BEEF CATTLE RESEARCH 2009

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Kansas State University Agricultural Experiment Station and Cooperative Extension Service

BEEF CATTLE RESEARCH 2009

Contents

Meats and Food Safety

Biological Variability and Chances of Error

Variability among individual animals in an experiment leads to problems in interpreting the results. Animals on treatment X may have higher average daily gains than those on treatment Y, but variability within treatments may indicate that the differences in production between X and Y were not the result of the treatment alone. Statistical analysis allows us to calculate the probability that such differences are from treatment rather than from chance.

In some of the articles herein, you will see the notation "$P<0.05$." That means the probability of the differences resulting from chance is less than 5%. If two averages are said to be "significantly different," the probability is less than 5% that the difference is from chance, or the probability exceeds 95% that the difference resulted from the treatments applied.

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

In other papers, you may see an average given as 2.5 ± 0.1. The 2.5 is the average; 0.1 is the "standard error." The standard error is calculated to be 68% certain that the real average (with unlimited number of animals) would fall within one standard error from the average, in this case between 2.4 and 2.6.

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

Length of the Weaning Period Affects Postweaning Growth, Health, and Carcass Merit of Ranch-Direct Beef Calves Weaned During the Fall

J. W. Bolte, K. C. Olson, J. R. Jaeger, T. B. Schmidt, D. U. Thomson, B. J. White, R. L. Larson, N. A. Sproul, L. A. Pacheco, 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) poor intake associated with introduction of novel feedstuffs into the animal's diet, (4) exposure to novel pathogens upon transport to a feeding facility and commingling with unfamiliar cattle, (5) inappropriately administered respiratory disease vaccination programs, and (6) poor response to respiratory disease vaccination programs. Management practices that are collectively referred to as preconditioning are thought to minimize damage to the beef carcass from the BRD complex.

Preconditioning management reduces the aforementioned risk factors for respiratory disease by (1) using a relatively long ranch-of-origin weaning period following maternal separation, (2) exposing calves to concentrate-type feedstuffs, and (3) producing heightened resistance to respiratory disease-causing organisms through a preweaning 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, optimal length of the ranch-of-origin weaning period has not been determined experimentally. The objective of this study was to test the validity of beef industry assumptions about appropriate length of ranch-of-origin weaning periods for calves aged 160 to 220 days and weaned during the fall.

Experimental Procedures

A total of 433 polled, spring-born calves (average body weight (BW) at weaning = 506 ± 81 lb; average birth date = 04/1/2007 ± 22 days) were used for this experiment. One set of calves (n = 265) originated from the Kansas State University Commercial Cow-Calf Unit. The second set (n = 168) originated from the Kansas State University Agricultural Research Center at Hays (ARCH). Bulls were castrated at least 120 days prior to the study. At each location, calves were blocked by sex 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. Calf age on the day of maternal separation averaged 160, 175, 190, 205, and 220 days of age for calves weaned 60, 45, 30, 15, and 0 days prior to shipping, respectively. The study was initiated on August 29 (75 days before shipping), and the common shipping date for all treatments was November 7

(day 0). Average calf age on the common shipping day was similar among treatments. Body condition score of cows at both locations was measured 75 days before and 14 days after the common shipping date.

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 were also individually identified with a color-coded ear tag corresponding to treatment at that time.

On the day of maternal separation, all calves were revaccinated for IBR, BVD, PI3, BRSV, and clostridial diseases by using the products previously described; calves were also treated for internal and external parasites with Dectomax (Pfizer Animal Health) and weighed. Calves at both locations were immediately transported a short distance (< 15 miles) to a central home-ranch weaning facility.

Calves were maintained in earth-floor pens (4 pens/treatment) at their respective home-ranch weaning facilities for a period of days corresponding to their treatment assignment. Calves were fed a common weaning ration (Table 1) during that period. The ration was formulated to achieve an average daily gain (ADG) of 2.0 lb at a dry-matter intake of 2.5% of BW.

Calves were monitored for symptoms of respiratory disease at 7:00 a.m. and 2:00 p.m. daily during the weaning phase of the experiment. Calves with clinical signs of BRD (Table 2), as judged by animal caretakers, were removed from home pens and evaluated. Each calf with clinical signs of BRD was weighed, had a rectal temperature measured, and was given a clinical illness score (Table 2). Calves that presented with a clinical illness score greater than 1 and a rectal temperature > 104.0°F were treated according to the schedule described in Table 3. Cattle were evaluated 72 hours posttreatment and re-treated on the basis of observed clinical signs.

Calves from all treatments and both origins were individually weighed and shipped approximately 180 miles from their respective weaning facilities to an auction market located at Hays, KS, on day 0. Calves from both locations were commingled with respect to gender, treatment, and BW and maintained on the premises of the auction market for 14 hours. The purpose of this step was to simulate pathogen exposure typically encountered by market-ready calves. Calves were shipped 5 miles directly to the ARCH feedlot from the auction market.

Upon arrival at the ARCH feedlot, cattle were individually weighed and assigned randomly to a receiving pen on the basis of treatment and gender. Cattle were fed a receiving ration for a period of 56 days after arrival at the ARCH. Feed intake was measured daily. Calves were monitored for symptoms of respiratory disease, and clinical illness was treated as in the home-ranch weaning phase (Tables 2 and 3). Body weights were measured at 28-day intervals during this receiving phase.

Following the receiving period, replacement heifers were removed, and cattle were placed on a common finishing ration (Table 4). Weights were taken every 60 days

throughout the finishing period until slaughter. Cattle were fed to reach an average endpoint of approximately 0.6 in. of backfat at the 12th rib and placed into one of three slaughter groups. Once steers and heifers reached the targeted carcass endpoint, as determined by ultrasound, they were transported 120 miles to a commercial abattoir. At the abattoir, livers were examined for abscesses, and lungs were examined for lesions. After carcasses chilled for approximately 48 hours, they were ribbed and graded. Carcass measurements including 12th rib fat thickness, 12th rib loin eye area, and marbling score were collected with digital imaging software. By using these measurements, yield grade and quality grade were assigned according to USDA guidelines. Kidney, pelvic, and heart fat were determined by difference in carcass weight after removal of all internal fat by dissection.

Results and Discussion

Calf BW was similar ($P>0.8$) among treatments at the beginning of the trial. Calf ADG during the 60 days preceding shipping tended to increase linearly ($P=0.09$) with longer weaning periods (Figure 1). Similarly, calf BW at shipping tended to increase linearly ($P=0.06$) with successively longer weaning periods (Figure 2). This probably occurred because calves were consuming a more energy-dense diet in the weaning facility than what was possible for herd mates that remained with their mothers on pasture. We concluded that under the conditions of our study, successively longer ranch-of-origin weaning periods improved calf BW and ADG prior to shipping. Incidence of undifferentiated fever during the 14-day period following maternal separation was greater ($P<0.01$) for calves on the 60-day weaning treatment than for those on the 45-, 30-, or 15-day weaning treatments (Figure 3). Reasons for the greater incidence of undifferentiated fever seen in the calves on the 60-day weaning treatment were unclear but may have been related to significant variation in daytime and nighttime temperatures that occurred during the first 14 days after maternal separation for that treatment.

Feed intake (dry-matter basis) during the first 30 days following shipping was less ($P<0.01$) for calves weaned 0 days than for those weaned 60, 45, 30, or 15 days prior to shipping (Figure 4). More experience consuming dry diets from a feed bunk prior to shipping translated to greater feed intake at the feedlot. Previous experience with concentrate-based feeds may benefit recently received calves in some circumstances; however, ADG and gain efficiency (G:F) in our study were similar ($P>0.12$) among treatments during the first 30 days in the feedlot. Calf BW 30 and 60 days after shipping increased linearly ($P<0.01$) with successively longer weaning periods. This indicates that treatments retained their relative ranks in body size from shipping to the end of the receiving period. Incidence of undifferentiated fever during the first 15 days after shipping was greater ($P<0.01$) for calves weaned 0 days than for those weaned 60, 45, 30, or 15 days (Figure 6).

Calf BW increased linearly ($P<0.02$) with longer weaning periods from feedlot receiving through 114 days on feed; however, calf BW was similar ($P>0.09$) between treatments from day 114 until harvest. Dry-matter intake during the first 30 days on feed was less for calves weaned 0 days than for those weaned 60, 45, 30, or 15 days; however, dry-matter intake was similar ($P>0.3$) among treatments from day 30 in the feedlot to

harvest. Calf ADG and G:F were similar (P>0.2) among treatments from feedlot receiving to 232 days on feed; however, ADG and G:F tended to increase linearly (P<0.06) with longer weaning periods from day 232 to harvest.

Days on feed decreased linearly (P=0.05) with successively longer weaning periods (Figure 7). This probably occurred because calves were slightly larger and more mature physiologically at the time of feedlot placement as length of the ranch-of-origin weaning period increased. Yield grade (Figure 8) and kidney, pelvic, and heart fat increased linearly (P 0.04), whereas fat thickness tended to increase linearly (P=0.06) with successively longer weaning periods. Dressing percentage, hot carcass weight, marbling, and loin eye area were similar (P>0.15) among treatments. Liver and lung scores at harvest also were similar (P>0.3) among treatments. The increase in undifferentiated fever for cattle weaned 0 days before shipping was not associated with significant damage to the lungs or a reduction in marbling score as has been reported by researchers working with market-sourced cattle. Differences in carcass characteristics among treatments may have occurred because calves weaned for longer periods of time were larger and more mature at the time of feedlot arrival.

Implications

In general, there was a great deal of similarity among weaning treatments in terms of health performance and growth performance during finishing. Carcass merit was also similar among treatments. This finding calls into question the validity of beef industry assumptions about the appropriate length of ranch-of-origin weaning periods for cattle that are moved quickly from their ranch of origin to a feedlot and not commingled with market-sourced cattle. Ranch-direct calves that are properly vaccinated before exposure to market conditions may not require ranch-of-origin weaning periods longer than 2 weeks for optimal health and growth performance during receiving and finishing. Although 2 weeks may be appropriate from the standpoint of sickness and ADG, an increase in calf BW prior to shipment to a feedlot or auction market may add value to calves that are sold after a brief ranch-of-origin weaning period.

Table 1. Ingredient and nutritional composition of the weaning diet

Ingredient	Dry-matter basis (%)
Extender pellets (alfalfa)	41.82
Corn gluten feed	18.22
Wheat midds	14.68
Cracked corn	10.78
Cottonseed hulls	7.68
Dried distillers grain	3.01
Molasses	1.67
Limestone	1.85

Nutrient composition	% of dry matter
CP	15.31
Ca	0.56
P	1.43
NE_m, Mcal/kg	1.44
NE_g, Mcal/kg	0.85

Diet also included salt, zinc sulfate, and Rumensin 80.

Table 2. 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 3. 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

Table 4. Average ingredient and nutritional composition of the finishing diet

Ingredient	Dry-matter basis (%)
Rolled milo	59.43
Sorghum silage	25.47
Soybean meal	11.04
Limestone	2.08
Ammonium sulfate	0.42

Nutrient composition	% of dry matter
CP	15.90
Ca	1.01
P	0.33
NE_m, Mcal/kg	1.75
NE_g, Mcal/kg	1.13

Diet also included salt, Rumensin 80, Tylan 40, and trace minerals.

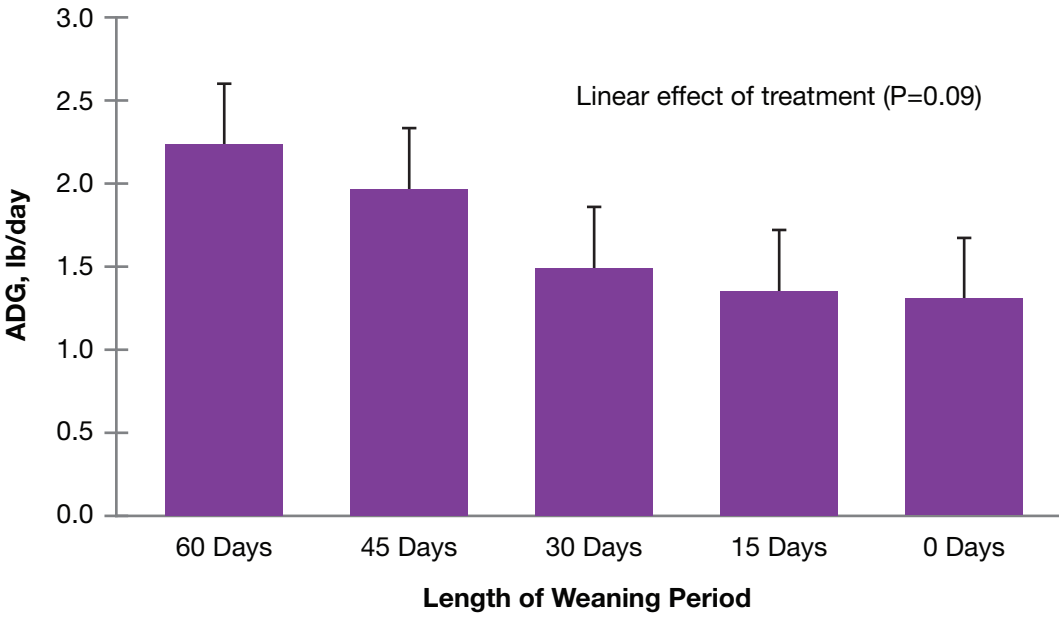


Figure 1. Effect of length of the ranch-of-origin weaning period on average daily gain (ADG) of calves during the 60 days prior to shipment to feedlot.

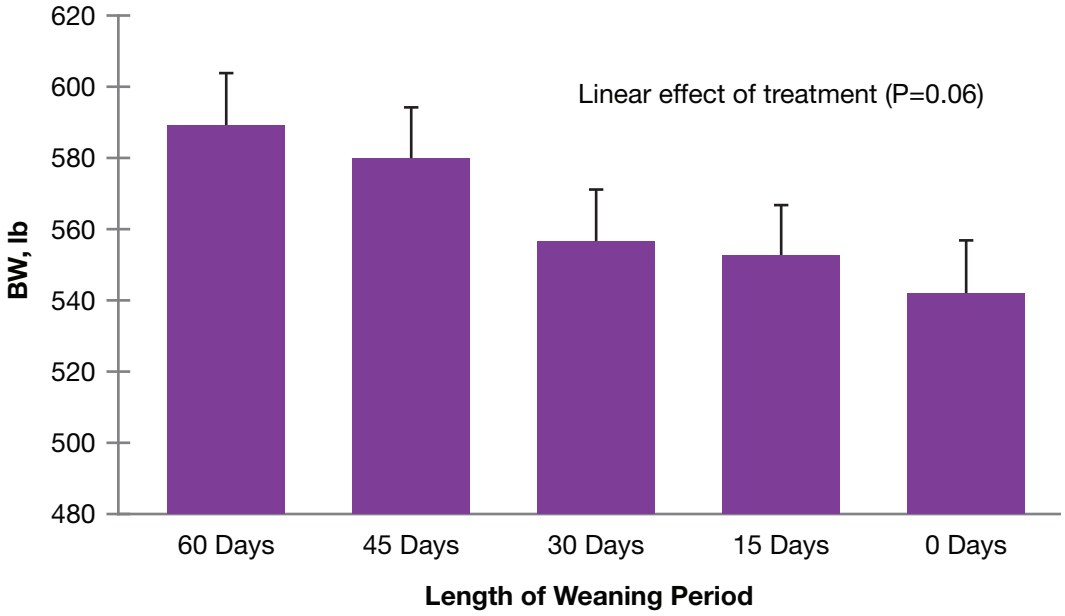
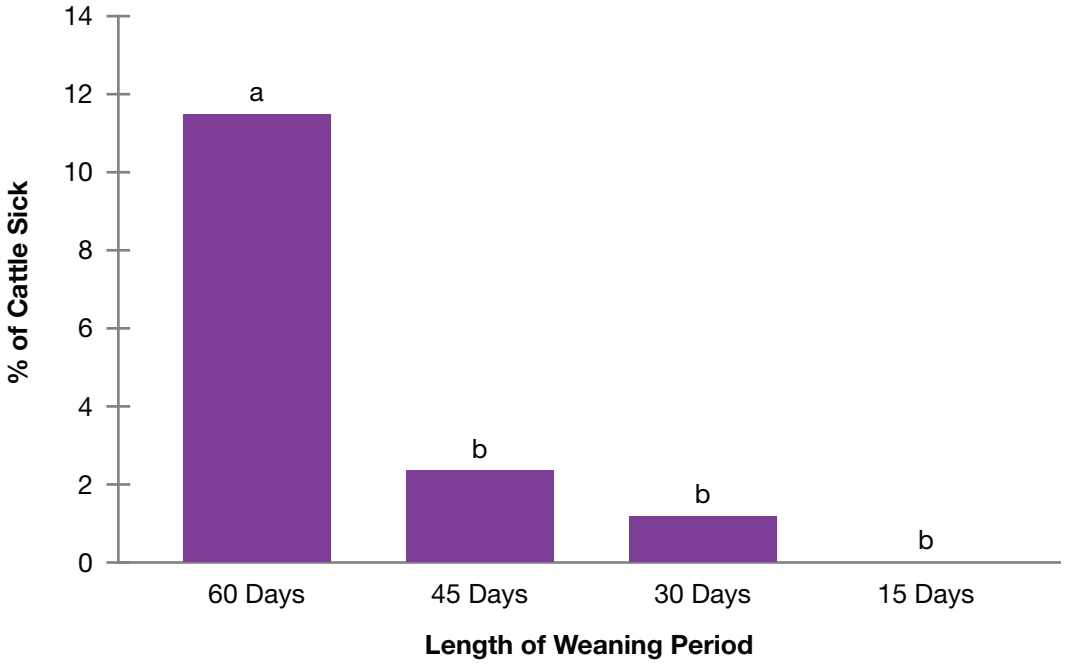
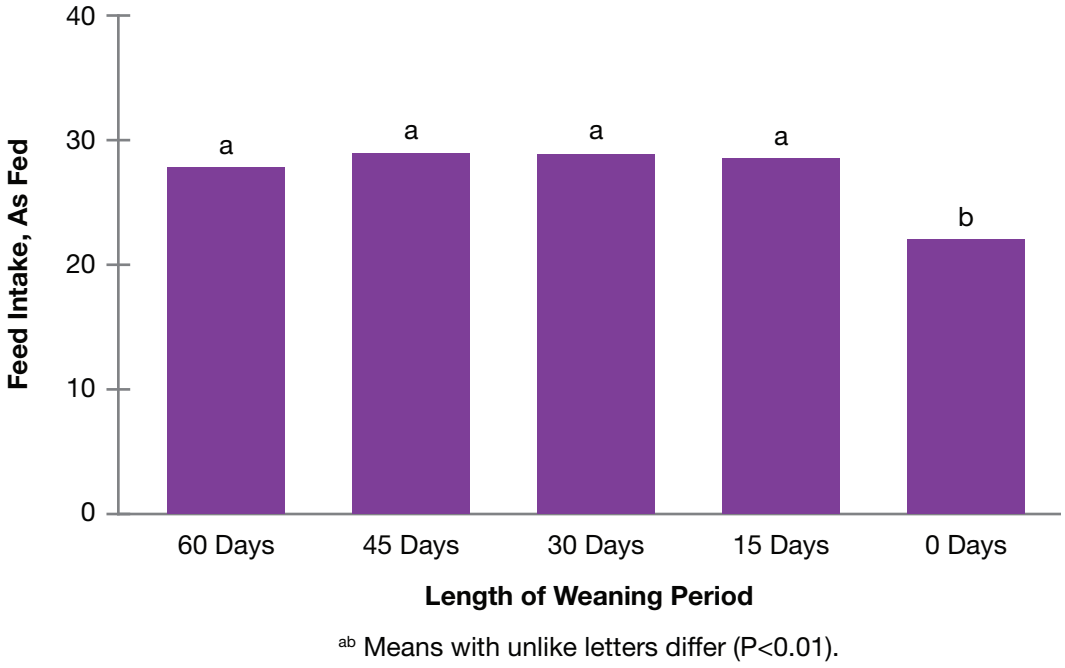


Figure 2. Effect of length of the ranch-of-origin weaning period on body weight (BW) of calves on the day of shipment to a commercial auction market.



[ab] Means with unlike letters differ (P<0.01).

Figure 3. Effect of length of the ranch-of-origin weaning period on incidence of undifferentiated fever in calves during the first 14 days after maternal separation prior to shipment to a commercial auction market.



[ab] Means with unlike letters differ (P<0.01).

Figure 4. Effect of length of the ranch-of-origin weaning period on feed intake by calves during the first 30 days after feedlot arrival.

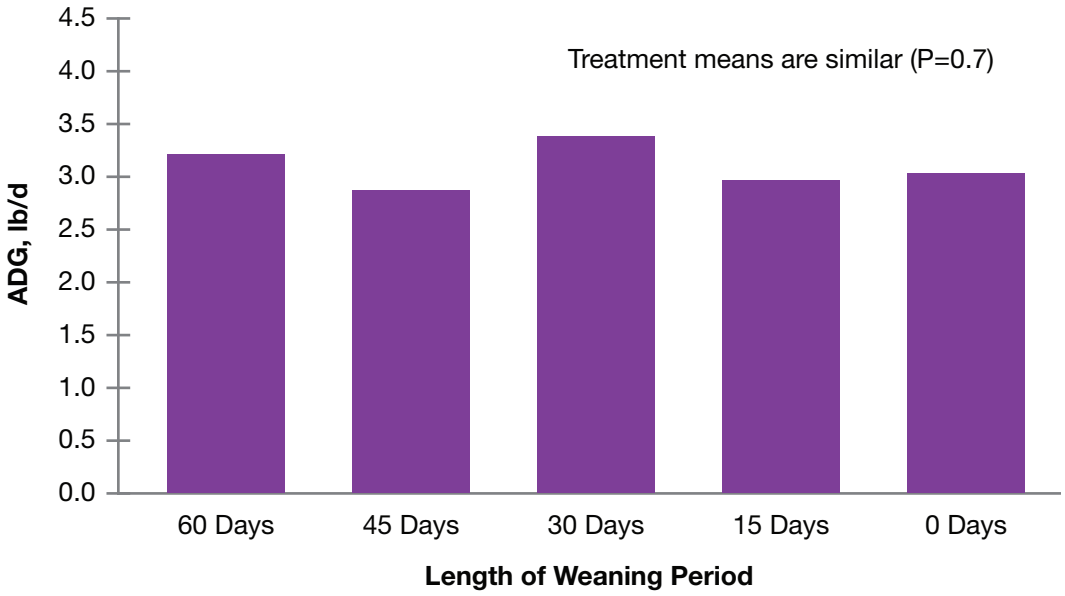
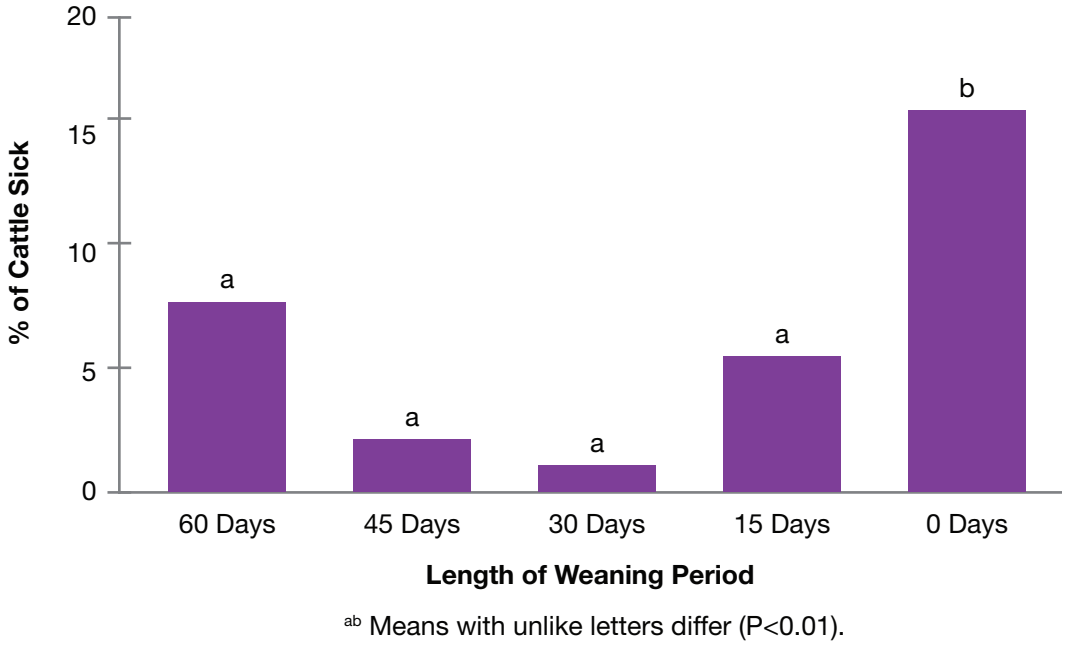


Figure 5. Effect of length of the ranch-of-origin weaning period on average daily gain (ADG) of calves during the first 30 days after feedlot arrival.



[ab] Means with unlike letters differ (P<0.01).

Figure 6. Effect of length of the ranch-of-origin weaning period on incidence of undifferentiated fever in calves during the first 15 days after feedlot arrival.

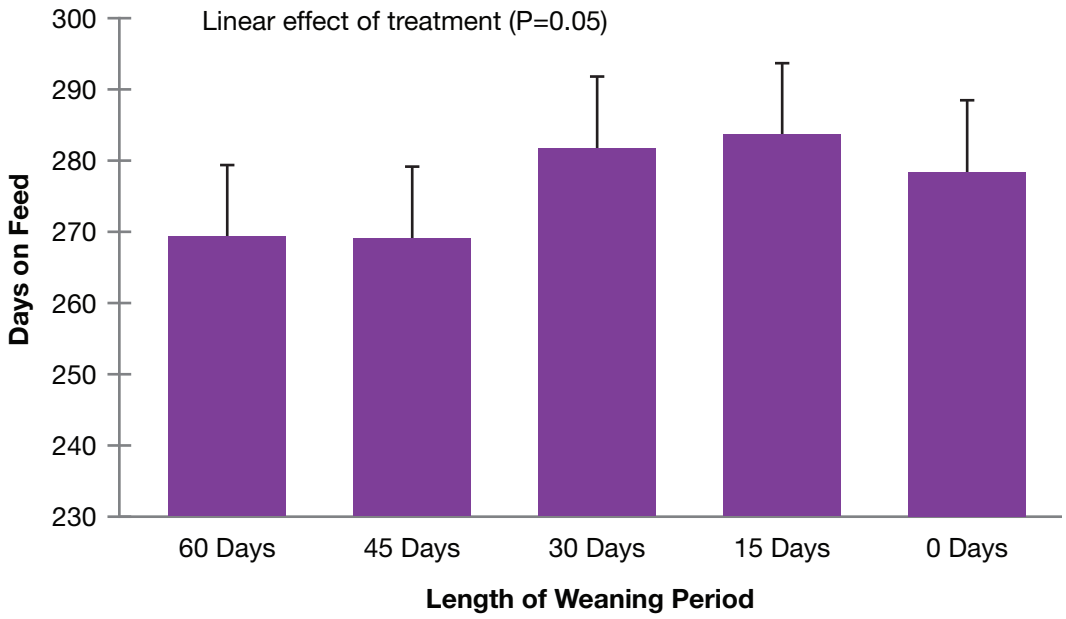


Figure 7. Effect of length of the ranch-of-origin weaning period on days on feed from feedlot arrival to harvest.

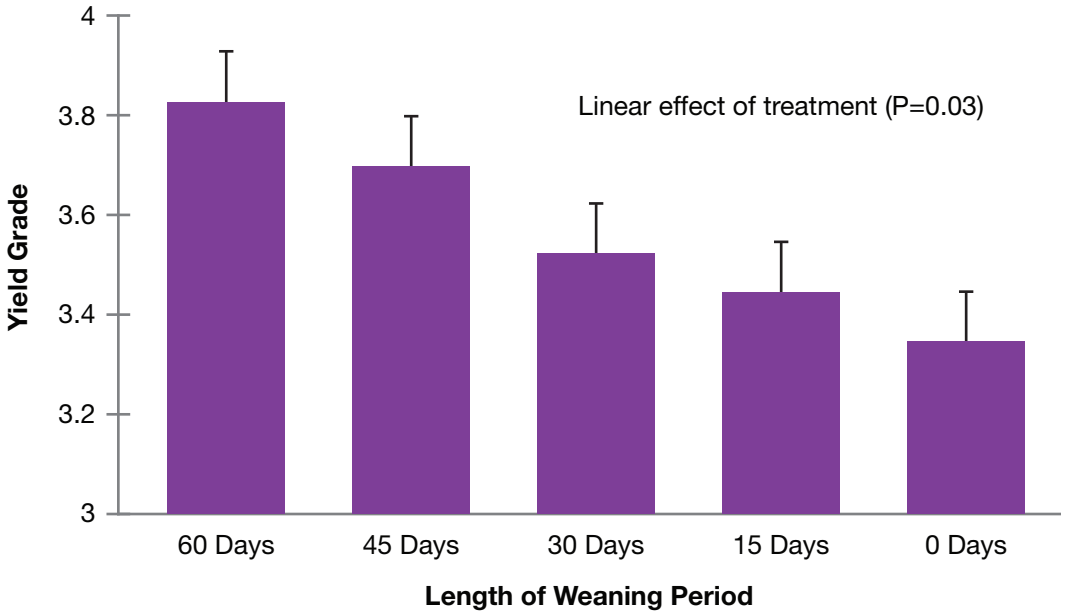


Figure 8. Effect of length of the ranch-of-origin weaning period on USDA yield grade of calves.

Length of the Ranch-of-Origin Weaning Period Does Not Affect Post-Receiving Growth or Carcass Merit of Ranch-Direct, Early-Weaned Beef Calves

J. W. Bolte, K. C. Olson, J. R. Jaeger, T. B. Schmidt, D. U. Thomson, B. J. White, R. L. Larson, G. A. Milliken, N. A. Sproul, L. A. Pacheco, 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 intake associated with introduction of novel feedstuffs into the animal's 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 that are collectively referred to as preconditioning are thought to minimize damage to the carcass from the BRD complex.

Preconditioning management can reduce the aforementioned risk factors for respiratory disease by (1) using a relatively long ranch-of-origin weaning period following maternal separation, (2) exposing calves to concentrate-type feedstuffs, and (3) producing heightened resistance to respiratory disease-causing organisms through a preweaning vaccination program. The effectiveness of such programs for preserving animal performance is highly touted by certain segments of the beef industry but poorly documented in peer-reviewed scientific literature.

Ranch-of-origin weaning periods of up to 60 days are suggested for preconditioning beef calves prior to sale; however, optimal length of the ranch-of-origin 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 calves aged 100 to 160 days and weaned during the summer.

Experimental Procedures

A total of 400 polled, spring-born calves (average body weight (BW) at weaning = 359 ± 69 lb; 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 Agricultural Research Center at Hays (ARCH). Bulls were castrated at least 14 days prior to the study. At each location, calves were blocked by sex 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 per location). Calf age on the date of maternal separation was 100, 115, 130, 145, and 160 days for calves weaned 60, 45, 30, 15, and 0 days relative to shipping, respectively. The study was initiated on June 15 (75 days before shipping), and the common shipping date for all treatments was August 24 (day 0).

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 were also individually identified with a color-coded ear tag corresponding to treatment at that time.

On the day of maternal separation, all calves were revaccinated for IBR, BVD, PI3, BRSV, and clostridial diseases; they were also treated for internal and external parasites with Dectomax (Pfizer Animal Health) 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 (4 pens/treatment) at their respective home-ranch weaning facilities for a period of days corresponding to their treatment assignment. Calves were fed a common weaning ration during that period that was based on chopped hay, soybean meal, and sorghum grain. It was 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 a.m. and 2:00 p.m. 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 a 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 > 104.0°F were treated according to the schedule described in Table 2. Cattle were evaluated 72 hours posttreatment and re-treated on the basis of 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, KS, on August 24 (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 the ARCH from the auction market.

Upon arrival at the ARCH feedlot, 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 the ARCH. Feed intake was measured daily. Calves were monitored for symptoms of respiratory disease, and clinical illness was treated as in the home-ranch weaning phase. Body weights were measured at 28-day intervals during the receiving phase.

Following the receiving period, replacement heifers were removed, and cattle were placed on a common finishing ration (Table 3). Weights were taken every 60 days throughout the finishing period until slaughter. Cattle were fed to reach an average endpoint of approximately 0.4 in. of backfat at the 12th rib and placed into one of three slaughter groups. Once steers and heifers reached the targeted carcass endpoint, as determined by ultrasound, they were transported approximately 180 miles to a commercial abattoir. At the abattoir, lungs were examined for lesions. After carcasses chilled for

approximately 24 hours, they were ribbed and graded. Carcass measurements including 12th rib fat thickness; 12th rib loin eye area; kidney, pelvic, and heart fat; USDA yield grade; USDA quality grade; and marbling score were collected by a trained evaluator blinded to treatment.

Results and Discussion

Calf BW at feedlot receiving tended to decrease linearly (P=0.06) with successively earlier weaning dates (Figure 1); however, calf BW was similar (P>0.2) among treatments from day 30 after feedlot arrival to harvest. Feed intake (dry-matter basis) during the first 30 days following shipping increased linearly (P<0.01) as the length of the ranch-of-origin weaning period increased; however, dry-matter intake was similar (P>0.3) among treatments from day 30 following shipping to harvest.

Daily gain and gain efficiency (G:F) in our study were similar (P=0.4) among treatments during the first 30 days in the feedlot (Figures 2 and 3, respectively). Similarly, calf ADG and G:F were similar (P>0.2) among treatments from day 30 in the feedlot until harvest.

Incidence of undifferentiated fever was similar (P=0.18, data not shown) among 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. In addition, incidence of undifferentiated fever was similar (P=0.12) among treatments during the first 30 days in the feedlot (Figure 4).

Days on feed tended to increase linearly (P=0.06) with successively longer weaning periods (Figure 5). Dressing percentage; fat thickness; hot carcass weight; kidney, pelvic, and heart fat; marbling; loin eye area; and yield grade were similar (P>0.2) among treatments. Liver and lung scores also were similar (P>0.3) among treatments.

In general, finishing performance and carcass merit of early-weaned lightweight calves was not improved by ranch-of-origin weaning periods of between 15 and 60 days.

Implications

Under the conditions of our study, ranch-of-origin weaning periods between 15 and 60 days did not improve post-receiving growth performance, health performance, or carcass merit of early-weaned lightweight calves compared with 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

Table 3. Average ingredient and nutritional composition of finishing diet

Ingredient	Dry-matter basis (%)
Rolled milo	59.43
Sorghum silage	25.47
Soybean meal	11.04
Limestone	2.08
Ammonium sulfate	0.42

Nutrient composition	% of dry matter
CP	15.90
Ca	1.01
P	0.33
NE_m, Mcal/kg	1.75
NE_g, Mcal/kg	1.13

Diet also included salt, Rumensin 80, Tylan 40, and trace minerals.

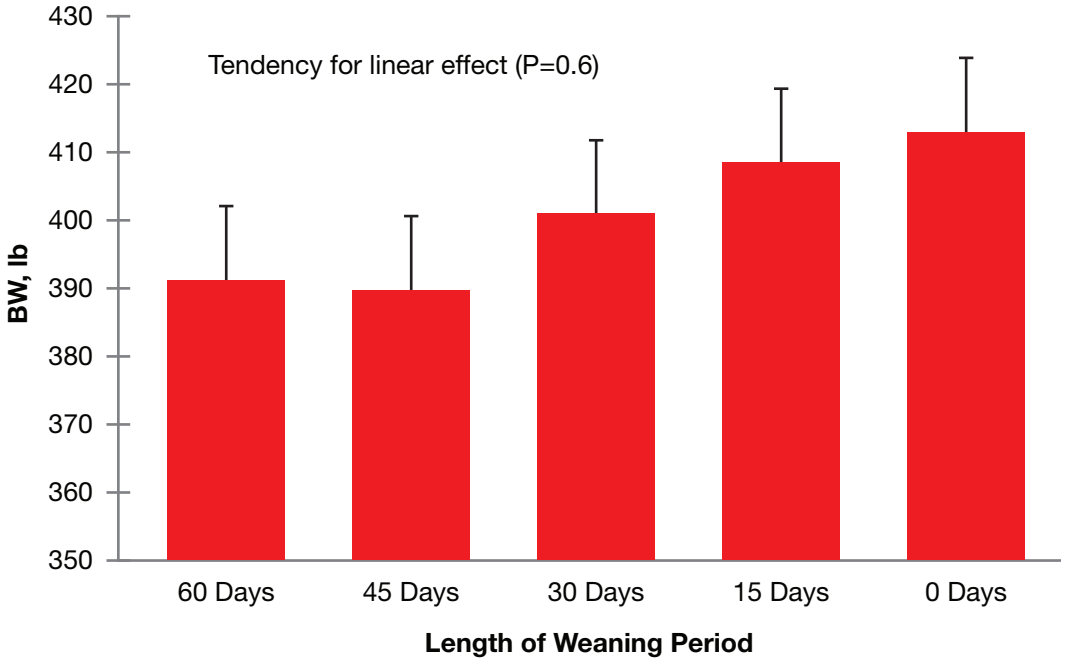


Figure 1. Effect of length of the ranch-of-origin weaning period on body weight (BW) of lightweight calves at feedlot arrival.

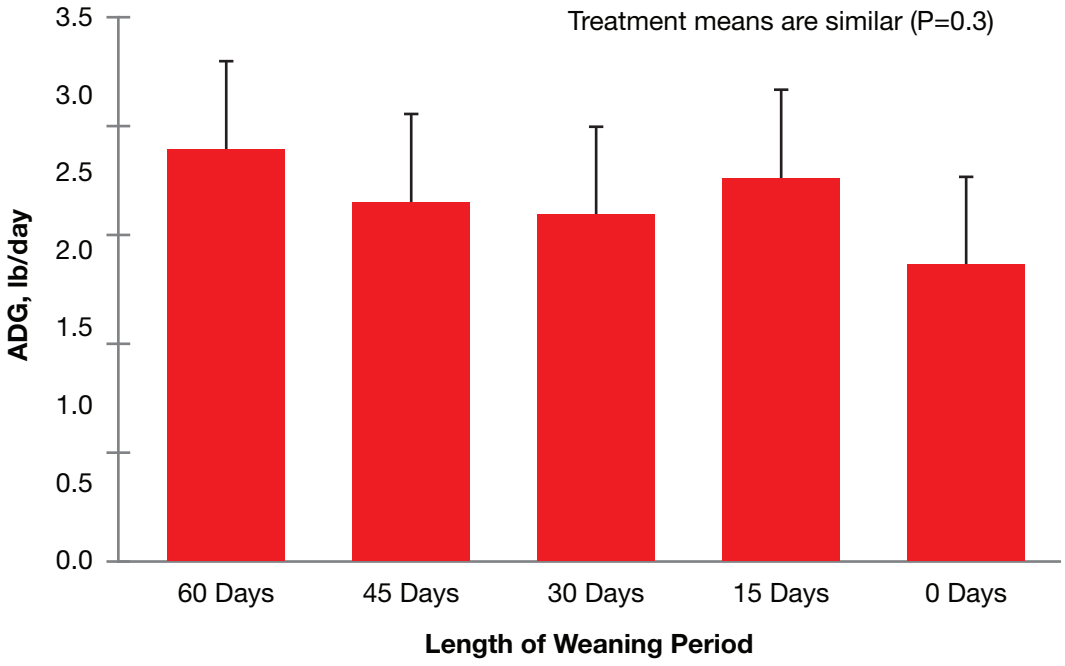


Figure 2. Effect of length of the ranch-of-origin weaning period on average daily gain (ADG) of lightweight calves during the first 30 days after feedlot arrival.

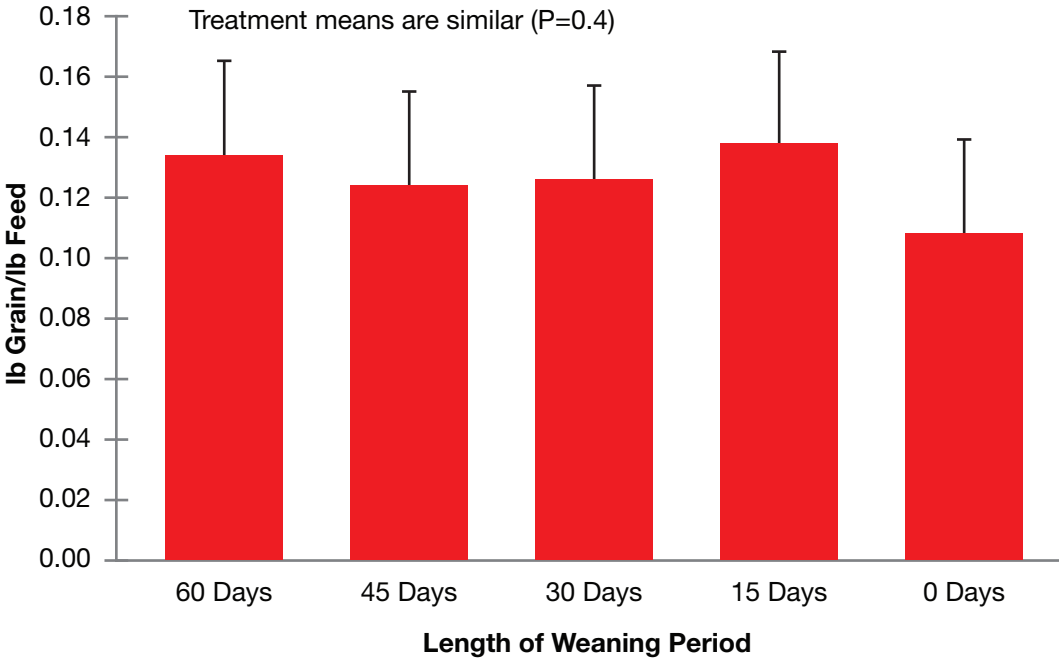


Figure 3. Effect of length of the ranch-of-origin weaning period on growth efficiency of lightweight calves during the first 30 days after feedlot arrival.

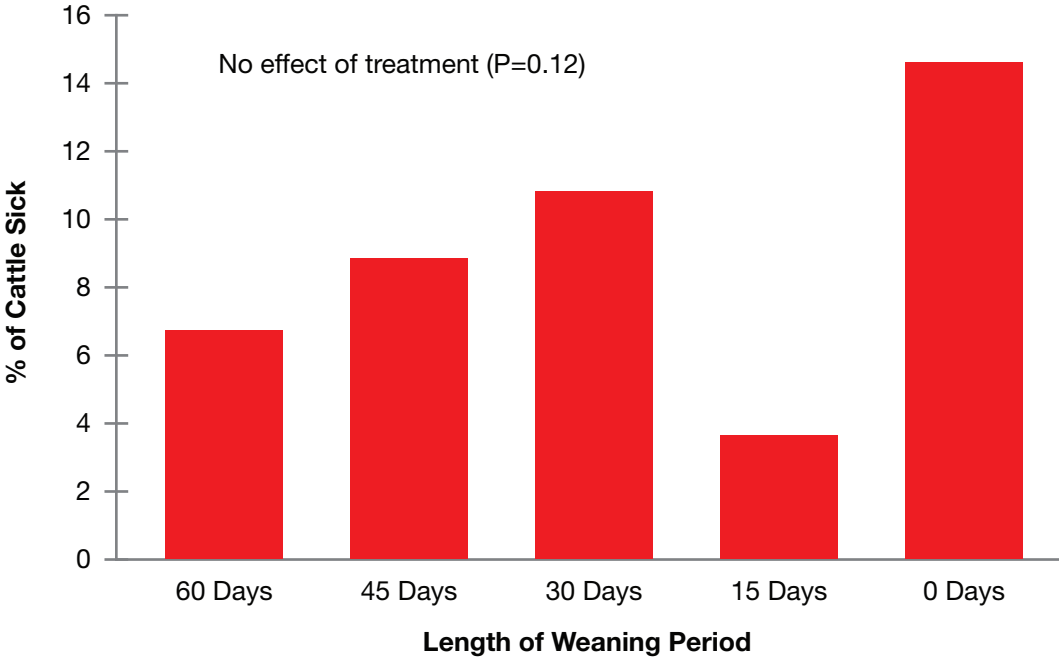


Figure 4. Effect of length of the ranch-of-origin weaning period on incidence of undifferentiated fever in lightweight calves during the first 30 days after feedlot arrival.

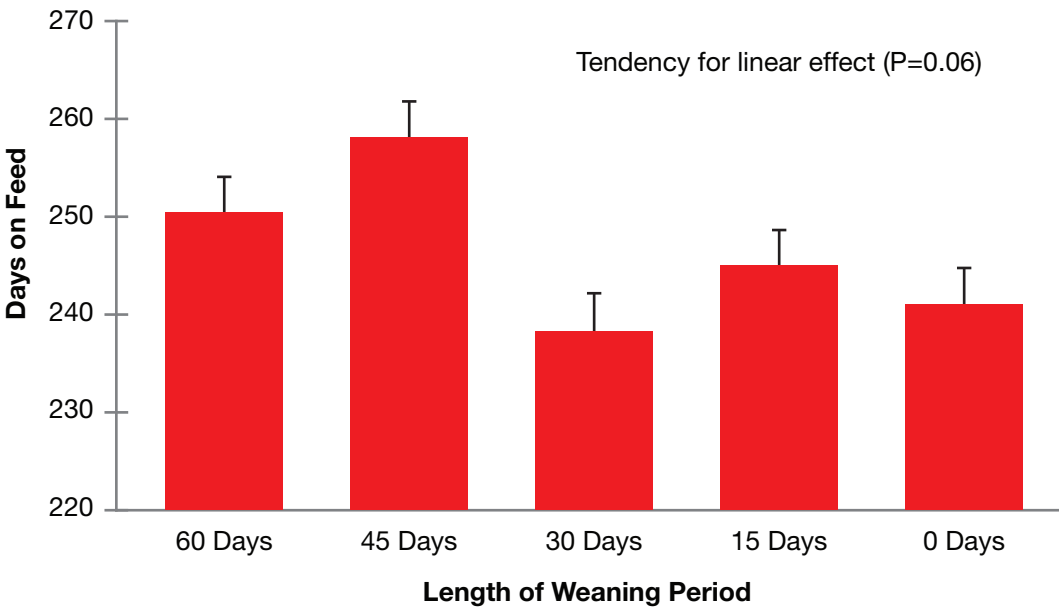


Figure 5. Effect of length of the ranch-of-origin weaning period on days fed from feedlot receiving to harvest.

Concurrent Metaphylaxis with Aureomycin and Draxxin in High-Risk Calves Has No Additive Effects on Cattle Health and Performance

J. O. Wallace, C. D. Reinhardt, and D. U. Thomson

Introduction

The shipping and receiving period is one of the most stressful experiences during a calf's lifetime. Stressors include weaning, commingling, transportation, processing, feed and water changes, and disease challenge placed on the animal upon entering a stocker operation or feedlot. These stressors result in decreased appetite, loss of body mass, decreased immunity, and increased risk of disease. Bovine respiratory disease complex has one of the highest treatment costs of all diseases affecting feedlot cattle and can negatively affect feedlot performance and carcass characteristics of animals, resulting in decreased profit.

Mass medication (metaphylaxis) is the treatment of all cattle at arrival processing despite observed health status by using either injectable or feed-grade antibiotics. However, no research has examined effects of concurrent metaphylaxis with both Draxxin (Pfizer Animal Health; New York, NY) and chlortetracycline simultaneously. Therefore, the objective of this study was to examine effects of concurrent metaphylaxis with Draxxin and chlortetracycline upon arrival on high-risk stocker calf health and performance.

Experimental Procedures

Two 41-day receiving studies were conducted at the Kansas State University Beef Stocker Unit during November 2007 and March 2008 to determine the response of high-risk stocker calves to concurrent metaphylaxis with Draxxin and Aureomycin (Alpharma Inc., Ridgefield Park, NJ). All cattle were sourced from an order buyer in Tennessee, and cattle were received over three consecutive days. Upon arrival, all calves were weighed, tagged, mass medicated with Draxxin (1.1 mL/100 lb), and palpated for sex (bull or steer). Calves were then given ad libitum access to long-stem prairie hay and water overnight. The following day, calves were vaccinated against clostridial and respiratory diseases and dewormed, and bulls were surgically castrated. Calves that arrived in March were also poured for lice. Each load was then blocked by arrival date and randomly assigned to one of three treatments for a total of 18 pens. Castrated bulls were equally distributed among the six pens within each alley. Cattle were weighed and revaccinated 12 days following initial processing and weighed again following the 41-day feeding period. Calves were stepped up by using three sequential growing diets ranging from 29 to 36.5% concentrate. Diets were fed with addition of the following treatments: no top-dress pellets (CON), top-dressed with Aureomycin-containing pellets [CTC; 10 mg CTC/pound of body weight (BW)], or top-dressed with the same pellets that did not contain any Aureomycin (PP). The PP pellets were top-dressed at an amount per unit BW equal to that of the CTC pellets. The CTC and PP treatments were top-dressed for two periods that each lasted 5 days (days 1 to 5 and days 7 to 11).

Cattle were observed daily for signs of illness and injury by personnel blinded to treatments. Calves were treated for respiratory disease with Draxxin only following a moratorium of 5 days post-metaphylaxis. Calves that were determined to need treatment were given Baytril (5 mL/100 lb or 5 mL/45.35 kg) as a first treatment; Nuflor (6 mL/100 lb or 6 mL/45.35 kg;) as a second treatment, if needed; and Bio-Mycin 200 (4.5 mL/100 lb or 4.5 mL/45.35 kg) as a third treatment, if needed.

Bunks were checked approximately twice daily, and feed was delivered in amounts sufficient to result in slick bunks both morning and afternoon. Calves were fed their respective diets at approximately 7:00 a.m. and 3:00 p.m. daily for 41 days.

Daily dry-matter intake, gains, and feed efficiencies were determined for each pen of calves. Health records were used to determine the number of animals treated and percentage death loss.

Performance and health data were analyzed by using the random effects MIXED model procedure of SAS. Treatment was included in the model as a fixed effect, and study and start date were included as random variables. Values were determined to be statistically different when $P \leq 0.10$.

Results and Discussion

Initial BW was different among the three treatments as a result of animals within each load being blocked by alley and randomized to pens by BW and sex (bull vs. steer). Final BW was also different among the three treatments (Table 1); however, it was reflective of initial weights with PP calves having the heaviest final BW, CTC calves having the lowest final BW, and CON calves being intermediate. Daily DMI was affected by treatment ($P=0.09$) and followed the same pattern as initial and final BW (PP calves consumed the most feed, and CTC calves consumed the least). Average daily gain and feed efficiency were not affected by treatment ($P>0.39$).

The percentage of total animals removed from pens because of illness and the percentage of retreatments were not affected by treatment ($P>0.20$). Additionally, there were no differences in death loss among the three treatments ($P=0.25$).

Lack of response to metaphylactic treatment could be a result of timing of administration of the two antibiotics. Effective concentrations of Draxxin have been observed for up to 8 days following subcutaneous administration in calves. It may have been more beneficial to administer the chlortetracycline to calves in this study following a moratorium of at least 8 days post-metaphylactic treatment with Draxxin.

Implications

This experiment showed no additive effects of metaphylaxis by using Draxxin concurrently with two 5-day periods in which Aureomycin was fed. These data may be beneficial to producers when designing treatment protocols for newly received high-risk stocker calves.

Table 1. Performance of calves receiving no pellets (CON), pellets containing chlortetracycline (CTC), or pellets without chlortetracycline (PP) during the 41-day receiving studies

	Treatment[1,2]				
Item	CON	CTC	PP	SEM	P-value
Head, no.	154	155	154		
Pens, no.	12	12	12		
Initial wt., lb	447[ab]	442[a]	452[b]	5.72	0.07
Final wt., lb	576[ab]	569[a]	584[b]	5.67	0.06
Daily DMI, lb	13.63[ab]	13.46[a]	14.13[b]	0.29	0.09
ADG, lb	3.15	3.11	3.22	0.14	0.39
G:F, lb	0.229	0.233	0.230	0.01	0.50
Pulls	25.7	25.7	22.7	0.06	0.80
Respiratory pulls	24.4	25.1	22.0	0.06	0.80
2nd Pulls	2.0	2.5	2.0	0.01	0.38
2nd Respiratory pulls	4.6	5.5	4.4	0.01	0.64
Death loss	2.0	2.0	3.3	0.01	0.25

[1] CON = fed three growing diets only; CTC = three growing diets top-dressed with pellets containing chlortetracycline (4 g/lb CTC) to provide 10 mg CTC per pound BW; PP = three growing diets top-dressed with pellets containing no CTC administered at the same amount per unit of BW as those in the CTC treatment (1.12 lb/head).
[2] Pellets were top-dressed from days 1 to 5 and days 7 to 11.
[ab] Within a row, numbers without a common superscript letter differ (P≤0.10).

Dried Corn Germ in Natural Finishing Programs Reduces Incidence of Liver Abscess

J. O. Wallace, J. S. Drouillard, and C. D. Reinhardt

Introduction

Changes in consumer preference for beef produced without growth promotants, ionophores, or antibiotics and consumers' willingness to pay price premiums for such products have led some producers to begin raising beef under "natural" feeding regimens. Some natural programs prohibit use of injectable antibiotics, feed additive drugs, or growth promoting implants throughout the life of the animal. This creates challenges for maintaining efficient growth and preventing disease or metabolic disorders.

A key problem facing producers who feed cattle under a natural regimen, without use of antibiotics such as tylosin and ionophores, is ruminal acidosis, which is commonly linked with liver abscesses. Abscesses are the primary cause for condemnation of livers, and severe abscesses have been shown to decrease daily gains (ADG) and efficiency of gain (F:G). In addition, severely abscessed livers can lead to greater carcass trim, ultimately reducing hot carcass weight (HCW) and dressing percentages. *Fusobacterium necrophrum* and *Actinomyces pyogenes*, normal inhabitants of the bovine rumen, are believed to be the primary and secondary bacteria that cause liver abscesses. Acidosis frequently causes ruminitis, which allows these bacteria to enter the portal circulation and migrate to the liver. The bacteria then colonize in the liver, ultimately creating abscesses.

We previously observed a decrease in number of abscessed livers of approximately 5 to 7%, compared with controls, when dried, full-fat corn germ (GERM) was included in diets of finishing steers and heifers at rates ranging from 5 to 15%. These diets also included tylosin, which is commonly used to control liver abscesses. We speculated that adding GERM to the diet may decrease starch or alter intake patterns, resulting in decreased bouts of acidosis and subsequent ruminitis, or may suppress growth of *F. necrophorum*. Both scenarios could lead to decreased liver abscesses. The latter hypothesis was refuted in a previous study when we observed a tendency for increased concentrations of *F. necrophorum* when feeding supplemental fat at a rate of 4%.

Objectives of this experiment were to assess the effect of GERM on growth performance, carcass yield and quality grades, and incidence of liver abscesses when fed to finishing cattle as part of a natural feeding regimen applied under commercial feeding conditions.

Experimental Procedures

Yearling Angus and Angus-cross steers and heifers (n = 4,199; initial body weight = 703 lb) were used to characterize feedlot performance, health, incidence of liver abscess, and carcass traits of feedlot cattle produced under a "natural" feeding regimen with and without GERM added to the finishing diet. Cattle were housed at a commercial feedlot in central Kansas. Prior to initiation of the experiment, cattle were grazing ryegrass or grass pasture. At processing, cattle were vaccinated for viral and clostridial diseases (Titanium IBR, AgriLabs, St. Joseph, MO, and Vision 7, Intervet Inc., Millsboro, DE), given an ex-

ternal parasiticide (Ivermax, RX Veterinary Products, Memphis, TN), tagged with color coded pen tags, and sorted into treatments on an every-other-head basis. After processing, cattle were pen weighed and placed in their respective pens.

Following a step-up period of 2 to 3 weeks, cattle were placed on one of two finishing diets (Table 1) primarily composed of corn: (1) traditional finishing diet containing no corn germ (Control) or (2) traditional finishing diet with 5% of the corn replaced with 5% dried corn germ on a dry-matter basis (5% GERM).

Samples were taken from each load of GERM delivered to the feedlot and analyzed for dry matter. Neutral detergent fiber of feed samples was analyzed by using the Ankom method (Ankom 200, Fairport, NY; AOAC, 2002). Samples were also analyzed for crude protein by using the combustion method (Leco FP2000, Leco Corp., St. Joseph, MI) and crude fat. Composition of the germ is shown in Table 2.

Prior to shipment to a commercial abattoir in Lexington, NE, cattle were visually sorted by feedlot personnel, and cattle being shipped were weighed. Days on feed, dry-matter intake, ADG, F:G, morbidity, and death loss were calculated for each pen of cattle. Slaughter data collected included HCW, incidence and severity of liver abscess, and dressing percentage. Additionally, USDA yield grade and USDA quality grades were determined by USDA graders.

Growth performance and carcass data were analyzed by using the GLM procedure of SAS. Pen was the experimental unit, and model effects included sex and treatment. Initial head count was included as a covariate to account for differences in pen size. Values were determined to be statistically different when $P \leq 0.05$.

Results and Discussion

Finishing performance, carcass characteristics, and liver abscesses of cattle fed 0 or 5% GERM are presented in Tables 3 through 5. No sex × treatment interactions ($P \geq 0.11$) were observed; therefore, only main effects of finishing treatment are presented. Days on feed were not different between the two treatments ($P=0.39$); however, they were numerically higher for the Control treatment. There is little research concerning fat supplementation to finishing cattle that examines days on feed. Theoretically, adding moderate levels of fat to finishing diets would increase energy density of the diet, allowing animals to finish quicker and reduce days on feed.

Adding GERM to the diet resulted in no differences in ADG on a live basis ($P=0.63$); however, when adjusted HCW were used as the final weight, ADG was improved for cattle receiving GERM ($P=0.04$). Adding GERM to the diet did not affect F:G ($P \geq 0.21$).

The percentage of cattle that fell out of the natural program because of being treated for illness was not affected by treatment ($P=0.47$). Percentage of death loss tended ($P=0.06$) to increase for cattle receiving 5% GERM; however, death loss in both treatments was minimal and affected fewer than 1% of the animals.

All carcass traits measured except liver abscesses were unaffected by finishing treatment ($P \geq 0.15$). We previously observed linear increases in fat thickness and kidney, pelvic,

and heart fat and a quadratic increase in USDA yield grade 4 carcasses when increasing amounts of GERM were added to steam-flaked corn diets.

Incidence of liver abscess was reduced by 12% when GERM was added to the diet (P=0.01). The percentage of mild abscesses was unaffected by treatment (P=0.97). The percentage of moderate abscesses tended (P=0.11) to be reduced, and severe abscesses were reduced by 8.2% when GERM was added to the diet. We previously observed a linear decrease in incidence of liver abscesses in two experiments in which cattle were fed increasing levels of GERM. The decrease in incidence of liver abscesses could also be the result of some component of the GERM altering rumen fermentation or inhibiting some portion of the pathway in which liver abscesses are developed.

Implications

Results of this experiment indicate that GERM can be used as a replacement for steam-rolled corn in finishing diets for naturally raised cattle. Growth performance and carcass characteristics were neither improved nor negatively affected by adding 5% GERM to diet. In addition, adding GERM to the diet may help control incidence of liver abscess in naturally raised cattle, a problem incurred by many producers who raise beef naturally, without use of tylosin.

Table 1. Experimental diets and nutrient composition (formulated) for cattle fed 0 or 5% full-fat corn germ during the finishing period (dry-matter basis)

				Finishing treatment			
				Control		5% Germ	
Item, %	Step 1	Step 2	Step 3	Step 4	Finish	Step 4	Finish
Steam-rolled corn	45.1	55.2	64.2	72.8	78.5	70.3	73.5
Corn germ	–	–	–	–	–	2.6	5.1
Alfalfa hay	41.3	31.5	21.2	11.9	4.7	11.8	5.9
Sorghum silage	2.6	2.6	2.6	2.6	2.3	2.6	2.2
Soybean straw	2.4	2.4	2.4	2.4	3.6	2.4	2.4
Wet distillers grains	6.1	4.5	4.6	4.6	4.6	4.6	4.6
Mineral supplement	2.5	3.8	5.0	5.7	6.3	5.7	6.3
Nutrient composition							
Crude protein, %	14.73	14.23	14.05	13.63	13.32	13.69	13.59
Crude fat, %	3.73	3.76	3.90	4.03	4.11	5.08	6.20
Calcium, %	0.90	0.87	0.85	0.78	0.76	0.78	0.75
Phosphorus, %	0.32	0.32	0.32	0.33	0.33	0.33	0.34
Potassium, %	1.08	0.97	0.86	0.76	0.68	0.76	0.69
NE_m, Mcal/kg	36.16	38.15	40.07	41.95	43.11	42.71	44.70
NE_g, Mcal/kg	23.32	25.09	26.83	28.49	29.54	28.98	30.58

Table 2. Laboratory analysis of dried full-fat corn germ samples taken from each load of corn germ delivered to the feedlot (dry-matter basis)

Sample date	Dry matter	Crude protein	Crude fat	Neutral detergent fiber
03/19/2007	96.19	12.13	41.84	37.45
05/03/2007	96.55	12.88	45.16	34.61
06/14/2007	98.17	12.23	45.87	31.90
08/06/2007	98.08	12.16	45.61	34.34
09/05/2007	99.03	11.89	42.92	39.03
10/02/2007	97.12	12.49	45.70	34.39
10/23/2007	97.27	12.44	45.52	33.33
11/20/2007	97.32	12.50	46.71	36.56
12/17/2007	97.32	12.79	44.91	34.19
01/19/2008	98.13	12.40	45.11	31.42
Mean	97.52	12.39	44.94	34.72
Standard deviation	0.843	0.302	1.458	2.374

Table 3. Feedlot performance of cattle fed 0 or 5% full-fat corn germ during the finishing period

	Treatment			
Item	Control	5% Germ	SEM	P-value
No. of head	2,102	2,097		
No. of pens	13	13		
Days on feed	173	168	4.76	0.41
Initial wt, lb	703	702	5.78	0.95
Final wt, lb[1]	1232	1226	11.5	0.61
DMI, lb/day	21.7	21.9	0.31	0.60
ADG, lb/day	2.71	2.73	0.044	0.63
F:G	8.05	8.01	0.13	0.85
Carcass adjusted				
Final wt, lb[2]	1206	1215	10.9	0.58
ADG, lb/d	2.54	2.69	0.044	0.04
F:G	8.59	8.22	0.21	0.21
Fallouts, %[3]	0.21	0.32	0.11	0.44
Death loss, %	0.07	0.73	0.24	0.06

[1] Calculated as final body weight × 0.96.
[2] Calculated as HCW/0.635.
[3] Fallouts were cattle removed from the natural program because of being treated for illness with a medication that is not allowed to be given to cattle in the natural program.

Table 4. Carcass characteristics of cattle fed 0 or 5% full-fat corn germ during the finishing period

	Treatment			
Item	Control	5% Germ	SEM	P-value
Carcass wt, lb	767	772	6.9	0.61
Dressing percentage[1]	61.9	62.6	0.430	0.23
USDA quality grade, %				
Prime	2.4	3.4	0.794	0.39
Premium choice	39.6	36.5	2.952	0.44
Low choice	44.3	47.1	2.716	0.47
Select	12.6	12.6	1.768	1.00
Standard	0.9	0.4	0.223	0.15
USDA yield grade, %				
YG 1	0.5	0.8	0.242	0.37
YG 2	23.5	19.7	3.637	0.45
YG 3	59.6	60.8	3.055	0.77
YG 4	15.3	17.3	2.356	0.55
YG 5	1.1	1.4	0.386	0.57

[1] Calculated as HCW/final weight × 0.96.

Table 5. Liver abscesses in cattle fed 0 or 5% full-fat corn germ during the finishing period

	Treatment			
Item, %	Control	5% Germ	SEM	P-value
Total liver abscesses	67.9	55.9	2.97	0.01
Mild abscesses[1]	27.3	27.2	1.34	0.97
Moderate abscesses[2]	18.6	14.9	1.58	0.11
Severe abscesses[3]	21.9	13.7	2.38	0.02

1 Mild = livers with one or two small abscesses.
2 Moderate = livers with two to four well organized abscesses less than 1 in. in diameter.
3 Severe = livers with one or more large abscesses.

Backgrounding Health Associated with Area of the Truck Where Cattle Were Housed During Transport

B. J. White, D. Blasi, and M. Epp

Introduction

Cattle are commonly moved between geographic regions by using commercial transport carriers, and the vast majority of cattle are transported at least one time during their lives. Both handling and travel associated with moving cattle between locations have been identified as potentially stressful events.

The objective of this research was to identify potential associations between calf location within the transport carrier and subsequent calf wellness in the short term (40 to 60 days) following shipment. Health outcomes and average daily gain (ADG) were used to measure calf wellness during the backgrounding period. Although some research has described the overall effect of hauling cattle, we are aware of no recent literature describing the effects of location within the vehicle on subsequent animal wellness and performance.

Experimental Procedures

Data for this project were collected in conjunction with normal operations of the Kansas State University Beef Stocker Unit; this research facility consists of 24 drylot pens in three strings of eight pens each. Southeastern origin cattle were procured and commingled in Tennessee and shipped to Manhattan, KS. Three loads would arrive over a period of 2 to 4 days during each backgrounding cycle. Upon arrival, cattle from each load were unloaded by section of the transport carrier and placed in holding pens, maintaining segregation of animals by original truck compartment. Cattle were weighed and individually identified by holding pen, and the section of the transport vehicle was recorded for each animal based on the schematic depicted in Figure 1.

Transport vehicles used in this project represent common configurations of cattle hauling systems. Animals were divided into up to eight compartments within the trailer: nose on top deck (NOT), nose on bottom deck (NOB), bottom deck middle forward (BDF), bottom deck middle rear (BDR), rear on the bottom (ROB), top deck middle forward (TDF), top deck middle rear (TDR), and rear on the top deck (ROT). Dividing gates exist between BDF and BDR as well as TDF and TDR; however, these gates were sometimes left open, creating a large compartment referred to as bottom middle (BOT) or top middle (TOP), respectively. A categorical variable was created to identify animals as having come from the bottom (NOB, BDF, BDR, BOT, ROB) or top decks (NOT, TDF, TDR, TOP, ROT). Proximity to the front of the transport vehicle was recorded by a variable with all truck compartments placed in into one of three categories: front (NOT, NOB), middle (TDF, TDR, TOP, BDF, BDR, BOT), or rear (ROT, ROB).

Arrival weight and gender (steer/bull) were used to randomly allocate calves from a single load to a string of eight pens, and load integrity was maintained for each string

(no mixing of cattle between loads within pens). During the study period, cattle at the facility participated in a variety of health and nutrition research projects, but the base preventative health program was similar among all studies. Approximately 24 hours post-arrival, cattle were processed with standard health protocols including castration for bulls, metaphylaxis, modified-live viral vaccines (infectious bovine rhinotracheitis, bovine viral diarrhea, para-influenza-3, bovine respiratory syncitial virus), 7-way clostridial vaccine, and anti-parasiticides. Vaccinations were boostered, and individual animal weights were recorded between 10 and 16 days after arrival for each load. Cattle were fed a total mixed ration twice a day that included a mixture of prairie hay, alfalfa, wet gluten feed, and cracked corn. Calves were fed for approximately 6 weeks, and just prior to exit from the facility, each animal was individually weighed.

Animals were evaluated twice daily for signs of potential illness including depression, anorexia, coughing, or musculoskeletal ailments. Calves with disease symptoms were removed from the pen and taken to a chute for further examination. Treatments were administered on the basis of predetermined treatment protocols. Because morbidity effects of transport conditions are potentially transient, these outcomes were evaluated in two manners: associations with treatment during the entire period and potential associations with treatment only in the first 14 days. This health figure also coincides with a similar period of time monitored through the gain between arrival and revaccination. Gross necropsies were performed on all cattle that died during the feeding phase.

Statistical Analysis

Individual animal health and performance data were imported into SAS to determine potential associations between these variables and transport conditions (location within the truck). Random effects were included in each model to account for the effects of arrival gender (steers/bulls), group arrival time, and lack of individuality of each animal due to hierarchical structure of lots (truckloads) within each arrival time period, and pens within each load.

Results and Discussion

Data were collected on 24 individual loads of calves procured between May 2006 and May 2008. Three lots were excluded from the dataset because of unloading conditions that resulted in mixing of cattle between truck segments prior to individual identification.

When effects of arrival time, gender, individual load, and pen were accounted for, no significant associations were identified between compartment of the transport vehicle and probability of dying or being treated for the first, second, or third time. Individual animal ADG over the entire period was not associated with section within the transport vehicle; however, period ADG from arrival to revaccination tended ($P=0.09$) to be associated with truck section. Cattle in the ROT section had lower gains compared with those in NOT and TOP and tended ($P< 0.10$) to have lower gains than those in BOT and NOB. Beyond ROT, few differences were identified between revaccination ADG associated with section of the truck.

Placement of cattle on the top or bottom deck was not significantly associated with any health or performance outcomes measured. When the truck was categorized as forward, middle, or rear, no associations were identified between placement in one of these three

areas and the probability to die, be treated within the first 14 days, or be treated a second or third time. However, cattle in the middle section were significantly (P=0.02) more likely to be treated at least once (0.17) than cattle in the most forward sections (0.12). Calves in the rear sections did not have a different model-adjusted probability for being treated (0.15) compared with calves in the other two sections. The least squares mean rate of gain from arrival to reweigh for cattle in the rear section (3.8 lb/head daily) was lower (P<0.05) than that for calves housed in the front section (4.2 lb/head daily). Cattle in the middle section also tended (P=0.06) to have lower least squares mean ADG during this period (4.0 lb/head daily) than cattle in the front section.

Although individual compartment of the transport vehicle was not related to health outcomes, an interesting tendency between compartment and short-term ADG was identified. Previous investigators identified a transient depression in ADG associated with transport, yet no literature has identified differences between cattle housed by section of the truck. The relationship with this short-term gain was further explored when the rear of the truck (ROT, ROB) was compared with the rest of the vehicle. Cattle in the two rear truck sections had lower ADG relative to cattle in the middle and forward sections of the truck. One hypothesis to explain this finding is that potentially toxic fumes from the transport vehicle move behind the vehicle because of airflow currents and enter the rear of the truck, exposing these calves to lower quality air first. This could lead to short-term mechanical or physiological insults that limit short-term ADG. This hypothesis may be supported by the fact that one of the few associations between health outcomes and location on the truck was identified between cattle in the most forward sections (NOT, NOB) when compared with cattle in the middle (BDF, BDR, BOT, TOP, TDF, TDR) or rear (ROT, ROB) compartments. In many transport vehicles, the front of the first two sections is solid or directly behind the cab of the truck and thus protected from direct intake of exhaust. If airflow from the exhaust enters the trailer from the rear and sides of the truck, the most forward sections would tend to be somewhat protected from this effect.

This research illustrates some associations between health and performance in backgrounded beef calves and location within a commercial transport vehicle. Much research has evaluated the potential welfare implications and stress associated with cattle transportation; however, very little information is available comparing the effect of areas within the truck. This data set is unique because included cattle had comparable arrival weights between lots, similar distributions between truck compartments, and were transported a similar distance from procurement to the backgrounding facility.

Implications

Our current project reveals that the environment within a commercial transport carrier is not likely homogeneous and cattle position within the transport vehicle may result in differing health and performance outcomes.

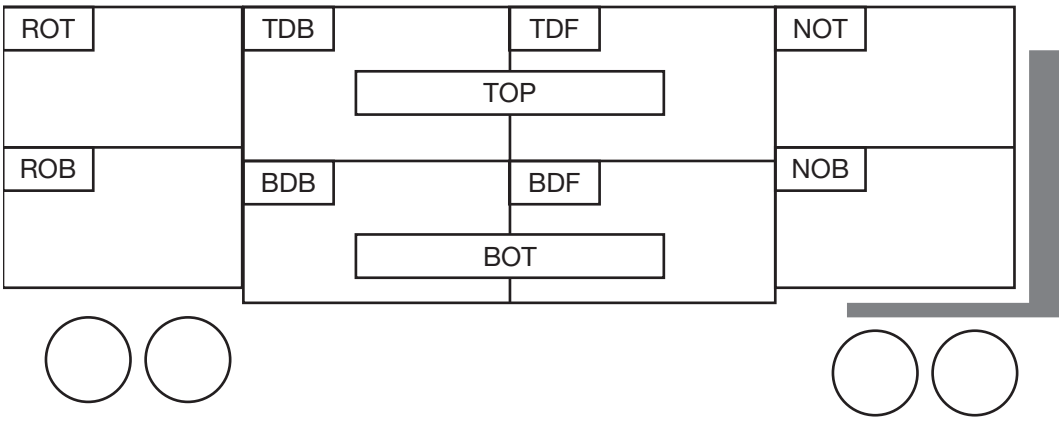


Figure 1. Location of compartments within a standard cattle transport trailer.
Truck compartments abbreviated as bottom deck rear (BDB), bottom deck front (BDF), bottom deck (bottom deck forward and back combined, BOT), rear on top (ROT), bottom deck nose (NOB), nose on top deck (NOT), rear on bottom (ROB), top deck back (TDB), top deck forward (TDF), and top deck (top deck back and forward combined, TOP).

Heifer Synchronization Using 7-11 Synch or 7-11 Synch + CIDR

D. R. Eborn, C. R. Spiker, R. R. Sullivan, and D. M. Grieger

Introduction

Two aims of heifer estrus synchronization protocols are to induce prepubertal heifers to start cycling by the beginning of the breeding season and to shorten time spent in estrous detection. Use of progestins such as melengestrol acetate (MGA) and intravaginal progesterone-releasing devices (CIDR) can induce prepubertal heifers to begin cycling as well as synchronize estrus in cycling heifers. In past years, a timed artificial insemination protocol (7-11 COSynch) has been tested with varying results. Pregnancy rates using 7-11 COSynch have typically ranged from 40 to 60%. The objective of the current trial was to determine the effect of a similar heat-detection protocol (7-11 Synch) with or without a CIDR. We compared heat response, interval to estrus, and conception rates in beef heifers.

Experimental Procedures

Beef heifers from the Kansas State University Purebred Teaching Unit (n = 57) and the Rufus F. Cox Cow-Calf Unit (n = 70) were assigned to one of two treatments: 7-11 Synch or 7-11Synch + CIDR (Figure 1). All heifers were fed MGA for 7 days and given an injection of prostaglandin-$F_{2\alpha}$ (Prostamate; TEVA Animal Health Inc., St. Joseph, MO) on the last day of MGA feeding (day 7). Four days later (day 11), all heifers received an injection of gonadotropin-releasing hormone (OvaCyst; TEVA Animal Health), and 1 week later on day 18, all heifers received a second injection of injection Prostamate. Heifers assigned to 7-11 Synch + CIDR were given an Eazi-Breed CIDR (TEVA Animal Health) at the time of the OvaCyst injection on day 11, and CIDR removal occurred at the time of the second Prostamate injection on day 18. Heifers were watched twice daily beginning at the day of the second Prostamate injection for 5 days and artificially inseminated 12 hours after the onset of estrus following the AM/PM rule. Conception rates due to the artificial insemination were determined by ultrasonography 30 to 32 days after the last day of artificial insemination.

Results and Discussion

Overall heat response was 108/127 (85%) and was not different between treatments. Estimated heat response for the 7-11 Synch and 7-11 Synch + CIDR was 85 and 86%, respectively. Predicted interval to estrus was 49 hours for 7-11 Synch + CIDR and 46 hours for 7-11 Synch and was not different between treatments (Figure 2). Conception rates for 7-11 Synch (36/55; 65%) and 7-11 Synch + CIDR (32/53; 60%) were not different (P=0.64). Pregnancy rates in each herd were more than 60% for each treatment, except for the 7-11 Synch + CIDR treatment in the commercial heifers (15/28; 53%). The lower conception rates may be due to small numbers of heifers. These preliminary results suggest that addition of the CIDR in the 7-11 Synch protocol does not improve heat response, change interval to estrus, or improve conception rates in artificial insemination.

Implications

Final pregnancy rates for 7-11 Synch and 7-11 Synch + CIDR are similar to those achieved with 7-11 COSynch by using timed artificial insemination in past years in these same herds. Current data suggest that using a CIDR in the 7-11 Synch system may decrease the time needed for estrous detection because of the greater synchrony of estrus in this protocol.

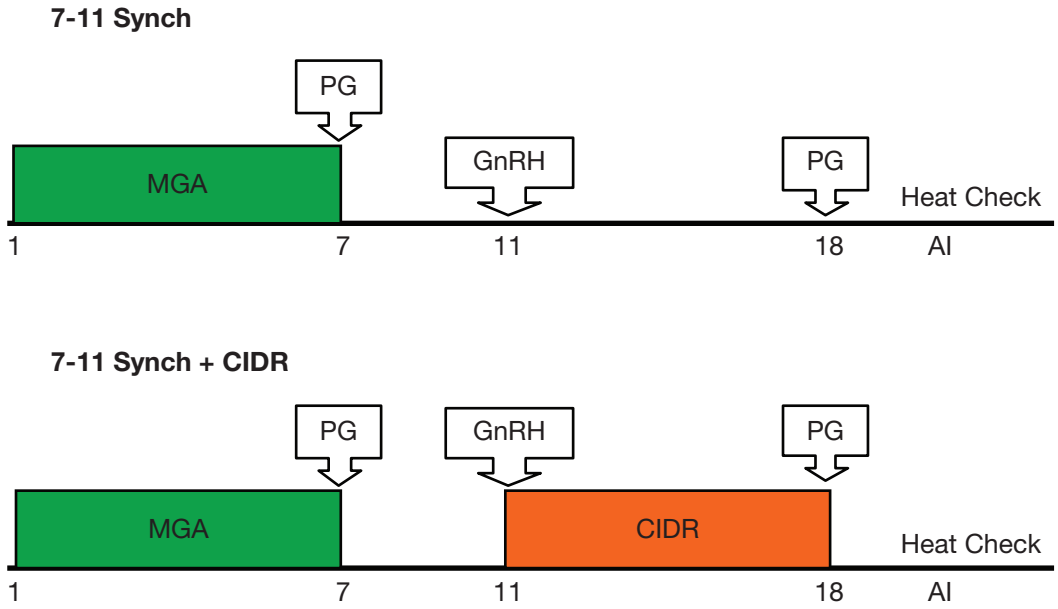


Figure 1. Heifers in both groups were treated the same with the exception of the insertion of CIDR in the 7-11 Synch + CIDR heifers.

MGA = melengestrol acetate; GnRH = gonadotropin-releasing hormone (OvaCyst); PG = prostaglandin-$F_{2\alpha}$ (Prostamate); CIDR = intravaginal progesterone-releasing devices. All heifers were watched twice daily for estrous activity for 5 days beginning at the Prostamate injection on day 18 and inseminated 12 hours after observed estrus.

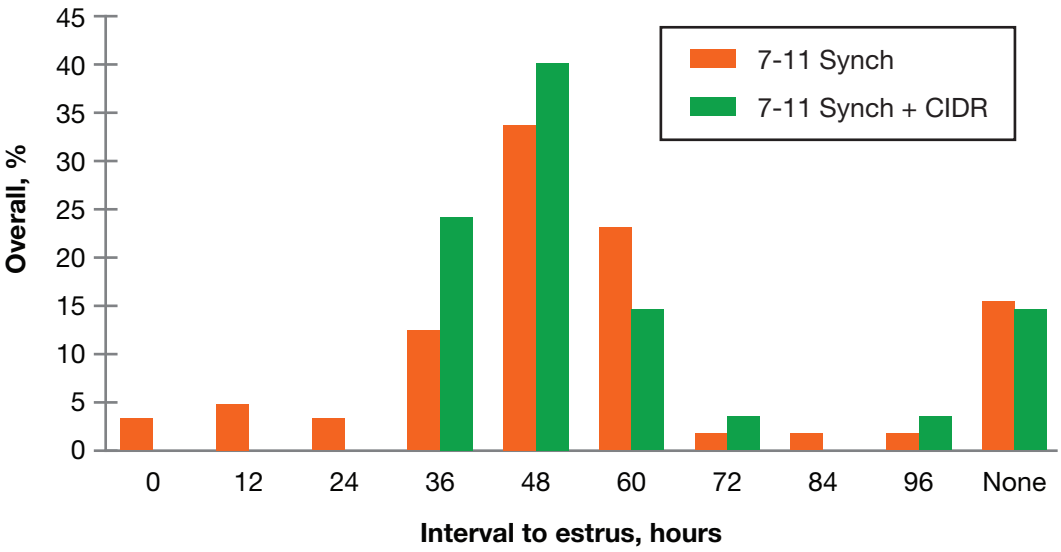


Figure 2. Heifers in the 7-11 Synch protocol tended to be more variable in their interval to estrus following the Prostamate injection.

Combinations of Steam-Flaked Corn, Dry-Rolled Corn, and Dried Distillers Grains Yield Beef with Similar yet Subtle Changes in Sensory Traits[1]

P. L. Black, G. L. Parsons, M. K. Shelor, M. E. Dikeman, K. K. Karges[2], M. L. Gibson[2], and J. S. Drouillard

Introduction

Rapid expansion of fuel ethanol production has made available abundant supplies of distillers grains with solubles, which are well-suited as a substitute for cereal grains in finishing cattle diets. Several recently reported experiments have revealed that feeding distillers grains may have adverse effects on carcass value as a result of the tendency to produce carcasses with lower quality grades and/or higher yield grades. The effects on quality grade have been most evident in flaked-grain diets, but effects on yield grade are more or less independent of the type of grain fed. In Kansas, two common methods for processing grains are steam flaking and dry rolling. Thus, feeding cattle distillers grains with different grain processing types is an important consideration for feedlots. Our experiment was designed to evaluate meat quality and composition in heifers fed flaked-corn diets containing dry-rolled corn and/or dried corn distillers grains.

Experimental Procedures

Crossbred yearling heifers (n = 689) were used in a finishing trial to evaluate the effects of feeding dry-rolled corn (DRC) and dried corn distillers grains with solubles (DDGS) in steam-flaked corn (SFC) diets. Diets consisted of SFC with 0 or 25% DDGS and 0 or 25% DRC (Table 1) in a 2 × 2 factorial arrangement of treatments. Heifers were blocked into light and heavy weight groups according to initial body weight and were fed in 28 dirt-surfaced pens with 23 to 25 head per pen. Heifers in the heavy and light weight blocks were fed once daily for 137 and 157 days, respectively. Four animals were randomly selected from each of 24 pens, and wholesale ribs were removed from one side of each carcass after a 24-hour chill. Ribeyes were collected from the rib sections and analyzed for color display life, lipid oxidation, and sensory attributes. Steaks (1-in. thick) were evaluated for color shelf life during a 7-day simulated retail display period as well as for purge loss during a 21-day aging period, weight loss during cooking, and lipid oxidation (TBARS). Sensory attributes were analyzed by the Department of Human Nutrition at Kansas State University on a 15-point scale. Traits analyzed were initial tenderness, juiciness, chewiness, beef flavor, residual connective tissue, mealy texture, fiber awareness, bloody/serumy flavors, metallic flavors, and rancidity.

[1] This project was funded in part by beef and veal producers and importers through their $1-per-head checkoff and was produced for the Cattlemen's Beef Board and state beef councils by the National Cattlemen's Beef Association.
[2] Dakota Gold Research Association, Sioux Falls, SD

Results and Discussion

Steaks from cattle fed the different diets did not differ in color display attributes or TBARS values (P>0.20; data not presented). Weight loss during cooking was greater for steaks from heifers fed DRC diets compared with steaks from their counterparts without DRC (P<0.05; Figure 1). Purge loss was not different among treatments (Figure 2). Replacing portions of SFC with DDGS had no effect (P>0.10) on sensory traits, lipid oxidation, or retail color display attributes (Table 2). However, addition of DRC to the diet did alter some sensory attributes; it decreased beef flavor and mealy texture and increased metallic flavor and chewiness (P<0.10). Vitamin E concentrations were lower for lean beef from cattle fed DDGS than for beef from cattle fed diets without DDGS (P<0.05; Figure 3).

Implications

Replacing a portion of SFC with DDGS would be expected to result in beef with similar sensory traits but lower vitamin E compared with beef from animals fed traditional flaked-corn diets, whereas adding DRC could cause some subtle negative effects on meat palatability.

Table 1. Composition of finishing diets containing steam-flaked corn (SFC) with or without dried corn distillers grains with solubles (DDGS) and/or dry-rolled corn (DRC)

	SFC		SFC + 25% DRC	
Ingredient, %	0% DDGS	25% DDGS	0% DDGS	25% DDGS
SFC	82.1	58.2	56.8	33.1
DDGS	–	25.4	–	25.3
DRC	–	–	25.5	25.3
Alfalfa hay	5.9	5.9	5.9	5.8
Corn steep liquor	6.5	6.4	6.4	6.4
Supplement[1,2]	2.8	2.5	2.7	2.5
Limestone	1.5	1.6	1.5	1.6
Urea	1.2	–	1.2	–
Nutrients, %				
Crude protein	14.7	16.3	14.8	16.4
Calcium	0.6	0.6	0.6	0.6
Phosphorus	0.3	0.5	0.2	0.4
Potassium	0.4	0.3	0.2	0.3
Ether extract	0.0	2.7	0.0	2.7
Neutral detergent fiber	3.3	10.8	3.3	10.7

[1] Formulated to meet or exceed nutritional requirements and provide 300 mg monensin, 90 mg tylosin, and 0.5 mg melengestrol acetate per animal daily.
[2] Optaflexx was included at 200 mg/animal for the final 42 days on feed.

Table 2. Sensory attributes of longissimus steaks from cattle fed steam-flaked corn (SFC) diets containing 0 or 25% dry-rolled corn (DRC) and 0 or 25% dried corn distillers grains with solubles (DDGS)

	SFC		SFC + 25% DRC			P-values		
Item[1]	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	DRC	DDGS	DRC*DDGS
Initial tenderness	10.3	10.0	9.8	10.2	0.20	0.56	0.98	0.14
Juiciness	4.7	4.7	4.6	4.9	0.20	0.62	0.39	0.52
Chewiness	9.1	9.2	9.4	9.3	0.08	0.07	0.97	0.15
Mealy texture	2.0	2.0	1.9	1.7	0.13	0.09	0.66	0.41
Fiber awareness	8.8	8.8	8.9	8.9	0.10	0.32	0.86	0.59
Residual connective tissue	2.4	2.5	2.6	2.5	0.12	0.37	0.98	0.31
Beef flavor	11.4	11.1	10.9	11.1	0.11	0.09	0.59	0.02
Bloody/serumy	3.9	3.8	3.8	3.9	0.13	0.94	0.96	0.29
Metallic flavor	1.6	1.7	1.9	1.8	0.11	0.08	0.91	0.49
Rancid flavor	0.1	0.1	0.1	0.2	0.05	0.20	0.43	0.48

[1] Sensory attributes were analyzed on a 15-point scale.

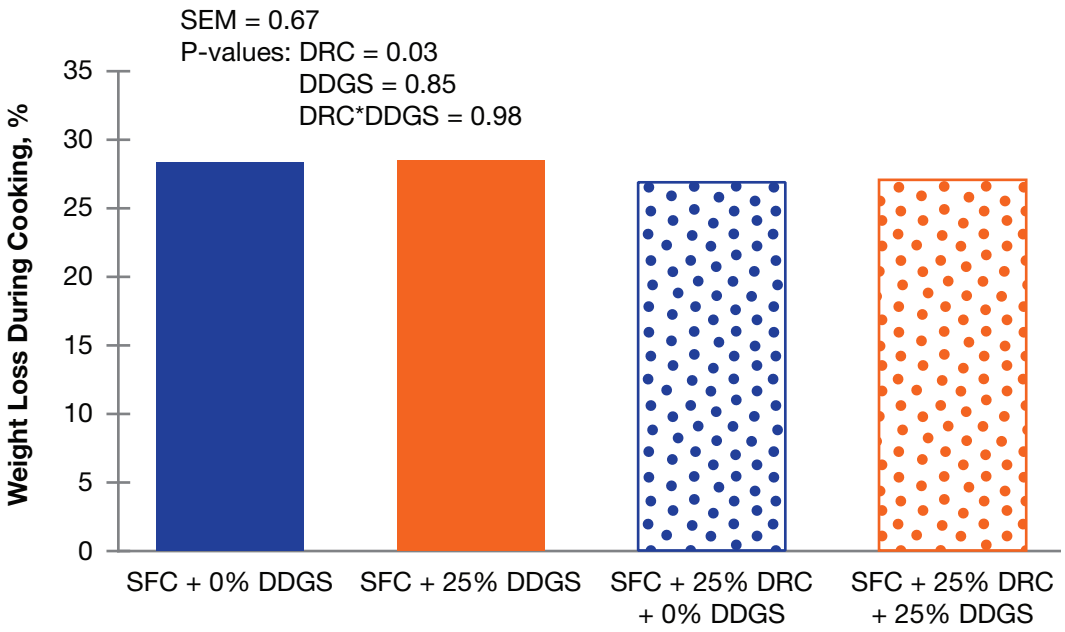


Figure 1. Cooking loss of steaks derived from cattle fed steam-flaked corn (SFC) diets with 0 or 25% dry-rolled corn (DRC) and 0 or 25% dried distillers grains with solubles (DDGS).

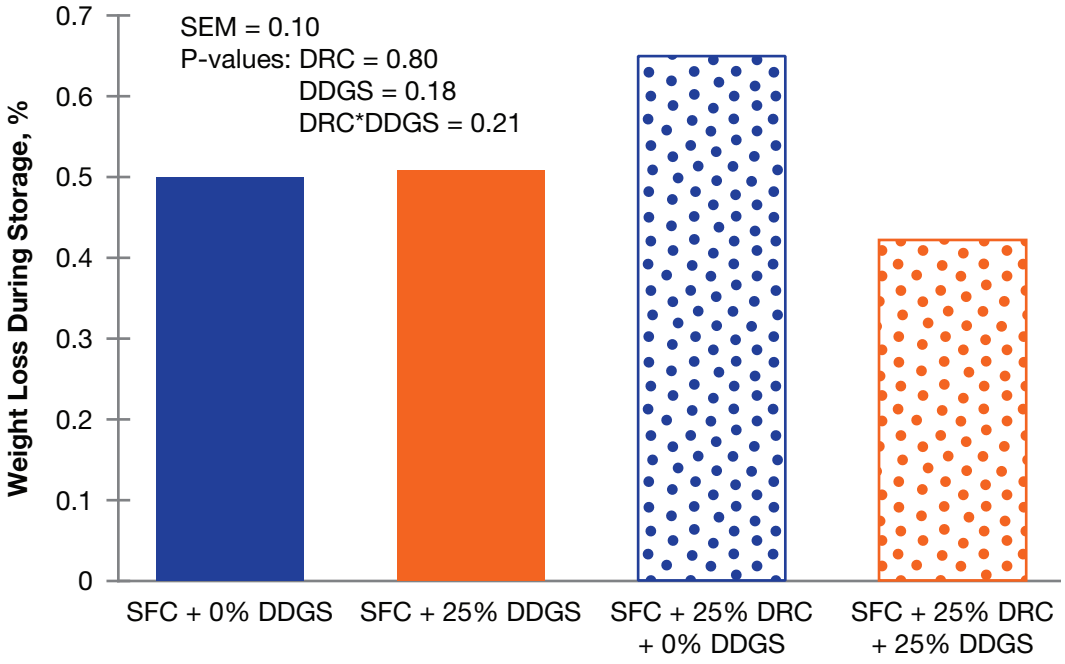


Figure 2. Purge loss of steaks derived from cattle fed steam-flaked corn (SFC) diets with 0 or 25% dry-rolled corn (DRC) and 0 or 25% dried distillers grains with solubles (DDGS).

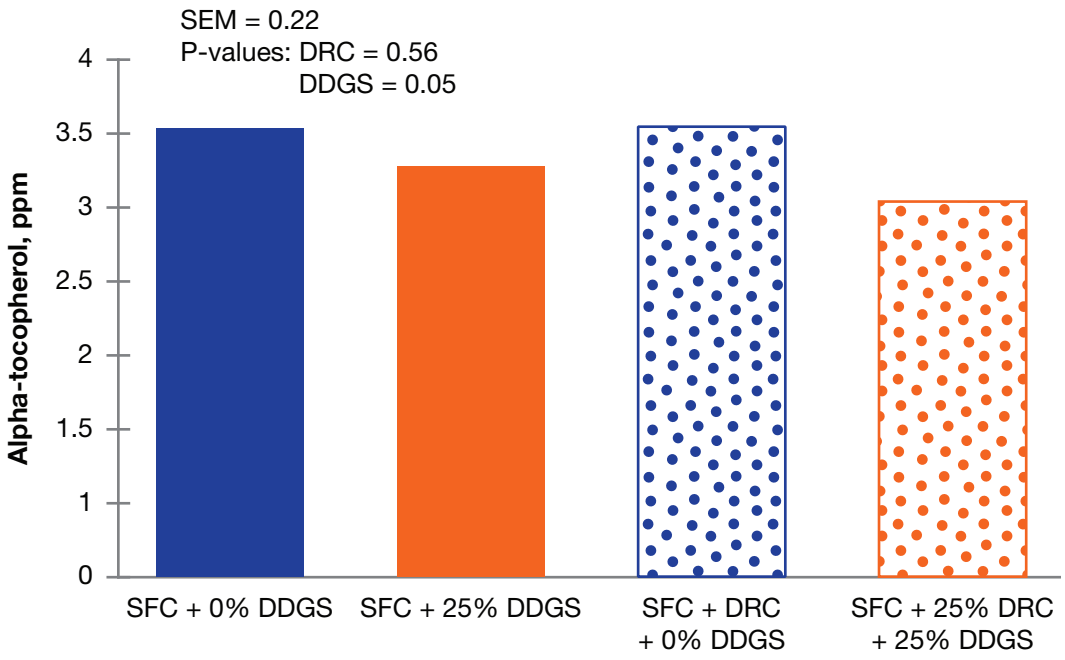


Figure 3. Vitamin E (tocopherol) concentrations of steaks derived from cattle fed steam-flaked corn (SFC) diets with 0 or 25% dry-rolled corn (DRC) and 0 or 25% dried distillers grains with solubles (DDGS).

Distillers Grains Do Not Change Carcass Composition but Change Some Fatty Acids When Added to Finishing Diet[1]

P. L. Black, G. L. Parsons, M. K. Shelor, M. E. Dikeman, J. S. Smith, K. K. Karges[2], M. L. Gibson[2], and J. S. Drouillard

Introduction

Distillers grains are a by-product of ethanol production and have become increasingly available in recent years. Some research has revealed negative effects of distillers grains on quality and yield grades. Distillers grains contain substantial amounts of unsaturated fats and therefore could alter the ratios of saturated and unsaturated fats to achieve a more desirable composition in beef. Heterocyclic amines are the carcinogenic compounds released during high-temperature grilling of meat and would be increased if fat composition is changed. Our objectives were to evaluate effects of feeding distillers grains on carcass fatness, fatty acid profiles, and formation of heterocyclic amines.

Experimental Procedures

Crossbred yearling heifers (n = 689) were used in a finishing trial to evaluate the effects of feeding dry-rolled corn (DRC) and dried corn distillers grains with solubles (DDGS) in steam-flaked corn (SFC) diets. Diets consisted of SFC with 0 or 25% DDGS and 0 or 25% DRC (Table 1) in a 2 × 2 factorial arrangement of treatments. Heifers were blocked into light and heavy weight groups according to initial body weight and fed in 28 dirt-surfaced pens with 23 to 25 heifers per pen. Heifers in the heavy and light weight blocks were fed once daily for 137 and 157 days, respectively. Wholesale ribs were collected from one side of four randomly selected cattle in each of 24 pens after a 24-hour chill. Weights of the 9th-10th-11th rib section were taken; then the rib was separated into lean, fat, and bone portions. After the portions were weighed, they were ground twice and frozen with liquid nitrogen. The lean and fat portions were then used to evaluate fatty acid profiles in the triglyceride and phospholipid fractions. Ribeyes collected from the 6th-7th-8th rib section were analyzed for heterocyclic amine concentrations after high-temperature grilling of steaks.

Results and Discussion

We evaluated the actual separated components of the rib section as well as the carcass percentages of various components that were predicted using the regression equations. Overall, carcass fat was approximately 28.5% when averaged across treatments. There were no differences among treatments with respect to percentage of carcass lean, fat, and bone ($P>0.10$; Table 2). We view this as being positive because it indicates that DDGS

[1] This project was funded in part by beef and veal producers and importers through their $1-per-head checkoff and was produced for the Cattlemen's Beef Board and state beef councils by the National Cattlemen's Beef Association.
[2] Dakota Gold Research Association, Sioux Falls, SD

and DRC can substitute for steam-flaked corn with no detrimental effects on carcass composition (Table 3). Fatty acid profiles, expressed as a percentage of total fatty acid content, are shown in Tables 3 and 4. Feeding DRC resulted in small but measureable increases in C12:0 (lauric), C14:0 (myristic), and C21:0 (henicosanoic) and a compensatory decrease in C18:1n9 (oleic) from triglycerides. The magnitude of these changes was relatively modest. The increase in myristic acid (C14:0) generally is not positive because this is one of the key fatty acids associated with plaque formation in atheroschlerosis. However, the change was relatively small and was apparent only in fat extracted from the separated lean. Feeding DDGS resulted in a number of changes in the proportions of fatty acids that appeared in the triglycerides extracted from the separated fat and lean portions of the rib. Generally, the C18:1 (oleic) fatty acids decreased in response to feeding DDGS, whereas the proportions of C18:0 (stearic) and C18:2 increased, including the trans-10, cis-12 isomer of conjugated linoleic acid. The proportion of C16:0 (palmitic) in fat extracted from the separated lean fraction also was significantly decreased, which generally is positive. Overall, changes in fatty acid profiles of steaks derived from cattle fed the different diets were, as expected, quite modest. We found no differences in the amount of heterocyclic amines in cooked steaks with addition of DRC or DDGS. This suggests that the industry can feed DDGS or DRC without increasing the amount of carcinogenic compounds that are formed when cooking beef at high temperatures.

Implications

Replacing a portion of steam-flaked corn with either DRC or DDGS resulted in similar carcass composition but some small unfavorable changes in fatty acid profile.

Table 1. Composition of finishing diets containing steam-flaked corn (SFC) with or without dried corn distillers grains with solubles (DDGS) and/or dry-rolled corn (DRC)

	SFC		SFC + 25% DRC	
Ingredient, %	0% DDGS	25% DDGS	0% DDGS	25% DDGS
SFC	82.1	58.2	56.8	33.1
DDGS	–	25.4	–	25.3
DRC	–	–	25.5	25.3
Alfalfa hay	5.9	5.9	5.9	5.8
Corn steep liquor	6.5	6.4	6.4	6.4
Supplement[1,2]	2.8	2.5	2.7	2.5
Limestone	1.5	1.6	1.5	1.6
Urea	1.2	–	1.2	–

[1] Formulated to meet or exceed nutritional requirements and provide 300 mg monensin, 90 mg tylosin, and 0.5 mg melengestrol acetate per animal daily.
[2] Optaflexx was included at 200 mg/animal for the final 42 days on feed.

Table 2. 9th-10th-11th rib separation values, actual and calculated, from cattle fed steam-flaked corn (SFC) diets containing 0 or 25% dry-rolled corn (DRC) and/or 0 or 25% dried distillers grains with solubles (DDGS)

	SFC		SFC + 25% DRC			P-values		
Item	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	DRC	DDGS	DRC*DDGS
Bone, % of dressed carcass	15.3	16.2	15.5	15.5	0.31	0.44	0.11	0.10
Lean, % of dressed carcass	56.1	54.0	55.4	55.6	0.84	0.56	0.23	0.18
Fat, % of dressed carcass	28.4	28.7	28.5	28.4	1.06	0.96	0.92	0.82
Lean , % of edible portion[1]	62.6	61.1	62.0	62.2	1.40	0.85	0.64	0.56
Fat, % of edible portion[1]	37.4	38.9	38.0	37.8	1.40	0.85	0.64	0.56

[1] Edible portion is the sum of lean and adipose tissues.

Table 3. Fatty acid profile of phospholipids extracted from the separated lean portion of the 9th-10th-11th rib section, reported as percentage of total fatty acids from phospholipids in sample

	SFC[1]		SFC + 25% DRC[1]			P-values		
Fatty acid[2]	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	DRC	DDGS	DRC*DDGS
Total phospholipids in sample	0.074	0.075	0.073	0.072	0.004	0.58	0.95	0.71
C14:0	0.27	0.36	0.35	0.35	0.04	0.38	0.29	0.32
C16:0	9.81	10.07	9.57	10.56	0.44	0.76	0.15	0.40
C18:0	12.60	13.17	13.03	13.21	0.24	0.31	0.11	0.40
C18:1n9c	12.59	10.35	12.52	10.63	0.63	0.86	0.01	0.78
C18:2n6c	21.37	23.71	20.75	24.06	0.78	0.86	0.01	0.53
C18:3n3	0.48	0.37	0.49	0.40	0.04	0.54	0.01	0.83
C20:3n6	3.46	3.17	3.40	3.24	0.10	0.93	0.02	0.52
C20:4n6	16.02	15.35	16.58	16.06	0.67	0.33	0.36	0.90
C20:5n3	1.48	1.41	1.63	1.27	0.12	0.97	0.09	0.23
C22:5n3	4.46	3.93	4.44	3.76	0.24	0.69	0.01	0.75
C22:6n3	0.58	0.57	0.68	0.50	0.05	0.82	0.06	0.09

1 SFC = Steam-flaked corn; DRC = dry-rolled corn; DDGS = Dried corn distillers grains with solubles.
2 Fatty acids are represented as number of carbon atoms:number of carbon double bonds. The "n" in fatty acid notation followed by a number denotes the location of the first C=C double bond, counting from the methyl end of the chain. The notations "c" and "t" characterize the double bond as cis or trans isomeric forms.

Table 4. Fatty acid concentrations of triglycerides extracted from separated lean portion of the 9th-10th-11th rib section, reported as percentage of total fatty acids from triglyceride in sample

	SFC[1]		SFC + 25% DRC[1]			P-values		
Fatty acid[2]	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	DRC	DDGS	DRC*DDGS
Total triglycerides in sample	8.33	8.02	7.95	8.07	0.60	0.79	0.88	0.72
C14:0	3.66	3.64	3.92	4.00	0.10	0.01	0.76	0.60
C16:0	3.78	3.38	3.75	3.59	0.10	0.38	0.01	0.23
C18:0	15.53	16.72	15.79	16.33	0.36	0.85	0.01	0.34
C18:1n9c	39.20	38.23	38.26	37.37	0.46	0.04	0.04	0.93
C18:2n6c	2.58	3.37	2.69	3.42	0.18	0.64	<0.0001	0.88
C18:3n3	0.19	0.21	0.20	0.22	0.007	0.21	0.01	0.77
C20:3n6	0.054	0.061	0.056	0.061	0.0041	0.82	0.14	0.71
C20:4n6	0.034	0.040	0.033	0.043	0.0049	0.85	0.09	0.65
C20:5n3	0.0009	0.0043	0.0005	0.0023	0.00204	0.54	0.19	0.69
C22:5n3	0.0217	0.0228	0.0246	0.0241	0.0019	0.24	0.84	0.66
C22:6n3	0.00003	0.00159	0	0.00088	0.00065	0.55	0.05	0.58

1 SFC = Steam-flaked corn; DRC = dry-rolled corn; DDGS = Dried corn distillers grains with solubles.

2 Fatty acids are represented as number of carbon atoms:number of carbon double bonds. The "n" in fatty acid notation followed by a number denotes the location of the first C=C double bond, counting from the methyl end of the chain. The notations "c" and "t" characterize the double bond as cis or trans isomeric forms.

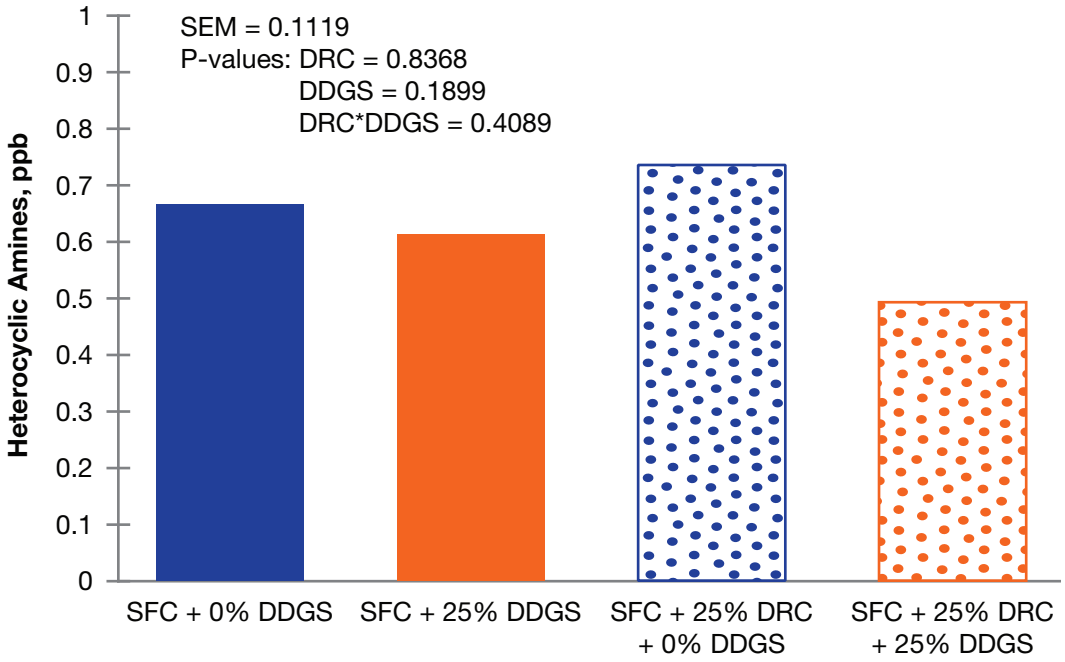


Figure 1. Concentrations of heterocyclic amines in steaks derived from cattle fed steam-flaked corn (SFC) diets containing 0 or 25% dry-rolled corn (DRC) and/or 0 or 25% dried distillers grains with solubles (DDGS).

Feeding Steam-Flaked Diets With and Without Dry-Rolled Corn and Dried Distillers Grains Results in Similar Feedlot Performance[1]

P. L. Black, G. L. Parsons, M. K. Shelor, K. K. Karges[2], M. L. Gibson[2], C. D. Reinhardt, and J. S. Drouillard

Introduction

Increased ethanol production in the United States has increased availability of by-products, giving producers an alternative to cereal grains. The by-product we evaluated was dried corn distillers grains with solubles. Research has been conducted at Kansas State University to evaluate the quantity of distillers grains that can be added to a finishing diet without negatively affecting feedlot performance or carcass value. Feeding cattle distillers grains is an important option for feedlots to consider. The second issue that has arisen is the energy costs associated with processing grains. In Kansas, two of the more common methods for processing grains are steam flaking and dry rolling. Previous research has shown that the nutritive value of distillers grains can be influenced by grain processing method. This experiment was designed to evaluate feedlot performance and carcass merit in heifers fed flaked-corn diets with added dry-rolled corn and/or dried corn distillers grains.

Experimental Procedures

Crossbred yearling heifers (n = 689) were used in a finishing trial to evaluate the effects of feeding dry-rolled corn (DRC) and dried corn distillers grains with solubles (DDGS) in steam-flaked corn (SFC) diets. Diets consisted of SFC with 0 or 25% DDGS and 0 or 25% DRC in a 2 × 2 factorial arrangement. Heifers were blocked into light and heavy weight groups according to initial body weight and fed in 28 dirt-surfaced pens with 23 to 25 heifers per pen. Heifers in the heavy and light weight blocks were fed once daily for 137 or 157 days, respectively. Weights were determined at the beginning of the study and directly before shipment to a commercial abattoir in Emporia, KS. At slaughter, incidence and severity of liver abscesses and hot carcass weights were recorded. After a 24-hour chill, kidney, pelvic, and heart fat; ribeye area; 12th rib fat thickness; incidence of dark cutting beef; marbling scores; USDA quality grades, and USDA yield grades were recorded.

Results and Discussion

Cattle fed the different diets had similar average daily gains, feed intakes, and feed conversion efficiencies. Similar results were also found for quality and yield grades; 12th rib fat thickness; kidney, pelvic, and heart fat; incidence and severity of liver abscess,

[1] This project was funded in part by beef and veal producers and importers through their $1-per-head checkoff and was produced for the Cattlemen's Beef Board and state beef councils by the National Cattlemen's Beef Association.
[1] Dakota Gold Research Association, Sioux Falls, SD

marbling score, and total carcass value. Cattle fed DRC had higher dressing percentages compared with their counterparts fed no DRC ($P<0.05$). Cattle fed DRC also tended to have larger ribeye areas than cattle fed no DRC ($P<0.10$).

Implications

Feeding flaked-corn diets with DDGS or DRC yielded similar feedlot performance and carcass value.

Table 1. Composition of finishing diets containing steam-flaked corn (SFC) with 0 or 25% dried corn distillers grains with solubles (DDGS) and/or 0 or 25% dry-rolled corn (DRC)

	SFC		SFC + 25% DRC	
Ingredient, %	0% DDGS	25% DDGS	0% DDGS	25% DDGS
SFC	82.1	58.2	56.8	33.1
DDGS	–	25.4	–	25.3
DRC	–	–	25.5	25.3
Alfalfa hay	5.9	5.9	5.9	5.8
Corn steep liquor	6.5	6.4	6.4	6.4
Supplement[1,2]	2.8	2.5	2.7	2.5
Limestone	1.5	1.6	1.5	1.6
Urea	1.2	–	1.2	–
Nutrients, %				
Crude protein	14.7	16.3	14.8	16.4
Calcium	0.6	0.6	0.6	0.6
Phosphorus	0.3	0.5	0.2	0.4
Potassium	0.4	0.3	0.2	0.3
Ether extract	0.0	2.7	0.0	2.7
Neutral detergent fiber	3.3	10.8	3.3	10.7

[1] Formulated to meet or exceed nutritional requirements and provide 300 mg monensin, 90 mg tylosin, and 0.5 mg melengestrol acetate per animal daily.
[2] Optaflexx was included at 200 mg/animal for the final 42 days on feed.

Table 2. Performance characteristics of heifers fed steam-flaked corn (SFC) diets containing 0 or 25% dry-rolled corn (DRC) and/or 0 or 25% dried distillers grains with solubles (DDGS)

	SFC		SFC + 25% DRC			P-values		
Item	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	DRC	DDGS	DRC*DDGS
Head count	172	172	172	173	–	–	–	–
Initial body weight, lb	675	676	676	676	14.5	0.97	0.98	0.98
Final body weight, lb[1]	1138	1132	1146	1146	15.1	0.12	0.65	0.66
Average daily gain, lb[1]	3.16	3.12	3.21	3.21	0.05	0.15	0.65	0.67
Dry matter intake, lb/day[1]	18.53	18.85	19.08	19.23	0.38	0.23	0.55	0.83
Feed:gain[2]	5.85	6.02	5.95	5.99	0.71	0.91	0.43	0.58

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.

Table 3. Carcass characteristics of heifers fed steam-flaked corn (SFC) diets containing 0 or 25% dry-rolled corn (DRC) and/or 0 or 25% dried distillers grains with solubles (DDGS)

	SFC		SFC + 25% DRC			P-values		
Item	0% DDGS	25% DDGS	0% DDGS	25% DDGS	SEM	DRC	DDGS	DRC*DDGS
Hot carcass weight, lb	723	719	727	728	4.2	0.48	0.85	0.84
Dressed yield, %	62.92	63.64	63.75	64.61	0.4	0.04	0.07	0.87
USDA quality grade								
Prime, %	0.6	0.6	1.2	0.1	0.6	1.00	0.32	0.32
Upper 2/3 Choice or greater, %	43.8	42.0	49.0	39.5	3.8	0.66	0.16	0.27
Choice, %	32.3	31.1	39.8	32.1	3.6	0.24	0.22	0.36
Select, %	49.8	52.7	46.9	55.9	3.8	0.98	0.12	0.43
Standard, %	7.1	1.2	1.2	2.4	2.1	0.25	0.25	0.09
Dark cutter, %	1.9	0.5	0.5	0.0	0.7	0.16	0.16	0.58
USDA yield grade								
Average	2.69	2.78	2.76	2.67	0.10	0.79	0.98	0.18
Yield grade 1, %	11.6	7.0	8.1	13.9	2.3	0.46	0.81	0.02
Yield grade 2, %	26.3	29.3	30.4	26.7	3.5	0.82	0.92	0.34
Yield grade 3, %	45.7	45.1	41.6	41.4	3.8	0.31	0.91	0.97
Yield grade 4, %	14.5	16.2	16.8	15.0	2.7	0.83	0.98	0.52
Yield grade 5, %	1.9	2.5	3.1	3.0	1.2	0.46	0.81	0.81
Kidney, pelvic, and heart fat, %	2.31	2.30	2.29	2.28	0.02	0.46	0.60	0.97
12th rib thickness, in.	0.51	0.53	0.50	0.50	0.02	0.27	0.44	0.45
Marbling score[1]	492	493	499	485	5.83	0.97	0.27	0.22
Liver abscess incidence, %	2.85	2.85	4.01	2.83	1.35	0.67	0.66	0.66
Ribeye area, in.[2]	12.72	12.65	12.92	12.88	0.13	0.09	0.67	0.92
Total carcass value, $	935	932	948	935	9.0	0.33	0.36	0.60

[1] 500 = Small 000.

Feed Depredation by European Starlings

B. E. Depenbusch, J. S. Drouillard, C. D. Lee, G. L. Parsons, and M. K. Shelor

Introduction

European starlings (*Sturnus vulgaris*) were first introduced to the United States in the late 1800s. It is believed that the starlings were imported from Europe and released in New York City's Central Park so that all of the birds mentioned in Shakespeare's works would inhabit the new country. For the next 50 years, the starling population grew exponentially; by 1942, starlings had spread to the West Coast. Starlings are not considered migratory and remain in the same general area year round; however, some may migrate several hundred miles. During much of the year, the inconspicuous starlings disperse into small flocks and feed on seeds, fruits, and insects. During winter months, starlings form flocks of several hundred up to 750,000 birds that share feeding and roosting sites. These large flocks prefer to roost in coniferous trees, which provide protection from wind and adverse weather conditions. Previous research has documented that a 3-oz starling consumes nearly 2 lb of feed in a 30-day period. Commercial feedlots have been infested with large populations of starlings during winter months. The attraction to feedlots is due to open feed bunks that provide a convenient source of feed. Currently, there are limited means for controlling starlings in feedlots. The objective of our experiment was to compare susceptibility of different rations to depredation by starlings.

Experimental Procedures

Finishing diets used in this study were formulated with commonly used feed ingredients (Table 1). Four different mixtures of meal-type rations were compared with an extruded ration (Table 2). The first diet was a dry-rolled corn diet with 6% alfalfa hay. The next two diets were based on steam-flaked corn; one contained 6% alfalfa hay, and the other contained 12% corn silage. The remaining meal-type diet was based on steam-flaked corn and 6% alfalfa hay but also contained 25% (dry-matter basis) dried corn distillers grains with solubles. The extruded diet was the exact same mixture as the steam-flaked corn and 6% alfalfa hay diet. Dry-rolled corn was processed to a mean geometric particle size of 4.1 mm (n = 23) by using a single stack roller mill, and steam-flaked corn was processed to a flake density of 28 lb/bu with a mean geometric particle size of 5.7 mm (n = 159). The pelleted diet was processed through a corotating, fully intermeshing, twin-screw extruder (Model BCTG-62, Bühler AG, Uzwil, Switzerland). All ingredients, including the corn and alfalfa hay, were processed by using the extruder and forced through a die to form pieces that were 0.75-in. in diameter and approximately 2 to 3 in. long.

Thirty individual feeding sites were constructed by partitioning concrete fence-line feed bunks into 30-in. sections. Each feeding site (i.e., 30 different feeding sites; 6 feeding sites/ration) received 30 lb of a ration prior to arrival of starlings. A wire mesh panel was secured on the pen side of the feed bunk to prevent disturbance of feed by cattle. Feeding sites were accessible to starlings for the entire day. After starlings left the feedlot and

returned to their evening roost, unconsumed feed was weighed and sampled. Samples of fresh and unconsumed feed were analyzed for crude protein, crude fat, starch, and crude fiber.

Results and Discussion

Table 3 shows amount of feed delivered, unconsumed feed recovered, and percentage of feed consumed by starlings over a 9-hour period. The steam-flaked corn/alfalfa hay ration was most subject to depredation by starlings (86%; P=0.01), whereas 79% of the steam-flaked corn/dried distillers grain ration and 76% of the steam-flaked corn/corn silage ration were consumed by starlings during the same period of time. The dry-rolled corn/alfalfa hay ration was less affected (66%, P=0.01) by starlings. Starlings did not consume any of the extruded ration. Figure 1 is a representative photograph of the feeding sites before and during a feeding episode. No starlings were perched in the third feeding site containing the extruded ration; however, the other feeding sites contained large numbers of starlings. Distribution and density of starlings remained fairly constant throughout the day.

Nutrient analyses of fresh and unconsumed feeds are summarized in Table 4. Concentrations of starch were lower ($P \leq 0.02$) in residual samples of all meal-type rations, suggesting that starlings preferentially eat grain. Protein and fiber both were higher in residual samples of the steam-flaked corn/alfalfa hay diet, suggesting that ingredients contributing to these nutrients (Table 1) were not consumed by the starlings. Concentrations of crude protein were greater ($P \leq 0.04$) in residual samples of the steam-flaked corn/alfalfa hay ration and the steam-flaked corn/dried distillers grain ration. Crude fat levels were higher (P=0.001) in residual samples of the steam-flaked corn/dried distillers grain ration, suggesting that birds eat grain rather than distillers grains. Crude fiber was greater ($P \leq 0.06$) in all of the residual samples collected from the meal-type rations compared with original concentrations. Crude protein, crude fat, starch, and crude fiber were similar ($P \geq 0.57$) for fresh and residual samples of the pelleted ration.

Figure 3 illustrates daily feed deliveries of the meal-type and extruded rations over a 142-day period. For the first 79 days, feed deliveries mirrored each other, with cattle fed meal-type ration consuming 25.4 lb/day of feed. However, on January 8, 2007, feed deliveries started to diverge. From January 8, 2007, to February 23, 2007, feed delivery of meal-type ration linearly increased by 33% from 25.4 to 37.9 lb/day of feed, whereas feed deliveries of the extruded pellet remained fairly stable. This divergence corresponds closely to the arrival (early January) and dispersal (early March) of wintering starlings. Interestingly, delivery of the meal-type ration linearly decreased from February 23, 2007, to pre-starling levels on March 11, 2007, after the wintering flock dispersed.

Implications

Feed depredation by starlings not only results in an economic loss for commercial feedlots but may also negatively affect animal performance because of alteration of the nutrient composition of the ration. Extruding feedlot rations may be a possible means of preventing bird predation.

Table 1. Nutrient content of individual feed ingredients (%, dry-matter basis)

Ingredient	Crude protein	Crude fat	Crude fiber
Steam-flaked corn	9.7	4.3[1]	9.0[1]
Dry-rolled corn	10.1	4.3[1]	9.0[1]
Alfalfa hay	14.5	2.4[1]	59.4
Corn silage	8.8	2.6[1]	49.7
Dried corn distillers grains	29.6	10.0	31.8
Corn steep liquor	32.0	–	–
Urea	291.0[1]	–	–
Soybean meal, dehulled	54.0[1]	1.6[1]	7.8[1]
Supplement	–	–	–

[1] Nutrient content based on 1996 Nutrient Requirements of Beef Cattle (National Research Council).

Table 2. Composition of total mixed rations (%, dry-matter basis)

Ingredient	DRC[1] with alfalfa hay	SFC[2] with alfalfa hay	SFC with corn silage	SFC with dried distillers grains	Extruded[3]
Steam-flaked corn		81.7	77.8	65.7	–
Dry-rolled corn	84.7	–	–	–	81.7
Alfalfa hay	6.0	6.0	–	6.0	6.0
Corn silage	–	–	12.0	–	–
Corn dried distillers grains	–	–	–	25.0	–
Corn steep liquor	6.0	6.6	–	–	6.6
Urea	0.4	1.2	1.1	0.4	1.2
Soybean meal	–	–	4.6	–	–
Supplement	2.9	4.5	4.5	2.9	4.5

1 DRC = Dry-rolled corn.
2 SFC = Steam-flaked corn.
3 Composition identical to the SFC diet. Ingredients were agglomerated together to form a pellet via extrusion processing.

Table 3. Feed delivered, residual feed recovered, and percentage of feed consumed by European starlings during a 9-hour exposure period (i.e., 7:30 a.m. to 4:30 p.m.)

Item	DRC[1] with alfalfa hay	SFC[2] with alfalfa hay	SFC with corn silage	SFC with distillers grains	Extruded[3]	SEM[4]	P-value
Feed delivered, lb	30.0	30.0	30.0	30.0	30.0	–	–
Residual feed, lb	10.4[a]	4.2[b]	7.3[c]	6.4[c]	30.0[d]	1.3	0.01
Feed disappearance, %	65.5[a]	86.0[b]	76.2[c]	78.7[c]	0[d]	4.3	0.01

1 DRC = Dry-rolled corn.
2 SFC = Steam-flaked corn.
3 Composition identical to the SFC diet. Ingredients were agglomerated together to form a pellet via extrusion processing.
4 SEM = Standard error of the mean.
[abcd] Within a row, means without a common superscript letter differ ($P<0.05$).

Table 4. Nutrient contents (%, dry-matter basis) of total mixed rations before (fresh) and after (residual) a 9-hour exposure (7:30 a.m. to 4:30 p.m.) to European starlings

Treatment	Crude protein	Crude fat	Starch	Crude fiber
Dry-rolled corn with alfalfa hay				
Fresh (n = 2)	12.9 ± 2.3[1]	4.4 ± 1.0	69.6 ± 12.7	15.1 ± 8.1
Residual (n = 7)	15.9 ± 2.4	3.6 ± 1.1	43.5 ± 12.7	27.3 ± 7.9
P-value (Fresh vs. Residual)	0.10	0.32	0.02	0.06
Steam-flaked corn with alfalfa hay				
Fresh (n = 2)	15.7 ± 2.3	3.7 ± 1.0	69.3 ± 12.7	14.7 ± 8.1
Residual (n = 7)	19.5 ± 2.4	3.4 ± 1.1	29.6 ± 12.7	37.0 ± 7.9
P-value (Fresh vs. Residual)	0.04	0.66	0.001	0.001
Steam-flaked corn with corn silage				
Fresh (n = 2)	13.9 ± 2.3	5.1 ± 1.0	67.2 ± 12.7	18.9 ± 8.1
Residual (n = 7)	16.0 ± 2.4	4.4 ± 1.1	28.3 ± 12.7	41.3 ± 7.9
P-value (Fresh vs. Residual)	0.24	0.43	0.001	0.001
Steam-flaked corn with dried distillers grains				
Fresh (n = 2)	16.0 ± 2.3	5.3 ± 1.0	61.0 ± 12.7	21.8 ± 8.1
Residual (n = 7)	21.9 ± 2.4	7.3 ± 1.1	21.8 ± 12.7	36.4 ± 7.9
P-value (Fresh vs. Residual)	0.001	0.01	0.001	0.03
Extruded pellets[2]				
Fresh (n = 2)	15.2 ± 2.3	2.2 ± 1.0	72.6 ± 12.7	14.0 ± 8.1
Residual (n = 7)	15.0 ± 2.4	2.5 ± 1.1	66.7 ± 12.7	13.0 ± 7.9
P-value (Fresh vs. Residual)	0.90	0.78	0.57	0.87

[1] Standard deviation.
[2] Composition identical to the SFC diet. Ingredients were agglomerated together to form a pellet via extrusion processing.

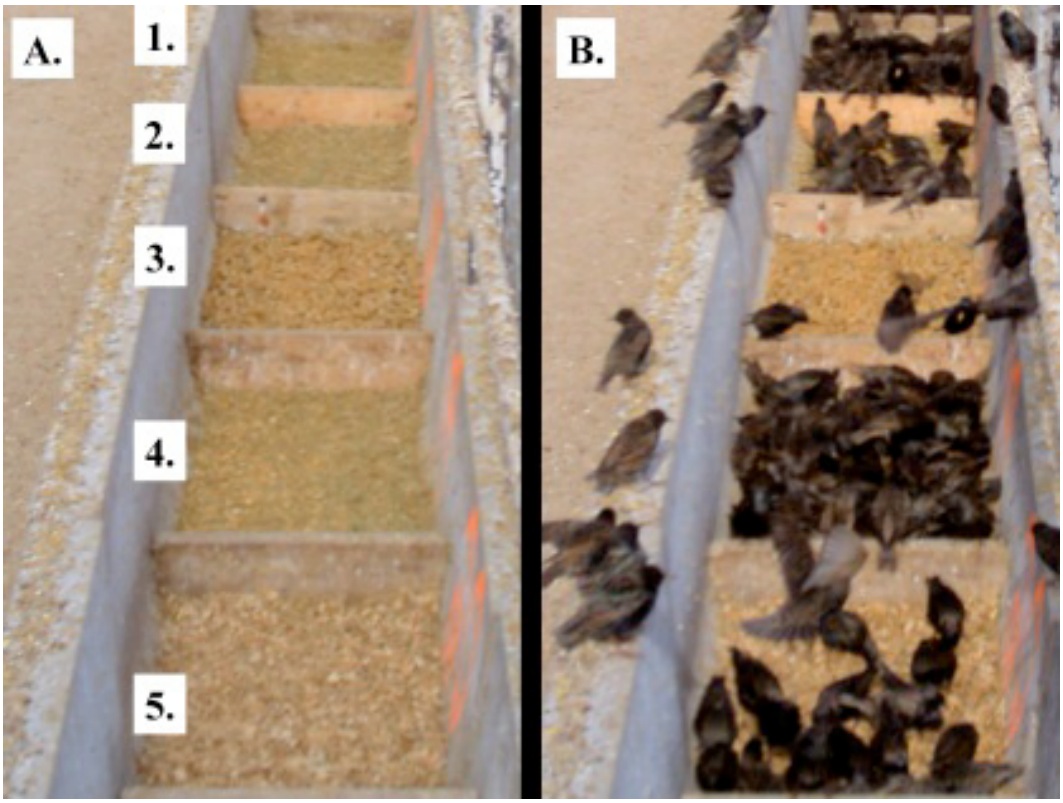


Figure 1. (A) feeding sites before arrival of European starlings and (B) preference exhibited by European starlings at the identical feeding locations.

1. Steam-flaked corn, alfalfa hay, and dried distillers grains.
2. Steam-flaked corn and alfalfa hay.
3. Extruded pellets.
4. Dry-rolled corn and alfalfa hay.
5. Steam-flaked corn and corn silage.

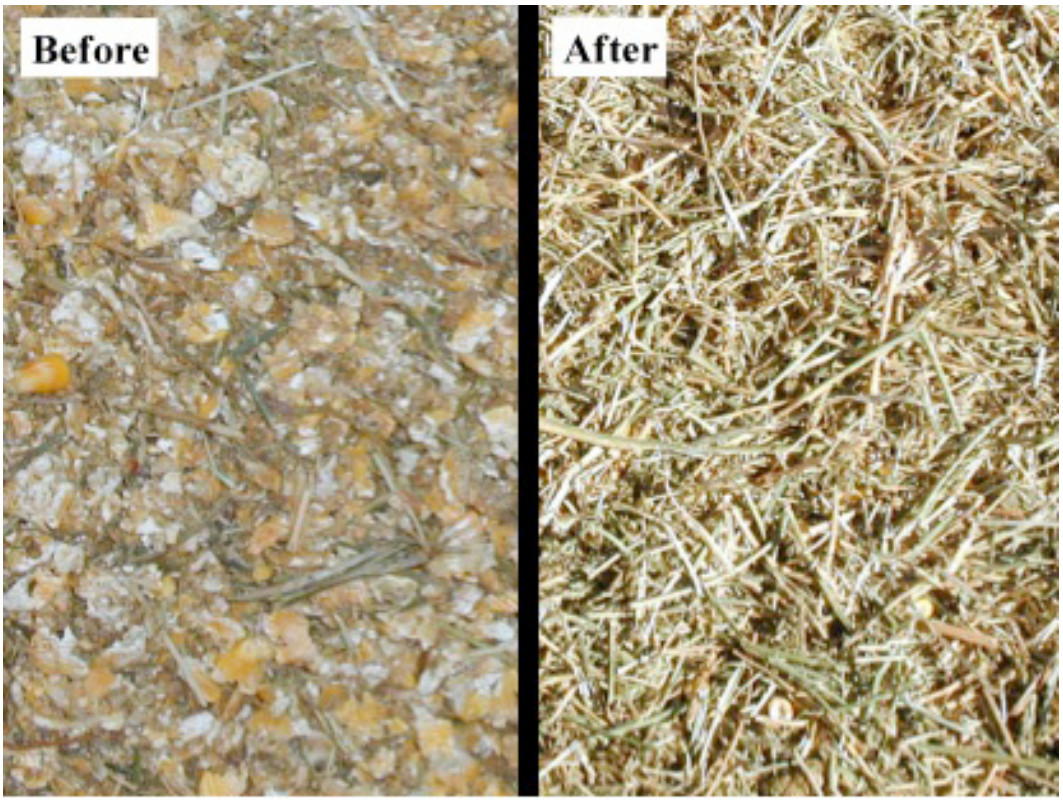


Figure 2. Steam-flaked corn and alfalfa hay diet before and after a 9-hour exposure period (i.e., 7:30 a.m. to 4:30 p.m.) to European starlings.

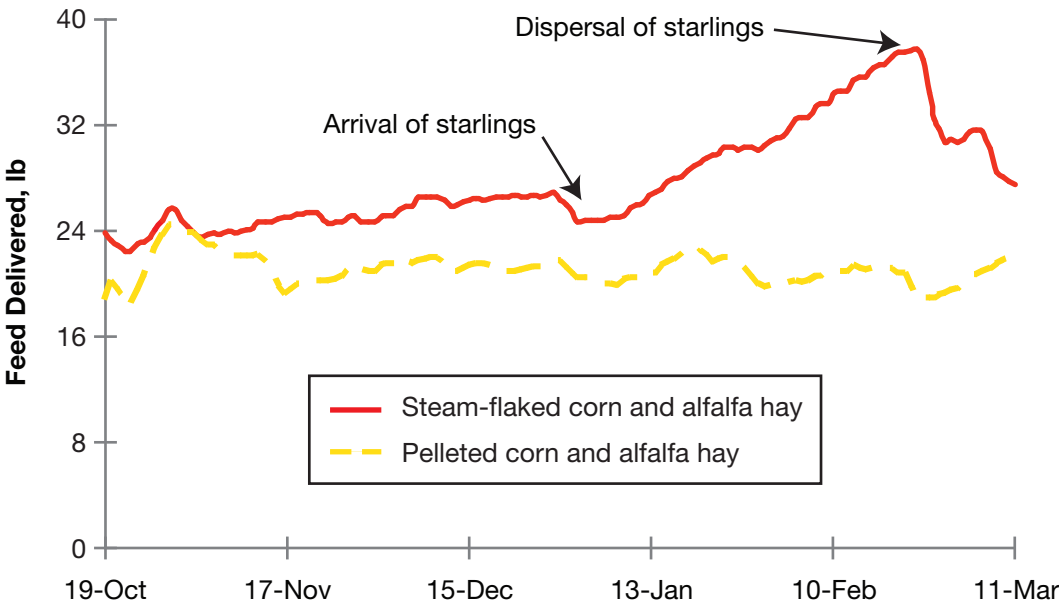


Figure 3. Differences in feed delivered to pens of cattle fed between October and March.
The sharp increase starting after January 1 is attributed to the arrival of large numbers of European starlings. The birds dispersed by March 1.

Extruded Complete Feed for Finishing Cattle

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Introduction

Steam flaking is the predominant means of processing grains in large commercial feedlots. Compared with dry rolling, steam flaking improves total tract digestibility and feed efficiency by 8 to 15%. In steam-flaked corn diets, alfalfa hay often is used as a source of roughage. A survey of industry consultants showed that the range of roughage levels used is between 4.5 and 13.5%. Roughages are commonly the highest-cost ingredient per unit of energy and are highly prone to shrink. Low roughage levels are desirable, but a modest level must be maintained to ensure rumen health. Cattle, like other species, can be selective in their eating. We proposed that we could achieve a greater level of grain processing with an extruded processed diet than with steam flaking. In addition, a complete extruded diet would ensure that all cattle received the desired ratio of concentrate and roughage.

Experimental Procedures

Seventy-two crossbred yearling heifers (796 ± 11 lb initial body weight) were obtained from a common source and used in a randomized complete block study. Treatments were arranged in a 2 × 3 factorial. Factor one was level of alfalfa hay (2 or 6%), and factor two was degree of processing (steam flaked, moderate-shear, or high-shear extrusion cooking). Shear is defined as the mechanical energy applied to the corn in the extruder. Different levels of shear can be achieved by altering pressure, friction, and retention time in the extruder. Experimental diets included either 82 or 85% corn depending on the level of alfalfa hay used (Table 1). Differences in the physical form of the traditional flaked corn diets and extruded diets are depicted in Figure 1. Heifers were confined to individual pens and fed once daily for 143 days.

In the steam-flaked diets, whole corn was steam treated in a 30-in. × 48-in. × 10-ft. steam chest for 45 minutes and then passed through an 18 × 24-in. flaker mill and processed to a bulk density of 28 lb/bu with an average particle size of 5,961 µm. Steam-flaked corn was then mixed in the appropriate proportion with alfalfa hay, corn steep liquor, and supplement in a stationary paddle mixer. For the extruded diets, cracked corn, alfalfa hay, corn steep liquor, and supplement were added to a corotating, fully-intermeshing, twin-screw extruder (BCTG-62, Bühler AG CH-9240, Uzwil, Switzerland). The ingredients were processed by a combination of mixing, cooking, and agglomerating into a complete extruded feed. Two parameter sets were used to achieve the moderate and high degrees of extrusion cooking.

After 143 days, heifers were weighed and shipped to a commercial abattoir (Tyson Fresh Meats Inc., Emporia, KS). Carcass weights and incidence of liver abscesses were measured at the time of slaughter, and ribeye area; kidney, pelvic, and heart fat; 12th rib fat thickness, USDA yield grade, USDA quality grade, and marbling score were measured after a 24-hour chill.

Forty-eight hours after the time of slaughter, loin sections were removed from the right side of carcasses and transported to the Kansas State University Meat Lab. Vacuum-packaged loin sections were allowed to age in a walk-in cooler for 14 days. Muscle pH and purge loss (i.e., loss of water) were determined following the aging period. Loin sections were then fabricated into steaks and frozen for subsequent analyses. Cooking loss, steak tenderness, lipid oxidation, and analysis of steak color were measured over an 8-day retail display period.

Results and Discussion

Growth performance

Heifers fed either moderate- or high-shear extruded diets consumed 19% less (P=0.01) feed than heifers fed steam-flaked corn diets (Table 2). Likewise, heifers fed the low (2%) alfalfa hay diet consumed 7% less (P=0.01) feed than heifers fed the high (6%) alfalfa hay diet. Average daily gains were not different (P>0.05) among the steam-flaked, moderate-shear, and high-shear extruded diets; however, heifers fed the low (2%) alfalfa hay diet gained 12% less (P=0.02) weight than heifers fed the high (6%) alfalfa hay diet. On average, feed efficiency was 15% greater (P=0.01) for heifers fed the moderate-shear and high-shear extruded diets compared with heifers fed the steam-flaked corn diets. Feed efficiency was similar (P>0.05) between the two alfalfa hay levels.

Carcass characteristics (Tables 3 and 4)

Final body weight and carcass weight were similar (P>0.05) among the steam-flaked, moderate-shear, and high-shear extruded diets. Carcasses from heifers fed the low (2%) alfalfa hay diet were lighter (P=0.02) than carcasses from heifers fed the high (6%) alfalfa hay diet. Incidence of liver abscesses was similar (P>0.05) among the steam-flaked, moderate-shear, and high-shear extruded diets. Interestingly, heifers fed the high (6%) alfalfa hay diet had greater (P=0.01) incidence of condemned livers due to abscesses than heifers fed the low (2%) alfalfa hay diet. Other carcass characteristics including dressed yield; ribeye area; kidney, pelvic, and heart fat; 12th rib fat thickness; USDA yield grade; and USDA quality grade were similar (P>0.05) among treatments. Conversely, marbling score was greater (P=0.01) for heifers fed steam-flaked corn diets compared with the average of the moderate- and high-shear extruded diets.

Meat attributes (Table 5)

Muscle pH was similar (P>0.05) between treatments. Loin sections from heifers fed steam-flaked corn diets retained less (P=0.03) water than loin sections from heifers fed either moderate- or high-shear extruded diets; however, cooking loss, steak tenderness, and lipid oxidation were similar (P>0.05) among treatments. Redness of retail display steaks (Figure 2) decreased after the 8-day display period but was similar (P>0.05) among treatments.

Implications

Extrusion-processed feed improved feed efficiency with no deleterious effects on carcass quality or meat attributes.

Table 1. Composition of finishing diets containing either 2 or 6% ground alfalfa hay

Ingredient, % of dry matter	2% alfalfa hay	6% alfalfa hay
Corn[1]	85.0	81.7
Corn steep liquor	6.6	6.6
Alfalfa hay	2.0	6.0
Limestone	1.7	1.6
Urea	1.2	1.2
Soybean meal	0.6	–
Vitamin/mineral premix	0.7	0.7
Supplement	2.2	2.2
Chemical composition, %		
Dry matter	80.0	80.0
Crude protein	14.0	14.0
Neutral detergent fiber	9.0	10.6
Calcium	0.7	0.7
Phosphorus	0.4	0.4

[1] Corn in steam-flaked diets was processed to 28 lb/bu by using an 18 × 24-in. flaker mill. Corn in the extruded diet was processed along with other ingredients by using a twin-screw extruder.

Table 2. Animal performance of yearling heifers fed either 2 or 6% alfalfa hay in steam-flaked corn diets or in a comparable extruded form

	2% alfalfa hay			6% alfalfa hay				P-value		
Item	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	SEM	Process	Roughage	Process × Roughage
No. of heifers	12	12	12	12	11	12	–	–	–	–
Days on feed	143	143	143	143	143	143	–	–	–	–
Initial BW, lb	796	796	796	796	794	796	11.5	0.97	0.83	0.94
Final BW, lb[1]	1144	1129	1100	1166	1157	1173	25.4	0.66	0.02	0.44
DMI, lb/d	21.8	17.0	16.5	21.8	19.2	18.3	0.75	0.01	0.01	0.14
ADG, lb/d	2.43	2.31	2.12	2.58	2.54	2.65	0.13	0.64	0.02	0.41
Feed:Gain[2]	8.97	7.36	7.78	8.45	7.56	6.91	0.33	0.01	0.24	0.19

1 Final BW = Carcass weight/63.5%.
2 Analyzed as gain:feed but reported as feed:gain

Table 3. Carcass characteristics of yearling heifers fed either 2 or 6% alfalfa hay in steam-flaked corn diets or in a comparable extruded form

	2% alfalfa hay			6% alfalfa hay				P-value		
Item	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	SEM	Process	Roughage	Process × Roughage
Carcass weight, lb	725	717	699	741	734	745	16.1	0.66	0.02	0.44
Dressed yield, %	63.9	63.8	63.5	62.7	64.2	62.9	0.49	0.26	0.27	0.26
Ribeye area, in.^{2}	12.6	13.2	12.3	13.0	12.9	13.0	0.40	0.60	0.32	0.42
Kidney, pelvic, and heart fat, %	2.08	2.04	2.13	2.27	2.14	2.15	0.10	0.68	0.23	0.71
12th rib fat, in.	0.50	0.40	0.44	0.41	0.48	0.45	0.008	0.94	0.85	0.23
Total liver abscess, %	0	0	0	16.7	9.1	25.0	7.9	0.61	0.01	0.61
A+	0	0	0	16.7	0	8.3	5.8	0.37	0.08	0.37
A	0	0	0	0	9.1	0	3.4	0.33	0.29	0.33
A-	0	0	0	0	0	16.7	4.6	0.13	0.15	0.13

Table 4. Yield grade and quality grade of yearling heifers fed either 2 or 6% alfalfa hay in steam-flaked corn diets or in a comparable extruded form

	2% alfalfa hay			6% alfalfa hay				P-value		
Item	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	SEM	Process	Roughage	Process × Roughage
USDA yield grade	3.1	2.5	2.7	2.8	2.9	2.9	0.17	0.47	0.44	0.08
YG 1, %	0	0	0	0	0	0	0	–	–	–
YG 2, %	8.3	50.0	41.7	25.0	27.2	16.7	12.9	0.25	0.33	0.20
YG 3, %	75.0	50.0	50.0	75.0	63.7	75.0	14.0	0.43	0.27	0.67
YG 4, %	16.7	0	8.3	0	0	8.3	6.7	0.37	0.32	0.37
YG 5, %	0	0	0	0	9.1	0	3.4	0.33	0.29	0.33
USDA quality grade, %										
Choice or better	83.3	58.3	66.7	58.3	63.6	58.3	14.2	0.76	0.43	0.57
Select	8.3	33.3	25.0	25.0	27.3	41.2	13.0	0.40	0.40	0.61
No roll	8.3	8.3	8.3	16.7	9.0	0	7.5	0.24	0.62	0.83
Marbling score[1]	538	408	430	499	428	415	26.7	0.01	0.61	0.56

[1] 400 = small, 500 = modest.

Table 5. Meat attributes of yearling heifers fed either 2 or 6% alfalfa hay in steam-flaked corn diets or in a comparable extruded form

	2% alfalfa hay			6% alfalfa hay				P-value		
Item	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	Steam-flaked corn	Moderate-shear extrusion	High-shear extrusion	SEM	Processing	Roughage	Process × Roughage
Muscle pH	5.49	5.47	5.48	5.47	5.49	5.45	0.015	0.67	0.37	0.33
Purge loss, %	1.5	2.1	1.9	1.7	2.4	2.3	0.24	0.03	0.18	0.83
Cooking loss, %	29.6	26.9	28.9	26.4	22.9	29.8	3.74	0.48	0.48	0.77
Shear force, lb[1]	6.6	7.3	6.8	7.3	7.3	7.1	0.33	0.46	0.35	0.42
Lipid oxidation[2]	0.68	1.06	1.02	0.82	0.89	0.95	0.15	0.23	0.73	0.57

[1] Pounds of force required to shear through 0.5-in. diameter core of steak as determined by Warner-Bratzler shear force.
[2] Thiobarbituric acid reactive substance, expressed as milligrams of malonaldehyde/kg of longissimus muscle.

Figure 1. Physical form of the steam-flaked corn (left) and extruded (right) diets fed to cattle.

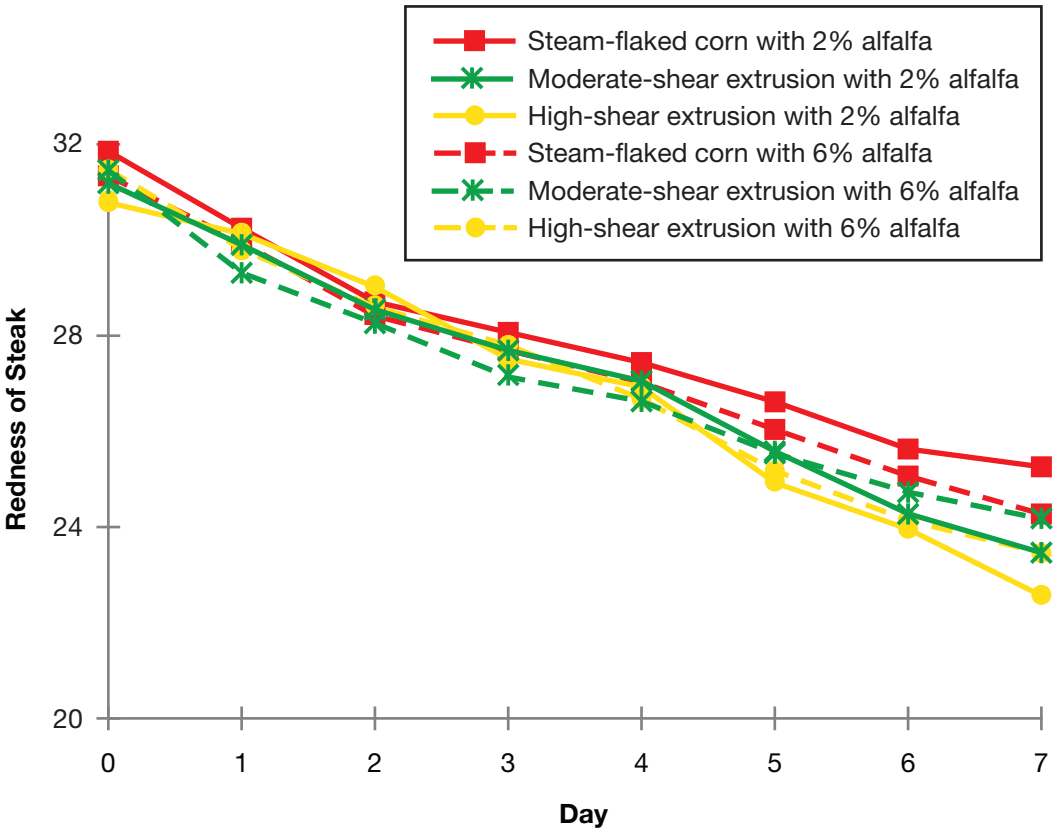

Figure 2. Redness of steaks over an 8-day period in a retail display case as determined by using a Hunter miniscan spectrophotometer.
Arbitrary units; 32 = bright cherry red; 20 = brownish color.

Effects of *Megasphaera elsdenii* on Ruminal pH, Ruminal Concentrations of Organic Acids, and Bacterial Genomes Following a Grain Challenge

M. R. McDaniel, J. J. Higgins, J. M. Heidenreich, M. K. Shelor, G. L. Parsons, P. H. Henning, and J. S. Drouillard

Introduction

Upon arrival in feedlots, cattle normally must be adapted to high-concentrate diets. The microbial population in the rumen of incoming cattle normally is suited to digestion of forages, and when cattle are transitioned onto concentrate diets, opportunistic bacteria that produce lactic acid can proliferate rapidly, leading to excesses of lactic acid in the rumen. High levels of lactic acid in the rumen may cause mild to severe acidosis. *Megasphaera elsdenii* is a lactate-utilizing bacterium that normally is present in rumens of cattle that have been adapted to high-grain diets, but numbers of the organism are relatively low during the step-up phase. Increasing the numbers of lactate-utilizing bacteria in newly arrived cattle by orally dosing with *M. elsdenii* may be a useful means of reducing the risk of ruminal acidosis in feedlot cattle. Our objectives were to evaluate ruminal parameters and determine efficacy of increasing ruminal populations of lactate-utilizing bacteria in cattle following an abrupt diet change and administration of 10 mL (low dose), 100 mL (medium dose), or 1000 mL (high dose) of a culture containing 1.62×10^8 CFU/mL of live *M. elsdenii* compared with a control group given a placebo without live *Megasphaera*.

Experimental Procedures

Crossbred Angus steers (n = 20; average initial body weight = 558 lb) fitted with ruminal cannulas were placed into individual stalls with slatted-floor pens equipped with individual feed bunks and automatic water fountains. Cattle were allowed free-choice access to alfalfa hay, salt, and clean water. After an initial 3-week adaptation period, cattle were weighed, blocked according to weight, and assigned randomly within blocks to one of four treatments. Treatments consisted of oral dosing with a placebo (100 mL of killed culture) or a low, medium, or high dose of a live culture containing *M. elsdenii* NCIMB 41125. Background samples were taken from animals at 8:00 a.m. on day 1 of the experimental period to establish ruminal conditions prior to introduction of carbohydrates into the diet. Steers were fasted for 24 hours. Beginning at 8:00 a.m. on day 2, ruminal contents were collected from each animal (hour 0), and the appropriate inoculum was administered as a liquid suspension via the rumen cannula. Immediately following dosing and sampling, steers were given free-choice access to a flaked corn diet with 66% concentrate and 34% roughage (Table 1). Immediately following sampling, ruminal pH was measured and subsamples were taken for analysis of ruminal organic acids.

Results and Discussion

Ruminal lactate concentrations increased ($P<0.05$) in response to the diet change and were lower for cattle that received *M. elsdenii* ($P<0.05$) than for the placebo group (Table 2). No differences were noted in ruminal pH among treatment groups prior to in-

troduction of grain (P<0.05). Following inoculation and introduction of the concentrate diet on the morning of day 2, ruminal pH decreased in all steers (P<0.05). Compared with the placebo group, cattle administered *M. elsdenii* maintained higher ruminal pH 24 hours after consuming the concentrate diet (P<0.05; Figure 1). Ruminal pH remained lower in the placebo group until 48 hours following the grain challenge (P<0.05). Although ruminal inoculation of cattle with a placebo or live cultures of *M. elsedenii* had no effect on total ruminal microbial populations (P>0.05), ruminal populations of total *M. elsdenii* increased within 24 hours after inoculation (P<0.05; Figure 2).

Implications

Dosing cattle with *M. elsdenii* before introducing a concentrate diet may help prevent accumulation of lactic acid and thus avoid severe depressions in ruminal pH. Inoculating cattle with *M. elsdenii* is an effective method of bolstering populations of lactate utilizers. Dosing newly-arrived feedlot cattle with *M. elsdenii* strain NCIMB 41125 may be useful for managing acidosis.

Table 1. Composition of experimental diet

Ingredients	Dry matter (%)
Steam-flaked corn	56.9
Ground alfalfa hay	33.2
Corn steep liquor	6.5
Vitamin mineral premix[1]	3.4
Nutrient composition	
Crude protein, %	15.7
NE_m, Mcal/kg	1.87
NE_g, Mcal/kg	1.23
Calcium, %	1.05
Phosphorus, %	0.36

[1] Formulated to provide 0.1 ppm cobalt, 10 ppm copper, 0.6 ppm iodine, 60 ppm manganese, 0.25 ppm selenium, 60 ppm zinc, 0.88% potassium, and 2205 IU/lb vitamin A.

Table 2. Ruminal volatile fatty acids and lactate concentrations (mM) before and after introduction of a grain-based diet

	M. elsdenii dose								
	Placebo		Low		Medium		High		
Hours post-challenge	0	24	0	24	0	24	0	24	SEM
Acetate	24.5	29.3	26.0	34.0	26.6	32.6	22.5	40.3	6.03
Propionate	4.6	17.4	5.0	17.1	5.6	28.1	3.9	19.7	3.93
Acetate:Propionate	5.5	9.6	5.8	1.9	4.9	1.2	5.9	2.0	2.34
Butyrate	2.5	13.3	2.0	9.6	3.2	16.0	2.1	19.3	2.99
Lactate	0.0	49.8	0.0	24.6	0.1	3.5	0.0	3.0	7.57

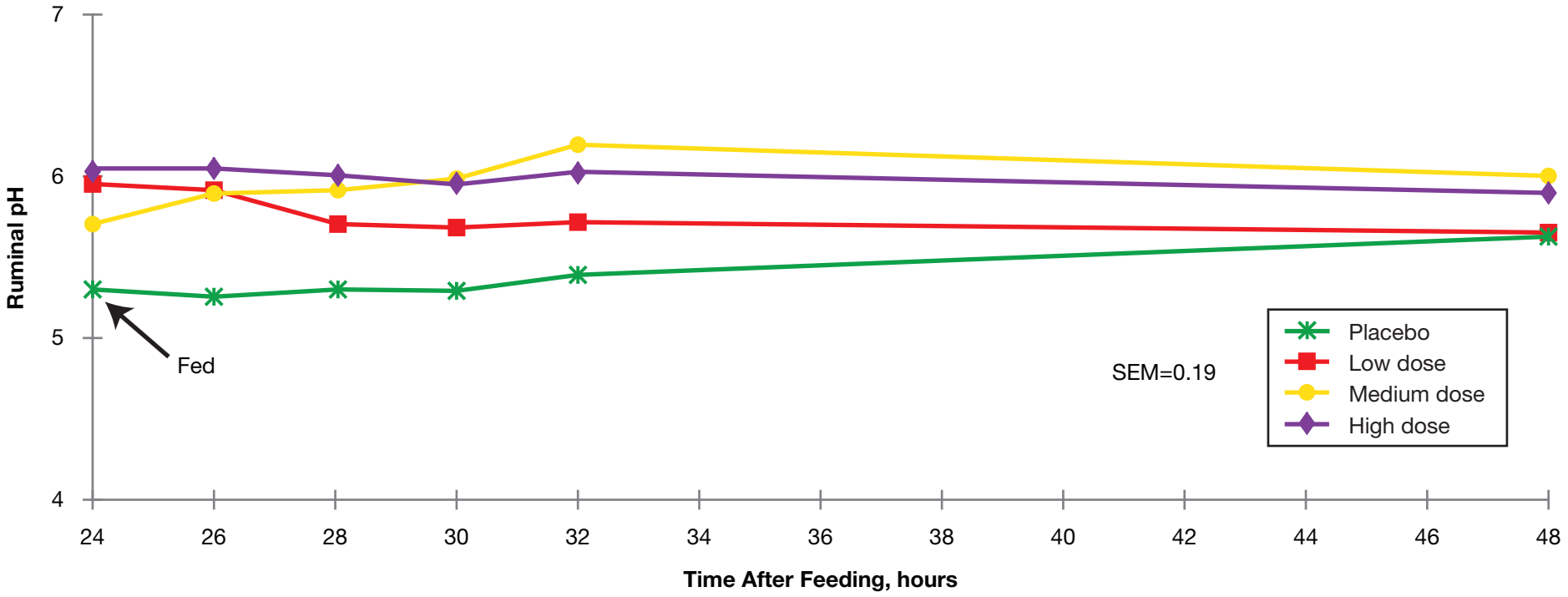

Figure 1. Ruminal pH following inoculation and grain challenge.
Ruminal pH remained higher 24 hours after feeding a grain-based diet in steers given a live dose than in steers given a placebo ($P<0.05$).

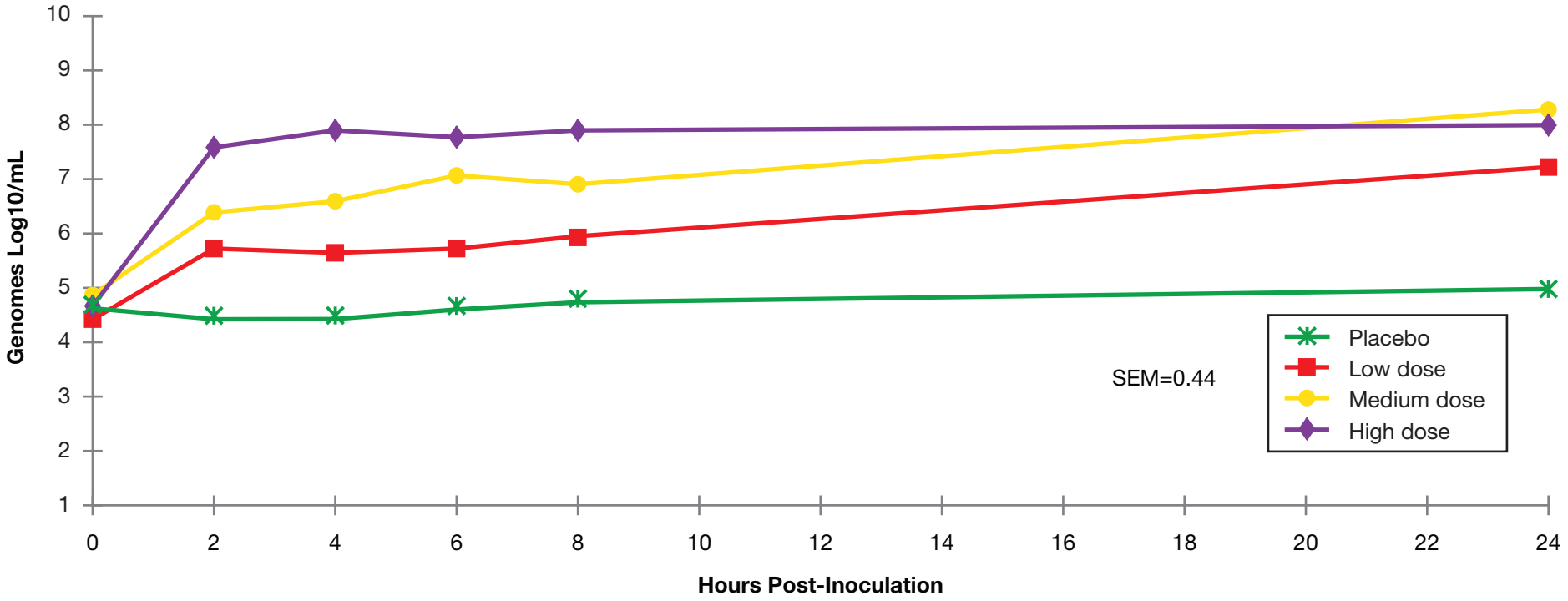

Figure 2. Total ruminal *M. elsdenii* following inoculation and grain challenge.
Ruminal populations of *M. elsdenii* were higher in steers dosed with live cultures (P<0.05).

Higher Ruminal pH Increases In Vitro Digestion of Diets Containing Dried Distillers Grains with Solubles

S. Uwituze, J. M. Heidenreich, and J. S. Drouillard

Introduction

Advantages of steam flaking grain are less with respect to growth performance and diet digestion when a portion of distillers grains is substituted for grain. Ruminal pH typically is lower in cattle fed flaked-grain diets than in cattle fed rolled-grain diets. Ruminal pH for cattle fed finishing diets based on steam-flaked corn is observed below pH 6.0. Previous research observed a 5% decrease in digestion of organic matter when 13% distillers grains (dry-matter basis) was added to steam-flaked corn finishing diets. A decline in ruminal pH below 6.2 reduces activity of ruminal fiber-digesting organisms. Furthermore, ruminal protein digestion declines with pH below 5.5. It is plausible that low ruminal pH may restrict digestion of distillers grains in flaked-grain diets. The objective of this study was to examine effects of pH on in vitro fermentative activity of ruminal contents from cattle adapted to a finishing diet containing 25% dried distillers grains (dry-matter basis).

Experimental Procedures

We conducted an in vitro study to investigate effects of three pH levels (5.0, 5.5, or 6.0) on fermentative activity of ruminal contents from cattle adapted to a finishing diet containing 25% (dry-matter basis) dried distillers grains with solubles at three incubation times (6, 12, and 24 hours). A 50:50 mixture of distillers grains and dry-rolled corn was fed to the test tube cultures. We reached our targeted pH levels by using citric acid to measure in vitro dry-matter disappearance or phosphoric acid to determine volatile fatty acids. Because citric acid is broken down in the rumen, it is conceivable that citrate degradation may produce some volatile fatty acids; hence, phosphate buffer was used as a control, especially for analysis of volatile fatty acids. There were two tubes containing substrate and two tubes without substrate for each of the buffer types, each of the three fermentation times, and each of the three pH levels. The experiment was repeated on three separate days (six observations/treatment for each buffer type). Whole ruminal contents were obtained from a ruminally cannulated steer fed a steam-flaked corn finishing diet with 25% dried distillers grains (dry-matter basis). The diet composition is further described in Table 1. After each time point, tubes were immediately placed in an ice water bath to cease fermentation rapidly while measuring final pH. After cooling, tubes were centrifuged at 30,000 × *g* for 20 minutes. Supernatant was decanted, and a portion was kept for subsequent analyses of volatile fatty acids. Pellets which remained in the tubes were dried at 100°C overnight and weighed to measure in vitro dry-matter disappearance.

Results and Discussion

In vitro dry-matter disappearance increased with increasing pH ($P<0.01$) and fermentation time ($P<0.01$, Figure 1). The linear increase of in vitro dry-matter disappearance as

pH increases may indicate that fiber digestion by fiber-digesting bacteria declines at pH levels below 6.0, which might affect digestion of distillers grains present in substrate.

There was an interaction between pH and fermentation time ($P<0.01$) with respect to total volatile fatty acid concentrations (Figure 2). Concentrations increased with increasing pH for the first 12 hours, but after 24 hours of incubation, volatile fatty acid concentrations decreased as pH increased. Volatile fatty acids are the end products of bacterial fermentation in the rumen. They represent the primary source of energy for cattle, so higher levels indicate more energy is available for cattle growth. The fact that volatile fatty acid concentration at 24 hours is higher at pH 5.0 than at pH 5.5 and 6.0 may indicate that fiber digestion and protein digestion are compromised at lower pH levels because fiber-digesting bacteria and protein-digesting bacteria struggle to survive at below pH 6.0. It is thus conceivable that it would take longer to digest feedstuffs rich in fiber, such as dried distillers grains with solubles, at such a low pH level. Because the bulk of ruminal content is digested during the first 6 hours after feeding, when pH is below 5.5, as shown in previous research, it is probable that low ruminal pH is a limiting factor for bacterial growth and subsequent digestion.

Implications

Higher pH levels led to greater dry-matter disappearance in vitro. These results may help explain decreases in cattle performance and diet digestibility when distillers grains are combined with grain that results in low ruminal pH, as is the case with flaked grains. Feeding strategies aimed at increasing ruminal pH may be a logical approach for improving digestion of dried distillers grains in flaked-grain finishing diets.

Table. 1. Composition of the diet fed to the cannulated steer donor of the ruminal fluid

Ingredients	Percentage of diet (dry-matter basis)
Steam-flaked corn	58.3
Corn dried distillers grains	25.1
Alfalfa hay	5.8
Corn steep liquor	6.3
Urea	0.1
Limestone	1.7
Supplement[1]	2.7
Analyzed composition, %	
Dry matter	79.2
Crude protein	16.0
Ether extract	5.4
Neutral detergent fiber	15.6
Calcium	0.7
Phosphorus	0.5
Potassium	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 ppm cobalt.

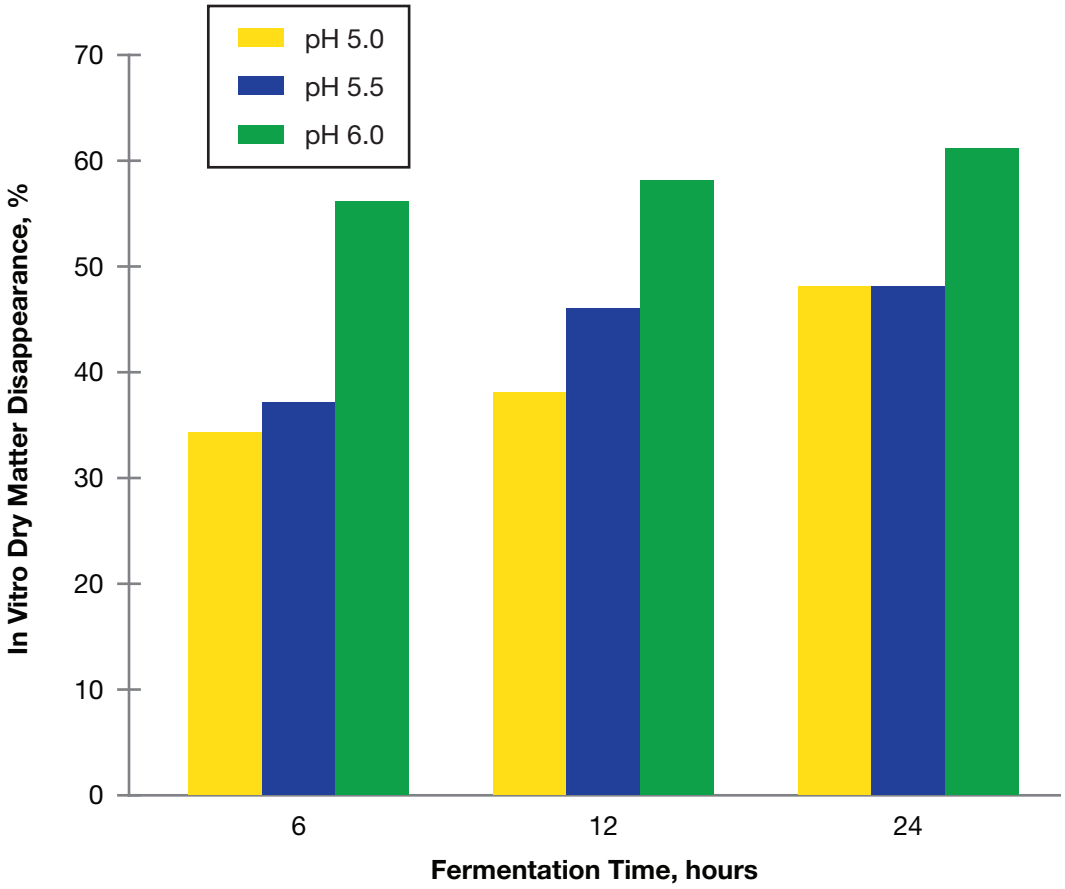

Figure 1. Effect of pH on in vitro dry-matter disappearance due to fermentation by ruminal contents from a steer adapted to a finishing diet containing 25% (dry-matter basis) dried distillers grains with solubles.

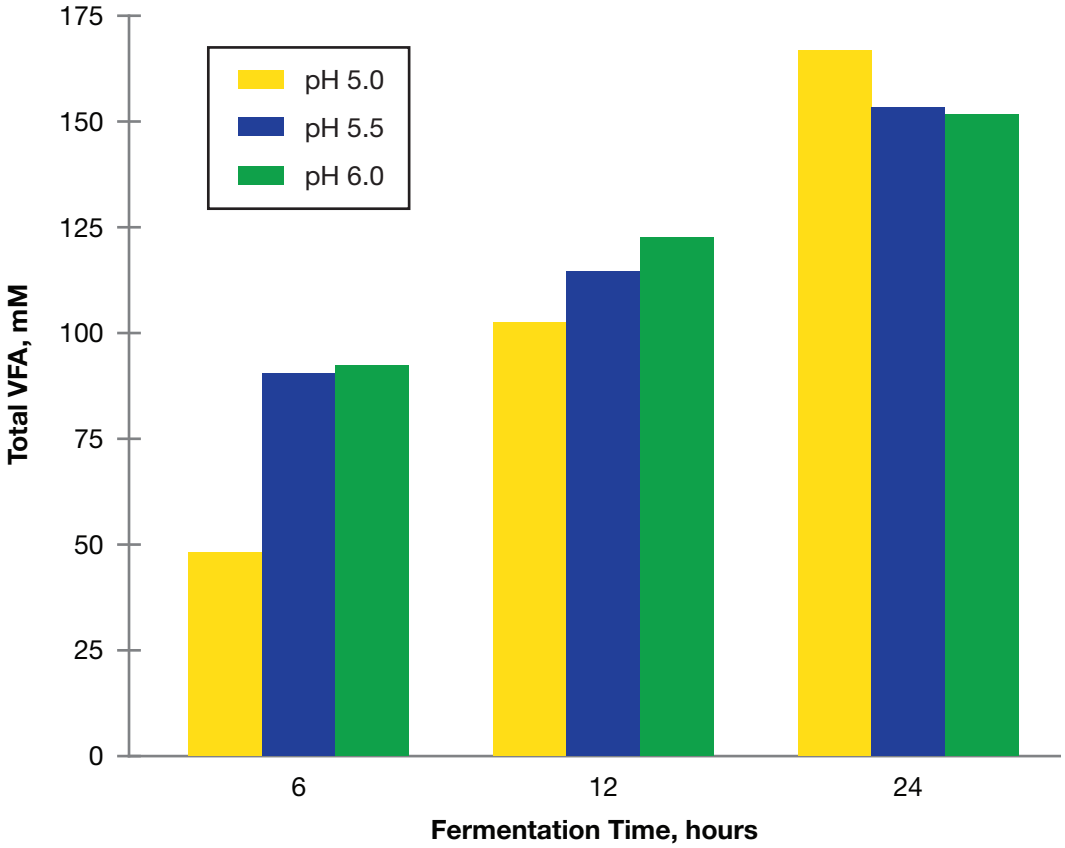

Figure 2. Effect of pH on total volatile fatty acid concentrations from in vitro fermentation by ruminal contents from a steer adapted to a finishing diet containing 25% (dry-matter basis) dried distillers grains with solubles.

Management Practices Affect Tenderness of Strip Loin but Not Knuckle Steaks from Fed Mature Cows[1]

S. Neill, J. A. Unruh, T. T. Marston, M. J. Daniel, M. E. Dikeman, M. C. Hunt, and J. J. Higgins

Introduction

Approximately 16% of cattle slaughtered in the United States are cows. When these cows are removed from the herd, they are typically in thin condition. Steaks from these cows are considered tougher than those from young steers and heifers but could potentially be improved with alternative management practices, such as high-concentrate feeding. Feeding high-concentrate diets, implanting, and feeding β-agonists prior to harvest have been shown to improve performance and carcass meat yields. However, the effect on steak tenderness of feeding Zilmax (zilpaterol hydrochloride; Intervet Inc., Millsboro, DE) to mature cows is unknown. Therefore, the objective of this study was to determine the effects of concentrate feeding, implanting, and feeding Zilmax on tenderness of strip loin and knuckle steaks from cull cows fed for 70 days.

Experimental Procedures

Sixty cull cows were assigned to one of five treatments: (1) grass fed on pasture (G), (2) concentrate fed (C) a grain sorghum-sorghum silage diet, (3) concentrate fed and implanted (CI) with Revalor-200 (200 mg of trenbolone acetate and 20 mg of estradiol; Intervet Inc.), (4) concentrate fed and fed Zilmax beginning on day 38 of the feeding period for 30 days followed by a 3-day withdrawal (CZ), and (5) concentrate fed, implanted, and fed Zilmax (CIZ). Cattle were fed for 70 days before slaughter and carcass data collection. Implanted cows were implanted on day 0 in the right ear with Revalor-200 per the manufacturer's instructions. Zilmax was fed at the end of the feeding period for 30 days prior to a required 3-day withdrawal before harvest. Seven cows were removed from the study because of health, pregnancy, or death. Removal was not related to treatment.

Cattle were humanely harvested at a commercial abattoir, where left sides were fabricated into boneless, closely-trimmed subprimal cuts according to guidelines of the North American Meat Processors Association (NAMP, 2006) approximately 72 hours postmortem. Steaks were cut from the strip loin and knuckle subprimals after aging in a vacuum package for 14 days. Two steaks from each subprimal were randomly assigned to Warner-Bratzler shear force (WBSF) testing and sensory panel evaluation. Steaks were weighed prior to cooking, cooked to an internal temperature of 104° F, turned, and cooked to a final internal temperature of 158° F. Following a 30-minute cooling period, steaks were reweighed to determine cooking loss percentages. Steaks were chilled at 32° F overnight, and eight 0.5-in.-diameter cores were removed parallel to the muscle fiber direction for WBSF determination using the Instron Universal Testing Machine

[1] Funded by the Beef Checkoff

with a 110-lb compression load cell and a crosshead speed of 9.84 in./minute. Sensory steaks were thawed in a refrigerator for 24 hours and cooked according to the procedures described previously. Following cooking, steaks were cut into 0.5 × 0.5 × 1-in. pieces for evaluation by a trained seven-member sensory panel. Steaks were scored on a scale of 1 to 8 for tenderness, flavor, juiciness, connective tissue content, and off-flavor intensity, where 8 = extremely tender, extremely intense, extremely juicy, none, none and 1 = extremely tough, extremely bland, extremely dry, abundant, abundant, respectively.

Data were analyzed as a completely randomized design by using the MIXED procedure of SAS. The model statement contained the respective response variables and treatment. Means were separated ($P<0.05$) by using the least significant difference procedure when the respective F-tests were significant ($P\leq0.05$).

Results and Discussion

Sensory panelists scored strip loin steaks from CIZ cows lower ($P<0.05$; tougher) for myofibrillar tenderness than steaks from CI, C, and G cows (Table 1). In addition, steaks from CZ cows received lower ($P<0.05$) scores than steaks from C and G cows. No differences were noted for juiciness or beef flavor among treatments. The amount of detectable connective tissue scored by sensory panelists was greater ($P<0.05$; lower score) for strip loin steaks from CIZ cows than for steaks from CI, C, and G cows. Steaks from CZ cows received lower ($P<0.05$) scores for detectable connective tissue than steaks from C cows. Sensory panelists scored strip loin steaks from CIZ cows lower ($P<0.05$; tougher) for overall tenderness than those from CI, C, and G cows, and steaks from CZ cows were scored lower ($P<0.05$) than steaks from C and G cows. Off-flavors were highest ($P<0.05$) for steaks from G cows. Strip loin WBSF values were highest ($P<0.05$; tougher) for steaks from CIZ cows than for steaks from cows in all other treatments. The WBSF values of steaks from the CZ cows were higher ($P<0.05$) than those of steaks from C, G, and CI cows. Cooking losses for strip steaks were similar ($P>0.05$) among all treatments.

Sensory panelists did not find any differences ($P>0.05$) in myofibrillar tenderness, connective tissue amount, or overall tenderness of knuckle steaks due to treatment (Table 2). However, steaks from CI cows were less juicy ($P<0.05$; lower score) than steaks from C and G cows. Beef flavor was scored higher ($P<0.05$) for steaks from the CI and G cows than for steaks from CIZ and CZ cows. A treatment difference trend ($P=0.07$) was observed by sensory panelists for off-flavor of knuckle steaks, with steaks from G cows having the most detectable off-flavor. Knuckle steaks from all treatments had similar ($P>0.05$) WBSF values and cooking losses.

Implications

A combination of concentrate feeding, implanting, and feeding Zilmax offers an opportunity to increase boneless, subprimal meat yields but would be expected to decrease tenderness of strip loin but not knuckle steaks from fed mature cows. All cow treatments resulted in steaks that were rated slightly tough to slightly tender. Therefore, postmortem tenderization protocols might be needed for all treatments to assure acceptable tenderness ratings.

Table 1. Sensory panel traits, Warner-Bratzler shear force (WBSF), and cooking loss means for steaks from the strip loin

	Treatments[1]						
Trait	CI	CIZ	CZ	C	G	SE	P-value
Myofibrillar tenderness[2]	4.5^{ab}	3.7^{c}	4.0^{bc}	5.1^{a}	4.9^{a}	0.26	<0.01
Juiciness[3]	5.3	5.6	5.5	5.5	5.6	0.13	0.36
Beef flavor[4]	5.6	5.4	5.6	5.6	5.4	0.10	0.34
Connective tissue[5]	5.8^{ab}	5.0^{c}	5.4^{bc}	6.1^{a}	5.8^{ab}	0.23	0.01
Overall tenderness[2]	4.7^{ab}	3.8^{c}	4.2^{bc}	5.3^{a}	4.9^{a}	0.25	<0.01
Off-flavor[6]	7.6^{a}	7.5^{a}	7.4^{a}	7.3^{a}	6.9^{b}	0.15	0.02
WBSF, lb	9.8^{c}	14.7^{a}	12.1^{b}	9.1^{c}	9.9^{c}	0.72	<0.01
Cooking losses, %	25.3	25.6	26.4	26.3	22.9	1.20	0.26

1 CI = fed concentrate and implanted with Revalor-200; CIZ = fed concentrate, implanted with Revalor-200, and fed Zilmax for 30 days before slaughter; CZ = fed concentrate and fed Zilmax; C = fed concentrate; G = grazed native pasture.
2 Scale: 8 = extremely tender, 1 = extremely tough.
3 Scale: 8 = extremely juicy, 1 = extremely dry.
4 Scale: 8 = extremely intense, 1 = extremely bland.
5 Scale: 8 = none, 1 = abundant.
6 Sale: 8 = none, 1 = extremely intense.
abc Within a row, means without a common superscript letter differ (P<0.05).

Table 2. Sensory panel traits, Warner-Bratzler shear force (WBSF), and cooking loss means for steaks from the knuckle

	Treatments[1]						
Trait	CI	CIZ	CZ	C	G	SE	P-value
Myofibrillar tenderness[2]	4.7	4.7	4.4	4.7	4.1	0.25	0.33
Juiciness[3]	5.0^{b}	5.3^{ab}	5.3^{ab}	5.4^{a}	5.6^{a}	0.17	0.04
Beef flavor[4]	5.9^{a}	5.4^{b}	5.4^{b}	5.5^{ab}	5.7^{a}	0.07	<0.01
Connective tissue[5]	5.9	5.7	5.6	5.3	5.3	0.21	0.13
Overall tenderness[2]	4.9	4.8	4.5	4.7	4.2	0.25	0.19
Off-flavor[6]	7.4	7.6	7.4	7.4	7.1	0.12	0.07
WBSF, lb	9.9	12.2	12.3	11.3	11.4	1.10	0.37
Cooking losses, %	30.9	32.0	31.7	32.7	29.3	2.30	0.82

1 CI = fed concentrate and implanted with Revalor-200; CIZ = fed concentrate, implanted with Revalor-200, and fed Zilmax for 30 days before slaughter; CZ = fed concentrate and fed Zilmax; C = fed concentrate; G = grazed native pasture.
2 Scale: 8 = extremely tender, 1 = extremely tough.
3 Scale: 8 = extremely juicy, 1 = extremely dry.
4 Scale: 8 = extremely intense, 1 = extremely bland.
5 Scale: 8 = none, 1 = abundant.
6 Scale: 8 = none, 1 = extremely intense.
ab Within a row, means without a common superscript letter differ (P<0.05).

The Combination of Implanting with Revalor-200 and Feeding Zilmax Increases Subprimal Meat Yield of Fed Cows[1]

S. Neill, J. A. Unruh, T. T. Marston, M. J. Daniel, J. R. Jaeger, and J. J. Higgins

Introduction

Mature cows are culled from herds for reasons such as poor performance and failure to rebreed. When these cows are removed from the herd, they are typically in thin condition and potentially can be fed to gain weight and increase income. Previous research has shown that feeding cull cows high-energy diets can increase carcass weight, fatness, and meat yield. Management practices of implanting and feeding β-adrenergic agonists, repartitioning agents that favor protein deposition at the expense of fat deposition, have been shown to further improve performance and carcass yields. As reported elsewhere in this publication, carcasses from concentrate-fed cows implanted with Revalor-200 (Intervet Inc., Millsboro, DE) and fed Zilmax (zilpaterol hydrochloride; Intervet Inc.) had more muscling as indicated by larger ribeye areas than carcasses from grass-fed cows and both implanted and non-implanted concentrate-fed cows. These carcasses potentially would have increased subprimal meat yields. Therefore, the objective of this study was to determine the effects of concentrate feeding, implanting, and feeding Zilmax on subprimal meat yield of mature cows fed for 70 days.

Experimental Procedures

Sixty cull cows were assigned to one of five treatments: (1) grass fed on pasture (G), (2) concentrate fed (C) a grain sorghum-sorghum silage diet, (3) concentrate fed and implanted (CI) with Revalor-200 (200 mg of trenbolone acetate and 20 mg of estradiol), (4) concentrate fed and fed Zilmax beginning on day 38 of the feeding period for 30 days followed by a 3-day withdrawal (CZ), and (5) concentrate fed, implanted, and fed Zilmax (CIZ). Cattle were fed for 70 days before harvest and carcass data collection. Implanted cows were implanted on day 0 in the right ear with Revalor-200 per the manufacturer's instructions. Zilmax was fed at the end of the feeding period for 30 days before a required 3-day withdrawal before slaughter. Seven cows were removed from the study because of health, pregnancy, or death. Removal was not related to treatment.

Cattle were humanely slaughtered at a commercial abattoir, where left sides were fabricated into boneless, closely-trimmed subprimal cuts according to guidelines of the North American Meat Processors Association (NAMP, 2006) approximately 72 hours postmortem. The ribeye roll from an 8-rib wholesale rib (modified NAMP #112); boneless, denuded brisket (modified NAMP #120); chuck roll (NAMP #116A); denuded chuck tender (modified NAMP #116B); and shoulder clod (NAMP #114) were removed from the forequarter. The wholesale round was further processed into the peeled knuckle (NAMP #167A); cap-off, top round (NAMP #169B); outside round (NAMP #171B); and eye of round (NAMP #171C), whereas the flank steak (NAMP #193) was removed

[1] Funded by the Beef Checkoff

from the wholesale flank. Lastly, the wholesale loin was broken down into a boneless, closely-trimmed strip loin (NAMP #180); denuded tenderloin (NAMP #190); boneless, closely-trimmed top sirloin butt (NAMP #184); and denuded bottom sirloin butt/tri-tip (NAMP #185D). Subprimal weights were recorded and subsequently divided by hot carcass weight (HCW) and initial body weight to calculate subprimal yields.

Data were analyzed as a completely randomized design by using the MIXED procedure of SAS. The model statement contained the respective response variables and treatment. Means were separated ($P<0.05$) by using the least significant difference procedure when the respective F-tests were significant ($P<0.05$).

Results and Discussion

Total chuck subprimals from carcasses of CIZ cows were heavier ($P<0.05$) than those from C and G cows (Table 1). In addition, total chuck subprimals from both CI and CZ cows were heavier ($P<0.05$) than total chuck subprimals from G cows, even though individual subprimal cut weights (shoulder clod, chuck tender, and chuck roll) were statistically similar ($P\geq0.18$) among treatments. Total weight of the modified ribeye roll was heavier ($P<0.05$) in all concentrate-fed cow groups than in G cows. Even though tenderloin weights were heavier ($P<0.05$) in carcasses from concentrate-fed than in those from G cows, total loin subprimal weights as well as weights of the strip loin, top sirloin butt, and bottom sirloin tri-tip did not differ ($P\geq0.16$) among feeding treatments. Total weights of round subprimal cuts from concentrate-fed cows were greater ($P<0.05$) than those from G cows. This difference can be largely attributed to heavier ($P<0.05$) top (inside) and bottom (outside) round weights from carcasses of the concentrate-fed cows than from carcasses of G cows. Conversely, there were no differences ($P\geq0.13$) in weights for eye of round, knuckle, or flank steaks among treatments. Carcasses from CIZ cows produced heavier ($P<0.05$) briskets than carcasses from C and G cows, and carcasses from CI and CZ cows produced heavier briskets ($P<0.05$) than carcasses from G cows.

Total subprimal cut weights from G cows were less ($P<0.05$) than those from concentrate-fed cows (Table 1). In addition, subprimal cut weights from CIZ cows were greater ($P<0.05$) than those from C cows. Total subprimal yields, as a proportion of HCW, did not differ ($P=0.13$) among treatments. However, expressed as a percentage of initial live weight, subprimal yields were lower ($P<0.05$) for G cows than for concentrate-fed cows. Among carcasses from concentrate-fed cows, yields of subprimal cuts from CIZ cows were greater ($P<0.05$) than those from CZ and C cows, and CI cows had greater ($P<0.05$) subprimal cut yields than C cows when expressed as a percentage of initial live weight.

Compared with G cows, concentrate-fed cows had carcasses with a greater total weight of boneless subprimals and a higher proportion of boneless subprimals when expressed as a percentage of initial live weight. Cows implanted and fed Zilmax had significantly greater total subprimal weights and a higher proportion of total subprimals when expressed as a percentage of initial live weight than cows fed concentrate only and numerically (not statistically) the greatest total weight and highest proportion of total subprimals of any treatments. Although not statistically significant, cows implanted and fed Zilmax also had the highest proportion of subprimals when expressed as a percentage of HCW.

Implications

Feeding a concentrate diet to cull cows offers an opportunity to increase the weight of boneless subprimals. To maximize the yield of these subprimals, concentrate-fed cows should be implanted and fed Zilmax during the later portion of the feeding period.

Table 1. Closely-trimmed subprimal weights per carcass side from cows fed for 70 days

	Treatment[1]						
Trait	CI	CIZ	CZ	C	G	SE	P-value
Hot carcass weight, lb	830[a]	840[a]	819[a]	804[a]	696[b]	25.6	<0.01
Chuck subprimals, lb	35.3[ab]	35.9[a]	34.8[ab]	32.2[bc]	29.5[c]	1.34	<0.01
Shoulder clod, lb	16.8	17.4	16.8	15.9	14.3	0.95	0.34
Chuck tender, lb	2.4	2.4	2.2	2.2	2.0	0.13	0.27
Chuck roll, lb	16.1	16.3	15.9	14.3	13.2	0.86	0.18
Ribeye roll, lb	12.3[a]	13.0[a]	11.9[a]	11.9[a]	10.1[b]	0.46	<0.01
Loin subprimals, lb	32.8	35.1	32.2	32.2	28.0	1.59	0.16
Tenderloin, lb	4.6[a]	4.9[a]	4.6[a]	4.4[a]	3.7[b]	0.18	<0.01
Strip loin, lb	12.3	13.0	11.9	12.3	10.6	0.64	0.21
Top sirloin, lb	14.6	15.2	14.1	14.3	12.3	0.84	0.26
Tri-tip, lb	1.5	1.7	1.5	1.4	1.1	0.18	0.24
Round subprimals, lb	43.4[a]	45.2[a]	44.1[a]	41.4[a]	36.2[b]	1.61	<0.01
Knuckle, lb	9.0	8.6	9.3	9.0	7.7	0.71	0.58
Inside round, lb	15.7[a]	16.8[a]	16.3[a]	15.0[a]	12.8[b]	0.68	<0.01
Outside round, lb	13.0[a]	13.9[a]	13.0[a]	12.3[a]	10.8[b]	0.51	<0.01
Eye of round, lb	5.7	6.2	5.5	5.1	4.4	0.35	0.13
Flank, lb	1.7	2.9	1.6	1.6	1.4	0.53	0.41
Brisket, lb	7.9[ab]	8.6[a]	7.5[ab]	7.1b[c]	5.5[c]	0.35	0.01
Total subprimals, lbs	133.6[ab]	140.4[a]	132.5[ab]	126.3[b]	109.8[c]	4.41	<0.01
Hot carcass weight[2], %	32.2	33.6	32.5	31.4	31.6	0.67	0.13
Initial live weight[3], %	23.9[ab]	25.3[a]	23.3[bc]	21.9[c]	19.5[d]	0.62	<0.01

1 CI = fed concentrate and implanted with Revalor-200; CIZ = fed concentrate, implanted with Revalor-200, and fed Zilmax for 30 days before slaughter; CZ = fed concentrate and fed Zilmax; C = fed concentrate; G = grazed native pasture.
2 100 × (2 × total subprimal weight)/hot carcass weight.
3 100 × (2 × total subprimal weight)/Initial live weight.
abcd Within a row, means without a common superscript letter differ (P<0.05).

The Combination of Implanting with Revalor-200 and Feeding Zilmax Increases Ribeye Area of Fed Cows[1]

S. Neill, J. A. Unruh, J. R. Jaeger, T. T. Marston, and J. J. Higgins

Introduction

Mature cows are typically removed from the cow herd for various reasons, such as reproductive inefficiency and poor performance. It has been estimated that as much as 15 to 25% of a ranch's revenue may be from cull cows. When cows are culled from the herd, they are normally in thin condition and potentially can be fed to gain weight and increase income. Previous studies indicate that feeding a high-energy diet and implanting cull cows can improve performance and increase meat yield.

Zilmax (zilpaterol hydrochloride; Intervet Inc., Millsboro, DE) is a β-adrenergic agonist approved as a growth promotant in feedlot cattle for use during the last 20 to 40 days prior to harvest. β-agonists repartition nutrients away from fat deposition and toward protein deposition. Studies in young animals have shown β-agonists to improve performance and carcass cutability characteristics. However, few studies using β-agonists in cull cows have been conducted. Therefore, the objective of this study was to determine the effects of concentrate feeding, implanting, and feeding Zilmax on performance and carcass characteristics of cull cows fed for 70 days.

Experimental Procedures

Sixty cull cows were assigned to one of five treatments: (1) grass fed on pasture (G), (2) concentrate fed (C) a grain sorghum-sorghum silage diet, (3) concentrate fed and implanted (CI) with Revalor-200 (Intervet Inc.; 200 mg of trenbolone acetate and 20 mg of estradiol), (4) concentrate fed and fed Zilmax beginning on day 38 of the feeding period for 30 days followed by a 3-day withdrawal (CZ), and (5) concentrate fed, implanted, and fed Zilmax (CIZ). Cattle were fed for 70 days before harvest and carcass data collection. Implanted cows were implanted on day 0 in the right ear with Revalor-200 per the manufacturer's instructions. Zilmax was fed at the end of the feeding period for 30 days before a required 3-day withdrawal prior to slaughter. Seven cows were removed from the study because of health, pregnancy, or death. Removal was not related to treatment.

Cows were stratified by weight, body condition score, and carcass characteristics measured by ultrasound before allotment to treatments. The two groups of G cows (six cows/group) were turned out on 50 acres of northwest Kansas native grass pasture. Concentrate-fed cows were fed a diet containing sorghum silage and ground grain sorghum (Table 1) in pens of six cows, resulting in two pens per treatment. During the initial 13 days, a step-up procedure was used to increase the proportion of ground grain sorghum in the diet. Bunks were read daily prior to feeding to establish the amount of feed to be provided. From 14 to 28 days, feed intake was closely monitored to establish a feeding level (28.0 lb dry matter/cow per day) for the remainder of the trial. A limit-feeding

[1] Funded by the Beef Checkoff

protocol was used to properly administer the correct amount of Zilmax in the diet. On day 14, all cows were treated with Dectomax Pour–On (Pfizer, Inc., La Jolla, CA) to eliminate internal and external parasites, and ears of implanted cows were palpated to confirm implant retention. Cows were ultrasounded and weighed again on days 36 and 70 of the trial. Cows were transported 130 miles to a commercial abattoir and humanely harvested.

Hot carcass weights were recorded at harvest, and all other carcass data were recorded 48 hours postmortem. Carcass data collected were evaluated by trained university personnel and included ribeye area; adjusted fat thickness; percentage of kidney, pelvic, and heart fat; marbling (100 = Practically Devoid^{00} to 1000 = Abundant^{100}); and final maturity (100 = A^{00} to 600 = E^{100}).

Data were analyzed as a completely randomized design by using the MIXED procedure of SAS. The model statement contained the respective response variables and treatment. Means were separated ($P<0.05$) by using the least significant difference procedure when the respective F-tests were significant ($P\leq0.06$).

Results and Discussion

Implanted cows fed the concentrate diet (CI and CIZ) had greater ($P<0.05$) weight gains over the first 36 days on feed than C cows, whereas concentrate-fed (C, CI, CZ, and CIZ) cows had greater ($P<0.05$) weight gains than G cows during the last 34 days on feed (Table 2). Although total gain for the entire 70-day feeding period was not statistically significant ($P=0.23$), implanted cows (CI and CIZ) had the greatest numerical weight gains, and G cows had the lowest weight gain. The CI cows had lower ($P<0.05$) feed:gain over the first 36 days than C cows; however, feed:gain for concentrate-fed cows during the last 34 days on feed and the entire 70-day feeding period was not affected by treatment ($P\geq0.39$). The lack of significant differences noted in gains for the concentrate-fed cows versus the G cows for the overall feeding period was likely the result of inherent variation in cull cows and an extremely good pasture. Rain throughout the summer allowed for abundant grass growth. Therefore, cows on grass had an ample source of nutrients, allowing them to gain weight during the trial.

During the initial 36 days on feed, ultrasound muscle depth gain was greater ($P>0.05$) for cows in three of the concentrate-fed treatments (CI, CIZ, and CZ) compared with G cows; whereas for the entire feeding period, CIZ cows had greater ($P>0.05$) ultrasound muscle depth gains than CI, C, and G cows. All concentrate-fed cows had greater ($P>0.05$) ultrasound muscle depth gains for the entire feeding period than G cows.

Dressing percentages and hot carcass weights were greater ($P<0.05$) for all concentrate-fed cows than for G cows. Carcasses from CIZ cows had the largest ($P<0.05$) ribeye areas of all treatment groups, whereas carcasses from the other concentrate-fed cows (CI, CZ and C) had larger ($P<0.05$) ribeye areas than carcasses from G cows. Adjusted fat thickness; kidney, pelvic, and heart fat; and yield grade were not affected ($P\geq0.15$) by treatment, nor were carcass maturity ($P=0.51$) or marbling score ($P=0.42$).

Implications

Concentrate-fed cull cows should exhibit increased hot carcass weights, dressing percentages, and ribeye areas compared with grass-fed cows. When fed a concentrate finishing diet, cows implanted with Revalor-200 and fed Zilmax would be expected to have the most carcass muscle as indicated by the largest ribeye areas and greatest ultrasound muscle depth gains.

Table 1. Ingredient composition of experimental diets

Ingredient	Dry matter (%)
Silage	19.7
Ground sorghum	77.3
Soybean meal/supplement[1]	3.0

[1] Supplement formulated to deliver the following per animal daily (as-fed basis): 0.50 lb soybean meal, 0.006 lb trace mineral, 0.0014 lb vitamin A, 0.022 lb calcium, 0.13 lb urea, and 0.06 lb salt. Rumensin (Elanco, Greenfield, IN) was added at 0.0006 lb; Tylan (Elanco, Greenfield, IN) was added at 0.0002 lb for cows on control diets and Zilmax cows until Zilmax was added in diet the last 30 days of the trial. Zilmax was added at 0.00023 lb.

Table 2. Performance and carcass yield data for cows fed for 70 days

	Treatment[1]						
Trait	CI	CIZ	CZ	C	G	SE	P-value
Initial body weight, lb	1120	1118	1144	1153	1135	41.7	0.96
First 36 days on feed							
Weight gain, lb	156^{a}	125^{ab}	110^{bc}	90^{c}	124^{ab}	13.1	<0.01
Ultrasound muscle depth gain, in.	0.11^{a}	0.29^{a}	0.20^{a}	0.06^{ab}	-0.21^{b}	0.12	0.02
Feed:gain	6.1^{a}	7.4^{ab}	8.4^{ab}	10.5^{b}	–	1.08	0.06
Second 34 days on feed							
Weight gain, lb	119^{a}	159^{a}	116^{a}	131^{a}	46^{b}	15.4	0.03
Ultrasound muscle depth gain, in.	0.03	0.20	0.19	0.09	0.01	0.12	0.69
Feed:gain	8.2	6.1	8.1	7.5	–	1.38	0.42
Overall feeding period							
Weight gain, lb	275	284	227	221	170	33.5	0.23
Ultrasound muscle depth gain, in.	0.13^{b}	0.50^{a}	0.39^{ab}	0.15^{b}	-0.20^{c}	0.13	<0.01
Feed:gain	7.0	6.7	7.9	8.7	–	1.11	0.39
Carcass traits							
Hot carcass weight, lb	830^{a}	840^{a}	819^{a}	804^{a}	696^{b}	25.6	<0.01
Dressing percentage, %	59.6^{a}	60.1^{a}	59.8^{a}	58.5^{a}	52.6^{b}	0.71	<0.01
Ribeye area, in.^{2}	14.2^{b}	15.6^{a}	13.5^{b}	13.5^{b}	11.3^{c}	0.59	<0.01
Adjusted fat thickness, in.	0.44	0.47	0.45	0.50	0.37	0.15	0.57
Kidney, pelvic, and heart fat, %	1.5	1.6	1.5	1.5	1.3	0.09	0.15
Yield grade	2.5	2.2	2.7	2.8	2.7	0.28	0.51
Marbling score[2]	435	414	459	426	354	39.2	0.42
Final maturity[3]	340	414	367	390	419	38.5	0.51

[1] CI = fed concentrate and implanted with Revalor-200; CIZ = fed concentrate, implanted with Revalor-200, and fed Zilmax for 30 days before slaughter; CZ = fed concentrate and fed Zilmax; C = fed concentrate; G = grazed native pasture.

[2] Marbling score: 300 = Slight^{00}, 400 = Small^{00}, etc.

[3] Final Maturity: 300 = C^{00}, 400 = D^{00}, 500 = E^{00}.

^{abc} Within a row, means without a common superscript letter differ (P<0.05).

Using Sequential Feeding of Optaflexx and Zilmax to Improve Performance and Meat Quality in Cull Beef Cows

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Introduction

Beef cows are culled from herds because of reproductive inefficiency, poor performance, old age, or farm downsizing due to high production costs. The National Market Cow and Bull Beef Quality Audit of 1999 reported that challenges associated with cull cow carcasses are undesirable dressing percentages and meat yields. Since 1999, an increasing number of producers are either selling cows in better physical condition or feeding cows a high concentrate ration for 50 to 100 days prior to harvest. According to the 2007 audit, cow carcasses were heavier and leaner and had more desirable muscle and fat color scores than in 1999. Although these improvements are positive steps toward increasing the value of cull cows, use of growth promoting agents, such as steroid implants and β-adrenergic agonists, can increase muscling and leanness more efficiently than feeding a concentrate ration alone. Currently, there are two β-agonists on the market for use in beef cattle in the United States: Optaflexx (ractopamine hydrochloride; Elanco, Greenfield, IN), a β_1-agonist, and Zilmax (zilpaterol hydrochloride; Intervet Inc., Millsboro, DE), a β_2-agonist. These growth promotants have been studied individually and in combination with implants (primarily in young steers and heifers), but no research published to date has investigated feeding a sequence of these growth promoting agents. Therefore, our objective was to investigate effects of feeding Optaflexx for 25 days followed by Zilmax for 20 days plus a 3-day withdrawal on cull cow performance, carcass traits, and meat quality.

Experimental Procedures

Sixty cull cows were purchased to meet established criteria (primarily of "British" breeding, not pregnant, between 2 and 8 years of age, between 1,000 and 1,300 lb, and having a body condition score between 2 and 4). These cows were placed on a concentrate ration (Table 1) for 82 days and assigned to one of four treatments: (1) Control = fed a concentrate ration for 82 days, (2) Optaflexx = fed a concentrate ration for 57 days then supplemented with Optaflexx for 25 days, (3) Zilmax = fed a concentrate ration for 59 days then supplemented with Zilmax for 20 days plus a 3-day withdrawal, and (4) Optaflexx + Zilmax = fed a concentrate ration for 34 days then supplemented with Optaflexx for 25 days followed by Zilmax for 20 days plus a 3-day withdrawal. On day 0, all cows were implanted with Revalor-200 (Intervet Inc.) per the manufacturer's instructions. There were five cows per pen, creating three replicate pens for each treatment. At the end of feeding, cows were transported to a commercial harvest facility and humanely slaughtered.

Hot carcass weights were recorded at harvest. At 72 hours postmortem, trained university personnel evaluated the following carcass traits: ribeye area; adjusted fat thickness;

percentage kidney, pelvic, and heart fat; yield grade; lean and fat color; and marbling. At 4 days postmortem, carcasses were fabricated, and the wholesale rib, tenderloin, and shoulder clod were retrieved. Longissimus steaks (aged for 21 days), psoas major steaks (aged for 21 days), and infraspinatus steaks (aged for 14 days) were evaluated for tenderness. A portion of the longissimus muscle was enhanced with a 0.1M solution of calcium lactate to a target pump of 10% at 4 days postmortem, and tenderness was evaluated after 14 days of aging. Steaks (1-in. thick) were cooked to an internal temperature of 158°F and chilled overnight at 32°F. Eight 0.5-in. cores were removed parallel to the muscle fiber direction. Warner-Bratzler shear force (WBSF) values were collected on each core by shearing perpendicular to the direction of the muscle fiber.

Data were analyzed as a completely randomized design. For performance traits, the GLM procedure of SAS was used with pen was the experimental unit. Carcass data and tenderness were analyzed by using the MIXED procedure of SAS with animal was the experimental unit. One cow was removed because of sickness, and one cow was removed because she had a negative average daily gain, leaving a total of 58 cows in the data set. Means were separated ($P<0.05$) by using the least significant difference procedure.

Results and Discussion

Weights at the beginning of the feeding period were similar for all treatments. There were no differences in average daily gain, finished weight, hot carcass weight, or dressing percentage among treatments (Table 2).

There also were no differences among treatments for adjusted fat thickness; percentage kidney, pelvic and heart fat; or yield grade (Table 2). However, there was a trend ($P=0.18$) for ribeye areas to be larger in the Zilmax and Optaflexx + Zilmax treatments (Figure 1). In addition, although not significant ($P=0.30$), marbling scores were the lowest in the Optaflexx treatment (Slight^{60}) and highest in the Optaflexx + Zilmax treatment (Small^{00}, Figure 2). Cows within the Optaflexx + Zilmax treatment also had numerically, although not significantly, more desirable lean color score compared with the other three treatments (Table 2).

Warner-Bratzler shear force values for nonenhanced longissimus steaks were similar for the Control, Optaflexx, and Optaflexx + Zilmax treatments (Figure 3). However, WBSF values for the Zilmax treatment were distinctively higher ($P<0.05$) than those of the other three treatments (Table 3). These data indicate that feeding either no β-agonist or the combination of Optaflexx followed by Zilmax will yield more tender longissimus steaks than feeding Zilmax alone.

There were no differences among treatments for WBSF values of enhanced longissimus steaks, and WBSF values for the enhanced steaks were noticeably lower for the Zilmax treatments compared with nonenhanced steaks (Table 3). Therefore, we conclude that enhancement with calcium lactate is beneficial in improving tenderness.

Infraspinatus steaks from Control cows had higher, less tender ($P<0.05$) WBSF values than steaks from cows in treatments that contained Optaflexx or the combination of Optaflexx and Zilmax (Table 3). We predict that this difference is due to a collagen dilution effect in which the growth promotants increased muscle cell growth and diluted the

effects of collagen. Warner-Bratzler shear force values were not different among treatments for steaks from the psoas major muscle.

Implications

Feeding Zilmax or a combination of Optaflexx + Zilmax had no effect on performance characteristics; however, there was a trend for cows supplemented with Zilmax alone or in combination with Optaflexx to have increased ribeye area measurements. In addition, feeding a sequence of Optaflexx followed by Zilmax can improve longissimus muscle tenderness compared with feeding Zilmax alone and could be beneficial in increasing marbling and lean color scores.

Table 1. Basic feed ration

Ingredient	Dry-matter basis (%)
Ground sorghum grain	76.95
Sorghum silage	20.04
Soybean meal (44%)	1.61
Minor/supplement[1]	1.40

1 Minor ingredients = urea, calcium, salt; for the Optaflexx and Optaflexx + Zilmax treatments, Optaflexx was added at 0.00044 lb for 25 days; for the Zilmax and Optaflexx + Zilmax treatments, Zilmax was added at 0.00023 lb for 20 days.

Table 2. Carcass traits of cull beef cows fed β-agonists

Item	Control	Optaflexx	Zilmax	Optaflexx + Zilmax	P-value
Initial weight, lb	1160	1150	1149	1154	0.93
Final weight, lb	1408	1385	1426	1427	0.53
Average daily gain, lb	3.43	3.26	3.84	3.79	0.63
Hot carcass weight, lb	815	820	849	859	0.42
Dressing percentage, %	59.0	59.3	59.7	60.2	0.58
Adjusted fat thickness, in.	0.35	0.37	0.34	0.38	0.92
Kidney, pelvic and heart fat, %	1.5	1.3	1.3	1.5	0.60
Yield grade	2.6	2.6	2.2	2.5	0.46
Lean color[1]	5.4	5.3	5.4	4.4	0.27
Fat color[2]	2.6	2.8	2.4	2.5	0.62

1 Scale: 1 = pale red, 7 = dark red.
2 Scale: 1 = bleached white, 5 = canary yellow.

Table 3. Muscle tenderness of cull cows fed β-agonists

Item	Control	Optaflexx	Zilmax	Optaflexx + Zilmax	P-value
Longissimus WBSF, lb	9.76[a]	8.75[a]	12.41[b]	10.42[a]	0.03
Enhanced longissimus WBSF, lb	8.97	8.73	9.59	9.48	0.60
Infraspinatus WSBF, lb	9.72[b]	8.36[a]	8.73[ab]	8.42[a]	0.04
Tenderloin WBSF, lb	6.46	6.49	6.66	6.13	0.12

[ab] Within a row, means without a common superscript letter differ (P<0.05).

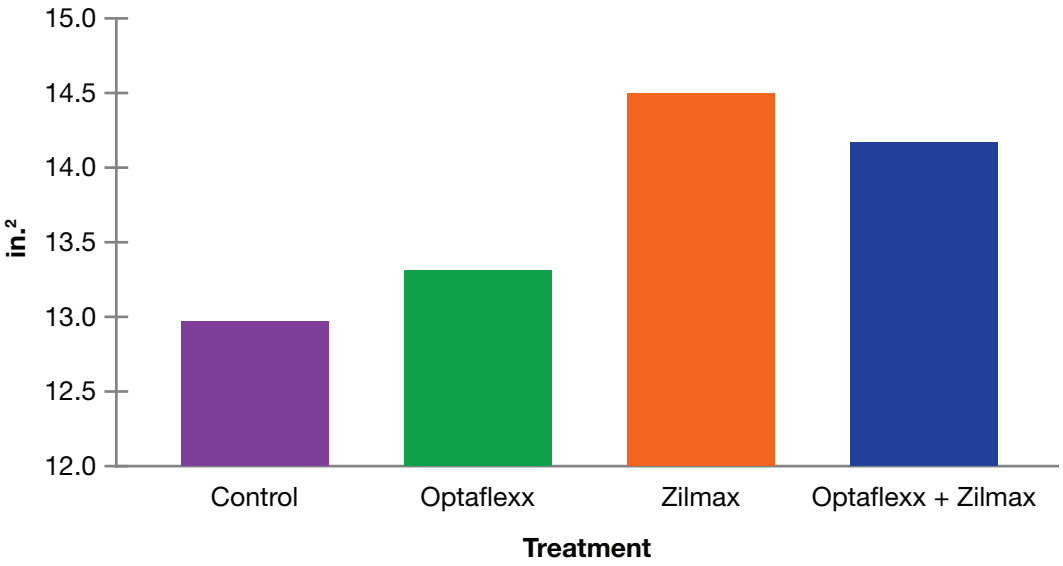


Figure 1. Ribeye area measurement of cull cows fed β-agonists.

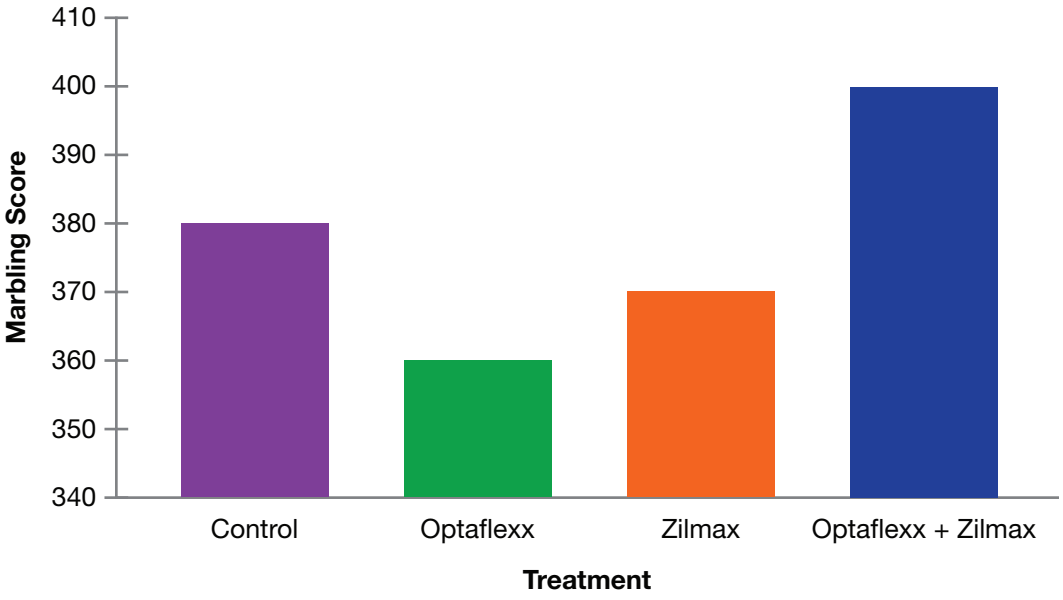
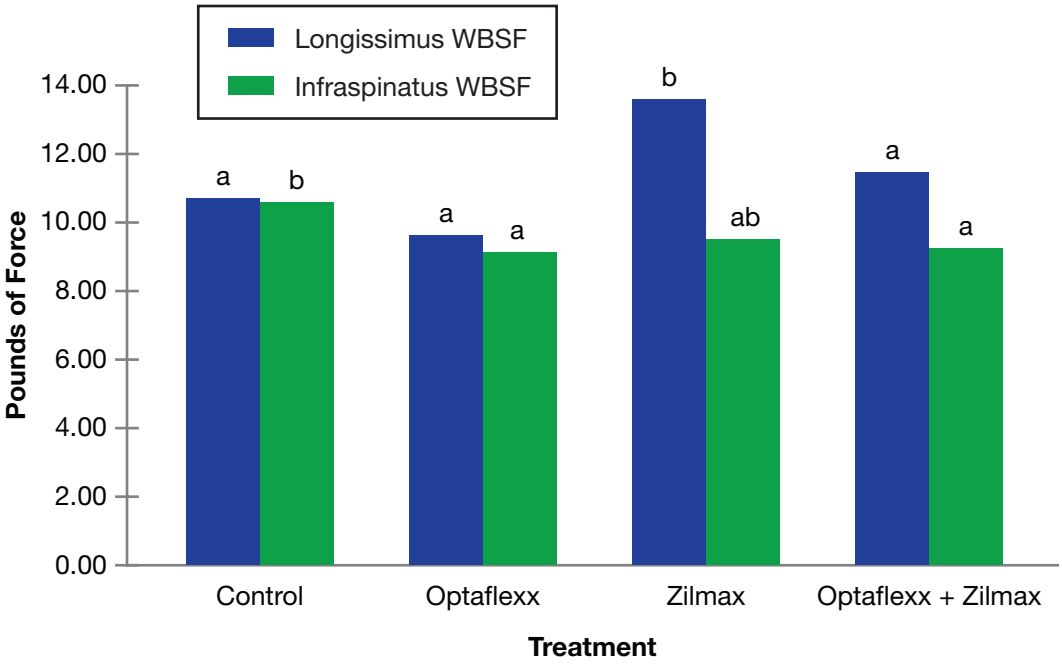


Figure 2. Marbling scores of cull cows fed β-agonists.
Marbling Score: 300 = slight[00], 400 = small[00], etc.



[ab] Means with a different letter differ (P<0.05).

Figure 3. Warner-Bratzler shear force values of selected nonenhanced muscles from cull cows fed β-agonists.

Aging Improves Tenderness of Longissimus Muscle Steaks from Fed Mature Cows

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Introduction

Steaks from cows are tougher than those from young steers and heifers. This difference is often attributed to the increased cross-linkage of collagen in muscle of mature animals that is considered very stable and more resistant to postmortem degradation. Aging steaks from young steers and heifers is a common postmortem practice used to improve tenderness of steaks from the ribeye roll and strip loin. Improvement in tenderness because of aging has been attributed to enzymatic degradation of, primarily, the myofibrillar fraction of muscle and is most beneficial for low connective tissue muscles. Because muscles from mature cows have more collagen cross-linking, postmortem tenderization methods, such as blade tenderization and enzymatic tenderization, are often used to increase tenderness of steaks from mature cows. However, few studies have investigated the effect of aging on tenderness of longissimus muscle steaks from fed mature cows. Therefore, the objective of this study was to determine effects of aging on tenderness of longissimus steaks of fed mature cows from different management strategies.

Experimental Procedures

Longissimus muscle (LM) steaks from 53 cull cows from five different management treatments were used in this study. Live animal performance and carcass traits are reported in other articles in this publication. During fabrication at approximately 72 hours postmortem, LM from the 12th rib and strip loins were removed and vacuum packaged. At 7 days postmortem, 12th rib LM muscle samples were removed from their vacuum bags and faced on both ends before a 1-in. steak was cut for 7-day Warner-Bratzler shear force (WBSF) determination. At 14 days postmortem, strip loins were removed from their vacuum bags, faced on the anterior end, and three 1-in. LM steaks were cut from the anterior end. Steaks were randomly assigned to 14, 21, and 28 days of aging. Steaks for 21- and 28-day aging were vacuumed packaged and stored at approximately 32°F.

Steaks were removed from the vacuum package and weighed to determine initial weight. Steaks were cooked to an internal temperature of 104°F, turned, and cooked to a final internal temperature of 158°F. Following a 30-minute cooling period, steaks were reweighed to determine cooking loss percentages. Steaks were chilled at 36°F overnight, and eight 0.5-inch cores were removed parallel to the muscle fiber direction for WBSF determination using the Instron Universal Testing Machine with a 110-lb compression load cell and a crosshead speed of 9.84 in./minute.

Data were analyzed as a completely randomized design by using the MIXED procedure of SAS with a 5 × 4 factorial arrangement of treatments. The model statement contained the respective response variables, management treatment, days of aging, and the management treatment × days of aging interaction. Means were separated ($P<0.05$) by using the least significant difference procedure when the respective F-tests were significant ($P<0.05$).

Results and Discussion

No management treatment × days of aging interactions (P<0.05) were observed. Steaks aged for 28 days had the lowest (P<0.05, most tender) WBSF values compared with all other days of aging (Table 1). Steaks aged for 21 days had lower (P<0.05) WBSF values than steaks aged for 7 and 14 days. Steaks aged for 7 days had the highest (P<0.05, toughest) WBSF values among aging treatments. Cooking loss percentages for all days of aging were not different.

Results indicate that increased postmortem aging continues to improve tenderness of LM steaks from fed mature cows in a near linear manner. These WBSF values suggest that shorter aging periods (7 and 14 days) would result in steaks that are considered "slightly tough" and continuing the aging period to 28 days would result in steaks that would be considered "slightly tender." Therefore, other postmortem tenderization techniques such as blade tenderization and enzymatic tenderization might also be used in combination with aging to assure LM tenderness.

Implications

Aging LM steaks from mature cows to 28 days improves tenderness, but other postmortem mechanical or enhancement strategies may provide additional assurance of improved tenderness.

Table 1. Day of aging means for Warner-Bratzler shear force (WBSF) and cooking loss for longissimus muscle steaks

	Aging (days)					
Trait	7	14	21	28	SE	P-value
WBSF, lb	11.9[a]	11.1[b]	10.0[c]	9.3[d]	0.27	<0.01
Cooking loss, %	25.0	25.3	25.1	25.1	0.56	0.99

[abcd] Within a row, means without a common superscript letter differ (P<0.05).

Needle-Free Injection Enhancement of Beef Improves Tenderness but Slightly Increases Microbial Translocation

A. Sutterfield, R. K. Phebus, B. A. Crow, M. E. Dikeman, J. P. Grobbel, and L. Hollis

Introduction

Blade tenderization has been used for decades to increase tenderness in beef cuts that are highly variable in tenderness or predicted to be "tough." Injection enhancement also is commonly used in industry to increase tenderness, juiciness, and flavor of some beef muscles. These processes have the potential to translocate microbial organisms on the exterior to interior portions of whole muscles. One research study reported that 3 to 4% of surface bacteria are transferred into the interior of muscles but only penetrate an average of ¼ inch deep into the surface. Even though the frequency of subprimal surfaces being contaminated with pathogens is low, translocation of these contaminants into the interior of subprimals by tenderization or injection procedures poses a public health risk. Microbial contamination on beef surfaces generally is eliminated during typical cooking; however, given the low infectious doses of pathogens such as *Escherichia coli* O157:H7, internalized contamination may survive if adequate temperatures are not reached at the center of cuts (i.e., rare and medium rare endpoints) and lead to illness. Industry groups have developed a guide, *Best Practices: Pathogen Control During Tenderizing/Enhancing of Whole Muscle Cuts* to minimize any hazard that may be present with such technologies.

Although needle injection enhancement currently is common in beef processing, there may be alternative, safer, or more effective means to apply these technologies. One potential method involves utilizing an air-pressured needle-free injection system similar to an instrument currently being investigated for use in vaccinating cattle. In theory, eliminating the need for physical penetration of the muscle with a needle-free instrument using air-pressure fluid streams would reduce the translocation of surface microbial contamination to the interior and would additionally minimize carryover contamination from subprimal to subprimal during continuous injection operations. Therefore, we investigated use of needle-free injection enhancement as an alternative strategy to needle injection enhancement. Our objectives were to determine the safety and efficacy of using needle-free injection for enhancing beef muscles and the application of needle-free injection enhancement for improving beef quality.

Experimental Procedures

We determined from a preliminary study that the optimal air pressure for needle-free injection enhancement was 25 lb/in.^{2} based on dispersion, visual acceptability, and penetration level. We also determined that needle-free injections should be made 0.32 in. apart in a grid pattern, by using a plexiglass template, to attain the same injection enhancement volume/weight retention as needle injection enhancement. Needles in the needle injector were spaced 0.7 × 1.0 in. apart in a staggered pattern.

Beef longissimus muscles (N = 15) from USDA Select, A-maturity carcasses were obtained from a commercial abattoir at 2 days postmortem and transported to the Kansas State University Meat Laboratory and stored at 34°F until 9 days postmortem. Fat was trimmed to ⅛ in., and each loin was halved and randomly assigned to one of two treatments: (1) needle injected (Model N30, Wolftec Inc., Werther, Germany) or (2) needle-free injected (Pulse Needle-Free Systems, Lenexa, KS).

A nonpathogenic generic *E. coli* strain (ATCC number 25922, MicroBiologics, St. Cloud, MN) grown in tryptic soy broth was used to make a master (test) inoculum providing 10^9 CFU/mL. Each of the two matching loin halves was inoculated to a target level of 10^{5-6} CFU/cm^2 on the fat side of the meat. Loins were allowed to sit inside the inoculation chamber for 10 minutes, removed, and *E. coli* was allowed to attach for 1 hour at 50°F. Once *E. coli* had attached, surface samples were taken by excising two samples, 2 in. in diameter by ⅛ in. deep, from the surface on opposite ends of each loin half and plated on *E. coli*/coliform (ECC) Petrifilm (3M Corporation). The plates were incubated at 95°F for 24 hours and then enumerated. The experiment was replicated on three separate days.

Matching loin halves were then injection enhanced on the inoculated (fat side) side with needle or needle-free injection. Injection was set to achieve a desired pump yield of 12%. A solution of water, salt (0.3%), phosphate (0.3%), and potassium lactate (1.5%) (Brifisol 85 Instant, BK Giulini Corp., Simi Valley, CA) was used for injection enhancement.

After being injected, loins were drained for 1 hour, and two 2-in. diameter cores were taken aseptically cross-sectionally from each loin half to represent the entire thickness of the loin. Both cores were set with the inoculated surface facing downward on a sanitized tray and placed in the freezer at 24°F for 1 hour. Cores were then removed from the freezer, and slices were taken beginning at the inoculated side of the surface and at the defined depths of 0.4, 1.2, and 2.0 in. across the muscle fibers by using sterile techniques.

Fifteen additional loins of similar quality were injection enhanced by using the same procedure described previously. Three steaks (1-in. thick) were cut from the anterior end of each muscle section. Two of these steaks were placed in separate foam trays and covered with polyvinyl chloride film for simulated retail color display. The remaining steak from each muscle section was vacuum packaged and stored at 35°F for 4 days until cooked and measured for slice shear force.

Steaks for visual color evaluation were displayed under continuous fluorescent lighting for 5 days at 35°F. Trained visual color panelists (n = 8) evaluated display color and surface discoloration daily. The color scale used by panelists was: 1 = very bright red, 2 = bright red, 3 = dull red, 4 = slightly dark red, 5 = slightly dark red or reddish tan, 6 = moderately dark red to tannish red, and 7 = tan to brown. Also on days 1 to 5, discoloration scores were considered as a percentage of surface metmyoglobin with the following scale: 1 = none (0%), 2 = slight discoloration (1-19%), 3 = small discoloration (20-39%), 4 = modest discoloration (40-59%), 5 = moderate discoloration (60-79%), 6 = extensive discoloration (80-99%), and 7 = total discoloration (100%).

On day 13 postmortem, steaks were taken from the 35°F storage environment and cooked in a forced-air convection oven at 320°F to an internal temperature of 158°F for longissimus slice shear force measurements. Within 2 minutes after cooking, a 0.40-in.-thick, 2-in.-long slice was removed from the lateral end of each steak parallel to the muscle fibers. The slice was sheared perpendicular to the muscle fibers by using an Instron Universal Testing Machine with a flat, blunt-end blade and a crosshead speed of 0.33 in./second. Peak shear force was recorded in pounds.

Statistical Analysis

Microbiology data were analyzed as a split-plot design by using the MIXED procedure of SAS. Fisher's least significant difference was used to determine differences among bacterial populations at the different depths. Significance was determined at probability values of $P<0.05$. Display color and slice shear force data were analyzed as a split-plot design by using the MIXED procedure. Fisher's least significant difference was used to determine differences between treatments. Significance was determined at probability values of $P<0.05$.

Results and Discussion

There was a difference in generic *E. coli* counts among depths ($P<0.001$) in both treatments. Figure 1 shows the distinct difference between surface, 0.4-in., 1.2-in. and 2.0-in. samples. The tendency of *E. coli* counts to increase from the depth of 0.4 and 1.2 in. to 2.0 in. could be due to artificial contamination introduced when brine pooled on the table surface during injections.

E. coli counts were higher ($P<0.001$) for needle-free injections than for needle injections (Figure 2). The closer spacing between injection sites provided for a greater number of penetrations in needle-free injected loins, which could account for this increase. Also, the use of air pressure could have caused the inoculum to be pushed further into the loin.

There was a significant ($P<0.001$) day by depth interaction in which the lowest microbial counts occurred for depths of 0.4, 1.2, and 2.0 in. on day 1 (Figure 3). The depth of 1.2 in. consistently had the lowest microbial counts on all three respective days. There were no differences between depths of 0.4 and 2.0 in. on days 2 and 3. The surface enumerations were at least double those of all depths on all days.

There was a treatment by depth interaction trend ($P<0.06$). Lowest microbial counts were found at depths of 1.2 and 2.0 in. with needle injection (Figure 4). The needle-free injection at 1.2 in. had similar microbial counts to needle injection at 2.0 in. There was no difference between 0.4 and 2.0 in. for both needle-free and needle injection. The surface was different than all depths for both treatments.

Relative to microbial data generated, the novel, first generation system that we used was not optimized to control microbial cross-contamination during sample preparation because an injection template was used to apply a series of single injections across the loin surface, and the number of penetrations per surface area of the needle-free and needle systems were not equivalent. Therefore, it is likely that additional development of

a needle-free injection system could be accomplished to reduce microbial contamination during operation.

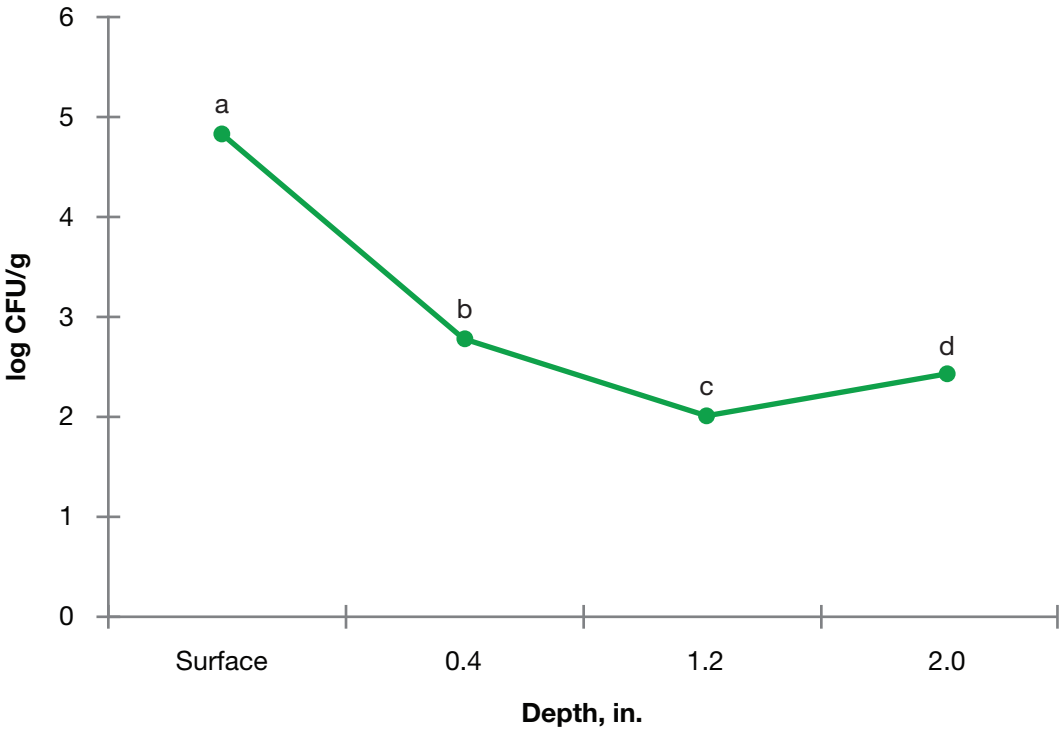
Pump yields were designed to be similar for both treatments so that differences in color and tenderness between treatments would not be a result of differing amounts of enhancement solution in the muscle. Average yields for needle-free and needle injection were 14.73 and 14.05%, respectively.

Steaks from both treatments became darker ($P<0.001$) as day of display increased, as expected. There was a treatment by day interaction ($P<0.05$) for visual color (Figure 5) in which needle injected steaks were darker on day 1 of display but not after day 1. There was no significant treatment or treatment by day interaction ($P>0.05$) effect for discoloration scores (data not shown). As expected, discoloration scores indicated that steaks from both treatments had increasing amounts of discoloration as day of display increased ($P<0.001$). Our results suggest that needle-free treatment improved visual color on day 1, but there were no differences between treatments for the remaining days of display.

Longissimus slice shear force values indicate that all steaks were tender, but steaks from loins that had been injected by using the needle-free technology were more tender ($P<0.05$) than those from loins that had been injected with the traditional needle injector (Table 1). Given the closer spacing of needle-free injection sites and application of injection from both sides, this increased mechanical tenderization is no surprise. However, the difference in appearance of muscle structure between steaks from the two treatments was virtually unnoticeable at the 25 psi setting that was used.

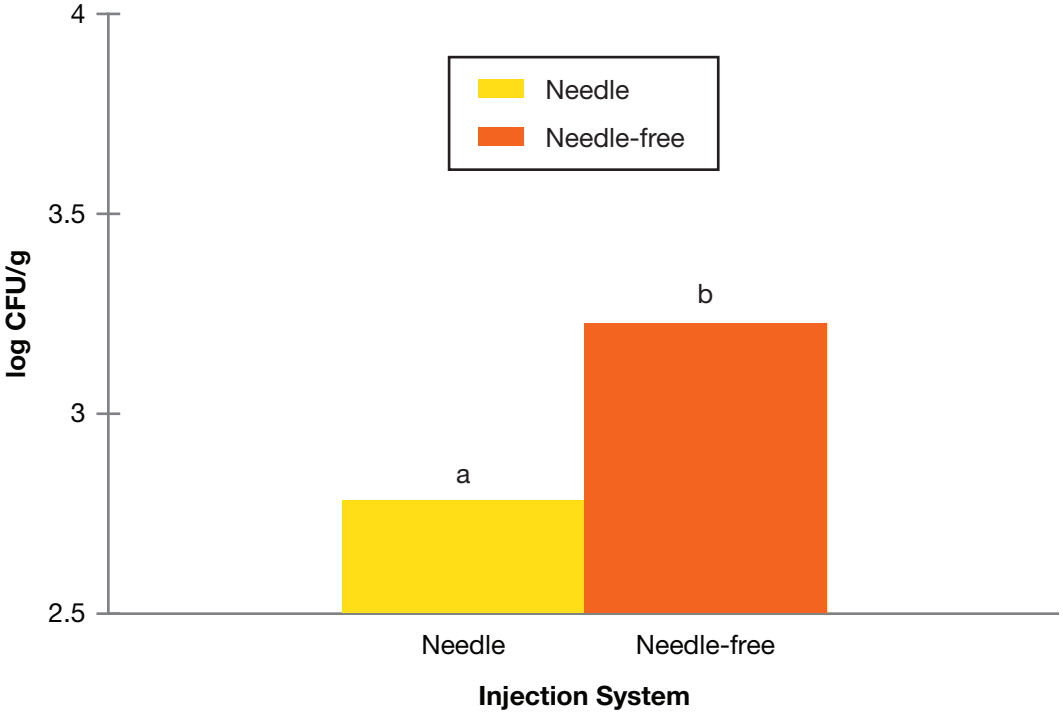
Implications

Our prototype needle-free injection enhancement system might be expected to slightly increase microbial translocation into the muscle interior by as much as 0.5 log10 CFU/g compared with needle injection but improve tenderness compared with needle controls and have no effect on color display life.



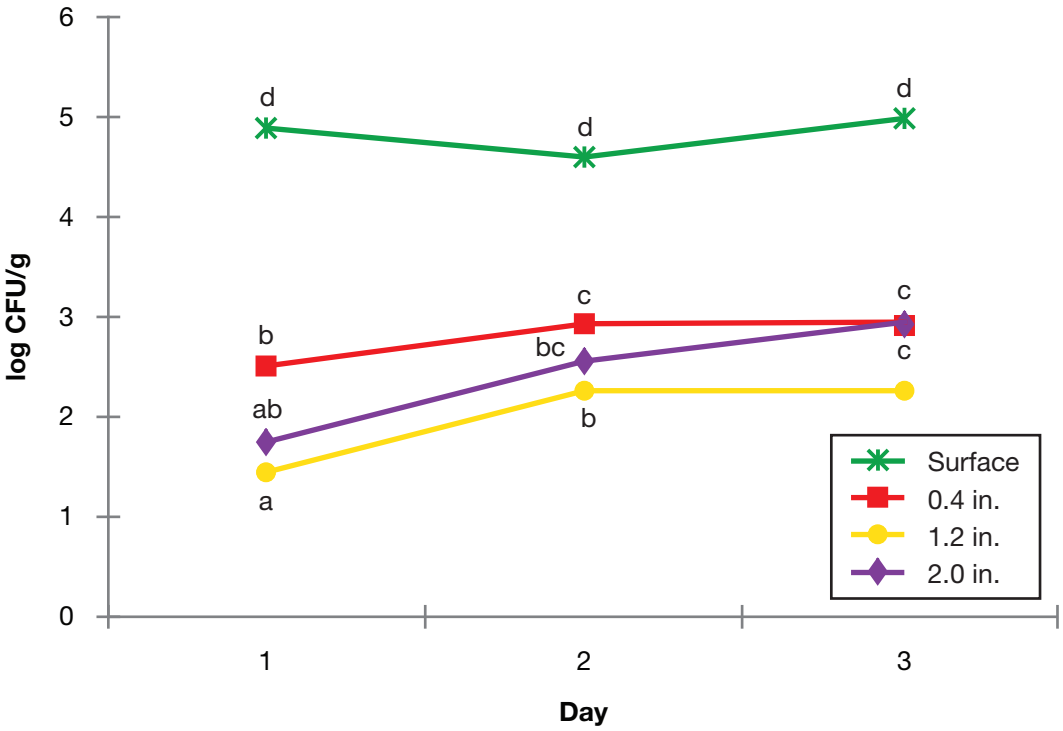
[abcd] Means with a different letter differ (P<0.05).

Figure 1. Average log CFU/g of generic *E. coli* on the inoculated surface and at depths of 0.40, 1.2, and 2.0 in. in beef longissimus enhanced by using needle and needle-free injection systems (pooled data).



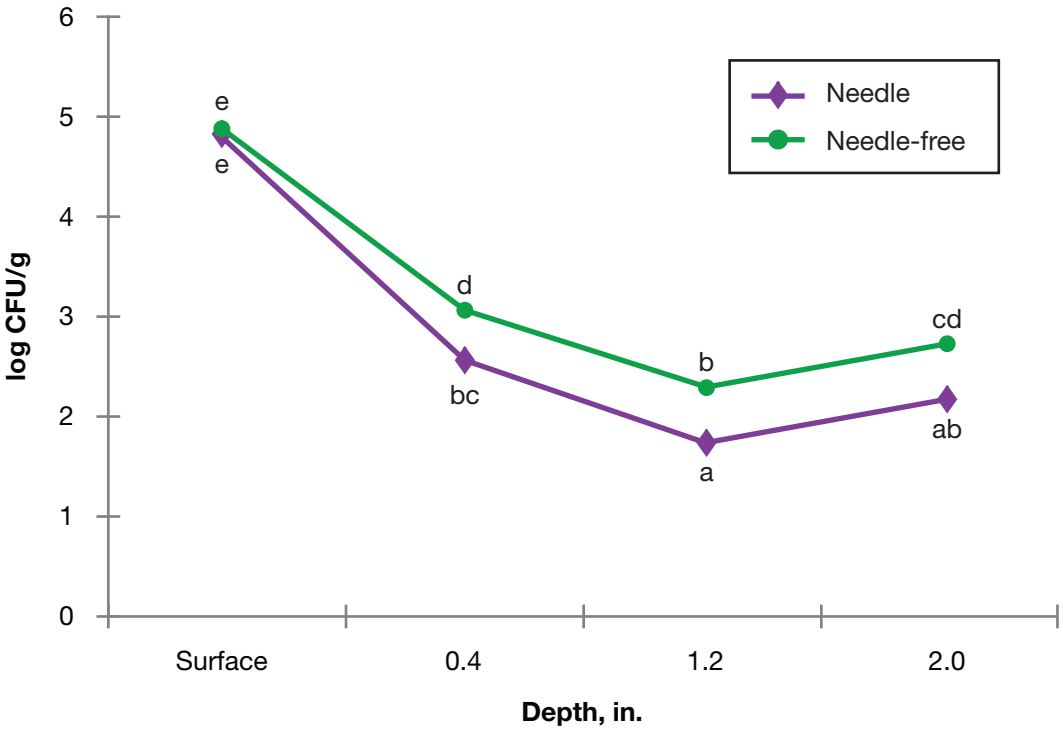
[ab] Means with a different letter differ (P<0.05).

Figure 2. Average log CFU/g of generic *E. coli* for needle or needle-free injection sytems used to enhance beef longissimus.



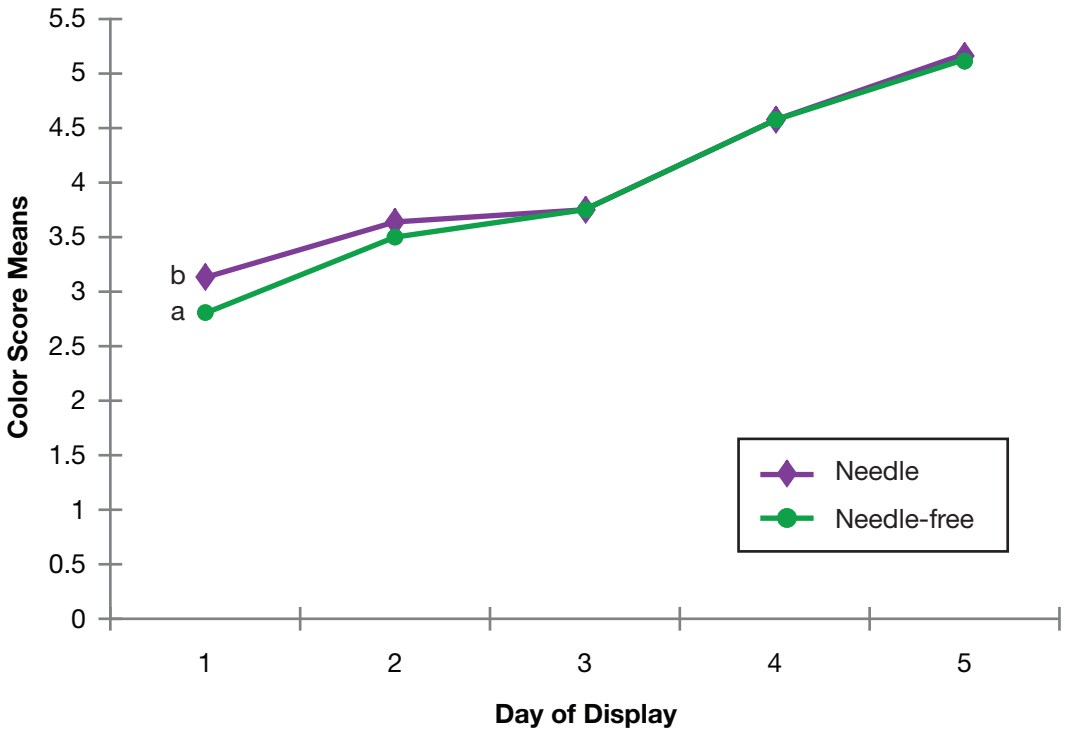
[abcd] Means with a different letter differ (P<0.05).

Figure 3. Mean log CFU/g depth by day (replication) interaction for needle or needle-free injection (pooled data) used to enhance beef longissimus.



[abcde] Means with a different letter differ (P<0.05).

Figure 4. Average log CFU/g of generic *E. coli* for needle and needle-free injection systems at the inoculated surface and at depths of 0.40, 1.2, and 2.0 in. in enhanced beef longissimus.



[ab] Means with a different letter differ (P<0.05).

Figure 5. Color score means for injection method by day of refrigerated display of beef longissimus enhanced by using needle or needle-free injection systems.
Display color score means scale: 1 = very bright red, 2 = bright red, 3 = dull red, 4 = slightly dark red, 5 = slightly dark red or reddish tan, 6 = moderately dark red to tannish red, 7 = tan to brown.

Table 1. Slice shear force values for beef longissimus enhanced by using needle or needle-free injection systems

Treatment	Shear values	SE
Needle-free	7.72[a]	0.70
Needle	10.08[b]	0.70

[ab] Within a column, means with a different superscript letter differ (P<0.05).

Near-Infrared Tissue Oximetry of Beef Longissimus Muscle for the Improvement of Meat Color and Meat Color Stability

A. Mohan, M. C. Hunt, T. A. Houser, and T. E. Barstow[1]

Introduction

Meat color as perceived by consumers serves as a valuable guide for assessing overall quality and wholesomeness of meat. The bright cherry-red color of beef is influenced by tissue oxygen consumption, obstacles to oxygen diffusion, and thickness of the oxymyoglobin layer. The dynamics of meat color depend on several physical properties of muscle including myoglobin redox status and concentration. Physical, chemical, and anatomical differences in muscles cause large variations in color from cut to cut, within a cut, and in cuts made parallel or perpendicular to muscle fibers. Clearly, muscle fiber orientation affects measurements of tenderness and cooking yields; however, variations in myoglobin redox dynamics, oxygen penetration, and color stability due to muscle fiber orientation (parallel or perpendicular) are not well documented. Among the various meat color measurement techniques available, near-infrared (NIR) methods have the advantages of being nondestructive, rapid, inexpensive, and adaptable for online measurements.

The NIR tissue oximeter is a relatively new biomedical device that has been used in exercise physiology and in medicine to measure hemoglobin and myoglobin oxygen saturation in brain tissue and cardiac and skeletal muscle. This instrument seems to have promise for use in measuring inherent properties of meat that are related to meat color stability. NIR tissue oximetry may provide continuous real-time measurements of changes in myoglobin oxygen status, thus providing information on tissue oxygenation and hemodynamics. The unique feature of the tissue oximeter is that it uses the theory of photon migration through tissue, allowing for absolute measurement of absorption in, for example, human or animal tissue. If the NIR absorption properties of any chromophore are known, quantitative analysis of color compounds is possible without constant calibration and validation. We are not aware of any research in which NIR tissue oximetry has been used to evaluate color of post-rigor meat.

This study was designed to evaluate whether NIR tissue oximetry has promise for measuring meat properties related to meat color. Specific objectives were to determine: (1) effects of parallel vs. perpendicular muscle fiber orientation of meat cuts on NIR measurements, (2) amounts of deoxymyoglobin (DMb), oxymyoglobin (OMb), and total myoglobin (TMb) in the superficial and subsurface layers of beef muscle (longissimus) stored in several packaging formats, and (3) tissue oximeter responses to post-rigor muscle fiber orientation and surface measures of color.

Experimental Procedures

The longissimus lumborum from three beef loins (USDA Select, A-maturity) were fabricated at 10 days postmortem into steaks about 2 × 3 × 4 in. with the fiber orientation

[1] Kansas State University Department of Kinesiology

either perpendicular (PR) or parallel (PL) to a designated muscle surface. Steaks were assigned to four packaging treatments: (1) vacuum packaging (VP), (2) high-oxygen modified atmosphere packaging (HiOx; 80% O_2, 20% CO_2), (3) polyvinyl-chloride film overwrap (PVC; 21,700 cc $O_2/m^2/24$ hour), and (4) HiOx that was converted to PVC after day 2 for subsequent storage in PVC (HiOx-PVC). Steaks were stored in the dark at 36°F for 0, 2, 4, 10, and 15 days, and color of the meat surface was measured after each storage time. Hue angle and chroma were calculated. Tissue oximetry (Figure 1) of the steaks was used to determine the surface and subsurface myoglobin redox status by using an NIR system (OxiplexTS model 96208, ISS Inc., Champaign, IL). The device works by emitting NIR light into tissue at known distances from a collector. This NIR spectrum can penetrate skin, subcutaneous fat/skull, and underlying muscle and is absorbed and scattered within the tissue. Light of two different wavelengths (692 and 834 nm) is used, and the light is modulated at a 110 MHz frequency. Collected light is measured and processed, and the absorption and scattering coefficients of the medium are determined. The assumption is that myoglobin is the only significant absorber of selected wavelengths in muscle and the OMb and DMb concentrations can be quantitated. Data were statistically analyzed by using type-3 tests of fixed effects of the MIXED procedure of SAS. F-test denominator degrees of freedom were estimated by using the Satterthwaite adjustment, and least squares means for significant F-tests were separated by using least significant differences.

Results and Discussion

Figure 2 shows a fiber orientation × packaging interaction ($P<0.05$) of NIR tissue oximeter response for percentages of OMb, DMb, and TMb. Steaks cut perpendicular to the fiber orientation and packaged in HiOx contained 65% OMb, whereas those packaged in HiOx-PVC had 60% OMb (Figure 2A) compared with steaks cut parallel to the fiber orientation ($P<0.05$). An opposite trend for fiber orientation effects was observed for DMb (Figure 2B). The TMb concentration did not differ ($P>0.05$) among steaks cut PR and PL, except for steaks packaged in HiOx-PVC (Figure 2C).

There was a fiber orientation × packaging × day interaction ($P<0.05$) for percentages of OMb and DMb in the four packaging formats (Figure 3). As expected at day 0, OMb percentages of steaks cut PR and PL (Figure 3A) and packaged in VP, PVC, and HiOx and HiOx-PVC were less than 5%, 7%, and 28%, respectively. By day 2, OMb dramatically increased to 78% in HiOx and HiOx-PVC packaged steaks cut either PR or PL, whereas steaks in PVC and VP had 48% and <5% OMb regardless of their fiber orientation. On day 10, OMb level increased to 90% in steaks cut PR and packaged in HiOx but remained the same in steaks cut PR and packaged in HiOx-PVC. However, OMb in steaks cut PL declined to 71% in HiOx and 66% in HiOx-PVC and did not change in steaks cut either PR or PL and packaged in PVC and VP. By day 15, OMb percentage declined further in all aerobic packages and increased slightly in the VP. Levels of DMb (Figure 3B) followed an opposite pattern; however, in general, steaks cut PR had lower percentages of DMb compared with steaks cut PL and packaged in HiOx and HiOx-PVC.

These data clearly demonstrate that fiber orientation affected NIR measurements of myoglobin oxygen status in aerobic packaging formats. Changes in myoglobin redox forms due to fiber orientation, packaging, and postmortem storage altered NIR quantitative measurements of myoglobin pigment forms that were expected from the treatment

combinations. There was a storage day × packaging interaction ($P<0.05$) of instrumental color (Figure 4). Steaks packaged in HiOx, HiOx-PVC, and PVC decreased ($P<0.05$) in a* (redness) and chroma (color intensity) as postmortem storage day advanced from day 0 to days 4, 10, and 15 (Figure 4B and 4E). On days 2 and 4, steaks packaged in HiOx and HiOx-PVC had greater redness intensity ($P<0.05$) than steaks packaged in PVC and VP. However, instrumental b* values decreased (less yellow) for steaks packaged in HiOx, HiOx-PVC, and PVC from days 0, 2, 4, and 10 to day 15 but remained unchanged in VP steaks (Figure 4C).

There were no significant change in muscle lightness (L* values) from days 0, 4, and 10 to day 15 (Figure 4A). Hue angles (overall color) increased for steaks packaged in VP from days 0, 2 and 4 and then decreased from day 10 to 15 ($P<0.05$) (Figure 4D). Differences among HiOx, HiOx-PVC, PVC, and VP were evident on day 15. These color measurements would be expected considering the redox forms of myoglobin present in the packages.

Implications

NIR tissue oximetry measurements have potential for rapid, real-time, and noninvasive assessment of color stability differences between muscles packaged in a variety of packaging formats. However, to obtain a repeatable measurement on post-rigor muscles, fiber orientation, tissue oxygen exposure, and storage time must be controlled.

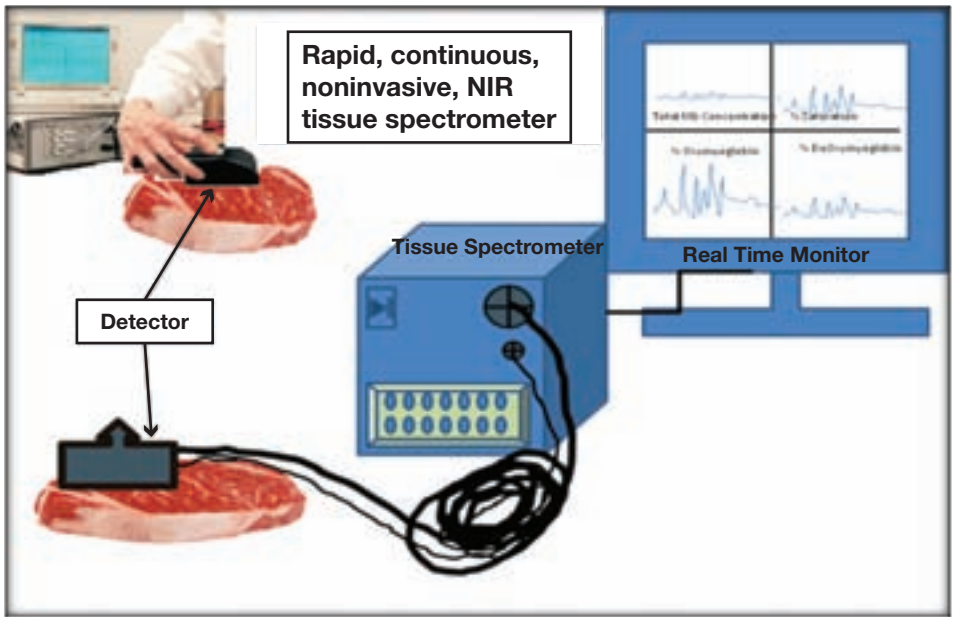


Figure 1. Diagrammatic representation of measuring meat properties by using a near-infrared tissue oximeter.

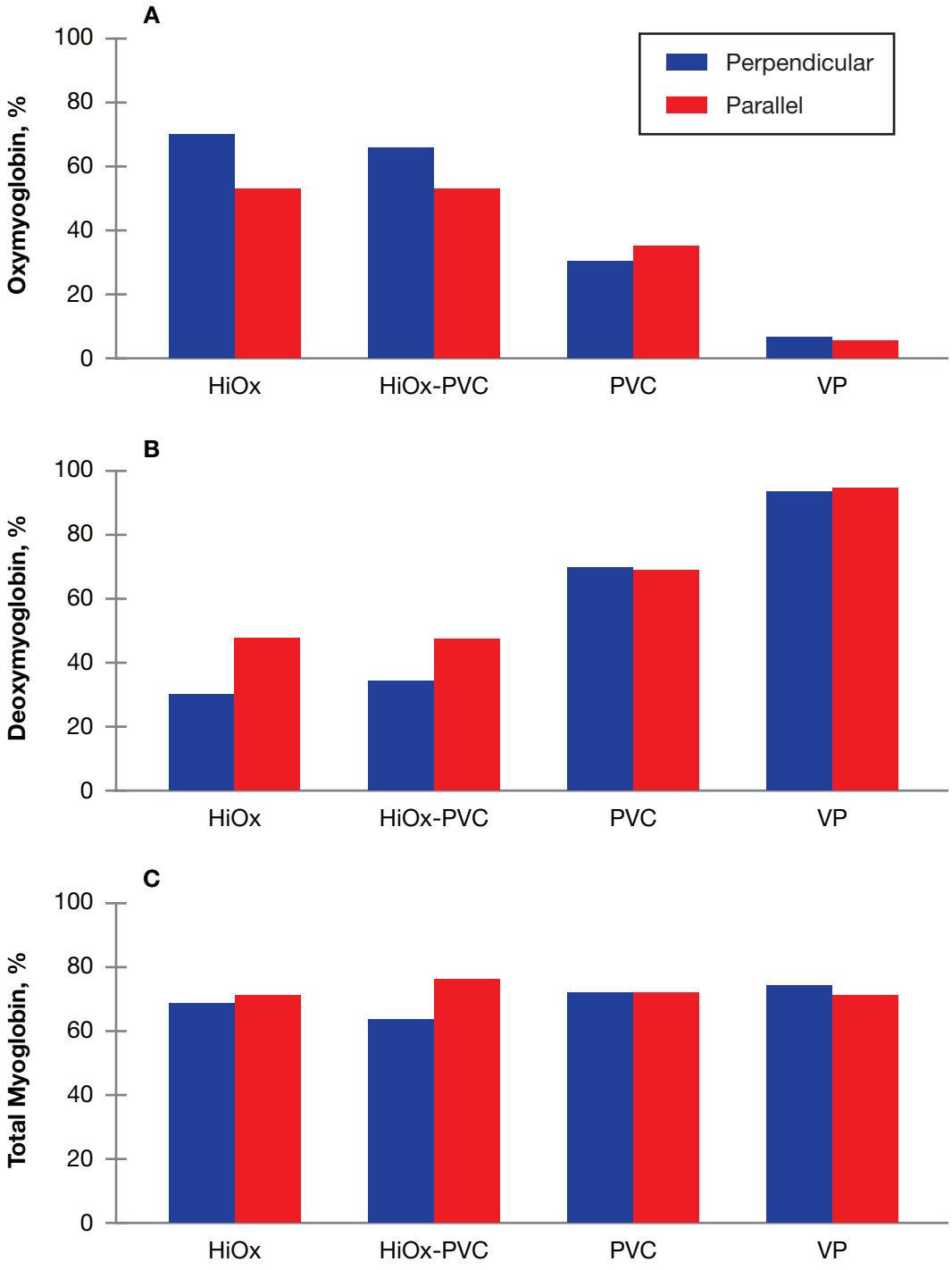


Figure 2. Fiber orientation × packaging interaction of near-infrared tissue oximeter for percentage of (A) oxymyoglobin, (B) deoxymyoglobin, and (C) total myoglobin.

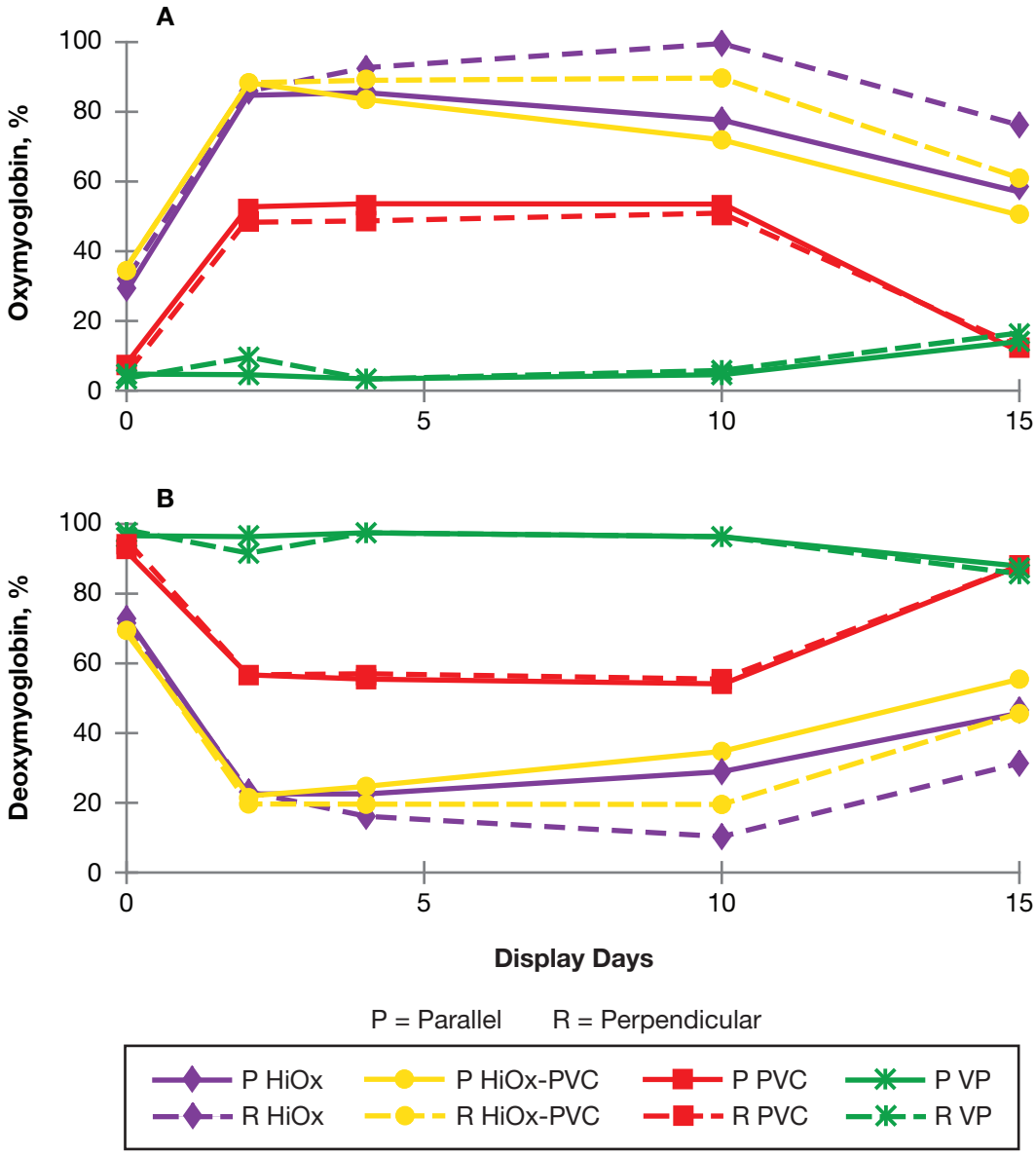


Figure 3. Packaging × day interaction of tissue oximeter response for (A) oxymyoglobin and (B) deoxymyoglobin.

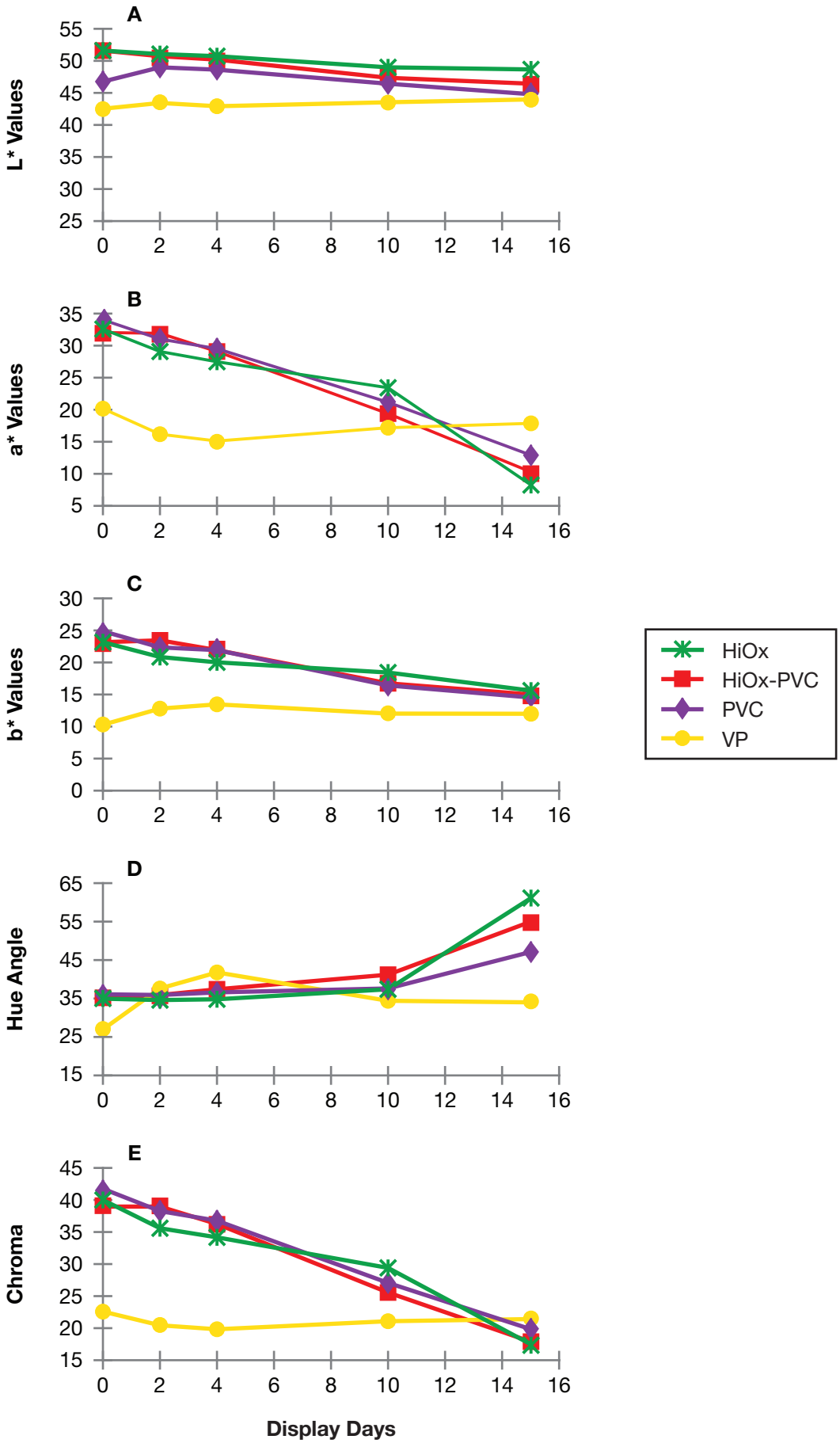


Figure 4. Storage day × packaging interaction for instrumental surface color.

Spotlight on Dry Aging Beef: Effects of Loin Type, Aging Methods, and Aging Time[1]

S. L. DeGeer, M. C. Hunt, C. L. Bratcher, B. A. Crozier-Dodson, D. E. Johnson, and J. F. Stika

Introduction

Dry aging is an old-time process used to produce a high quality beef product marketed to high-end customers. Its most unique quality is the distinctive dry-aged flavor. Dry aging has been accomplished through many protocols over the years, but an optimum protocol has not been adopted. Practitioners of this art are very interested in providing a consistent, quality, safe product.

Traditionally, dry aging is done without packaging, which places more emphasis on plant quality control practices to achieve a consistent product. This limits the number of processors that have the ability to produce dry-aged product. Packaging bags with a very high water vapor transmission rate that may simulate traditional dry aging are now available. If the quality from dry aging in these bags is equal to that obtained with the traditional unpackaged method, other processors might consider dry aging because this bag allows for less stringent facility needs and potentially greater yields. Overall, an in-the-bag dry-aging system would require fewer controls and still result in decreased weight losses, which would provide a significant yield advantage.

Objectives of this research were to determine the combined effects of two different dry-aging methods (unpackaged and in the bag), two loin-cut styles (bone-in shell loins and boneless strip loins), and two aging times (21 and 28 days) on flavor, juiciness, tenderness, palatability, development of the unique dry-aged flavor, moisture vapor loss, and microbial growth. An additional objective was to determine effects of vacuum packaging after dry aging on dry-aged flavor stability of steaks.

Experimental Procedures

Six pairs (both the left- and right-side loins from a carcass) of bone-in, Certified Angus Beef, strip shell loins (#175; NAMP, 1997) and six pairs of boneless, Certified Angus Beef, strip loins (#180; NAMP, 1997) were fabricated 2 days postmortem. Three additional pairs of bone-in and boneless loins were selected for determination of weight losses associated with dry aging.

Loins selected from carcasses that had normal bloomed beef color and absent of quality defects were vacuum packaged (Hollymatic Vacuum Packager, Hollymatic Corp., Countryside, IL), shipped to a dry-aging facility, and then stored at 37.4° F for a total of 9 days postmortem. Loins were then cut transversely at the midlength so that each pair provided four half-loin sections. No subcutaneous fat was trimmed prior to aging. These sections were each dry aged by one of two methods for one of two aging times.

[1] The authors thank Certified Angus Beef; MacPak, LLC; Buckhead Beef Foods Co.; and Tyson in Emporia, KS, for their support in this study.

One of eight treatment combinations (two cut styles × two aging methods × two aging times) were assigned randomly to the eight loin sections after 9 days of refrigerated storage. Sections assigned to unpackaged dry aging were aged on racks directly exposed to the environmental conditions in the dry-aging cooler. Sections assigned to the bag aging treatment were vacuum packaged in dry-aging bags (11.8 × 23.6 × 0.002 in.; thermoplastic elastomer made of flexible polymere and rigid polyamide; water vapor transmission rate 2500 g/m²/24 hours at 100.4° F and 50% relative humidity; MacPak, LLC, Wayzata, MN). These bags have a much greater than normal water vapor transmission rate, which facilitates a more efficient exchange of water vapor from product surface to the atmosphere, thereby simulating dry-aging conditions.

Samples were taken for pH, shear force, moisture, fat, protein, thiobarbituric acid-reactive substances (TBARS), microbial, and sensory analyses. Weight losses were measured throughout the drying process on additional loins and sample loins.

Results and Discussion

The loins selected had an expected pH and typical composition for more highly marbled cuts of the longissimus lumborum muscle. Tenderness, juiciness, mealiness, and Warner-Bratzler shear force did not differ ($P>0.05$) among the four cut style × aging method combinations (Table 1). Overall, aged beef flavor was higher for steaks from strip loins than for those from shell loins. In addition, brown roasted notes also tended ($P<0.08$) to be higher for steaks from the boneless loins. Thus, it appears that leaving the bone on the loin decreased flavor development, perhaps by limiting the loss of moisture during aging and reducing the "concentration" of flavor components. Differences between the other flavor traits were either not significant or small.

Perhaps noteworthy are the TBARS values, which are indicative of lipid oxidation. Less ($P<0.05$; data not shown) oxidation occurred in steaks from loins dry aged in the bag than in steaks from loins aged traditionally. However, the higher TBARS values did not seem to negatively affect sensory flavor. In fact, it appears that some lipid oxidation may be contributing to the development of dry-aged flavor.

Weight losses (Table 2) during dry aging were lowest ($P<0.05$) for shell loins in the bag, intermediate for shell loins aged traditionally, and highest for strip loins aged by either method. Weight loss differences for strip loins aged traditionally or in a bag approached significance ($P<0.1$). Apparently, bone removal from loins accentuates greater moisture movement because of greater exposed surface area, regardless of aging method. In addition, percentages of trim losses were greater for strip loins than for shell loins. Use of bone-in, shell-style loins would have economic advantages over boneless product; however, additional trimming must be done by consumers. Weight losses during cooking for steaks from loins aged in the bag were 2 to 3% more than those for traditionally aged steaks.

Weight loss on whole dry-aged loins increased as aging time increased (Figure 1). Weight loss during dry aging is expected and likely associated with development of many dry-aged traits. However, controlling weight loss is also an important economic factor. These data show that aging in a bag that is highly permeable to moisture vapor significantly reduced weight losses yet produced product with dry-aged sensory properties

similar to those of a product dry aged traditionally. In addition, dry aging in a bag would provide processors with more process control, which could have important economic ramifications.

Initial aerobic plate counts for selected loins were similar ($P>0.05$; data not shown). *Escherichia coli* and coliforms were lower ($P<0.05$; data not shown) for shell loins than for boneless loins; however, none of the bacteria were pathogenic. Counts for yeasts, molds, and lactic acid bacteria were low and not different ($P>0.05$; data not shown) among treatment combinations. At the end of dry aging, aerobic plate counts were similar for three of the treatment combinations, whereas counts for shell loins aged in the bag were elevated (3×105 CFU/cm^2). No significant differences occurred for the other microbial traits at the end of dry aging.

Because dry-aged product must be stored before consumption, some steaks from all treatment combinations were vacuum packaged and stored post-dry aging for an additional 7 days. Tenderness, juiciness, and mealiness scores were not different among treatment combinations; however, mealiness scores were higher ($P<0.05$; data not shown) than those of steaks not stored in vacuum. Aged beef flavor was scored more uniformly across treatment combinations and did not differ between steaks from shell vs. strip loins. All other sensory trait scores were essentially the same as those of steaks not stored in vacuum. Thus, it appears that product dry aged traditionally or in a bag can be stored post-dry aging with negligible losses in palatability.

In general, there were few significant differences for many traits due to aging time; however, some important differences occurred. Aging for 28 days increased moisture and protein percentages (data not shown); however, this effect most likely was due to the greater lipid content (12 vs. 10%) of the cuts aged 21 vs. 28 days. Percentage of trim loss was greater ($P<0.05$) at 28 vs. 21 days, and the amount of aging losses was numerically greater at 28 days but was not significantly ($P>0.05$) different from that at 21 days.

The only sensory trait that differed ($P<0.05$) because of aging time was sourness, which was slightly higher at 21 vs. 28 days after 7 days of vacuum storage. Overall, it appears that aging for 28 days does not significantly increase unique dry-aged flavor components compared with aging for 21 days.

Implications

- Dry aging in a bag will produce dry-aged flavor and microbial growth equal to that achieved with traditional dry aging.
- Dry-aged product can be vacuum stored post-dry aging with negligible loss in palatability.
- Bone-in shell loins have higher yields of dry-aged product than boneless strip loins.
- Product dry aged for 21 days will have the same flavor profile but less weight loss than product dry aged for 28 days.

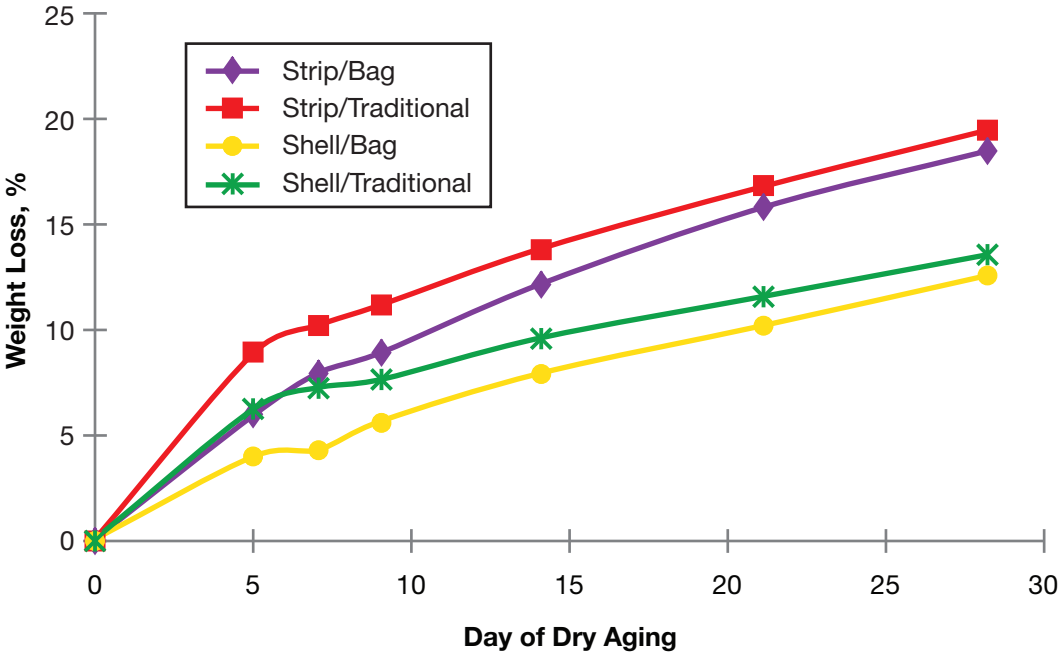


Figure 1. Weight loss throughout the aging process of beef shell and strip loins dry aged unpackaged or packaged in a bag with high moisture vapor permeability.

Table 1. Means for sensory traits[1] and WBSF[2] of steaks (end of dry aging) from beef shell and strip loins dry aged traditionally and in a bag

	Treatment combinations				
	Shell loin		Strip loin		
Trait	Traditional	Bag	Traditional	Bag	SEM[3]
Tenderness	8.5[a]	8.5[a]	9.1[a]	9.2[a]	0.28
Juiciness	5.4[a]	5.3[a]	5.7[a]	5.8[a]	0.22
Mealiness	1.0[a]	1.3[a]	1.0[a]	1.0[a]	0.15
Overall aged beef flavor intensity	6.8[b]	6.8[b]	7.4[a]	7.7[a]	0.18
Beef flavor intensity	10.5[b]	10.4[b]	10.9[ab]	11.1[a]	0.19
Brown roasted	10.4[c]	10.5[bc]	10.9[ab]	11.2[a]	0.17
Bloody serumy	5.3[a]	5.1[a]	5.2[a]	5.3[a]	0.16
Metallic	2.0[ab]	2.1[a]	1.9[b]	2.0[ab]	0.07
Astringent	1.9[a]	2.1[a]	1.9[a]	2.0[a]	0.06
Sweet	1.7[b]	1.6[b]	1.6[b]	1.8[a]	0.04
Salty	2.1[a]	2.1[a]	2.1[a]	2.2[a]	0.05
Sour	2.0[a]	2.0[a]	1.9[a]	2.0[a]	0.06
Bitter	2.2[b]	2.4[a]	2.3[ab]	2.3[ab]	0.06
WBSF, lb/ 0.5-in. core	6.8[a]	6.6[a]	5.9[a]	5.7[a]	0.16

1 Sensory traits were evaluated on a 15-point scale: 1 = lowest intensity and 15 = greatest intensity.
2 Warner-Bratzler shear force.
3 Standard error of the mean.
abc Within a row, means without a common superscript letter differ ($P<0.05$).

Table 2. Means for weight losses of beef shell and strip loins dry aged traditionally and in a bag

	Treatment combinations				
	Shell		Strip		
Trait	Traditional	Bag	Traditional	Bag	SEM[1]
Age loss[2], %	14.7[b]	11.1[c]	19.1[a]	17.5[a]	0.92
Trim loss[3], %	22.5[b]	23.5[b]	34.4[a]	34.1[a]	1.1
Cook loss[4], %	16.2[b]	18.3[a]	15.0[b]	18.4[a]	0.87

[1] Standard error of the mean.
[2] (Weight loss during aging/weight before aging) × 100.
[3] (Weight loss due to trimming/untrimmed weight) × 100.
[4] (Weight loss during cooking/weight before cooking) × 100.
[abc] Within a row, means without a common superscript letter differ ($P<0.05$).

Thermal Process with Additional Drying Provides Proper Lethality for Controlling Pathogens During Jerky Production

K. J. K. Getty, N. M. Harper, and E. A. E. Boyle

Introduction

The New Mexico Department of Health linked salmonellosis to beef jerky in 2003 after 26 individuals became ill; this prompted a recall of nearly 21,600 lb of product. Following this incident, the USDA's Food Safety and Inspection Service instituted the *Compliance Guideline for Meat and Poultry Jerky Produced by Small and Very Small Plants* in 2004 and updated this document in 2007 with the *Quick Guide on Jerky Processing*. The *Quick Guide* states that water activity for jerky products should be ≤ 0.85 for safety and a moisture-to-protein ratio (MPR) must be ≤ 0.75:1 for product to be labeled as jerky. Small meat processing businesses that produce jerky products must validate that their processes achieve a ≥ 5-log reduction of *Escherichia coli* O157:H7 and a ≥ 6.5-log reduction of *Salmonella* spp. Therefore, the objective of this study was to determine effects of a worst-case scenario thermal processing schedule on reducing *E. coli* O157:H7 and *Salmonella* spp. in chopped and formed beef jerky.

Experimental Procedures

Fresh chopped and formed all-beef jerky batter was obtained from a commercial processor. The product was separated into three 4-lb batches. Two treatments were studied: an *E. coli* O157:H7 five-strain inoculated batch and a *Salmonella* spp. five-strain inoculated batch. A control batch was also prepared with sterile deionized water added to simulate moisture added to the inoculated batches.

Raw jerky batter was extruded by using a manual jerky gun with a 0.25 × 1-in. jerky nozzle and placed onto polyscreen sheets with eight strips per sheet. A replication consisted of both inoculated batches and a control batch placed in the smokehouse simultaneously. Three replications were conducted. Once loaded, the smokehouse cart was placed in a commercial smokehouse and thermally processed (Table 1).

Raw inoculated samples were taken from the inoculated jerky batter. Heat-treated samples were taken at six different times (end of Stages 2, 3, 4, 5, after 30 minutes into Stage 6, and after 60 minutes into Stage 6; Table 1). Population levels of *E. coli* O157:H7 and *Salmonella* spp. were determined for both raw and heat-treated samples. In addition, heat-treated samples with counts below the detection limit were tested for a positive or negative level of either *E. coli* O157:H7 or *Salmonella* spp.

Water activity and fat, moisture, and protein content were analytically determined on non-inoculated control batches. Water activity samples were taken at the end of Stage 4, after 30 minutes into Stage 6, after 60 minutes into Stage 6, after 90 minutes into Stage 6, and at the end of Stage 6. Two ounces (two strips) from the end of Stages 4 and 6 were vacuum packaged and placed in frozen storage (-80° C) prior to analysis for fat, moisture, and protein content.

Results and Discussion

Initial levels of *E. coli* O157:H7 and *Salmonella* spp. populations from the inoculum were 8.5 and 8.1 log CFU/g. Raw inoculated batter averaged 6.2 log CFU/g for *E. coli* O157:H7 and 5.8 log CFU/g for *Salmonella* spp. (Table 2). *E. coli* O157:H7 populations ranged from 0.9 to 4.8 log CFU/g during Stages 2, 3, 4, 5, and 6, whereas *Salmonella* spp. populations ranged from 0 (no surviving bacteria) to 2.4 log CFU/g for the same stages. However, *E. coli* O157:H7 populations were reduced to 0.9 log CFU/g after 30 minutes into Stage 6 and 1.4 log CFU/g after 60 minutes into Stage 6. Although the worst-case scenario commercial thermal process met the ≥ 5.0 log CFU/g for *Salmonella* spp., a further drying step was needed for the necessary reduction of *E. coli* O157:H7.

Water activity at the end of the commercial thermal process (end of Stage 4) was 0.727 with a MPR of 1.27:1 (Table 3). Additional drying steps were needed to meet the MPR required by government regulations as well as for reduction of *E. coli* O157:H7. The additional drying began at 145 °F dry bulb with no injected relative humidity for 90 minutes followed by 170 °F dry bulb with 15% relative humidity for 120 minutes. At the end of the additional drying process, water activity was lowered to 0.600, whereas the MPR was only 0.815:1.

The worst-case commercial thermal process achieved the required 5 log reduction of *Salmonella* spp. but did not achieve the reduction standards for *E. coli* O157:H7. However, a ≥ 5.0 log CFU/g reduction of *E. coli* O157:H7 was achieved through a further drying process of 145 °F (no relative humidity) for 90 minutes. The additional drying did not achieve the MPR of ≤ 0.75:1 for jerky, so this product cannot be labeled as jerky. An even longer drying time would be needed to reduce moisture content to meet the MPR performance standard for jerky. However, the product may be labeled as a kippered beef product, which must have a MPR of ≤ 2.03:1.

Implications

A thermal process with additional drying for producing chopped and formed jerky provided proper lethality to control *E. coli* O157:H7 and *Salmonella* and, therefore, provides a process that will produce safe jerky for consumers.

Table 1. Worst-case scenario thermal processing schedule and sampling times for chopped and formed beef jerky

Stage	Dry bulb (°F)	Relative humidity[1] (%)	Blower speed[2]	Stage time	Sampling time
0[3]	–	–	–	–	Raw
1[4]	125	20	Medium	45	
2[4]	130	20	Medium	60	End of stage
3[4]	135	23	High	45	End of stage
4[4]	140	22	High	45	End of stage
5[5]	145	–	High	90	End of stage
6[5]	170	15	High	120	After 30 and 60 min into stage

1 The smokehouse has an automated damper system and exhaust damper and the ability to inject steam humidity as needed to control humidity.
2 Medium speed = 788.8 ± 52.7 ft/min and high speed = 1141.5 ± 111.9 ft/min.
3 Stage 0 = raw meat batter.
4 Commercial thermal process.
5Additional drying process.

Table 2. Means and standard errors of *Escherichia coli* O157:H7 and *Salmonella* spp. populations at seven sampling times during production of chopped and formed beef jerky

Stage[1]/ Sampling time	Pathogen population (log CFU/g)			
	E. coli O157:H7		*Salmonella* spp.	
	Mean	Standard error	Mean	Standard error
Raw	6.2[a]	0.07	5.8[b]	0.08
Stage 2[2]	4.8[b]	0.21	2.4[c]	0.36
Stage 3[2]	3.7[bc]	0.08	0.7[d]	0.23
Stage 4[2]	3.2[cd]	0.50	0[4e]	0.00
Stage 5[3]	2.1[de]	0.95	0[4e]	0.00
Stage 6 (30 min in)[3]	0.9[e]	0.44	0[4e]	0.00
Stage 6 (60 min in)[3]	1.4[e]	0.26	0[4e]	0.00

[1] Times and dry bulb smokehouse temperatures for thermal stages: Stage 2 – 45 min at 125°F and 60 min at 130°F, Stage 3 – 45 min at 125°F and 60 min at 130°F and 45 min at 135°F, Stage 4 – 45 min at 125°F and 60 min at 130°F and 45 min at 135°F and 45 min at 140°F, Stage 5 – 45 min at 125°F and 60 min at 130°F and 45 min at 135°F and 45 min at 140°F and 90 min at 145°F, Stage 6 – 45 min at 125°F and 60 min at 130°F and 45 min at 135°F and 45 min at 140°F and 90 min at 145°F and 120 min at 170°F.
[2] Commercial thermal process.
[3] Additional drying step.
[4] Denotes no *Salmonella* survived the process.
[abcde] Within a column, means without a common superscript letter differ (P<0.05).

Table 3. Water activity and proximate analysis means and standard deviations of control chopped and formed beef jerky at different sampling times for the commercial thermal process and additional drying processes

Stage	Water activity	Percent moisture	Percent protein	MPR[1]
End of Stage 4	0.727 ± .004	36.73 ± 0.91	23.46 ± 0.63	1.27:1
30 min into Stage 6	0.663 ± .026			
60 min into Stage 6	0.642 ± .035			
90 min into Stage 6	0.631 ± .031			
End of Stage 6	0.600 ± .020	19.64 ± 0.82	24.09 ± 0.75	0.815:1

[1]Moisture-to-protein ratio.

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