service in the future are more probable than those facilities that do not plan to add a RFID tagging service in the future.

Implications

Livestock market operators need additional and on-going information regarding NAIS standards, adoption requirements, and costs. This information will affect operators'adoption rates and views of the NAIS.

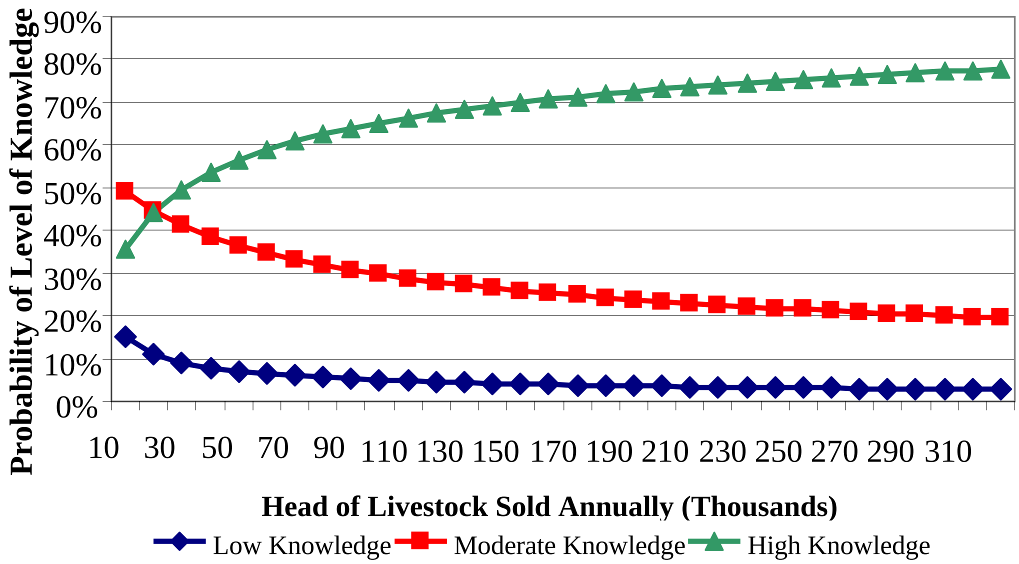

Figure 1. Probability of Livestock Market Operators' Level of Knowledge of NAIS Program Standards Based on Annual Livestock Sales.

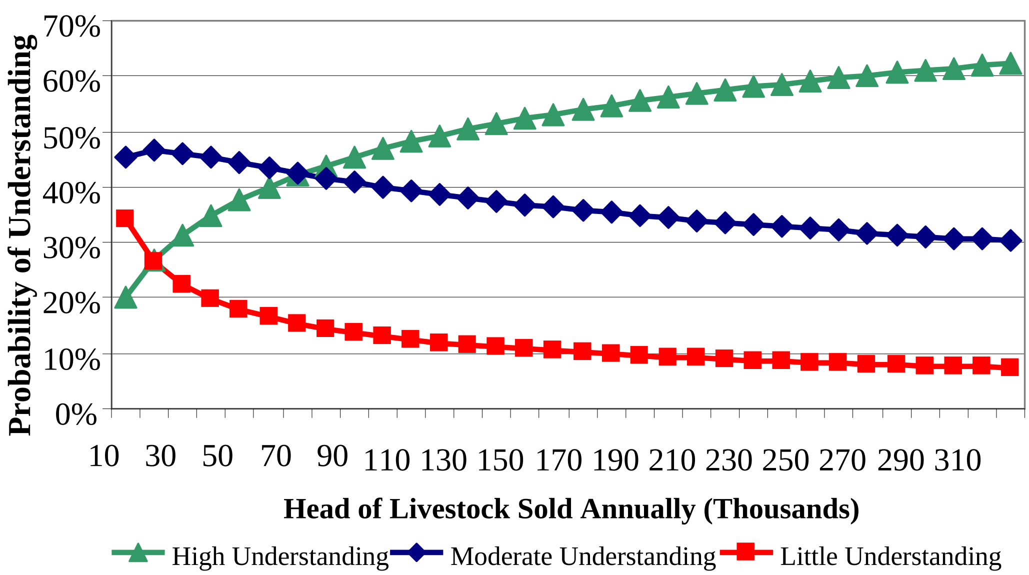

Figure 2. Probability of Livestock Market Operators' Level of Understanding of How to Adopt NAIS Practices Based on Annual Livestock Sales.

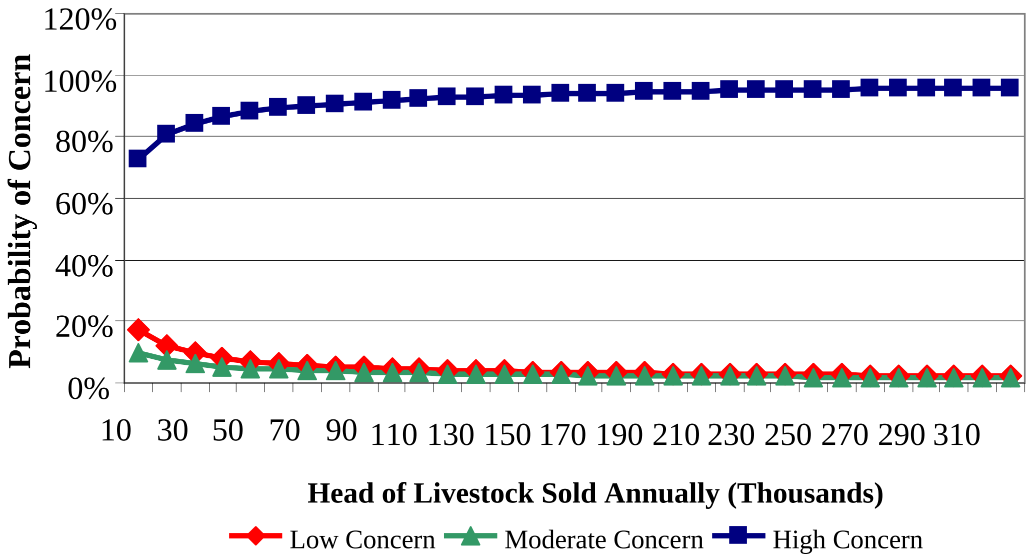

Figure 3. Probability of Livestock Market Operators' Level of Concern about Sale Speed Being Adversely Affected by NAIS Based on Annual Livestock Sales.

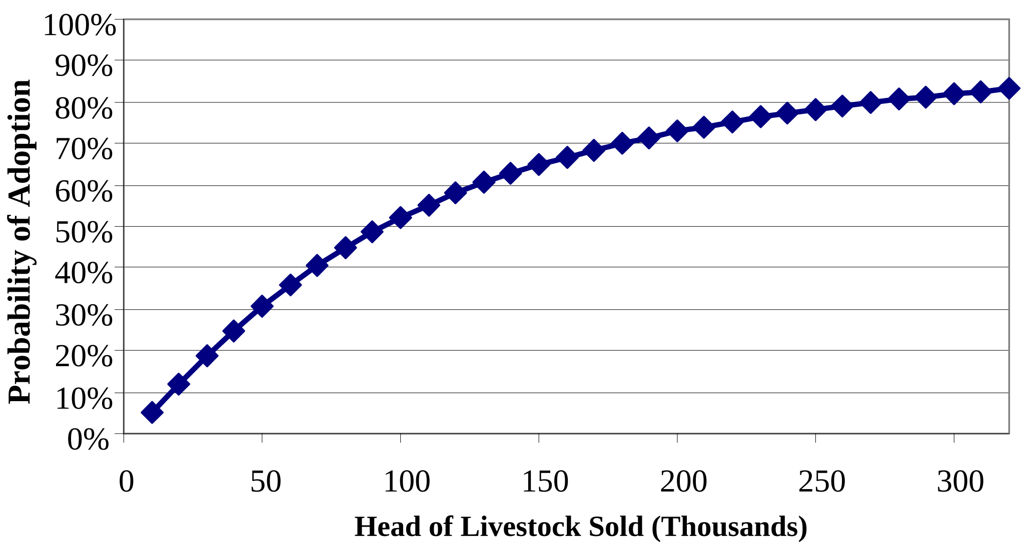

Figure 4. Probability of Livestock Market Adopting a RFID Reader System Based on Annual Livestock Sales.

COSTS OF ADOPTING RADIO FREQUENCY IDENTIFICATION READER SYSTEMS AND TAGGING SERVICES IN LIVESTOCK AUCTION MARKETS

K. Bolte[1], K. Dhuyvetter[1], and T. Schroeder[1]

Introduction

Livestock industry initiatives such as the National Animal Identification System (NAIS), marketing alliances, and production verification programs are leading to increased use of electronic animal identification systems. Livestock markets are one place where animal movement and identification information can be recorded easily. Auction market facilities can differentiate themselves by offering electronic individual animal identification and tracking services to customers. However, facility modifications, installation, and operating equipment needed to record electronic animal identification information at the speed of commerce involves costs. The more animals that the radio frequency identification (RFID) reading technology would be used on, the lower the cost of investment per animal for the livestock market. Thus, auction markets will be reluctant to invest in RFID reading and recording equipment if there is little demand for the service by customers. This concern has likely increased with the NAIS becoming explicitly voluntary. Also, some market operators are concerned that producers will expect livestock markets to offer tagging services if RFID equipment is available for use. The investment required to adopt an electronic animal identification system and how this investment would affect a livestock market's business are also major concerns. This study examines the investments required for livestock markets to adopt RFID reader systems and tagging services.

Experimental Procedures

A national survey of livestock market operators was conducted to collect information related to costs of adopting RFID technology. A section of the survey asked livestock market operators 1) if they would offer a RFID tagging service if the NAIS was fully implemented and 2) questions relating to the costs of offering this service. Another section of the survey asked livestock markets if they had adopted a RFID reader system. If they had, questions regarding costs of adoption were asked. Fifty-five percent of livestock auction market managers stated they would provide a RFID tagging service for customers if the NAIS were fully implemented. Only 14% of survey respondents had installed RFID reader systems.

Using the data collected, annualized costs of offering a cattle RFID tagging service and reader system were estimated. Annualized costs are the sum of annualized investments and annual expenses. Annual expenses are expenses that occur on a yearly basis, and investments represent the capital outlay required for adoption. Annualized investments were calculated by annualizing the total investment given an interest rate and number of years the system was expected to be used. An 8% in-

[1]Department of Agricultural Economics.

terest rate was used to reflect the cost of borrowing money for an operating loan. The expected useful life for the tagging service investment (chutes, facility modifications, etc.) was 10 years. The expected useful life of adding a RFID reader system included the electronic reader system with a useful life of 3 years, the facility modification a life of 6 years, and computer investment with a life of 3 years. At the end of the useful life the assumed salvage value was zero for all investments. From this information, cost estimates and economies of scale were evaluated for both investments.

Results and Discussion

The annualized cost per head of livestock using a RFID tagging service averaged $3.21 per head and ranged from $0.00[2] to $61.49 per head, excluding the cost of an RFID tag. Most livestock markets (90%) would experience annualized costs of less than $5.00 per head for a RFID tagging service, excluding the cost of the RFID tag. Economies of size were present, so markets with higher percentages of livestock using a tagging service have a competitive advantage over livestock markets with smaller percentages of livestock using the service. The annual cost per head decreases up to approximately 11,755 head of livestock using the service, and then the cost per head remains constant at $1.51 (Figure 1). For comparison, Michigan currently requires all cattle sold through auction markets to have electronic identification. Michigan auction markets are charging $6 per head for tagging if they supply the tag and $3 per head if the seller supplies the tag.

Among livestock market survey respondents who had installed RFID reader systems, total investments in RFID reader systems ranged from $5,250 to $63,000, and annual cattle sales among these facilities ranged from 12,000 to 275,000 head. Total investments were annualized and added to the annual expenses to find the annualized cost of a RFID reader system. The annualized cost per head of cattle using a reader system assuming 25% of the cattle sold annually were using the RFID reader system are shown in Figure 2. The 25% utilization value was chosen to simulate what could occur if the NAIS remains voluntary and the system was used on only one-quarter of cattle sold through auction markets. The average annualized cost per head of cattle using the systems was $0.76, the maximum was $4.02, and the minimum was $0.14. Given our assumptions, the annualized cost per head of cattle using the system could be used as an estimate of the expected fee charged to owners of cattle that use the RFID reader system at a livestock market.

Figure 3 shows the annualized cost per head of cattle sold annually when the costs are allocated over 100% of cattle marketed annually. This is a scenario useful to livestock market operators who might choose to increase commission fees for all cattle sold at their facility after installing a reader system. This scenario also depicts what the cost might be if the NAIS were to become mandatory and 100% of animals sold through the livestock market used the RFID reader system. The average annualized cost per head of cattle sold was $0.19 with maximum and minimum values of $1.01 and $0.04 per head, respectively.

Based on estimated annual costs, economies of scale exist in RFID system adoption (i.e., larger-volume livestock markets have lower costs per head). Most auction markets would have annual costs associated with RFID

[2]One livestock market indicated they would not incur any additional cost by adding a tagging service.

systems of less than $0.30 per head of cattle sold annually, with large volume markets having annual costs less than $0.11 per head of cattle sold annually.

Figure 4 shows expected annualized costs of RFID readers systems of four "typical" livestock markets based on varying levels of cattle using the system. This figure shows economies of size are related both to market size and intensity of use of RFID reader systems. Smaller-volume livestock markets that use an electronic reader system intensively (i.e., on a high percentage of cattle sold annually) can compete cost-wise with larger volume markets that use a reader system on a small percentage of cattle.

Implications

Due to the voluntary nature of the NAIS, livestock markets that can find value opportunities in adopting animal identification tracking systems will be more likely to adopt these practices. Large-volume livestock markets and those that will send a higher percentage of cattle through such a system are much more likely adopters of RFID technology than small-volume markets and/or those that would not heavily utilize the system. If the NAIS remains voluntary, additional specialization and differentiation across auction markets is likely.

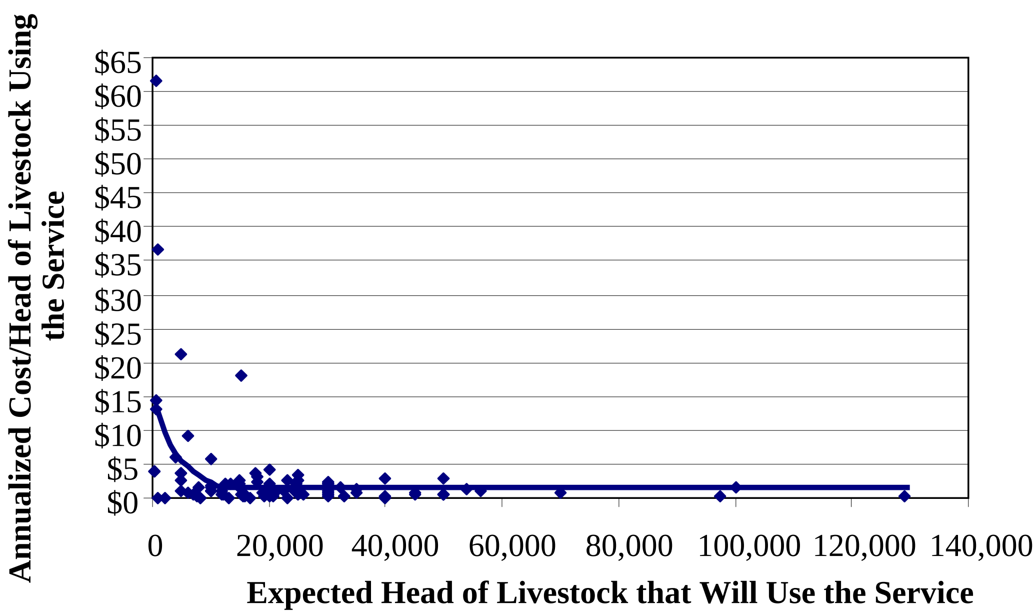

Figure 1. Livestock Market Annualized Cost of a RFID Tagging Service per Head of Livestock Using the Service.

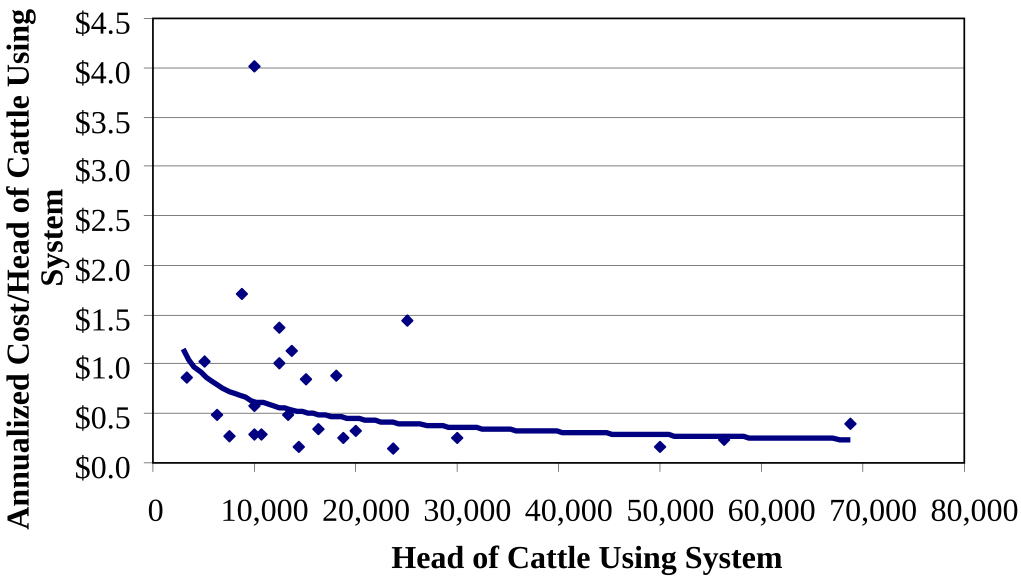

Figure 2. Livestock Market Annualized Costs of a RFID Reader System Based on 25% of Annual Cattle Sales.

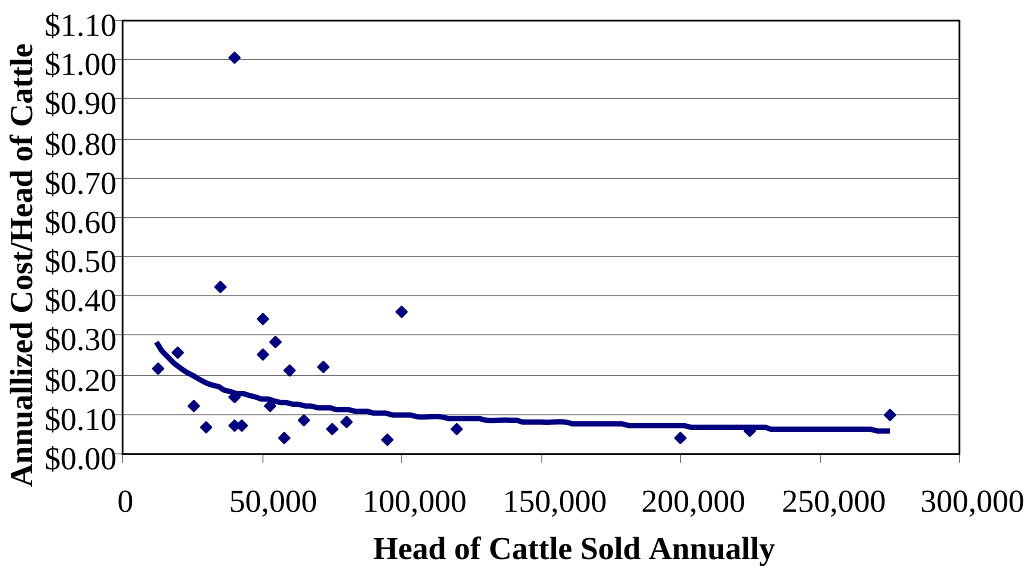

Figure 3. Livestock Market Annualized Costs of a RFID Reader System Based on 100% of Annual Cattle Sales.

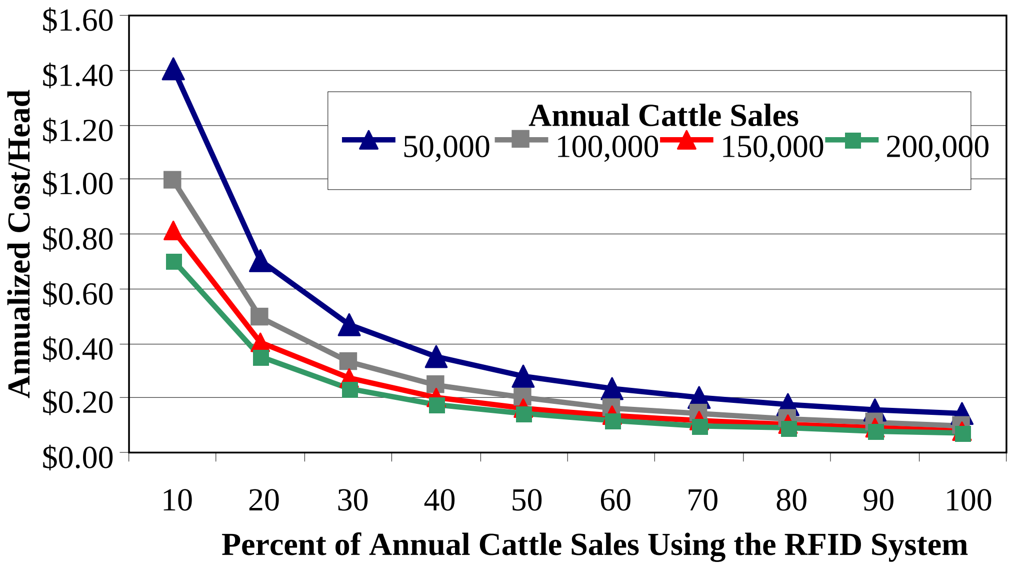

Figure 4. Four Hypothetical Livestock Markets' Expected Annualized Costs of RFID Reader Systems Based on Varying Levels of Cattle Using the System.

NUTRIENT BALANCE OF A COMMERCIAL FEEDLOT

J. M. DeRouchey, S. Q. Jones, and J. M. Ham[1]

Introduction

The ability to develop nutrient balance for a livestock operation is important for maintaining a long-term sustainable production system and for compliance with current and future environmental regulations. Producers invest considerable financial resources in farm inputs, primarily feed and livestock. When animals leave the farm, they retain a portion of the feed nutrients they consumed, but the majority of consumed nutrients are excreted. Once excreted, certain compounds in the manure volatilize, which lowers the manure nutrient content and diminishes economic value of the manure as fertilizer. In addition, these volatile compounds can create air quality concerns. Operations designated as concentrated animal feeding operations must develop nutrient management plans to provide documentation that the manure produced will be applied at agronomic rates for environmental protection. Understanding the nutrient balance of a livestock operation is critical in developing whole-farm manure management plans.

Objectives of this experiment were to determine the nutrient balance of a commercial feedlot and measure amounts of recoverable nitrogen and phosphorus from the feedlot pen surface.

Experimental Procedures

A commercial feedlot in south-central Kansas with a capacity of approximately 35,000 cattle was used for this experiment from November 2005 to May 2006. Within the feedlot, eight adjoining pens were used for data collection. Both heifers and steers, as well as cattle at different weights and feeding durations, were used in the experiment. Average number of head and body weight per pen were 66 and 958 lbs, respectively. Each pen had a total area of 20,664 ft^2, which equated to an average of 313.5 ft^2 per head.

Daily logs were kept for each pen. Data included head count, ration, and amount of feed delivered. Data also were provided on starting and ending weight for each group of cattle housed in the pens. Data were used to determine occupancy of pens during the entire experiment.

Samples of all rations fed during the experiment were taken at the bunk for analyses of daily calculations of nitrogen and phosphorus intake. Diets were based on steam-flaked corn, corn silage, alfalfa hay, and wet distiller's grains, and the proportions of each varied with feeding stage.

Prior to the experiment, all pens were cleaned uniformly following the standard pro-

[1]Department of Agronomy.

tocol of the feedlot. At the conclusion of the experiment, pens were individually cleaned and weights of removed manure were recorded by pen. All manure removed from the eight pens was hauled to a common storage area and piled. A total of 15 manure samples (approximately 30 lbs total) were then taken from the manure pile representing all eight pens. This composite sample was mixed thoroughly and sub-sampled. Four sub-samples were collected and analyzed at a commercial laboratory for Kjeldahl nitrogen and phosphorus. The four sub-sample analyses were averaged to determine the mean concentration of nutrients in the collected manure.

All calculations were completed on a per animal basis within pen. Results are presented as grams/animal per day (Tables 1 and 2). Intakes of nitrogen and phosphorus were calculated based on daily feed deliveries and analyzed nutrient levels of the diets. Values of nitrogen and phosphorus retention are referenced from values obtained from Kissinger et al. (2007) in a large scale nutrient balance study representing six feedlots in Nebraska (nitrogen = 28.0 grams per animal per day; phosphorus = 6.5 grams per animal per day). Excretion of nitrogen and phosphorus was determined by subtraction of retained nutrients from nutrient intake. Nitrogen and phosphorus in manure were determined from the actual manure analysis and volume of manure collected by pen. Amounts of nitrogen and phosphorus lost were determined by subtracting the amount excreted from the amount in the collected manure. Also, the standard deviation for each calculated value was determined.

Results and Discussion

Nitrogen intake for cattle in the experiment was 210.7 grams/animal per day. Based on the assumed nitrogen retention of 28 grams/animal per day, 13.3% of nitrogen fed was retained by the animal. In addition, 135.6 grams/animal per day of nitrogen was lost or non-recovered, which represents 74.2% of the amount of nitrogen excreted.

Table 1. Nitrogen Balance of a Commercial Feedlot[a]

Item,	Mean	SD
N intake, g/animal daily	210.7	29.8
N retained, g/animal daily	28.0[b]	
N excreted, g/animal daily	182.7	29.8
N manure, g/animal daily	47.1	14.4
N lost, g/animal daily	135.6	26.6
N lost, % of excreted	74.2	7.6

[a]Represents eight pens in a 35,000 cattle capacity feedlot from November 2005 through May 2006.
[b]Referenced value from Kissinger et al. (2007).

Table 2. Phosphorus Balance of a Commercial Feedlot[a]

Item,	Mean	SD
P intake, g/animal daily	33.0	4.3
P retained, g/animal daily	6.5[b]	
P excreted, g/animal daily	26.5	4.3
P manure, g/animal daily	17.6	5.4
P lost, g/animal daily	8.8	4.7
P lost, % of excreted	33.3	18.5

[a]Represents eight pens in a 35,000 cattle capacity feedlot from November 2005 through May 2006.
[b]Referenced value from Kissinger et al. (2007).

Phosphorus intake for cattle in the experiment was 33.0 grams/animal per day. Based on the assumed phosphorus retention of 6.5 grams/animal per day, 19.7% of phosphorus fed was retained by the animal. Also, 8.8 grams/animal per day phosphorus was lost or non-recovered, which represents 33.3% of the amount of phosphorus excreted. This level of phosphorus loss was higher than previously published values and was not expected to be this high because phosphorus is not volatile.

The percentage loss of nitrogen recovery can be explained mainly by volatilization of nitrogen from the feedlot surface and secondarily from runoff during rain events or not recovering all nitrogen in the manure from the pen surface. Nitrogen in the form of ammonia can volatilize and contribute to decreased air quality, increased odor, and reduced economic value of the manure for fertilizer. Discrepancy in phosphorus recovery is likely due to unaccounted runoff losses, mixing manure with soil after precipitation events, inconsistent scraping depths at the start or at the conclusion of the experiment, or a combination of these factors.

During the entire experiment, 8.4 inches of rainfall were recorded. However, 4.05 inches were received during the last 45 days of the experiment. With wet conditions present during the last portion of the study, challenges in obtaining complete manure removal at the end of the study might have occurred, which could have resulted in underestimation of recovery of total manure, especially phosphorus.

Implications

Significant amounts of nutrient excretion relative to nutrient intake levels occur in feedlot cattle. This, coupled with subsequent losses of excreted nutrients, particularly nitrogen, from the pen surface needs to be addressed further.

BEHAVIOR OF BEEF COWS GRAZING TOPOGRAPHICALLY RUGGED NATIVE RANGE IS INFLUENCED BY MINERAL DELIVERY SYSTEM

N. A. Sproul, K. C. Olson, J. S. Drouillard, J. R. Jaeger, J. W. Bolte, D. R. Linden, R. A. Kreikemeier, L. A. Pacheco, M. D. Thomas, and J. J. Higgins[1]

Introduction

Poor grazing distribution is a major problem on rangelands of the western United States. Grazing animals tend to congregate in areas near water, shade, and level terrain. These areas typically become overgrazed, while less preferred areas of pasture remain under-grazed. Solutions to localized overgrazing include cross-fencing and water development; however, most land managers are unwilling to bear the expense associated with these strategies.

Most types of supplements, including mineral supplements, have potential to lure cattle into under-utilized areas of range and pasture. Cows spend up to 40% of their time within 650 yards of self-fed supplements, but relationships between terrain use, mineral supplement delivery method, and mineral supplement consumption remain unclear.

Experimental Procedures

The study was conducted on four pastures (approximately 300 acres each) at the Kansas State University Commercial Cow-Calf Unit. These native range pastures were dominated by Big Bluestem (*Andropogon gerardii*), Indiangrass (*Sorghastrum nutans*), Sideoats grama (*Bouteloua curtipendula*), and Little Bluestem (*Schizachyrium scoparium*). All pastures were characterized by moderately rugged terrain (10 to 20% slopes) and contained a single centrally located surface water source. Each pasture was grazed from February to May 2007 by 60 mature beef cows (average initial body weight (BW) = 1239 ± 84 lb); calving occurred during April and May.

Treatments consisted of a self-fed mineral delivered in either a dry granular form (DRY) or as a low-protein, cooked molasses-based block (BLOCK). Supplemental mineral for DRY was supplied free choice to cattle via a single covered mineral feeder. Block was supplied ad libitum to cattle via open-topped barrels (15 animals per feeder) spaced within 10 yards of one another. Both DRY and BLOCK were deployed in each pasture. Pasture was considered the experimental unit. No additional salt was supplied to cattle.

Forage utilization in the vicinity of each supplement type and the frequency and duration of herd visits to the vicinity of each supplement were measured during four 14-day periods. Supplements were moved to new locations each period. Within each pasture, supplements were placed a minimum of 200 yards apart in locations with similar forage species composition, slope, and distance from water. Above-ground biomass was measured in a circular area (radius = 110 yards) around each supplement site on day 1 and day 14 of

[1]Department of Statistics.

each period. Grazing exclusion cages were set up at each site to serve as an index of forage availability. Motion-sensitive cameras, programmed to take time- and date-stamped pictures at 5-min intervals, were placed inside the exclusion cages to record the frequency and duration of herd visits to each supplement deployment site. Herd visits to each site were defined as the interval of time between when the first and last pictures were taken. A herd visit was considered complete when the interval between pictures was at least 30 minutes. Mineral disappearance from feeders was considered equivalent to consumption.

Results and Discussion

Forage availability did not limit dry matter intake by cattle at any time during this experiment. Standing forage biomass was 2,466 lbs/acre during February; 2,449 lbs/acre during March; 2,098 lbs/acre during April; and 2,008 lbs/acre during May.

Consumption of BLOCK was greater than DRY during each month of the experiment (Figure 1). Moreover, the magnitude of the difference was affected by month (treatment × period, $P = 0.03$). In general, consumption of both supplement types declined over time as the forage transitioned from winter dormancy to spring growth. Average intakes of BLOCK and DRY during the experiment were 0.42 and 0.13 lbs/cow per day, respectively.

Greater consumption of BLOCK likely stemmed from more frequent herd visits to sites where BLOCK was deployed compared with sites where DRY was deployed (Figure 2; $P<0.02$). Additionally, herd visits to BLOCK sites were longer than those to DRY sites (Figure 3; $P<0.01$). Average duration of herd visits to both supplement types generally decreased as forage conditions improved (cubic effect, $P<0.01$; Figure 4).

There was a weak trend ($P=0.16$) for the total length of nighttime visits (6 p.m. to 6 a.m.) to be greater for BLOCK than DRY (1.12 vs. 0.87 hours/day). Similarly, herds tended ($P=0.15$) to visit BLOCK more often than DRY during the night time hours (56.7 vs. 50.1% of all visits). Other researchers have reported that cattle spend more time around molasses-based supplements at night than other supplement types.

Standing forage biomass around supplement deployment sites was similar for BLOCK and DRY ($P>0.54$) before and after each experimental period. Measurements of forage disappearance during the trial were complicated by rapid forage growth during the last two months of the trial.

Implications

Data suggest that block supplements influence the behavior of grazing cattle to a greater degree than dry mineral supplements. Molasses-based mineral supplements might be more effective than dry, granular mineral supplements at luring grazing cattle into underutilized areas of pasture.

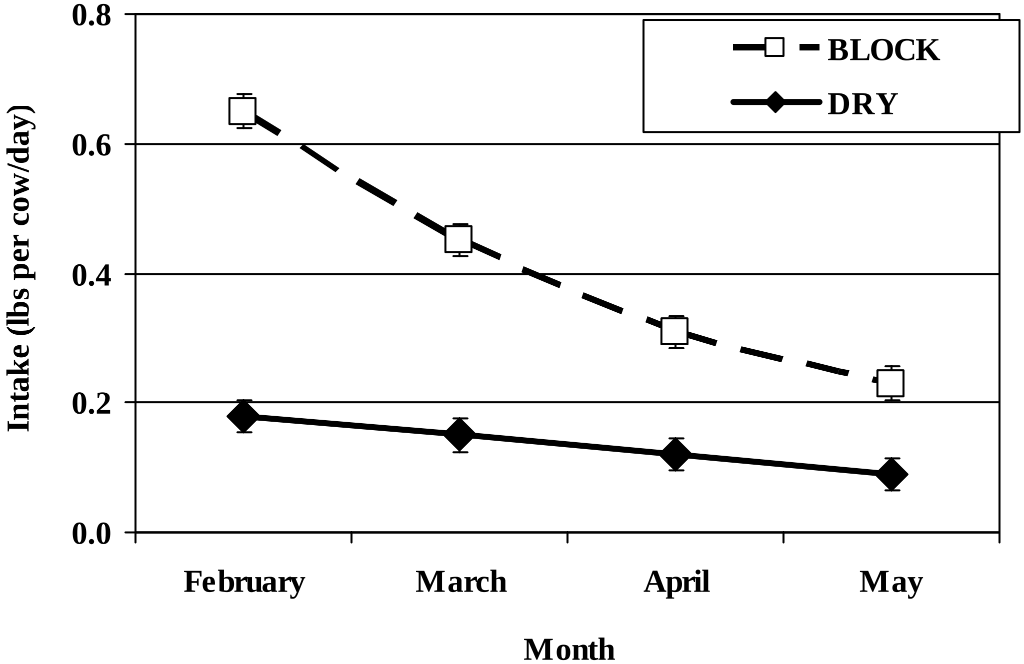

Figure 1. Effect of Mineral Delivery System and Advancing Season on Intake of Mineral Supplements by Cows (treatment × period interaction; P = 0.03).

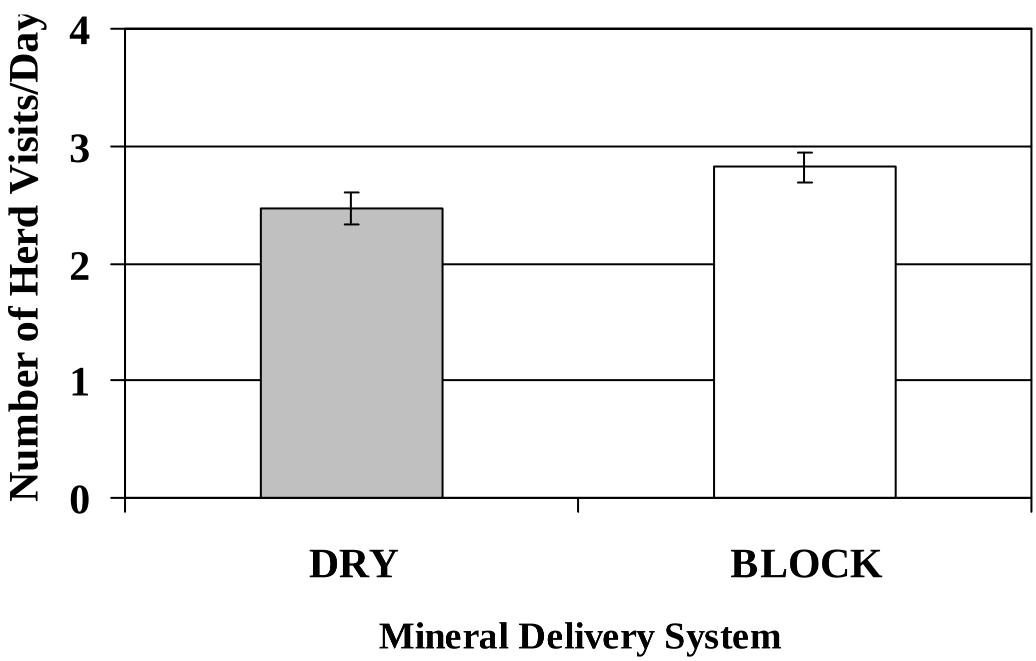

Figure 2. Effect of Mineral Delivery System on the Number Times Beef Cows Visited Supplement Deployment Sites (main effect of treatment; P = 0.02).

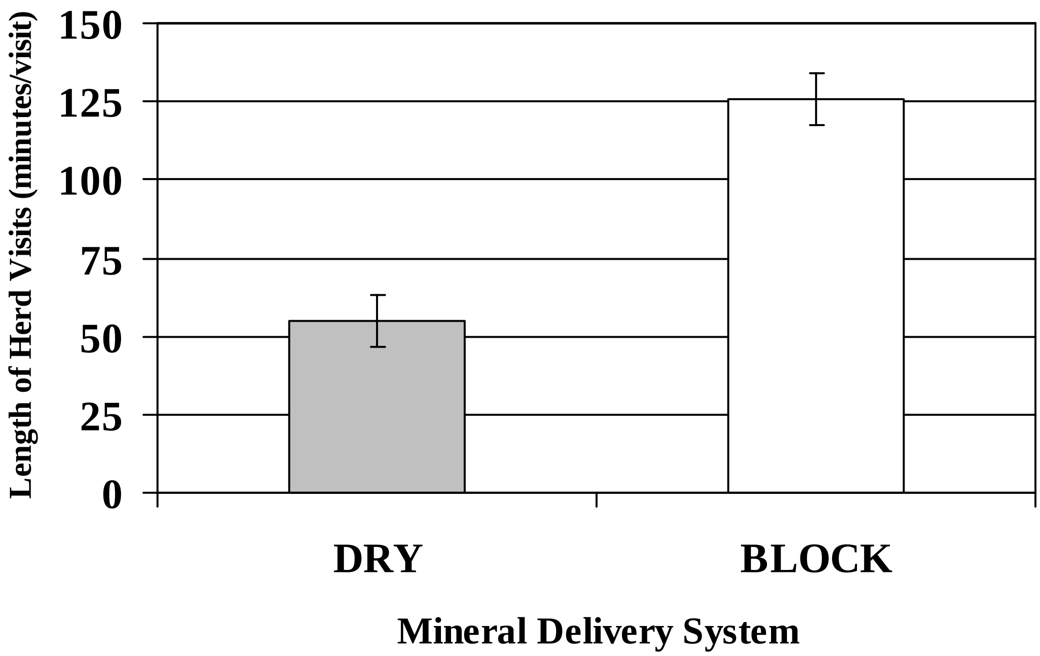

Figure 3. Effect of Mineral Delivery System on the Length of Herd Visits to Supplement Deployment Sites (main effect of treatment; P<0.01).

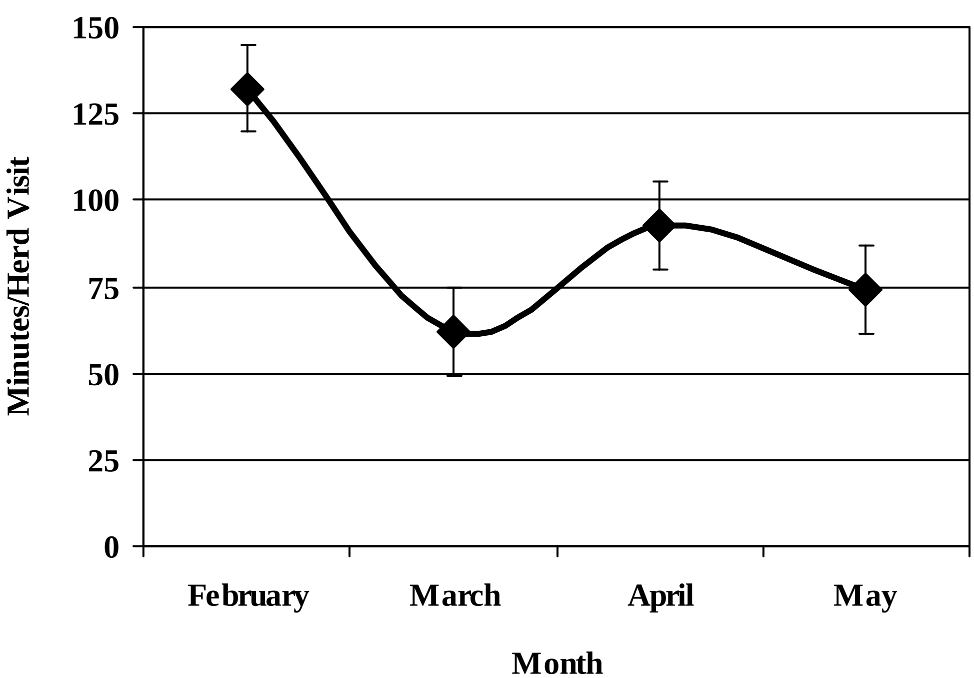

Figure 4. Effect of Advancing Season on the Duration of Herd Visits to All Supplement Deployment Sites (main effect of period; P<0.01).

LENGTH OF THE WEANING PERIOD DOES NOT AFFECT POST-WEANING GROWTH OR HEALTH OF LIGHTWEIGHT SUMMER-WEANED BEEF CALVES

J. W. Bolte, K. C. Olson, J. R. Jaeger, D. U. Thomson, B. J. White, R. L. Larson, G. A. Milliken, N. A. Sproul, and M. D. Thomas

Introduction

Bovine respiratory disease (BRD) is the most economically devastating feedlot disease. Risk factors associated with incidence of BRD include: 1) stress associated with maternal separation; 2) stress associated with introduction to an unfamiliar environment; 3) low feed intake associated with the introduction of novel feedstuffs into the diet; 4) exposure to novel pathogens upon transport to a feeding facility and commingling with unfamiliar cattle; and 5) inappropriately administered respiratory disease vaccination programs. Management practices collectively referred to as preconditioning are thought to minimize carcass damage resulting from BRD.

Preconditioning management attempts to eliminate or reduce risk factors for respiratory disease by: 1) employing a relatively long ranch-of-origin weaning period following maternal separation, 2) exposing calves to concentrate-type feedstuffs, and 3) improving resistance to respiratory pathogens through a pre-weaning vaccination program. The effectiveness of such programs for preserving animal performance is highly touted by certain segments of the beef industry.

Ranch-of-origin weaning periods of up to 60 days are suggested for preconditioning beef calves prior to sale; however, the optimal length of the weaning period has not been determined experimentally. The objective of this study was to test the validity of beef industry assumptions about the appropriate length of ranch-of-origin weaning periods for summer-weaned calves aged 100 to 160 days.

Experimental Procedures

A total of 400 polled, spring-born calves (average body weight (BW) at weaning = 359 ± 69 lbs; average birth date = 03/21/2006 ± 19.5 days) were used for this experiment. One set of calves (n = 200) originated from the Kansas State University Cow-Calf Unit. The second set (n = 200) originated from the Kansas State University Agricultural Research Center at Hays (ARCH). Bulls were castrated at least 14 days prior to the study. At each location, calves were blocked by gender and age and assigned randomly to treatments that corresponded to the length of time between separation from their dam and shipping: 60, 45, 30, 15, or 0 days (n = 40/treatment at each location). Average age of calves on the date of maternal separation was 100, 115, 130, 145, and 160 days of age for calves weaned 60, 45, 30, 15, and 0 days before shipping, respectively. The study was initiated on June 15, 2007 (day -75 relative to shipping), and the common shipping date for all treatments was August 24, 2007 (day 0). All treatments had similar average age at shipping (160 ± 19 days). Body condition score of cows at both locations was measured 60 days before and 60 days after shipping.

All calves were given an initial modified-live vaccination for IBR, BVD, PI3, BRSV, (Bovi-Shield Gold FP, Pfizer Animal Health Exton, PA) and clostridial disease (Vision 7 with SPUR®, Intervet Inc., Millsboro, DE) 2 weeks prior to separation from their dam. They also were individually identified with a color-coded ear tag corresponding to treatment.

On the day of maternal separation, all calves were re-vaccinated for IBR, BVD, PI3, BRSV, and clostridial diseases; they also were treated for internal and external parasites using Dectomax® (Pfizer Animal Health Exton, PA) and weighed. Calves were immediately transported a short distance (< 15 miles) to a central home-ranch weaning facility.

Calves were maintained in earth-floor pens (four pens/treatment) at their respective home-ranch weaning facilities for a period of days corresponding to their assigned treatment. During that period, calves were fed a common weaning ration based on chopped hay, soybean meal, and sorghum grain and formulated to achieve an average daily gain (ADG) of 2.0 at a dry matter intake of 2.5% of BW.

Calves were monitored for symptoms of respiratory disease at 7:00 am and 2:00 pm daily during the weaning phase of the experiment. Calves with clinical signs of BRD, as judged by animal caretakers, were removed from home pens and evaluated. Each calf with clinical signs of BRD was weighed, had rectal temperature measured, and was given a clinical illness score (Table 1). Calves that presented with a clinical illness score greater than 1 and a rectal temperature >104.0ºF were treated according to the schedule described in Table 2. Cattle were evaluated 72 hours post-treatment and re-treated based on observed clinical signs.

Calves from all treatments and both origins were individually weighed and shipped from their respective weaning facilities to an auction market located at Russell, Kansas on August 24, 2007 (day 0). Calves from both locations were commingled with respect to gender, treatment, and body weight and maintained on the premises of the auction market for 14 hours. During that time, calves were moved through the normal processing facilities. The purpose of this step was to simulate pathogen exposure typically encountered by market-ready calves. Calves were shipped directly to ARCH from the auction market.

Upon arrival at ARCH, cattle were individually weighed and assigned randomly to a receiving pen on the basis of treatment and gender. Cattle continued to be fed the diet introduced after maternal separation for a period of 56 days after arrival at ARCH. Feed intake was measured daily. Calves were monitored for symptoms of respiratory disease, and clinical illness was treated as in the home-ranch receiving phase. Body weights were measured at 28-day intervals during this receiving phase.

Results and Discussion

Calf body weight at maternal separation and ADG from maternal separation to shipping decreased linearly ($P<0.03$) with successively earlier weaning dates (Figure 1). Consequently, calf BW at shipping tended to decrease linearly ($P = 0.06$) with successively earlier weaning dates. This probably occurred because calves were an average of 15 days younger at each weaning date. Longer suckling periods were associated with better ADG between weaning and shipping; however, calf ADG from birth to shipping was similar ($P>0.20$) between treatments. We concluded that under the conditions of our study, ranch-of-origin weaning periods of 60 to 15 days had modest affects on calf ADG prior to shipping. Incidence of undifferentiated fever was similar ($P = 0.18$) between treatments prior to shipping. In fact, only three calves were treated for respiratory disease and none expired during the pre-shipment phase of this study.

Feed intake (dry basis) during the first 30 days following shipping increased linearly (P = 0.02) as the length of the ranch-of-origin weaning period increased. Greater experience consuming grower diets prior to shipping translated to greater feed intake of a similar diet at the feedlot. Previous experience with concentrate-based feeds might benefit recently-received calves in some circumstances; however, incidence of undifferentiated fever, gain, and feed:gain in our study were similar (P>0.12) between treatments during the first 30 days in the feedlot (Figures 2, 3, and 4).

Similarity among weaning treatments in terms of growth and health performance calls into question beef industry assumptions about the appropriate length of ranch-of-origin weaning periods. Ranch-fresh, lightweight calves that are properly vaccinated before exposure to market conditions might not require ranch-of-origin weaning periods longer than 2 weeks.

Body condition score of cows was similar (P = 0.94) at the outset of the trial and increased linearly (P = 0.03) with successively earlier weaning dates (Figure 5). Earlier weaning dates can provide beef producers with significant financial benefits in terms of reduced feed costs and improved reproductive performance associated with improved cow body condition.

Implications

Under the conditions of our study, ranch-of-origin weaning periods of between 15 and 60 days did not improve calf health or growth performance relative to shipping calves immediately after maternal separation.

Table 1. Scoring System Used to Classify the Severity of Clinical Illness

Clinical Illness Score	Description	Clinical Appearance
1	Normal	No abnormalities noted.
2	Slightly Ill	Mild depression, gaunt, +/- cough
3	Moderate Illness	Severe depression, labored breathing, ocular/nasal discharge, +/- cough
4	Severe Illness	Moribund, near death, little response to human approach.

Table 2. Treatment Schedule Used to Treat Calves Diagnosed with Bovine Respiratory Disease Complex

Treat	Drug	Dose	Route of Injection
1st Pull	enrofloxacin (Baytril®)	5 ml/CWT	Subcutaneous
2nd Pull	florfenicol (Nuflor®)	6 ml/CWT	Subcutaneous
3rd Pull	oxytetracycline (Biomycin 200®)	5 ml/CWT	Subcutaneous

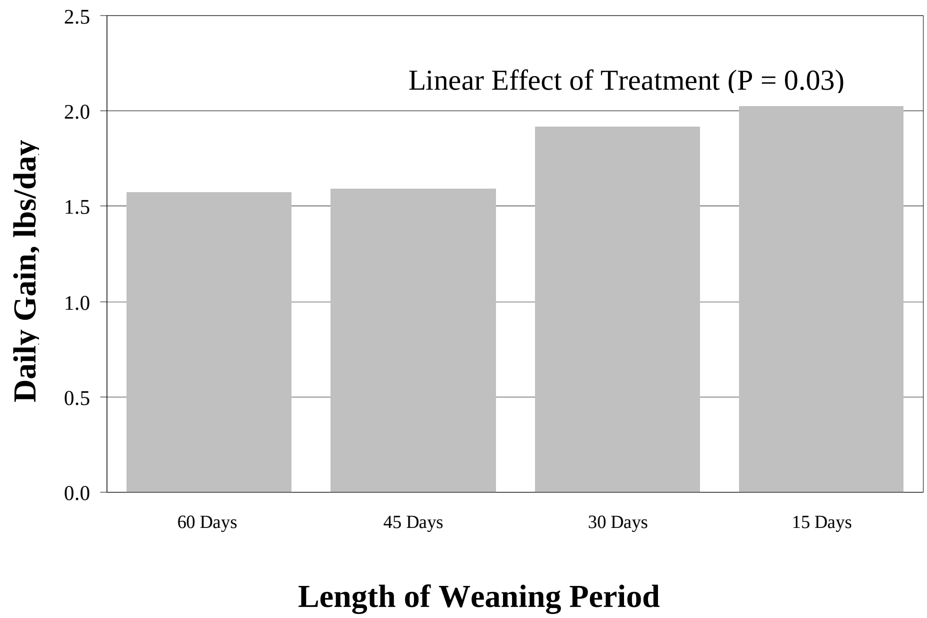

Figure 1. Effect of the Length of Ranch-of-origin Weaning Period on Daily Gain of Lightweight Calves Between Weaning and Shipment to an Auction Market.

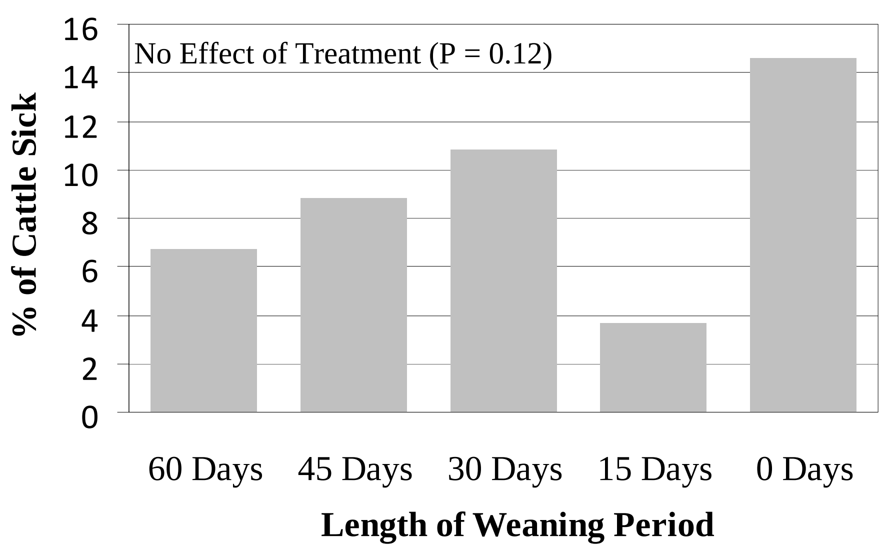

Figure 2. Effect of the Length of Ranch-of-origin Weaning Period on Incidence of Undifferentiated Fever in Lightweight Calves During the First 30 Days After Feedlot Arrival.

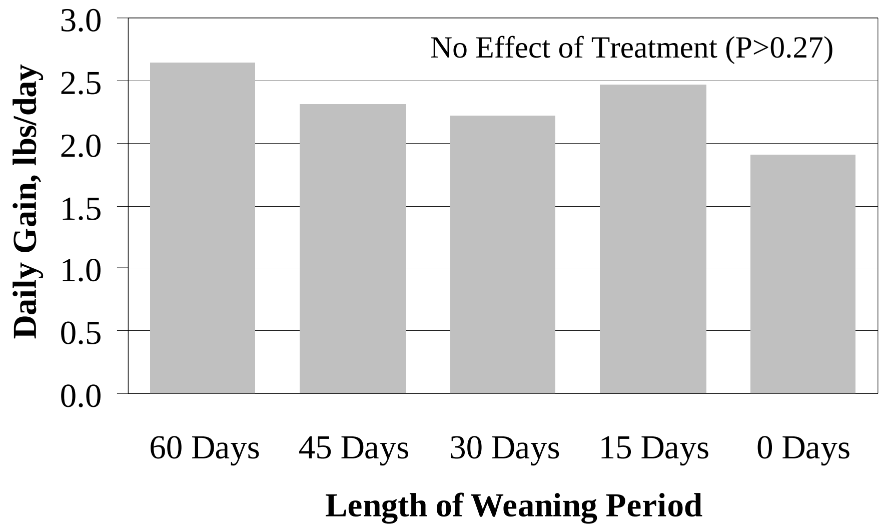

Figure 3. Effect of the Length of Ranch-of-origin Weaning Period on ADG of Lightweight Calves During the First 30 Days After Feedlot Arrival.

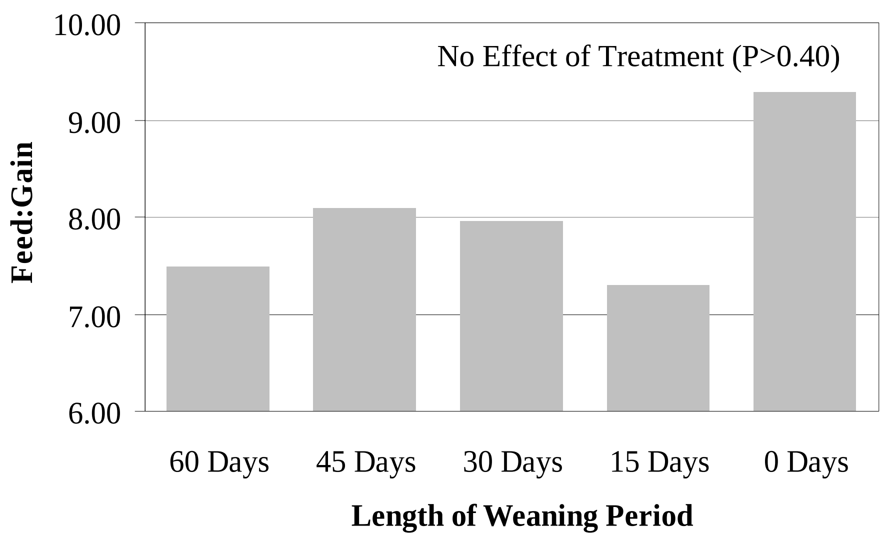

Figure 4. Effect of the Length of Ranch-of-origin Weaning Period on Growth Efficiency of Lightweight Calves During the First 30 Days After Feedlot Arrival.

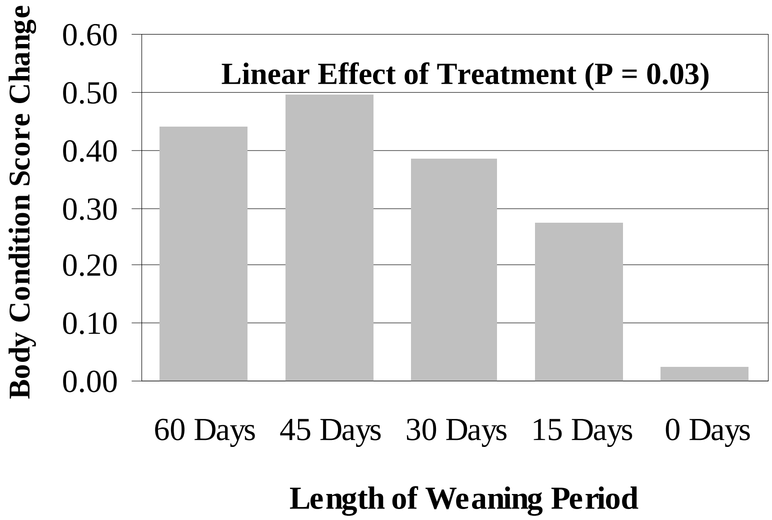

Figure 5. Effect of the Length of Fanch-of-origin Weaning Period on Cow Body Condition Score Change from 60 Days Before Calf Shipping to 60 Days After Calf Shipping.

HEIFERS SIRED BY BULLS WITH LOW RESIDUAL FEED INTAKE ESTIMATED BREEDING VALUES HAVE LOWER RESIDUAL FEED INTAKE THAN HEIFERS SIRED BY BULLS WITH HIGH RESIDUAL FEED INTAKE ESTIMATED BREEDING VALUES[1]

J. Minick Bormann, D. W. Moser, and T. T. Marston

Introduction

Feed is one of the largest costs in a cow/calf or feedlot operation. However, very little data is available to aid producers in genetically improving their herd for feed efficiency. In Australia, bull tests record individual feed intakes, which are used to calculate Estimated Breeding Values (EBV) (analogous to EPD) for residual feed intake (RFI). Residual feed intake measures the degree to which feed intake deviates from expected levels based on the animal size and rate of gain. Negative values are good; they indicate the animal ate less than expected for its size and growth rate. Our objective was to determine differences in feed efficiency traits of progeny from bulls with divergent genetic merit for RFI.

Experimental Procedures

Angus bulls with high and low RFI EBV were selected from the Australian Angus Association sire summary. Average EBV of the three low RFI (efficient) bulls was -1.06 lbs, and the average EBV of the two high RFI (inefficient) bulls was 0.73 lbs. These sires were mated to Angus cross commercial cows from the Kansas State University Cow-Calf Unit in spring of 2005. Resulting heifer calves (n=50) were blocked by sire into two groups, and feed intake data were collected on each group for 42 days using the Calan gate (American Calan, Inc., Northwood, NH) feed intake measuring system. After the feed intake test was completed, the gain test was continued; heifers were on gain test for a total of 58 days. Heifers were allowed free-choice access to a high-roughage, complete diet. Bi-weekly body weights were used to calculate a regression to determine mid-test body weight and average daily gain (ADG). Actual feed intake was regressed on mid-test metabolic body weight and ADG for the test group to calculate a predicted feed intake for each heifer. RFI was calculated for each heifer by subtracting predicted intake from actual intake. Test group was used as a fixed effect in all analyses.

Results and Discussion

Least square means for heifer RFI were -0.53 lbs for heifers sired by low RFI EBV bulls and 0.64 lbs for heifers sired by high RFI EBV bulls (P = 0.18). Least square means for heifer feed:gain ratio were 12.14 lbs/lb for heifers sired by low RFI EBV bulls and 12.52 lbs/lb for heifers sired by high RFI EBV bulls (P = 0.87). Average daily gain of heifers sired

[1]The authors thank the American Angus Association and Angus breeders for their support of this project.

by low RFI bulls (2.6 lbs/day) was similar to that of heifers sired by high RFI bulls (2.7 lbs/day; P = 0.47). Regression of heifer RFI on sire RFI EBV was 0.63 lbs of heifer RFI per pound of sire RFI EBV, which is similar to the expected 0.50 lb of heifer RFI per pound of sire RFI EBV.

Implications

Differences in daughter RFI were similar to that predicted by sire RFI EBV. Additional research will be conducted to determine correlations between RFI and other traits, such as fertility and carcass traits.

DISTILLER'S GRAIN MARKET PRICE RELATIONSHIPS, DISCOVERY, AND RISK MANAGEMENT

T. W. Van Winkle and T. C. Schroeder[1]

Introduction

The substantial increase in corn use by the ethanol refinery industry (Figure 1) has resulted in livestock producers, especially cattle feeders, substituting distiller's grain (DG) for corn in feed rations. DG futures markets do not exist, but actively traded corn and soybean meal (SBM) futures are the most probable markets for hedging DG price risk. Therefore, the ability to offset DG price risk using corn and SBM futures is incorporated into analysis to quantify the strength of price relationships. If DG prices and corn or SBM futures prices are strongly related, then a viable cross hedging opportunity might exist. If they are not related, then cross hedging DG price risk in corn or SBM could increase risk. The growing importance of DG markets demonstrates a need for information regarding price relationships in the industry. The purpose of this study is to determine DG price relationships across locations and over time. Particular objectives include estimating how strongly related DG prices are across different locations, determining whether price leadership is present, and quantifying risk in cross hedging DG using existing futures contracts.

Procedure

Data used in this analysis are a compilation of public and private sources including the USDA Agricultural Marketing Service weekly feedstuff's report, *Feedstuff's* magazine, and the University of Missouri's dairy extension service weekly price quotes. Data include locations of Lawrenceburg, IN; Atlanta, GA; Buffalo, NY; Chicago, IL; Los Angeles, CA; Okeechobee, FL; Portland, OR; Minneapolis, MN; Muscatine, IA; Atchison, KS; and Macon, MO. The DG prices all are weekly quotes covering a period from the beginning of 2001 through 2006. Weekly average settlement prices for corn and SBM futures contracts used in the cross hedging portion are Chicago Board of Trade quotes obtained from the Commodity Research Bureau.

To gain a better understanding of DG price relationships across locations, we tested for the presence of long-run equilibrium relationships between prices from different markets. Market combinations showing long-run price relationships that move together over time are considered closely linked. Conversely, if prices across locations do not tend to move together, then evidence suggests that the markets are segmented.

After we evaluated the presence of long-run equilibrium relationships, we determined how quickly prices are adjusted by individual firms in response to price changes at other locations to detect price leadership among various DG market locations. A speed-of-adjustment estimate with a value of "1" indicates the market fully reacts rapidly (within

[1]Department of Agricultural Economics.

one week) to price changes at other locations. On the other extreme, a speed-of-adjustment estimate near zero implies a very slow reaction for one market to change in response to price at another market location.

Lastly, an analysis of cross-hedging DG via corn and SBM futures contracts was done using ordinary least-squares regression. Estimates for the cross-hedge ratios were obtained through this procedure. A combination of corn and SBM futures were chosen for the cross-hedging feasibility analysis because these commodities are expected to be most closely related to DG prices.

Results and Discussion

Tests of the long-run equilibrium relationship for each pair-wise DG market location and the futures markets indicated 27 of 78 (35%) combinations have a long-run relationship ($P \leq 0.05$). Some locations, such as Lawrenceburg, IN, Buffalo, NY, and Minneapolis, MN, had stronger tendencies to be more closely related to other markets. Overall, results indicate DG market prices across locations are somewhat independent of each other without strong linkages.

Considerable bi-directional information flow is present in DG markets, indicating there is not a dominant market location in regard to price leadership. Corn and SBM futures markets tend to lead the various DG market prices with little feedback. When corn and SBM futures prices change, DG market prices tend to follow with similar direction price changes, but DG market prices do not cause noticeable changes in corn or SBM prices.

Speed-of-price adjustment was estimated to determine how quickly markets respond to price changes at other locations. Speed-of-adjustment coefficient estimates are reported in Table 1. Most of the speed-of-adjustment coefficient estimates are statistically significant ($P \leq 0.05$). However, estimates range from 0.028 to 0.216, suggesting that the overall reaction time across the spatial markets is slow.

Results of assessing opportunity for cross-hedging DG using corn and SBM futures varied noticeably by location. Estimated cross-hedge ratios are presented in Table 2. The magnitude of the hedge ratios is location dependent, but the model does a poor job of capturing the price variability in the cash DG market. Using a combination of the two futures contracts does not appear to enhance the ability to explain price variability in the DG market. Therefore, cross hedging DG via corn and SBM futures contracts doesn't appear viable.

Implications

The lack of strong linkages in DG prices across location indicates buyers of DG would likely benefit from shopping around to determine the location of the best price each time DG purchase decisions are made. Monitoring prices at multiple locations is likely to be valuable for DG purchasers, as no leading markets appear to serve as barometers of other DG market prices. Also, DG prices at different locations are slow to react to price changes at other locations, meaning these markets tend to be independent and might be information starved. Perhaps additional public market information could help link DG markets more strongly across location. Existing corn and SBM futures markets are not viable cross hedges for DG, which motivates use of forward contracting or development of a DG futures market to manage DG price risk over time.

Table 1.

Speed of adjustment coefficient results

	Dependent variable											
Independent	Lawrenceburg	Atlanta	Buffalo	Chicago	Los Angeles	Okeechobee	Portland	Minneapolis	Muscatine	Atchison	Macon	Corn
Atlanta	0.140*											
Buffalo	0.216*	0.009										
Chicago	0.115*	0.036*	0.090*									
Los Angeles	0.149*	0.065*	0.085*	0.060*								
Okeechobee	0.120*	0.012	0.075*	0.042*	0.080*							
Portland	0.094*	0.024	0.054*	0.053*	0.042	0.094*						
Minneapolis	0.139*	0.050*	0.085*	0.039	0.108*	0.145*	0.067*					
Muscatine	0.111*	0.041*	0.004	0.038*	0.099*	0.158*	0.043*	0.058*				
Atchison	0.142*	0.052*	0.096*	0.057*	0.135*	0.148*	0.079*	0.148*	0.041*			
Macon	0.155*	0.031	0.079*	0.037	0.000	0.142*	0.071*	0.053	0.022	0.035		
Corn	0.061*	0.042*	0.039*	0.041*	0.071*	0.136*	0.053*	0.069*	0.048*	0.035*	0.065*	
SBM	0.067*	0.029*	0.057*	0.025	0.028	0.092*	0.043*	0.056*	0.046*	0.028*	0.037*	0.012

* $P \leq 0.05$

Table 2.

Cross Hedging Estimates for DG using Corn and SBM futures, Weekly 2001-2006

	Intercept	Corn	Soybean Meal	Adj. R^2
Lawrenceburg	0.128	0.557	0.003	-0.006
	(0.573)	(0.868)	(0.930)	
Atlanta	0.099	1.720	0.055	0.034
	(0.421)	(0.345)	(0.004)	
Buffalo	0.054	1.759	0.059	0.014
	(0.769)	(0.520)	(0.041)	
Chicago	0.110	2.826	0.031	0.004
	(0.565)	(0.319)	(0.302)	
Los Angeles	0.084	9.497	0.077	0.094
	(0.630)	(0.000)	(0.005)	
Okeechobee	0.101	-5.248	0.039	-0.001
	(0.738)	(0.240)	(0.411)	
Portland	0.100	4.175	0.078	0.035
	(0.608)	(0.147)	(0.011)	
Minneapolis	0.111	4.607	0.062	0.025
	(0.582)	(0.121)	(0.049)	
Muscatine	0.081	2.735	0.088	0.061
	(0.590)	(0.218)	(0.000)	
Atchison	0.083	3.189	0.044	0.026
	(0.551)	(0.121)	(0.041)	
Macon	0.077	6.969	0.080	0.057
	(0.691)	(0.015)	(0.008)	

Note: The numbers in the parentheses are P-values

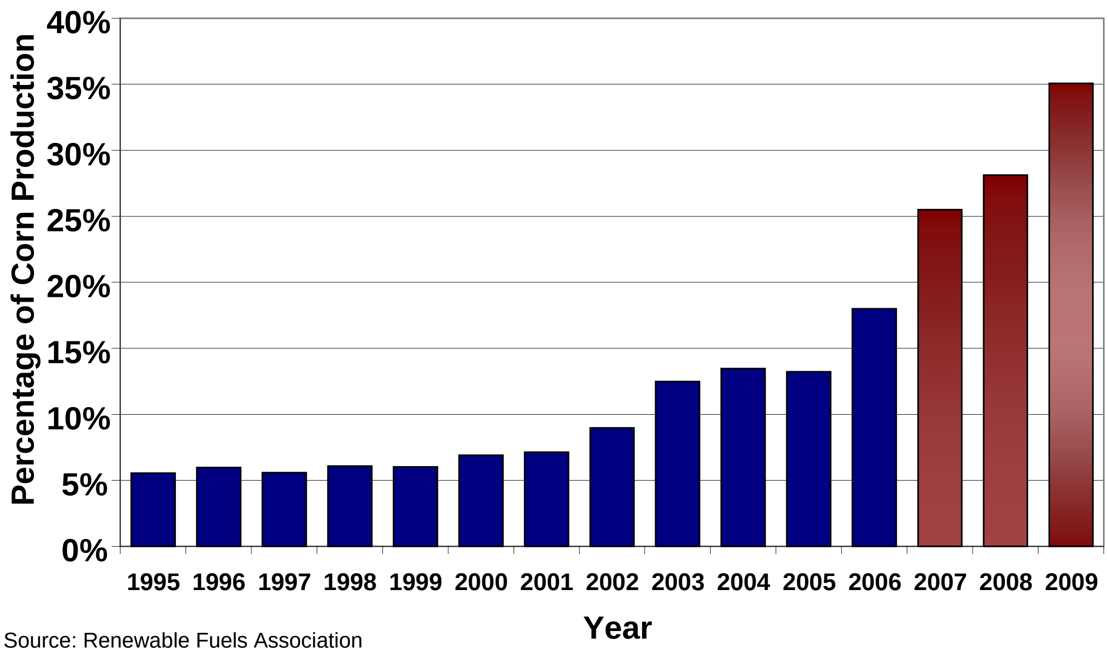

Figure 1. Percentage of U.S. Corn Production Used for Ethanol Production 1995-2009 ('07-'09 forecasted).

RESTRICTED FEEDING IMPROVES PERFORMANCE OF GROWING STEERS DURING SUBSEQUENT GRAZING ON NATIVE FLINT HILLS PASTURE

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Introduction

Beef stocker operators are margin-operators, and rising feed costs force them to consider alternative feeding strategies to reduce production costs. Limit-feeding is a management technique that has positive implications for cost control. In this experiment, we restricted dry matter intake to determine if steers could compensate for a period of dietary restriction during intensive early grazing. This study illustrated that limit-feeding could reduce feed costs for stocker and background operators.

Experimental Procedures

Three loads of highly stressed, crossbred calves (n = 329; body weight = 420 lbs) were weighed and tagged on arrival at the Kansas State University Beef Stocker Unit. Calves were given a metaphylactic antibiotic (Draxxin[1]), vaccinated for clostridial and viral diseases, and de-wormed; bulls were castrated, and all animals were fed the Base 1 ration (Table 1). Following processing, steers from each load were placed in a row of eight pens divided into two blocks with four pens in each block. Steers were randomly assigned to pens and treatments within a block. Treatments consisted of a control group (full-fed) and steers restricted to dry matter intakes of 2.50, 2.25, or 2.00% of body weight. Steers were fed the same diet two times daily. Two step-up rations, Base 1 and 2 (Table 1), were fed for 18 days before treatments began. Steers were weighed at 14 day intervals, and intakes of restricted treatments were adjusted according to body weight on days 30, 45, and 62. Final weights with common gut-fill were measured on day 67.

On day 67, steers were de-wormed, implanted with Ralgro[2], and allotted by weight and treatment to burned, native tallgrass pastures with equal stocking densities. Each treatment group was evenly distributed in each pasture. Steer weights were measured 45 and 90 days after turn out. Steers were placed in the previous pens for five days and fed Base 1 at 2.00% of body weight (Table 1) to equalize gut-fill.

Results and Discussion

Average daily gain (ADG) of steers fed free choice was 28, 32, and 51% higher than steers fed 2.50, 2.25, and 2.00% of body weight, respectively. The ADG of steers fed 2.50 and 2.25% of body weight was similar ($P>0.05$) at the conclusion of the drylot phase. When compared with all other treatments, steers fed 2.00% of body weight had the lowest gains during the drylot period. Feed:Gain

[1]Draxxin is a registered trademark of Pfizer Inc., New York, NY.
[2]Ralgro is a registered trademark of Schering-Plough Animal Health, Summit, NJ.

was more desirable for steers restricted to 2.50 or 2.25% of body weight compared with steers fed free choice or at 2.00% of body weight. Steers fed at 2.00% of body weight had poorer feed conversion efficiency than steers in any other treatment. Overall, steers fed free-choice cost 25% more (P<0.01) than steers that were limit-fed (Table 2).

Steers fed free choice had the poorest gains during the first 45 days of grazing; those fed at 2.00% body weight had the greatest gains (P<0.05). Animal performance tends to suffer during the second 45 days of grazing due to declining forage quality. Daily gains for all treatments were numerically lower during this period. Steers fed free-choice had the poorest daily gains overall during grazing. Final weights for steers fed free-choice, 2.50, and 2.25% body weight after grazing were not different (P>0.05); however, steers fed 2.00% body weight still had the smallest final weights of all treatments.

Implications

Limit-feeding in the drylot phase of stocker or background operations can decrease feed costs and increase performance of steers during subsequent grazing compared with full-feeding in the drylot phase.

Table 1. Drylot Ration Ingredients (% dry matter)

	Base 1[1]	Base 2[2]	Base 3[3]
Dry rolled corn	30.00	30.67	36.76
Wet corn gluten feed	28.00	35.96	36.76
Alfalfa hay	23.00	15.49	15.01
Prairie hay	16.00	15.19	8.47
Mineral supp.	3.00	2.70	3.00
Ration costs, $/ton	107.56	107.83	111.53

[1]Base 1 fed for 9 days following arrival of steers.
[2]Base 2 fed for 6 days following Base 1.
[3]Base 3 fed for remainder of feeding trial.

Table 2. Steer Performance by Treatment in Drylot

	Receiving Treatments[1]			
	Free-choice	2.50% BW	2.25% BW	2.00% BW
No. head	83	81	81	82
Initial body weight, lbs	420	418	420	420
Final body weight, lbs	587[a]	561[b]	557[b]	530[c]
Overall body weight gain, lbs	167	143	139	110
ADG, lbs	3.12[a]	2.29[b]	2.13[b]	1.61[c]
Feed:Gain	5.67	5.34	5.25	5.76
Cost[2] $/hd/trt/day	1.03[a]	0.79[b]	0.78[b]	0.74[c]

[1]Receiving treatments:
Free-choice: steers fed at free choice managed on slick-bunk; 2.50% BW: steers fed at 2.50% of BW; 2.25% BW: steers fed at 2.25% BW; 2.00% BW: steers fed at 2.00% BW.
[2]Costs/ton of DRC: $152; WCGF: $60; Alfalfa: $140; Prairie Hay: $80; Mineral Suppl.: $180
[abc]Means within a row without a common superscript letter differ (P<0.05).

Table 3. Steer Performance by Treatment During Grazing

	Receiving Treatments[1]			
	Free-choice	2.50% BW	2.25% BW	2.00% BW
Turn out weight, lbs[2]	587	561	557	530
Mid-grazing body weight, lbs[3]	693	671	671	645
Final-grazed body weight, lbs[4]	781[a]	770[a]	770[ab]	745[b]
Overall body weight gain, lbs	196	207	211	216
Grazing period 1 ADG, lbs/day	2.33[a]	2.42[b]	2.51[b]	2.57[c]
Grazing period 2 ADG, lbs/day	1.87	2.05	2.05	2.07
Overall ADG, lbs/day	2.09	2.24	2.29	2.31

[1]Receiving Treatments:
Free-choice: steers fed free choice managed on slick bunk; 2.50% BW: steers fed at 2.50% BW; 2.25% BW: steers fed at 2.25% BW; 2.00% BW: steers fed at 2.00% BW.
[2]Turn out May 1.
[3]Mid-grazing weight measured June 15.
[4]Final-grazed weight measured July 27.
[abc]Means within a row without a common superscript letter differ (P<0.05).

CRUDE GLYCERIN IN STEAM-FLAKED CORN-BASED DIETS FOR BEEF CATTLE

G. L. Parsons, M. K. Shelor, and J. S. Drouillard

Introduction

Plant oils contain large amounts of triglycerides that will react to a catalyst, such as methanol. The transesterification reaction between the oil and alcohol will produce approximately 10% crude glycerin and 90% biodiesel. Crude glycerin is distilled for use in human products such as soaps, cosmetics, and moisturizers, but the usefulness of glycerin as a feed source for livestock is unclear. Rapid expansion of the biodiesel industry has created excess supplies of crude glycerin. It is thought that glycerin can be used in ruminant diets to decrease feed costs, but crude glycerin from biodiesel production can contain various levels of methanol, which can be toxic to livestock at increased levels. The purpose of this experiment was to determine the effects of feeding crude glycerin derived from soybean oil in steam-flaked corn finishing diets fed to beef cattle.

Experimental Procedures

In March 2007, 375 crossbred yearling heifers (929.5 ± 63 lbs) were used in a finishing trial. Upon arrival, all cattle were offered *ad libitum* access to alfalfa hay and water before processing. Within 24 hours of arrival, cattle received injections of Bovishield[1] 4 and Ultrabac[1] 7 vaccines and were treated with internal and external parasiticide. Cattle were implanted with Revalor[2]-200 and gradually adapted to a 94% concentrate diet with 6% alfalfa hay (Table 1). Dietary treatments consisted of 0, 2, 4, 8, 12, or 16% crude glycerin (dry matter basis). Cattle were transitioned from the control diet to diets containing increasing proportions of glycerin over a 10-day period. Cattle were blocked by initial weight and randomly assigned within block to each of the six treatments. Three weight blocks were used with six to seven animals per pen and nine pens per treatment. Cattle were housed in 54 concrete-surfaced pens (392.9 ft^2) with roofs covering feed bunks and half the pen. Cattle were fed free choice once daily.

On day 85, pens were weighed using a platform scale and shipped to a commercial abattoir in Emporia, KS. At slaughter, hot carcass weight and incidence and severity of liver abscesses were measured. After a 24-hour chill period, USDA yield grade; USDA quality; marbling score; 12th-rib fat thickness; kidney, pelvic, and heart fat; and ribeye area were measured.

Results and Discussion

Glycerin increased average daily gain when added at levels less than 8% of the dry matter diet. Reductions in dry matter intake were observed when glycerin levels increased above 8%. Feeding glycerin at 2, 4, 8, and 12

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[1]Bovishield and Ultrabac are registered trademarks of Pfizer Animal Health.
[2]Revalor is a registered trademark of Intervet, Inc.

% of the diet increased feed efficiency by 10.8, 10.0, 7.2, and 3.1%, respectively. Final body weights increased by 28.0, 17.8, and 11.7 pounds when glycerin was added at 2, 4, and 8% of the diet, respectively, but reductions in final body weight occurred when glycerin was fed at the 12 and 16% levels.

Hot carcass weights increased by 17.8, 11.3, and 7.3 pounds when glycerin was fed at 2, 4, and 8% levels, respectively, but were reduced at levels 12% and greater. *Longissimus* muscle area decreased when glycerin was added to the diet. Feeding glycerin caused reduced subcutaneous fat over the 12th-rib and lower marbling scores. Lower marbling scores resulted in a 1.3 to 16.4% reduction in the percentage of glycerin-fed cattle grading UDSA Choice. The percentage of glycerin-fed cattle grading USDA Select increased between 0 and 14.8%. Treatment had no effect on percentage of kidney, pelvic, and heart fat or the percentage of liver abscesses.

Implications

Adding glycerin at 2 to 8% of the steam-flaked, corn-based finishing diet improved weight gains and efficiency, but higher levels appear detrimental.

Table 1. Experimental Diets and Calculated Dietary Nutrients for Cross-bred Heifers Fed Diets Containing 0, 2, 4, 8, 12, and 16% Crude Glycerin

	% Crude Glycerin, dry matter basis					
Ingredient, %	0	2	4	8	12	16
Steam-flaked corn	82.6	80.2	77.8	73.0	68.2	63.4
Corn steep liquor	5.7	5.7	5.7	5.7	5.7	5.7
Alfalfa hay	5.9	5.9	5.9	5.9	5.9	5.9
Glycerin[1]	0.0	2.0	4.0	8.0	12.0	16.0
Protein/mineral premix[2]	3.6	4.1	4.5	5.2	6.0	6.8
Feed additive premix[3]	2.2	2.2	2.2	2.2	2.2	2.2
Nutrients						
Dry matter, %	81.0	81.2	81.3	81.5	81.7	82.0
CP	14.9	14.9	14.8	14.7	14.6	14.5
Ca	0.7	0.7	0.7	0.7	0.7	0.7
P	0.3	0.3	0.3	0.3	0.3	0.3

[1]Methanol content of glycerin, <0.01%
[2]Formulated to provide 0.1 ppm Co; 10 ppm Cu; 0.6 ppm I; 60 ppm Mn; 0.25 ppm Se; 60 ppm Zn; 1.0% K; 2,640 IU/kg vitamin A.
[3]Feed additive premix was formulated to provide 300 mg monensin, 90 mg tylosin, and 0.5 mg melengestrol acetate per heifer daily using ground corn as the carrier.

Table 2. Feedlot Performance of Heifers Fed 0, 2, 4, 8, 12, 16% Crude Glycerin for Final 85 Days on Feed

	% Crude Glycerin (dry matter basis)							Contrasts		
Item	0	2	4	8	12	16	SEM	Linear	Quadratic	Cubic
Number of heifers	62	62	61	63	63	62	-	-	-	-
Initial weight, lbs	929.6	929.5	929.0	929.8	929.9	929.4	8.95	-	-	-
Final weight[1], lbs	1153	1181	1171	1165	1149	1122	11.4	*	*	-
Dry matter intake, lbs	19.5	19.6	19.1	19.0	18.5	17.2	0.29	*	*	-
Average daily gains, lbs	2.63	2.96	2.85	2.76	2.58	2.26	0.20	*	*	-
Feed:Gain	7.41	6.61	6.67	6.88	7.18	7.61	0.02	-	*	-

[1]Calculated by dividing HCW by a common dressing percentage of 63.5%.
* = P<0.05, † = P<0.10

Table 3. Carcass Characteristics of Heifers Fed 0, 2, 4, 8, 12, or 16% Crude Glycerin

	% Crude Glycerin (Dry matter basis)							Contrasts			
Item	0	2	4	8	12	16	SEM	Linear	Quadratic	Cubic	0 vs Glycerin
Hot carcass weight, lbs	732.2	746.0	743.5	739.5	729.5	712.2	10.24	*	*	-	-
Rib-eye area, in^2	12.88	13.38	13.02	12.82	12.66	12.62	0.24	*	-	-	-
USDA Yield Grade											
Yield grade 1,%	11.4	16.1	13.2	11.1	12.7	15.9	4.03	-	-	-	-
Yield grade 2,%	32.0	32.8	31.2	33.3	28.6	40.5	6.51	-	-	-	-
Yield grade 3,%	51.9	51.1	47.6	44.5	50.8	42.1	6.6	-	-	-	-
Yield grade 4 & 5,%	4.8	0.0	7.9	11.1	6.4	1.6	2.61	-	†	*	-
Average yield grade	2.5	2.35	2.52	2.55	2.54	2.29	0.09	-	-	*	-
USDA Quality Grade											
Prime, %	3.2	0.0	1.6	0.0	0.0	1.6	1.28	-	-	-	†
Choice, %	53.7	50.3	57.4	42.9	52.4	37.3	6.11	†	-	-	-
Select, %	43.1	46.6	37.8	53.9	46.0	57.9	5.6	†	-	-	-
No Roll, %	0	3.2	3.2	3.2	1.6	3.2	1.7	-	-	-	-
Marbling[1]	435	405	416	398	410	397	9.67	*	-	-	*
Kidney, pelvic, and heart fat, %	2.24	2.21	2.19	2.24	2.2	2.19	0.04	-	-	-	-
12th-rib fat thickness, in	0.48	0.43	0.46	0.46	0.46	0.40	0.02	*	-	*	†
Liver abscess, %	11.1	6.6	17.7	9.5	4.7	17.7	4.11	-	-	-	-

[1]Marbling scores were obtained by a commercial abattoir; Slight =3 00-399, Small = 400-499, Modest = 500-599.
* = P<0.05, † = P<0.10.

SUBSTITUTING STEAM-FLAKED CORN WITH DISTILLER'S GRAINS ALTERS RUMINAL FERMENTATION AND DIET DIGESTIBILITY

S. Uwituze, G.L. Parsons, M. K. Shelor, B.E. Depenbusch, K. K. Karges[1], M. L. Gibson[1], and J. S. Drouillard

Introduction

Rapid expansion of fuel ethanol production in the High Plains, where feedlots commonly use steam-flaked corn diets, has popularized substituting dried distiller's grains with solubles (DDGS) for a portion of the steam-flaked corn. Most of the starch in corn is removed during ethanol production. The residual material is rich in fiber, ruminal undegradable protein, and fat. Adding roughage to high-concentrate finishing diets helps maintain ruminal function by stimulating salivation, rumination, and gut motility. The source and level of roughage can influence dry matter intake. Our objective was to examine ruminal fermentation characteristics and diet digestibility when steam-flaked corn-based finishing diets were fed with either 0 or 25% DDGS, using alfalfa hay or corn silage as roughage sources.

Experimental Procedures

Cannulated Holstein steers (n = 12) were used in a finishing study. Four dietary treatments based on steam-flaked corn were used: 0% DDGS with 6% alfalfa hay, 0% DDGS with 10% corn silage, 25% DDGS with 6% alfalfa hay, or 25% DDGS with 10% corn silage (dry matter basis). Steers were randomly assigned to each experimental diet. Diets were fed free choice and formulated to contain similar amounts of crude protein (Table 1). Weights of fresh feed provided and feed removed were recorded. Steers were housed in individual slatted floor pens measuring 49 ft^2. Pens were equipped with individual feed bunks and water fountains that allowed continual access to clean water. The study was conducted during two periods, each consisting of a 17-day adaptation phase and 3-day collection phase. Three animals were assigned to each diet in each period. Ruminal digesta samples were collected at 2-hour intervals after feeding during the collection phase and used to determine ruminal pH and ruminal concentrations of ammonia, volatile fatty acids, and lactate. Fecal samples were collected at each sampling point, composited per animal and period, and used to determine total fecal output and total tract digestibility of dry matter, organic matter, neutral detergent fiber (NDF), crude protein, starch, and fat. One animal became ill during the experiment and was removed from all analyses.

Results and Discussion

Ruminal pH for all dietary treatments was below 5.8 for more than half of the 24-hour measurement period. Cattle fed 25% DDGS had consistently lower ruminal pH throughout the 24-hour period when alfalfa hay was fed, but they had the highest pH when corn silage was used as a roughage source from 12 to 22

[1]Dakota Gold Research Association, Sioux Falls, SD.

hours after feeding. We hypothesized that feeding DDGS in steam-flaked corn-based diets would decrease fiber digestion due to low ruminal pH. Surprisingly, neutral degerent fiber digestibility was similar for cattle fed diets with and without DDGS (Table 2). However, feeding 25% DDGS resulted in 6.1% lower organic dry matter digestion compared with feeding no DDGS. This decrease seems attributable to a depression in digestibilities of starch and crude protein when DDGS replaces a portion of the steam-flaked corn. Additionally, ruminal ammonia concentrations were drastically lower in steers fed diets containing 25% DDGS than in those fed 0% DDGS for the majority of time. It is conceivable that replacing a portion of steam-flaked corn with DDGS limits nitrogen availability, which could reduce digestibility due to inadequate rumen microbial growth. Also, it is possible that low ruminal pH can depress activity of protein-degrading bacteria. Total volatile fatty acid concentration was lowest when 25% DDGS was fed using corn silage as roughage but was not affected by DDGS level when alfalfa hay was fed. When DDGS is added to steam-flaked corn diets, ruminal availability of protein might be a limiting factor for bacteria growth and subsequent fermentation.

Implications

Feeding DDGS at moderate levels in steam-flaked corn-based diets might require additional degradable intake protein supplementation to ensure adequate available nitrogen for bacterial growth and subsequent digestion of dietary organic matter.

Table 1. Composition of Finishing Diets Based on Steam-flaked Corn Containing Alfalfa Hay or Corn Silage With or Without DDGS

	Alfalfa Hay		Corn Silage	
Item	0% DDGS	25% DDGS	0% DDGS	25% DDGS
Ingredients, (% dry matter)				
Steam flaked corn	82.7	59.7	76.8	54.7
Dried distiller's grains with solubles	-	24.3	-	24.0
Alfalfa hay	5.6	5.6	-	-
Steep liquor	6.0	6.1	6.0	6.0
Corn silage	-	-	11.0	11.0
Supplement[1]	5.6	4.2	6.4	4.3
Analyzed Composition (%)				
Dry matter	80.0	81.2	70.1	70.5
Crude protein	15.9	16.4	14.2	15.9
Fat	3.1	4.8	2.9	5.1
Fiber	10.8	16.8	11.6	17.7
Calcium	0.7	0.7	0.7	0.7
Phosphorus	0.3	0.5	0.3	0.5
Potassium	0.7	0.7	0.7	0.7

[1]Formulated to provide 300 mg/day monensin, 90 mg/day tylosin, 1000 IU/lb vitamin A, 10 ppm copper, 60 ppm zinc, 60 ppm, manganese, 0.5 ppm iodine, 0.25 ppm selenium, and 0.15 cobalt.

Table 2: Digestion by Cannulated Holstein Steers Fed Steam-flaked Corn-based Diets Containing 0% or 25% DDGS with Alfalfa Hay or Corn Silage

	Alfalfa hay		Corn silage			P values		
Item	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM[1]	Roughage source	DDGS level	Roughage source × DDGS level
Number of observations	5	5	6	6				
Digestibility,%								
Dry matter	83.6[ac]	76.9[b]	81.3[bc]	76.1[bd]	1.40	0.33	<0.01	0.64
Organic matter	84.9[ac]	78.5[b]	83.2[bc]	77.5[bd]	1.52	0.40	0.01	0.83
Starch	98.7[ac]	97.6[a]	98.1[ac]	96.8[bc]	0.30	0.07	0.01	0.73
NDF	39.8	37.8	30.5	32.8	6.71	0.31	0.98	0.74
Crude protein	79.8[ac]	72.6[ac]	74.0[c]	69.8[ac]	1.88	0.07	0.02	0.48
Fat	84.7	86.8	84.4	87.2	1.33	0.97	0.10	0.79

[1]When observations are missing, larger SEM is presented.
[abcd]Means within a row without a common superscript letter differ ($P<0.05$).

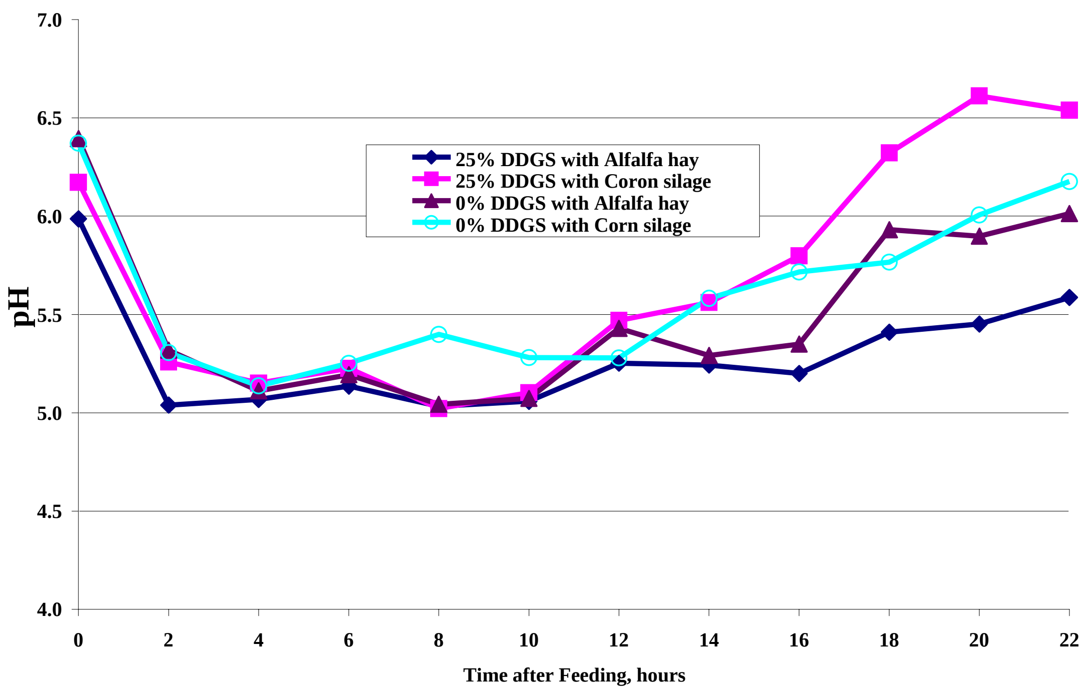

Figure 1. Ruminal pH of Steers Fed Steam-flaked Corn-based Diets Containing 0% or 25% DDGS with Alfalfa Hay or Corn Silage[ab]

[a]Interaction between roughage source, DDGS level, and Time post feeding ($P<0.05$)
[b]Interaction between roughage source and DDGS level ($P<0.05$)

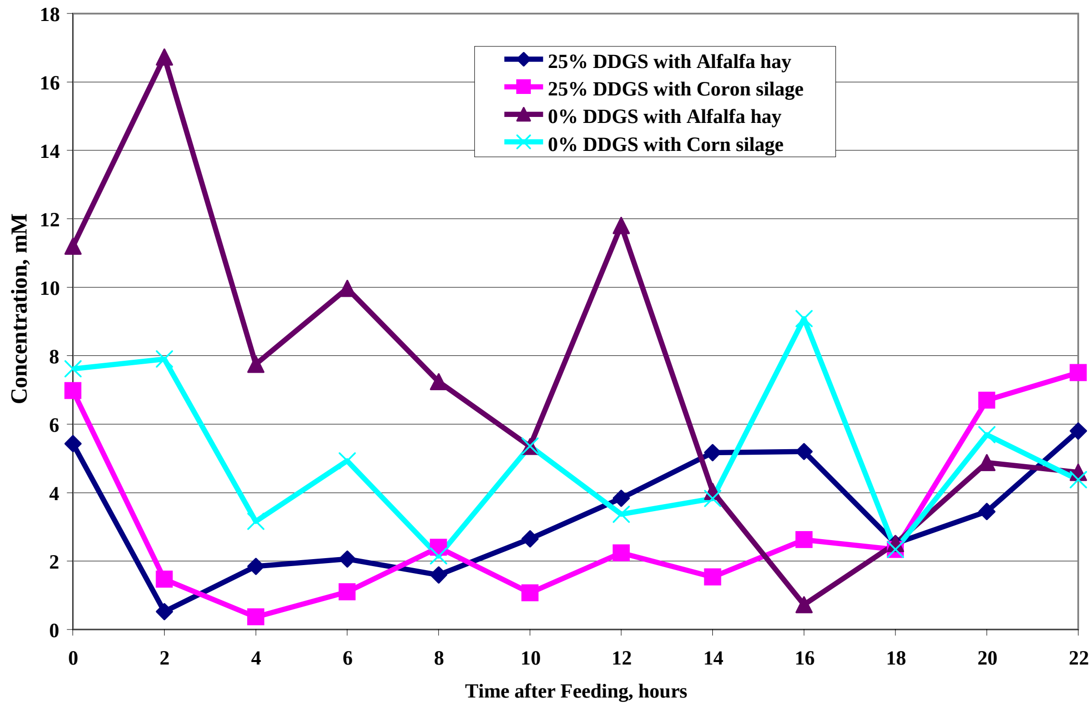

Figure 2. Ruminal Ammonia of Steers Fed Steam-flaked Corn-based Diets Containing 0% or 25% DDGS with Alfalfa Hay or Corn Silage [ab]

[a]Interaction between DDGS level, and time post feeding ($P<0.05$).
[b]Interaction between roughage source and DDGS level ($P<0.05$).

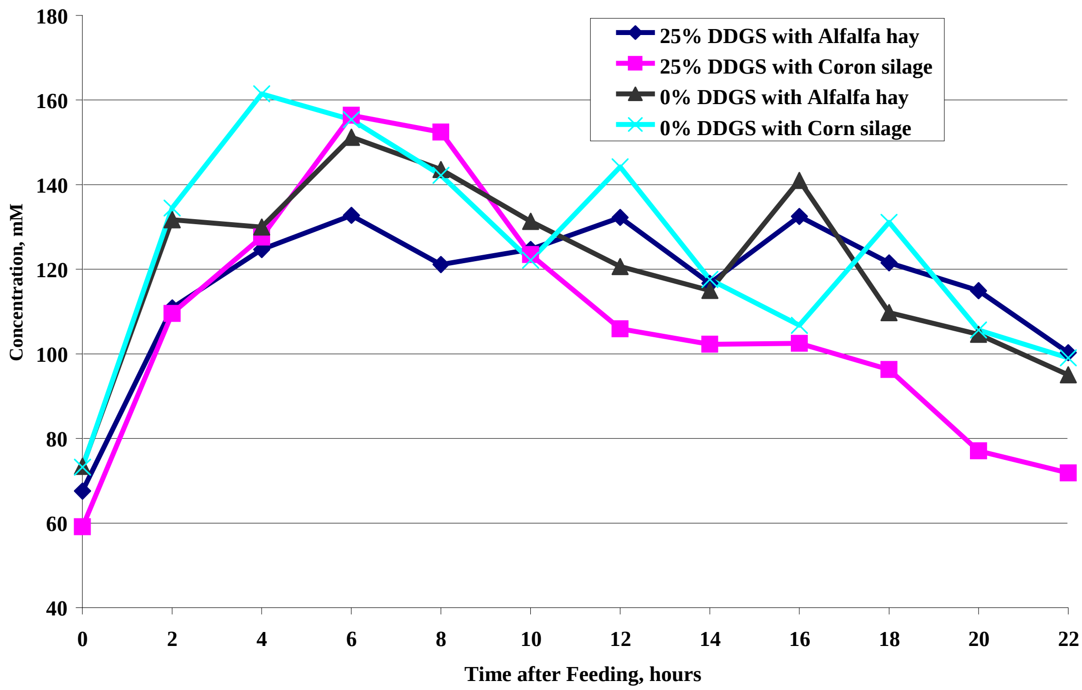

Figure 3. Ruminal Total Volatile Fatty Acid of Steers Fed Steam-flaked Corn-based Finishing Diets Containing 0% or 25% DDGS with Alfalfa Hay or Corn Silage[a b]

[a]Interaction between roughage source and DDGS level (P<0.05)
[b]Effect of time after feeding (P<0.05)

EVALUATION OF DRIED DISTILLER'S GRAINS AND ROUGHAGE SOURCE IN STEAM-FLAKED CORN-BASED FINISHING DIETS

S. Uwituze, G. L. Parsons, M. K. Shelor, B. E. Depenbusch, K. K. Karges[1], M. L. Gibson[1], and J. S. Drouillard

Introduction

Dried distiller's grains with solubles (DDGS) are the main byproduct of dry milling, the process used most frequently for fuel ethanol production. DDGS consist of the spent grains following ethanol distillation and are high in protein, fat, fiber, and minerals. Alfalfa hay and corn silage are roughages most commonly included in feedlot diets and are one of the most expensive ingredients in feedlot diets on an energy basis. Comparing use of alfalfa hay and corn silage in conjunction with DDGS can provide useful information on how to obtain maximum benefit from these ingredients. Our objective was to evaluate the use of corn DDGS as a partial replacement for steam-flaked corn when corn silage or alfalfa hay were used in feedlot diets.

Experimental Procedures

Heifers (n = 358; 786 lbs) were used in a finishing trial. Experimental diets were based on steam-flaked corn and contained 0% DDGS with 6% alfalfa hay, 0% DDGS with 10% corn silage, 25% DDGS with 6% alfalfa hay, or 25% DDGS with 10% corn silage (dry matter basis). On arrival at the feedlot, heifers were fed ground alfalfa hay and water free choice. One day after arrival, heifers received Revalor[2]–200 implant, Bovishield[3]–IV, Fortress[3]–7, and Phoenectin[4] pour-on. Heifers were blocked by weight and randomly assigned to treatments and pens; 24 pens were used, with six pens per treatment and 14 to 15 heifers per pen. Heifers had free-choice access to four step-up diets leading to the final finishing diets (Table 1). Heifers were housed in dirt-surfaced pens that were 33 ft wide × 80 ft deep. Pens provided 18 to 20 linear inches of bunk space per animal and were equipped with fence-line water fountains that were shared between adjacent pens. Pen weights were collected before cattle were shipped to a commercial abattoir in Emporia, KS. Heifers were harvested on day 97; hot carcass weights and incidence and severity of liver abscesses were recorded the same day. Ribeye area; 12th-rib fat thickness; kidney, pelvic, and heart fat; marbling score; USDA yield grade; USDA quality grade; and incidence of dark cutting beef were recorded following a 24-hour chilling period.

Results and Discussion

Partial replacement of steam-flaked corn with DDGS did not affect dry matter intake, average daily gain, or feed efficiency. Dry

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[1]Dakota Gold Research Association, Sioux Falls, SD.
[2]Revalor is a registered trademark of Intervet, Inc.
[3]Bovishield and Fortress are registered trademarks of Pfizer Inc.
[4]Phoenectin is a registered trademark of IVX Animal Health, St. Joseph, MO.

matter intakes were higher for heifers fed corn silage than for heifers fed alfalfa hay, but daily gains and feed efficiencies were similar. There were no differences among treatments with regard to carcass weight; dressing percentage; fat thickness over the 12th-rib; kidney, pelvic, and heart fat; or quality grades. Overall, heifers were relatively lean. The average yield grade for all treatment groups was near to 2. Liver abscess rates were higher for cattle fed 25% DDGS compared with those fed 0% DDGS when alfalfa hay was the roughage source but were higher for cattle fed 0% DDGS when corn silage was the roughage source.

Implications

Heifers fed DDGS as partial replacement for steam-flaked corn had similar growth performance and carcass quality compared with heifers fed no DDGS. Corn silage and alfalfa hay were comparable roughages when a portion of steam-flaked corn was replaced with DDGS.

Table 1 Composition of Finishing Diets Based on Steam-flaked Corn Containing Alfalfa Hay or Corn Silage with or without Dried Distiller's Grains (DDGS)

	Alfalfa Hay		Corn Silage	
Item	0% DDGS	25% DDGS	0% DDGS	25% DDGS
Ingredients, (% dry matter)				
Steam flaked corn	82.7	59.7	76.8	54.7
Dried distiller's grains with solubles	-	24.3	-	24.0
Alfalfa hay	5.6	5.6	-	-
Corn steep liquor	6.0	6.1	6.0	6.0
Corn silage	-	-	11.0	11.0
Supplement[1]	5.6	4.2	6.4	4.3
Analyzed Composition (%)				
Dry matter	80.0	81.2	70.1	70.5
Crude protein	15.9	16.4	14.2	15.9
Fat	3.1	4.8	2.9	5.1
Fiber	10.8	16.8	11.6	17.7
Calcium	0.7	0.7	0.7	0.7
Phosphorus	0.3	0.5	0.3	0.5
Potassium	0.7	0.7	0.7	0.7

[1]Formulated to provide 300 mg/day monensin, 90 mg/day tylosin, 0.5 mg/day melengesterol-acetate, 1000 IU/lb vitamin A, 10 ppm copper, 60 ppm zinc, 60 ppm manganese, 0.5 ppm iodine, 0.25 ppm selenium, and 0.15 cobalt.

Table 2: Growth Performance of Heifers Fed Various Steam-flaked Corn-based Diets

	Alfalfa hay		Corn silage			P -value		
Item	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	DDGS level	Rough-age source	DDGS level × roughage source
Head count	89	90	90	89	-	-	-	-
Days on feed	97	97	97	97	-	-	-	-
Initial weight, lbs	786	786	786	786	29	0.95	0.89	0.61
Final weight, lbs[1]	1107	1097	1115	1100	9	0.19	0.56	0.85
Average daily gain, lbs/day	3.32	3.20	3.39	3.24	0.31	0.19	0.56	0.85
Dry matter intake, lbs/day	17.8	17.4	18.5	18.0	0.5	0.14	0.05	0.88
Feed:Gain	5.8	5.6	5.9	6.0	0.75	0.81	0.23	0.60

[1]Final weight was calculated by dividing carcass weight by a common dressing percentage (63.5%).

Table 3: Carcass Performance of Heifers Fed Various Steam-flaked Corn-based Diets

	Alfalfa hay		Corn silage			P -value		
Item	0 % DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	DDGS level	Rough-age source	DDGS level × roughage source
Hot carcass weight, lbs	703	696	707	698	6	0.21	0.60	0.82
Dressed yield, %	62.9	63.7	62.9	63.4	1.8	0.43	0.78	0.25
Ribeye area, in^2	12.8	13.0	13.0	12.8	0.2	0.77	0.78	0.25
12^{th}-rib fat, in	0.50	0.49	0.48	0.45	0.03	0.53	0.29	0.79
Kidney, pelvic, and heart fat, %	2.14	2.13	2.13	2.16	0.03	0.81	0.74	0.60
Liver abscess, %	3.4	7.9	11.1	5.6	2.0	0.82	0.20	0.02
Marbling score[1]	476	466	482	491	9	0.96	0.10	0.31
Yield grade	2.31	2.22	2.31	2.31	0.11	0.67	0.68	0.67
Prime,%	0.0	1.1	0.0	0.0	0.6	0.33	0.33	0.33
Choice, %	36.0	30.3	35.6	44.8	4.8	0.71	0.15	0.13
Select,%	59.5	61.8	63.3	48.5	4.4	0.17	0.30	0.07
Standard,%	0.0	0.0	0.0	2.2	1.1	0.33	0.33	0.33
No roll,%	4.4	12.0	1.1	4.5	3.3	0.11	0.12	0.54

[1]Marbling score 400-499 = Slight.

DETERMINING OPTIMUM FLAKE DENSITY FOR FEEDLOT HEIFERS

M. L. May, M. J. Quinn, B. E. Depenbusch, and J. S. Drouillard

Introduction

Escalating costs of natural gas and electrical utilities have greatly increased the cost of flaking grain for feedlots. Energy demand for flaking is inversely related to bulk density of flaked grain; the lighter, more highly processed flakes typically require longer steaming times and greater roll pressures, which ultimately decreases mill. Corn is most commonly flaked to a density of about 28 lb/bushel, and published research results indicate that levels less than 28 lb/bushel afford no further advantage with respect to animal performance. Little information is available concerning the relative feed value of grains flaked to heavier bulk densities. Flaking grains to heavier bulk densities could make it possible to increase mill throughput and reduce energy costs associated with flaking. In this study, our objective was to evaluate milling efficiency and cattle performance when grains were flaked to densities of 28, 32, and 36 lb/bushel.

Experimental Procedures

Heifers (n = 358) were allocated to 48 feedlot pens, each containing six to eight cattle. Pens were assigned to one of three treatments (16 pens per treatment), which consisted of finishing diets made from steam-flaked corn processed to densities of 28, 32, or 36 lb/bushel. Cattle were fed once daily throughout the 115-day finishing trial. At the termination of the study, cattle were weighed as pens and subsequently transported to a commercial abattoir in Emporia, KS, for harvest. Information was collected for severity and incidence of liver abscesses; hot carcass weight; back fat over the 12th rib; kidney, pelvic, and heart fat percentage; yield grade; marbling score; and quality grade.

In addition to animal performance and carcass quality attributes, data also were collected to evaluate milling efficiency when corn was processed to the three different densities. Total mill throughput in tons per hour was determined for each grain, and this information was used to calculate energy expenditure associated with processing grains to different densities. Particle size was measured daily for flaked grain samples and weekly for total mixed rations using a Ro-Tap (W. S. Tyler, Mentor, OH) sieving machine equipped with a series of seven sieves with openings ranging from 9,500 to 1,180 μm.

Results and Discussion:

Starch availability ranged from a high of 47% for corn flaked to a density of 28 lb/bushel down to 35% for corn flaked to a density of 36 lb/bushel. As bulk density increased, mill throughput increased fairly dramatically. Increasing flake density also increased the average particle size of flakes and improved durability of the flaked grain throughout the mixing process, as evidenced by the decreased proportion of small particles that tend to accumulate in feed bunks. However, these improvements in flake integrity did not positively improve cattle performance. Processing corn to heavier bulk densities resulted in small decreases in gain, as well as slightly higher feed intakes. Carcass traits were mostly unaffected by degree of grain processing. Overall, efficiency tended to improve with more rigorous processing of the grain. Compared with cattle fed 28-lb flakes, feeding corn flaked to densities of 32 or 36 lb/bushel yielded gain efficiencies that were 2 to 5% poorer than those of cattle fed the 28-lb flakes. Using an estimated feed cost of $200/ton (dry basis), the poorer efficiency of under-processed flakes increased cost of production by $0.01 to $0.03 per pound of gain, equating to approximately $0.03 to $0.08 per animal daily.

Implications:

Improvements in mill efficiency that are attributable to flaking grain to heavier bulk densities do not offset increased costs associated with poorer feed conversion efficiency.

Table 1. Composition of Steam-flaked Corn-based Finishing Diets Containing Different Flaked Densities Fed to Yearling Heifers

	Flake Density, lb/bushel		
Item, % dry matter	28	32	36
Steam-flaked corn	83.0	83.0	83.0
Alfalfa hay	6.4	6.4	6.4
Corn steep	3.9	3.9	3.9
Limestone	1.9	1.9	1.9
Urea	1.4	1.4	1.4
Mineral/vitamin premix[1]	1.2	1.2	1.2
Feed additive premix[2]	2.2	2.2	2.2
Nutrient Analyses			
Crude protein, %	13.86	13.80	13.85
Calcium, %	0.71	0.71	0.71
Phosphorus, %	0.25	0.25	0.25
Potassium, %	0.30	0.30	0.30
Net Energy, Mcal/100 lb			
Maintenance	111	110	108
Gain	79	78	76

[1]Formulated to provide (dry matter basis) 0.15 ppm cobalt; 10 ppm copper; 0.6 ppm iodine; 60 ppm zinc; 60 ppm manganese, 0.25 ppm selenium; and 1,200 IU/lb of vitamin A.
[2]Provided 300 mg/day Rumensin, 90 mg/day Tylan, and 0.5 mg/day MGA.

Table 2. Influence of Bulk Density on Dry Matter and Available Starch of Flaked Grain and Mill Efficiency

	Flake Density, lb/bushel					
Item	28	32	36	SEM	Lin	Quad
Dry matter, %	84.54	84.39	84.22	0.27	0.39	0.99
Starch availability, %[1]	46.73	39.27	34.87	0.32	<0.01	<0.01
Rate, tons/hour	2.22	2.45	3.40	0.13	<0.01	0.13
Mill efficiency, %[2]	100	114	152.8	---	---	---

[1]Measured by incubating 25 g of intact flakes in 100 mL of a 2.5% (wt/vol) amyloglucosidase enzyme solution for 15 minutes, and subsequently determining percentage of solubles on a refractive index scale.
[2]Efficiency is expressed as a percentage relative to grain flaked to a density of 28 lb/bushel.

Table 3. Growth Performance of Yearling Heifers Fed Finishing Diets Containing Corn Flaked to Different Densities

	Flake Density, lb/bushel					
Item	28	32	36	SEM	Lin	Quad
Number of pens	16	16	16	-	-	-
Number of heifers	116	118	121	-	-	-
Initial weight, lbs	740	742	745	5.36	0.51	0.85
Final weight, lbs[1]	1069	1065	1060	7.89	0.43	0.92
Dry matter intake, lb/day	16.82	16.91	16.98	0.18	0.52	0.95
Daily gain, lb[1]	2.85	2.81	2.73	0.08	0.29	0.85
Feed:gain[1,2]	5.90	6.02	6.22	0.15	0.13	0.83

[1]Final live weight was computed as hot carcass weight divided by a common dresses yield of 0.635.
[2]Statistics were performed as gain:feed, reported as feed:gain.

Table 4. Carcass Characteristics for Yearling Heifers Fed Finishing Diets Containing Corn Flaked to Different Densities

	Flake Density, lb/bu					
Item	28	32	36	SEM	Lin	Quad
Hot carcass weight, lb	679	676	673	5.01	0.43	0.92
USDA quality grade						
Prime, %	3.7	1.7	3.3	1.80	0.88	0.40
Upper 2/3 Choice, %	21.1	18.0	22.6	3.11	0.73	0.33
Choice, %	61.0	54.5	58.2	4.98	0.69	0.41
Select, %	33.3	42.2	37.6	4.74	0.53	0.25
No roll, %	1.0	0.8	0.9	0.91	0.91	0.87
Dark cutter, %	0.9	0.9	0.0	0.73	0.39	0.62
Marbling score[1]	536	516	536	11.57	0.99	0.17
Average yield grade	2.69	2.62	2.75	0.06	0.50	0.16
Yield grade 1, %	5.98	2.45	4.02	2.12	0.51	0.33
Yield grade 2, %	31.0	39.8	24.2	3.98	0.24	0.02
Yield grade 3, %	51.4	51.2	65.2	4.54	0.04	0.21
Yield grade 4 %	11.7	6.6	5.8	2.09	0.06	0.40
Liver Abscess, %	3.6	4.9	5.0	1.89	0.62	0.79
Kidney, pelvic, heart fat, %	2.33	2.40	2.39	0.04	0.26	0.40
Ribeye area, square inches	12.96	12.89	12.24	0.16	0.01	0.15
Back fat 12th-rib, inches	0.57	0.58	0.59	0.02	0.57	0.80

[1]Marble Score 500=Small.

Table 5. Particle Size Distribution, Geometric Mean Diameter, and Geometric Mean Diameter Standard Deviation of Steam-flaked Corn Where Flake Densities were 28, 32, or 36 lb/bushel

	Flake Density, lb/bushel					
Item	28	32	36			
Screen size, µm	Particle size distribution, %[1]			SEM	Lin	Quad
9,500	52.15	43.54	24.40	12.57	<0.01	0.04
6,700	32.97	45.80	64.61	15.92	<0.01	0.12
4,750	6.63	4.79	3.77	1.45	<0.01	0.52
3,350	2.94	2.23	1.98	0.50	<0.01	0.56
2,360	1.51	1.01	0.58	0.47	<0.01	0.82
1,700	0.76	0.48	0.22	0.27	<0.01	0.98
1,180	0.62	0.36	0.19	0.22	<0.01	0.40
< 1,180	2.41	1.79	1.25	0.58	<0.01	0.82
GMD, µm[2]	6,163	6,565	7,000	55.23	<0.01	0.81
GSD[3]	3.47	2.90	2.75	0.11	<0.01	0.13

[1]Percentage of sample remaining on screen.
[2]GMD = geometric mean diameter.
[3]GSD = geometric standard deviation.

Table 6. Particle Size Distribution, Geometric Mean Diameter, and Geometric Mean Diameter Standard Deviation of Complete Diets Where Flake Densities were 28, 32, or 36 lb/bushel

	Flake Density, lb/bushel					
Item	28	32	36	SEM	Lin	Quad
Screen size, µm	Particle size distribution, %[1]					
9,500	4.56	12.15	12.34	4.44	<0.01	<0.01
6,700	22.87	36.01	45.71	11.46	<0.01	0.41
4,750	22.21	16.47	12.70	4.79	<0.01	0.37
3,350	15.07	11.26	9.61	2.80	<0.01	0.16
2,360	9.26	6.12	5.38	2.06	<0.01	0.01
1,700	6.04	4.19	3.50	1.32	<0.01	0.14
1,180	14.58	9.98	7.75	3.48	<0.01	0.24
< 1,180	5.41	3.82	3.01	1.22	<0.01	0.33
GMD, µm[2]	2,990	4,420	4,565	284.47	<0.01	0.07
GSD[3]	1.80	1.66	1.53	0.03	<0.01	0.78

[1]Percentage of sample remaining on screen.
[2]GMD = geometric mean diameter.
[3]GSD = geometric standard deviation.

DIGESTIBILITY OF DRIED DISTILLER'S GRAINS WITH SOLUBLES IN STEAM-FLAKED OR DRY-ROLLED CORN DIETS

M. L. May, M. J. Hands, M. J. Quinn, J. O. Wallace, C. D. Reinhardt, L. Murray, and J. S. Drouillard

Introduction

In previous experiments, we observed that the nutritional value of dried distiller's grains is less when added to finishing diets made of steam-flaked corn than when added to diets of dry-rolled corn. We hypothesized that effects of grain processing on value of distiller's grains are attributable to differences in the digestion characteristics of grains processed via flaking or dry rolling. In this study, our objective was to evaluate differences in ruminal metabolism and total tract digestion of diets made from dry-rolled or steam-flaked corn with and without dried distiller's grains.

Procedures

Holstein steers (n = 16; 773 lbs) were used in a metabolism study. Two 15-day experimental periods were used, each consisting of a 12-day diet adaptation phase and a 3-day sample collection phase. Cattle were fed in individual pens with free access to diets. Treatments were: steam-flaked corn with 0% dried distiller's grains with solubles (DDGS), steam-flaked corn with 25% DDGS, dry-rolled corn with 0% DDGS, and dry-rolled corn with 25% DDGS (Table 1). Diets were formulated to contain similar fat content. Steers were dosed daily with 10 mg of chromic oxide via the ruminal cannula, which was used as an indigestible marker to estimate total fecal output. Collection times for feces and ruminal digesta were at hours 0, 6, 12, and 18 post feeding on day 1; hours 2, 8, 14, and 20 on day 2; and hours 4, 10, 16, and 22 on day 3. Ruminal pH was measured immediately after retrieving samples from the rumen. Concentrations of ruminal ammonia and volatile fatty acids also were determined from the digesta samples. Additionally, apparent total tract digestibilities were determined for dry matter, organic matter, neutral detergent fiber, starch, and fat (ether extract).

Results and Discussion

Steers fed dry-rolled corn consumed more dry matter, organic matter, and neutral detergent fiber than those fed steam-flaked corn. Steers fed dry-rolled corn also excreted more dry matter, organic matter, starch, neutral detergent fiber (NDF) and ether extract than those fed steam-flaked corn. Apparent total tract digestibilities of dry matter, organic matter, starch, NDF, and ether extract all were greater when cattle were fed flaked grain diets than when they were fed rolled grain diets.

Ruminal ammonia concentrations were higher for cattle fed dry-rolled corn than for cattle fed steam-flaked corn. This likely reflects the increased demand for ruminally available protein when grains are flaked and decreased protein availability due to the effects of hydrothermal processing of flaked corn. Acetate, acetate:propionate ratio, butyrate, isobutyrate, isovalerate 2-methyl, and 3-mthyl isovalerate concentrations were greater for dry-rolled corn ($P<0.05$), but total volatile fatty acids (VFA) concentrations were not affected by grain processing. Propionate, lactate, and valerate concentrations were greater in cattle fed steam-flaked corn diets. Changes in ruminal pH were generally more dramatic for cattle fed flaked grain rations compared with those fed dry-rolled rations. Prior to feed, ruminal pH actually was higher for cattle fed flaked grain, but pH dropped quickly after feeding, which reflects the high fermentability of flaked grains compared with dry-rolled grains.

Adding 25% DDGS to the diet decreased intake of starch and ether extract, but increased NDF intake. Actual fat content of DDGS was lower than projected, which led to a slight reduction in fat intake with diets containing DDGS. Apparent total tract digestibility of ether extract was decreased by feeding 25% DDGS vs. 0% DDGS. Digestibilities of dry matter and organic matter digestion tended to be lower when DDGS were included in the diet, but these differences were not influenced by the type of grain fed.

Feeding DDGS had no noticeable effect on concentrations of VFA. Ruminal lactate concentrations were increased with DDGS, and the increase tended to be greater when DDGS were added to flaked diets than when added to dry-rolled diets. In spite of the significant increases in lactate, the absolute amounts were relatively low (less than 5 mM).

Ruminal ammonia concentrations decreased substantially when cattle were fed diets containing 25% DDGS. This change is a direct consequence of replacing degradable forms of nitrogen, such as soybean meal and urea, with DDGS, which are less ruminally degraded. The low levels of ruminal ammonia that result from feeding DDGS, especially when fed in combination with flaked grain, might limit digestion of these diets.

Implications:

Ruminal ammonia could be a limiting factor in diets containing dried distiller's grains, especially when steam-flaked corn is the grain source. Decreases in ruminal pH at critical times when feeding dried distiller's grains might also contribute to decreases in animal performance by altering digestibility.

Table 1. Composition of Diets (dry matter basis) Fed to Cannulated Holstein Steers. Diets Contained Either Steam-flaked or Dry-rolled Corn and 0 or 25% Dried Distillers's Grains with Solubles (DDGS)

	Dry-rolled corn		Steam-flaked corn	
Item, % of dry matter	0% DDGS	25% DDGS	0% DDGS	25% DDGS
Steam-flaked corn	-	-	73.85	56.44
Dry-rolled corn	73.82	56.40	-	-
Corn silage	13.84	13.84	13.82	13.83
DDGS	-	25.24	-	25.21
Vegetable oil	2.18	-	2.18	-
Soybean meal	4.45	-	4.45	-
Urea	1.17	0.14	1.19	0.14
Limestone	1.62	1.65	1.62	1.65
Mineral/vitamin premix[1]	0.69	0.53	0.69	0.53
Feed additive premix[2]	2.19	2.20	2.19	2.20
Nutrients				
Ether extract	5.80	5.24	5.81	5.24
Starch	54.82	37.53	55.07	43.74
NDF	13.13	17.52	13.63	17.58
Organic matter	97.37	97.50	97.35	97.41
Crude Protein	15.48	15.35	15.00	14.99
Calcium	0.71	0.64	0.71	0.64
Phosphorus	0.30	0.46	0.30	0.46

[1]Mineral/vitamin premix formulated to provide (dry basis) 1200 IU/lb vitamin A, 0.15 ppm cobalt, 10 ppm copper, 0.5 mg iodine, 60 ppm manganese, 60 ppm zinc, and 0.25 ppm selenium.
[2]Premix provided 300 mg Rumensin and 90 mg Tylan per day in a ground corn carrier.

Table 2. Digestion Characteristics for Cannulated Holstein Steers Fed Diets Containing Steam-flaked or Dry-rolled Corn and 0 or 25% Corn Dried Distiller's Grains with Solubles (DDGS)

	Dry-rolled corn		Steam-flaked corn			P-Values		
Item	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	Grain	DDGS	Grain × DDGS
Intake, lb/day								
Dry matter	19.41	19.03	17.40	16.21	0.73	<0.01	0.10	0.40
Organic matter	18.90	18.57	16.94	15.79	0.70	<0.01	0.10	0.39
Starch	10.62	7.14	9.63	8.68	0.42	0.40	<0.01	<0.01
NDF	2.56	3.33	2.38	2.84	0.11	<0.01	<0.01	0.08
Ether extract	1.12	0.99	1.01	0.86	0.04	<0.01	<0.01	0.55
Fecal excretion, lb/day								
Dry matter	4.14	4.38	2.60	2.82	0.37	<0.01	0.34	0.99
Organic matter	3.88	4.05	2.25	2.53	0.35	<0.01	0.30	0.82
Starch	1.21	0.90	0.13	0.09	0.15	<0.01	0.17	0.35
NDF	2.11	2.44	1.28	1.54	0.22	<0.01	0.06	0.90
Ether extract	0.086	0.117	0.066	0.073	0.011	<0.01	0.03	0.12
Apparent total tract digestibility, %								
Dry matter	78.84	77.71	85.30	82.88	1.49	<0.01	0.11	0.56
Organic matter	79.80	78.88	86.88	84.20	1.44	<0.01	0.10	0.43
Starch	89.00	88.27	98.53	99.06	1.57	<0.01	0.94	0.65
NDF	17.09	29.14	47.10	46.42	6.28	<0.01	0.22	0.20
Ether extract	92.27	88.44	93.58	91.60	0.82	<0.01	<0.01	0.20

Table 3. Ruminal VFA Concentrations of Cannulated Holstein Steers Fed Diets Containing Steam-flaked or Dry-rolled Corn with 0 or 25% Dried Distiller's Grains with Solubles (DDGS)

	Dry-rolled corn		Steam-flaked corn			P-Values		
Item, Mm	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	Grain	DDG	Grain × DDGS
Acetate	50.55	47.39	41.07	40.89	1.81	<0.01	0.22	0.29
Propionate	29.03	23.76	35.02	35.28	2.87	<0.01	0.31	0.29
Acetate:propionate ratio	2.03	2.06	1.25	1.32	0.21	<0.01	0.79	0.92
Butyrate	11.57	11.18	8.19	8.00	0.98	<0.01	0.73	0.90
Lactate	0.22	0.36	0.74	1.54	0.20	<0.01	0.01	0.07
Valerate	2.20	1.59	2.76	3.01	0.64	0.07	0.68	0.36
Isobutyrate	0.78	0.76	0.52	0.59	0.05	<0.01	0.59	0.37
Isovalerate 2-methyl	2.53	1.90	1.30	0.99	0.48	0.03	0.28	0.70
Isovalerate 3-methyl	0.67	0.66	0.39	0.50	0.07	<0.01	0.39	0.37
Total VFA production	97.20	87.13	89.04	89.70	4.74	0.45	0.15	0.13

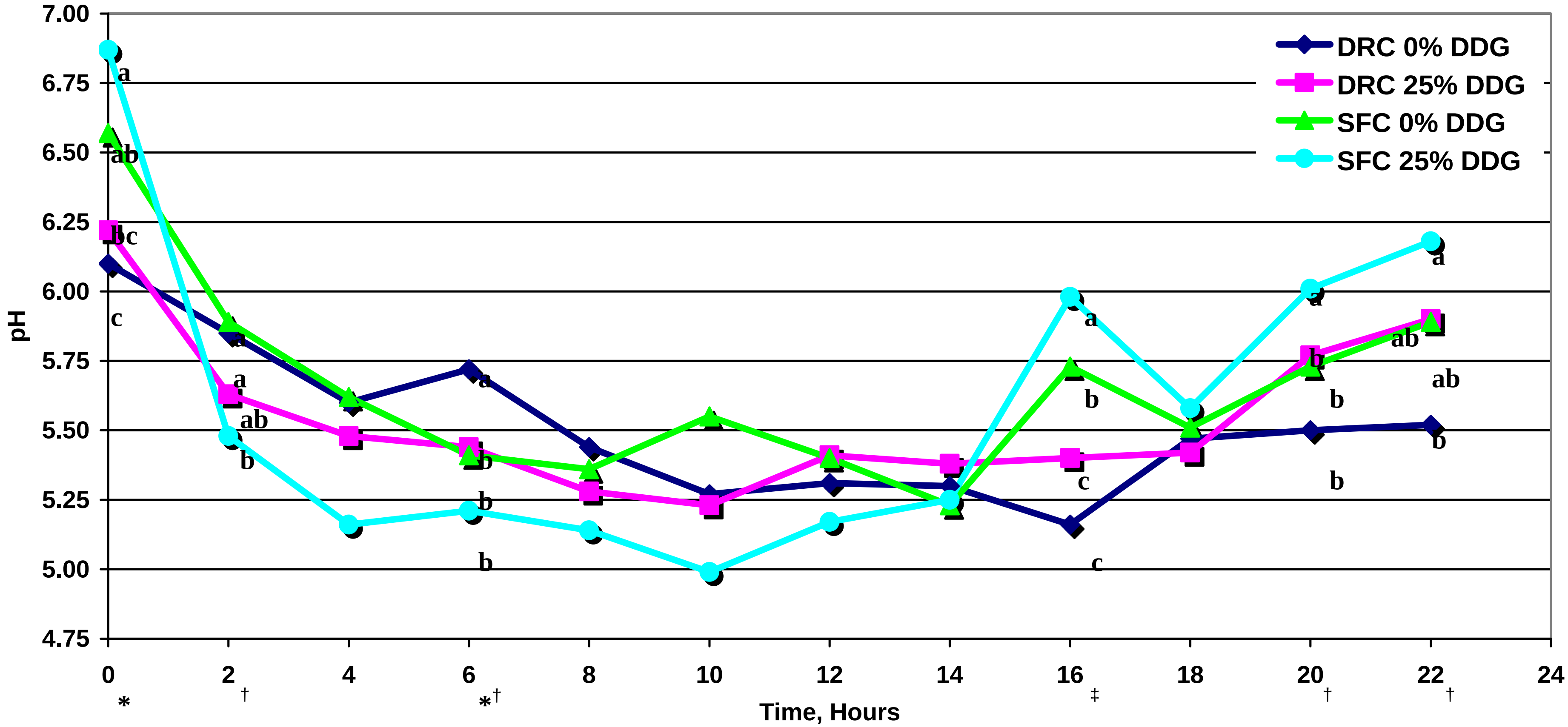

Figure 1. Ruminal pH of Cannulated Holstein Steers Fed Steam-flaked or Dry-rolled Corn Diets Containing 0 or 25% Dried Distiller's Grains with Solubles (DDGS).

[abc]Means within hour without a common superscript letter differ (P<0.05).
*Effect of grain processing method (P<0.05).
[†]Effect of DDGS (P<0.05).
[‡]Interaction between grain processing method and level of DDGS (P<0.05).

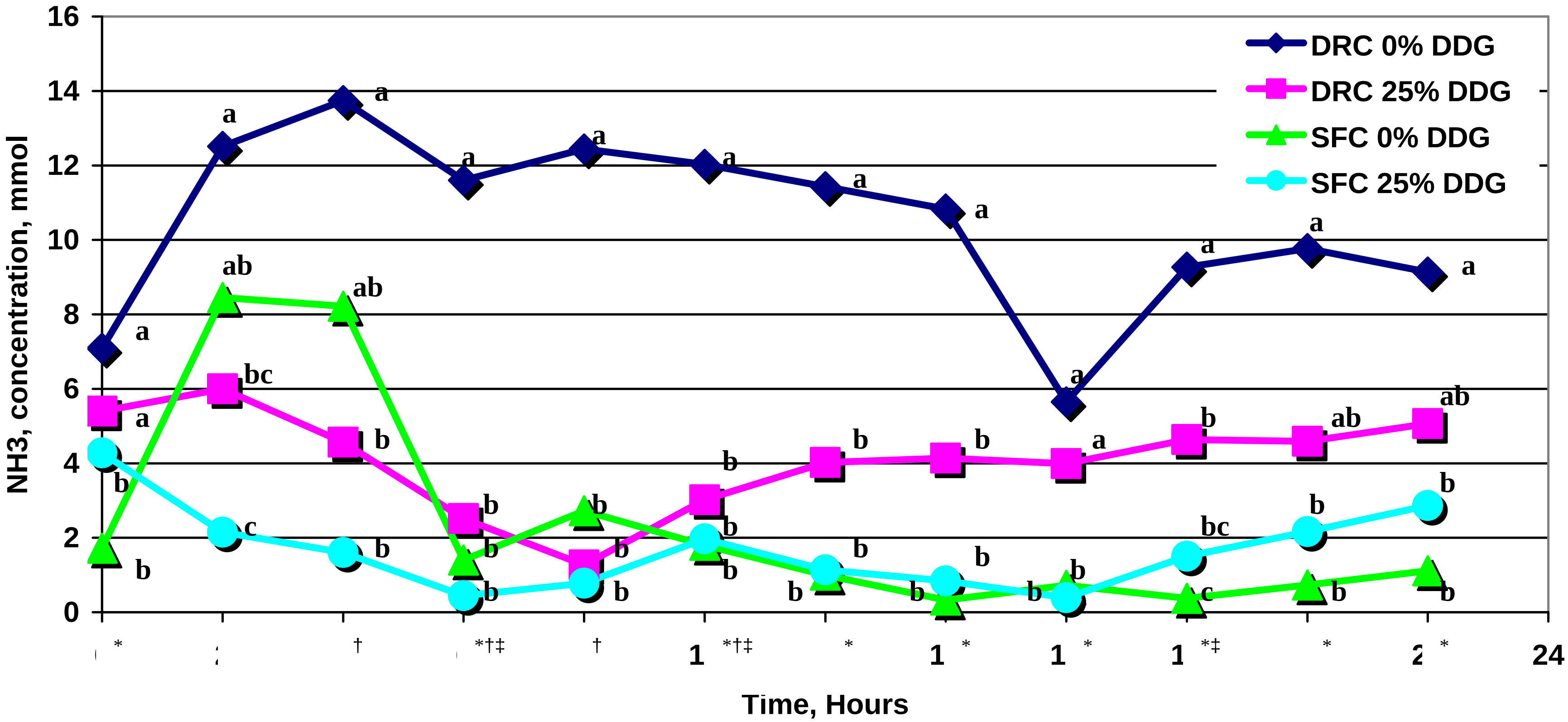

Figure 2. Ruminal Ammonia Concentrations of Cannulated Holstein Steers Fed Steam-flaked or Dry-rolled Corn Diets Containing 0 or 25% Dried Distiller's Grains with Solubles (DDGS).

[abc]Means within hour without a common superscript letter differ (P<0.05).
*Effect of grain processing method (P<0.05).
†Effect of DDGS (P<0.05).
‡Interaction between grain processing method and level of DDGS (P<0.05).

DRIED DISTILLER'S GRAINS WITH SOLUBLES IN STEAM-FLAKED OR DRY-ROLLED CORN DIETS WITH REDUCED ROUGHAGE LEVELS

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Introduction

Distiller's grains have been used extensively in the U.S. Corn Belt, where producers commonly feed dry-rolled or high-moisture corn. Fuel ethanol production is expanding into the High Plains, where most feedlots flake grain. Compared with dry-rolled corn, steam-flaked corn usually increases or has no change in average daily gain, yields lower dry matter intake and results in 12 to 16% improvement in efficiency. Previous research at Kansas State University and elsewhere suggests that the value of distiller's grains is different in flaked grain diets than in dry-rolled diets. We think this might be due to lower rumen pH when flaked grains are fed, perhaps reducing digestibility of the diet, especially the fibrous components. Because distiller's grains contain considerable amounts of fiber, it might be possible to add less roughage to finishing diets that contain distiller's grains, and doing so, improve efficiency.

Procedures

Crossbred-yearling heifers (n = 582) were used in a finishing trial to determine the feasibility of reducing roughage levels when dried distiller's grains with solubles (DDGS) are included in the diet. Basal diets consisted of steam-flaked or dry-rolled corn and contained either 0% DDGS, with 15% corn silage; 25% DDGS with 15% corn silage; or 25% DDGS with 5% corn silage. Heifers were fed in 24 dirt-surfaced pens, with four pens per treatment and between 21 and 25 heifers per pen. Heifers were fed once daily for 110 days. Heifers were weighed as a pen at the beginning of the study and immediately before delivery to a commercial abattoir in Emporia, KS. At harvest, incidence and severity of liver abscesses and hot carcass weights were recorded. Following a 24-hour chill period, USDA yield grade; USDA quality grade; marbling score; 12th-rib fat thickness; kidney, pelvic and heart fat; ribeye area; and incidence of dark cutting beef were recorded.

Results and Discussion

Cattle fed flaked corn consumed less feed and were more efficient than those fed dry-rolled corn. Cattle fed steam-flaked corn had a numerically greater final live weights and hot carcass weights compared with cattle fed rolled corn. USDA yield grades (as determined by USDA graders) were higher for heifers fed rolled corn than for those fed flaked corn, but calculated yield grades were not different. Lowering the level of roughage in finishing diets decreased feed intake, but did not affect gain. Additionally, cattle were approximately 6.5% more efficient when silage level was reduced, regardless of method

[1]Dakota Gold Research Association, Sioux Falls, SD.

used to process the grain. Dressed yield tended to be greater when cattle were fed less roughage. In contrast with some of our previous experiments, feeding DDGS had no affect on quality grade.

Implications

Contrary to previous experiments, feeding dried distiller's grains had no negative effects on performance or carcass merit. It may be feasible to decrease roughage levels in feedlot diets containing distiller's grains.

Table 1. Composition of Steam-flaked or Dry-rolled Corn Based Finishing Diets with Reduced Corn Silage Levels and 25% Dried Distiller's Grains with Solubles (DDGS)

	Dry-rolled corn			Steam-flaked corn		
	0% DDGS	25% DDGS	25% DDGS	0% DDGS	25% DDGS	25% DDGS
Item, % dry matter	15% Silage	15% Silage	5% Silage	15% Silage	15% Silage	5% Silage
Steam-flaked corn	-	-	-	74.06	56.51	65.72
Dry-rolled corn	74.25	56.75	65.91	-	-	-
Corn silage	13.31	13.32	4.37	13.41	13.40	4.41
DDGS	-	25.40	25.05	-	25.54	25.22
Vegetable oil	2.20	-	-	2.22	-	-
Soybean meal	4.49	-	-	4.52	-	-
Urea	1.22	0.15	0.30	1.22	0.15	0.30
Limestone	1.64	1.66	1.72	1.65	1.67	1.72
Vitamin/mineral supplement[1]	0.68	0.52	0.51	0.68	0.52	0.47
Feed additive premix, %[2]	2.19	2.20	2.17	2.20	2.20	2.18
Nutrients						
Crude Protein	15.37	15.34	15.51	14.72	14.85	14.93
Calcium	0.75	0.67	0.65	0.75	0.66	0.65
Phosphorus	0.32	0.48	0.48	0.32	0.47	0.46
Ether extract	5.82	5.31	5.39	5.84	5.32	5.40
Neutral detergent fiber	10.98	19.28	13.54	11.05	19.37	13.62

[1]Vitamin/mineral supplement formulated to provide 1200 IU/lb Vitamin A, 0.15 ppm cobalt, 0.5 ppm iodine, 10 ppm copper, 60 ppm zinc, 60 ppm manganese, and 0.25 ppm selenium on a dry matter basis.
[2]Premix provided 300 mg Rumensin, 90 mg Tylan, and 0.5 mg MGA per animal daily in a ground corn carrier.

Table 2. Performance of Yearling Heifers Fed Steam-flaked or Dry-rolled Corn Based Finishing Diets Containing Corn Dried Distiller's Grains with Solubles (DDGS)

	Dry-rolled corn			Steam-flaked corn				Contrasts[3]				
	0% DDGS	25% DDGS	25% DDGS	0% DDGS	25% DDGS	25% DDGS						
Item	15% Silage	15% Silage	5% Silage	15% Silage	15% Silage	5% Silage	SEM	1	2	3	4	5
No. of pens (heifers)	4 (93)	4 (95)	4 (94)	4 (94)	4 (91)	4 (94)	-	-	-	-	-	-
Initial weight, lb	830	830	830	830	833	833	0.95	0.11	0.09	0.36	0.62	0.44
Final weight, lb[1]	1,108	1,117	1,112	1,134	1,119	1,119	8.19	0.08	0.64	0.82	0.20	0.94
Dry matter intake, lb	18.44[a]	18.46[a]	17.14[bc]	17.80[ab]	16.96[bc]	15.55[d]	0.15	<0.01	0.19	<0.01	0.18	0.88
Average daily gain, lb[1]	2.53	2.58	2.58	2.78	2.62	2.60	0.08	0.13	0.52	0.92	0.19	1.00
Feed:Gain[1,2]	7.25[a]	7.09[ab]	6.62[bc]	6.41[cd]	6.45[cd]	6.02[d]	0.18	<0.01	0.88	0.02	0.62	0.90

[1]Final weight, average daily gain and efficiency were computed by using carcass-adjusted final weights. Final live weight = hot carcass weight divided by a common dressed yield of 0.635.
[2]Statistics were performed as gain:feed, reported as feed:gain.
[3]Contrast 1: Dry-rolled corn diets vs. steam-flaked corn diets.
Contrast 2: Diets with 0% DDGS and 15% silage vs. diets containing 25% DDGS and 15% silage.
Contrast 3: DDGS diets with 15% silage vs. DDGS diets with 5% silage.
Contrast 4: Interaction between grain source and DDGS (15% silage).
Contrast 5: Grain source by roughage level interaction for diets containing DDGS.
[abc]Means within a row without a common superscript letter differ (P<0.05).

Table 3. Carcass Characteristics of Yearling Heifers Fed Steam-flaked or Dry-rolled Corn Based Finishing Diets Containing Corn Dried Distiller's Grains with Solubles (DDGS)

	Dry-rolled corn			Steam-flaked corn				Contrasts[2]				
	0% DDGS	25% DDGS	25% DDGS	0% DDGS	25% DDGS	25% DDGS						
Item	15% Silage	15% Silage	5% Silage	15% Silage	15% Silage	5% Silage	SEM	1	2	3	4	5
Hot carcass weight, lb	705	707	707	720	711	711	5.26	0.08	0.64	0.78	0.22	0.96
Dressed yield, %	63.30[a]	64.28[abd]	65.00[bcd]	63.27[ab]	63.90[ab]	65.27[bcd]	0.36	0.89	0.04	<0.01	0.63	0.38
USDA quality grade												
Prime, %	1.04	0.00	1.00	0.00	1.04	2.23	0.92	0.59	1.00	0.25	0.27	0.92
Choice, %	56.89	62.86	61.11	66.94	67.98	61.64	3.80	0.11	0.37	0.30	0.52	0.55
Upper 2/3 Choice or greater, %	18.13	13.77	15.52	22.15	16.94	19.84	3.77	0.24	0.22	0.52	0.91	0.91
Select, %	39.99	37.14	34.77	32.02	30.98	34.00	3.78	0.13	0.61	0.93	0.81	0.49
Standard, %	2.09	0.00	0.00	1.04	0.00	0.00	0.66	0.53	0.03	1.00	0.44	1.00
Dark cutter, %	1.04	0.00	2.08	0.00	0.00	2.13	1.10	0.72	0.64	0.07	0.64	0.98
USDA yield grade	2.59	2.65	2.66	2.54	2.42	2.54	0.06	0.02	0.64	0.30	0.16	0.34
Calculated yield grade	2.90	2.83	2.89	2.94	2.86	2.88	0.07	0.71	0.31	0.57	0.91	0.83
Yield grade 1, %	6.53	4.17	7.43	8.47	11.82	5.64	2.47	0.21	0.84	0.56	0.26	0.07
Yield grade 2, %	36.68	39.49	35.60	39.27	39.31	42.81	4.75	0.42	0.77	0.97	0.77	0.45
Yield grade 3, %	48.23	45.70	41.89	73.70	41.44	42.78	4.26	0.46	0.58	0.78	0.98	0.55
Yield grade 4 and 5, %	8.56	9.60	14.00	8.56	6.38	8.77	3.42	0.33	0.87	0.34	0.64	0.77
Marbling score[2]	519	517	522	528	531	530	7.33	0.11	0.92	0.80	0.74	0.65
Kidney, pelvic, heart fat, %	2.34	2.37	2.34	2.36	2.35	2.40	0.05	0.57	0.84	0.98	0.58	0.33
Back fat over 12th rib, in	0.54	0.55	0.58	0.58	0.57	0.55	0.02	0.58	0.84	0.73	0.73	0.21
Ribeye area, square in	12.8	13.1	13.1	13.1	13.2	13.0	0.15	0.44	0.24	0.52	0.45	0.53
Liver abscess, %	2.17	2.17	1.00	2.13	2.08	4.64	1.73	0.44	0.99	0.73	0.99	0.32

[1]Marbling score 500 = Small.
[2]Contrast 1: Dry-rolled corn diets vs. steam-flaked corn diets.
Contrast 2: Diets with 0% DDGS and 15% silage vs. diets containing 25% DDGS and 15% silage.
Contrast 3: DDGS diets with 15% silage vs. DDGS diets with 5% silage.
Contrast 4: Interaction between grain source and dried distiller's grains (15% silage).
Contrast 5: Grain source by roughage level interaction for diets containing DDGS.
[abcd]Means within a row without a common superscript letter differ (P<0.05).

DRIED DISTILLER'S GRAINS IN STEAM-FLAKED CORN FINISHING DIETS WITH DECREASED ROUGHAGE LEVELS

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Introduction

Distiller's grains are the primary co-product derived from fuel ethanol production. As the fuel ethanol industry expands into the High Plains, distiller's grains are becoming increasingly available as an alternative feed for livestock. Optimizing the use of distiller's grains in flaked grain rations is important to maintaining a competitive advantage among feedlot producers in this region. Because distiller's grains are relatively high in fiber, it is conceivable that the level of roughages in feedlot diets could be reduced when distiller's grains are fed to cattle. Roughages normally have low energy density; therefore, the cost per unit of energy from roughages usually is relatively high compared with cereal grains or grain co-products. If the use of distiller's grains would allow roughage levels to be decreased in finishing diets without deleterious consequences for health or performance, this generally would be viewed as a positive attribute. Our objective was to evaluate performance of feedlot cattle fed diets with and without distiller's grains, and assess the effect of reducing the level of added roughage in diets containing distiller's grains.

Experimental Procedures

Crossbred-yearling heifers (n = 384) were used in a finishing experiment to compare three dietary treatments. Diets all contained steam-flaked corn as the principal energy source. Dietary treatments (dry basis) included a control with 0% dried distiller's grains with solubles (DDGS) and 15% corn silage, and two diets containing 25% DDGS—one with 15% corn silage, and the other with only 5% corn silage. Heifers were fed in 24 pens with 15 to 16 cattle per pen and eight pens per treatment. Cattle were transitioned to finishing diets using a series of step-up rations. Final finishing diets were fed twice daily for a period of 85 days. The weight of each pen was measured at the start of the study and again immediately before transporting to a commercial abattoir in Emporia, KS. At harvest, incidence and severity of liver abscesses and hot carcass weight were recorded. After a 24-hour chill, USDA yield grade; USDA quality grade; marbling score; 12th-rib fat thickness; kidney, pelvic and heart fat; ribeye area; and incidence of dark cutting beef were recorded for each animal.

Results and Discussion

Cattle fed the diet containing 25% DDGS with 15% corn silage had feedlot performance equal to that of cattle fed the control diet without DDGS. Carcass attributes were mostly unchanged when distiller's grains were substituted for flaked corn, execpt that cattle fed 25% DDGS produced a greater percentage of yield grade 4 and yield grade 5 carcasses. These results are consistent with observations

[1]Dakota Gold Research Association, Sioux Falls, SD.

in previous experiments, in which cattle fed DDGS tended to deposit greater amounts of body fat. Feeding DDGS had no negative effect on quality grade. In fact, the percentage of carcasses that graded USDA Choice or better was numerically greater when cattle were fed diets with DDGS. No other notable effects on carcass characteristics were observed in this study.

Reducing levels of corn silage from 15% to 5% reduced feed intake by approximately 5% in cattle fed DDGS compared with cattle fed the control diet without DDGS. Gains were numerically lower and efficiencies were slightly improved by feeding the lower roughage level, though these differences were not statistically significant. Cattle fed the low-roughage diet maintained carcass attributes similar to those in other treatments.

Implications

When corn silage is used as the roughage source, dried distiller's grains are an effective replacement for steam-flaked corn. When dried distiller's grains are added to finishing diets, it might be feasible to decrease roughage levels with no deleterious effects on cattle performance or carcass quality.

Table 1. Composition of Experimental Diets Fed to Finishing Heifers. Diets Contained Steam-flaked Corn with 15% Corn Silage, 15% Corn Silage plus 25% Corn Distiller's Grains with Solubles (DDGS) or 5% Corn Silage with 25% DDGS

	Steam-flaked corn		
	0% DDGS	25% DDGS	25% DDGS
Item, % dry matter	15% Silage	15% Silage	5% Silage
Steam-flaked corn	75.30	55.52	65.76
Corn silage	14.81	14.85	4.94
DDGS	-	24.72	24.67
Soybean meal	4.32	-	-
Urea	1.17	0.33	0.16
Limestone	1.58	1.85	1.81
Mineral/vitamin supplement[1]	0.68	0.58	0.51
Feed additive premix[2]	2.14	2.15	2.15
Nutrients			
Crude Protein	13.90	14.27	14.02
Calcium	0.59	.57	0.63
Phosphorus	0.23	0.39	0.37
Ether extract	3.24	4.81	5.23
Neutral detergent fiber	9.75	18.35	11.80

[1]Mineral/vitamin supplement formulated to provide (dry basis) 1,200 IU/lb Vitamin A, 0.15 ppm cobalt, 10 ppm copper, 0.5 ppm iodine, 60 ppm zinc, 60 ppm manganese, and 0.25 ppm selenium.
[2]Provided 300 mg Rumensin, 90 mg Tylan, and 0.5 mg MGA/day in a ground corn carrier.

Table 2. Performance Characteristics for Heifers Fed Steam-flaked Corn-based Finishing Diets with Reduced Corn Silage Levels and 25% Corn Dry Distiller's Grains with solubles (DDGS)

	Steam-flaked corn			
	0% DDGS	25% DDGS	25% DDGS	
Item	15% Silage	15% Silage	5% Silage	SEM
Number of pens	8	8	8	-
Number of heifers	125	126	126	-
Initial weight, lbs	835	831	831	7.57
Final weight, lbs[1]	1082	1074	1072	9.21
DMI, lb[1]	19.87[a]	19.34[ab]	18.79[b]	0.32
ADG, lb[1]	2.91	2.85	2.83	0.07
Feed/gain[1,2]	6.85	6.79	6.65	0.14

[1]Final live weight was computed by taking hot carcass weight divided by 63.5 dressing percentage.
[2]Statistics were performed as gain:feed, reported as feed:gain.
[ab]Means within a row without a common superscript letter differ ($P<0.05$).

Table 3. Carcass Characteristics for Heifers Fed Steam-flaked Corn-based Finishing Diets with Reduced Corn Silage Levels and 25% Corn Dry Distiller's Grains with Solubles (DDGS)

	Steam-flaked corn			
	0% DDG	25% DDG	25% DDG	
Item	15% Silage	15% Silage	5% Silage	SEM
Hot carcass weight, lb	687	682	681	5.84
Dressing percent	63.23[a]	63.46[ab]	63.73[b]	0.20
USDA quality grade				
Prime, %	0.78	0.00	0.00	0.45
Upper 2/3 choice, %	15.26	12.55	9.53	2.73
Choice, %	55.11	62.24	61.93	4.00
Select, %	40.10	37.76	36.46	3.88
No roll, %	1.62	0.00	0.78	0.74
Low grade, %	0.78	0.00	0.00	0.45
Dark cutter, %	0.83	0.00	0.83	0.70
Marbling score[1]	517	505	503	8.66
Average yield grade	2.62	2.74	2.66	0.07
Calculated yield grade	2.67[c]	2.90[d]	2.72[cd]	0.09
Yield grade 1, %	2.40	1.56	1.62	1.02
Yield grade 2, %	39.27	36.35	39.11	4.50
Yield grade 3, %	53.49	47.92	48.18	4.78
Yield grade 4 and 5 %	5.68[c]	14.12[d]	11.09[cd]	2.87
Liver abscess, %	1.62	3.96	6.30	1.65
Kidney, pelvic, heart fat, %	2.24	2.28	2.27	0.04
Back fat 12th-rib, inches	0.55	0.58	0.56	0.02
Rib eye area, square inches	13.34	12.79	13.15	0.17

[1]Marbling Score 500=Small.
[ab]Means within a row without a common superscript letter differ ($P<0.05$).
[cd]Means within a row without a common superscript letter differ ($P<0.10$).

FORAGE INTAKE BY PREGNANT AND LACTATING FIRST-CALF HEIFERS

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Introduction

Forage dry matter intake by mature cows usually decreases during the final 4 to 8 weeks of gestation and then increases dramatically during the first 4 to 8 weeks of lactation. Rapid fetal growth during late pregnancy causes a physical impingement of the rumen. This reduction in ruminal capacity can cause prepartum reduction in forage intake. The rumen recovers its normal volume after calving. The increase in forage intake typical of the postpartum period is driven by milk production. Little research has focused on forage intake patterns by first-calf beef heifers during late gestation and early lactation. It is unknown if forage intake by growing heifers is similar to that of mature cows; moreover, poorly understood intake potential of heifers during the time preceding the second breeding season might contribute to the characteristically high rate of reproductive failure by these animals. Our objective was to measure the effects of advancing gestation and lactation on dry matter intake by first-calf heifers.

Experimental Procedures

Commercial Angus heifers (n = 11; average initial body weight = 1155 ± 116 pounds) were individually fed chopped warm-season grass hay for 137 days from 10 weeks prepartum to 10 weeks postpartum. Hay was fed to heifers free-choice; hay offered and hay refused were recorded daily. Heifers were housed indoors in individual tie-stalls (approximately 6 ft x 3 ft) in an environmentally controlled barn throughout the study period. Treatments were based on pregnancy status. Six heifers began the study pregnant (average initial day of gestation = 213). After calving (average calving day = day 69 of the study), they were milked by machine twice daily for an average of 10 weeks to approximate milk consumption by a nursing calf. The remaining five heifers served as non-pregnant, non-lactating controls.

Results and Discussion

Forage intake by both groups of heifers increased ($P<0.01$) over the course of the study (Figure 1), probably because heifers were growing. During the 4 weeks preceding calving, forage intake by the pregnant heifers decreased ($P<0.01$) compared with that of non-pregnant heifers. Similar depressions in dry matter intake (DMI) have been noted for mature cows during the 8- to 4-week period before calving. The majority of fetal growth occurs during this time. Rapidly growing tissues of the fetus, uterus, and placenta expand into the space inside the body cavity that is normally occupied by the rumen.

In our study, forage intake by pregnant heifers recovered rapidly following calving. By 2 weeks postpartum, it was again equal ($P>0.10$) to that of non-pregnant, non-lactating heifers. Forage intake was similar ($P>0.01$) between treatment groups for remainder of the study. This is in stark contrast to what other researchers have reported about intake patterns by lactating mature cows. Normally, diet DMI by mature cows increases dramatically during the first 4 to 8 weeks of lactation. This distinctive increase in intake is caused by the nutrient requirements associated with milk production. Presumably, lactating first-calf heifers experience a similar upswing in nutrient requirements; however, the lactating heifers in our study did not increase forage intake relative to non-lactating heifers. Reasons for this response are not immediately clear. These data might indicate that the increase in feed intake characteristic of mature cows during early lactation might be absent in first-calf heifers.

Implications

The dramatic increase in feed intake normally observed in mature beef cows during early lactation may be absent in first-calf beef heifers. Absence of a vigorous intake response during the post-calving/pre-breeding period could be a causal factor in reproductive failure by first-calf heifers.

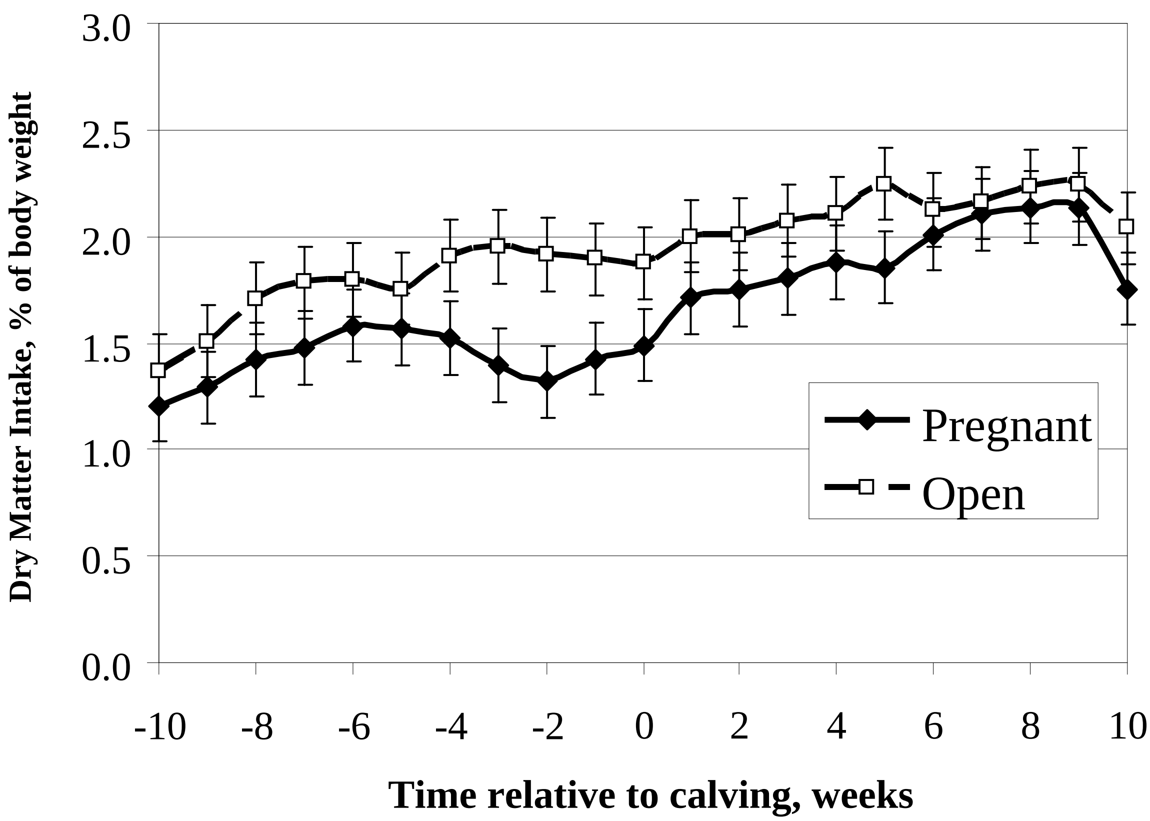

Figure 1. Dry Matter Intake by Pregnant or Lactating Heifers vs. Non-pregnant, Non-lactating Heifers.

EFFECT OF ZILPATEROL-HCL (ZILMAX[1]) ON IMPLANTED AND NON-IMPLANTED FEEDLOT STEER PERFORMANCE AND CARCASS CHARACTERISTICS

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Introduction

Zilpaterol-HCl (Zilmax) is a β_2-adrenergic receptor agonist approved as a growth promotant in feedlot cattle for use during the last 20 to 40 days prior to harvest. It is orally active and improves performance and total body lean tissue. The recommended dosage is 7.6 grams per ton of feed on a 100% dry matter basis.

Steroidal implants are used in feedlot animals to improve average daily gain, feed efficiency, and total lean tissue deposition. Little is known about how Zilmax and steroidal implants influence growth performance when used in combination. Our objective was to evaluate performance of steers administered Zilmax in combination with the steroidal implant, Revalor[1]-S.

Experimental Procedures

Crossbred steers (n = 2279) with an initial body weight of 940 lbs were assigned to 24 pens. The trial was conducted as a 2x2 factorial, with Zilmax feeding and implant as main effects. One of four treatments was applied to each pen: 1) Revalor-S without Zilmax 2) Revalor-S with Zilmax 3) no implant, no Zilmax 4) no implant with Zilmax. Ultrasound was used to estimate initial body fat. Steers were stratified by body fat and assigned to pens. Steers were implanted with Revalor-S 91 days before harvest. Zilmax was included in the diet starting at 33 days before harvest and then withdrawn from the ration three days before slaughter, as required by the U.S. Food and Drug Administration. The finishing diet consisted of 27.6% flaked corn, 20% high moisture corn, 25% sweet bran, 19.6% corn silage, 2.9% tallow, and 4.9% finisher supplement on a dry matter basis. A 4% shrink was applied to the initial and final live weights. Carcass characteristics were measured at slaughter.

Results and Discussion

Revalor-S increased hot carcass weights, dressing percentage, and ribeye area, but decreased marbling scores (Table 1). These results are consistent with previous studies on steroidal implants.

Feeding Zilmax increased hot carcass weight, dressing percentage, and ribeye area. Conversely, Zilmax decreased 12th-rib fat thickness and marbling score, indicating that Zilmax increased the amount of lean tissue deposited when fed 30 days before harvest.

[1]Zilmax and Revalor are registered trademarks of Intevet Inc., Millsboro, DE.

Revalor-S and Zilmax had an additive effect on performance. Hot carcass weights of steers receiving the combination were 69.4 lbs heavier than the control group (Table 1). The largest numerical dressing percentage was observed in the group administered the combination of Revalor-S and Zilmax (Table 1). Ribeye area of steers receiving the combination was 2.6 in^2 larger than that of control steers (Table 1). Marbling scores and 12th-rib fat thickness of steers receiving the combination of Zilmax and Revalor-S were numerically less than other treatments.

Implications

Results suggest that Zilmax improved animal performance and increased lean tissue deposition by finishing steers. When combined with Revalor-S, Zilmax resulted in additional improvements in performance and lean tissue growth.

Table 1. Effects of Revalor-S and Zilmax (fed for the final 30 days on feed plus a 3-day withdrawal) on Performance During the Final 91 Days on Feed by Finishing Beef Steers

	Treatment					*P*-values[1]		
Revalor-S:	None	Rev-S	None	Rev-S				Rev-S ×
Item Zilmax:	None	None	Zilmax	Zilmax	SE[2]	Rev-S	Zilmax	Zilmax
Initial BW, lbs[3]	939.3	940.2	939.1	939.6	14.05	0.72	0.84	0.91
Final BW, lbs[3]	1,291.7	1,320.6	1,316.5	1,347.0	20.88	<0.01	<0.01	0.88
ADG, lbs/d	3.89	4.20	4.16	4.49	0.191	<0.01	<0.01	0.85
DMI, lbs/d	22.72	23.23	22.51	23.01	0.594	0.02	0.27	0.99
Feed:gain	5.87	5.56	5.44	5.14	0.141	<0.01	<0.01	0.88
HCW, lbs	818.1	842.6	865.6	887.5	13.17	<0.01	<0.01	0.60
Dressing %	62.94	63.31	65.42	65.57	0.139	0.05	<0.01	0.38
12th rib fat, in	0.60	0.59	0.55	0.53	0.013	0.31	<0.01	0.78
Marbling score[4]	369.5	353.4	339.9	323.5	6.53	<0.01	<0.01	0.96
Ribeye area, in^2	13.96	14.69	15.76	16.58	0.198	<0.01	<0.01	0.66

[1]Probability of a quarter F-test of the main effects of Revalor-S implant (Rev-S), Zilmax, and the Rev-S × Zilmax interaction.
[2]Pooled SE of simple-effect means, n = six pens/treatment with 90 to 100 steers/pen initially and 89 to 100 steers/pen at slaughter. Due to the slightly unbalanced numbers among treatments and heteroscedasticity in some cases, the largest SE values were reported.
[3]A 4% shrink was applied to initial and final live weights. Deads-in calculations considered that dead or removed animals contributed to the initial BW but not to the final BW.
[4]300 = Slight; 400 = Small; 500 = Modest.

BIOLOGICAL VARIABILITY AND STATISTICAL EVALUATION OF DATA

The variability among individual animals in an experiment leads to problems in interpreting the results. Animals on treatment X may have a higher average daily gain than those on treatment Y, but variability within the groups may indicate that the difference between X and Y is not the result of the treatment alone. You can never be totally sure that the difference you observe is due to the treatment, but statistical analysis lets researchers calculate the probability that such differences are from chance rather than from the treatment.

In some articles, you will see the notation "P<0.05." That means the probability that the observed difference was due to chance is less than 5%. If two averages are said to be "significantly different," the probability is less than 5% that the difference is due to chance, and the probability exceeds 95% that the difference is true and was caused by the treatment.

Some papers report correlations: measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together) or negative (as one gets larger, the other gets smaller). A perfect correlation is either +1 or -1. If there is no relationship at all, the correlation is zero.

You may see an average given as 2.5 ± 0.1. The 2.5 is the average; 0.1 is the "standard error." That means there is a 68% probability that the "true" mean (based on an unlimited number of animals) will be between 2.4 and 2.6. "Standard deviation" is a measure of variability in a set of data. One standard deviation on each side of the mean is expected to contain 68% of the observations.

Many animals per treatment, replicating treatments several times, and using uniform animals all increase the probability of finding real differences when they actually exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals in an experiment. In the research reported herein, statistical analyses are included to increase the confidence you can place in the results.

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

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Some of the research reported here was carried out under special FDA clearances that apply only to investigational uses at approved research institutions. Materials that require FDA clearances may be used in the field only at levels and for the uses specified in that clearance.

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