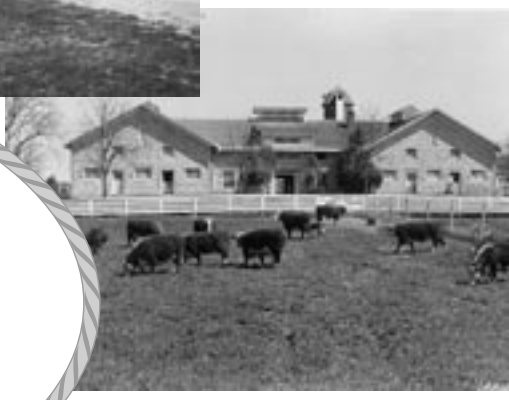
Beef Cattle Research

Animal Sciences and Industry Centennial

Celebrating 100 years of excellence in Animal Science



KANSAS STATE UNIVERSITY

CATTLEMEN'S DAY

2005



Report of Progress 943

Kansas State University
Agricultural Experiment Station
and Cooperative Extension Service

TABLE OF CONTENTS

REPRODUCTION

MEAT SCIENCE AND FOOD SAFETY

Contribution No. 05-144-S from the Kansas Agricultural Experiment Station.

A BRIEF HISTORY OF THE DEPARTMENT OF ANIMAL SCIENCES AND INDUSTRY AT KANSAS STATE UNIVERSITY

Miles McKee

The Department of Animal Sciences and Industry at Kansas State University celebrates its 100th anniversary this year. This review outlines some of the key historical moments in its development.

On February 9, 1858, a group of early Manhattan settlers received a charter from the legislative assembly of the Territory of Kansas for the formation of the Bluemont College Association. A cornerstone for a classroom was laid May 10, 1859, and classes started January 9, 1860. Finances apparently became a problem, and the Association offered to donate to the State of Kansas ". . . our College Building, Library, and apparatus, together with one hundred and twenty (120) acres, more or less, of land contiguous, as a College site." On February 19, 1863, the provisions of the Morrill Act were accepted, and the Kansas State Agricultural College was established on the site of Bluemont College at the northwest corner of Claflin Road and College Avenue. This was the first Land-Grant school chartered in the United States. Instruction at the College began September 2, 1863, with 52 students.

In April of 1871, the township of Manhattan, fearful that the State University at Lawrence was trying to take over the Agricultural College and make it a department of the University, voted $12,000 in bonds for the purchase of additional land for the farm. This bond money, and some legislative appropriations from 1870, were used by the Regents to purchase an additional 315 acres of land for the college. Included in the purchase was 155 acres adjoining the town site of Manhattan, which was approximately one mile east of the existing college. This acreage, known as the new campus, composes most of today's campus.

The legislature of 1872 appropriated $15,000 "- - to fence, improve and stock the state farm, and to develop the agricultural department of said college." Of this amount, $5,000 was set aside for the construction of a barn, the first building on the new campus.

The records of the June 4, 1873, Board of Regents meeting state, "Major Miller was authorized to purchase four head of three-year-old steers at five cents." These steers probably were used for research, as reported in the Eleventh Annual Report, issued in 1873, which states, "Experiments were conducted in feeding of cattle and the relative value of our native grasses for the purpose tested." The Fifth Biennial Report covering the years 1885 and 1886 reported that experimental work during the period tested corn meal versus corn-and-cob meal for beef making, corn-and-cob meal for fattening pigs, cooked versus raw corn for fattening pigs, pork production from one-half acre of alfalfa pasture, and the effect of cold versus warm water for milk cows. The next Biennial Report contained the following:

> "During the first week in September eighteen tons of sorghum were cut into inch length and packed away in the silo for use in the condition of 'ensilage'. Late in January the silo was opened, and the great mass of its contents found to be in good condition.

> The ensilage seemed to be relished by the stock, with few exceptions, and its consumption was attended with but little waste. Of course, no satisfactory conclusion can be drawn from a single, very limited trial, such as we were able to give ensilage last year. This fact, however, was very apparent from the first: that capital required for machinery, men and teams, in making ensilage, puts the system quite out of the reach of farmers in general."

The first purebred breeding animals purchased for the farm were selected by Regent J. K. Hudson and Major Miller in 1873, and included cattle, swine, and poultry. In September 1873, there was an additional "- - $2,210 appropriated for purchase of additional breeds of swine, cattle and poultry and the necessary outbuildings for them."

The day before commencement in 1886, the college held a public sale of stock. "The attendance was very large, the feeling excellent, and the bidding often spirited." Eight Shorthorn cows and heifers averaged $134.37, seven yearling bulls averaged $117.14, and four Jersey cows averaged $96.25. Professor Shelton, the Professor of Agriculture, was convinced the surplus stock should be sold in that way.

Final approval for the establishment of the Agriculture Experiment Station, using federal funds, was February 8, 1888. It should be pointed out, however, that the college had been doing research for 20 years before the federal funds became available.

In 1897, after several deaths from tuberculosis in the cattle herds over the previous 20 years, the Regents voted to have the entire herd tested with the newly discovered tuberculin. Confidence in the tuberculin test was low and administering it was very time consuming. All cattle were confined to the barn and their temperature taken every hour for three days before the injection of the tuberculin and every hour for three days after the injection. Fifteen reactors to the tuberculin were identified. They were subsequently driven into a trench and shot, and a public post mortem was conducted. All fifteen were full of tuberculosis lesions. The remaining purebred cattle, sheep, and hogs were sold one month later. The College was without purebred livestock until 1901, when the State Senate voted $10,000 to purchase cattle.

On July 10, 1901, the Board of Regents voted to divide the Farm Department into an Agricultural Department, composed of work in animal husbandry and crop production, and a Department of Dairying and Farmers' Institutes. In 1902, there was a further division to Department of Agriculture, now known as Agronomy, Department of Dairy and Animal Husbandry, and a Department of Dairying. September 27, 1905, the Regents established separate departments for dairy and for animal husbandry. The two departments remained separate until 1977, when dairy, poultry, and animal sciences were combined to form the Department of Animal Sciences and Industry.

Since its formation in 1905, the Department has had the following Heads: R. J. Kinzer, Wilbur A. Cochel, Charles W. McCampbell, A. D. "Dad" Weber, Rufus F. Cox, Don L. Good, and Jack G. Riley. In addition, President Henry J. Waters was acting head between Kinzer and Cochel. Janice E. Swanson became interim department head January 1, 2005.

The first competitive judging team to represent the College was a livestock team, coached by R. J. Kinzer, which judged at the International Livestock Show held in Chicago in November of 1903. First marking had the Kansas team winning, but six weeks later it was announced that, on a remarking, the team representing Iowa State had won the contest. At present, the Department sponsors seven judging teams. These teams and the year they

first competed are: Livestock, 1903; Dairy Cattle, 1908; Poultry, 1921; Dairy Products, 1926; Meats, 1927; Wool, 1950; and Horses, 1980.

The first Farmers' Institute was held in Manhattan, in conjunction with the Union Agricultural Society of Manhattan, on November 14, 1868. Institutes were held annually until 1874, when one of the speakers was critical of President Anderson. Annual Institutes were started again in 1880. Starting in 1881, Institutes were held in other sites as well as Manhattan. These "traveling" presentations were very popular, and reached a high point during the 1900-01 school year, when 156 were held. In 1906, these meetings were referred to as State Farmers Institutes. In 1915, the name changed to Farm and Home Week and was attended by both men and women. During the week, the different departments in Agriculture and Home Economics had a specific day to make their presentations. We do know that in 1919 the Animal Husbandry presentations were known as Livestock Feeders' Day. At some time Farm and Home Week ceased to exist, but Livestock Feeders' Day continued. In the beginning, discussions related to beef cattle, horses, sheep, and swine; over time, the various species groups started hosting their own species day. The beef cattle day became known as Feeders' Day. In 1973, Feeders' Day became Cattlemen's Day and was moved from May to the first Friday in March, a date that has continued.

The Agriculture departments were first housed in Anderson, moved to Fairchild in 1894 and to Holton in 1900. The Animal Husbandry Department moved to the east wing of Waters Hall in 1913 and to Weber Hall in 1957, which, with Call Hall, is the present home of the Department of Animal Sciences and Industry.

In 1923, an addition to the north end of East Waters, to be used for meats work, was completed. Animals were slaughtered in the new addition and there was a refrigerated room where carcasses could be hung. Animals to be slaughtered were penned across the street in the judging pavilion. Sheep were carried across the street for slaughter, hogs were walked across in a triangular construction of panels, and cattle were fitted with a halter that had a lead rope long enough to reach from the pen across the street to a heavy metal ring in the floor of the slaughter house.

Live radio broadcasts from the College were started February 11, 1924, through an arrangement with KFKB, a 5000-watt station at Milford, Kansas, which was owned by Dr. J. R. Brinkley. The program, known as "The College of the Air," offered five different courses, one of which was a course in livestock and dairy taught by members of the department. Students would enroll, ten weeks later take a test over the material presented and, if they received a satisfactory grade, were given a certificate of graduation. Because the station was so powerful, students enrolled from almost every state and Canada.

On March 5, 1931, the governor signed a bill that officially changed the name of the college from Kansas State Agricultural College to Kansas State College of Agriculture and Applied Science. March 27, 1959, the name was officially changed to Kansas State University of Agriculture and Applied Science. In more recent years, it has become Kansas State University.

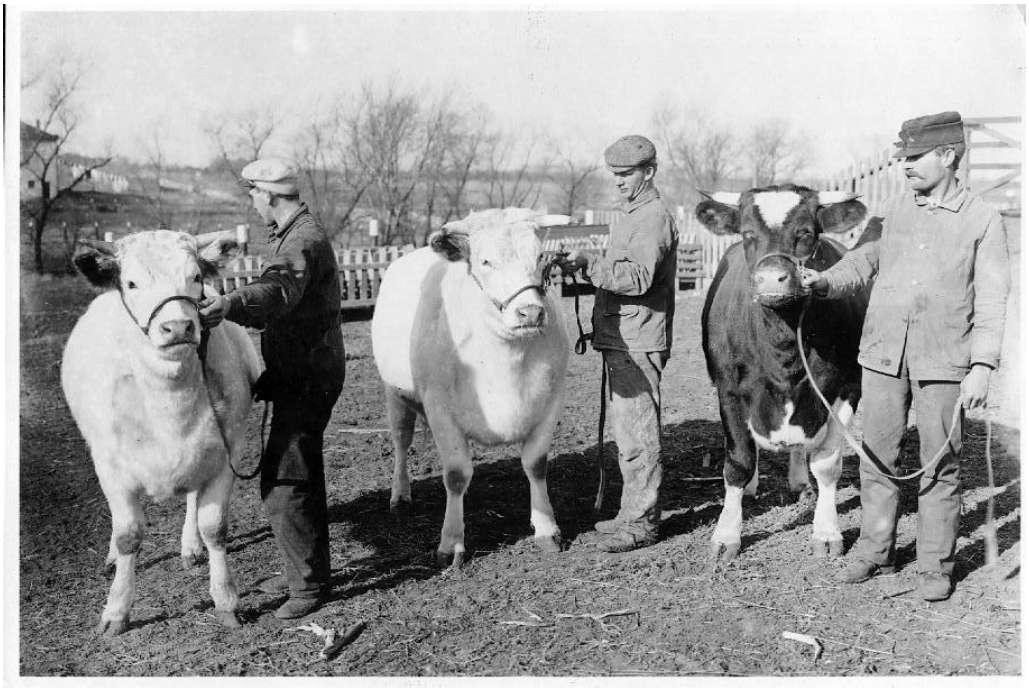
In 1947, President Milton S. Eisenhower requested funds from the state legislature to develop an artificial breeding program in Kansas for dairy cows. Land, housing, and bulls had to be secured. On January 2, 1950, the Kansas Artificial Breeding Unit, designed to serve the dairy industry, opened for business on land that was part of the original Bluemont College. Over the years, the unit, better known as KABSU, also began to service the beef industry. With the merger of departments in 1977, the unit became a part of the Depart-

ment of Animal Sciences and Industry. Today the unit is housed on Tuttle Creek Boulevard.

A tornado ravaged several of the barns and sheds used by the department on June 6, 1966. A group of concerned individuals formed the Livestock and Meat Industry Council (LMIC), designed to raise money and give industry support for the rebuilding of the facilities, future research projects, and other needs of the department. In 1971, this group sponsored a Stockman's' Dinner the evening before Livestock Feeders' Day at which Rufus Cox, former head of the department, was honored. No dinner was held in 1972, but since 1973 it has been an annual event. Starting with the 1975 dinner, an individual, couple, or family who has made a significant contribution to the livestock and meat industry has been honored.

The International Meat and Livestock Program, more commonly known as IMLP, was started in 1986 with funds provided by the state legislature. The charge was to help sell Kansas livestock and livestock products abroad and to help other countries with their livestock and meat production. Bill Able, the first director, traveled extensively the first year, with visits to Asia, South America, and Mexico, where he visited with government, business, and industry leaders about the new program and its availability. Short courses have been offered on campus for international students covering such areas as livestock production, meat and meat products, dairy herd management and product manufacturing, artificial insemination, embryo transfer, horse breeding, or any other related area requested by a country.

Today, the Department of Animal Sciences and Industry maintains purebred and commercial cattle, sheep, hogs, horses, and poultry. These animals are used for teaching and for research. In addition to Cattlemen's Day, there is also a Swine Day, a Sheep Day, and a Dairy Day. The latest research information is presented at these meetings.



Show Cattle – 1905

EFFECTS OF OPTAFLEXX™ ON FINISHING STEER PERFORMANCE AND USDA QUALITY AND YIELD GRADES

E. R. Loe, J. S. Drouillard, T. J. Klopfenstein[1], G. E. Erickson[1], and B. E. Dicke[2]

Summary

Crossbred yearling steers (2,015 head) were fed at a commercial feedyard near Larned, Kansas, to evaluate the effects of feeding Optaflexx™ at 0 or 200 mg ractopamine-HCl per steer daily for the final 29 days on feed. Steers were fed a common diet, based on steam-flaked corn, throughout their finishing period. Cattle that were fed Optaflexx™ had heavier final bodyweights (1264 vs. 1236 lb). Optaflexx™-fed cattle gained 17.9% faster (carcass adjusted basis) and tended to consume more feed during the last 29 days on feed. Feed efficiency was 14% better during the last 29 days for the Optaflexx™-fed steers. Feeding Optaflexx™ increased carcass weight by 19.7 lb and increased carcass weight gained during the last 29 days on feed by 11.2 lb. There were more liver abscesses for the control steers (19.7%) than for Optaflexx™-fed steers (13.5%). Quality grade was not affected by feeding Optaflexx™. There was a decrease in USDA Yield Grade 2 carcasses (49.6 vs. 54.8%) and an increase in USDA Yield Grade 4 carcasses (3.3 vs 1.7%) when cattle were fed Optaflexx™. Performance of the steers from the time that they were sorted into their treatment pens until slaughter (98 days) was improved by feeding Optaflexx™ during the last 29 days on feed. For the full 98-day period, daily gain was 8% greater for steers fed Optaflexx™ vs. control, feed intake was greater for the steers fed Optaflexx™, and feed efficiency was moderately improved (3.3%). Steers that received Optaflexx™ gained 6.4% more bodyweight during the 98-day feeding period. These data show that addition of Optaflexx™ into finishing diets fed to steers is beneficial, increasing bodyweight and carcass gain and improving conversion of feed to beef without affecting USDA quality grade.

Introduction

Within the last year, the U.S. Food and Drug Administration approved Optaflexx™ for addition to feedlot cattle diets during the final 28 to 42 days on feed. Optaflexx™ is the trade name for the compound ractopamine-HCl, a β-agonist that attaches to β-1 receptors located primarily on muscle fibers, stimulating muscle growth. Responses to Optaflexx™ have been measured as increases in live-weight gain, carcass weight gain, gain efficiency, and carcass yield. The present study was conducted to determine if these responses could be achieved under commercial cattle-feeding conditions.

Procedures

Two thousand fifteen yearling steers (891 lb reimplant bodyweight) were fed at a commercial feedyard near Larned, Kansas, to evaluate the effect on finishing performance and USDA Quality and Yield Grade of feeding Optaflexx™ for the last 29 days of the feeding period. Groups of cattle were sorted into their treatment pens at initial processing (six replications) or reimplantation (two replications). All cattle received a terminal

[1]University of Nebraska, Lincoln.
[2]Cattlemen's Nutritional Services.

implant (Component® TE-S with Tylan; average days on terminal implant was 92) the day they were sorted into their treatment pens. At reimplantation or initial processing, cattle were split into treatment groups on the basis of the order of processing, such that even-numbered cattle were placed into one group and odd-numbered cattle were placed into another. Each group had been pre-assigned to a treatment and pen. Cattle that were sorted into the Optaflexx™ group were given an eartag that was a different color and contained a different lot number than the eartags of the control cattle. The number of cattle within a pen ranged from 91 to 206 steers. There were eight replications of each treatment.

An average of 29 days before the projected slaughter date, cattle were removed from their pens and weighed as a group. Feeding Optaflexx™ started on this day and was continued until the cattle were shipped for slaughter. Diets (Table 1) were formulated to provide 0 or 200 mg per day of ractopamine-HCl (0 or 2 g/day of Optaflexx™) for control and Optaflexx™ groups, respectively. Feed additives, including Rumensin, Tylan, and Optaflexx™, were added by using a microingredient machine, and separate trucks were used for mixing and delivering each experimental diet to prevent the possibility of cross contamination. Throughout the experiment, cattle identified as sick were treated in accordance with standard operating procedures of the feedlot. Cattle identified as bullers were sorted and removed from the home pens and placed into a buller pen. Total weight of each pen was measured at 1) reimplant/initial processing time, 2) the start of Optaflexx™ feeding, and 3) immediately before shipping to a commercial slaughter facility in Emporia, Kansas.

Results and Discussion

Optaflexx™ was incorporated into the diets an average of 29 days before shipping the cattle to a commercial slaughter facility. The Optaflexx™ steers had slightly heavier initial bodyweights (1155 vs. 1142 lb for Optaflexx™ and control, respectively, Table 2) and had heavier final bodyweights, whether bodyweight was measured live or calculated as hot carcass weight divided by a common 63.5% dress. Optaflexx™ increased rate of gain by 17.9% (calculated using carcass weights). Even though the Optaflexx™-fed steers had a tendency for greater feed consumption during the last 29 days on feed, they had a 13.9% improvement in feed efficiency during that time. Bodyweight gain was 15.5 lb greater for Optaflexx™-fed cattle during Optaflexx™ feeding.

Table 1. Composition and Nutrient Content of Diet[a]

Item	% of Dry Matter
Steam-flaked corn	64.3
Distiller's grains	15.4
Haylage	5.5
Tallow	2.5
Liquid supplement	5.3
Dry supplement	7.0
Actual nutrient content, %	
Crude protein	15.2
Crude fat	7.5
Calcium	0.7
Phosphorus	0.6

[a]Diets fed were similar except that the Optaflexx™ diet contained 200 mg/steer daily of ractopamine-HCl (0 or 2 g/steer daily of Optaflexx™).

Optaflexx™ increased hot carcass weight 19.7 lb and total pounds of carcass accumulated 11.2 lb. Feeding Optaflexx™ did not influence dressing percentage. Control steers had a dressed yield of 63.9%, compared with 64.0% for Optaflexx™ steers. The incidence of liver abscesses was greater for control cattle than for those fed Optaflexx™. Quality grade was not affected by feeding Optaflexx™.

There was a decrease in the percentage of USDA Yield Grade 2 carcasses and an increase in percentage USDA Yield Grade 4 carcasses for cattle fed Optaflexx™.

There were 2,006 steers that finished the study. There were no cattle that died during the time that Optaflexx™ was fed. The only cattle that were removed from the study were buller steers. The incidence of bullers was not statistically different between treatments (6 for control and 3 for Optaflexx™).

The data from the last 29 days of the feeding period (the days that Optaflexx™ was fed) suggest that feeding 200 mg/steer daily of ractopamine-HCl enhanced performance of finishing steers. Overall performance (reimplant to slaughter, Table 4) was better for steers fed Optaflexx™. Calculated over a 98-day feeding period, Optaflexx™-fed steers gained 8% faster, also consuming 0.8 lb more feed daily, which led to a modest improvement in total finishing-period feed efficiency of 3.3%.

Incorporating Optaflexx™ into finishing diets in a commercial feedyard during the last 29 days on feed improved live-weight gain and gain efficiency similar to that claimed by the manufacturer. Furthermore, carcass quality grade was not affected by feeding Optaflexx™. These data show that dressing percentage was not affected by Optaflexx™. The carcasses of steers fed Optaflexx™ contained more fat than carcasses from steers not fed Optaflexx™. Optaflexx™ is an effective feed additive for improving steer performance when fed in commercial feedyards.

Table 2. Performance of Steers during Optaflexx™ Feeding (Last 29 Days on Feed)

Item	Control	Optaflexx™	SEM	P
Pens	8	8	–	–
Cattle started Optaflexx™ period	1003	1012	–	–
Cattle ended Optaflexx™ period	997	1009	–	–
Average days of Optaflexx™ feeding	29	29	–	–
Initial weight, lb	1141.9	1155.2	5.4	0.13
Final live weight, lb	1235.5	1264.3	6.4	0.02
Carcass-adjusted final weight, lb [a]	1242.7	1273.7	6.2	0.009
Daily gain, lb [b]	3.18	3.73	0.10	0.007
Carcass-adjusted daily gain, lb [c]	3.46	4.08	0.09	0.002
Live bodyweight gain, lb	93.6	109.1	2.6	0.004
Feed offered, lb/day [d]	20.9	21.7	0.3	0.07
Carcass-adjusted feed:gain [e]	6.02	5.29	–	0.001

[a]Hot carcass weight divided by a common 63.5% dress.
[b]Final live weight minus initial weight divided by days fed Optaflexx™.
[c]Carcass-adjusted final weight minus initial weight divided by days fed Optaflexx™.
[d]Average feed delivered (dry matter basis).
[e]Analyzed as carcass-adjusted gain:feed, with the inverse reported here as feed:gain. SEM for gain:feed was 1.8% of the average value.

Table 3. USDA Quality and Yield Grades of Steers Fed Optaflexx™ during the Last 29 Days on Feed

Item	Control	Optaflexx™	SEM	P
Pens	8	8	–	–
Cattle started Optaflexx™ period	1003	1012	–	–
Cattle ended Optaflexx™ period	997	1009	–	–
Average days of Optaflexx™ feeding	29	29	–	–
Hot carcass weight, lb	789.1	808.8	3.9	0.009
Hot carcass weight gain, lb [a]	64.1	75.3	1.4	<0.001
Dressing %	63.9	64.0	0.1	0.25
USDA Prime, %	0.3	0.3	0.2	0.97
USDA Choice, %	35.8	36.3	1.7	0.84
USDA Select, %	55.1	55.7	1.6	0.82
No roll, %	8.8	7.7	0.7	0.35
Dark carcasses, %	0.12	0.11	0.12	0.98
USDA Yield Grade 1, %	16.8	18.1	1.3	0.51
USDA Yield Grade 2, %	54.8	49.6	1.3	0.02
USDA Yield Grade 3, %	26.6	28.7	1.5	0.37
USDA Yield Grade 4, %	1.7	3.3	0.5	0.05
USDA Yield Grade 5, %	0.1	0.2	0.1	0.36
Liver abscesses, % [b]	19.7	13.5	1.5	0.04

[a]Hot carcass weight gain was calculated as hot carcass weight minus carcass weight at the beginning of the Optaflexx™ feeding period. Carcass weight at the beginning of the Optaflexx™ feeding period was estimated from live weight, assuming 4% shrink and a dressed yield of 63.5%.

[b]Only 5 pens from each treatment had liver abscess scores recorded.

Table 4. Performance of Steers from Initial Processing or Reimplantation to Harvest (Day 0 to 98) when Optaflexx™ Was Only Fed to Steers in the Optaflexx™ Treatment during the Last 29 Days on Feed

Item	Control	Optaflexx™	SEM	P
Number of pens	8	8	–	–
Average days on feed [a]	98	98	–	–
Arrival weight, lb	887.9	894.5	2.9	0.14
Final live weight, lb	1235.5	1264.3	6.4	0.02
Average daily gain, lb	3.48	3.75	0.05	0.008
Live body weight gain, lb	347.6	369.8	4.2	0.008
Feed offered, lb/day [b]	20.9	21.7	0.2	0.01
Feed:gain [c]	5.98	5.78	–	0.09

[a]Weighted average of total days on feed (range was 84 to 127).

[b]Average feed delivered (dry matter basis).

[c]Analyzed as carcass-adjusted gain:feed with the inverse reported here as feed:gain. SEM for gain:feed was 1.0% of the average value.

RESPONSE OF HEIFERS FED OPTAFLEXX™ TO SUPPLEMENTAL PROTEIN

D. K. Walker, E. C. Titgemeyer, J. S. Drouillard, E. R. Loe, B. E. Depenbusch, and A. S. Webb

Summary

An experiment was conducted to determine the relationship between metabolizable protein supply and feeding Optaflexx™ (ractopamine-HCl) on growth and carcass characteristics of feedlot heifers. Seventy-two crossbred heifers (initially weighing 1048 lb) were fed diets based on steam-flaked corn. Treatments were arranged as a 2 × 3 factorial and included: 0 or 2 grams per heifer daily of Optaflexx™ (0 or 200 mg/day ractopamine-HCl), and diets containing one of three different protein sources (urea, solvent soybean meal, and expeller soybean meal). Optaflexx™ was fed for the final 28 days before slaughter. Optaflexx™ improved daily gain, feed efficiency, carcass-adjusted daily gain, and carcass-adjusted feed efficiency. Responses in gain and efficiency based on final live weights were dependent on protein source; for heifers fed no Optaflexx™, performance was best with expeller soybean meal, whereas performance was best with urea-based diets when Optaflexx™ was added to diets. Gains and efficiencies based on carcass weights were not affected by dietary protein source. Final live weights were 20 lb greater and carcass weights were 15 lb greater when heifers were fed Optaflexx™. Carcass characteristics were impacted little by either Optaflexx™ or dietary protein source. It does not seem that dietary metabolizable protein supply needs to be increased from that of typical finishing diets to achieve maximum response to Optaflexx™.

Introduction

Optaflexx™ is a growth promotant that recently has been introduced to the market in the United States. Optaflexx™ is the trade name for ractopamine hydrochloride, a β_1 adrenergic agonist that can lead to marked alterations in metabolism that result in increased leanness and muscle accretion. Data on the response to feeding Optaflexx™ to finishing heifers are limited. The objectives of our study were to determine the impact of feeding Optaflexx™ to heifers for 28 days before slaughter and to determine if increasing the amount of metabolizable protein available to the heifers would improve their performance.

Procedures

Seventy-two crossbred heifers (1048 lb initial weight) were used in a 2 × 3 factorial arrangement. Treatments included: 0 or 2 g/heifer daily of Optaflexx™ (providing 0 or 200 mg/day ractopamine-HCl; Elanco Animal Health), and one of three diets, based on steam-flaked corn, that contained either urea, solvent soybean meal, or expeller soybean meal as the primary supplemental protein source (Table 1). Heifers were fed individually and were given ad libitum access to their respective diets. Heifers were implanted with Revalor®-H (Intervet) 60 days before initiating Optaflexx™ feeding. Initial body weights were measured one day before initiation of Optaflexx™ feeding, and final body weights

were measured on the day of slaughter. Hot carcass weights were determined at slaughter, and other carcass characteristics were measured after a 24-hour chill. For reasons not related to treatment, data from one heifer were deleted from the analysis.

Results and Discussion

Our diets were formulated such that they would provide different amounts of protein to the small intestine (i.e., metabolizable protein), with the urea diet providing the least and the expeller soybean meal diet presumably providing the most. Performance of finishing heifers typically does not respond to the changes in protein supply that we implemented. Our hypothesis was that heifers fed Optaflexx™ might respond to increases in metabolizable protein supply because Optaflexx™ was expected to increase growth rate and lean tissue deposition, which might lead to a greater need for absorbable protein from the diet.

Optaflexx™ significantly increased average daily gain, with the response dependent on the protein source (Table 2). In the heifers not receiving Optaflexx™, increases in metabolizable-protein supply, particularly from the expeller soybean meal, led to improvements in daily gains. In contrast, for heifers fed Optaflexx™, the greatest daily gains were observed in heifers fed the urea-supplemented diet.

When daily gains were calculated with final weights based on carcass weights, Optaflexx™ still led to increases in daily gains, but no statistically significant effects of diet were present. For heifers fed Optaflexx™, however, the numerically greatest carcass-adjusted gains were observed in heifers fed the urea-supplemented diets, suggesting that there was no benefit of increasing the metabolizable protein supply, even when Optaflexx™ was fed. The carcass-adjusted gains of heifers not fed Optaflexx™ followed our expectation, in that they did not respond to changes in protein supply with changes in growth rate.

Feed intake was not affected by either Optaflexx™ or by dietary protein source. Feed efficiencies followed the pattern observed for daily gains, with improvements observed in response to Optaflexx™. Feed efficiencies based on live weights followed the trends observed for daily gains, although the interaction between Optaflexx™ and dietary protein source was not significant. Feed efficiencies calculated on the basis of carcass-adjusted body weights did not demonstrate any effect of dietary protein source.

Final live weights were 20 lb greater and carcass weights were 15 lb greater when heifers were fed Optaflexx™, but these differences were not statistically significant due to variation in the initial weights of the heifers.

In general, carcass characteristics were not greatly different among treatments, but the number of heifers used in our experiment was not large enough to ferret out small, but economically important, differences that might exist. Percentage of kidney, pelvic, and heart fat was statistically less for heifers fed solvent soybean meal without Optaflexx™ and for heifers fed expeller soybean meal with Optaflexx™, although these differences are unlikely to be of biological importance.

The results gathered from this experiment show that Optaflexx™ fed to heifers 28 days before slaughter can improve daily gains and feed efficiency. When final weights of heifers were based on carcass weight, dietary protein source had little effect on heifer performance. Our data do not support the concept that dietary metabolizable-protein supply needs to be increased beyond that presently used in typical feedlot diets to maximize the performance response of finishing heifers to Optaflexx™.

Table 1. Diet Composition

Ingredients	Urea	Solvent Soybean Meal	Expeller Soybean Meal
	---------- % of dry matter ----------		
Steam-flaked corn	82.4	77.0	75.7
Separator byproduct	6.0	6.0	6.0
Alfalfa hay	6.0	6.0	6.0
Urea	1.5	0.5	0.5
Solvent soybean meal	–	6.6	–
Expeller soybean meal	–	–	7.9
Limestone	1.5	1.4	1.4
Salt	0.3	0.3	0.3
Vitamins and minerals [a]	0.1	0.1	0.1
RTM premix [b]	2.2	2.2	2.2

[a]Provided 0.13 ppm Co, 10 ppm Cu, 0.63 ppm I, 0.17 ppm Fe, 60 ppm Mn, 0.25 ppm Se, 60 ppm Zn, and 1200 IU/lb Vitamin A to final diet.
[b]Fed to provide (mg/heifer daily): ractopamine-HCl (0 or 200 depending on treatment), melengestrol acetate (0.5), monensin (300), and tylosin (90).

Table 2. Growth and Carcass Characteristics of Heifers Fed 0 or 2 grams/day of Optaflexx™ with One of Three Protein Dietary Sources

	Control			Optaflexx™			
Item	Urea	Solvent Soybean Meal	Expeller Soybean Meal	Urea	Solvent Soybean Meal	Expeller Soybean Meal	SEM
Number of heifers	11	12	12	12	12	12	–
Initial body wt., lb	1047	1047	1048	1048	1048	1048	14
Final live wt., lb	1134	1145	1164	1180	1163	1158	18
Feed intake, lb dry matter	18.89	18.81	19.85	20.17	19.61	18.25	0.80
Daily gain, lb/day[ab]	3.01	3.37	3.99	4.55	3.98	3.78	0.34
Carcass-adj. daily gain, lb/day[ae]	3.50	3.28	3.66	4.73	4.20	4.12	0.40
Feed:gain[ac]	6.40	5.58	5.04	4.49	4.96	4.88	–
Carcass-adj. feed:gain[ace]	5.48	5.77	5.50	4.21	4.53	4.43	–
Hot carcass wt., lb	701	697	704	723	713	712	12
Dressing %	61.7	60.9	60.5	61.4	61.5	61.5	0.57
Kidney, pelvic, heart fat, %[b]	2.15	1.96	2.17	2.12	2.17	1.92	0.06
Ribeye area, square inches	14.2	13.0	12.7	13.3	14.0	14.2	0.54
12th-rib fat thickness, inch	0.27	0.26	0.30	0.29	0.33	0.30	0.034
Marbling score[d]	338	390	346	344	338	348	22
USDA Choice, %	27	33	8	25	17	8	–
USDA Select, %	64	42	92	58	75	58	–
USDA Standard, %	9	25	0	17	8	34	–
USDA Yield Grade 1, %	36	33	8	17	25	58	–
USDA Yield Grade 2, %	55	42	58	58	58	17	–
USDA Yield Grade 3, %	9	25	34	25	17	25	–

[a]Significant effect of Optaflexx™ ($P<0.05$).

[b]Significant Optaflexx™ × protein source interaction ($P<0.05$).

[c]Data were analyzed statistically as gain:feed, and the inverse is reported here as feed:gain; SEM for gain:feed was 7% of the average value, and SEM for carcass-adjusted gain:feed was 11% of the average value.

[d]Slight[00] = 300.

[e]Calculated by dividing carcass weight by mean dressing percentage (61%) and using this value as the final live weight.

OPTIMIZING USE OF WET SORGHUM DISTILLER'S GRAINS WITH SOLUBLES IN FLAKED-CORN FINISHING DIETS

R. W. Daubert, J. S. Drouillard, E. R. Loe, J. J. Sindt, B. E. Depenbusch, J. T. Fox, M. A. Greenquist, and M. E. Corrigan

Summary

A finishing trial was conducted using 637 heifers (initially 849 lb) to determine the optimal amount of wet sorghum distiller's grains with solubles (WDGS) in finishing diets containing steam-flaked corn. Dietary treatments consisted of six concentrations of WDGS (0, 8, 16, 24, 32, and 40%; dry basis). Heifers were placed into dirt-surfaced feedlot pens (25 to 30 heifers/pen; 4 pens/treatment) and fed for 58 days. Daily gain responded in a quadratic manner ($P<0.01$), peaking with 8% WDGS in the finishing diet. Average daily gains during the 58-day finishing period were 2.79, 3.11, 3.05, 2.89, 2.70, and 2.55 lb/day for cattle fed 0, 8, 16, 24, 32, and 40% WDGS, respectively. Dry matter intake decreased linearly ($P<0.01$) as content of WDGS increased. Feed efficiency was optimized with 16% WDGS (6.81, 6.49, 6.19, 6.64, 6.96, and 7.18 lb dry feed per lb gain for cattle fed 0, 8, 16, 24, 32, and 40% WDGS, respectively). Animal performance data were used to compute net energy gain (NEg) values of each diet, yielding estimates of 69.9, 71.7, 75.8, 71.2, 68.9, and 67.6 Mcal/cwt for diets containing 0, 8, 16, 24, 32, and 40% WDGS, respectively (quadratic effect, $P<0.03$). Ribeye area decreased linearly ($P<0.02$) as concentration of WDGS increased in the diet. The percentage of USDA Yield Grade 1 carcasses decreased linearly ($P<0.05$), and the percentage of USDA Yield Grade 3 carcasses increased linearly ($P=0.05$) as the content of WDGS was increased. Average USDA Yield Grade increased linearly ($P<0.02$) as content of WDGS was increased. Grid-based carcass values were not significantly different across dietary treatments. Regression analysis of efficiency data indicates that the optimum amount of sorghum WDGS in steam-flaked corn diets is approximately 15%. Diets containing as much as 24% WDGS yielded efficiencies equal or superior to diets containing no WDGS.

Introduction

Continued expansion of the fuel ethanol industry will increase availability of distillery byproducts, which are well suited for use as animal feed. The predominant byproduct from the fermentation of grains for fuel ethanol production is distiller's grains with solubles. Distiller's grains with solubles commonly contain the protein fraction of the grain as well as the bran, which is high in fiber, and the germ, which is high in fat. As a consequence, wet distiller's grains are valuable both as a source of protein and energy. Addition of wet distiller's grains in finishing diets based on dry-rolled grains can improve feed efficiency and increase average daily gain. Because we recognize that flaked grains are superior to dry rolled grains in supplying energy, this study was designed to identify the optimal amount of wet sorghum distiller's grains in finishing diets based on steam-flaked corn.

Procedures

In October 2003, 637 yearling, crossbred heifers (initially weighing 849 lb) were used in a 58-day finishing trial. Pens were ranked from heaviest to lightest average body weight,

and were randomly allotted, within strata, to each of the six dietary treatments (Table 1). Cattle were fed in dirt-surfaced pens of 25 to 30 animals each, with a total of four pens per treatment. Pens provided approximately 200 square feet surface area per heifer. Cattle were vaccinated, implanted with Revalor® 200, and treated for internal and external parasites. Feed was delivered once daily for ad libitum intake. Cattle in each pen were weighed before being transported to a commercial abattoir in Emporia, Kansas. Hot carcass weight and incidence of liver abscesses were recorded at time of slaughter. Yield grade, quality grade, marbling, incidence of dark cutters, 12th-rib fat thickness, ribeye area, and percentage of kidney, pelvic, and heart fat were recorded after a 72-hour chill.

Results and Discussion

Heifer performance is reported in Table 2. Replacing steam-flaked corn with WDGS yielded a quadratic effect ($P<0.02$) on daily gain. The maximal rate of growth was achieved when the amount of WDGS was 8% of the diet dry matter, and decreased as the proportion of inclusion increased. Feed intake was also maximized with 8% WDGS, and decreased linearly ($P<0.02$) as the proportion of WDGS in the diet increased. A quadratic effect ($P<0.02$) was observed for feed efficiency. Efficiency was optimized at 16% WDGS and decreased at amounts beyond 16%.

Net energy concentrations of diets are shown in Table 4. A quadratic effect was observed for dietary net energy available for gain ($P<0.03$), dietary net energy available for maintenance ($P<0.03$), and net energy available for gain of WDGS ($P<0.04$). Dietary concentrations of net energy for maintenance and net energy for gain peaked at 16% WDGS in the diet. Net energy for gain of WDGS peaked at 8%. Adding WDGS at 8, 16, or 24% yielded performance that was equal or superior to adding no WDGS. Exceeding 24% WDGS reduced performance of finishing feedlot cattle, suggesting that WDGS would need to be purchased at a discount relative to corn when fed at higher concentrations.

Carcass characteristics of heifers fed different amounts of WDGS are shown in Table 3. Replacing steam-flaked corn with WDGS in the diet resulted in a linear ($P<0.02$) decrease in ribeye area. There also was a linear effect ($P<0.06$) on the percentage of USDA Yield Grade 1 and USDA Yield Grade 3 carcasses, with cattle depositing more fat as the proportion of WDGS increased. Average USDA Yield Grades were 1.76, 2.06, 1.87, 2.15, 2.01, and 2.13 for heifers fed diets containing 0, 8, 16, 24, 32, and 40% WDGS, respectively (linear effect, $P<0.02$).

Grid-based carcass values of heifers fed different amounts of WDGS are shown in Table 5. Generally speaking, there were no clear effects of WDGS on carcass value when evaluated by using a marbling-based grid, or with a muscle-based grid at Choice-Select spreads of $2/cwt or greater. There was a tendency ($P=0.08$) for carcass value to decrease linearly as dietary inclusion of WDGS increased, based on the muscle grid with a Choice-Select spread of zero. The incidences of liver abscesses and percentage of dark cutters were not affected by addition of WDGS in the diet.

In summary, replacing steam-flaked corn in finishing diets with WDGS is a viable option for improving dry matter intake, daily gain, and feed efficiency of cattle. WDGS can be added at proportions as high as 24% without compromising performance during the last 2 months before slaughter. This experiment indicates that optimal efficiency is achieved when WDGS is added to flaked-corn finishing diets at approximately 15% of the diet dry matter.

Table 1. Composition of Diets Fed to Heifers During the Final 58 Days of Feedlot Finishing

	Wet Distiller's Grains with Solubles, % of Dry Matter					
Ingredient, % of dry matter	0	8	16	24	32	40
Flaked corn	83.6	76.9	70.3	63.6	56.1	48.1
Alfalfa hay	7.0	7.0	7.0	7.0	7.0	7.0
Wet distiller's grains w/solubles	---	8.0	16.0	24.0	32.0	40.0
Soybean meal	3.4	2.4	1.3	0.7	---	---
Rumensin/Tylan/MGA premix[a]	2.5	2.5	2.5	2.5	2.5	2.5
Limestone	1.5	1.5	1.5	1.5	1.5	1.5
Urea	1.20	0.84	0.48	0.12	---	---
KCl	0.47	0.49	0.52	0.54	0.55	0.55
Salt	0.31	0.31	0.32	0.32	0.33	0.33
Vitamin/mineral premix[b]	0.14	0.14	0.14	0.13	0.13	0.13

[a]Formulated to provide 300 mg/day Rumensin, 90 mg/day Tylan, and 0.5 mg/day MGA.
[b]Formulated to provide 0.1 ppm cobalt, 8 ppm copper, 0.5 ppm iodine, 48 ppm manganese, 0.25 pm selenium, 48 ppm zinc, and 1000 IU/lb vitamin A in the diet dry matter.

Table 2. Performance of Heifers Fed Flaked-Corn Diets with Increasing Percentages of Diet Dry Matter as Wet Sorghum Distiller's Grains with Solubles During the Final 58 Days of Feedlot Finishing

	Wet Distiller's Grains with Solubles, % of Dry Matter							P-Value	
Item	0	8	16	24	32	40	SEM	Linear	Quadratic
No. of heifers	99	93	92	98	102	99			
Initial weight, lb[a]	849	848	848	848	849	849	8.4	0.94	0.93
Final weight, lb	1049	1084	1073	1073	1057	1057	9.7	0.61	0.09
Carcass-adjusted final weight, lb	1011	1029	1025	1016	1006	997	11.5	0.14	0.20
Dry matter intake, lb/day	19.0	20.2	18.9	19.2	18.8	18.3	0.28	<0.01	0.37
Carcass-adjusted gain, lb/day	2.79	3.11	3.05	2.89	2.70	2.55	0.09	<0.01	<0.01
Carcass-adjusted efficiency[c]	6.81	6.49	6.19	6.64	6.96	7.18	0.18	0.04	<0.01

[a]Calculated using a 4% shrink.
[b]Average daily gain and efficiency were computed by using carcass-adjusted final weights. Final live weight = hot carcass weight / 63.5% dress.
[c]Statistics were performed as gain:feed, reported as feed:gain.

Table 3. Carcass Characteristics of Heifers Fed Flaked-Corn Diets with Increasing Percentages of Diet Dry Matter as Wet Sorghum Distiller's Grains with Solubles During the Final 58 Days of Feedlot Finishing

	Wet Distiller's Grains with Solubles, % of Dry Matter							P- Value	
Item	0	8	16	24	32	40	SEM	Linear	Quadratic
Hot carcass weight, lb	641	653	651	645	638	632	7.3	0.15	0.20
Dress, %	63.7	62.7	63.2	62.6	62.9	62.4			
Ribeye area, square inches	12.6	12.2	12.5	12.3	12.0	11.7	0.21	<0.01	0.15
12th-ib fat thickness, in	0.35	0.39	0.37	0.38	0.37	0.40	0.016	0.14	0.70
Kidney, pelvic, and heart fat, %	2.1	2.2	2.2	2.2	2.2	2.2	0.039	0.41	0.81
USDA Yield Grade									
1, %	32.8	15.5	33.2	11.8	25.8	13.4	4.8	0.04	0.99
2, %	57.8	63.0	46.7	63.2	47.4	61.6	4.5	0.77	0.38
3, %	9.2	21.4	19.9	22.7	26.7	23.7	5.4	0.06	0.55
4, %	0	0	0	2.17	0	0	1.0	0.36	0.47
USDA Yeld Grade, average	1.76	2.06	1.87	2.15	2.01	2.13	0.094	0.02	0.43
Marbling score[a]	486	507	482	524	500	509	9.1	0.08	0.64
USDA quality grade									
Prime, %	0	1.1	0	0	0	0	0.46	0.39	0.74
Choice, %	33.9	47.5	33.9	56.4	34.9	53.4	5.7	0.10	0.68
Select, %	57.7	46.2	63.7	38.4	59.4	44.2	5.1	0.23	0.95
Standard, %	5.2	4.0	2.2	3.0	4.7	1.1	2.2	0.34	0.68
Dark cutter, %	3.0	1.0	0	2.0	0.9	1.1	1.0	0.36	0.36
Liver abscess	1.9	3.2	2.2	2.0	2.0	2.2	1.6	0.85	0.96

[a]Marbling score: Slight = 400-499, Small = 500-599.

Table 4. Net Energy Values with Increasing Percentages Diet Dry Matter as Wet Sorghum Distiller's Grains with Solubles

	Wet Distiller's Grains with Solubles, % of Dry Matter							P-Value	
Item	0	8	16	24	32	40	SEM	Linear	Quadratic
Dietary NEg, Mcal/lb	0.699	0.717	0.758	0.712	0.689	0.676	0.019	0.14	0.03
Dietary NEm, Mcal/lb	1.007	1.030	1.075	1.021	0.998	0.984	0.021	0.15	0.03
NEg of WDGS, Mcal/lb[a]	---	1.243	1.216	0.848	0.748	0.717	0.137	0.09	0.04

[a]Based on NEg for steam-flaked corn of 0.767 Mcal/lb.

Table 5. Grid-based Carcass Values of Heifers Fed Flaked-Corn Diets with Increasing Percentages of Diet Dry Matter as Wet Sorghum Distiller's Grains with Solubles During the Final 58 days of Feedlot Finishing

	Wet Distiller's Grains with Solubles, % of Dry Matter							P- Value		
Choice-Select Spread, $	0%	8%	16%	24%	32%	40%	SEM	Linear	Quadratic	Control vs WDGS
Muscle-Based Grid[a]	Total Carcass Value, $									
0	843	855	856	840	835	826	10	0.08	0.18	0.98
4	826	842	839	829	818	814	10	0.13	0.18	0.81
8	809	829	822	818	802	803	11	0.21	0.19	0.62
12	792	816	805	807	785	791	11	0.32	0.20	0.47
16	775	802	787	796	768	779	12	0.47	0.22	0.36
20	758	789	770	785	752	768	12	0.64	0.25	0.28
Marbling-Based Grid[a]										
0	829	849	846	835	825	823	10	0.20	0.16	0.58
4	812	836	829	824	809	811	11	0.31	0.17	0.42
8	795	823	812	813	792	800	11	0.45	0.18	0.31
12	778	810	795	802	775	788	12	0.63	0.20	0.24
16	761	797	778	791	759	776	12	0.81	0.23	0.19
20	744	784	761	780	742	765	13	0.97	0.26	0.15

[a]Base carcass price = $130.00/cwt; Choice-Select spread in $4/cwt increments.

EVALUATION OF GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS IN RESPONSE TO ORAL DOSING AND DAILY ADMINISTRATION OF A YUCCA-DERIVED SARSAPONIN TO FINISHING STEERS

B. E. Depenbusch, J. S. Drouillard, E. R. Loe, M. E. Corrigan, and M. A. Greenquist

Summary

Three hundred sixty-eight crossbred, yearling steers (737 lb) were used in a finishing trial comparing a yucca-derived sarsaponin (YUCCA) to a control diet. Finishing diets based on dry-rolled corn were fed for an average of 134 days before slaughter. Animals were randomly assigned to treatments and allotted to 54 pens with seven steers each. On day 0, cattle assigned to YUCCA were orally drenched with 50 mL of SarStart® *plus* (SarTec Inc., Anoka, MN), and control cattle were orally drenched with an equal volume of water. Steers receiving YUCCA were supplemented with 1 gram per steer daily of a dried yucca extract (SarStart® DSC) for the first 30 days on feed, and then with 0.5 gram per steer daily from day 31 to harvest. Body weight, dry matter intake, average daily gain, and feed efficiency were not different between treatments for either the first 30 days or for the entire finishing period. Dressing percentage, hot carcass weight, USDA quality grade, USDA yield grade, and percentage of liver abscesses also were not different between treatments. Incorporating yucca-derived sarsaponin in the ration and as an oral drench had no effect on animal performance or carcass characteristics.

Introduction

Sarsaponin is a product extracted from the desert plant *Yucca schidigera,* and it has detergent-like characteristics. Yucca initially was used as a feed additive to bind ammonia and reduce fecal odor. Further research revealed that yucca extract might favorably alter ruminal fermentation. Several studies have evaluated the effects of yucca-extract supplementation on digestion and performance of ruminant animals, with results being mixed. Differences in gain and efficiency of as much as 3% have been observed, but these differences generally have not been statistically significant. Differences in feed efficiency as little as 3% would have substantial economic impact for commercial feedlots.

The objectives of this study were to evaluate the impact of yucca supplementation on animal performance, feed efficiency, and carcass attributes of finishing feedlot cattle fed finishing diets based on dry-rolled corn. This study was designed to detect differences in feed efficiency as small as 3%.

Procedures

Three hundred sixty-eight crossbred, yearling steers (737 lb) were obtained

from a common source and used in a randomized complete-block design finishing trial comparing a dry-rolled corn diet supplemented with a yucca-derived sarsaponin (YUCCA) with a control diet. Upon arrival, steers were offered ad libitum access to chopped alfalfa hay and fresh water. Twenty-four hours after arrival, cattle were implanted with Component™ E-C and received Bovishield 4 and Fortress-7 vaccines. Body weights were measured at processing and were used to assign treatments. Fifty-four pens were used in this study (27 pens for control and 27 pens for YUCCA), with each pen containing seven animals. For reasons unrelated to treatments, two animals from YUCCA and eight animals from the control diet were removed from study. After treatment assignment, cattle assigned to YUCCA were orally drenched with 50 mL of SarStart® *plus*, and control cattle were orally drenched with an equal volume of water. Steers on the YUCCA treatment also were supplemented with 1 gram per head daily of a dried yucca extract (SarStart® DSC) in the diet for the first 30 days. SarStart® DSC was reduced from 1 gram to 0.5 gram per head daily from day 31 through harvest. Steers were allowed ad libitum access to four step-up diets, leading to the final finishing diet that contained 78% dry-rolled corn and 8% alfalfa hay (Table 1). Steers were housed in 54 concrete-surfaced pens (118 square feet), with overhead shade (59 square feet) covering the bunk and half of the pen. Pens included automatic water fountains and a 10.5-foot fence-line feed bunk. Total weight of steers in each pen was measured on day 30, 56, 74, and 120 with a pen scale. Weights also were measured just before harvest.

Cattle were harvested on two separate occasions because of visual differences in body composition of animals. On day 120, 36 pens of the heaviest and more conditioned cattle (Group 1) were shipped to a commercial abattoir in Emporia, Kansas, where carcass data were collected. Hot carcass weight and liver abscess scores were obtained at the time of harvest. Ribeye area; subcutaneous fat thickness over 12th rib; kidney, pelvic, and heart fat; marbling score; USDA quality grades; and USDA yield grades were measured after a 72-hour chill. Final body weight was calculated by dividing hot carcass weight by a common dressing percentage of 63.5%. Animal performance and efficiency for cattle from these 36 pens were calculated by using the hot carcass adjusted weight. On day 148, the cattle from the remaining 18 pens (Group 2) were shipped to slaughter. Carcass data were not available for these cattle, and final body weights for these cattle were calculated by shrinking the gross live weights by 4%.

Table 1. Composition of Finishing Diet

Item	% of Dry Matter
Ingredient	
Dry-rolled corn	77.8
Steep	10.2
Alfalfa	7.6
Supplement [a]	2.3
Nutrient, calculated	
Crude protein, %	13.0
Fat, %	3.8
Calcium, %	0.70
Phosphorus, %	0.38

[a]Formulated to provide 320 mg Rumensin and 90 mg Tylan per steer daily.

Results and Discussion

Receiving Data. Animal performance during the first 30 days of the finishing period is reported in Table 2. Body weights at day 30 were not different between treatments (P>0.66). Dry matter intake, average daily gain, and feed efficiency were not significantly different between treatments (P≥0.31).

Finishing Performance. Animal performance for the entire finishing period is reported in Table 3 for the animals harvested in Group 1 and in Table 4 for the animals harvested in Group 2. Carcass data were not collected for Group 2. As a consequence, average daily gain and efficiency of gain were calculated by using either a hot carcass adjusted live weight (Group 1) or the shrunk live weight of animals before shipping (Group 2). Initial body weights were similar (P>0.99) between treatments. Final weights, average daily gain, dry matter intake, and feed efficiencies were similar (P≥0.26) for control and yucca-supplemented cattle.

Carcass Data. Carcass data for Group 1 are reported in Table 5. Hot carcass weight and dressing percentage were not different between treatments (P>0.30). No differences between treatments were detected for ribeye area (P>0.30); kidney, pelvic, and heart fat (P>0.90); or 12th-rib fat thickness (P>0.90). No differences were detected for percentages of USDA Yield Grade 1, 2, and 3, and percentage Choice or better carcasses (P>0.60).

Implication. Orally drenching yearling steers with SarStart® *plus* and adding SarStart® DSC to a finishing diet based on dry-rolled corn had no effect on animal performance and efficiency in our study.

Table 2. Performance of Yearling Cattle during the First 30 Days of the Finishing Period

Item	Control	Yucca	SEM	P value
No. of head	188	187	-	-
No. of pens	27	27	-	-
Days on feed	30	30	-	-
Initial weight, lb	737	737	43	0.99
30-day weight, lb	851	855	45	0.66
Dry matter intake, lb/day	17.7	17.9	0.72	0.31
Average daily gain, lb/day	3.80	3.91	0.11	0.38
Feed:gain	4.65	4.57	0.15	0.57

Table 3. Overall Performance of Yearling Cattle (Group 1)

Item	Control	Yucca	SEM	P value
No. of head	120	124	-	-
No. of pens	18	18	-	-
Days on feed	120	120		
Initial weight, lb	774	774	38	1.00
Final weight, lb[a]	1159	1150	38	0.44
Dry matter intake, lb/day	22.2	22.0	0.69	0.47
Average daily gain, lb/day[a]	3.23	3.15	0.05	0.28
Feed:gain	6.86	6.97	0.22	0.41

[a]Carcass-adjusted final weight calculated by dividing hot carcass weight by a common dress yield of 63.5%.

Table 4. Overall Performance of Yearling Cattle (Group 2)

Item	Control	Yucca	SEM	P value
No. of head	61	63	-	-
No. of pens	9	9	-	-
Days on feed	148	148		
Initial weight, lb	663	663	9.6	1.00
Final weight, lb[a]	1177	1196	16.9	0.45
Dry matter intake, lb/day	20.2	20.7	0.34	0.27
Average daily gain, lb/day[a]	3.17	3.30	0.07	0.26
Gain:feed	6.35	6.29	0.10	0.65

[a]Final weight calculated as live weight minus a common shrink of 4.0%.

Table 5. Carcass Characteristics of Yearling Cattle (Group 1)

Item	Control	Yucca	SEM	P value
No. of head	120	124	-	-
No. of pens	18	18	-	-
Days on feed	120	120	-	-
Hot carcass weight, lb	736	730	24	0.44
Dressing percentage	60.1	59.9	0.1	0.30
Longissimus muscle area, $inch^2$	13.2	13.1	0.41	0.32
Kidney, pelvic, and heart fat, %	2.2	2.2	0.04	0.94
12th-rib fat, inches	0.35	0.35	0.01	0.94
USDA Yield Grade				
1, %	4	3	1.7	0.61
2, %	78	76	4.3	0.70
3, %	18	21	4.4	0.49
Marbling score	449	442	3	0.13
USDA quality grade				
Choice, %	91	87	3.4	0.41
Select, %	9	13	3.4	0.41
Liver abscess, %	8	13	3.1	0.18

EFFECTS OF ENERGY SOURCE ON METHIONINE UTILIZATION BY GROWING STEERS

G. F. Schroeder, E. C. Titgemeyer, M. S. Awawdeh, and D. P. Gnad

Summary

We evaluated the effect of energy source on amino acid utilization in growing steers. Ruminally cannulated Holstein steers (372 lb) were limit-fed (4.2 lb/day dry matter) a diet based on soybean hulls. A 2 × 5 factorial arrangement of treatments was used: 0 or 3 grams/day of methionine and five sources of energy. The energy sources evaluated were infused in amounts of 1.3 Mcal ME/day and included: control (none), glucose (0.79 lb/day), fat (0.33 lb/day), acetate (0.85 lb/day), and propionate (0.59 lb/day). Acetate and propionate were infused continuously into the rumen, whereas glucose and fat were infused into the abomasum. Nitrogen balance was increased by methionine supplementation, indicating that this amino acid limited protein deposition. Energy supplementation also increased nitrogen balance, with or without supplemental methionine, without differences among energy sources. The results of our study suggest that amino acid utilization by growing steers is improved by energy supplementation, regardless of the source of energy.

Introduction

Based on studies using growing pigs, most of the nutrient-requirement systems for cattle have assumed that when protein is limiting, energy supply does not affect protein deposition. In a recent study, however, we observed that growing steers increased protein deposition in response to increased energy supply, even when methionine limited protein accretion. This indicates that the assumptions of the current nutrient-requirement models for cattle are not correct, and that the amount of energy should be considered to more precisely estimate amino acid utilization. It is unknown if the energy source may also affect amino acid utilization. The objective of our study was to determine the effect of energy source on methionine utilization in growing steers.

Procedures

Ruminally cannulated Holstein steers (372 lb initially) were allocated in double, balanced 6 × 6 Latin-square designs. The steers were limit-fed (4.2 lb/day dry matter) a diet based on soybean hulls (83%), wheat straw (7.6%), cane molasses (4.1%) and vitamin-mineral mix. All steers received supplemental energy by ruminal infusion of 400 grams/day of acetic acid. The treatments were arranged as a 2 × 5 factorial, with the factors being the amount of methionine (0 or 3 grams/day) and five energy sources [control (none), glucose (0.79 lb/day), fat (0.33 lb/day), acetate (0.85 lb/day), and propionate (0.59 lb/day)] each providing 1.3 Mcal ME/day. The amounts of methionine were selected to be in the range of linear response for our experimental model. Ruminal infusion of acetate and propionate, and abomasal infusion of glucose and fat, allowed increases in the energy supply to the cattle without increasing ruminal protein synthesis.

The basal diet was formulated to provide a low protein:energy ratio, small amounts of ruminally undegradable protein, and enough ruminally available nitrogen to support microbial growth. Feed restriction maintained a low supply of amino acids to create a limitation in

methionine such that a response to its supplementation could be achieved. A mixture containing all of the essential amino acids except methionine was continuously infused abomasally to prevent limitations in protein synthesis by an amino acid other than methionine. Thus, protein deposition in our model was clearly limited by methionine supply. Nitrogen balance was used as an estimate of protein deposition by the steers.

Results and Discussion

The infusion of methionine increased nitrogen retention (18.8 vs. 23.5 grams/day, Figure 1), indicating that this amino acid limited protein accretion. This increase was related to a decrease in urinary nitrogen excretion. The average increase in nitrogen retention (4.7 grams/day) by methionine supplementation would represent a 0.33-lb increase in the daily gain, if it is assumed that body weight gain of Holstein steers contains 19.7% protein. The estimated efficiency of supplemental methionine utilization was 20%, based on the assumptions that retained nitrogen is directly converted to deposited protein and that deposited protein contains 2% methionine. This efficiency of utilization is much less than values (64%) used by the most recent National Research Council publication for predicting requirements of growing cattle.

Steers supplemented with energy had less urinary nitrogen excretion, resulting in improvements in nitrogen retention, with or without methionine supplementation (Figure 1). No significant differences among the energy sources were observed. Although the interaction between methionine and energy supply was not statistically significant, the effects of energy supply seemed to be greater when the steers received methionine supplementation (Figure 1). The changes in nitrogen balance in response to energy supply would represent increases in daily gain of 0.08 and 0.25 lb when 0 or 3 grams/day of methionine were supplemented, respectively, with no large differences among energy sources. These results suggest that energy supply increases the efficiency of amino acid utilization, regardless of the energy source.

The results of our study suggest that the energy supply affects the efficiency of amino acid utilization. Thus, the use of a single efficiency is not appropriate for growing cattle. Estimates of amino acid requirements in growing cattle may require consideration of the amount of energy supplied. Although the inclusion of energy intake represents an increase in complexity for estimating amino acid requirements, our results indicate that the type of energy source does not greatly affect amino acid utilization.

This research was supported by NRI Competitive Grants Program/CSREES/USDA, Award No. 2003-35206-12837.

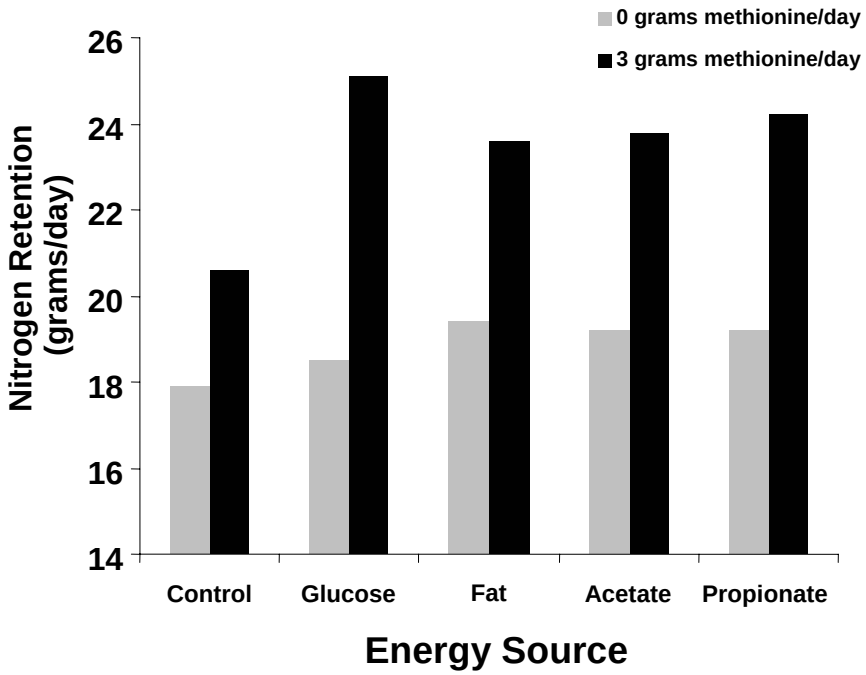


Figure 1. Effects of Energy Source and Methionine Supplementation on Nitrogen Retention in Growing Steers. Effect of methionine ($P<0.01$). Effect of energy supplementation ($P<0.01$). Effect of energy source ($P>0.10$).

EFFECTS OF MELENGESTEROL ACETATE ON INFLAMMATORY RESPONSE DURING *MANNHEIMIA HAEMOLYTICA* CHALLENGE

M. E. Corrigan, J. S. Drouillard, M. F. Spire, D. A. Mosier, J. E. Minton, J. J. Higgins, E. R. Loe, B. E. Depenbusch, and J. T. Fox

Summary

Previous trials conducted at Kansas State University demonstrated that melengesterol acetate (MGA) increased growth rates and tended to reduce chronic sickness in heifers naturally challenged with undifferentiated bovine respiratory disease. Our study was conducted to gain further insight into the mode of action of MGA. Crossbred heifers (n=47; 511 lb) were used to evaluate effects of MGA on lung pathology and markers of inflammation in cattle after an intrabronchial *Mannheimia haemolytica* challenge. On day 0, cattle were assigned to diets (54% concentrate) that provided 0 or 0.5 mg MGA per heifer daily. On day 14 each heifer was intrabronchially inoculated with *M. haemolytica*. Blood samples were collected from each heifer immediately before inoculation and 12, 24, 48, 72, 96, 120, and 138 hours after inoculation. Heifers were then euthanized for postmortem examination. After the challenge, heifers fed MGA had greater numbers of neutrophils and white blood cells, as well as greater serum haptoglobin and fibrinogen concentrations. The incidence of post-challenge lung lesions was greater in heifers fed MGA, and lung lesion scores tended to be more severe in heifers fed MGA, compared with those of controls. These data indicate that MGA does not reduce inflammation in heifers 138 hours after *M. haemolytica* challenge, suggesting that there are other modes of action for the beneficial effects on growth and reduction of chronicity in feedlot heifers.

Introduction

Undifferentiated bovine respiratory disease is the most costly disease plaguing the beef industry today. Roughly 75% of sickness and 50% of death losses in feedlot cattle are attributable to bovine respiratory disease, with an estimated annual cost of $1 billion. Bovine respiratory disease is a multifactorial complex that is influenced by viral infection, weaning, transportation, commingling, and temperature extremes. Stress, coupled with a primary viral infection, can allow bacteria often found in the upper respiratory tract of healthy animals to proliferate in the lower respiratory tract. *Mannheimia haemolytica* is generally considered the most virulent and important pathogen associated with severe respiratory disease in feedlot cattle, inducing severe pneumonia characterized by local production of many inflammatory mediators and the influx and activation of inflammatory cells. The first inflammatory cells to arrive are neutrophils, which accumulate at the site of infection in response to proteins called cytokines. Pro-inflammatory cytokines, which include tumor necrosis factor-alpha (TNF-α), activate the endothelium, causing it to express receptors (called cell-adhesion molecules) for inflammatory cells. These receptors allow inflammatory cells to attach to the endothelium and emigrate out of the blood and into tissue spaces. Overly activated inflammatory cells cause damage to the lung, and prolonged inflammation can lead to extensive and irreparable damage, leaving these areas of the lungs non-functional.

Previous research from our laboratory indicated that MGA, a synthetic progestin commonly used to suppress estrous in feedlot cattle, improved growth rates and reduced chronic sickness in heifers naturally challenged with respiratory disease. Similar compounds have also been shown to alter inflammation in other animal species. Our study was conducted to evaluate the effects of MGA on biological markers of inflammation and lung-tissue damage in heifers experimentally infected with *M. haemolytica*.

Procedures

Forty-eight crossbred heifers were purchased from a local sale barn and transported to the K-State Beef Cattle Research Center in Manhattan, Kansas. No antibiotics or vaccines were administered to the calves any time after arrival to avoid interfering with progression of the experimental infection, and heifers were acclimated to the facility for a period of 1 to 5 weeks before being placed on the study. On day 0 of the experiment, calves were stratified by weight and randomly assigned, within strata, to one of two diets formulated to provide 54% concentrate:46% roughage and either 0 or 0.5 mg MGA per heifer daily. On day 14, all heifers were weighed and *M. haemolytica* was intrabronchially inoculated into the lungs. Blood samples were collected immediately before inoculation and 12, 24, 48, 72, 96, 120, and 138 hours after inoculation. After the final blood collection, calves were euthanized and transported to the KSU College of Veterinary Medicine Diagnostic Lab for necropsy. Each animal was given a lung-lesion score based on the percentage of each lung lobe affected by lesions according to the formula: total calculated lung-lesion score = [(left cranial % x 0.05) + (left posterior cranial % x 0.06) + (left caudal % x 0.32) + (right cranial % x 0.06) + (right posterior cranial % x 0.05) + (right middle % x 0.07) + (right caudal % x 0.35) + (intermediate % x 0.04)]. Complete blood cell counts were performed on smear slides.

One heifer in the MGA treatment group died between 48 and 72 hours after inoculation, and data from this heifer were excluded from the statistical analysis. This heifer had severe pneumonia, which was considered to be the cause of death.

Results and Discussion

All heifers in this study exhibited mild signs of respiratory disease after challenge. Heifers that did not receive MGA had elevated circulating white blood cells at 12 and 24 hours after the inoculation, but the increase was smaller than that observed for heifers fed MGA ($P<0.01$, Figure 1). This rise in white blood cells was due in large part to an increase in circulating neutrophils at 12 and 24 hours after the challenge, with MGA leading to a greater increase in circulating neutrophils ($P<0.01$, Figure 2). These findings are consistent with an earlier trial in which MGA caused increased numbers of circulating neutrophils in heifers 4 hours after injection with *E. coli* lipopolysaccharide. Progesterone and synthetic progestins, in some animal species, reduce endothelial expression of cell-adhesion molecules. We speculate that the larger number of circulating neutrophils in cattle fed MGA could be caused by a decrease in endothelial cell-adhesion molecules, thus decreasing subsequent neutrophil emigration into the lung tissue. This reduced influx of neutrophils early after challenge in heifers fed MGA may have allowed bacteria to proliferate more readily in the lung, potentially explaining why MGA increased incidence of lung lesions (60.9% vs. 25.0%; $P<0.02$) and tended to increase severity of lung lesions (lung-lesion score: 3.08% vs. 1.04%; $P=0.06$: Table 1) 138 hours post-inoculation. The serum TNF-α concentrations were marginally higher ($P=0.13$) for heifers fed no MGA (Figure 3). Increased serum TNF-α would be expected after *M. haemolytica* challenge, but no post-challenge increase in TNF-α was detected. Possible explanations of this include a low virulence of the bacteria used, as evidenced by

the limited severity of lung lesions, or the challenge may have been insufficient to stimulate higher systemic concentrations of TNF-α. The lack of an effect of MGA on serum TNF-α does not rule out the possibility that MGA decreased secretion of TNF-α or other pro-inflammatory cytokines by blood cells in the lung, but this cannot be determined from our study because concentrations of TNF-α in the lungs were not measured.

Concentrations of the acute-phase proteins (fibrinogen and haptoglobin) were elevated in both treatment groups after inoculation. However, concentrations of fibrinogen (Figure 4) and haptoglobin (Figure 5) were not greater in cattle fed MGA, compared with controls, until 72 and 96 hours after inoculation, respectively. These data further support the contention that the bacterial pathogens proliferated more readily in the lungs of heifers fed MGA, thus causing a more severe acute-phase response later in the challenge period.

Chronic inflammation is the result of an exaggerated inflammatory response that is often characterized as a reaction to products produced during the inflammatory response rather than to the initial pathogen. Anti-inflammatory agents have been shown to be useful in attenuating chronic inflammation, but are not generally accepted as beneficial in bacterial infections or low-severity inflammation because they hinder the body's ability to clear the pathogen. Heifers in our study exhibited mild clinical signs of respiratory disease after challenge. The bacteria used had a limited ability to initiate an inflammatory response, and it is possible that this played a role in the greater incidence of lesions in heifers fed MGA. The beneficial effects of MGA observed in a previous trial may have been due to greater incidence and severity of the natural disease challenge. Heifers in the previous trial experienced a morbidity rate of 75.6% and a mortality rate of 9.9%.

MGA increased incidence and severity of lung lesions in heifers subjected to a mild experimental challenge with *M. haemolytica*. Results of our study suggest that the previously observed improvements in growth and reduction of chronicity in heifers with more severe, naturally occurring, undifferentiated respiratory disease was not due to an attenuation of the inflammatory response to *M. haemolytica*. Further studies need to be conducted to examine the effects of MGA on respiratory disease in cattle.

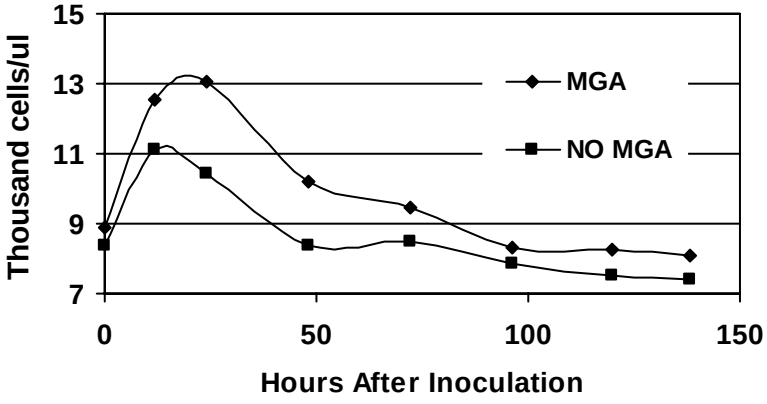


Figure 1. Circulating White Blood Cell Concentration of Heifers Fed Either 0 or 0.5 mg of MGA Daily for 20 Days and Inoculated on Day 14 with *M. haemolytica*. Effect of treatment, P<0.01; effect of sampling time, P<0.01; effect of interaction between treatment and sampling time, P=0.80.

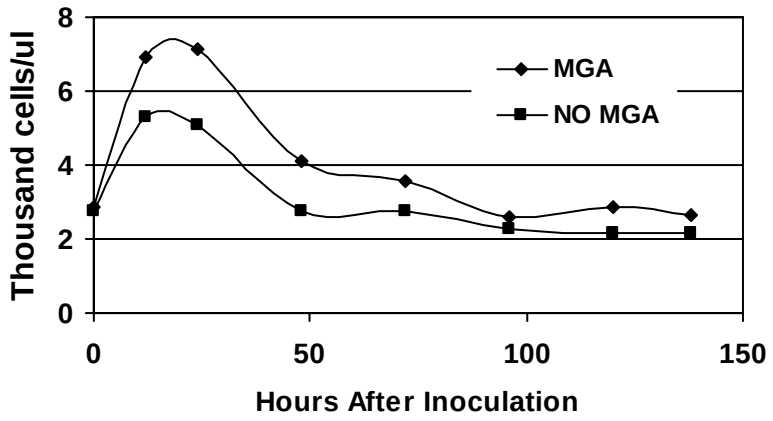


Figure 2. Circulating Mature Neutrophils of Heifers Fed Either 0 or 0.5 mg of MGA Daily for 20 Days and Inoculated on Day 14 with *M. haemolytica*. Effect of treatment, P<0.01; effect of sampling time, P<0.01; effect of interaction between treatment and sampling time, P=0.61.

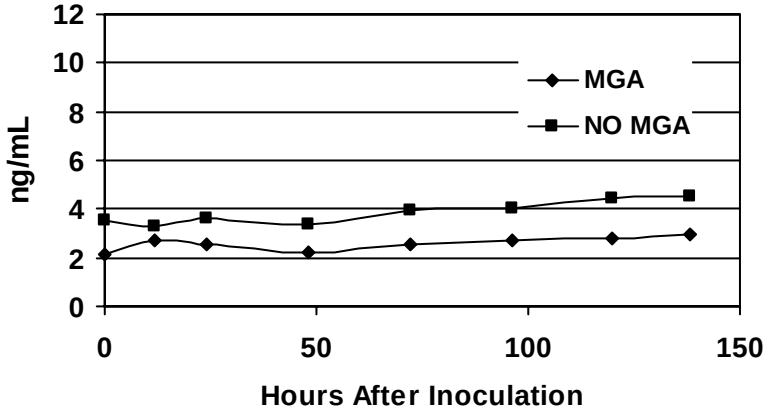


Figure 3. Serum TNF-α of Heifers Fed Either 0 or 0.5 mg of MGA Daily for 20 Days and Inoculated on Day 14 with *M. haemolytica*. Effect of treatment, P=0.13; effect of sampling time, P=1.00; effect of interaction between treatment and sampling time, P=1.00.

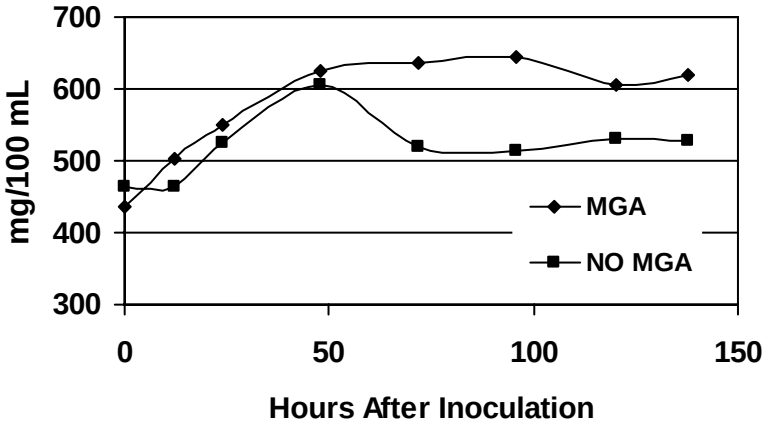


Figure 4. Circulating Fibrinogen of Heifers Fed Either 0 or 0.5 mg of MGA Daily for 20 Days and Inoculated on Day 14 with *M. haemolytica*. Effect of treatment, P<0.01; effect of sampling time, P<0.01; effect of interaction between treatment and sampling time, P=0.20.

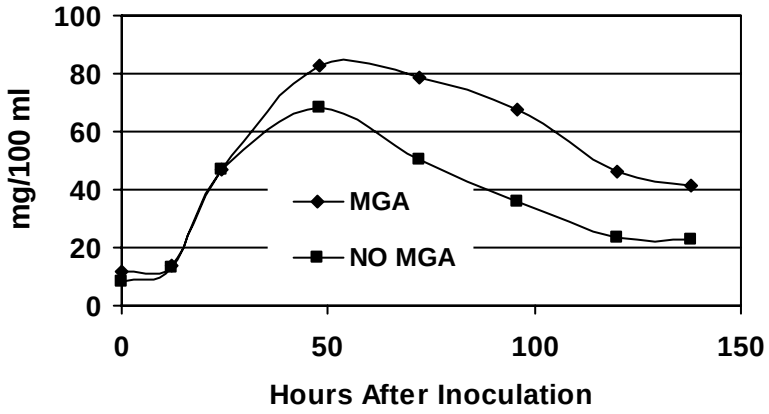


Figure 5. Serum Haptoglobin of Heifers Fed Either 0 or 0.5 mg of MGA Daily for 20 Days and Inoculated on Day 14 with *M. haemolytica*. Effect of treatment, P<0.01; effect of sampling time, P<0.01; effect of interaction between treatment and sampling time, P=0.56.

Table 1. Average Lung Scores 138 Hours After Inoculation with *M. haemolytica* for Heifers Fed 0 or 0.5 mg of MGA

	MGA, mg/day		
Item	0.5	0	P-value
Number of heifers	23	24	-
Average score[a]	3.08	1.04	<0.06

[a]Total calculated percentage lung-lesion score = [(left cranial % x 0.05) + (left posterior cranial % x 0.06) + (left caudal % x 0.32) + (right cranial % x 0.06) + (right posterior cranial % x 0.05) + (right middle % x 0.07) + (right caudal % x 0.35) + (intermediate % x 0.04)].

A COMPARISON OF FORAGE YIELD AND QUALITY IN A SIMULATED GRAZE-OUT FOR TWELVE VARIETIES OF HARD RED AND WHITE WINTER WHEAT

R. L. Hale[1], C. T. Thompson[1], T. J. Dumler[1], and C. T. MacKown[2]

Summary

Six hard white winter wheat varieties (Burchett, Lakin, NuFrontier, NuHills, Nu-Horizon, and Trego) and six hard red winter wheat varieties (2137, Jagalene, Jagger, OK101, Stanton, and Thunderbolt) were planted in two southwestern Kansas counties, Clark and Stanton, to compare simulated graze-out forage yield and quality. Four replicated plots were planted in September 2003 for each variety at each location. Forage samples were collect from each plot during December 2003, March 2004, and April or May 2004. Dry matter content, dry matter yield, crude protein, acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), net energy (NEm, NEg), relative feed value (RFV), and nitrate nitrogen were determined. Significant location-by-variety interactions were observed for most factors. Although significant differences in crude protein and energy were detected, it is unlikely that the performance of stock cattle would differ when grazing each of the varieties because the lowest crude protein concentration would support excellent gain, and because the differences in energy were relatively small.

Introduction

It has been estimated that as much as 6 million acres of winter wheat in Kansas are grazed during a good forage-producing year. Wheat pasture provides an economical, high-quality forage for livestock during a time of year that few other grazable forage sources are available. Winter wheat can be grazed until the formation of the first hollow stem (jointing) without reducing grain yield. Dual-purpose wheat programs (forage and grain) permit producers to more effectively and profitably utilize their land. At times, producers will forgo a grain harvest and graze out the wheat to maximize profitability. Although hard red winter wheat varieties dominate, it is anticipated that the use of hard white winter wheats will increase substantially because of economic incentives associated with white wheat milling, end uses, and market opportunities. Kansas Agricultural Statistics Service reported increased white-wheat acres of 0.2, 0.8, 1.1, 2.7, and 4.9% of total wheat acres for the years 2000 to 2004, respectively, but research examining forage yield and quality of white wheat has been limited. This experiment examined the forage yield and quality in a simulated graze out of six popular hard white winter wheat varieties and six hard red winter wheat varieties.

Procedures

Six hard white winter wheat varieties (Burchett, Lakin, NuFrontier, NuHills, Nu-Horizon, and Trego) and six hard red winter wheat varieties (2137, Jagalene, Jagger,

[1]Southwest Area Research and Extension Center, Garden City.
[2]USDA ARS El Reno, Oklahoma.

OK101, Stanton, and Thunderbolt) were planted in two locations in southwestern Kansas, specifically in Clark and Stanton counties. Producers prepared the land and applied 65 lbs of nitrogen (Clark) or 80 lbs of nitrogen (Stanton) per acre before wheat planting. On September 16, 2003, each variety was planted in four replicated plots at each location in 10-inch rows at a depth of approximately 1.75 inches. The planting rates were 90 lbs seed per acre at the dryland Clark County plots and 120 lbs per acre at the irrigated Stanton County plots. Eleven lbs of nitrogen and 52 lbs of P_2O_5 per acre were applied with the seed. Soil type at both locations was a silt loam. On March 26, 2004, liquid urea ammonium nitrate was applied at 30 lbs nitrogen per acre at both sites.

Forage samples were collected on December 31, 2003, March 19, 2004, and April 29, 2004, at Clark County and December 30, 2003, March 25, 2004, and May 4, 2004, at Stanton County. Cuttings were collected from the same 6 feet of closely clipped row length in each plot. Samples were immediately dried at the Garden City Research and Extension Center and then sent to a commercial laboratory for analysis of crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF). Relative feed value (RFV), total digestible nutrients (TDN), and net energy contents (maintenance - NEm, gain - NEg) were calculated from the laboratory analyses. Nitrate-nitrogen assays were performed at the USDA-ARS laboratory in El Reno, OK. Data from the three cuttings were summed for statistical analysis.

Results and Discussion

Wheat varieties had different yields and compositions at the two locations, so values are presented for each variety at each location (Tables 1 to 4).

A wide range in forage dry matter yields (3553 to 5672 lb/acre) was observed across varieties at both locations. The varieties producing the most were Lakin, Jagalene, Trego, and NuFrontier at Clark County, yet they did not differ statistically from seven other location-by-variety combinations. Clark County tended to have more top yielding varieties than Stanton County did.

Dry matter content differed from the greatest to the least by 5.4 percentage units. It is interesting that the 12 driest forages all came from Clark County, with Trego having the greatest dry matter content in Clark County, but having the least in Stanton County.

Crude protein in the forage ranged from 17.9 to 24.0%. The eight variety/location combinations with the most crude protein ranged from 21.4 to 24.0%, and they were significantly different than the six with the least, which ranged from 17.9 to 19.7% crude protein. Seven of the eight variety/location combinations with the most crude protein were from Stanton. NuHills was the only variety in the top group from both locations.

Acid detergent fiber (ADF), a measure of cellulose and lignin plant fractions, increases as a plant matures. Greater ADF is associated with lesser nutrient digestibility and energy availability. Acid detergent fiber ranged from 23.3 to 25.8% across all location-by-variety combinations, and was relatively evenly distributed across locations. Jagalene and NuHorizon in both counties, and NuHills in Clark County, had significantly less ADF than the five locations-by-variety combinations with the greatest ADF concentrations (Thunderbolt, Burchett, OK101, and Jagger in Clark County and Trego in Stanton County).

Neutral detergent fiber (NDF) measures hemicellulose, cellulose, and lignin. As NDF increases, feed intake tends to decrease. Although NDF ranged from 43.5 to 48.8%, there was no location-by-variety interaction. Jagger, Stanton, Lakin, Thunderbolt, and OK101

all had greater NDF than Jagalene, NuHills, and NuHorizon did.

Total digestible nutrients (TDN), related to digestible energy, ranged from 72.3 to 74.6%. Jagalene and NuHorizon in both locations had greater TDN than Jagger, Burchett, and OK101 had in Clark County or Trego had in Stanton County. Net energy for maintenance (NEm), ranging from 0.68 to 0.71 Mcal/lb, differed by variety only. NuHills, NuHorizon, and Jagalene had greater NEm than Jagger, Burchett, OK101, Stanton, and Thunderbolt had. Net energy for gain (NEg) concentrations ranged from 0.44 to 0.48 Mcal/lb. Jagalene at both locations and NuHills and NuHorizon in Clark County had greater NEg than Jagger, Thunderbolt, Burchet, Lakin and OK101 had in Clark County and Trego had in Stanton County. Relative feed value (RFV) is an index value calculated from ADF and NDF, and it is a quality-based factor commonly used in marketing of alfalfa hay. A greater RFV indicates that the forage is expected to yield greater animal intake and digestibility. RFV ranged from 135 to 153. NuHills, NuHorizon, and Jagalene in both locations had greater RFV than Jagger, Thunderbolt, Burchet, Lakin, and OK101 had in Clark County and Trego and 2137 had in Stanton County.

Nitrate-nitrogen ranged from 101 to 527 ppm, with Stanton County varieties tending to have more nitrates. The greatest nitrates in an individual plot was 1503 ppm. All were less than Kansas State University's "generally safe" recommendation of 3000 ppm.

The number of location-by-variety interactions makes it difficult to draw broad conclusions, but there seemed to be location differences in yield and quality factors that might be explained by differences in the stage of growth at the two locations. Clark County plots had somewhat higher yields but lower nutritional quality. Although the Stanton County location was irrigated and Clark County location was not, other factors such has a higher elevation and fewer growing degree units in Stanton County could have suppressed forage production. Stanton County forages may have been less mature and, therefore, slightly greater in nutritional quality. Although there was variation between locations, Jagalene tended to be a good yielder, and Jagalene, NuHills, NuHorizon, and NuFrontier tended to have greater energy concentrations, regardless of location.

The varieties evaluated are among the more popular wheats planted, but they do not represent all wheat varieties. Also, our experiment did not evaluate all growing conditions or cultural practices. Factors not examined in our experiment will influence yield and quality. They include moisture, soil type, fertility, and management practices, and they should be considered when selecting a wheat variety for grazing or grain production. Cattle performance would be expected to be the same when grazing each of the different varieties because the least crude protein concentration would support excellent growth, and because the energy differences among varieties were relatively small. Variety differences between locations were most probably related to plant maturity, which would have more impact on nutritional content and stocker gain than the protein and energy differences observed in our experiment would have.

Table 1. Wheat Forage Dry Matter Yield and Dry Matter and Crude Protein Contents by Location and Variety

		Yield, lbs DM/acre			Dry Matter, %			Crude Protein, %		
		Location		Variety	Location		Variety	Location		Variety
Variety	Color	Clark	Stanton	Mean	Clark	Stanton	Mean	Clark	Stanton	Mean
2137	Red	5282^{cd}	4130^{ab}	4706	27.7^{cde}	24.6^{a}	26.1	19.3^{abc}	19.7^{abc}	19.5
Burchett	White	4810^{bcd}	4614^{bc}	4712	29.0^{efgh}	25.0^{a}	27.0	20.0^{bcd}	22.9^{fg}	21.4
Jagalene	Red	5669^{d}	4585^{bc}	5127	29.2^{fgh}	25.1^{a}	27.1	19.3^{abc}	24.0^{g}	21.7
Jagger	Red	5256^{bcd}	3553^{a}	4405	28.1^{cdefg}	26.6^{bc}	27.3	20.4^{bcde}	22.3^{ef}	21.4
Lakin	White	5672^{d}	4474^{b}	5073	29.5^{gh}	25.3^{ab}	27.4	17.9^{a}	21.0^{bcde}	19.5
NuFrontier	White	5312^{d}	4301^{ab}	4806	27.0^{cd}	25.1^{a}	26.1	20.0^{bcd}	21.4^{def}	20.7
NuHills	White	4046^{ab}	3661^{a}	3853	27.7^{cde}	24.7^{a}	26.2	21.9^{ef}	23.8^{g}	22.9
NuHorizon	White	4742^{bc}	4864^{bcd}	4803	28.7^{efgh}	25.1^{a}	26.9	19.8^{bcd}	22.0^{ef}	20.9
OK101	Red	4660^{bc}	3802^{ab}	4231	28.3^{defgh}	25.3^{ab}	26.8	19.2^{ab}	20.5^{bcde}	19.8
Stanton	Red	4945^{bcd}	4121^{ab}	4533	28.4^{efgh}	24.5^{a}	26.4	20.0^{bcd}	20.9^{bcde}	20.4
Thunderbolt	Red	5140^{bcd}	4480^{b}	4810	27.9^{cdef}	24.7^{a}	26.3	20.6^{bcde}	22.8^{fg}	21.7
Trego	White	5656^{d}	5156^{bcd}	5406	29.6^{h}	24.1^{a}	26.9	18.3^{a}	21.0^{cde}	19.7

^{abcdefgh}Means having differing superscripts within each measurement differ significantly (P<0.05).

Table 2. Wheat Forage Acid Detergent Fiber, Neutral Detergent Fiber, and Total Digestible Nutrients by Location and Variety

		Acid Detergent Fiber, %			Neutral Detergent Fiber, %			Total Digestible Nutrients, %		
		Location		Variety	Location		Variety	Location		Variety
Variety	Color	Clark	Stanton	Mean	Clark	Stanton	Mean	Clark	Stanton	Mean
2137	Red	25.0^{cdef}	25.0^{cdef}	25.0	47.1	45.3	46.2^{j}	73.1^{abcd}	73.1^{abcd}	73.1
Burchett	White	25.2^{def}	24.7^{bcdef}	25.0	47.1	45.4	46.2^{j}	72.9^{ab}	73.4^{abcdef}	73.1
Jagalene	Red	24.1^{abc}	23.3^{a}	23.7	45.2	43.5	44.4^{h}	73.9^{defg}	74.6^{g}	74.3
Jagger	Red	25.8^{f}	24.4^{bcde}	25.1	48.0	46.0	47.0^{jkl}	72.3^{a}	73.7^{bcdef}	73.0
Lakin	White	24.9^{cdef}	24.4^{bcde}	24.7	48.3	46.2	47.3^{kl}	73.2^{abcde}	73.6^{bcdef}	73.4
NuFrontier	White	24.2^{abcd}	24.4^{bcde}	24.3	46.8	45.9	46.4^{j}	73.8^{cdefg}	73.6^{bcdef}	73.7
NuHills	White	24.0^{ab}	24.4^{bcde}	24.2	45.8	44.5	45.1^{hi}	74.0^{efg}	73.7^{bcdef}	73.8
NuHorizon	White	23.7^{ab}	24.2^{abc}	23.9	45.5	44.9	45.2^{i}	74.2^{fg}	73.8^{cdefg}	74.0
OK101	Red	25.2^{def}	24.9^{cdef}	25.1	48.2	46.7	47.4^{l}	72.9^{ab}	73.2^{abcd}	73.0
Stanton	Red	24.8^{cdef}	24.7^{bcdef}	24.8	47.5	46.0	46.7^{jkl}	73.2^{abcde}	73.3^{abcdef}	73.3
Thunderbolt	Red	25.1^{def}	24.4^{bcde}	24.8	48.8	45.7	47.3^{kl}	73.0^{abc}	73.7^{bcdef}	73.3
Trego	White	24.3^{abcde}	25.4^{ef}	24.9	46.5	46.4	46.5^{jk}	73.8^{bcdefg}	72.7^{ab}	73.2

^{abcdefg}Means having differing superscripts within each variable differ significantly (P<0.05).
^{hijkl}Overall variety means having differing superscripts differ significantly (P<0.05).

Table 3. Wheat Forage Net Energy Concentrations by Location and Variety

		Net Energy Maintenance, Mcal/lb			Net Energy Gain, Mcal/lb		
		Location			Location		
Variety	Color	Clark	Stanton	Variety Mean	Clark	Stanton	Variety Mean
2137	Red	0.695	0.695	0.695^{fg}	0.457^{bcd}	0.455^{abc}	0.456
Burchett	White	0.690	0.697	0.694^{f}	0.455^{abc}	0.460^{bcd}	0.457
Jagalene	Red	0.705	0.710	0.707^{h}	0.470^{de}	0.477^{e}	0.474
Jagger	Red	0.682	0.702	0.692^{f}	0.442^{a}	0.465^{cde}	0.454
Lakin	White	0.695	0.700	0.697^{fg}	0.455^{abc}	0.462^{bcd}	0.459
NuFrontier	White	0.702	0.697	0.700^{fgh}	0.470^{de}	0.462^{bcd}	0.466
NuHills	White	0.705	0.700	0.702^{gh}	0.470^{de}	0.465^{cde}	0.467
NuHorizon	White	0.710	0.702	0.706^{h}	0.470^{de}	0.467^{cde}	0.469
OK101	Red	0.692	0.695	0.694^{f}	0.455^{abc}	0.457^{bcd}	0.456
Stanton	Red	0.692	0.695	0.694^{f}	0.460^{bcd}	0.457^{bcd}	0.459
Thunderbolt	Red	0.690	0.697	0.694^{f}	0.450^{ab}	0.467^{cde}	0.459
Trego	White	0.702	0.690	0.696^{fg}	0.465^{cde}	0.450^{ab}	0.457

^{abcde}Means having differing superscripts within each variable differ significantly (P<0.05).
^{fgh}Overall variety means having differing superscripts differ significantly (P<0.05).

Table 4. Wheat Forage Relative Feed Value and Nitrate-Nitrogen Content by Location and Variety

		Relative Feed Value			Nitrate Nitrogen, ppm		
		Location			Location		
Variety	Color	Clark	Stanton	Variety Mean	Clark	Stanton	Variety Mean
2137	Red	142^{cde}	145^{defg}	143	231^{abcde}	162^{ab}	196
Burchett	White	141^{bcd}	144^{defg}	143	205^{abcde}	312^{cdef}	258
Jagalene	Red	150^{hi}	153^{i}	152	132^{a}	527^{g}	329
Jagger	Red	137^{ab}	143^{cdef}	140	196^{abcd}	300^{cdef}	248
Lakin	White	138^{abc}	143^{cdefg}	141	101^{a}	278^{bcdef}	189
NuFrontier	White	141^{bcd}	143^{cdefg}	142	198^{abcd}	256^{bcdef}	227
NuHills	White	146^{efgh}	147^{gh}	146	245^{bcdef}	310^{cdef}	277
NuHorizon	White	147^{fgh}	147^{gh}	147	142^{ab}	296^{cdef}	219
OK101	Red	138^{abcd}	140^{bcd}	139	179^{abc}	233^{abcde}	206
Stanton	Red	139^{abcd}	142^{cdef}	141	195^{abcd}	350^{ef}	272
Thunderbolt	Red	135^{a}	144^{defg}	139	178^{abc}	381^{f}	280
Trego	White	145^{defg}	141^{bcde}	143	175^{abc}	332^{def}	253

^{abcdefghi}Means having differing superscripts within each variable differ significantly (P<.05).

YIELD OF IRRIGATED COOL-SEASON GRASSES IN SOUTHWESTERN KANSAS

R. L. Hale[1], C. T. Thompson[1], T. J. Dumler[1], M. Hampton[2], and G. L. Gold[3]

Summary

Nine varieties and a commercial mix of perennial cool-season grasses were planted in four replicated plots in two counties in southwestern Kansas to evaluate yield and adaptability when produced under irrigation. The varieties were smooth bromegrass, 'Slate' intermediate and 'Hycrest' crested wheatgrass, 'Kentucky 31' and 'Max-Q®' tall fescue, 'Profile' orchardgrass, 'Hykor' festulolium, and 'Dixon®' and 'Lakota®' matua grass. The mix was Sharp Brothers' 'Pasture Mix #6®', a blend of smooth bromegrass, 'Regar' meadow bromegrass, Slate, Profile, and 'Garrison' creeping foxtail. Grasses were planted in September 2002. Forage samples were collected in the spring and fall of 2003 and 2004 to measure dry matter content and yield. Fall 2003 samples were not collected at Stevens County because calves grazed them. The greatest grazing preference was for orchardgrass. The least preferred was crested wheatgrass. Spring cuttings yielded less forage than expected in Ford County in 2004 and in Stevens in both years due to dry winters and higher than normal spring temperatures in 2004. Annual dry matter yields ranged from 10,565 to 13,694 lb per acre in Ford County during 2003, 5661 to 9032 lb per acre in Ford in 2004, and 6189 to 14,552 lb per acre in Stevens County in 2004. The consistently highest-producing grasses for both years were the fescues, intermediate wheatgrass, orchardgrass, and the pasture mix. The matuas had high yields in Ford County during 2003, but winter kill reduced the other spring yields. However, new grass plants from a high 2003 and 2004 seed production improved fall 2004 matua yields. The overall lowest-producing grass was crested wheatgrass.

Introduction

Interest in irrigated grass production has increased in southwestern Kansas during the past few years. In 2001, grass producers were surveyed for grasses used, management practices, and reasons for converting from traditional crops. Reasons given were related to existing corn and cattle prices, effluent utilization, reduced well-water production, and importance in a cattle-production program. Cool-season grasses have several advantages over warm-season grasses, including ease of establishment, earlier use after planting, longer growing season, and potentially higher forage yields. Disadvantages include poor summer production and less-efficient use of water and fertilizers than warm-season grasses. Although several cool-season grasses are being used, there has been limited research comparing grass species under irrigation in southwestern Kansas. This project evaluated the adaptability and yield of several cool-season grasses and the economics of production under irrigation.

[1]Southwest Research and Extension, Garden City.
[2]Dodge City Community College.
[3]Stevens County Agricultural Extension Agent.

Procedures

Nine varieties and one commercial mix of cool-season grasses were planted in two counties in southwestern Kansas. The varieties were smooth bromegrass, 'Slate' intermediate and 'Hycrest' crested wheatgrass, 'Kentucky 31' and 'Max-Q®' tall fescue, 'Profile' orchardgrass, 'Hykor' festulolium, and 'Dixon®' and 'Lakota®' matua grass. The smooth bromegrass variety was not stated, but it is likely was 'Achenbach'. Kentucky 31 was endophyte free, whereas Max-Q® contained an endophyte that does not produce toxins harmful to livestock. Festulolium is a cross of tall fescue and perennial ryegrass. The matuas are also called bromegrass but are actually a rescuegrass. Reportedly, Dixon is better adapted to southern climates, whereas Lakota® has a northern adaptability. The cool season mix was Sharp Brothers' 'Pasture Mix #6®' (PM6), a blend of smooth bromegrass, 'Regar' meadow bromegrass, Slate, Profile, and 'Garrison' creeping foxtail.

Each variety and the mix were planted in four randomly assigned plots in both locations. The Ford County plots were under a 2.4-acre center pivot sprinkler at Dodge City Community College, which has a Ulysses silt loam soil type. The Stevens County plots were under a 15-acre pivot on a Vona-Tivoli loamy fine sand. The plots were planted on September 6 and 7 of 2002 in Stevens and Ford counties, respectively. At the Ford County location, the grasses were planted into standing sorghum-sudangrass stubble left after haying. Five days after planting, the plots were sprayed with glyphosate (0.75 lbs A.E./acre) to kill the sorghum-sudangrass regrowth and weeds. At the Stevens County location, the seed was planted into existing common crabgrass cover that had been grazed short and sprayed with glyphosate 7 days before planting. A no-till grass drill, with depth bands, was used to plant the seed 0.25 inches deep in 8-inch row spacing. Planting rates were: crested wheatgrass 15 lb/acre, intermediate wheatgrass and orchardgrass 20 lb/acre, smooth bromegrass 22 lb/acre, and the matuas, fescues, festulolium, and pasture mix 25 lb/acre. Approximately 45 lbs of nitrogen per acre were applied as urea in early October. The soil was closely monitored to ensure it remained moist throughout the fall.

During the following years, extensive hand weeding, Dual Magnum® (1.5 pint/acre), Treflan® (10 lbs/acre), Paramount® (8 oz./acre) with crop oil, and 2,4-D (1 pint/acre) were used as needed to develop pure research stands. The chemicals were not used until stands were well established and may be too cost prohibitive for use in pastures. Common weeds were crabgrass, grassy sandbur, henbit, bindweed, buckwheat, and pigweed. Urea provided 150 lbs of nitrogen per acre before spring green-up and 100 lbs of nitrogen before fall regrowth. Phosphorous and potassium were applied during the fall, according to recommendations based on soil samples collected at each location. Plots were irrigated when necessary to provide a minimum of 22 inches total water during the growing season.

Forage samples were collected by cutting 20 square feet of each plot to a height of approximately 4 inches. Samples were collected at late-boot to early-head stages in the spring of 2003 (Table 1). Subsequent cuttings were collected from all varieties when late boot was first observed in any variety. This occurred on June 1, 2004, and October 21, 2004, in Stevens County, and on October 13, 2004, and October 29, 2004, in Ford County. In early October 2003, calves gained access to and grazed the Stevens County plots. The plots were not sampled, but they were ranked for apparent grazing preference on the basis of evidence of grazing and remaining grass height. The plots were then mowed to a 4-inch height.

Results and Discussion

Table 1 shows fall grazing preference of the Stevens County plots. Orchardgrass was the most preferred, having been grazed the shortest. It was followed in preference by smooth bromegrass, intermediate wheatgrass, and the pasture mix. Dry stems from the spring's post-cutting regrowth and seed production may have been responsible for the reduced preference for the two matua grasses relative to the three previous grasses. The two fescues were the next preferred, with festulolium being slightly less desirable. The calves essentially did not graze the crested wheatgrass. Grazing preferences will likely differ in the spring, and may have little impact on intake in a monoculture pasture. There was no obvious preference for any of the pasture-mix varieties, inasmuch as all were grazed to a similar height.

Table 1 also lists the date at which each grass was cut when at the late-boot to early-head stage in the spring of 2003. The two matuas were the earliest developing grasses. It is interesting that they also exhibited rapid regrowth after spring and fall cuttings, to the point of producing a seed head in early summer. Festulolium and the fescues were cut on the same date as the matuas were in Ford County, but were cut 8 days later in Stevens County. Orchardgrass, smooth bromegrass, the pasture mix, and crested wheatgrass generally exhibited slower development. Intermediate wheatgrass was typically the last to reach the late-boot stage, as indicated in Ford County and as observed in unclipped sections of plots in 2004.

Considerable differences in the dry matter content (Table 2) occurred between varieties and locations. A narrow range in dry matter content was observed in the spring of 2003, which was the only time that all varieties at both locations were cut at a similar stage of maturity. The wide ranges in dry matter content of subsequent cuttings likely occurred because the grasses were not cut at similar maturities.

Spring yields for 2003 (Table 3) indicate that the grasses were either better established or less winter stressed in Ford than in Stevens County. Low spring 2004 (Table 4) yields in both counties may have been the result of plant stress caused by the abnormally dry winter and unseasonably high spring temperatures. Annual yields were poorer in Ford County during 2004 than in 2003, despite the cool, wet summer. Grass yields were higher in Stevens County than in Ford County in 2004.

The matuas suffered an estimated 15 to 25% winterkill in Stevens County in 2003 and 2004 and a 15 to 20% kill in Ford County in 2004, resulting in low spring yields. These were the only varieties to have winterkill losses. Seed production during both years produced new plants, however, which improved fall yields. Ford County annual matua yields were among the highest in 2003 when there was no winter kill.

Despite low spring yields, the fescues and festulolium had high fall yields, making them some of the top annual producers in Ford County during 2003 and 2004, and the highest producing varieties in Stevens County during 2004. These three varieties seem to be better adapted to Stevens County than the other grasses, on the basis of the 2004 annual yields.

Intermediate wheatgrass, smooth bromegrass, orchardgrass, and the pasture mix had the highest spring yields of all grasses at both locations during both years. Fall yields of these four grasses were similar to, or lower than, the fescues and festulolium. Although intermediate wheatgrass was the highest annual forage producer during 2003, all varieties in Ford County produced more than 10,000 lbs of forage dry matter per acre that year. In 2004, festulolium, intermediate wheatgrass, Kentucky 31, Max-Q®, orchardgrass, and

PM6® yielded more than 8,000 lb/acre of forage dry matter in Ford County and more than 10,000 lb/acre in Stevens County. Crested wheatgrass, being the shortest grass, had the lowest annual yields at both locations.

Choosing a grass variety for irrigated production should not be based on annual yield only. Important agronomic factors that should be considered include soil and climate adaptation, fertility and water requirements, and winter hardiness. Animal-related factors include species and class of animals that will consume the forage, and their nutritional requirements, forage nutritional quality, and grazing tolerance. Other factors to consider include primary use, whether haying or grazing, and management style. These factors, as well as others, all have an important place in determining what species and variety is best adapted to the environment, the intended use, and management.

Table 1. Spring 2003 Cutting Dates by County and Calf Preference for Fall Growth in Stevens County 2003

	2003 Spring Cutting		Calf Grazing Preference
Variety	Ford	Stevens	Stevens Fall 2003*
Crested wheatgrass	May 22	May 6	4[d]
Dixon® matua	May 12	April 28	2.3[b]
Hykor festulolium	May 12	May 6	3.3[c]
Intermediate wheatgrass	May 29	May 20	2[b]
Kentucky 31 fescue	May 12	May 6	3[c]
Lakota® matua	May 12	April 28	2.3[b]
Max-Q® fescue	May 12	May 6	3[c]
Orchardgrass	May 22	May 20	1[a]
Sharp's PM6®	May 22	May 20	2[b]
Smooth brome	May 22	May 20	2[b]

*1 = most preferred, 4 = least preferred.
[abcd]Means having different superscripts differ significantly (P<0.05).

Table 2. Dry Matter Content of Irrigated Cool-season Grasses in 2003 and 2004

	2003			2004			
	Spring		Fall*	Spring		Fall	
Variety	Ford	Stevens	Ford	Ford	Stevens	Ford	Stevens
Crested wheatgrass	25.9^{ab}	28.7^{a}	25.3^{c}	37.0^{ab}	32.8^{cde}	37.1^{bc}	37.9^{b}
Dixon® matua	24.2b^{cde}	24.5^{abcde}	34.3^{a}	30.0^{ef}	26.5^{f}	28.2^{hi}	33.5^{defg}
Hykor festulolium	25.7^{abc}	22.9^{de}	30.9^{ab}	32.0^{de}	28.8^{ef}	34.2^{defg}	34.9^{def}
Intermediate wheatgrass	23.0^{de}	22.7^{de}	24.3^{c}	32.7^{de}	36.3^{abc}	36.3^{cd}	39.0^{ab}
Kentucky 31 fescue	23.7^{cde}	23.0^{de}	30.6^{abc}	34.2^{bcd}	31.7^{de}	31.4^{gh}	32.1^{g}
Lakota® matua	24.7^{abcde}	24.9^{abcde}	29.4^{abc}	30.1^{ef}	28.8^{ef}	26.6^{i}	36.2^{cd}
Max-Q® fescue	23.8^{cde}	22.6^{de}	30.5^{abc}	34.5^{abcd}	31.0^{de}	32.1^{fg}	33.4^{defg}
Orchardgrass	24.5^{abcde}	21.4^{e}	30.2^{abc}	30.6^{e}	30.3^{ef}	33.0^{efg}	35.5^{cde}
Sharps PM6®	24.0^{cde}	24.4^{bcde}	27.2^{bc}	32.3^{de}	30.0^{ef}	31.3^{gh}	35.3^{cde}
Smooth bromegrass	25.4^{abcd}	26.4^{ab}	32.5^{ab}	31.7^{de}	37.8^{a}	33.1^{defg}	41.4^{a}
Location average	24.5	24.1	29.5	32.5	31.4	32.4	35.9

*No fall cuttings in Stevens County.
^{abcdefghi}Seasonal means having different superscripts differ significantly (P<0.05).

Table 3. Dry Matter Yield of Irrigated Cool-season Grasses in 2003

	Spring			Fall*	Annual*
Variety	Ford	Stevens	Both	Ford	Ford
Crested wheatgrass	5755^{cd}	1289^{g}	3522	4901^{c}	10656^{d}
Dixon® matua	4078^{ef}	672^{g}	2375	8632^{a}	12710^{bcd}
Hykor festulolium	3070^{f}	1196^{g}	2133	8726^{a}	11796^{cd}
Intermediate wheatgrass	9905^{a}	5088de	7497	6938^{b}	16842^{a}
Kentucky 31 fescue	3388^{f}	998^{g}	2193	8789^{a}	12177^{bcd}
Lakota® matua	5175^{cde}	741^{g}	2958	8519^{a}	13694^{bc}
Max-Q® fescue	4306^{ef}	1238^{g}	2772	9888^{a}	14194^{b}
Orchardgrass	6056^{bcd}	3577^{f}	4817	5146^{c}	11203^{d}
Sharps PM6®	6567^{bc}	3841^{ef}	5204	5862^{bc}	12429^{bcd}
Smooth bromegrass	7162^{b}	3892^{ef}	5527	5552^{bc}	12714^{bcd}
Location average	5546	2253		7295	12841

*No fall cuttings in Stevens County.
^{abcdefg}Seasonal or annual means having different superscripts differ significantly (P<0.05).

Table 4. Dry Matter Yield of Irrigated Cool-season Grasses in 2004

	Spring			Fall			Total Annual		
Variety	Ford	Stevens	Both	Ford	Stevens	Both	Ford	Stevens	Both
Crested wheatgrass	2396	1069	1732[bcd]	3265[h]	5120[fg]	4192	5661[e]	6189[de]	5925
Dixon® matua	1498	953	1225[e]	4770[g]	8188[bc]	6479	6268[de]	9141[c]	7705
Hykor festulolium	1689	1245	1467[de]	6329[ef]	13307[a]	9818	8018[c]	14552[a]	11285
Intermediate wheatgrass	2639	2639	2639[a]	6268[ef]	9069[b]	7669	8907[c]	11708[b]	10307
Kentucky 31 fescue	1868	1133	1500[de]	6715[de]	12125[a]	9420	8583[c]	13258[a]	10920
Lakota® matua	1206	1086	1146[e]	4988[fg]	8487[b]	6738	6194[de]	9573[c]	7884
Max-Q® fescue	1673	1623	1648[cd]	6985[cde]	12192[a]	9588	8658[c]	13815[a]	11236
Orchardgrass	2383	1764	2073[b]	6650[de]	9878[b]	8264	9032[c]	11641[b]	10337
Sharps PM6®	2450	1492	1971[bc]	6302[ef]	8542[b]	7422	8751[c]	10033[c]	9392
Smooth bromegrass	2348	1867	2108[b]	5048[fg]	7940[bcd]	6494	7396[cd]	9807[c]	8602
Location average	2015[i]	1487[j]		5732	9485		7747	10972	

[abcdefgh]Seasonal or annual means having different superscripts differ significantly (P<0.05).
[ij]Location means differ significantly (P<0.05).

NUTRIENT VALUES FOR HARVESTED FORAGES FROM NORTHEASTERN KANSAS

T. T. Marston, D. L. Davis, B. D. Wood, and R. L. Schaub

Summary

Forage testing is an important management tool available to cattle producers. Hay samples (n=42) from Shawnee, Douglas, and Osage counties of various forages (mostly alfalfa, brome hay, and prairie hay) recently were analyzed for nutrient composition. Results indicate that variability in crude protein and fiber (ADF and NDF) content exists. Alfalfa samples possessed crude protein content greater than reported values, whereas prairie samples were close to National Research Council reported values. In contrast, brome hay samples often had less crude protein than their NRC book values. Single samples of other forage types revealed that nutrient profiles of alternative forages could be successfully integrated into cattle feeding programs. These results strongly support the continued need for producers to practice forage sampling to optimize cattle feeding costs.

Introduction

Forages harvested in Kansas are the primary ingredients used in winter cow diets. Many factors affect the nutrient value of mechanically harvested forages, such as variety, plant maturity, weather, harvesting techniques, fertilization, and storage. Often, producers rely on nutrient values reported in nutritional publications (like the NRC) instead of using forage testing to formulate diets. Reported values have significant usefulness, but, because of the differences between operations in forage quality, forage testing allows producers to more accurately formulate diets to meet their particular needs. Therefore, our objective was to report differences in key nutrient concentrations in mechanically harvested hay samples from northeastern Kansas.

Procedures

Hay samples (n = 42 from 25 different operations located in Shawnee, Douglas, and Osage counties) were taken from round bales stored outside from harvest to early October. Hay samples were collected by inserting a hay probe perpendicular to the side of the bale. Samples were immediately placed into plastic bags and later analyzed for dry matter, nitrogen, acid detergent fiber (ADF), and neutral detergent fiber (NDF) at the Analytical Laboratory, K-State Department of Animal Sciences and Industry. Crude protein was assumed to equal the nitrogen content times 6.25. Total digestible nutrients (TDN) were calculated from ADF values. Reported nutrient values were taken from the NRC 2000 publication, The Nutrient Requirements of Beef Cattle.

Results and Discussion

Nutrient compositions of forage samples are listed in Tables 1 and 2. Table 1 contains data from alfalfa, brome, and prairie samples. Enough samples were collected within each of these forage types to calculate means and standard deviations. Other forage types had only one or two samples, so only the individual sample values are reported.

Many producers increase the protein content of cattle diets by feeding alfalfa hay. The average alfalfa hay sample tested contained

5.5% more crude protein than listed in the NRC. This would indicate that producers would be able to reduce the use of alfalfa hay if they perform forage testing instead of relying strictly on reported book values. The wide range (more than 10%) and large standard deviations of crude protein concentrations indicates the necessity of forage testing to correctly formulate cattle diets. Further statistical analysis indicated that harvesting sequence (cuttings) also had an effect on crude protein content. Crude protein content increased as cuttings progressed from first to fifth cuttings (see Table 3). Measurements of fiber, both NDF and ADF, and energy (total digestible nutrients, TDN) follow similar patterns as producers harvested alfalfa throughout the growing season. Fiber values decreased and energy content increased as the alfalfa crop advanced through the harvesting sequence. Relative feed value (RFV) of the alfalfa hay increased from first to fifth cutting. Crude protein and RFV are often used to evaluate alfalfa hay, so hay producers should give particular attention to these measures.

Results from brome hay samples reflect the difficult haying conditions experienced by many of the producers this past year. Lower crude protein concentrations, along with greater NDF (fiber) contents (compared with reported book values), reveal that producers may have either delayed baling until the brome grass was mature, left the hay in windrows longer than anticipated, or both. The percentage of TDN in the harvested brome grass bales was nearly the same as reported NRC values. It is common for cow/calf producers to use brome hay with minimal protein supplementation when feeding cows in mid and late gestation. This year's results indicate that some producers should consider small amounts of protein supplementation (up to 0.5 lb of crude protein) to satisfy gestating, dry cow requirements.

Average prairie hay samples contained crude protein concentrations almost identical to reported book values. Reduced NDF and greater calculated TDN contents indicate that producers harvested an excellent grass crop in 2004. The range in contents of crude protein, fiber, and energy shows that, for the most part, the prairie hay is not only high quality but also consistent in its nutrient profile.

Complements of other forages were included for analysis (Table 2). In most instances, there was no replication within these grass/forage species, so only limited information can be garnered. Collective results show that cattle producers can utilize a wide array of forage sources to satisfy their herds' dietary needs. Forage intake increases as the protein content of forage approaches 7%. Almost all samples analyzed, with the exception of wheat straw, had crude protein contents at or exceeding 7%, indicating they would require little protein supplement for most gestating, dry-cow feeding situations.

Table 1. Nutrient Composition of Alfalfa, Brome Grass, and Prairie Hay Samples (Dry Matter Basis)

	Reported Value[a]	Mean	Standard Deviation	Minimum	Maximum
Alfalfa (15 samples)	---------- % of dry matter ----------				
Dry matter	91.0	86.7	2.0	83.3	90.2
Crude protein	17.0	22.7	3.4	16.4	27.5
NDF	49.0	42.0	6.7	30.3	52.5
ADF		31.6	5.1	23.5	39.8
TDN[b]	60.0	64.3	4.0	57.9	70.6
Brome hay (11 samples)					
Dry matter	91.0	88.0	1.5	84.3	90.3
Crude protein	10.0	8.0	1.7	5.7	12.2
NDF	57.7	67.1	1.6	65.2	69.5
ADF		41.8	1.2	40.5	44.7
TDN[b]	56.0	56.3	0.9	54.1	57.3
Prairie hay (10 samples)					
Dry matter	91.0	89.3	1.5	86.4	91.7
Crude protein	5.3	5.6	1.0	4.2	7.3
NDF	72.7	67.6	1.9	64.3	70.7
ADF		42.4	1.1	40.9	44.1
TDN[b]	48.0	55.9	0.9	54.5	57.0

[a]Reported value as listed in NRC, 2000 (Alfalfa Hay = Mid-Bloom N; Brome Hay, Late bloom; Prairie Hay).
[b]Total digestible nutrients was calculated as TDN% = 88.9 – (0.779 × ADF%).

Table 2. Nutrient Composition of Harvested Forage Samples (Dry Matter Basis)

Forage	No. Samples	Dry Matter	Crude Protein	NDF	ADF	TDN
		---------- % of dry matter ----------				
Crabgrass	1	83.3	9.4	67.0	44.3	75.5
Fescue	2	86.9	7.2	70.6	45.7	53.3
Weeds[a]	1	91.2	10.3	60.1	45.3	53.6
Straw	1	89.9	5.5	73.6	48.2	51.4
Wheat	1	87.9	12.7	52.5	37.5	59.7

[a]Sample contained an unidentified mixture of broadleaf and grass species grown in an abandoned beef cattle confinement pen.

Table 3. Nutrient Composition (Dry Matter Basis) of Alfalfa Hay Samples

Cutting	No. Samples	Dry Matter	Crude Protein	NDF	ADF	TDN	RFV[a]
		---------- % of dry matter ----------					
First	2	87.8	18.3[b]	48.9[b]	38.5[b]	58.9[b]	112[b]
Second	7	86.9	22.6[bc]	43.7[b]	32.6[bc]	63.4[bc]	139[b]
Third	1	88.5	20.1[b]	43.8[b]	33.0[bc]	63.2[bc]	134[b]
Fourth	3	86.0	24.9[c]	39.6[bc]	29.0[c]	66.3[c]	157[cd]
Fifth	2	85.2	26.1[c]	31.8[c]	24.7[c]	69.7[c]	204[d]

[a]RFV is an index that combines estimated digestibility and potential intake of a forage calculated from ADF and NDF fractions, respectively.
[bcd]Means in a column without a common letter differ, $P<0.05$.

EFFECT OF ADDING AUREOMYCIN® FOR ANAPLASMOSIS CONTROL OR RUMENSIN® TO MINERAL SUPPLEMENTS ON SUMMER BEEF COWHERD PERFORMANCE

R. M. Breiner, D. A. Llewellyn, and T. T. Marston

Summary

Two hundred forty-six commercial Angus-based cows were used to determine the effect of adding Aureomycin® for anaplasmosis control or Rumensin® to mineral supplements on summer beef cowherd performance. Cow/calf pairs were randomly allotted to summer native-pasture groups by treatment, and were fed an industry-standard mineral/trace mineral supplement for the duration of the trial. The study had three treatments: (1) control mineral supplement with no medication added, (2) the same base supplement with the addition of Aureomycin® (0.5 mg/lb cow body weight daily), and (3) the base supplement with the addition of Rumensin® (200 mg/cow daily). Feed additives were blended into the mineral mix to provide the targeted daily consumption. Treatments were initiated May 6 and maintained through October 6. Mineral intake was similar among treatments. Cow and calf weight gains were similar among treatments during the first 32 days of the study. By the trial end, there were no significant differences in cow body condition score gains and pregnancy rates. Total calf gains for the duration of the trial were similar for groups supplemented with Aureomycin®, and Rumensin®, and both were greater than for control calves (21 and 18 lb greater, respectively). Overall herd health was enhanced by feeding Aureomycin® when compared with control or Rumensin®. Foot rot was the main health concern in this trial, and the addition of Aureomycin® to mineral supplements reduced foot rot.

Introduction

Mineral supplementation is an important practice for cow/calf operations to meet cow mineral requirements during the summer grazing periods. Lack of specific minerals can decrease cow weights, calf gains, and reproductive rates. Still, the addition of medicated mineral premixes over and above standard mineral packages has the benefit of increasing cowherd performance and weight gains while reducing herd health concerns. The objective of this study was to determine the effects of medicated mineral supplements on cow and calf weights, cow body condition scores, and incidence of sickness compared with performance of a standard mineral supplement.

Procedures

Two hundred forty-six commercial Angus-based cow/calf pairs were randomly allotted to three treatment groups that were balanced for dam and calf age. Cows were weighed and body condition scored April 26 to establish baseline measures. On May 6, cows and calves were weighed, cows were body condition scored, and then pairs were sorted into treatment pastures. Pasture groups were allotted randomly to treatments. All cattle grazed native pastures with water available at all times. Cattle were rotated among the pastures on a 2- to 4-week schedule. A standard mineral/trace mineral supplement was provided to all pastures throughout the duration of the trial. All treatments were administered in an

industry-standard mineral supplement. Treatments were: (1) control mineral supplement with no medication added, (2) the same base supplement with the addition of Aureomycin®-90 (chlortetracycline HCl, 0.5 mg/lb body weight) for anaplasmosis control, and (3) the base supplement with the addition of Rumensin® (monensin sodium, 200 mg/cow daily). All cattle had free-choice access to mineral feeders throughout the trial. Mineral supplement consumption was monitored weekly, orts were recorded, and concentrations of medications were maintained to provide the designated amounts. On October 5, cows were weighed and body condition scored, and calf weaning weight was recorded. Cow weights, gains, body condition scores, and pregnancy rates were measured. Cow weight and condition scores were measured at the beginning of the trial, immediately before the breeding season, and on the weaning date. Cow/calf pairs were gathered in the late afternoon one day before measuring cattle weights, and were fed 10 lb/pair of prairie hay in drylots with no access to water. Cows and calves were separated just before weighing and body condition scoring, which began early the next morning. Body condition (scale 1 to 9, 1=emaciated, 9=obese) was determined by averaging the estimates obtained from four independent observers. Observers used both visual and palpation techniques to determine their score.

Blood samples were collected May 16 and May 26 to determine the percentage of cows cycling before estrous synchronization and breeding. Estrous synchronization consisted of two shots of $PGF_{2\alpha}$, on May 26 and June 6, to initiate the breeding season. Cows were artificially inseminated to three purebred Angus bulls from June 7 through June 11 by using heat detection and the AM/PM rule. Polled Hereford bulls were then turned out on June 15 for natural service. Natural breeding season lasted 65 days. Pregnancy confirmation by rectal palpation occurred from October 14 to October 22.

In addition, cow and calf incidence of bovine respiratory disease, foot rot, pinkeye, and general health concerns for cattle were measured throughout the study. Sickness, health treatments, and mortality records were kept on the entire herd. Cows and calves were vaccinated and processed according to a protocol designed by our consulting veterinarian.

Results and Discussion

Daily mineral consumption was between 4.4 and 5.2 ounces per cow/calf pair (Table 1). Mineral intake was similar among treatments, but, numerically the Rumensin®-containing mineral was consumed in lesser amounts than the other mineral mixes. Mineral intake remained fairly constant from the beginning to the end of the trial. Rumensin® intake averaged 216 mg per cow/calf pair daily. Aureomycin® intake averaged 910 mg per cow/calf pair daily. The average weight of the cows fed Aureomycin® was 1084 lbs. Therefore, cows consumed an average of 0.84 mg Aureomycin®/lb body weight throughout the trial.

Table 2 lists the weights, body condition scores, and pregnancy rate of the cows. It is remarkable that cows gained nearly 3.7 lb/day during the first 32 days of the trial. These dates correspond to the 32 days before the start of the breeding season. Much of the weight gain can be attributed to gut fill as pasture quality improved over this period due to warming temperatures and rainfall (May 2004). Cow and calf weight gains were similar among treatments during the first 32 days of the experiment. During the first 32 days, cows fed Rumensin® gained about 0.1 body condition score more than did cows fed Aureomycin®. By weaning time, however, all treatments showed similar gains in body condition score. Body condition scores remained similar between treatments throughout the trial. Pregnancy rates were similar between treatments, ranging from 88.9 to 92.0%.

Calf gains were similar among treatments during the first 32 days of the trial (Table 2). Total calf gains for the duration of the experiment were similar for calves of cows supplemented with Aureomycin® and Rumensin®, and both were greater than gains of control calves (21 and 18 lb greater, respectively).

Table 3 shows the herd health data. Herd health was improved by feeding Aureomycin®, compared with the control or Rumensin®. The most common illness detected and treated was foot rot. Pinkeye and respiratory diseases were minimal throughout the trial period. Combining all categories of illness, cattle fed Aureomycin® incurred fewer bouts of sickness.

Addition of either Aureomycin® or Rumensin® to mineral supplements fed to cow/calf pairs grazing summer pastures will increase calf weaning weights without sacrificing cowherd weight, body condition, or reproductive rates. The addition of Aureomycin® to mineral supplements reduced the incidence of foot rot. This can lead to substantial savings in medical costs, labor costs, and animal handling.

Table 1. Average Intake of Mineral Mixes Used in Experiment

	Treatment		
Item	Control	Aureomycin®	Rumensin®
No. of cow/calf pairs	62	91	93
No. of pasture groups	2	3	3
Mineral intake, oz/pair daily	4.9	5.2	4.4
Medication intake, mg/pair daily	0	910	216

Table 2. Effects of Mineral Medication Treatments on Cowherd Performance

	Treatment			Contrast P-value	
Item	Control	Aureomycin®	Rumensin®	Control vs. Medicated	Aureomycin® vs. Rumensin®
Initial cow wt, lb	1013	977	981		
Initial BCS[a]	5.0	4.9	4.9		
Initial calf wt, lb	218	219	218		
Start of Trial to Beginning of Breeding Season (32 days)					
Cow breeding wt, lb	1109	1098	1108	0.25	0.07
Cow breeding BCS	5.0	5.0	5.1	0.52	0.19
Calf wt, lb	301	302	302	0.82	0.73
Cow wt gain, lb	121	114	120	0.61	0.32
Cow BCS change	0.15	0.18	0.30	0.08	0.03
Calf wt gain, lb	83	84	83	0.87	0.45
Start of Trial to Weaning (152 days)					
Cow Weaning wt, lb	1194	1181	1180	0.14	0.95
Cow Weaning BCS	5.1	5.1	5.0	0.40	0.18
Calf weaning wt, lb	561	579	581	0.0002	0.74
Cow wt gain, lb	206	198	192	0.28	0.60
Cow BCS change	0.2	0.2	0.2	0.52	0.98
Calf wt gain, lb	343	362	362	0.0001	0.97
Pregnancy rate, %	90.2	92.0	88.9	0.95	0.49

[a]Body condition score, estimated on a scale of 1 = emaciated to 9 = obese.

Table 3. Effect of Mineral Medication Treatments on Incidence of Cowherd Health Problems

	Treatment			
Item	Control	Aureomycin®	Rumensin®	P-value
No. of cows and calves	124	182	184	
	------ Percentage of Cattle Treated for Illness ------			
Foot rot	21.0	6.6	19.4	0.0006
Repull for foot rot	22.2	8.3	26.3	0.08
Pink eye	0.8	0.0	0.5	0.99
Respiratory diseases	0.0	0.0	0.5	0.99
All illnesses	21.8	6.6	20.4	0.0003

COMPARISON OF DECTOMAX® AND VALBAZEN® ON FEEDLOT STEER PERFORMANCE AND CARCASS TRAITS

J. A. Christopher, T. T. Marston, J. R. Brethour, and G. L. Stokka

Summary

Two hundred thirty-nine steers were fed at the K-State Agricultural Research Center–Hays to compare the effects of different deworming agents on feedlot performance and carcass traits. This experiment consisted of two replications with steers being fed a finishing diet based on ground sorghum-grain for approximately 100 days. Before the start of each replication, steers were commingled for approximately 30 days and then stratified into high- and low-marbling groups via ultrasound measurements. Within each marbling group, steers were randomly allotted to a treatment. Treatments consisted of an oral application of Valbazen® or a subcutaneous injection of Dectomax® dewormer. Dosages of deworming products followed label instructions. At time of treatment and 12 days later, fecal grab samples were analyzed for indications of internal parasite infestation. Both deworming agents reduced fecal egg counts. Feedlot performance, as measured by daily gain and feed efficiency, was unaffected by treatment. Dectomax®-treated cattle had greater marbling scores and had a greater percentage of carcasses grading USDA Choice or greater than did cattle given Valbazen®. Steers receiving Dectomax® had thicker backfat and greater Yield Grade measurements than did the Valbazen®-treated steers. Other carcass traits were similar between treatment groups. Our data indicate that both Dectomax® and Valbazen® deworming agents can effectively reduce internal parasites, but feedlot steers given Dectomax® had more intramuscular and external fat deposition.

Introduction

When cattle are dewormed upon entering the feedlot or during the finishing phase, performance and carcass measurements are improved. It is unknown whether this response is due to the clearing of internal parasites, control of external parasites, and/or a biological response to the product. The major objective of this study was to determine if Dectomax® enhances marbling scores independent of its ability to deworm feedlot cattle.

Procedures

The cattle used in this study were large-framed, heavy-weight steers with the genetic propensity to marble. They were gathered from several local sources near Hays, Kansas. When these cattle were brought to the feedlot to begin the finishing phase, they were commingled, vaccinated for bovine respiratory disease, and given an estrogenic implant. Steers were fed a common finishing diet for about 60 days before being allotted to treatment.

Ultrasound measurements and Cattle Performance Enhancement Company (CPEC) predictions were used to select steers with similar harvest endpoints. Steers were fed 103 days. Within each harvest date, steers were stratified into high- and low-marbling groups. Steers were randomly allotted to treatments within each marbling/harvest group. Treatments consisted of: 1) steers received 4

ml/100 pounds body weight of Valbazen® oral drench, or 2) steers received subcutaneous injection of Dectomax® at 1 ml/110 pounds body weight. At the time of treatment application, fecal grab samples were collected from 80 steers and analyzed for worm egg counts. Twelve days after treatment application, fecal samples were collected and similarly analyzed.

During the two replications, steers were fed a common finishing ration consisting primarily of finely ground, dry, grain sorghum. The diet contained sorghum silage, soybean meal, urea, and ammonia sulfate. The diet also included 100 g calcium carbonate, 25 g sodium chloride, 300 mg of Rumensin, 90 mg Tylan, 30,000 IU Vitamin A per head per day, and a trace mineral premix that provided adequate amounts of copper, manganese, zinc, iron, iodine, and cobalt. Steers were fed in four, 30-head capacity pens. Feed deliveries were recorded daily for each pen. Beginning and intermediate body weights were measured, whereas final body weights were calculated from carcass weights adjusted via a common dressing percentage. Fecal samples were analyzed by microscope to count number of intestinal parasite eggs. Cattle were harvested at a commercial facility (National Beef, Dodge City, Kansas), and carcass data were retrieved after a 24-hour carcass chill.

Results and Discussion

The fecal egg count data showed steers shedding an average of 16 eggs/gram of feces at the start of the trial. Eggs counts diminished to 1.0 egg/gram for Valbazen® and 5.2 eggs/gram for Dectomax®, indicating both products were effective at reducing shedding of eggs (Table 1).

The performance and carcass data are presented in Table 2. Average daily gain was not different between treatments. Cattle treated with Dectomax® had more intramuscular fat at the time of harvest than did cattle treated with Valbazen®. This resulted in a tendency for a greater number of cattle given Dectomax® to have a USDA quality grade of Choice or higher. Steers receiving Dectomax® also had thicker backfat and tended to have higher USDA Yield Grades. This experiment showed a tendency for steers treated with Dectomax® to have greater amounts of external and intramuscular fat than did steers receiving Valbazen®, suggesting that this effect may be independent of its deworming capacity.

Table 1. Effect of Deworming with Valbazen® or Dectomax® on Fecal Egg Counts of Feedlot Steers

	Valbazen®	Dectomax®	SEM	P-value
Day 0 egg count, eggs/gram feces	17.5	14.7	3.9	0.62
Day 12 egg count, eggs/gram feces	1.0	5.2	2.6	0.26

Table 2. Performance and Carcass Traits from Feedlot Steers Treated with Valbazen® or Dectomax®

Item	Valbazen®	Dectomax®	SEM	P-value
Number of steers	120	119		
Initial weight, lb	1005	1000		
Initial marbling score[a]	449	450		
Final weight, lb	1384	1374		
Average daily gain, lb	3.68	3.64	0.11	0.91
Feed intake, lb/day dry matter	27.7	28.0		
Feed:gain	7.52	7.69		
Hot carcass weight, lb	879	872		
Backfat, inches	0.51	0.57	0.03	0.02
Ribeye area, square inches	15.04	14.66	0.22	0.09
USDA Yield Grade	2.39	2.56	0.12	0.08
Kidney, pelvic, heart fat, %	2.41	2.52	0.07	0.09
Marbling score[a]	530	545	13.3	0.05
USDA Choice or greater, %	60.0	68.1	7.0	0.11
USDA Prime, %	3.3	4.2	3.0	0.61

[a]Marbling score scale: 400 = Slight 00, 500 = Small 00, 600 = Modest 00, etc.

FEEDLOT PERFORMANCE, HEALTH, AND CARCASS CHARACTERISTICS OF BEEF HEIFERS TREATED WITH CYDECTIN® OR DECTOMAX® AT PROCESSING

R. L. Hale, D. Gray[1], and R. Armendariz[2]

Summary

Two parasite-control products were compared in an experiment evaluating growth performance, health, and carcass characteristics. Crossbred heifers (n=1747; 837 lb average weight) were randomly assigned to receive either Cydectin® or Dectomax®. Both products were administered at processing at 1 ml per 22 lb of body weight. Cattle were randomly allotted to 12 paired pens by treatment based on source, truckload, and arrival date. Fecal egg counts taken at processing (9.74 eggs per gram) and at reimplanting (0 eggs per gram) indicated that both products were effective in eliminating adult female gastrointestinal parasites. No differences were detected in average daily gain, feed intake, feed efficiency, or most carcass characteristics. Respiratory pulls, realizer cattle, and death loss did not differ between treatments. In this experiment, similar growth performance, health, and carcass traits were observed for heifers treated with either macrocyclic lactone product.

Introduction

Internal and external parasites are a common problem in cattle. Economic losses to the U.S. cattle industry due to parasitism have been estimated to be more than a billion dollars annually. Internal parasites decrease performance by reducing feed intake, reducing available nutrients, and impairing nutrient utilization. Lice and mites also reduce cattle performance. Grubs cause losses due to hide and muscle tissue damage. Carcass and animal health can be improved with parasite control through better nutrient availability and utilization.

Several cattle products based on macrocylic lactones, a class of endectocides that control both internal and external parasites, have been marketed since 1984. The products are oral drenches, injectables, or pour-ons. Product differences also include the carrier and the active ingredient. Carriers have been either alcohol or oil based. The active ingredients come from one of two chemical families; milbemycins or avermectins. Moxydectin, the active ingredient in Cydectin®, is a milbemycin, whereas doramectin, the active ingredient in Dectomax®, is an avermectin. There are some differences between efficacy and persistence (post-treatment control) of the two products. Although there are differences in label claims with regard to species controlled, a number of the species such as Cooperia and Thelazia spp. are not economically import, particularly in specific locales. The five most economically important internal parasites in cattle are Dictyocaulus, Haemonchus, Nematodirus, Ostertagia, and Trichostrongyles. Table 1 lists the similarities and differences between Cydectin® and Dectomax® for internal and external parasite control. Numerous studies have attributed im-

[1]Formerly with Fort Dodge Animal Health.
[2]Fort Dodge Animal Health.

proved feedyard performance to internal and external parasite control with the use of the macrocyclic lactones. This experiment was conducted to evaluate feedlot performance and carcass traits of heifers treated with either Cydectin® or Dectomax® for internal parasite control. The presence and control of grubs, lice, mites, and horn flies was not evaluated in this study.

Procedures

Yearling crossbred heifers (n=1747) averaging 837 lbs originated from three ranches in South Dakota and Wyoming. Approximately 24 hours after arrival at a southwestern Kansas feedyard, the heifers were processed, and each animal received a four-way modified live viral vaccine, a clostridial vaccine, an implant containing 20 mg estradiol benzoate and 200 mg testosterone, and a uniquely numbered eartag. One of each pair of heifers was assigned to either Cydectin® or Dectomax® according to a predetermined randomization schedule. The cattle were treated topically along the back with 1 ml of one product per 22 lbs of body weight (0.5 mg active ingredient / 2.2 lb). The cattle were blocked by origin, truckload, and arrival date and were randomly allotted to neighboring pens by treatment. Six pens per treatment were used, with 134 to 196 heifers in each pen. Numbers of heifers in paired pens differed by no more than one animal. The heifers were placed on feed October 10, 2001. The cattle were fed the same steam-flaked rations, and adjusted to the finishing ration two to three weeks after arrival. Feed and water were offered for ad libitum consumption. Approximately 80 days before harvest, the heifers were revaccinated with a modified live IBR/BVD vaccine and reimplanted with a 200-mg trenbolone acetate implant. Each pair of pens was harvested on the same day at a commercial abattoir in southwestern Kansas. Days on feed ranged from 128 to 139, with an average of 133 days. Carcass data were collected after a 26- to 28-hour chill.

Fecal samples were collected at processing from one randomly predetermined animal of every 10 animals in each treatment. The samples were again collected from the same heifers at reimplanting. The number of eggs per gram of feces was determined at a commercial laboratory by using the modified Wisconsin method, a commonly used and accurate method for counting internal parasite eggs.

Individual weights measured at processing were summed by pen for use as initial weights. Pen weights measured before shipment for harvest were used as final weights after a 4% pencil shrink. Feed delivery from the feedyard closeout summary was used as feed intake. Average daily gain, feed intake, and feed efficiency were calculated with deads in.

Results and Discussion

Individual fecal samples collected at processing ranged from 0 to 124 eggs per gram with an average of 9.74 eggs per gram. Both Cydectin® and Dectomax® eliminated gastrointestinal parasites, as indicated by fecal evaluation at reimplanting (0 eggs per gram).

Animal performance and carcass traits are listed in Table 2. Initial body weights were similar between the two treatments, as were average daily gain, feed intake, and feed efficiency. No differences were detected for respiratory pulls, realizer animals, and death loss. Final weight, hot carcass weight, and dressing percentage were similar. No differences were observed for the quality traits of marbling score, carcass maturity, and dark cutting. The percentage of USDA Prime carcasses tended to be higher (P=0.10; 3.71 vs. 2.13%) and kidney, pelvic, and heart fat was slightly greater (P=0.06; 2.34 vs. 2.26%) in carcasses from Cydectin®-treated heifers. Backfat, ribeye area, and USDA Yield Grades were not different.

Although this study did not have an untreated control group, other research has shown the benefit of treating feedlot cattle for parasites. Research has consistently shown improved gain, feed efficiency, health, and carcass traits with the use of broad-spectrum endectocides. These benefits are the result of greater feed intake, more available nutrients, and better nutrient utilization. The incidence of grubs and mites has decreased with the use of the macrocyclic lactones. Lice continue to be a common cattle problem, and also can affect performance if not controlled. Cydectin® and Dectomax® supported similar feedlot performance and animal health.

Table 1. Active Ingredient, Concentration, Dosage, and Parasite Control Comparison of Cydectin® and Dectomax®

Item	Cydectin®	Dectomax®
Active ingredient	Moxydectin - Milbemycin family	Doramectin - Avermectin family
Concentration	5 mg / ml	5 mg / ml
Dosage	0.5 mg active ingredient / 2.2 lb 1 ml product / 22 lb	0.5 mg active ingredient / 2.2 lb 1 ml product / 22 lb
Carrier	Oil	Alcohol
Gastrointestinal roundworms	*Ostertagia ostertagi* (adult and L_4, including inhibited larvae)[4] *Haemonchus placei* (adult and L_4)[2] *Trichostrongylus axei* (adult and L_4) *Trichostrongylus colubriformis* (adult and L_4) *Cooperia oncophora* (adult and L_4) *Cooperia pectinata* (adult) *Cooperia punctata* (adult and L_4) *Cooperia spatulata* (adult) *Cooperia surnabada* (adult and L_4) *Bunostomum phlebotomum* (adult) *Nematodirus helvetianus* (adult and L_4) *Oesophagostomum radiatum* (adult and L_4)[4]	*Ostertagia ostertagi* (adult and L_4, including inhibited larvae)[4] *Ostertagia lyrata* (adults) *Haemonchus placei* (adult and L_4)[5] *Trichostrongylus axei* (adult and L_4) *Trichostrongylus colubriformis* (adult and L_4) *Cooperia oncophora* (adult and L_4)[3] *Cooperia pectinata* (adult) *Cooperia punctata* (adult and L_4)[4] *Cooperia surnabada* (adult) *Bunostomum phlebotomum* (adult) *Oesophagostomum radiatum* (adult and L_4)[4] *Trichuris* spp. (adults)
Lungworms	*Dictyocaulus viviparus* (adult and L_4)[6]	*Dictyocaulus viviparus* (adult and L_4)[3]
Eyeworms		*Thelazia gulosa* (adults) *Thelazia skrjabini* (adults)
Cattle grubs	*Hypoderma bovis* *Hypoderma lineatum*	
Mites	*Chorioptes bovis* *Psoroptes ovis* (*Psoroptes cummunis* var. *bovis)*	
Lice	*Linognathus vituli* *Haematopinus eurysternus* *Solenopotes capillatus* *Bovicola (Damalina) bovis*	*Linognathus vituli* *Haematopinus eurysternus* *Solenopotes capillatus* *Bovicola (Damalina) bovis*
Horn flies	*Haematobia irritans*[1]	*Haematobia irritans*[1]

[1]7 days, [2] 14 days, [3] 21 days, [4] 28 days, [5] 35 days, or [6] 42 days post-treatment control (persistency).

Table 2. Performance, Health, and Carcass Characteristics of Yearling Heifers Treated with Cydectin® or Dectomax®

Item	Cydectin®	Dectomax®	SEM	P-value
Number of pens	6	6	-	-
Number of heifers	873	874	-	-
Initial weight, lb	837	838	13.3	0.88
Final weight, lb	1278	1281	14.5	0.37
Daily gain, lb	3.32	3.34	0.02	0.41
Intake, as fed lb/day	30.1	30.0	0.38	0.76
Feed:gain, as-fed	9.06	8.96	0.07	0.31
Respiratory pulls, %	1.49	1.50	0.30	0.99
Realizers, %	0.12	0.12	0.08	0.99
Death loss, %	0.57	0.46	0.18	0.37
Hot carcass weight, lb	806	808	10.2	0.41
Dressing percentage	63.11	63.08	0.12	0.82
Backfat, inches	0.59	0.59	0.02	0.74
Ribeye area, square inches	14.56	14.74	0.16	0.47
Kidney, pelvic, heart fat, %	2.34	2.26	0.04	0.06
USDA Yield Grade				
Average	2.84	2.78	0.08	0.48
1, %	16.0	18.7	2.36	0.34
2, %	43.8	42.1	2.04	0.28
3, %	29.3	30.7	2.40	0.64
4, %	10.1	7.4	1.60	0.24
5, %	0.8	1.1	0.41	0.34
Marbling score	Sm^{76}	Sm^{74}	5.29	0.72
B and C maturity, %	2.1	3.2	0.51	0.29
Dark cutters, %	0.12	0.24	0.10	0.58
USDA quality grade				
Prime, %	3.7	2.1	0.67	0.10
Choice, %	69.4	69.9	1.03	0.87
Select, %	25.3	25.8	1.39	0.90
Standard, %	1.1	1.4	0.31	0.53
No roll, %	0.3	0.7	0.23	0.54

SEROLOGICAL RESPONSES TO IBR VIRAL VACCINE AND *MANNHEIMIA HAEMOLYTICA* BACTERIN/LEUKOTOXOID ADMINISTERED WITH NEEDLE-FREE INJECTION TECHNOLOGY

L. C. Hollis, J. F. Smith, B. J. Johnson, S. Kapil[1], and D. A. Mosier[1]

Summary

Yearling steers were randomized to treatment and vaccinated with 5-way modified live viral vaccine and *Mannheimia haemolytica* bacterin/toxoid by using either needle-free or standard needle injection. Blood samples were collected from all animals at the time of vaccination and 21 days later, and the serum was analyzed for antibody titers to infectious bovine rhinotracheitis (IBR) virus and *M. haemolytica* leukotoxoid. Serological responses to the IBR viral fraction of the 5-way viral vaccine were significantly greater on day 21 after administration with the needle-free injection system. Serological responses to the *M. haemolytica* leukotoxoid tended to be greater on day 21 after administration with the needle-free injection system.

Introduction

Beef quality-assurance guidelines recommend that the most tissue-friendly route of administration of injectable products be used whenever possible. One new technology that offers potential to meet that objective is the use of a needle-free injection device (Felton 250 Pulse™ Needle-Free Injector), a pneumatically powered device (Figure 1) that uses air pressure to administer the vaccine through the skin and into the underlying subcutaneous or muscle tissues (Figure 2). The question arises: Do the cattle respond to the vaccines the same way as when vaccinated with conventional needle and syringe? The purpose of this study was to compare efficacy, as measured by seroconversion, when a vaccine and a bacterin/leukotoxoid were injected with either needle-free or traditional needle injection methods.

Procedures

One hundred eleven uniform yearling steers (806 lb) from a single ranch were used for the study. Animals were individually identified, blood samples were collected, and serum was harvested from blood and frozen. All animals were vaccinated with a 5-way modified live respiratory viral vaccine (Bovi-Shield® Gold 5) and a *M. haemolytica* bacterin/leukotoxoid (One Shot®). Needle-free and standard needle routes of administration were randomized between pairs of animals as they entered the squeeze chute. Those animals selected to receive the viral vaccine by needle-free injection received the bacterin/leukotoxoid by standard needle injection. The other animal of each pair received the viral vaccine by needle injection and the bacterin/leukotoxoid by needle-free injection. The Felton needle-free injector was set to 85 psi to ensure intramuscular injection of the viral vaccine, and it was set at 75 psi to ensure subcutaneous injection of the bacterin/leukotoxoid. On day 21, blood samples were collected from all steers, and the serum

[1]Diagnostic Medicine/Pathobiology.

was harvested. All serum samples were forwarded to the Kansas State University Veterinary Diagnostic Laboratory and were analyzed for antibody titers to IBR virus and *M. haemolytica* leukotoxoid. Antibody titers from day 0 and day 21 were compared and statistically analyzed (Table 1).

Results and Discussion

Serological responses to the IBR fraction of the 5-way viral vaccine were significantly greater (P=0.0014) on day 21 after administration with the needle-free injection system than with the standard needle route of administration. Serological responses to the *M. haemolytica* bacterin/toxoid also tended to be greater (P=0.06) on day 21 after administration with the needle-free injection system. This study indicated that use of a needle-free injection system resulted in serological responses at least as good as traditional needle injection methods.

Table 1. Serological Responses to IBR Vaccine and *Mannheimia haemolytica* Bacterin/Toxoid

Treatment	Day 0 Titer	SEM	Day 21 Titer	SEM
IBR				
Needle	2.0	0.67	42[b]	5.9
Needle-free	2.5	0.47	70[a]	10.8
P value	0.95		0.0014	
Mannheimia haemolytica				
Needle	0.240	0.009	0.299	0.011
Needle-free	0.259	0.011	0.326	0.011
P value	0.20		0.06	

[ab]Values differ, P≤0.05.

Figure 1. Felton Pulse 250 Needle-free Injection System.

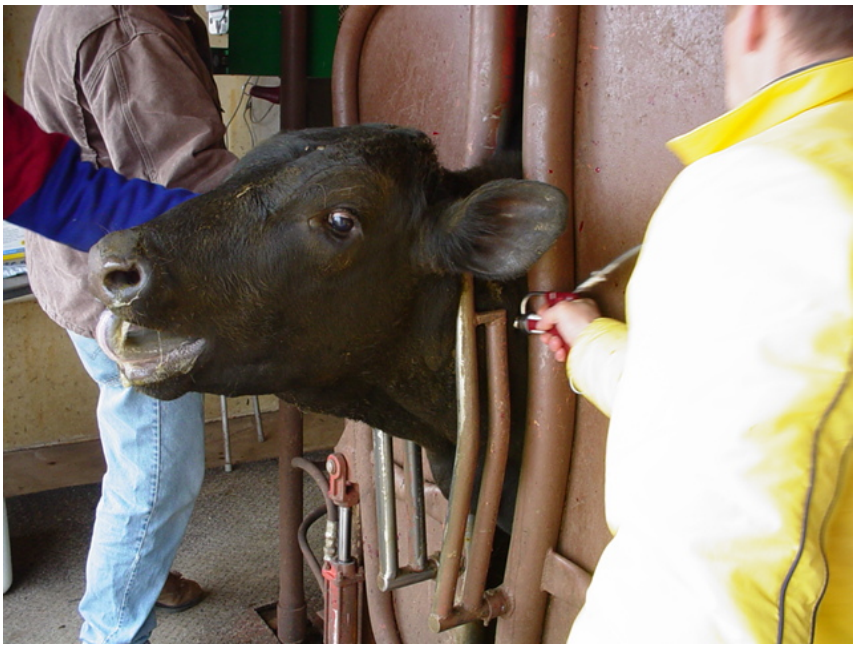


Figure 2. Felton Needle-free Injector.

INFLUENCE OF EARLY WEANING AND WINTER PROTEIN SUPPLEMENTATION ON WEIGHT AND CONDITION SCORE OF SPRING-CALVING BEEF COWS GRAZING NATIVE TALLGRASS PRAIRIE

K. W. Harborth, D. A. Llewellyn, and T. T. Marston

Summary

Ninety-two pregnant, mature, spring-calving cows grazing low-quality tallgrass-prairie were used to determine if early weaning of calves reduces the supplementation cost during the subsequent winter. Calves were weaned on June 23, 2003, (early weaning) or October 15, 2003, (fall weaning). Cows were assigned to winter feeding groups and fed one of two amounts of a common soybean meal-milo supplement (45% crude protein; dry matter basis). The two supplementation amounts were fed three times weekly and were prorated to 4 lb/day and 2.8 lb/day. The four treatment groups were: 1) early weaning – 4 lb/day supplement, 2) early weaning – 2.8 lb/day supplement, 3) fall weaning – 4 lb/day supplement, and 4) fall weaning – 2.8 lb/day supplement. Cows were supplemented from November 14, 2003, through calving in early March 2004. Cows with calves weaned early were initially heavier and had higher initial body condition scores than did cows that were weaned in the fall. Although losses of body weight and body condition through the winter were greater for early-weaning cows than for fall-weaning cows, final body weights and body condition scores were still greater for the early-weaning cows than for the fall-weaning cows. Supplementation with 4 lb/day led to less body weight loss over the winter and heavier final body weights than did supplementation with 2.8 lb/day, but final body condition score and body condition score loss over the winter were not affected by the amount of winter supplementation. Cow-calf producers can balance responses to early weaning and to winter supplementation to target appropriate cow weights and body condition scores at calving.

Introduction

Investigations over the last two decades have demonstrated that early weaning of spring-born calves may result in production advantages. Although many facets of early weaning have been studied, the long-term effects on cow performance are worthy of further investigation. Significant summer gains in body condition score are possible by the dams of early-weaned calves, and this may represent an opportunity for cow-calf producers to increase body condition scores before the cows enter the rigors of the winter grazing period. Previous investigations have noted the relationship between body condition and reproductive performance. Likewise, the summer and fall increases in body weight and body condition scores may have the potential to moderate the herd's dependence on winter protein supplementation while grazing the typically low-quality forage of tallgrass prairie. In doing so, significant reductions in winter feed costs may be realized. This study was to evaluate the effects of weaning calves early on the response of their dams to supplemental protein during the subsequent winter.

Procedures

Ninety-two mature, pregnant, spring-calving, crossbred beef cows, previously used in a study evaluating the effect of weaning time, were blocked by winter grazing group

(i.e. pastures of 300 acres), stratified by body weight and body condition, and randomly assigned to one of two grazing groups within each previous treatment (i.e., early weaning on June 23, 2003, or fall weaning on October 15, 2003). Two winter supplementation amounts were randomly assigned to the feeding groups: 4 lb/day or 2.8 lb/day of a common soybean meal-milo supplement (45% crude protein; dry matter basis), which was bunk fed three times weekly (Monday, Wednesday, and Friday) and prorated to the daily amounts. The four treatment groups were: 1) early weaning – 4 lb/day supplement, 2) early weaning – 2.8 lb/day supplement, 3) fall weaning – 4 lb/day supplement, and 4) fall weaning – 2.8 lb/day supplement. Supplementation commenced on Nov. 14, 2003, and continued until calving, at which time all cows were handled similarly. Cow body weights and body condition scores were recorded on Nov. 14, Jan. 7, Feb. 13, and within 48 hours of calving. A commercial mineral supplement was provided throughout the experiment.

Results and Discussion

There were no significant interactions between weaning time and supplementation amount. Cows with calves weaned in June were heavier (Table 1) and had higher condition scores (Table 2) at the beginning and end of the trial. These cows also lost more body weight during the length of the study (P=0.02). The advantage in initial weight and condition can be accounted for by the longer time available for them to recover from the stresses of lactation.

When comparing the two supplementation rates, cows receiving 4 lb/day of the supplement gained more weight from November 14 to January 7, as well as during the entire trial period, than did cows fed 2.8 lb/day, but there were no significant differences in body condition due to supplementation amount. The greater weight gains of cows receiving 4 lb/day of the supplement may have been due to a greater gut fill because they received more of the supplement. It is also possible that true differences existed due to supplementation amount, but the differences were too small to detect in our experiment.

From our results, it seems that cow-calf producers can balance responses to early weaning and to winter supplementation to target appropriate cow weights and body condition scores at calving. For example, the final body weights of early-weaning cows receiving 2.8 lb/day of the supplement were similar to those of fall-weaning cows receiving 4 lb/day. Thus, if a producer could benefit from weaning calves early, dams could be provided with less winter supplement, and they still could maintain an acceptable body weight at calving.

Table 1. Influence of Early Weaning and Supplementation Amount on Cow Body Weight

	Early Weaning [a]		Fall Weaning [a]					
	Supplementation Amount, lb/day [a]					Statistical Comparison (P-value)		
Item	4.0	2.8	4.0	2.8	SEM[b]	Early vs. Fall Wean	4.0 vs. 2.8 lb/day	Interaction
No. of cows	23	22	24	23				
Initial weight, lb	1355	1270	1237	1224	23.2	<0.01	0.06	0.16
Weight changes, lb								
Nov. 14 - Jan. 7	30	18	37	22	3.9	0.21	0.02	0.70
Jan. 7 - Feb. 13	33	36	46	43	6.4	0.16	0.88	0.76
Feb. 13 - Calving[c]	-159	-172	-155	-169	9.4	0.66	0.21	0.97
Nov. 14 - Calving[c]	-97	-117	-73	-99	9.2	0.02	0.02	0.57
Final weight, lb	1258	1153	1164	1125	22.8	<0.01	<0.01	0.26

[a]Early weaning = June 23; Fall weaning = October 15. Supplement was a soybean meal-milo supplement (45% crude protein; dry matter basis) fed three times weekly.
[b] SEM = standard error of the mean.
[c]Average calving date = mid March.

Table 2. Influence of Early Weaning and Supplementation Amount on Cow Body Condition Scores[a] (BCS)

	Early Weaning [a]		Fall Weaning [a]					
	Supplementation Amount, lb/day [a]					Statistical Comparison (P-value)		
Item	4.0	2.8	4.0	2.8	SEM [b]	Early vs. Fall Wean	4.0 vs. 2.8 lb/day	Interaction
No. of cows	23	22	24	23				
Initial BCS	5.9	6.0	5.1	5.1	0.10	<0.01	0.74	0.46
BCS changes								
Nov. 14 - Jan. 7	-0.13	-0.20	-0.09	-0.16	0.06	0.59	0.22	0.99
Jan. 7 - Feb. 13	-0.04	-0.13	0.02	-0.09	0.08	0.39	0.28	0.96
Feb. 13 - Calving[d]	-0.43	-0.30	-0.11	-0.08	0.10	0.02	0.44	0.68
Nov. 14 - Calving[d]	-0.61	-0.63	-0.19	-0.32	0.09	<0.01	0.49	0.51
Final BCS	5.25	5.34	4.92	4.75	0.10	<0.01	0.74	0.22

[a]Body condition score: 1 = emaciated; 9 = obese.
[b]Early weaning = June 23; Fall weaning = October 15. Supplement was a soybean meal-milo supplement (45% crude protein; dry matter basis) fed three times weekly.
[c]SEM = standard error of the mean.
[d]Average calving date = mid-March.

EFFECTS OF EARLY WEANING ON FEEDLOT PERFORMANCE OF BULLS AND STEERS

E. K. Schlickau, J. A. Unruh, T. T. Marston, J. Brethour, and M. E. Dikeman

Summary

Crossbred Hereford × Angus calves (n = 103) were used to determine the effects of early weaning on feedlot performance of bulls and steers. Treatments were: 1) early-weaned (117 days of age) bulls, 2) early-weaned steers, 3) normal-weaned (220 days of age) bulls, and 4) normal-weaned steers. Early-weaned calves were placed on a grower ration at an average age of 134 days and on a finishing ration at 182 days of age. Normal-weaned calves were placed on a finishing ration at 242 days of age. Weight, feed intake, and ultrasound measurements were recorded during the feeding period. Three early-weaned cattle were removed due to chronic bloat, and four early-weaned cattle died in the feedlot. The feedlot period was terminated at either 358 or 387 days of age. Early-weaned cattle had greater average daily gains early in the feedlot period, but normal-weaned cattle had greater gains later in the feedlot period. Excluding the initial weight at 117 days of age, early-weaned cattle maintained heavier weights throughout the feeding period. Bulls had greater average daily gains until feedlot entry of normal-weaned calves, but steers had greater average daily gains later in the feedlot period, resulting in similar final weights. For early-maturing British-type cattle, early weaning resulted in heavier final weights, but it may not be the most viable management strategy because of disadvantages in animal health. Overall, there was no growth-performance advantage for leaving males intact, suggesting that the implant regimen used for these steers was sufficient to compensate for the expected loss in performance when bulls are castrated.

Introduction

Some consumers prefer "natural" non-implanted beef with minimal fat. Feeding bulls may provide an opportunity to meet this specification and improve performance compared with that of steers. Increased muscle gain can be obtained through the use of bulls for beef production. Although the use of bulls for meat production was extensively researched in the early 1980s, it has not been evaluated in combination with the practice of early weaning. Early weaning of steers has been shown to improve feed efficiency, accelerate marbling deposition, and decease age at slaughter. Our objective was to investigate the use of early weaning and bulls on feedlot performance.

Procedures

One hundred three male Hereford × Angus calves born from January 31 to April 6, 2003, were used for this experiment. Calves were blocked by birth date and sire, then randomly assigned to one of four groups: 1) early-weaned bulls, 2) early-weaned steers, 3) normal-weaned bulls, and 4) normal-weaned steers. All calves were injected with Fortress® 7 (Pfizer Animal Health) on May 27 (average age of 86 days); at this time, calves assigned to the steer groups were castrated and implanted with Component® E-C (VetLife).

At an average age of 117 days, calves assigned to early weaning were weaned, weighed, injected with Bovi-Shield® 4 (Pfizer Animal Health), randomly assigned to pens by sex class (two bull pens and two steer pens),

and fed a complete starter ration. At an average age of 134 days, weight was recorded, and calves were shipped to the Agriculture Research Center in Hays, Kansas. The early-weaned calves were fed a grower ration and adjusted to a finishing ration at an average age of 182 days.

The calves designated for normal weaning remained with the cows on native grass near Manhattan, Kansas, with no creep feed throughout the summer. At an average age of 201 days, calves were injected with Bovi-Shield® 4, One Shot® (Pfizer Animal Health), and Fortress® 7. Calves were weaned, weighed, randomly assigned to pens by sex class (two bull pens and two steer pens), and fed a complete starter ration at an average age of 218 days. At an average age of 242 days, calves were weighed, shipped to Hays, and adjusted to a finishing ration. All calves were then injected with Bovi-Shield® 4, and steers were implanted with Synovex® Choice (Fort Dodge). Steers were re-implanted with Synovex® Choice at an average age of 328 days. Feed intake was recorded daily for each pen.

Three cattle (two early-weaned steers and one early-weaned bull) were removed from the trial due to chronic bloating. Three early-weaned steers and one early-weaned bull died during the early feedlot phase. The cause of death was not determined. Data collected from these seven animals were not included in analysis.

At average ages of 269 and 328 days, calves were weighed, and ultrasound (Aloka, Wallingford, Connecticut, and Cattle Performance Enhancement Company cattle software; Oakley, KS) was used to determine marbling score and backfat over the first lumbar vertebrae. Ultrasound measures were then used to project feedlot termination. One randomly selected pen from each treatment was terminated when the steers were projected to have 0.4 inches of backfat. The remaining four pens were terminated when the bulls were projected to have 0.4 inches of backfat. Calves were consolidated and commingled with the other pens for shipment at average ages of either 358 or 387 days.

Results and Discussion

Early-weaned cattle initially had live weights similar to normal-weaned calves (117 days of age; Table 1). At 242 and 328 days of age (Table 1) and at the end of the feeding period (Table 2), early-weaned cattle were heavier than normal-weaned cattle. As a result, early-weaned cattle had greater weight per day of age than did normal-weaned cattle at all times except at 117 days of age.

Early-weaned calves had greater average daily gains from the time of early weaning to feedlot entry of the normal-weaned calves (Table 1). During the first 27 days that normal-weaned calves were in the feedlot (242 to 269 days of age), early-weaned cattle also had greater average daily gains. Early-weaned cattle had lesser average daily gains following this period until the termination of the trial (Table 2).

These results suggest that early-weaned cattle gain more rapidly during the early post-weaning period than do normal-weaned cattle, due to greater nutrient intake; early-weaned cattle continue to have an advantage in gain while normal-weaned cattle are adjusting to the feedlot. During the finishing phase, early-weaned cattle lose their advantage in gain but still have heavier final weights than normal-weaned cattle.

Bulls and steers had similar weights and weight-per-day-of-age at all times measured (Table 1). Compared with steers, bulls had greater average daily gains from early weaning to feedlot entry of normal-weaned cattle, but had lesser gains from 269 days of age until the end of the feeding period (Table 2).

It is well documented that bulls gain faster than steers due to the anabolic effects of testosterone, although this was not true during the feedlot period in our study. It may be that the implant regimen for steers yielded responses similar to the natural testosterone produced by bulls. Also, increased activity (fighting, etc.) may have caused bulls to expend more energy and have lesser gains later in the feedlot period.

Normal-weaned cattle had less dry matter intake but similar gain-to-feed ratios compared with early-weaned cattle during their first 27 days in the feedlot (Table 3). Compared with normal-weaned cattle, early-weaned cattle had similar feed intakes, but less efficient ($P<0.05$) gain-to-feed ratios during the finishing phase.

Bulls consumed less dry matter, but gained with similar efficiency to steers from feedlot entry of the early-weaned cattle to feedlot entry of the normal-weaned cattle (Table 3). After normal-weaned cattle entered the feedlot (242 days of age), bulls and steers had similar dry matter intakes and gain-to-feed ratios.

In our study, seven early-weaned cattle were removed due to chronic bloat or death. There were no deaths or instances of chronic bloat in the normal-weaned groups. The increased incidence of respiratory disease and death in our study may be partly due to stress at early weaning. The increased incidence of bloat may have been due to high feed intake or fluctuating consumption patterns induced by sub-acute acidosis.

Marbling score and backfat thickness, measured by ultrasound at 267 and 328 days of age, were greater for early-weaned cattle than for normal weaned cattle (Table 1). The greater intramuscular fat of early-weaned cattle can be partly attributed to the greater nutrient intake during the early feedlot period.

Bulls tended to have less ultrasound backfat at 269 days of age and had less ultrasound backfat at 328 days of age than steers did (Table 1). Bulls and steers had similar ultrasound marbling at both times, but this was not consistent with the carcass data (reported in an accompanying article). Bulls may have lost more marbling than steers did when cattle were mixed before slaughter, due to increased mounting and fighting activity.

In our study with early-maturing British-type cattle, early-weaned cattle and bulls gained faster early in the feeding period, whereas normal-weaned cattle and steers gained faster later in the feedlot period. Early-weaned cattle had heavier final weights than normal-weaned cattle had, but bulls and steers had similar final weights. Overall, there was no growth-performance advantage for bulls, suggesting that the implant regimen was sufficient to compensate for the expected loss in performance when bulls are castrated.

Table 1. Effects of Weaning Time and Sex Class on Growth Characteristics of Early-maturing British-type Cattle

	Weaning Time		Sex Class		
Item	Early[a]	Normal[b]	Steers	Bulls	SEM
No. of cattle	45	51	47	49	
Weight, lb					
117 days	356	368	365	359	7.1
242 days	712[e]	663[f]	681	694	11.5
269 days[c]	786	729	749	766	11.7
328 days	1035[e]	970[f]	1002	1003	15
Weight per day of age, lb					
117 days	3.11	3.22	3.22	3.11	0.07
242 days	2.98[e]	2.76[f]	2.84	2.89	0.04
269 days	2.91[e]	2.71[f]	2.78	2.84	0.04
328 days	2.95[e]	2.71[f]	2.8	2.84	0.04
Daily gain, lb/day					
117-242 days	2.67[e]	2.36[f]	2.43[h]	2.62[g]	0.13
242-269 days	3.64[e]	1.92[f]	2.82	2.73	0.71
Marbling score[d]					
269 days	4.4[e]	4.0[f]	4.3	4.2	0.09
328 days	4.9[e]	4.5[f]	4.7	4.6	0.11
Backfat thickness[d], inches					
269 days	0.21[e]	0.12[f]	0.17	0.15	0.008
328 days	0.33[e]	0.25[f]	0.33[g]	0.26[h]	0.012

[a]Early-weaned calves were weaned at 117 days of age and entered the feedlot at 134 days of age.
[b]Normal-weaned calves were weaned at 220 days of age, entered the feedlot at 242 days of age.
[c]Weaning time x sex class interaction ($P<0.05$) in which normal-weaned steers (709 lb) were lighter ($P<0.05$) than normal-weaned bulls (749 lb), early-weaned bulls (782 lb), and early-weaned steers (790 lb).
[d]Obtained by ultrasound; 4.0=Sl00, 5.0=Sm00.
[ef]Within a row and weaning time, means having different superscript letters differ ($P<0.05$).
[gh]Within a row and sex class, means having different superscript letters differ ($P<0.05$).

Table 2. Effects of Weaning Time, Sex Class, and Feedlot Group on Final Feedlot Performance of Early-maturing British-type Cattle

	Weaning Time		Sex Class		Feedlot Group[a]		
Item	Early[b]	Normal[c]	Steers	Bulls	358 days	387 days	SEM
No. of cattle	45	50	45	49	49	47	
Weight, lb	1117[e]	1077[f]	1109	1086	1065[i]	1130[j]	15.7
Weight per day of age, lb	3.00[e]	2.87[f]	2.95	2.91	2.95	2.91	0.04
Daily gain[d], lb/day	3.22[f]	3.51[e]	3.53[g]	3.20[h]	3.4	3.33	0.13

[a]Cattle were fed to average ages of either 358 or 387 days of age.
[b]Early-weaned calves were weaned at 117 days of age and entered the feedlot at 134 days of age.
[c]Normal-weaned calves were weaned at 220 days of age and entered the feedlot at 242 days of age.
[d]Average daily gain from 269 days of age to end of feedlot period.
[ef]Within a row and weaning time, means having different superscript letters differ (P<0.05).
[gh]Within a row and sex class, means having different superscript letters differ (P<0.05).
[ij]Within a row and feedlot group, means having different superscript letters differ (P<0.05).

Table 3. Effects of Weaning Time and Sex Class on Pen Average Daily Gain, Dry Matter Intake, and Gain-to-Feed Ratio of Early-maturing British-type Cattle

	Weaning Time		Sex Class		
Item	Early[a]	Normal[b]	Steers	Bulls	SEM
134 to 242 days of age[c]					
No. of pens	-	-	2	2	
Dry matter intake, lb/day	-	-	16.5[f]	16.3[g]	0.333
Gain:feed	-	-	0.145	0.185	0.026
242 to 269 days of age					
No. of pens	4	4			
Dry matter intake, lb/day	20.0[d]	16.6[e]	18.1	18.5	0.736
Gain:feed	0.123	0.104	0.119	0.108	0.012
270 days of age to harvest					
No. of pens	4	4			
Dry matter intake, lb/day	22.00	21.60	22.1	21.5	0.260
Gain:feed	0.140[d]	0.165[e]	0.158	0.147	0.005

[a]Early-weaned calves were weaned at 117 days of age, and entered the feedlot at 134 days of age.
[b]Normal-weaned calves were weaned at 220 days of age, and entered the feedlot at 242 days of age.
[c]Early-weaned pens only.
[de]Within a row and weaning time, means having different superscript letters differ (P<0.05).
[fg]Within a row and sex class, means having different superscript letters differ (P<0.05).

EFFECTS OF EARLY WEANING ON CARCASS AND RIBEYE STEAK CHARACTERISTICS OF BULLS AND STEERS

E. K. Schlickau, J. A. Unruh, M. E. Dikeman, T. T. Marston, and J. Brethour

Summary

Crossbred Hereford × Angus calves (n = 103) were used to determine the effect of early weaning on carcass and ribeye (longissimus muscle) characteristics of bulls and steers. Treatments were: 1) early-weaned (117 days of age) bulls, 2) early-weaned steers, 3) normal-weaned (220 days of age) bulls, and 4) normal-weaned steers. Cattle were harvested at 360 and 389 days of age. At 36 hours postmortem, carcass quality and cutability were measured. Ribeye steaks were aged 14 days and scored for color, Warner-Bratzler shear force, and sensory panel evaluations. Carcasses from early-weaned cattle had greater dressing percentages, heavier weights, greater fat thicknesses, and higher numerical USDA Yield Grades (lower cutability). They also had more marbling and greater USDA quality grades, but had similar longissimus color, shear force, and sensory panel scores, compared with those of normal-weaned cattle. Bulls had greater dressing percentages, but had similar carcass weights to steers. Bull carcasses had less fat thickness and greater ribeye areas, resulting in lower numerical USDA Yield Grades (higher cutability) than steers had. They also had less marbling, darker color, and lower USDA quality grades than steers did. Longissimus muscles from bulls were darker, had greater shear forces, and had lower sensory panel tenderness scores than those from steers. For early-maturing British-type cattle, early weaning is a viable management strategy to produce heavier, higher-quality carcasses than those of normal-weaned cattle. Carcasses from early-weaned cattle are fatter and have lower cutability. For a non-implant "natural" market, bulls could be an alternative for producing high-cutability carcasses. Steaks may be less tender, however, and pre-harvest management must be optimized to reduce dark-cutting carcasses.

Introduction

Some consumers prefer "natural" non-implanted beef with minimal fat. Feeding bulls may provide an opportunity to meet this specification and improve performance compared with that of steers. Increased muscle gain can be obtained through the use of bulls for beef production. Although the use of bulls for meat production was extensively researched in the early 1980s, it has not been evaluated in combination with the practice of early weaning. Early weaning of steers has been shown to increase marbling and may improve tenderness. Our objective was to investigate the use of early weaning and bulls on carcass composition and ribeye characteristics.

Procedures

One-hundred three male Hereford × Angus calves born from January 31 to April 6, 2003, were used in this experiment. Calves were blocked by birth date and sire, then randomly assigned to one of four treatment groups: 1) early-weaned (117 days of age) bulls, 2) early-weaned steers, 3) normal-weaned (220 days of age) bulls, and 4) normal-weaned steers.

Management and performance data are reported in the companion article. At average ages of 269 and 328 days, calves were weighed, and ultrasound (Aloka, Wallingford,

CT, and Cattle Performance Enhancement Company cattle software; Oakley, KS) was used to determine backfat over the first lumbar vertebra. Ultrasound measures were used to project harvest date. One pen from each treatment was randomly chosen for harvest when the steers were projected to have 0.4 inches of backfat. The remaining four pens were harvested when the bulls were projected to have 0.4 inches of backfat.

Three days before to harvest, four pens (one from each treatment) were assigned to the first harvest group and commingled for shipment. At 360 days of age, the first group was slaughtered at a federally inspected, commercial processing facility, and carcass data were collected. Five days before to the next harvest date, the remaining four pens were commingled for shipment, and they were slaughtered at 389 days of age.

Carcass cutability and quality characteristics were evaluated at 36 hours postmortem. Boneless rib sections (11-12 rib) were collected, transported to Kansas State University, and aged under refrigeration in vacuum-packaged bags for 2 weeks. After aging, rib sections were faced, and three 1-inch thick ribeye (longissimus muscle) steaks were obtained, starting from the posterior end, for Warner-Bratzler shear force, trained sensory panel, and pH evaluations, respectively. Instrumental and visual color at 14 days postmortem was collected on the first steak, which was later used for measuring Warner-Bratzler shear force.

Results and Discussion

Early-weaned cattle had greater dressing percentages, heavier hot carcass weights, greater external fat thicknesses, and higher numerical USDA Yield Grades (lower cutability) than normal-weaned cattle had (Table 1).

Bulls had greater dressing percentages, larger ribeye areas, and lower numerical USDA Yield Grades than steers had (Table 1). Sex class did not affect hot carcass weight. In a harvest group × sex class interaction, steers harvested at 389 days of age had the greatest fat thicknesses (Table 2); steers harvested at 360 days of age had greater fat thicknesses than did bulls harvested at 360 days of age, with bulls harvested at 389 days of age being intermediate.

Early-weaned cattle had greater marbling scores, resulting in higher average USDA quality grades than those of normal-weaned cattle (Table 1). Weaning time did not affect bone maturity or ribeye color.

Bulls had ribeyes with less marbling and a darker color than ribeyes from steers (Table 1). Bulls and steers exhibited similar bone maturity. In addition, bulls had a larger number of dark-cutting carcasses than steers did. Dark cutting results from the depletion of glycogen before harvest. When commingled before harvest, bulls in this study were more likely to become stressed and have greater energy (glycogen) expenditure than steers were, resulting in a larger percentage of dark-cutting carcasses.

At 14 days postmortem, longissimus muscle instrumental color, visual color, and pH were not affected by weaning time (Table 1). A sex class × harvest group interaction was observed, in which lower visual color scores (brighter and more cherry red) were observed for longissimus muscles from steers harvested at either 360 or 389 days of age than for longissimus muscles from bulls harvested at either 360 or 389 days of age (Table 2). In addition, longissimus muscles from bulls harvested at 389 days of age had lower visual color scores than did longissimus muscles from bulls harvested at 360 days of age. In support of visual color observations, longissimus muscles from bulls had lower L* and b* values, but greater a* values, than did longissimus muscles from steers (Table 1), indicating that bulls had

darker, redder, and less-yellow longissimus muscles.

In a harvest group × sex class interaction, steers harvested at 360 days of age had a lower longissimus muscle pH than did steers harvested at 389 days of age and bulls harvested at either 360 or 389 days of age (Table 2). These data agree with the greater incidence of dark cutters in bulls in the first harvest group, because dark-cutting beef has higher muscle pH and darker color scores than typical beef does.

Weaning time did not affect Warner-Bratzler shear force or sensory panel scores (Table 3). Cooked longissimus muscles from bulls were less tender than were longissimus muscles from steers, as indicated by greater shear force values, as well as lower sensory panel scores for myofibrillar tenderness, connective tissue amount, and overall tenderness. Steaks from bulls and steers had similar ($P>0.10$) sensory panel scores for juiciness, flavor, and off-flavor intensity.

Sensory panelists found more connective tissue in steaks from bulls than in those from steers. The amount of connective tissue detected by a sensory panel is often associated with connective-tissue maturation and collagen cross-linking. In addition, muscle dehydration due to pre-harvest stress may have contributed to decreased myofibrillar tenderness. The combination of myofibrillar and connective-tissue factors resulted in greater Warner-Bratzler shear force values and lesser overall sensory panel tenderness scores in steaks from bulls than in those from steers.

Except for flavor, sensory attributes and Warner-Bratzler shear forces were not affected by harvest group. Steaks from cattle harvested at 389 days of age had more beef flavor than did those from cattle harvested at 360 days of age. This may be partly attributed to a tendency of the later harvest group to have greater marbling scores.

For early-maturing British-type cattle, early-weaned cattle had heavier carcasses that were higher quality, but were fatter and had lower cutability, than those of normal-weaned cattle. Bulls may be an option for the production of “natural” non-implanted beef that has higher cutability than beef from steers, but steaks from bulls were less tender and had less marbling than did steaks from steers. Pre-harvest management must be optimized to prevent the occurrence of dark-cutting carcasses.

Table 1. Effects of Weaning Time, Sex Class, and Harvest Group on Carcass and Ribeye (Longissimus Muscle) Characteristics of Early-maturing British-type Cattle

	Weaning Time		Sex Class		Harvest Group[a]		
Item	Early[b]	Normal[c]	Steers	Bulls	360 days	389 days	SEM
No. of cattle	45	51	47	49	49	47	
Dressing percentage	61.6[j]	60.1[k]	60.5[m]	61.3[l]	60.3[o]	61.5[n]	0.3
Hot carcass weight, lb	695[j]	688[k]	672	666	655[o]	695[n]	10.6
Fat thickness, inches[d]	0.53[j]	0.41[k]	-	-	-	-	0.2
Ribeye area, inches[2]	11.90	12.10	11.7[m]	12.2[l]	11.9	11.9	0.14
USDA Yield Grade	3.22[j]	2.70[k]	3.24[l]	2.68[m]	2.80[o]	3.12[n]	0.08
Bone maturity[e]	160	163	161	162	165	158	5
Marbling scored[f]	399[j]	350[k]	387[l]	363[m]	369	381	8
Visual color (36 hours)[g]	4.20	4.50	3.5[m]	5.2[l]	4.4	4.2	0.2
USDA quality grade[h]	4.2[j]	3.6[k]	-	-	-	-	0.1
No. of dark cutters	5	6	2	9	7	4	
Instrumental color[i]							
L*	42.50	43.00	44.2[l]	41.2[m]	42.8	42.68	0.6
a*	27.40	28.10	26.7[m]	28.8[l]	26.9[o]	28.6[n]	0.4
b*	18.30	18.90	19.9[l]	17.3[m]	18.1	19.1	0.4
Visual color[dgi]	5.60	5.60	-	-	-	-	0.11
pH[di]	5.80	5.70	-	-	-	-	0.04

[a]One pen from each treatment combination was randomly selected for harvest at 360 or 389 days of age.
[b]Early-weaned calves were weaned at 117 days of age and entered the feedlot at 134 days of age.
[c]Normal-weaned calves were weaned at 220 days of age and entered the feedlot at 242 days of age.
[d]Sex class x harvest group interaction (P<0.05, Table 2).
[e]100=A-00, 200=B-00.
[f]Slight00=300, Small00=400.
[g]Scale of 1-8: 1=bleached red, 4=cherry red, 8=dark red.
[h]5=Choice-, 4=Select+, 3=Select-.
[i]Ribeye measurements at 14 days postmortem.
[jk]Within a row and weaning time, means having different superscript letters differ (P<0.05).
[lm]Within a row and sex class, means having different superscript letters differ (P<0.05).
[no]Within a row and harvest group, means having different superscript letters differ (P<0.05).

Table 2. Harvest Group x Sex Class Interaction Means for Carcass Traits and Ribeye Longissimus Muscle) Characteristics of Early-maturing British-type Cattle

	360 Days of Age		389 Days of Age		
Item	Steers	Bulls	Steers	Bulls	SEM
No. of cattle	24	25	23	24	
Fat thickness, inches	0.48[d]	0.38[e]	0.61[c]	0.41[de]	0.03
USDA quality grade[a]	4.0[d]	3.8[d]	4.4[c]	3.7[d]	0.2
Visual color[b]	5.1[e]	6.2[c]	5.2[e]	5.7[d]	0.15
pH, 14 days postmortem	5.6[d]	5.9[c]	5.8[c]	5.8[c]	0.06

[a]5=Choice-, 4=Select+, 3=Select-.
[b]Ribeye color scores of 1 to 8 at 14 days postmortem: 1=bleached red, 4=cherry red, 8=very dark red.
[cde]Within a row means having different superscript letters differ (P<0.05).

Table 3. Effects of Weaning Time, Sex Class, and Harvest Group on Ribeye (Longissmus Muscle) Sensory Panel Scores and Warner-Bratzler Shear Force Values of Early-maturing British-type Cattle

	Weaning Time		Sex Class		Harvest Group		
Item	Early	Normal	Steers	Bulls	360 days	389 days	SEM
No. of cattle	45	50	47	48	49	46	
Sensory panel[a]							
Myofibrillar tenderness	5.6	5.6	5.9[b]	5.3[c]	5.5	5.6	0.12
Connective tissue amount	6.8	6.8	7.0[b]	6.5[c]	6.0	7.0	0.07
Overall tenderness	5.7	5.7	6.0[b]	5.4[c]	5.7	5.8	0.12
Juiciness	5.7	5.7	5.7	5.7	5.8	5.7	0.07
Flavor	5.8	5.8	5.8	5.8	5.7[e]	5.9[d]	0.06
Off flavor	7.7	7.6	7.6	7.7	7.7	7.6	0.06
Shear force, lb	11.7	11.7	10.1[c]	12.6[b]	11.7	11.7	0.44

[a]Sensory panels evaluated steaks on an eight-point scale; (myofibrillar and overall tenderness: 1=extremely tough to 8=extremely tender; connective tissue: 1=abundant to 8=none; juiciness: 1=extremely dry to 8=extremely juicy; flavor: 1=extremely bland to 8=extremely intense; off flavor: 1=abundant to 8=none).
[bc]Within a row and sex class, means having different superscript letters differ (P<0.05).
[de]Within a row and harvest group, means having different superscript letters differ (P<0.05).

ECONOMIC VALUES ASSOCIATED WITH EXPECTED PROGENY DIFFERENCES (EPD) FOR ANGUS BULLS AT AUCTION

K. Dhuyvetter[1], R. Jones[1], T. Turner[1], and T. Marsh[1]

Summary

The two primary objectives of this study were to re-examine the economic values of production expected progeny differences (EPD) and how they relate to the values assigned to actual weights, and to assess the impact that ultrasound EPD have on Angus bull prices. Buyers consider the EPD birth weight to be more important than actual birth weight when selecting bulls. For the remaining production EPD, however, the actual measures were considered more important than the EPD. All four ultrasound EPD were significantly related to price, with three out of the four exhibiting the expected response. Comparisons among premiums/discounts associated with ultrasound EPD, production EPD, and actual weights showed that EPD for ultrasound ribeye area had significantly larger price responses than did either the EPD for birth weight or the actual adjusted yearling weight. This finding suggests that breeders who currently fail to report this data should consider its inclusion in future production sales.

Introduction

The purebred cattle industry has undergone a period of significant informational change in the last 20 years. The development and use of expected progeny differences (EPD), which are statistical estimates of performance for a given animal's progeny, has been a primary component of this change. Since their introduction, EPD have been increasingly accepted and used by purebred producers selling breeding stock, but the impact EPD have had in the market place and on commercial cattle producers is less clear. Previous research has demonstrated that some EPD, specifically birth weight, are valued by producers when they purchase bulls, but the magnitudes of the economic values of EPD relative to the corresponding actual underlying phenotypic measures have been surprisingly small.

In this study we re-examine the role of performance EPD in determining value for purebred Angus bulls. Specific consideration was given to carcass and ultrasound EPD, in an attempt to define their role in breeding stock selection. Other measures, such as actual weights, ultrasound scores, regional issues, and marketing factors, also were examined as they pertain to the value of purebred Angus bulls.

Procedures

Data for this study were collected from purebred Angus producers across the Midwest, Rocky Mountain, and Northwest regions of the United States. Producers were contacted by phone, written correspondence, and email, requesting sale catalogs and price data from their most recent production sale. Data were collected on 8285 bulls from 60 sales in

[1]Department of Agricultural Economics.

an 11-state region. Variables gathered from this process included prices, registration numbers, and various marketing factors specific to each sale. Data relating to actual weights and EPD were not recorded at this time, although animals found to have incomplete production records were noted for each sale.

The collection of all actual weights, EPD, and pedigrees was done in cooperation with the American Angus Association. Registration numbers for each bull were given to the American Angus Association, which then generated a database with all relevant genetic information for each bull. This database was then combined with the existing record of prices and marketing factors to create a complete summary of variables for each observation. Summary statistics for price, actual weights, EPD, and marketing factors are presented in Table 1.

No two sales in this study reported exactly the same number or types of variables in their sale catalogs. These discrepancies were noted and are accounted for in that models were specified using only data that were available to buyers at the time of the sale (i.e., data reported in the sale catalog).

Actual production measures, EPD, and marketing factors formed the basis for a conceptual model of bull prices that was specified as:

Bull Price = function of:
(Actual production measures,
Production EPD, Ultrasound EPD,
Marketing factors, Sire, Sales).

Actual production measures included age, birth weight, adjusted weaning weights, and yearling weights; ultrasound scans included adjusted intramuscular fat, ribeye area, and 12^{th}-rib fat thickness. Production EPD included birth, weaning, milk, and yearling weights. Ultrasound EPD include intramuscular fat, ribeye area, fat thickness, and percentage of retail product. The marketing factors recorded from each sale are sale order, semen retention, season of the sale (fall versus spring), picture, embryo transfer, pathfinder dam, and the inclusion of full brothers and females in the sale. Sire was a series of dummy variables used to capture bulls who are the progeny of highly ranked Angus sires. Sales identified bulls sold in a particular state or sale. A hedonic modeling approach, using OLS regression, was applied to the data to obtain estimates for each of the variables presented in the conceptual model. In accord with previous work, the dependent variable, price, was transformed to log form.

Results and Discussion

Specific regression results from the first specification of this model are available from the authors. The three actual performance measures were all significant and exhibited the expected sign relationships to price: birth weight was negatively related to price, whereas weaning and yearling weights were positively related to price. Buyers are likely to pay less for heavier birth weights due to expected increases in calving difficulty. Adjusted weaning and yearling weights provide buyers with a measure of a bull's ability to add additional pounds of gain. This is desirable because it provides a picture of the expected performance of a bull's progeny.

Comparing the coefficients for the EPD and actual weights revealed larger values for the EPD relative to the related actual weights, but this comparison is not appropriate because of differing units involved. Elasticities provide a unit-less comparison between the two genetic measures and offer a measurement that is readily comparable across variables. The elasticities for the actual weights are greater than the elasticities for the EPD.

A problem with the elasticities is that they only show the effect of the variable at a certain point, however, here being the mean. This

technique ignores the true behavior of most variables by assuming that a 1% change in all variables occurs with equal likelihood. It is best to examine the effect a variable has on price across a standardized range of likely changes. This allows the effects of a variable to be evaluated at many points while still providing comparisons between variables of differing units. To compare the relative value of EPD versus actual weights, standardized premiums were calculated based on standard deviation incremental changes in the variable of interest. Figure 1 depicts the comparison of the standardized (equally likely) premiums for actual birth weight and EPD for birth weight. Here it is seen that the EPD for birth weight has slightly larger standardized premiums associated with it than does the actual birth weight. From this result, it can be argued that EPD for birth weight is the more significant genetic measure, despite the higher elasticity of birth weight.

Figure 2 shows that adjusted yearling weight has larger standardized premiums than EPD for yearling weight does when the relationship between these two variables was accounted for. Thus, although buyers may pay greater premiums for the genetic information in EPD for birth weight relative to actual birth weight, it seems that they are unwilling to do so for EPD for yearling weight.

Reasons for the difference between birth weight and yearling weight are not entirely clear. A possible explanation may lie in the accuracy of the EPD at the time of sale. Bulls are typically sold at one year of age or older. Buyers may believe that the EPD for yearling weight are, in fact, unreliable for yearling bulls. Because EPD for yearling weight is based solely on records of related animals (parents, grandparents, and siblings), they may believe that the possible variation in the EPD is quite large and, thus, they place more confidence in the actual yearling weight.

A second model including carcass ultrasound EPD was developed to examine the value that buyers place on carcass quality. Each of the ultrasound EPD in this model were significant, indicating that buyers value the information they provide. The EPD for intramuscular fat and for ribeye area variables were positively related to price, indicating that additional units of intramuscular fat and ribeye increased the price paid for a bull. The coefficient for relating price to EPD for backfat thickness was negative, implying that increases in fat thickness decreased value. The EPD for percentage of retail product was expected to be positively related to price, given that a bull's ability to sire progeny that yield greater quantities of retail product would be desirable to a buyer, but the estimated coefficient was negative. Reasoning for the negative relationship of this variable to price is unknown. On the basis of elasticities, the EPD for ribeye area had the greatest effect on price among the ultrasound EPD, although its effects were much smaller than the effects of any of the actual production measures or production EPD. This indicates that the ultrasound EPD provide additional information to buyers, but do not seem to be as important as other factors used in making purchasing decisions.

Figure 3 compares the standardized premiums received for EPD for ribeye area, EPD for birth weight, and actual adjusted yearling weight. The premiums received for EPD for ribeye area are considerably greater than those received for EPD for birth weight or for actual adjusted yearling weight at sales that report all three measures. This contradicts the earlier conclusion, derived from the elasticities, but again provides a reasonable examination of the effects of the variables (because of the "likelihood" of change in the value). The findings in Figure 3 suggest that the inclusion of ultrasound EPD should be considered by sales, given the high premiums received for bulls possessing large ultrasound ribeye EPD.

Variables pertaining to various market factors were also included in the models. These factors were shown to be as significant in determining value as genetic measures were, and indicate that bulls that are aggressively marketed will likely bring premiums relative to bulls not benefiting from marketing. Additional variables used to describe the sire of the bull and the sale at which he was sold, showed various levels of significance as well. The significance of the sire variables indicates that buyers believe additional information, not contained in the bull's genetic record, is captured by the bull's sire. Significance of several sale variables suggests that buyers recognize the reputations of breeders and are willing to pay premiums or discounts for comparable animals sold at different sales.

Purebred bull purchasers are using information from both actual physical characteristics and EPD when making bull purchasing decisions. Buyers seem to pay particular attention to birth weight EPD, adjusted yearling weights, and ultrasound ribeye EPD.

Table 1. Summary Statistics for Bull Price and for Variables Included in the Model to Explain Differences in Purebred Bull Prices

Variable	n	Mean	Std Dev	Minimum	Maximum
Price	8285	2565	1908	875	51,500
Production Measures					
Age, days	8285	447	125	98	1829
Birth weight, lb	7986	83.5	9.9	40	124
Adjusted weaning weight, lb	8063	660	72	378	988
Adjusted yearling weight, lb	7380	1168	114	636	1742
Adjusted intramuscular fat, %	7255	3.7	0.9	0.8	10.5
Adjusted ribeye area, square inches	7243	12.4	1.6	6.5	18.8
Adjusted rib fat, inches	7259	0.3	0.1	0.0	0.8
EPD for:					
Birth weight	8227	2.6	1.6	-3.8	9.6
Weaning weight	8253	38.3	6.7	11.0	71.0
Milk	8253	20.3	4.6	0.0	36.0
Yearling weight	8252	72.6	11.4	19.0	125.0
Carcass weight	4575	5.2	6.3	-16.0	30.0
Marbling	4575	0.18	0.12	-0.13	0.75
Ribeye area	4575	0.13	0.13	-0.35	0.59
Fat thickness	4575	0.00	0.02	-0.05	0.05
Percentage retail product	4575	0.06	0.24	-0.87	0.77
Ultrasound intramuscular fat	7814	0.07	0.14	-0.40	0.74
Ultrasound ribeye area	7814	0.12	0.21	-0.62	1.00
Ultrasound fat	7814	0.00	0.02	-0.06	0.06
Ultrasound retail product	7814	0.02	0.28	-0.96	1.20
Marketing Factors[1]					
Sale order	8285	0.50	0.29	0	1
Semen third	8285	0.20	0.40	0	1
Semen half	8285	0.08	0.27	0	1
Season of sale	8285	0.77	0.42	0	1
Picture	8285	0.11	0.31	0	1
ET	8285	0.21	0.41	0	1
Full brother	8285	0.10	0.30	0	1
Pathfinder	8285	0.06	0.23	0	1
Female in sale	8285	0.46	0.50	0	1

[1]Sale order = order of sale that bull was sold (in percentile); Semen third = one third of semen rights retained by the seller; Semen half = one half of semen rights retained by the seller; Season of sale = the season that the sale was held; Picture = bulls whose picture appeared in the sale catalog; ET = bulls who are listed as embryo transfers; Full brother = bulls who have a full brother in the sale; Pathfinder = bulls whose dam is a pathfinder; Female in sale = sale selling females as well as bulls.

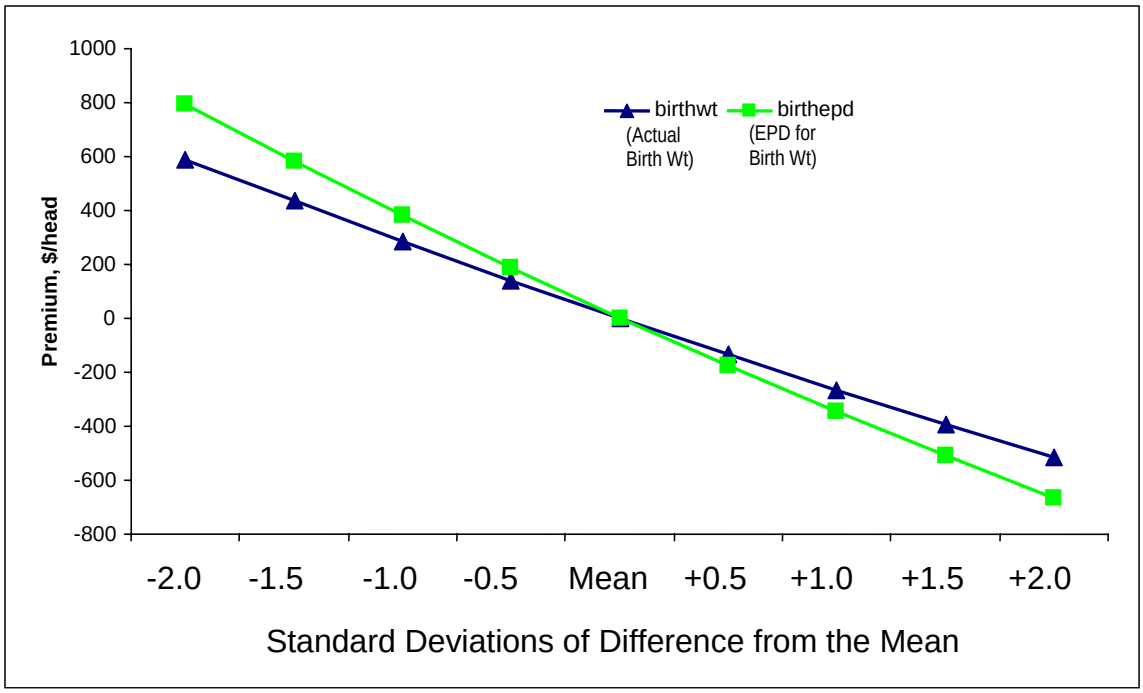


Figure 1. Predicted Premiums for Birth Weight and Birth Weight EPD.

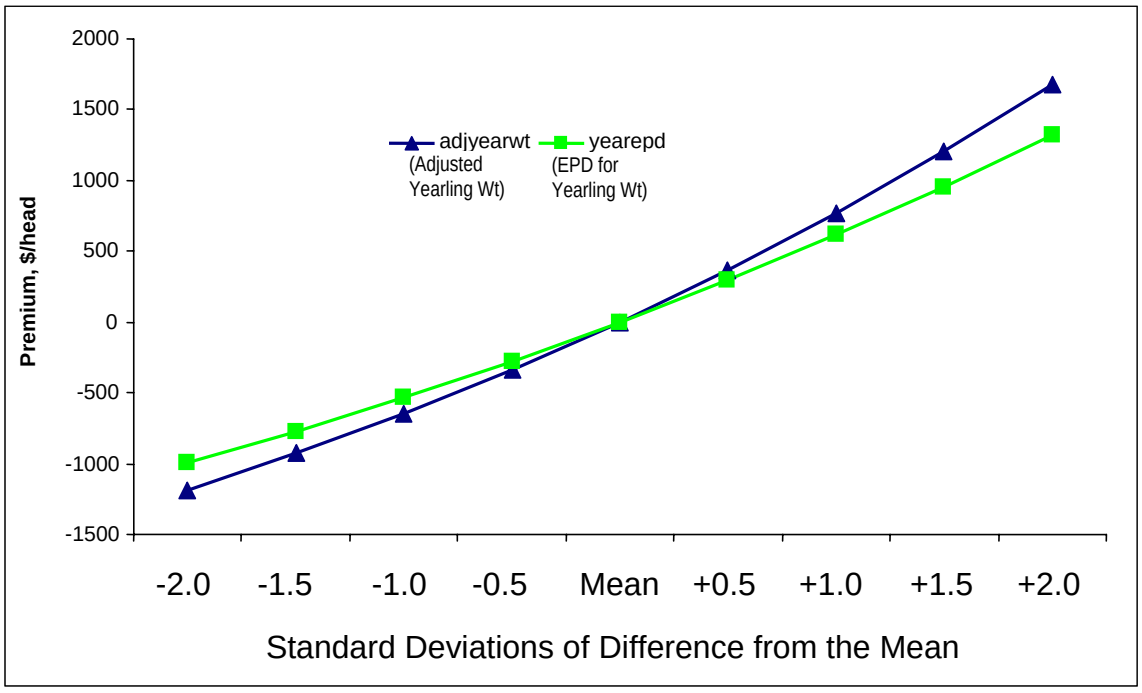


Figure 2. Predicted Premiums for Adjusted Yearling Weight and Yearling Weight EPD.

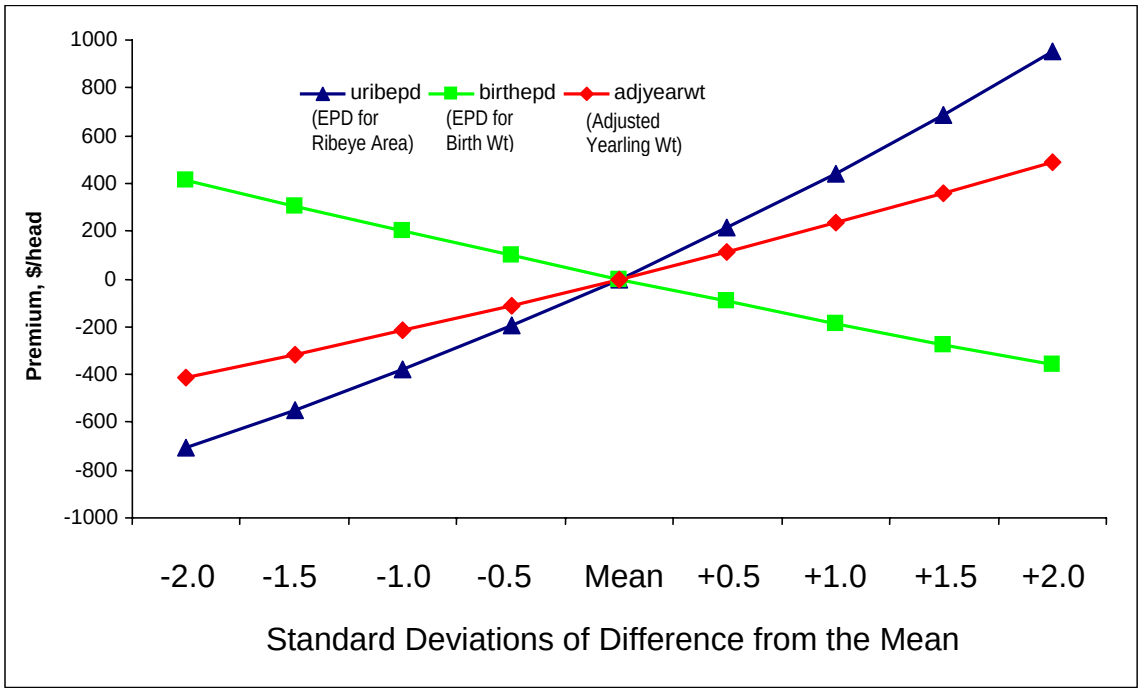


Figure 3. Predicted Premiums for Ultrasound Ribeye EPD, Birth Weight EPD, and Adjusted Yearling Weight.

ECONOMIES OF SCALE IN FINISHING CATTLE

R. W. Porter[1] and R. Jones[1]

Summary

The results of this study indicate that farmer-feeders who finish as few as 700 head per year can compete with the large commercial feedlots from a cost perspective. The lack of a sophisticated feed mill does not prevent the farmer-feeder from being competitive with the large commercial feedlots in feed costs. This might be explained by the farmer feeder producing much of the feed, which reduces transportation and transaction costs. The farmer-feeder has non-feed costs that average 64% more than those of the large commercial feedlots. The significantly greater costs for depreciation, repairs, and maintenance may be explained by having fewer numbers of cattle to spread the equipment over. As evidenced by the rapid structural change in the cattle feeding industry, it is not easy for the relatively smaller-scale farmer-feeder operation to compete in the cattle feeding industry. This cost-comparison study indicates that it is possible for well managed small-scale feeders to be competitive from an overall cost perspective.

Introduction

Given the dramatic structural changes in the cattle-feeding industry over the past 40 years, one might assume that economies of scale so strongly favor the large commercial feedlots that the small farmer-feeder could not possibly be competitive. This must not always be the true, however, because there are still small farmer-feeders who continue to feed cattle profitably. The issue of economies of scale always generates interesting debate among industry participants and observers.

With that said, surprisingly few previous studies have specifically examined the impact of size on the cost structure in cattle feeding. For cattle fed in Texas during 1980 and 1981, fixed costs were significantly lower for feedlots with more than 16,000 head capacity. In Iowa feedlots, the converse was true; non-feed costs were fairly flat over a range of sizes. Iowa feedlots tended to be diversified with farming and other livestock operations, however, so economies of scope might mask economies of scale. In Texas feedlots, non-feed costs were less for feedlots larger than 50,000 head capacity. Approximately one-third of the fixed costs of Texas feedlots are for the feed mill. Iowa feeders tend to transfer much of the feed-milling costs to higher costs for prepared feed.

Our evaluation compares operating-cost information for the small farmer/feeder with similar information obtained from large commercial feedlots. We compare various measures of costs for the two types of operations. Because the two classes of feedlots are dramatically different in size, we make all comparisons on cost per pound of gain. In addition, we attempt to determine what factors drive cost differences between the two types of operations.

[1]Department of Agricultural Economics.

Procedures

Economies of scale occur when more units are produced at a lower cost per unit. Economists suggest that division of labor, specialization, and spreading of overhead costs are the primary ways that economies of scale are achieved. In addition, larger feedlots may enjoy lower input costs because of volume discounts for inputs and more negotiating effort.

The data for our study come from the Kansas Farm Management Association (KFMA) and a sample of large commercial feedlots (LCF). The KFMA data represent 35 backgrounder-feeders who provided cattle-feeding-enterprise data for three consecutive years (1997, 1998, and 1999). These feeder operations ranged in size from operations that finished 100 head per year to those that finished 1900 head per year. The LCF data represent 55 feedlots, finishing an average of 78,251 head per year. The LCF data include lots from Kansas, Texas, and Oklahoma for the same 3-year time period.

The summary data for small and large KFMA feedlots (Table 1) were calculated by using the "best fit" equations presented in Figures 1 through 3, computed where the smallest (100 head) and largest (1900 head) intercept the trend line. The LCF data are averages from all of the large feedyards.

Additional data from LCF were results of a "Feed Yard Cost Survey." These data include a more comprehensive breakdown of cost categories that could be compared with KFMA cost categories. This LCF data comes from 19 to 28 feedlots (depending on year) that are not necessarily the same as the 55 feedlots in the previous data set.

The KFMA raw data were aggregated into categories that mirror a close-out from a commercial feedlot; all feed and non-feed costs were included. Not included were costs that would customarily be borne by the owner of cattle in a commercial feedlot. An example of excluded costs would be the interest costs on the cattle. In addition, no adjustment was made in the KFMA data for the expected returns above all accounting costs that a feedlot would expect to recover from operating a feedlot (returns to management and risk). Included interest cost (operating interest) was derived from the depreciation and variable interest costs. Transportation costs (either "to" or "from" the feedlot) were not included, although an argument can be made that a farmer-feeder would be more likely than the large feedlot to bear transportation costs, especially to the packer, as the cattle would more likely be sold on a grid.

The KFMA data are robust enough to demonstrate changes in costs as the size of the enterprise changes. The data from the large commercial feedlots could not be used to assess variation in costs as a function of feedlot size, however, because individual commercial feedlot size was not reported, to maintain confidentiality. Therefore, the KFMA individual firm data are compared to averages from LCF.

Results and Discussion

Figure 1 best summarizes the results of our study. The KFMA feedlots had a calculated average total cost of gain that started at $0.62 per pound of gain for the smallest feedlots (100 head per year), declining to $0.50 per pound of gain for the largest feedlots (1900 head per year). This compares to the LCF data that reveal a total cost of gain of $0.52 for feedlots averaging 78,252 head per year (Table 1). This comparison reveals that it is quite possible for the larger farmer-feeder operations to be competitive with the large feedlots from the perspective of total cost of gain.

Figure 2 summarizes feed-only costs of gain. The KFMA feeders had a calculated average feed-only cost of gain that started at $0.46 per pound of gain for the smallest feedlots (100 head per year), declining to $0.42

per pound of gain for the largest feedlots (1900 head per year). These results compare with the LCF average for feed-only cost of gain of $0.445 for feedlots averaging 78,252 head per year (Table 1).

Figure 3 summarizes the non-feed costs of gain. The KFMA feedlots had a calculated average non-feed cost of gain that started at $0.16 per pound of gain for the smallest feedlots (100 head per year), declining to $0.08 per pound of gain for the largest feedlots (1900 head per year.) The LCF had non-feed costs of gain of $0.075 for feedlots averaging 78,252 head per year (Table 1).

These results (Figures 1 to 3, and Table 1) show that larger KFMA feedlots can be competitive with the very large commercial feedlots on total cost of gain. It is surprising that the feed-only costs are similar for both. One might hypothesize that the worse feed efficiency from feeding dry-rolled grain in the KFMA feedlots was offset by the lesser processing costs from not having a steam flaker and a lesser grain cost because the farmer would otherwise be selling grain at wholesale prices, whereas the large commercial feedlots buy their grain at higher costs that include transaction costs. Hay and silage are usually priced much lower at the farm than at a large commercial feedlot. Another possible explanation for the farmer-feeders having lower feed costs is that many farmer feeders feed their own cattle and these cattle do not have to adapt to a new feedlot (private discussions with cattle feeders suggest that these "adaptation" costs can be quite high).

The most striking observation is that the KFMA feedlots had non-feed costs that were on average more than 60% higher than the non-feed cost for the very large commercial feedlots. Even the larger feedlots in the KFMA data set had non-feed costs that were slightly greater than the costs for the large commercial feedlots. A breakdown of data in Table 2 helps to explain why the KFMA feedlots had these higher non-feed costs.

Table 2 illustrates some striking differences in the non-feed costs between the KFMA feedlots and the LCF feedlots. An obvious problem with this data is that we do not know exactly how the allocations were made. The operators had a total cost that they had to allocate among the various categories, and some subjective allocation likely occurred. Thus, there is higher confidence in the aggregate of these non-feed costs than in each individual cost category.

With that said, results presented in Table 2 reveal that the labor cost for the KFMA data is only 78% of the cost for LCF. Operators of smaller feedlots may not account for all of the unpaid farm labor when reporting costs, or they may value their work at a lower rate. In addition, they are not subject to workman's compensation costs, and they would have a simpler feeding system, perhaps requiring less labor. The insurance cost for KFMA is 22% higher than for LCF. This is likely because the smaller feedlots have more value per head in buildings and equipment to insure.

The interest cost for KFMA is 3.72 times that for LCF. This is likely because the smaller feedlots have a higher investment cost per head. It is also possible that we were not able to adequately separate the interest cost on the cattle from the interest cost on the facilities, equipment, and variable costs. The tax cost for the KFMA is only 72% of the tax cost for LCF. This is hard to reconcile with the insurance and interest costs being higher because there is more facility cost per head. It is possible that the smaller feedlots are taxed at a lower rate because they are classified as agriculture, whereas the feedlots are classified as commercial. The utilities cost for KFMA is 21% higher than for LCF. It is possible that non-feedlot utilities were included in the reported cost measure because it is harder for

the farmer/feeder to allocate such costs to the appropriate enterprises.

The depreciation, repair, maintenance, and machine hire costs for KFMA are 2.97 times as high as those for LCF. It is quite plausible that total machine costs are very subject to economies of scale, so it just costs the smaller operators more on a per-unit basis. Larger feedlots would have larger equipment, but it would be used more hours per day and would be spread over significantly more units of gain. The marketing and professional organization costs also are 3.27 times higher for the KFMA than for LCF. This is plausible because the smaller feedlot may have to hire someone to help in marketing the cattle, and they may sell cattle on a delivered basis (grade and yield) so that the smaller feedlot is responsible for the trucking cost to the packer. In contrast, the larger feedlots probably sell most of their cattle FOB the feedlot.

Modest-sized farmer-feeder operations can be cost competitive overall with the larger commercial feedlots. Feed-only costs seem to be the easiest to "keep in line". It may be much more difficult and require good management and attention to detail to achieve competitiveness in the non-feed cost categories.

Table 1. Summary Statistics for Cost

	KFMA Data			
Cost Category	100 head	1900 head	Average	Large Commercial Feedyards
	---------- $/lb of Gain ----------			
Total cost	$0.62	$0.50	$0.56	$0.52
Feed-only cost	$0.46	$0.42	$0.437	$0.445
Non-feed cost	$0.16	$0.08	$0.122	$0.075

Table 2. Breakdown of Non-feed Costs

Data Source	KFMA	LCF	KFMA/LCF
	------- $/lb of Gain --------		
Feed and medicine	0.4369	0.446	0.98
Labor	0.029	0.0373	0.78
Insurance	0.0022	0.001822	1.22
Interest	0.0248	0.0067	3.72
Taxes	0.0022	0.00301	0.72
Utilities	0.007	0.0058	1.21
Depreciation, repair, and maintenance	0.027	0.0091	2.97
Marketing and professional organization	0.0298	0.0091	3.27
Total non-feed costs	0.122	0.0745	1.64
Total cost of gain	0.5589	0.5205	1.07

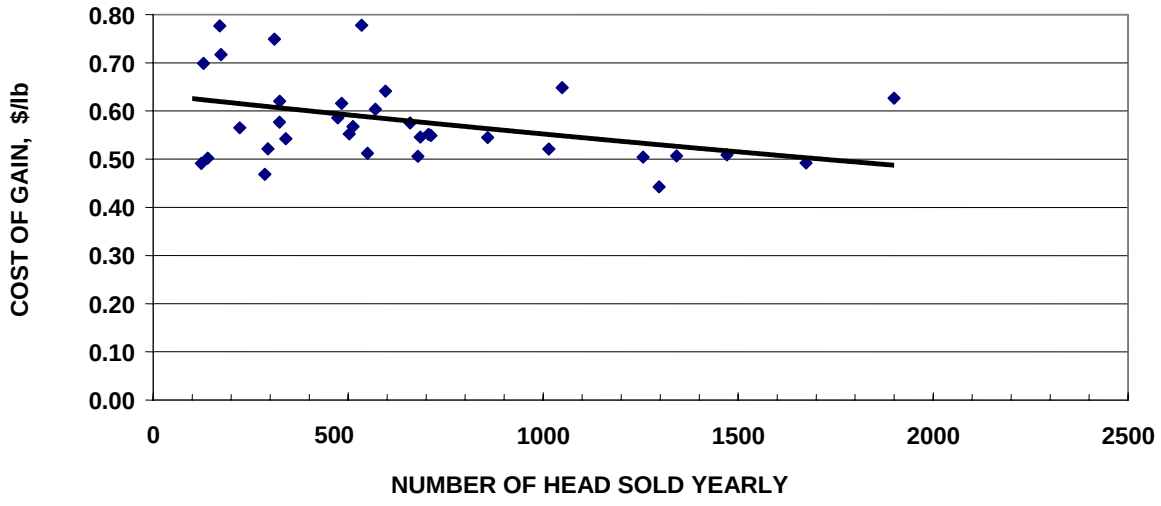


Figure 1. Total Cost of Gain for Farm Management for Backgrounder-Feeders (1997 – 1999).

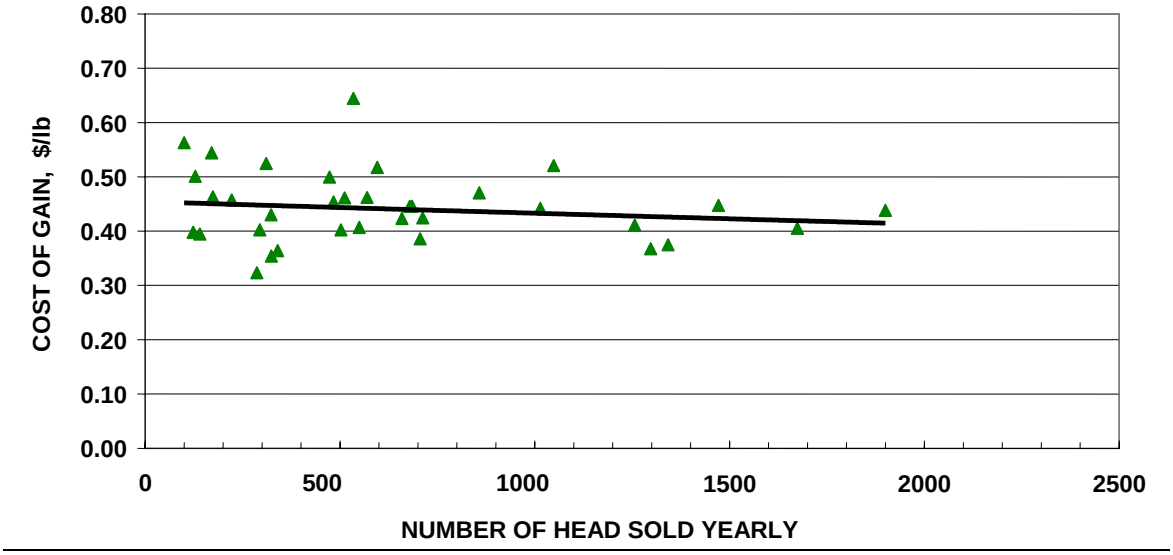


Figure 2. Feed Cost of Gain for Farm Management for Backgrounder-Feeders (1997 – 1999).

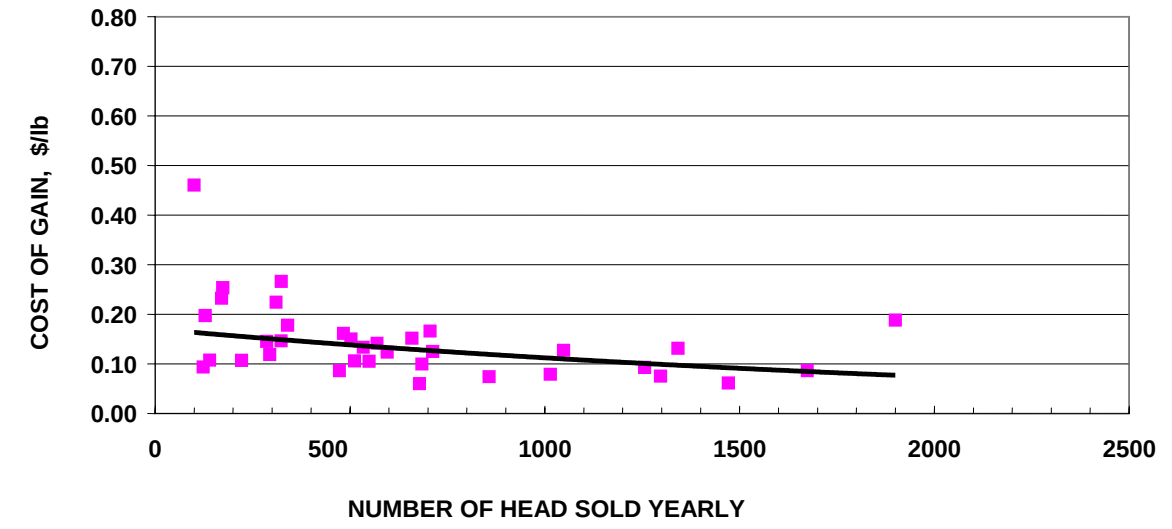


Figure 3. Non-Feed Cost of Gain for Farm Management for Backgrounder-Feeders (1997 – 1999).

EVALUATION OF ESTRU$ ALERT®, KAMAR®, AND FIL® TAILPAINT AS AIDS FOR DETECTION OF ESTRUS

S. K. Johnson

Summary

Three estrus-detection aids were evaluated in beef heifers after synchronization of estrus with a typical melengesterol acetate (MGA)/ prostaglandin $F_{2\alpha}$ (PGF) protocol. Devices were applied at the time of PGF administration. Application time was longest for Kamar® patches, intermediate for Estru$ Alert® patches and FiL® Tailpaint, and shortest for controls. The degree to which the detection aids were activated at first observed estrus was dependent on the time of day when first observed and the type of device. A greater proportion of Estru$ Alert® and FiL® Tailpaint devices were 75% to fully activated when first observation of estrus was in the morning, compared with first observations in the afternoon. Time of day did not influence degree of Kamar® patch activation. At breeding, more than 90% of Estru$ Alert® and Kamar® devices were fully activated, whereas more variation in degree of activation was present in heifers with FiL® Tailpaint. Use of detection aids did not increase estrous-detection rate or AI pregnancy rates, compared with those of controls when visual observation was intensive. Use of detection aids still requires observation at least twice per day to time inseminations, because the degree of color change/activation is not consistently an indicator of time since onset of estrus.

Introduction

For artificial insemination programs dependent on heat detection, accurate identification of females in estrus is critical to the success of the program. A variety of heat-detection aids have been available over the years, and newer ones have joined the market. Electronic aids are available, but cost and more application challenges make them less practical for use in synchronization systems.

Colorado State University research has shown pregnancy rates twice as high as a result of using heat detection for 2 hours in the morning and evening and one hour at noon in a synchronized group of cows, compared with use of heat detection for 30 minutes twice a day. Even with the increased observation time, it is impractical to observe animals around the clock, and the limits of daylight hours generally mean that animals will not be observed for a large portion of the day. Estimates indicate that 29% of females initiate estrus between midnight and 6 a.m. For situations in which the value of AI pregnancies is high, use of relatively inexpensive, easily applied aids may help detect animals that only exhibit estrus during the dark. A challenge with most detection aids is that there are some gray areas in reading the devices, especially as the intensity of visual observations decrease.

[1]Sincere appreciation is expressed to Losey Land and Cattle Co. for their participation in this study and to Stan Robb for dedication and attention to detail during many hours of heat detection.

The objective of the current study was to evaluate estrus-detection aids for ease and time of application, variation in degree of activation at estrus and breeding, and benefits to heat-detection rates and pregnancy rates.

Procedures

Estrus was synchronized in 398 Angus and Angus crossbred heifers by feeding 0.5 mg daily of melengesterol acetate (MGA) per heifer for 14 days, followed by prostaglandin $F_{2\alpha}$ (PGF; 25 mg, i.m.; ProstaMate®) 19 days later. At the time PGF was administered, heifers received a Kamar® heatmount detector (n=96), an Estru$ Alert® patch (n=105), or FiL® Tailpaint (n=104), all according to label directions, or received nothing (control; n=93). Two of four pens received PGF on each of two consecutive days. Each treatment was applied to groups of 9 to 16 heifers before switching to the next treatment. A starting and ending time was recorded for each treatment replicate. One person operated the hydraulic chute and administered PGF, one applied detection aids, and a third loaded the alley.

Estru$ Alert® is a self-adhesive patch similar to a lottery scratch card. As the animal is mounted during estrus, the scratch-off silver surface is gradually removed to reveal a florescent layer underneath. The Kamar® heatmount detector contains a built-in timer that releases a red coloring when activated (requires a 3-second mount, according to company literature). The cylinder containing the dye is covered with an outer plastic layer that appears red when fully activated. FiL® Tailpaint is applied to the tail head from a convenient plastic bottle whose lid is an application brush.

Detection of estrus occurred in a manner consistent with previous years in which no detection aids were used. From approximately 36 to 144 hours after PGF administration during daylight hours, heifers were observed for estrus at least 8 hours per day. Before and after that time period, less time was spent. When a heifer was first observed in standing estrus, the detection aid was scored from 0 to 4, based on color change from initial application; 0=unchanged, 1=25% color change, 2=50% color change, 3=75% color change, 4=total color change. A second score was taken at AI. An effort was made to note lost devices and interpret partial color changes. Attempts to do this were only moderately successful because control animals were in the same pens, and marks made to identify control animals did not all remain intact.

Results and Discussion

The average time to administer PGF was 44 ± 3 seconds per heifer and was least ($P<0.05$) for control heifers. Estru$ Alert® and FiL® Tailpaint both required 59 ± 3 seconds per heifer, which was less ($P<0.05$) than the 75 ± 3 seconds for Kamar® patches. Less time per animal ($P<0.05$) was required for treatments on Day 1 than on Day 2. This difference may relate to the size of the treatment replications each day, 15 to 16 for Day 1 and 9 to 10 for Day 2.

The first day devices were applied, heifers were held in an alley way after being treated and before returning to their pens. In this situation, some tail paint did not have sufficient time to dry before being subjected to rubbing chins from heifers turning around in close quarters. The second day more room was given to the heifers when they left the chute, and this problem was prevented.

Three Estru$ Alert® patches and one Kamar® patch were lost within 24 hours of application. Two additional Kamar® patches and one Estru$ Alert® patch were missing, and four Kamar® patches were broken open (pressure-sensitive device gone) on heifers that had not been observed in estrus by 7 days after administrations of PGF. At the time devices

were applied, heifers were shedding, and notes were made of individuals with hair condition that might contribute to loss. None of these animals lost devices. A light mist present at the end of the second day of application did not seem to affect device retention. One heifer with an activated Kamar® patch was observed positioning herself so that she could rub the top of the patch under the top cable over the feed bunks. Heifers were in a feedlot setting, with no trees or branches near the pens.

The distribution of device scores when the heifers were first observed in standing estrus is shown in Table 1. Observers failed to record a score for 13.3% (31/233) of heifers. For Estru$ Alert® and FiL® Tailpaint, there was a larger proportion of scores of 3 or 4 at first observed estrus when estrus was in the morning rather than the afternoon. The proportion of heifers with Kamar® patches that scored 3 or 4 was similar, regardless of time of day detected. This likely reflects differences in the amount of activity it takes for full activation and the amount of activity that occurred before daylight in the morning. When standing estrus was observed in the afternoon, more Kamar® devices were fully activated at first observation than were FiL® Tailpaint applications. This likely reflects a more rapid change in color with one or two good mounts with a Kamar® patch.

Distribution of device scores at breeding (Table 2) were similar for Kamar® and Estru$ Alert® devices, with a majority fully activated. A greater percentage of heifers with FiL® Tailpaint had scores of 0 or 1 at breeding, compared with Estru$ Alert® and Kamar® devices. Of the 15 heifers that had a score of 1 at breeding, 11 of 15 (73%) were pregnant to AI. More experience with the amount of FiL® Tailpaint to apply would likely result in more consistent product removal. In addition, problems due to early paint loss in the alley on the day of application and the fact that untreated controls were in the same pens and lost their distinguishing mark, limit the reliability of our evaluation of the FiL® Tailpaint. Cost of FiL® Tailpaint is $0.15-0.20 per animal, compared with roughly $0.90 to $1.10 per animal for Estru$ Alert® or Kamar® devices.

Estrous response from PGF administration through 144 hours after PGF was 86.0%, 86.7%, 86.4,% and 85.6% for control, Estru$ Alert®, Kamar®, and FiL® Tailpaint groups, respectively, and did not differ among treatments. AI pregnancy rates during the same time period did not differ and were 60.0%, 57.1%, 64.6%, and 67.3%, respectively.

The FiL® Tailpaint and Estru$ Alert® patches were also used on a group of cows being fed MGA on pasture during late May and early June. Although there were some trees and brush in the pasture that could contribute to false readings, the fly season probably had the biggest impact on the effectiveness of the devices in these settings. The Estru$ Alert® patches were in a location on the cow's back where they could easily be brushed by the cow's tail swatting flies. A company representative later indicated that we should have positioned the devices closer to the tail during fly season to reduce this problem. The FiL® Tailpaint was a water-based version, and water solubility, particularly after wading into the pond for a drink, may have contributed to the rapid loss of tail paint that occurred in this setting. The oil-based version of the product likely would have been more appropriate in this setting. As used, neither device was very helpful over an extended period in a pasture setting.

Although the directions for the Kamar® patch indicate that a partial color change should be interpreted as positive, the manager at this commercial operation only inseminated one heifer in this category. In this instance, secondary evidence of mounting activity from an irritated hip brand was convincing. If an Estru$ Alert® patch is scraped accidentally by a hard object, a single mark is observed. Chances of an accident totally polishing off

the Estru$ Alert® patch are slim, making it much easier to identify a false positive. A fully activated Estru$ Alert® is very easy to see, and can aid the sorting process.

Table 1. Distribution of Device Scores at First Observed Standing Estrus when Estrus was First Observed in the Morning or Afternoon and Early Evening

		Device Score				
Item	No.	0	1	2	3	4
Detected before noon		---------- % (number) ----------				
Estru$ Alert®	45	2 (1)	16 (7)	7 (3)	20 (9)	56 (25)
Kamar®	46	17 (8)	13 (6)	7 (3)	4 (2)	59 (27)
FiL® Tailpaint	43	0 (0)	12 (5)	49 (21)	28 (12)	12 (5)
Detected afternoon and evening						
Estru$ Alert®	36	6 (2)	47 (17)	22 (8)	11 (4)	14 (5)
Kamar®	28	25 (7)	25 (7)	4 (1)	0	46 (13)
FiL® Tailpaint	35	3 (1)	37 (13)	46 (16)	6 (2)	9 (3)

Table 2. Distribution of Device Scores at AI

		Device Score				
Device	No.	0	1	2	3	4
		---------- % (number) ----------				
Estru$ Alert®	88	1 (1)	0	1 (1)	6 (5)	92 (81)
Kamar®	81	5 (4)	0	1 (1)	2 (2)	92 (74)
FiL® Tailpaint	92	1 (1)	16 (15)	33 (30)	28 (26)	22 (20)

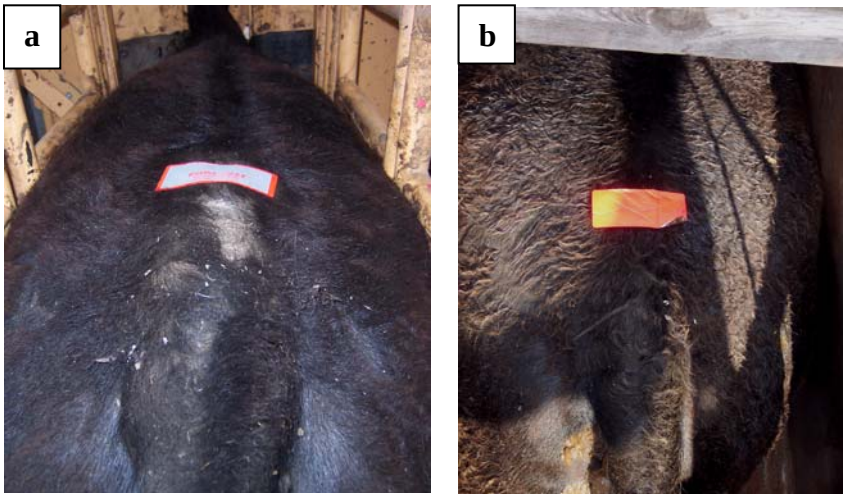


Figure 1. Estru$ Alert® Patch at Application (a) and AI (b; device score 4).

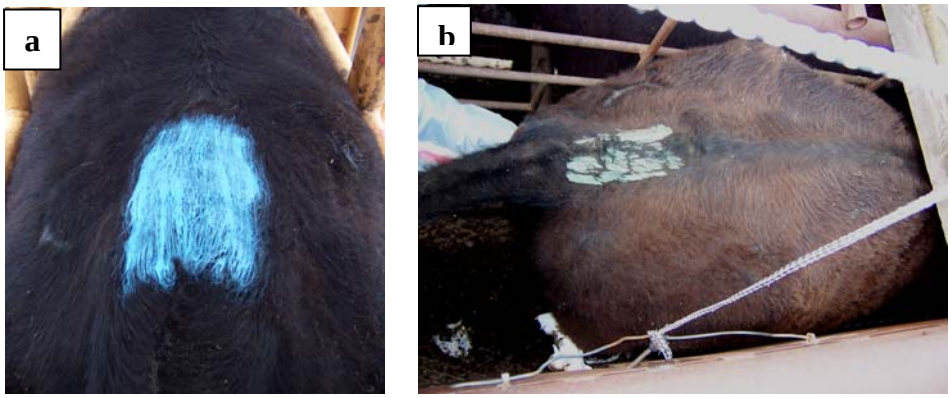


Figure 2. FiL® Tailpaint at Time of Application (a) and at AI (b; device score 1).

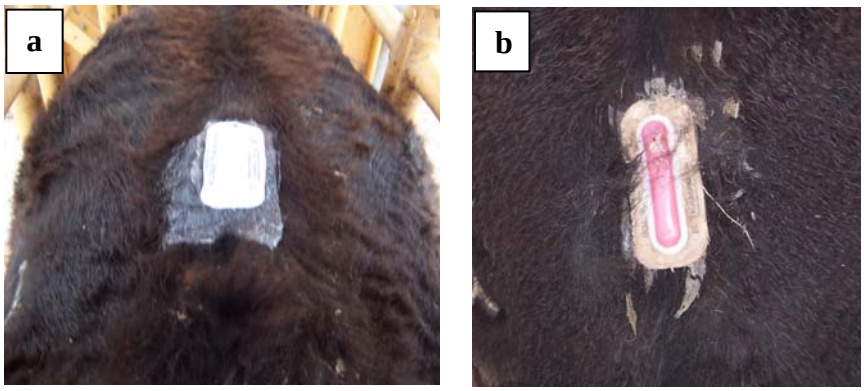


Figure 3. Kamar Heatmount Detector at Application (a) and at AI (b; device score 4).

FEEDING MELENGESTEROL ACETATE (MGA) IN ADVANCE OF ESTRUS SYNCHRONIZATION OF VIRGIN BEEF HEIFERS

B. T. Gray and T. T. Marston

Summary

The objective of this experiment was to determine if a 7-day feeding of melengesterol acetate (MGA) about 2 months before the breeding season would have an effect on puberty onset, response to estrous synchronization, and fertility. "Progesterone priming" with MGA increased the number of heifers that began cycling before estrous synchronization. This did not increase the percentage of heifers that were observed in standing heat after estrous synchronization, however, regardless of whether standard MGA/PGF or Select Synch protocol was used. The conception rates and overall pregnancy rates were similar between treatments. Many factors affect the reproductive performance of replacement heifers; slight decreases in the age of puberty onset seem to have little effect.

Introduction

Cow/calf producers and operations that develop replacement heifers realize that reproductive rates are extremely important to their operations. Heifers that reach puberty several months before the breeding season are more likely to respond to estrous synchronization, to have improved AI conception rates, and to have greater pregnancy rates at the end of a controlled breeding season. Often heifers will have a shortened estrous cycle before their first fertile heat. This "short cycle" seems to have a "progesterone priming" effect on the reproductive system. MGA is a relatively inexpensive, easy-to-use, oral progestin. The objective of this experiment was to determine if a 7-day feeding of MGA about 2 months before the breeding season would have an effect on puberty, response to estrous synchronization, and fertility.

Procedures

A 2-year experiment was conducted at four locations in Kansas with spring-born, virgin beef heifers (n = 347; average weight = 742 lb; average age = 418 days) in 2002 and 2003. Purebred and crossbred heifers were studied depending on location. Heifers were assigned randomly to treatments applied before estrous synchronization and, within each of these groups, heifers were randomly assigned to an estrous-synchronization protocol. Treatments consisted of heifers being fed either 0 (n = 170; control) or 0.5 mg per heifer daily of melengesterol acetate (n = 177; MGA) for 7 consecutive days, beginning 65 days before estrus-synchronization protocols of feeding 0.5 mg per heifer daily of MGA (n=174) for 14 consecutive days, followed 19 days later with an injection of 25 mg of $PGF_{2\alpha}$ (Lutalyse®, Pharmacia Animal Health, Kalamazoo, MI) (MGA+PGF) or of injecting 100 μg of GnRH (n=173, Factrel®, Fort Dodge), followed 7 days later with a 25-mg injection of $PGF_{2\alpha}$ (SELECT SYNCH). Therefore, four different treatments were studied: control/MGA+PGF, control/SELECT SYNCH, MGA/MGA+PGF, and MGA/SELECT SYNCH (Figure 1). After estrous synchronization, heifers were observed for estrus two or more times daily and were artificially inseminated approximately 12 hours after visually confirmed standing heat. Trained technicians (n = 11) were used for the various 6- to 7-day breeding period, depending on location. Heif-

ers were placed with bulls 4 to 6 days after the AI breeding period (see Table 1 for length of natural breeding season at each location) or continued to be observed for estrus and artificially inseminated for the rest of the breeding season. Transrectal ultrasonography (Aloka 500V or 210 ultrasound scanner, Corometrics Medical Systems, Wallingford, CT: equipped with a 5.0 MHz linear array transducer) was used between 30 and 45 days after AI to determine whether heifers conceived to AI. Rectal palpation was performed to verify pregnancy in the fall after the breeding season. Blood samples were collected from 188 heifers (3 locations) at 10-day intervals before the start of control/MGA feeding and estrous synchronization to classify the pubertal status of heifers.

Results and Discussion

Progesterone concentrations indicated that 66% of the heifers (125/188) had achieved puberty before the start of the experiment. Therefore, the pre-estrus synchronization part of treatments could only influence the pubertal status of about one-third of the heifers sampled.

The 7-day feeding of MGA increased the percentage of pubertal heifers before the commencement of estrous synchronization (Table 2). Table 3 lists the reproductive responses of heifers that had not reached puberty until after the start of the experiment. For only those heifers that achieved puberty after the beginning of the trial, the 7-day feeding of MGA induced more heifers into puberty before estrous synchronization, but it did not affect the number of heifers observed in standing heat with either estrous-synchronization protocol or the number that conceived to AI, and did not affect final pregnancy rates. Treatments that used the MGA+PGF estrous synchronization protocol had greater pregnancy rates than SELECT SYNCH in this trial.

The reproductive-response data collected from all locations are listed in Table 4. No differences were noted between treatments for percentage of heifers observed in standing heat or conceiving to AI or for final pregnancy rates.

Reducing the age of puberty by "progesterone priming" the bovine reproductive system with melengesterol acetate seemed to have little effect on reproductive performance of virgin beef heifers. To improve the development of replacement heifers, it seems that producers should focus on genetics, nutritional programs, achieving target weights, reproductive-tract scoring, estrous synchronization, and male fertility.

Table 1. Description of Heifers and Management Used

	Location				
Item	A	B	C	D	E
No. heifers	52	79	88	57	71
Breed type	Purebred	Xbred	Xbred	Purebred	Pure & Xbred
Length of breeding season, days	120	76	48	114	66
Average age, days	433 ± 20	403 ± 15	418 ± 12	417 ± 18	421 ± 16
Average weight, lb	711 ± 61	727 ± 63	750 ± 54	705 ± 73	813 ± 69

Table 2. The Effect of 7-day MGA Feeding on the Percentage of Previously Prepubertal Beef Heifers that Attained Puberty Between the MGA Feeding Period and the Start of Estrous Synchronization

	Pre-estrus Synchronization MGA Feeding [a]		
Location	Control	MGA	P-value
	---------- % (no./no.) ----------		
A	25 (3/12)	56 (5/9)	0.16
B	25 (1/4)	100 (6/6)	0.04
C	37 (7/19)	69 (9/13)	0.10
Overall	31 (11/35)	75 (21/28)	0.004

[a]Control = no MGA fed before estrous synchronization; MGA = MGA was fed for 7 consecutive days about 2 months before estrous synchronization.

Table 3. Treatment Responses of Only Those Heifers that Reached Puberty After the Initial 7-day MGA Feeding Period

Response	Control/ MGA+PGF	Control/ SELECT SYNCH	MGA/ MGA+PGF	MGA/ SELECT SYNCH
	---------- % (no./no.) ----------			
Observed in standing heat	82 (14/17)	78 (14/18)	88 (14/16)	83 (10/12)
Pregnant to AI	64 (9/14)	35 (5/14)	50 (7/14)	60 (6/10)
Final pregnancy rate	76 (13/17)	50 (9/18)	69 (11/16)	67 (8/12)

Table 4. Reproductive Responses of Heifers to Treatments

Item	Control/ MGA+PGF	Control/ SELECT SYNCH	MGA/ MGA+PGF	MGA/ SELECT SYNCH	P-value
No. heifers	80	90	94	83	
	---------- % (no./no.) ----------				
Observed standing heat	81 (65/80)	80 (72/90)	86 (81/94)	75 (62/83)	0.21
Pregnant to AI	56 (36/65)	43 (31/72)	60 (49/81)	51 (32/62)	0.75
Final pregnancy rate	74 (58/79)	66 (59/90)	76 (71/94)	65 (54/83)	0.81

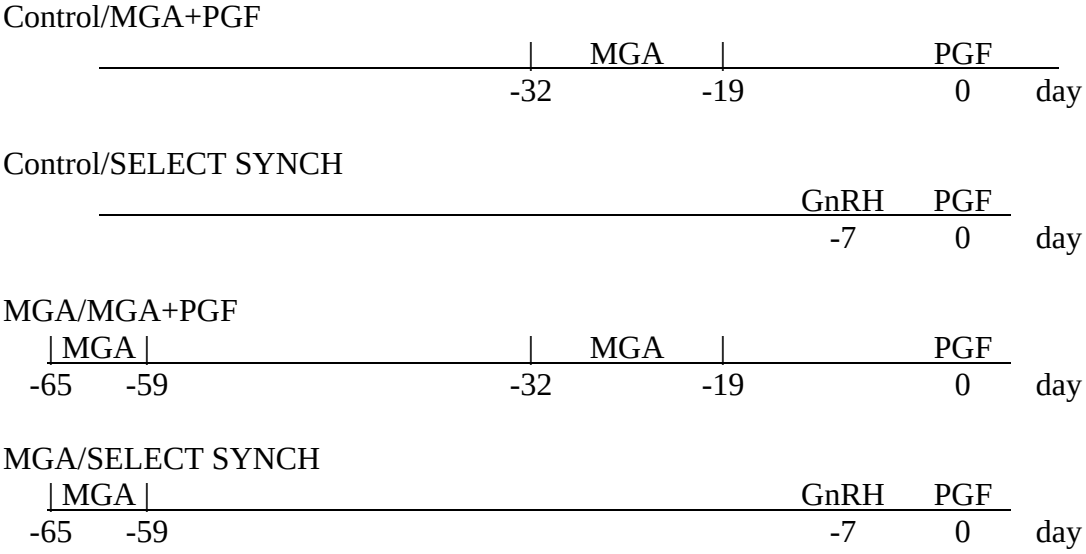


Figure 1. Experimental Design of Treatments Applied Before and During Estrous Synchronization (control/MGA+PGF, control/SELECT SYNCH, MGA/MGA+PGF, and MGA/SELECT SYNCH; top to bottom). Melengestrol acetate (MGA; 0.5 mg per heifer daily) was administered for 7 days during the MGA period and 14 days during estrus synchronization. Gonadotropin-releasing hormone (GnRH; 100 μg) and prostaglandin $F_{2\alpha}$ (PGF; 25 mg) were injected on days -7 and 0, respectively.

EFFECTS OF PACKAGING ON BONE MARROW DISCOLORATION IN BEEF ARM, RIB, SHOULDER BLADE, AND THORACIC VERTEBRA BONES

J. P. Grobbel, M. E. Dikeman, J. S. Smith, D. H. Kropf, and G. A. Milliken

Summary

Meat retailers have reported bone marrow discoloration to be a problem, especially in modified-atmosphere packages (MAP). To evaluate causes of bone marrow discoloration in different beef bones and packaging systems, 36 beef arm bones, ribs, shoulder blades, and thoracic vertebrae from USDA Select and Choice carcasses were obtained from a commercial abattoir, cut into 1-inch-thick sections at 4 days postmortem, and packaged into 1) polyvinyl chloride film (PVC) overwrap; 2) high-oxygen (80% O_2, 20% CO_2) MAP; or 3) ultra-low-oxygen (70% N_2, 30% CO_2) MAP. Packages were displayed under continuous fluorescent lighting for 4 days at 35.6˚F. Ribs, shoulder blades, and thoracic vertebrae packaged in PVC and high-oxygen MAP developed undesirable gray or black discoloration during display. In ultra-low-oxygen MAP, mean visual-color scores were acceptable throughout display. The a* values (larger values equate to redder color) for ribs, shoulder blades, and thoracic vertebrae decreased ($P<0.05$) over time. Arm-bone marrow had less oxidation and dramatically less total iron and hemoglobin than did marrow from ribs and thoracic vertebrae. The much larger amounts of iron and hemoglobin in ribs and thoracic vertebrae likely correspond to marrow discoloration. In summary, bone marrow discoloration occurs in ribs, shoulder blades, and thoracic vertebrae packaged in PVC or high-oxygen MAP. Bones packaged in ultra-low-oxygen MAP or arm bones packaged in PVC or high-oxygen MAP had minimal oxidation and discoloration.

Introduction

Occurrence of the 'black bone' condition in modified-atmosphere packages (MAP) of bone-in, beef retail cuts has been reported by meat retailers. Consumers may perceive bone discoloration ('black bone') as unwholesome, and it may affect their overall perception of a fresh meat product. Bone marrow discoloration has been reported in high-oxygen MAP beef and pork and also in cuts packaged in polyvinyl chloride film (PVC). As more meat is being sold as case-ready, it is important to find causes of, and preventions for, this problem.

One researcher suggested that bone blackening occurs when bone is cut and hemoglobin is released to the surface, where it will accumulate when the red blood cells are disrupted. Over time and through exposure to air, hemoglobin on the surface of the bone turns from red to brown to black. Other possibilities include bone marrow that contains more total pigments, more hemoglobin, and more iron when compared with muscle. Furthermore, lipid content in bovine bone marrow differs among bones and among their locations. The lipid contents of bovine bone marrow from cervical vertebrae, lumbar vertebrae, and leg bones have been analyzed. Bone marrow from cervical vertebrae contained the least lipid, whereas marrow from leg bones had the most. In addition, bone marrow resembles adipose tissue more than it resembles muscle or liver tissue. Thus, lipid oxidation may also be a factor in the development of bone marrow discoloration. Beef lumbar vertebrae have been found to discolor within 24

hours when packaged in high-oxygen MAP, primarily due to the oxidation of hemoglobin.

The objectives of this experiment were to determine the prevalence in different packaging systems of bone marrow discoloration in beef arm bones, ribs, thoracic vertebrae, and shoulder blades, and to determine factors that may cause bone marrow discoloration.

Procedures

Thirty-six beef arm bones, ribs, shoulder blades, and thoracic vertebrae from USDA Select and Choice carcasses obtained from a commercial abattoir were cut into 1-inch-thick sections at 4 days postmortem by using a band saw, and sections were packaged into one of three package types: 1) PVC overwrap; 2) high-oxygen (80% O_2, 20% CO_2) MAP; and 3) ultra-low-oxygen (70% N_2, 30% CO_2) MAP. One each of an arm bone, a shoulder blade, and a thoracic vertebra, and two rib bones were placed in each package. The PVC samples were packaged in foam trays with oxygen-permeable film. High-oxygen and ultra-low-oxygen MAP packages were packaged in rigid plastic trays and were covered with barrier lidding film. Each ultra-low-oxygen MAP had one activated oxygen scavenger added to the package. There were two replications of 18 packages of each system. Within each replication, 12 packages remained in the display case through day 4, whereas 6 packages were opened on day 2 of display (mid display) for instrumental color readings.

Packages were displayed under continuous fluorescent lighting for 4 days at 35.6˚F. Packages were rotated twice daily to maintain a random display case placement.

Instrumental CIE a* measurements were collected with a Hunter labscan 2. CIE a* measures red (+) to green (-). Bones were scanned before packaging on day 0 and after visual color scores were collected on days 2 and 4.

Ten trained visual panelists scored the porous portion of bone-marrow for color once each day for 4 days, beginning on day 0. Bone sections in high-oxygen MAP and in PVC packages were scored according to the seven-point scale: 1) bright reddish-pink to red, 2) dull pinkish-red, 3) slightly grayish-pink or grayish-red, 4) grayish-pink or grayish-red, 5) moderately gray, 6) all gray or grayish-black, and 7) black discoloration. Ultra-low-oxygen MAP bones were scored according to the seven-point scale: 1) bright purplish-red or purplish-pink, 2) dull purplish-pink or purplish-red, 3) slightly grayish purple or pink, 4) grayish-purple or grayish-red, 5) moderately gray, 6) all gray or grayish-black, and 7) black discoloration.

Bone marrow was extracted and analyzed for: 1) 2-thiobarbituric acid reactive substances (TBARS) content, a measure of oxidation, 2) myoglobin and hemoglobin pigment concentrations, and 3) total iron and phosphorus concentrations.

Results and Discussion

Visual Color Display. Visual color scores for the four bone types and three packaging systems are shown in Table 1. Arm-bone marrow became darker ($P<0.05$) with each day of display, but by day 4 of display, the visual score was still only a ‘dull pinkish-red’ for bones packaged in PVC or high-oxygen MAP and a ‘slightly grayish purple or pink’ for those packaged in ultra-low-oxygen MAP. According to panelist observations, the arm bones did not turn gray or black during display and remained acceptable in color. There were no differences between PVC and high-oxygen packages for arm-bone visual color scores. No comparisons were made between visual color of bones packaged in PVC or high-oxygen MAP with visual color of bones packaged in ultra-low-oxygen MAP because

different color scales were used for the packaging methods.

Visual scores for rib-bone marrow increased (more gray) ($P<0.05$) with increased display time in all packaging types. In samples packaged in PVC or high-oxygen MAP, the ribs were 'grayish-pink or -red' by day 1 of display and were 'moderately gray' from day 2 to 4. Ribs packaged in ultra-low-oxygen MAP were only 'slightly grayish purple or pink' by the end of display.

Shoulder-blade bone marrow became darker ($P<0.05$) with increased display time in all three packaging types. Visual color scores for bones packaged in PVC or high-oxygen MAP were 'grayish-pink or -red' beginning on day 1 of display, whereas those in ultra-low-oxygen MAP were only 'slightly grayish-pink or -red'. Visual color scores were lower for bones packaged in PVC than for those packaged in high-oxygen MAP at all days except day 0 and 4.

Visual color scores showed that bone marrow from thoracic vertebrae turned dark ($P<0.05$) by day 1 of display and continued to become darker through day 4 of display. In samples packaged in PVC or high-oxygen MAP, visual scores were already 'moderately gray' by day 1, whereas thoracic vertebra packaged in ultra-low-oxygen MAP were only 'slightly grayish-pink or -red'. Package differences ($P<0.05$) were only found between PVC and high-oxygen MAP on day 0.

In PVC or high-oxygen MAP packaging, arm-bone marrow did not discolor and had visual color scores much more desirable than those of the other bones (approximately a 3-point advantage on a 7-point scale from day 1 through 4 of display). Ribs, shoulder blades, and thoracic vertebrae packaged in PVC or high-oxygen MAP had undesirable discoloration, with a significant proportion described as 'black bone.' In ultra-low-oxygen MAP packaging, mean visual color scores were acceptable throughout display. In addition, arm bones and ribs had better scores (less gray or black) ($P<0.05$) than did shoulder blades and thoracic vertebrae.

Instrumental Color. In general, a* values decreased more (less red) for ribs, shoulder blades, and thoracic vertebrae in PVC or high-oxygen MAP packaging than in ultra-low-oxygen MAP packaging (Table 2). Instrumental a* readings show results similar to those observed by panelists in the visual color scores for bones packaged in PVC or high-oxygen MAP. Changes in color were minor between day 2 and day 4 for bones packaged in ultra-low-oxygen MAP.

Arm bones had smaller a* (less red) values than did the other bones. The a* values for ribs, shoulder blades, and thoracic vertebrae decreased over time, which corresponded to increased visual color scores (more discoloration). In addition, a* value changes from bones packaged in ultra-low-oxygen MAP were smaller, matching much smaller changes in visual color score.

Differences in a* between bones packaged in either PVC or high-oxygen MAP packaging and in ultra-low-oxygen MAP packaging at day 2 and 4 in all bone types would be expected because of the presence or lack of oxygen in the packages, respectively. Initial instrumental color was measured before packaging; therefore, we would expect values at day 0 to be similar, but values at day 2 and 4 to be different, among the different packages.

Bone Marrow Analyses. 2-Thiobarbituric acid reactive substances (TBARS) for bones in different package types during display are shown in Table 3. Oxidation was considerably less for arm-bone marrow than for marrow from ribs and thoracic vertebrae and, for the arm bone, did not change over display time. Ultra-low-oxygen MAP packaging resulted in the least change in TBARS from day 0 to 4.

Marrow from ribs and thoracic vertebrae had dramatically more ($P<0.05$) total iron and hemoglobin than did arm-bone marrow (Table 4). Arm-bone and rib marrow had more ($P<0.05$) phosphorus than did marrow from thoracic vertebrae; rib marrow had more ($P<0.05$) myoglobin than did marrow from thoracic vertebrae (Table 4). Myoglobin was undetectable in arm-bone marrow. The much greater total iron and hemoglobin in ribs and thoracic vertebrae likely corresponds to bone marrow discoloration.

Overall, the ribs, shoulder blades, and thoracic vertebrae turned dark ('grayish-black') in PVC or high-oxygen MAP packaging during 4 days of display. These bones turned dark within 24 hours. Preliminary research within our laboratory showed that this happened between approximately 5 and 24 hours after packaging (data not shown). In contrast, arm bones remained acceptable in color throughout 4 days of display. One possible explanation for arm bones maintaining an acceptable color while ribs, shoulder blades, and thoracic vertebrae darkened over storage time is the difference in bone marrow composition. There are two types of marrow; red and yellow. Red marrow is described as the hemopoietically active marrow that is present in vertebrae and ribs. Yellow marrow is adipose tissue in bone marrow and is found in the distal portion of long bones. Thus, arm-bone marrow contains much more yellow marrow and lacks the abundance of red marrow and hemoglobin found in ribs and vertebrae that show more extreme discoloration. If the major component of arm-bone marrow is lipid, and lipid oxidation shows an increase in TBARS values, then the extremely small TBARS values found in arm-bone marrow in our study indicate that lipid oxidation is not a primary cause of marrow discoloration.

Some change in color occurs in bones packaged in ultra-low-oxygen MAP; overall, however, these bones remain acceptable in color and will bloom to a reddish color when exposed to oxygen. The lack of oxygen in the ultra-low-oxygen MAP may inhibit or greatly slow oxidation in ribs, shoulder blades, and vertebrae. When packaged in PVC or high-oxygen MAP, ribs, shoulder blades, and thoracic vertebrae discolor. The TBARS results suggest that less oxidation of hemoglobin and(or) myoglobin in marrow from thoracic vertebrae occurs in ultra-low-oxygen MAP packaging, compared with that in PVC or high-oxygen MAP packaging.

Bone marrow discoloration occurred in ribs, shoulder blades, and thoracic vertebrae packaged in PVC or high-oxygen MAP. Bones packaged in ultra-low-oxygen MAP, or arm bones packaged in PVC or high-oxygen MAP, had minimal discoloration. It seems likely that bone discoloration is caused primarily by oxidation of hemoglobin, but heme-catalyzed lipid oxidation, or a combination of the two, could play roles.

Table 1. Visual Color Scores[ab] for Bones in Different Package Types from Day 0 to 4 of Display at 35.6°F

Bone	Package[c]	Day 0	1	2	3	4
Arm	PVC	1.5^{v}	2.0^{w}	2.2^{x}	2.3^{y}	2.6^{z}
Arm	High	1.4^{w}	1.8^{x}	2.1^{y}	2.2^{y}	2.5^{z}
Arm	Ultra-low	1.8^{w}	2.5^{x}	2.9^{y}	2.8^{y}	3.0^{z}
Ribs	PVC	1.7^{ev}	4.6^{dw}	5.0^{dx}	5.2^{dy}	5.3^{dz}
Ribs	High	1.4^{dw}	4.6^{dx}	5.1^{dy}	5.2^{dy}	5.3^{dz}
Ribs	Ultra-low	2.1^{w}	2.5^{x}	2.8^{y}	3.0^{z}	3.1^{z}
Shoulder blade	PVC	2.1^{ev}	4.2^{dw}	4.9^{dx}	5.1^{dy}	5.5^{dz}
Shoulder blade	High	1.8^{dv}	4.6^{ew}	5.2^{ex}	5.4^{ey}	5.6^{dz}
Shoulder blade	Ultra-low	2.3^{v}	3.1^{w}	3.4^{x}	3.6^{y}	3.7^{z}
Thoracic vertebra	PVC	2.2^{ew}	5.3^{dx}	5.8^{dy}	5.8^{dy}	6.1^{dz}
Thoracic vertebra	High	1.6^{dw}	5.2^{dx}	5.6^{dy}	5.8^{dyz}	5.9^{dz}
Thoracic vertebra	Ultra-low	2.7^{w}	3.1^{x}	3.3^{y}	3.4^{yz}	3.5^{z}

[a]Standard error for all means = 0.14.

[b]High-oxygen and PVC color scale: 1=bright reddish-pink to red, 2=dull pinkish-red, 3=slightly grayish-pink or grayish red, 4=grayish-pink or grayish red, 5=moderately gray, 6=all gray or grayish-black, and 7=black discoloration; Ultra-low-oxygen color scale: 1=bright purplish-red or purplish-pink, 2=dull purplish-pink or purplish-red, 3=slightly grayish purple or pink, 4=grayish-purple or grayish-red, 5=moderately gray, 6=all gray or grayish-black, 7=black discoloration.

[c]PVC = polyvinyl chloride overwrap film; High = high-oxygen modified-atmosphere packaging; and Ultra-low = ultra-low-oxygen modified-atmosphere packaging.

[d,e]Means with different superscript letters within bone type and within columns (PVC vs. High) differ ($P<0.05$).

[v,w,x,y,z]Means with different superscript letters across rows (days) differ ($P<0.05$).

Table 2. Instrumental CIE a* Values for Bones in Different Package Types from Day 0, 2, and 4 of Display at 35.6°F

Bone	Package[a]	Day		
		0	2	4
Arm	PVC	14.0^{z}	15.2^{cz}	15.2^{cz}
Arm	High	13.7^{y}	15.0^{cyz}	15.1^{cz}
Arm	Ultra-low	13.6^{z}	11.3^{by}	10.2^{by}
Ribs	PVC	26.6^{z}	18.1^{by}	16.7^{by}
Ribs	High	25.7^{z}	19.4^{by}	17.3^{bx}
Ribs	Ultra-low	25.7^{z}	22.8^{cy}	21.2^{cy}
Shoulder blade	PVC	25.1^{z}	18.6^{by}	16.3^{bx}
Shoulder blade	High	24.0^{z}	20.2^{by}	15.6^{bx}
Shoulder blade	Ultra-low	24.6^{z}	23.9^{cz}	24.0^{cz}
Thoracic vertebra	PVC	26.6^{z}	16.5^{by}	14.4^{bx}
Thoracic vertebra	High	25.7^{z}	18.7^{by}	14.3^{bx}
Thoracic vertebra	Ultra-low	26.2^{z}	22.6^{cy}	22.7^{cy}
SEM	--	0.52	0.85	0.62

[a]PVC = polyvinyl chloride overwrap film; High = high-oxygen modified-atmosphere packaging; and Ultra-low = ultra-low-oxygen modified-atmosphere packaging.
[b,c]Means with different superscript letters within bone type and within columns differ P<0.05).
[x,y,z]Means with different superscript letters across rows (days) differ (P<0.05).

Table 3. 2-Thiobarbituric Reactive Substances[a] for Bones in Different Package Types from Day 0 and 4 of Display at 35.6°F

Bone	Package[b]	Day		SEM
		0	4	
Arm	PVC	0.03^{z}	0.06^{z}	0.02
Arm	High	0.03^{z}	0.06^{z}	
Arm	Ultra-low	0.03^{z}	0.04^{z}	
Ribs	PVC	0.74^{z}	0.77^{dz}	0.03
Ribs	High	0.74^{y}	0.84^{dz}	
Ribs	Ultra-low	0.74^{y}	0.65^{cz}	
Thoracic vertebra	PVC	0.67^{y}	1.04^{dz}	0.03
Thoracic vertebra	High	0.67^{y}	1.01^{dz}	
Thoracic vertebra	Ultra-low	0.67^{y}	0.75^{cz}	

[a]mg malonaldehyde/ kg sample.
[b]PVC = polyvinyl chloride overwrap film; High = high-oxygen modified-atmosphere packaging; and Ultra-low = ultra-low-oxygen modified-atmosphere packaging.
[c,d]Means with different superscript letters within bone types and within columns differ ($P<0.05$).
[y,z]Means with different superscript letters across rows (days) differ ($P<0.05$).

Table 4. Total Iron, Phosphorus, Hemoglobin, and Myoglobin for Bone Marrow from Arm Bones, Ribs, and Thoracic Vertebrae

Bone	Total Iron (ppm)	Phosphorus (ppm)	Hemoglobin (mg/g)	Myoglobin (mg/g)
Arm	8.1^{x} (±0.54 [a])	868^{z} (±93)	4.5^{y} (±0.45)	ND[b]
Ribs	237^{z} (±11)	847^{z} (±44)	160^{z} (±13)	0.530^{z} (±0.05)
Thoracic Vertebra	219^{y} (±8.9)	574^{y} (±42)	153^{z} (±6.4)	0.313^{y} (±0.02)

[a]Standard error of the mean.
[b]Not detectable.
[x,y,z]Means with different superscript letters within columns differ ($P<0.05$).

EFFECTS OF ANTIOXIDANTS ON BONE MARROW DISCOLORATION IN BEEF LUMBAR VERTEBRAE IN DIFFERENT PACKAGING SYSTEMS

J. P. Grobbel, M. E. Dikeman, E. J. Yancey, J. S. Smith, D. H. Kropf, and G. A. Milliken

Summary

To evaluate how antioxidants might prevent bone marrow discoloration, beef lumbar vertebrae held at 35.6°F for 6 or 14 days postmortem before packaging were cut into 1-inch-thick sections and packaged into 1) PVC overwrap; 2) high-oxygen (80% O_2, 20% CO_2) modified atmosphere packages (MAP); or 3) ultra-low-oxygen (70% N_2, 30% CO_2) MAP. Before packaging, bones were treated with: no treatment application (control); 1.25% or 2.5% ascorbic acid; 0.1% or 0.2% rosemary; or a combination treatment of 0.15% Origanox™ + 0.3% ascorbic acid. Packages were displayed under continuous fluorescent lighting for 4 days at 35.6°F. Untreated lumbar vertebrae and those treated with 0.1 or 0.2% rosemary discolored to gray or grayish-black, as measured by visual color scores and instrumental a* values, in PVC and high-oxygen MAP. The 1.25% ascorbic acid and 0.15% Origanox™ + 0.3% ascorbic acid were able to maintain desirable color scores through day 2 of display in PVC and high-oxygen MAP, but not after 4 days. The 2.5% ascorbic acid treatment was most effective in preventing discoloration and maintaining initial color in both PVC and high-oxygen MAP. In ultra-low-oxygen MAP, the 1.25% ascorbic acid treatment was as effective as the 2.5% ascorbic acid treatment in preventing bone marrow discoloration. In general, discoloration tended to be greater in bones held 14 days postmortem before packaging than in those held 6 days. Ascorbic acid treatments, particularly the 2.5% application, were effective in preventing bone marrow discoloration.

Introduction

Bone marrow discoloration, and its occurrence in modified atmosphere packaged (MAP) bone-in beef retail cuts, has been observed by industry personnel, especially meat retailers. Consumers may perceive bone discoloration as unwholesome, and it might affect their acceptance of a fresh meat product. Bone marrow discoloration has been reported in high-oxygen MAP beef and pork and also in cuts packaged in polyvinyl chloride film (PVC).

Some researchers have found that supplementing pigs with vitamin E (198 and 207 ppm) for 105 days increased a* (redness) values of lumbar vertebrae over non-supplemented pigs in a 5-day display. Other published literature found that treating beef lumbar vertebrae with 1.5 or 2.5% ascorbic acid was effective in minimizing lumbar vertebrae discoloration, with the 2.5% ascorbic acid treatment being the most effective through a 5-day display.

Ascorbic acid (vitamin C) is a generally recognized as safe (GRAS) substance and can be applied at no more than 500 ppm to delay discoloration. Several studies have indicated that ascorbic acid can extend beef color stability. Rosemary in powder, extract, or oleoresin form has also been shown to improve beef color stability and inhibit oxidation. The Food and Drug Administration has given rosemary GRAS status as well.

The objectives of this experiment were to evaluate the effects of applying antioxidant

treatments in preventing bone marrow discoloration from occurring in beef lumbar vertebrae.

Procedures

Seventy-two beef lumbar vertebrae from USDA Select and Choice carcasses obtained from a commercial abattoir were held at 35.6°F for either 6 or 14 days postmortem. Lumbar vertebrae were cut into 1-inch-thick sections and packaged into one of three packages: 1) polyvinyl chloride film (PVC) overwrap; 2) high-oxygen (80% O_2, 20% CO_2) modified atmosphere package (MAP); and 3) ultra-low-oxygen (70% N_2, 30% CO_2) MAP. Before packaging, bone sections were treated with one of the following antioxidant treatments: control with no treatment application; 1.25% or 2.5% ascorbic acid; 0.1% or 0.2% rosemary extract; or a combination treatment of 0.15% Origanox™ WS and 0.3% ascorbic acid. Origanox™, a natural antioxidant that is extracted from edible herbs, is easily dissolved in water. An aliquot of the given antioxidant solution was pipetted onto the marrow cut surface of individual bones. In each package, there was one vertebra section for each of the antioxidant treatments and a control. The PVC samples were packaged in foam trays overwrapped with oxygen-permeable film. Bones assigned to high-oxygen and ultra-low-oxygen MAP packages were packaged in rigid plastic trays and covered with barrier lidding film. Each ultra-low-oxygen MAP had one activated oxygen scavenger added to the package. Within each individual package, lumbar vertebrae sections were from the same animal.

Packages were displayed under continuous fluorescent lighting for 4 days at 35.6°F. Packages were rotated twice daily to maintain a random sample placement.

Instrumental CIE a* measurements were collected by using a Hunter labscan 2. CIE a* measures red (+) to green (-). Immediately after opening packages, bone sections were scanned. Instrumental color scores were taken on day 0, 2, and 4 of display.

Ten trained panelists scored the porous portion of bone marrow for visual color once each day for 5 days, beginning on day 0. High-oxygen MAP and PVC packages were scored according to a seven-point scale: 1) bright reddish-pink to red, 2) dull pinkish-red, 3) slightly grayish-pink or grayish-red, 4) grayish-pink or grayish-red, 5) moderately gray, 6) all gray or grayish-black, and 7) black discoloration. Ultra-low-oxygen MAP bones were scored according to a different seven-point scale: 1) bright purplish-red or purplish-pink, 2) dull purplish-pink or purplish-red, 3) slightly grayish-purple or pink, 4) grayish-purple or grayish-red, 5) moderately gray, 6) all gray or grayish-black, and 7) black discoloration.

Lumbar vertebrae marrow was extracted and analyzed for 2-thiobarbituric acid reactive substances (TBARS), a measure of oxidation.

Results and Discussion

The effects of antioxidant treatments on lumbar vertebrae packaged in PVC are shown in Table 1. For lumbar vertebrae held for 6 days postmortem before being cut and displayed, the control and both rosemary treatments were distinctly gray by day 1 and stayed gray or grayish-black throughout display in PVC packages. Vertebrae treated with 1.25% ascorbic acid turned ‘slightly grayish-pink or -red’ on day 3 of display, and those treated with 2.5% ascorbic acid turned only ‘slightly grayish-pink or -red’ by the last day of display in PVC packages. Vertebrae treated with the combination of 0.15% Origanox™ + 0.3% ascorbic acid did not turn ‘grayish-pink or -red’ until day 2 of display in PVC packages, but were ‘moderately gray’ at the end of display. Visual color differences between lumbar vertebrae held 6 vs. 14 days and packaged in PVC suggest that bones held for

longer times before packaging for display tended to discolor a little faster.

Treatment comparisons within high-oxygen MAP are presented in Table 2. When vertebrae were held 6 days postmortem before cutting and packaging, the control and both rosemary treatments were 'grayish-pink or -red' or 'moderately gray' by day 1 and stayed 'moderately gray' or 'grayish-black' throughout display in high-oxygen MAP. Vertebrae remained 'reddish-pink' throughout the 4-day display when treated with 1.25 or 2.5% ascorbic acid. Vertebrae treated with the combination of 0.15% Origanox™ + 0.3% ascorbic acid did not turn 'grayish-pink or -red' until day 2 of display when packaged in high-oxygen MAP. Lumbar vertebrae packaged in high-oxygen MAP held 14 days postmortem showed similar results to those held 6 days postmortem.

Table 3 lists treatment comparisons for lumbar vertebrae held 6 or 14 days in ultra-low-oxygen MAP. Lumbar vertebrae held 6 days and packaged in ultra-low-oxygen MAP remained 'purplish-red or -pink' for all treatments except control, 0.2% rosemary, and the combination of 0.15% Origanox™ + 0.3% ascorbic acid on day 4, when the latter became 'slightly grayish-purple or pink.' Lumbar vertebrae held 14 days and packaged in ultra-low-oxygen MAP were either a 'dull purplish-pink or -red' or 'slightly grayish-purple or pink' throughout the 4-day display. Visual color differences between lumbar vertebrae held 6 and 14 days packaged in ultra-low-oxygen MAP generally indicated that bones held 14 days discolored more than bones held 6 days postmortem. Although antioxidant treatments are not needed as much in ultra-low-oxygen MAP, the 1.25% ascorbic acid treatment was as effective as the 2.5% ascorbic acid treatment.

Control lumbar vertebrae darkened dramatically in PVC and high-oxygen MAP; discoloration in ultra-low-oxygen MAP was much less extensive. In general, 0.1 and 0.2% rosemary treatments were not effective in preventing discoloration in PVC and high-oxygen MAP. The 2.5% ascorbic acid treatment was most effective in preventing discoloration and maintaining initial color in both PVC and high-oxygen MAP. The 1.25% ascorbic acid and the combination of 0.15% Origanox™ + 0.3% ascorbic acid were able to maintain desirable color scores through day 2 of display in PVC and high-oxygen MAP but not through day 4 of display.

Other research indicates that ascorbic acid does not have any effect on the color of the ribeye muscle. This is important because the positive effects of ascorbic acid application to bone to prevent discoloration should not cause negative effects on the muscle color.

Overall, mean a* values for lumbar vertebrae held 6 and 14 days and packaged in PVC, high-oxygen MAP, and ultra-low-oxygen MAP corresponded to visual color score trends (data not shown). Lumbar vertebra treated with ascorbic acid had higher or no change in a* values over display time.

Lumbar vertebrae held 6 days and packaged in PVC had smaller TBARS values for most treatments on day 2 and(or) day 4 than did those held 14 days (data not shown). The ascorbic acid treatments (1.25%, 2.5%, and combination) generally were effective in minimizing changes in TBARS during display. The rosemary treatments and control resulted in distinct increases in TBARS when vertebrae were held 14 days before display. For all treatments and days, including the initial samples on day 0, lumbar vertebrae held 6 days and packaged in high-oxygen MAP had smaller TBARS values than did those held 14 days (data not shown). In all three packaging systems, bones held 14 days postmortem had larger TBARS values than did those held 6 days. Overall, ascorbic acid treatments were most effective in minimizing TBARS changes throughout display.

Although lipid and pigment oxidation are closely related, it is not completely understood exactly how they relate to each other. It is suggested that lipid oxidation produces a radical that, in turn, acts directly to encourage pigment oxidation and/or causes the pigment-reducing systems to be indirectly damaged.

Bone darkening may be due to an oxidation reaction or a combination of oxidation reactions. When bones become discolored, this could be through oxidation of the hemoglobin and myoglobin present in bone marrow. Ascorbic acid can reduce methemoglobin in both aerobic and anaerobic solutions. Also, the heme proteins present could catalyze lipid oxidation reactions. Vertebrae bone marrow has a lot of iron and hemoglobin present and seems to discolor more quickly and severely than other bones. The presence of more polar lipid and cell membranes in such bone marrow may also provide a better environment for lipid oxidation to take place, especially with iron present. Previous research in our laboratory indicated that TBARS values in arm bones did not increase throughout display. Because arm bone marrow is mostly yellow (adipose) marrow, this suggests that lipid oxidation is not the primary form of oxidation taking place to cause bone marrow discoloration. One possibility is that bone marrow discoloration could be caused by lipid oxidation that is catalyzed by iron. As a consequence, bone marrow discoloration may be caused by a combination of oxidation reactions.

In summary, untreated lumbar vertebrae discolored when packaged in PVC and high-oxygen MAP. Rosemary treatments were not effective in preventing bone discoloration in lumbar vertebrae packaged in PVC and high-oxygen MAP. Ascorbic acid treatments, particularly the 2.5% application, were very effective in preventing bone marrow discoloration, and were superior to other treatments of our study.

Table 1. Visual Color Score[ab] for Different Antioxidant Treatments of Lumbar Vertebrae Packaged at 6 or 14 Days Postmortem in Polyvinyl Chloride Overwrap from Day 0 to 4 of Display at 35.6°F

		Display Day				
Antioxidant Treatment	Days Postmortem	0	1	2	3	4
Control	6	2.3^{ev}	5.1^{ewx}	5.3^{fx}	5.7^{fy}	5.9^{ez}
1.25% Ascorbic acid	6	1.5^{cdv}	2.0^{cdw}	2.5^{dx}	3.7^{dy}	4.6^{dz}
2.5% Ascorbic acid	6	1.5^{cdw}	1.7^{cwx}	2.0^{cx}	2.7^{cy}	3.1^{cz}
0.1% Rosemary	6	2.0^{ew}	4.9^{ex}	5.2^{fy}	5.4^{fyz}	5.8^{ez}
0.2% Rosemary	6	1.9^{dex}	5.0^{ey}	5.1^{fy}	5.5^{fz}	5.8^{ez}
0.15% Origanox™ + 0.3% Ascorbic acid	6	1.3^{cv}	2.3^{dw}	3.8^{ex}	4.7^{ey}	5.1^{dz}
Control	14	3.5^{ew}	5.1^{fx}	5.4^{gy}	5.7^{eyz}	5.9^{fz}
1.25% Ascorbic acid	14	1.7^{cdv}	2.2^{dw}	3.3^{dx}	4.2^{dy}	4.9^{dz}
2.5% Ascorbic acid	14	1.8^{cdw}	2.1^{cwx}	2.3^{cx}	3.1^{cy}	3.9^{cz}
0.1% Rosemary	14	3.2^{ew}	4.8^{efy}	5.3^{fgz}	5.4^{ez}	5.4^{efz}
0.2% Rosemary	14	3.0^{dew}	4.5^{ex}	4.9^{fy}	5.3^{ey}	5.7^{fz}
0.15% Origanox™ + 0.3% Ascorbic acid	14	1.4^{cv}	2.8^{dw}	4.0^{ex}	4.6^{dy}	5.1^{dez}

[a]Standard error for all means = 0.20.

[b]1=bright reddish-pink to red, 2=dull pinkish-red, 3=slightly grayish-pink or grayish-red, 4=grayish-pink or grayish-red, 5=moderately gray, 6=all gray or grayish-black, and 7=black discoloration.

[c,d,e,f,g]Means with different superscript letters within columns within postmortem age differ ($P<0.05$).

[v,w,x,y,z]Means with different superscript letters across rows differ ($P<0.05$).

Table 2. Visual Color Scores[ab] for Different Antioxidant Treatments of Lumbar Vertebrae Packaged at 6 or 14 Days Postmortem in High-oxygen Modified Atmosphere Packaging from Day 0 to 4 of Display at 35.6°F

Antioxidant Treatment	Days Postmortem	Display Day 0	1	2	3	4
Control	6	1.4^{cx}	5.1^{ey}	5.5^{fz}	5.6^{ez}	5.8^{ez}
1.25% Ascorbic acid	6	1.3^{cw}	1.5^{cwx}	1.8^{cxy}	1.8^{cyz}	2.2^{cz}
2.5% Ascorbic acid	6	1.4^{cx}	1.5^{cxy}	1.8^{cxyz}	1.8^{cyz}	2.0^{cz}
0.1% Rosemary	6	1.4^{cx}	4.6^{dey}	5.2^{efz}	5.2^{ez}	5.5^{ez}
0.2% Rosemary	6	1.4^{cw}	4.5^{dx}	5.0^{ey}	5.3^{eyz}	5.5^{ez}
0.15% Origanox™ + 0.3% Ascorbic acid	6	1.4^{cv}	1.9^{cw}	3.1^{dx}	3.6^{dy}	4.1^{dz}
Control	14	2.4^{ew}	4.4^{dx}	5.0^{ey}	5.5^{ez}	5.8^{ez}
1.25% Ascorbic acid	14	1.9^{cdx}	1.9^{cx}	2.0^{cxy}	2.4^{cyz}	2.6^{cz}
2.5% Ascorbic acid	14	1.7^{cx}	1.8^{cxy}	2.0^{cxy}	2.1^{cyz}	2.4^{cz}
0.1% Rosemary	14	2.4^{dew}	4.6^{dx}	5.1^{ey}	5.4^{eyz}	5.6^{ez}
0.2% Rosemary	14	2.3^{dew}	4.8^{dx}	5.4^{ey}	5.6^{eyz}	5.8^{ez}
0.15% Origanox™ + 0.3% Ascorbic acid	14	1.8^{cw}	1.9^{cw}	2.6^{dx}	3.2^{dy}	3.7^{dz}

[a]Standard error for all means = 0.20.

[b]1=bright reddish-pink to red, 2=dull pinkish-red, 3=slightly grayish-pink or grayish-red, 4=grayish-pink or grayish-red, 5=moderately gray, 6=all gray or grayish-black, and 7=black discoloration.

[c,d,e,f]Means with different superscript letters within columns within postmortem age differ ($P<0.05$).

[v,w,x,y,z]Means with different superscript letters across rows differ ($P<0.05$).

Table 3. Visual Color Score[ab] for Different Antioxidant Treatments of Lumbar Vertebrae Packaged at 6 or 14 Days Postmortem in Ultra-low-oxygen Modified Atmosphere Packaging from Day 0 to 4 of Display at 35.6°F

Antioxidant Treatment	Days Postmortem	Display Day 0	1	2	3	4
Control	6	2.2^{cw}	2.5^{cwx}	2.6^{cxy}	2.9^{cyz}	3.2^{cz}
1.25% Ascorbic acid	6	2.1^{cx}	2.4^{cxy}	2.5^{cyz}	2.7^{cyz}	2.9^{cz}
2.5% Ascorbic acid	6	2.1^{cx}	2.3^{cxy}	2.4^{cxy}	2.7^{cyz}	2.9^{cz}
0.1% Rosemary	6	2.1^{cx}	2.5^{cy}	2.6^{cyz}	2.7^{cyz}	2.9^{cz}
0.2% Rosemary	6	2.1^{cw}	2.4^{cwx}	2.4^{cxy}	2.8^{cyz}	3.0^{cz}
0.15% Origanox™ + 0.3% Ascorbic acid	6	2.0^{cw}	2.2^{cwx}	2.5^{cxy}	2.7^{cy}	3.0^{cz}
Control	14	2.7^{dy}	3.7^{dz}	3.7^{ez}	3.6^{ez}	3.6^{dz}
1.25% Ascorbic acid	14	2.1^{cx}	2.3^{cxy}	2.5^{cy}	3.0^{cdz}	2.9^{cz}
2.5% Ascorbic acid	14	2.1^{cx}	2.4^{cxy}	2.5^{cy}	2.7^{cyz}	2.9^{cz}
0.1% Rosemary	14	2.6^{dy}	3.5^{dz}	3.5^{dez}	3.5^{ez}	3.4^{dz}
0.2% Rosemary	14	2.8^{dy}	3.5^{dz}	3.5^{dez}	3.7^{ez}	3.5^{dz}
0.15% Origanox™ + 0.3% Ascorbic acid	14	2.3^{cdx}	2.5^{cx}	3.1^{dy}	3.4^{dez}	3.5^{dz}

[a]Standard error for all means = 0.20.

[b]1=bright purplish-red or purplish-pink, 2=dull purplish-pink or purplish-red, 3=slightly grayish-purple or pink, 4=grayish-purple or grayish-red, 5=moderately gray, 6=all gray or grayish-black, 7=black discoloration.

[c,d,e]Means with different superscript letters within columns within postmortem age differ ($P<0.05$).

[w,x,y,z]Means with different superscript letters across rows differ ($P<0.05$).

SURVEY OF COOKING PRACTICES AND METHODS FOR BEEF STEAKS AND ROASTS

L. J. Franken, E. J. Harvey, J. L. Marsden, R. K. Phebus, and C. Pearsall

Summary

To support the development of Good Manufacturing Practices for the use of mechanical tenderization in the meat processing industry, a questionnaire was distributed to home, retail, and institutional preparers of beef steaks and roasts. Five hundred individuals in the United States were surveyed on their cooking practices and methods for preparing steaks and roasts. The survey was circulated to individuals from seven states, and consisted of nine questions that addressed where and how participants cooked steaks and roasts. Survey participants were directed to answer all questions that pertained to them and their methods for cooking of steaks and roasts. Results indicated that most participants used color as an indicator of doneness of steaks, whereas cooking time was most often used to indicate doneness of roasts. None of those who were surveyed knew the recommended minimum internal temperature (145°F) for cooking steaks or roasts.

Introduction

Mechanical tenderization is widely used by meat processors to improve tenderness and consistency of the beef products. Blade tenderization, a widely used form of mechanical tenderization in the beef industry, works by passing small, thin blades vertically through subprimal cuts to sever connective tissue and muscle fiber. Steaks and roasts fabricated from blade-tenderized beef subprimals typically are not visually distinguishable from non-tenderized counterparts by consumers.

Microbial contamination, including that from pathogenic bacteria, of steaks or roasts can occur during slaughter and processing, even when good sanitation practices are followed. Proper cooking of beef steaks and roasts is an important step in food safety. Consumers tend to prepare steaks over a wide range of doneness values (rare to well done). Steaks and roasts prepared from intact raw beef products pose very low risk because surface bacterial contamination is easily destroyed by direct contact with heat. Consumer products prepared from mechanically tenderized subprimals potentially can contain low rates of microbial contamination internalized within the muscle. According to the Food and Drug Administration 2001 Food Code, steaks and roasts should be cooked to a minimum internal temperature of 145°F and held for a minimum of 15 seconds to ensure that bacteria throughout the entire muscle cannot survive.

Procedures

A questionnaire was distributed to 500 individuals through personal contact, email, and telephone. The questionnaire consisted of the following nine questions:

1. Where do you cook steaks and/or roasts (check all that apply)? (Home, Hotel/Restaurant, Institution/Hospital School)

2. How do you determine doneness? (Check temperature using a thermometer, Use meat color as an indicator, Use cooking time as an indicator)

If yes to using a thermometer, do you know what minimum internal temperature to cook your steak or roast? (Yes, No)
If yes, what temperature?

3. What level of doneness do you prefer or typically prepare (Check all that apply)? (Rare, Medium Rare, Medium, Medium Well, Well)

4. What is the most common thickness of steaks you prepare (check all that apply)? (½ inch or smaller, ¾ inch, 1 inch, 1 ¼ inch, 1 ½ inch or larger)

5. Are your steaks usually frozen and thawed prior to cooking? (Yes, No, Do Not Freeze Steaks)

6. What method do you use to cook your steaks (Check all that apply)? (Home Grill, Pan Fry, Commercial Grill, Oven Broil)

7. Do you tenderize your steaks before cooking? (Yes All Cuts, Yes Some Cuts, No Cuts – Go to question 9)

8. What do you use to tenderize your steaks? (Chemical Meat Tenderizer – i.e. Papain, Mechanical Meat Tenderizer – i.e. Mallet)

9. Do you marinate your steaks before cooking? (Always, Sometimes, Never)

Results and Discussion

The 500 participants in the survey resided in seven different states (Arizona, California, Florida, Kansas, Missouri, Nevada, and New York). Of these 500 individuals, 495 (99%) stated they cooked steaks and roasts at home, 20 (4%) cooked at a hotel or restaurant, and 5 (1%) cooked at an institution/hospital/school.

When determining doneness of cooked steaks, 406 participants (81%) indicated that they used color, whereas 173 (35%) selected cooking time, and 61 (12%) selected thermometers. Doneness of roasts was determined by cooking time for 285 participants (57%), with 181 (36%) using meat color and 128 (26%) using thermometers. Of those using a thermometer, 69 (37%) stated that they knew the minimal internal temperature to cook a steak or roast, whereas 32 (6%) marked that they did not know the correct temperature. No one listed 145°F as the proper minimal internal temperature, but 48 (70%) out of the 69 selected a temperature greater than 145°F. The range for minimum internal cooking temperature was 120°F to 170°F.

The most common doneness of steaks preferred by participants was medium-well, with 173 (35%) responses, followed by medium with 169 (34%), medium-rare with 135 (27%), well with 66 (13%), and rare with 23 (5%) responses. Preference for doneness of roasts had 173 responses (35%) for medium-well, 152 (30%) for well, 131 (26%) for medium, 58 (12%) for medium rare, and 13 (3%) for rare.

Steaks with thickness of ¾ inch were most commonly prepared by participants, with 233 responses (47%), followed by 1-inch steaks with 215 (43%), ½-inch steaks with 105 (21%), 1-¼ inch steaks with 50 responses (10%), and 1-½ inch or larger steaks with 24 (5%).

Most participants stated that they usually thawed their steaks before cooking (455 or 96% of responses); only 21 (4%) stated they did not thaw steaks before cooking. Thirty-nine participants (8%) stated they did not freeze steaks. Twenty-four participants (5%) did not respond to this survey question.

The most commonly selected method of cooking steaks was home grilling, with 446 responses (89%). Oven broiling was the second most common method of cooking, with 157 responses (31%). Pan-frying had 114 responses (23%), and commercial grilling had only 37 responses (7%).

The majority (279 or 56% of responses) of those surveyed did tenderize steaks before cooking. Of those who tenderize, 220 (44%) tenderize some cuts, whereas 59 (12%) said they tenderized all cuts. Two hundred twenty-one of the participants who responded (44%) did not tenderize any steaks.

The method of tenderizing used most frequently by those surveyed was chemical, with 144 responses (52%). Mechanical tenderizing had 138 responses (49%), and 28 (10%) responded that they use other types of tenderizing. Other methods of tenderizing included marinade (6), seasoning and spices (5), Italian salad dressing (1), fork (1), butcher (1), cutter (1), jacard (1), and hammer (1).

Most of those surveyed marinate their steaks before cooking, with 409 of 495 responses (83%). Of those who marinate, 311 (63%) responded that they marinated sometimes, and 98 (20%) responded that they always marinate. Eighty-six (17%) responded that they never marinate steaks.

In establishing good manufacturing practices for mechanical tenderizing of beef products, various cooking practices for beef steaks and roasts need to be considered. Survey results indicted that most participants used color as an indicator of doneness of steaks, whereas cooking time was mostly used for roasts. None of those who were surveyed knew the recommended minimum internal temperature for cooking steaks or roasts. This survey indicated that a wide variety of consumer preparation practices are used for beef steaks and roasts, particularly related to monitoring of the cooking process and the use of different tenderization/marination practices. It is important, if not essential, that the meat industry and other professional groups provide scientifically valid consumer guidance information to ensure safety of these products.

EFFECTS OF CETYLPYRIDINIUM CHLORIDE TREATMENT OF ROAST BEEF ON *LISTERIA MONOCYTOGENES* POPULATIONS AND QUALITY ATTRIBUTES

M. Singh, H. Thippareddi, R. K. Phebus, J. L. Marsden, T. J. Herald, and A. L. Nutsch

Summary

The effectiveness of cetylpyridinium chloride (CPC) for reducing microbial populations, in particular *Listeria monocytogenes*, on ready-to-eat roast beef was evaluated. Roast beef slices inoculated with *L. monocytogenes* were dipped in a solution of 1% CPC for 1 minute. Samples were then vacuum packaged and stored at refrigeration temperature. The effects of CPC treatment on microbial populations, as well as on color and texture of the roast beef samples, was evaluated over a 42-day period. Immediately after CPC treatment, *L. monocytogenes* populations were reduced by 99 to 99.99%, with the treatment being somewhat more effective on exterior than on sliced/cut surfaces. Throughout 42 days of refrigerated storage, populations of *L. monocytogenes*, total bacteria, and lactic acid bacteria remained lower on CPC-treated samples than on non-treated samples. Treatment with CPC did not significantly affect the color or texture of roast beef. Treatment with CPC, especially when applied to products before slicing, may serve as an effective antimicrobial intervention for ready-to-eat meat products.

Introduction

Listeria monocytogenes is a foodborne pathogen of significant public health concern due to the severity of disease in susceptible individuals. Approximately 1,700 cases of listeriosis are reported annually in the United States, but the source of infection is usually not determined. Ready-to-eat meat products are among the products most commonly associated with foodborne listeriosis. The U.S. Department of Agriculture Food Safety and Inspection Service classifies deli-type products that are sliced at the point of production or at retail, such as cured hams, roast beef or turkey, bologna, luncheon meat, pastrami, and other cold cuts, as high-risk products.

The microbiological safety of ready-to-eat meat products can be enhanced by applying interventions such as organic acids and post-packaging pasteurization technologies. A product known commercially as CECURE™ (Safe Foods Corporation, North Little Rock, Arkansas) is a 40% concentrate of cetylpyridinium chloride (CPC), a quaternary ammonium compound that is the active ingredient in some mouthwashes. CPC has been shown to be effective against foodborne pathogens such as *Escherichia coli* O157:H7, *Salmonella* spp., *Listeria* spp., and *Campylobacter* spp. in a variety of food matrices. This study was designed to examine the effectiveness of CPC for eliminating *L. monocytogenes* contamination on exterior and cut/sliced roast beef surfaces before packaging, and to determine the influence of CPC treatment on quality attributes (color and firmness).

Procedures

Roast beef was cut into slices (6 × 6 × 2 inches), with each slice having a "sliced/cut"

surface and an "exterior" surface (original surface in contact with the casing during cooking operations). Slices were inoculated with *L. monocytogenes* at either a low concentration (approximately 1,000 colony forming units [CFU]/cm^2) or a high concentration (approximately 10,000,000 CFU/ cm^2). Roast beef samples used to evaluate the effect of CPC treatment on color and texture were not inoculated.

Individual slices (both inoculated and non-inoculated) of roast beef were treated by immersing in a 77°F solution of 1% CPC for 1 minute. Slices were then vacuum packaged and stored at either 32°F (in dark conditions) or at 39°F (in a lighted display) for 42 days. Samples were analyzed on days 0, 3, 7, 14, 21, 28, and 42 of storage.

Tissue samples were excised from both the exterior surface and the sliced/cut surface of roast beef slices. Samples were homogenized with 0.1% sterile diluent in a blender for 2 minutes, and serial dilutions were then prepared in sterile diluent. *L. monocytogenes* populations were determined by plating on modified Oxford agar and tryptose phosphate agar with incubation at 95°F for 24 to 48 hours. Non-inoculated roast beef samples were also analyzed for total aerobic plate counts and lactic acid bacteria (naturally occurring bacterial populations).

The color attributes (L* values for lightness; a* values for redness; and b* values for yellowness) of roast beef samples were evaluated with a Hunter Miniscan spectrophotometer. A Stable Micro Systems TA-XT2 texture analyzer was used to determine firmness.

Results and Discussion

Treatment of roast beef slices with CPC resulted in an immediate initial reduction of *L. monocytogenes* populations, with a 99% reduction observed on sliced/cut surfaces, and a 99.99% reduction observed on exterior surfaces. Although CPC treatment did not completely eliminate *L. monocytogenes* from the roast beef samples, remaining populations were significantly lower on CPC-treated samples than on non-treated samples throughout the 42-day storage period.

The total aerobic plate counts of both treated and non-treated roast beef samples gradually increased over storage time, but the populations on CPC-treated samples increased more slowly than on non-treated samples. At the end of the 42-day storage period, populations of non-treated samples were approximately 10,000 CFU/cm^2, whereas populations on CPC-treated samples were approximately 100 CFU/cm^2. Similar trends were observed for lactic acid bacterial populations.

Treatment with CPC did not significantly impact the color or texture of roast beef samples, indicating that the effect of CPC treatment on color and texture would be of no practical importance.

Results from this experiment provide evidence of the ability of CPC to reduce *L. monocytogenes* contamination on ready-to-eat deli products, such as roast beef. Because no detrimental impacts on product quality were observed, the use of CPC as an antimicrobial treatment for ready-to-eat deli products before to slicing warrants further exploration.

ANTIMICROBIAL EFFECTS OF COLLOIDAL SILVER WASHES AGAINST *SALMONELLA* AND *ESCHERICHIA COLI* O157:H7 ON FRESH BEEF

R. R. Coger, L. J. Franken, R. K. Phebus, J. L. Marsden, and T. Herald

Summary

Beef carcasses and fresh fabricated beef products potentially can be contaminated with disease causing microorganisms (pathogens) via animal dressing procedures and contamination from the plant environment or workers. Concentrated efforts have been made by the meat industry to develop and implement a wide array of strategies to control such contamination. Spraying beef flank (*Rectus abdominus*) samples with 32 ppm colloidal silver (ASAP®, American Biotech Labs) solution for 20 seconds reduced *Salmonella* and *Escherichia coli* O157:H7 numbers by greater than 90% after 4 hours. Inoculated samples treated with 22 ppm colloidal silver, 22 ppm colloidal silver plus 1.5% hydrogen peroxide, 10 ppm colloidal silver, or 10 ppm colloidal silver plus potassium persulfate had moderate to slight pathogen reductions compared with those treated with 32 ppm colloidal silver. Although not yet approved for use on foods (but approved for other human health applications), a colloidal silver rinse implemented in conjunction with other antimicrobial intervention technologies during the beef carcass conversion and/or fabrication processes could be an effective strategy against *Salmonella* and *E. coli* O157:H7. Further studies should be conducted on colloidal silver's antimicrobial effectiveness on lean tissues versus adipose tissue, and on sensory and functional effects on fresh meat products during storage.

Introduction

The United States Department of Agriculture (USDA) Pathogen Reduction, Hazard Analysis Critical Control Point (HACCP) system final rule of 1996 mandates that meat- and poultry-processing plants implement and comply with HACCP programs. These programs strive to reduce and/or eliminate the risks associated with meat and poultry products through use of valid process controls and application of antimicrobial technologies during processing. The ruling focuses attention on the prevention and reduction of microbial pathogens on raw products. Many HACCP models call for an antimicrobial rinse to be used after a beef carcass has been eviscerated but before chilling. Antimicrobial rinses on chilled carcasses, fabricated raw beef subprimals, and beef trimmings are now being permitted by the USDA as critical control points in HACCP programs.

Colloidal silver is nanometer-size particles of silver produced by electrolysis in purified water. The antimicrobial properties of silver particles have been widely reported. Currently, silver is approved and used in water purification systems, medical bandages for burn victims, dental fillings, and as a lining in surgical catheters because it inhibits growth of infectious microorganisms. Colloidal silver solutions potentially could be used as antimicrobial rinses for raw beef products to reduce

the presence of pathogens and, thus, serve as a critical control point in HACCP programs. This study was conducted to evaluate the efficacy of a solution of 32 ppm of colloidal silver for inactivating pathogens on fresh beef tissue, and to evaluate colloidal silver's efficacy over a range of solution concentrations and formulas.

Procedures

Preparation of Bacterial Cultures. Bacterial cultures were obtained from the Kansas State University stock culture collection, cultivated in the laboratory, and mixed to form five-strain inoculation solutions of both *Salmonella* and *E. coli* O157:H7. Each inoculation solution contained 1 billion colony-forming units per ml (CFU/ml) of the respective pathogen cultures. These mixed inoculation solutions were diluted to 1 million or 10,000 CFU/ml and used as a spray to inoculate beef flank tissue surfaces.

Time Study. Beef flank samples (*Rectus abdominus*) were trimmed to 5 x 3-inch pieces and spray inoculated on the exterior surface with the five-strain mixture of *Salmonella* or *E. coli* O157:H7 at 1 million CFU/ml or 10,000 CFU/ml. The actual *Salmonella* densities achieved on the meat surface were 100,000 and 2,500 CFU/cm^2 for the high and low concentration inoculum solutions, respectively. For *E. coli* O157:H7, the respective meat surface inoculation densities were 16,000 and 8,000 CFU/cm^2.

The beef samples were hung vertically on hooks attached to a motorized track that pulled the samples through a model spray cabinet. Treatments of either 32 ppm of ASAP® (American Bio Tech Labs, Alpine, UT) colloidal silver or deionized water were applied at 20 psi from a distance of 5 inches in the model pressure-rinse cabinet for 20 seconds. The spray nozzle delivered approximately 20 ml of solution to the surface of each sample. Duplicate core samples were randomly drawn from the inoculated exterior surface of each beef sample at 0, 20, 60, and 240 minutes after treatment. Surviving bacterial concentrations on beef samples were enumerated on selective and recovery culture media. Bacterial reductions due to the antimicrobial treatments were calculated by subtracting the amount of residual bacteria on inoculated/treated samples at the specified sampling times from the original post-inoculation concentration on inoculated/untreated samples at 0 minutes.

Concentration Study. This study followed the same experimental design as the time study, except that treatments were 22 ppm ASAP® colloidal silver, 22 ppm ASAP® colloidal silver with 1.5% hydrogen peroxide, 10 ppm ASAP® colloidal silver, 10 ppm ASAP® colloidal silver with 10 ppm potassium persulfate, and deionized water only.

Results and Discussion

An initial lethal effect was observed when inoculated fresh beef samples were treated with 32 or 22 ppm colloidal silver solution, resulting in a greater than 95% reduction of *Salmonella* and *E. coli* O157:H7 within 4 hours. These two colloidal silver washes resulted in the greatest pathogen reductions of the treatments evaluated. Furthermore, colloidal silver was slightly more effective against *E. coli* O157:H7 than against *Salmonella* (Figures 1 and 2).

The 1.5% hydrogen peroxide colloidal silver formulation caused significant textural changes to the fat covering, and left a bleached appearance to the surface of the lean tissue. In terms of pathogen reductions, the performance of 22 ppm colloidal silver with 1.5% hydrogen peroxide formulation was not significantly different than the 22-ppm colloidal silver solution alone. The 10-ppm colloidal silver solution resulted in an 81% pathogen reduction. The addition of potassium per-

sulfate to this 10-ppm solution enhanced the reductions to approximately 90%.

Numerous chemical washes have been evaluated in similar laboratory and commercial studies. Pathogen reductions tend to be similar for most chemical treatments reported in literature (90 to 99% reductions). Washing with colloidal silver (22 or 32 ppm) provided pathogen reductions within this typical range. Chemical washes for beef operations are needed because some smaller processors cannot afford the thermal systems widely used by medium or large-scale processors, or have no room on the processing floor for their installation. Slaughter operations that use thermal technologies for decontamination of prechilled carcass sides would benefit from having an effective chemical wash to apply to chilled carcasses, subprimals, and beef trimmings.

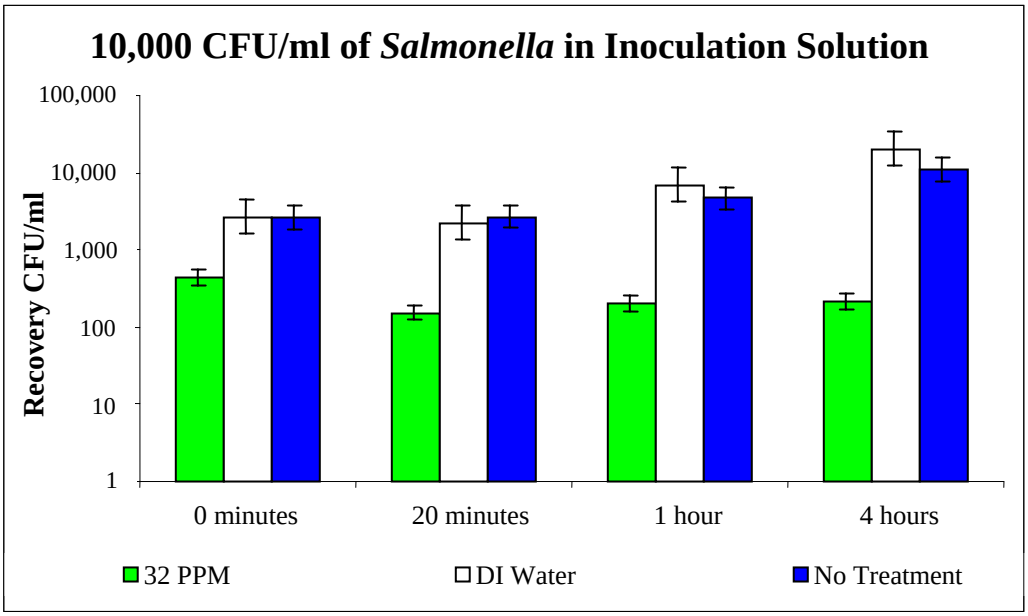


Figure 1. Residual Amounts of *Salmonella* Detected on Beef Flank Tissue After Spray Treatment with Deionized Water or 32 ppm of Colloidal Silver Solution.

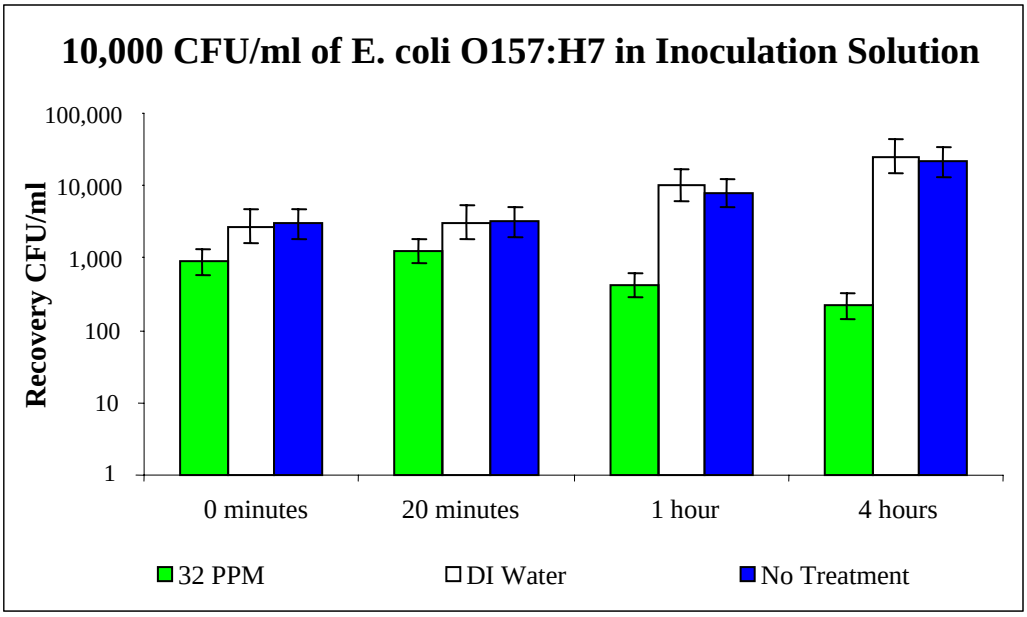


Figure 2. Residual Amounts of *Escherichia coli* O157:H7 Detected on Beef Flank Tissue After Spray Treatment with Deionized Water or 32 ppm of Colloidal Silver Solution.

EVALUATION OF THE GROVAC™ SYSTEM FOR DECONTAMINATION OF RETAIL BEEF TRIMMINGS TO CONTROL *E. COLI* O157:H7 AND *SALMONELLA*

R. Forgey, R. K. Phebus, T. Herald, J. L. Marsden, L. J. Franken, and C. A. Tanus

Summary

The Grovac™ intervention system was evaluated for its effectiveness in reducing *E. coli* O157:H7 and *Salmonella* inoculated on the surfaces of beef trimmings. Designed to be used in a batch process, the Grovac™ system involves treating beef trimmings in a mixture of citric acid and a hypotonic salt solution while tumbling under vacuum. Beef trimmings were inoculated with a five-strain cocktail of *E. coli* O157:H7 and *Salmonella*, then subjected to no treatment, water with a 1-hour drain treatment, water with an overnight drain treatment, Grovac™ with a 1-hour drain treatment, and Grovac™ with an overnight drain treatment. Data indicated that the Grovac™ system may be a viable method for retailers to use with in-house beef grinding operations to reduce *E. coli* O157:H7 and *Salmonella* risks. Reductions in these pathogen populations were 85 and 80%, respectively, after draining for 18 hours at 36°F.

Introduction

Since 1986, ground beef manufacturers, retailers, food service, and consumers have feared *E. coli* O157:H7 in their ground beef. The USDA and the ground beef industry have spent several years and millions of dollars working to combat this issue through the development of antimicrobial intervention strategies, the introduction of Hazard Analysis Critical Control Point (HACCP) systems, and consumer education programs. Most of these risk reduction efforts have been aimed at the beef manufacturing plants, particularly slaughter-level carcass decontamination systems, with a good degree of success. To best ensure the microbial safety of retail-ready ground beef, sequential intervention technologies (hurdles) throughout the production chain need to be developed and implemented. Although cooking beef to 160°F will eliminate the hazard of *E. coli* O157:H7 from the product, it does not eliminate the problems associated with cross-contamination that often occur in consumers' kitchens or in food service operations.

Commercial ground beef is produced by mixing pieces trimmed from larger beef cuts (subprimals) during fabrication processes and grinding fat and lean component streams into coarsely or finely ground wholesale products. The percentage of fat for each grind is obtained by mixing the proper combination of lean muscle meat with fat from trimmings. Thus, a production load of ground beef can contain meat from many different cuts of beef from various sources and of differing quality.

The manufacture of this product in centralized beef processing facilities ensures production under strict standards of hygiene and quality control. The retail butcher's shop faces many challenges in today's marketplace. They have the pressures of increased competition, a shortage of skilled meat cutters, and the risk associated with selling ground beef that may harbor *E. coli* O157:H7. At the retail store (butcher shop), the production of ground beef allows minimization of economic (yield) losses associated with trimming steaks and roasts. These table trimmings are generally

mixed with coarse ground chubs for final grinding, followed by retail case display for 1 to 2 days. Until now, there has been no antimicrobial intervention strategy available to the retail meat grinder that would allow him to minimize his risk of selling contaminated beef. This void in retail-level technology puts the entire beef production complex at risk of USDA action, recalls, negative publicity, and litigation in the event contamination occurs, especially if it affects public health. By placing a validated intervention technology at this final stage of ground beef production, where contamination with enteric pathogens would be expected to be infrequent and at very low rates, a significant hurdle would be in place that would further reduce the likelihood that pathogen-contaminated ground beef would reach the consumer.

The Grovac™ Intervention System is a simple and inexpensive method designed to decrease bacterial concentrations on ground beef while extending the shelf life of the product. The Grovac™ system is designed to be used as a batch process, and is adaptable to small volume situations often encountered in retail butcher shop operations. It involves treating the beef trimmings in a mixture of citric acid and a hypotonic salt solution while tumbling under vacuum. The citric acid lowers the pH on the outside of the beef to a level that kills most disease-causing meat-borne bacteria and acts as an antioxidant in the final product, delaying the conversion of oxymyoglobin to metmyoglobin. This stabilizes the bright red color for a longer period of time.

The Grovac™ system has been commercially tested and is now in use in fresh seafood and poultry processing facilities. At Kansas State University, this system was evaluated with encouraging results against meat-borne pathogens inoculated onto beef trimmings. Since those studies, in-house studies at Costco Wholesale have led to an adjustment (optimization) in processing parameters of the beef trimmings in the Grovac™ system. In these Costco studies with the Grovac™ system, generic microbial reductions have remained good and the shelf-life stability (color) of retail ground beef has been enhanced. Based upon the success of the previous KSU studies and preliminary Costco studies, the initiated current studies were initiated to formally evaluate the efficacy of the optimized Grovac™ system against *Salmonella* and *E. coli* O157:H7 in laboratory-based inoculation studies.

Procedures

Preparation of Cultures. Five strains each of *Salmonella* and *E. coli* O157:H7 were activated from frozen storage, and all five strains of each pathogen were mixed in a single, sterile, spray bottle for use in meat inoculation. The target inoculation solution concentration was 10 million colony forming units (CFU) per ml.

Inoculation of Beef Trimmings. Beef trimmings were obtained from a Costco Wholesale location (Kansas City, MO). Trimmings were generated from store operations the previous day, stored at < 32°F, and delivered by 10 a.m. the next morning to the K-State Food Microbiology Laboratory. Beef trim samples were chopped in a sterile food processor, and duplicate subsamples were placed into sample bags with sterile diluent. These subsamples were homogenized in a lab blender and plated by using APC and ECC Petrifilm to establish native microbiological quality of the beef trimmings. For inoculation, beef trimmings (18 lb) were placed onto white butcher's paper so pieces were not touching, and then placed inside a sealed Plexiglas inoculation chamber. The mixed inoculum was sprayed through a hole in the chamber onto the exposed surfaces of the beef trimmings. After allowing the inoculated beef to sit inside the inoculation chamber for 5 minutes, the chamber was opened and the beef trimmings were turned to expose the side that originally faced the paper. The chamber was

resealed and the alternate side of the trimmings was inoculated as previously described. Then, trimmings were placed inside a sterile plastic bag and hand mixed to uniformly distribute the surface inoculum. The bag was held at 50°F for 30 minutes to allow microbial attachment. Trimmings were randomly selected from the bag after 30 minutes of chilled storage and chopped in a sterile food processor, and duplicate subsamples were placed into sterile bags with sterile diluent. These subsamples were homogenized for 2 minutes, serially diluted, and plated onto selective media to establish pathogen inoculation rates. An inoculation rate of 100,000 CFU/gram was targeted. The rest of the inoculated trimmings was subjected to specified treatments.

Application of the Grovac™ Decontamination Process. The Grovac™ decontamination process consists of 2 minutes of tumbling of trimmings under vacuum (25 inches of Hg) in a 2.27% citric acid/0.45% sodium chloride solution. A water only treatment application served as the process control. The Grovac™ and water-only processes occurred in a Biosafety Level-2 food processing laboratory set at 50°F, and the solution temperature was ambient. Each test batch of inoculated trimmings was treated in the described manner, removed from the Grovac™ chamber, and allowed to drain for 1 hour. Half of the Grovac™-treated beef trimmings were placed into 36°F storage in a plastic container overnight [approximately 18 hours; *overnight sample*], whereas the other half were analyzed immediately after the 1 hour of draining [*1-hour sample*]. The overnight sample container had holes in the bottom to allow for drainage of residual moisture overnight. Portions of the 1-hour and overnight sample trimmings were aseptically removed, placed into a sterile food processor, and chopped to provide homogeneous samples. From each sample, duplicate subsamples were drawn, placed into sterile bags with diluent, and mixed for 2 minutes, and serial dilutions were plated to enumerate the amounts of residual pathogens. Selective agars were used to allow separate enumerations of *Salmonella* spp., injured *Salmonella*, *E. coli* O157:H7, and injured *E. coli* O157:H7. The average counts from these duplicates were calculated, and the overall pathogen reductions due to the treatments were determined.

Results and Discussion

The Grovac™ system was effective in reducing both *E. coli* O157:H7 and *Salmonella* counts on beef trimmings, although the reductions were only moderate (65 to 90% using an overnight drain procedure). The retail beef industry has very few options available to choose from in the way of intervention strategies. Over the past 10 years, retailers have vigorously pursued consumer education and outsourcing of ground beef production as methods to reduce the risk of *E. coli* O157:H7 contamination in beef. The Grovac™ system may be a viable method for retailers to use for in-house beef grinding operations.

Reductions in *Salmonella* counts were observed with both the water treatment and the Grovac™ treatments after 1 hour of draining (55 and 62% reductions, respectively). Samples from both the water and Grovac™ treatments showed more reductions in *Salmonella* numbers (78 and 85%, respectively) when samples were allowed to drain overnight. When comparing the Grovac™ treatment to the water-only treatment, the Grovac™ treatment led to greater bacterial reductions than the water-only treatment did in all instances.

After 1 hour of draining, both water and Grovac™ treatments resulted in 60% reductions in *E. coli* O157:H7 populations. These reductions increased to 63% for water and 80% for Grovac™ after 18 hours of draining.

The Grovac™ system did not produce large reductions in bacterial numbers, but the reality of the typical microbial quality of beef

in the retail market must be kept in mind. When a subprimal cut reaches the retail market, it has likely been exposed to at least one microbial intervention process, so the bacterial load on that piece of meat is typically quite low and the chance of high concentrations of a pathogenic organism on that beef is negligible. Removing greater than 80% of the initial bacterial population, which this Grovac™ system was able to do, is substantial to the meat industry. If the initial count of *E. coli* O157:H7 or another pathogen is 100 CFU/gram or less, after treatment with an intervention process like the Grovac™ system, 10 or less CFU/gram theoretically will remain. The Grovac™ system is an appropriate microbial intervention to be used at this level of the food chain, adding yet another barrier to microbial contamination of beef.

VALIDATION OF PROCESS CAPABILITIES FOR DIRECTLY ACIDIFIED BEEF AND VENISON-CONTAINING BEEF SNACK STICKS FOR CONTROL OF *E. COLI* O157:H7

S. K. Stoltenberg, K. J. K. Getty, H. Thippareddi, R. K. Phebus, and T. M. Loughin

Summary

USDA/FSIS guidelines require sausage manufacturers to validate their processes to assure that they can achieve a five-log (99.999%) reduction of *E. coli* O157:H7. Some small meat processors use encapsulated acids instead of lactic acid starter cultures to produce directly acidified sausages. The objectives of this study were to determine 1) the effects of typical thermal processing temperatures and times on reducing *E. coli* O157:H7 in directly acidified all-beef and venison-containing beef snack sticks, 2) the effect of fat content (10 and 25%) on lethality, and 3) the effect of acid type (citric versus lactic) on lethality. For both all-beef and venison-containing beef snack sticks, *E. coli* O157:H7 reductions of approximately 3 log cycles (99.9%) were observed when product internal temperature reached 148 and 155ºF. Reductions increased to more than 5 log cycles after 2 hours of slow drying in which the smokehouse temperature was sequentially decreased to 70°F. Encapsulated citric acid was slightly more effective at lowering product pH, compared with the encapsulated lactic acid. Similar pathogen reductions were observed with 10 and 25% fat content. This study demonstrates that the defined processing schedule used to manufacture beef and venison-containing beef snack sticks is adequate to provide microbiologically safe products and to meet USDA guidelines for pathogen reduction. The processing schedule must include an extended drying phase, in addition to the thermal step, to meet these requirements.

Introduction

In 1994, an *E. coli* O157:H7 outbreak was linked to a dry, fermented, pre-sliced, pork and beef salami product purchased from delicatessen counters in a Seattle grocery chain. Twenty individuals were involved in the salami outbreak, with the median age of 6 years old (range 23 months to 77 years). Three were hospitalized, and one 2-year old developed hemolytic uremic syndrome (HUS), a severe and life-threatening kidney complication. Three individuals in California also became sick from the same incident. Because of this outbreak of *E. coli* O157:H7 being linked to a dry, fermented sausage product for the first time, the USDA/FSIS developed guidelines requiring sausage manufacturers to validate their processes to assure that they can achieve a five-log (99.999%) reduction of *E. coli* O157:H7.

Some small meat processors use encapsulated acids instead of lactic acid starter cultures to produce dry, directly acidified sausages. Encapsulated acids are used to provide the characteristic tangy taste of typically fermented sausage products. Because of the lack of starter cultures for these products, the time required to produce these products is shortened, inasmuch as ripening/fermentation is not required. Directly acidified snack sticks have the potential to cause foodborne illness through *E. coli* O157:H7 because of their low-temperature processing parameters and product properties. This study was designed to quantify the potential for survival of *E. coli*

O157:H7 in beef snack stick products per USDA reduction guidelines.

Procedures

This research project consisted of two phases: Phase 1: all-beef stick validation, and Phase 2: venison-containing beef stick validation. The treatments for each phase were 10 or 25% fat content (green weight) and encapsulated citric or lactic acid. Both control and inoculated batches were prepared. For each phase, a replication consisted of one batch of each treatment being placed in the smokehouse simultaneously. Three replications were completed for each phase.

Fresh beef trimmings and beef fat were obtained from the K-State Meat Lab, and batches were weighed to contain 10% and 25% fat (90% and 75% lean, respectively). The product was ground and formulated with a snack-stick seasoning [Blend 116, Legg's Old Plantation Seasonings, A.C. Legg Inc., Calera, AL] and cure (6.25% sodium nitrite) (A.C. Legg, Packing Co., Inc. Birmingham, AL). The mixture was split into two batches and either encapsulated lactic acid (Meatshure 509, Balchem Encapsulates, Slate Hill, NY) or encapsulated citric acid (Meatshure 333, Balchem Encapsulates) was added. Each batch was then equally divided to provide one non-inoculated batch (control) of each acid and fat content and one inoculated batch of each acid and fat content. For the control batch, 1.2 ounces of sterile deionized water was mixed evenly into the meat batter. The batch receiving the inoculum was spread evenly onto a flat surface in a laminar flow hood to allow for even distribution of inoculum. The inoculum (1.2 ounces of a 5-strain mixture of *E. coli* O157:H7 cultures) was intermittently applied drop-wise over the meat surface and massaged with gloved hands until thoroughly mixed into the meat batter.

The meat batter was stuffed into pre-soaked 0.83-inch-diameter smoked collagen casings (Mid-Western Research & Supply, Wichita, KS). Each stick (18 to 24 inches long) was tied with string, hung vertically on the smokehouse truck, and randomly placed into a commercial smokehouse (Alkar Model 450-UA, Alkar, Lodi, WI). The thermal process included a dry bulb temperature of 110ºF for 1 hour with relative humidity (RH) of 25%, followed by a ripening state at 110ºF and 25% RH for 5 hours. A fast-drying step followed at 120ºF and 25% RH for 40 minutes, followed by 1 hour at 130ºF and 25% RH, 40 minutes at 140ºF and 25% RH, and a hot-air finish with the smokehouse temperature at 180ºF and 25% RH until the internal product temperature reached 155ºF. A cool down slow drying period followed for 20 minutes at 130ºF, 20 minutes at 110ºF, 20 minutes at 90ºF, and 1 hour at 70ºF. The pH was measured in duplicate on both control and inoculated samples.

***E. coli* O157:H7 Enumeration**. Raw meat control samples were collected before inoculation and also were collected from the control batches to assure that no pathogenic *E. coli* O157:H7 was in the meat before inoculation. Raw inoculated samples were taken from the inoculated meat batter to determine the initial inoculum content of the product. Both selective and injury recovery media were used for the enumeration *E. coli* O157:H7 populations in each sample.

Heat-treated samples (one inoculated and one non-inoculated control) were collected when the internal product temperature reached 148ºF and 155ºF, as well as at the end of the drying cycle. The non-inoculated control sample was used for proximate analysis, pH, titratable acidity, and water activity. The inoculated sample was used for *E. coli* O157:H7 enumeration and pH analysis. Samples and sterile diluent were blended, and serial dilutions were plated on agar.

***E. coli* O157:H7 Enrichment**. Modified *E. coli* broth containing sodium novobiocin

antibiotic was used for enrichment of heat-treated sausage samples. The samples were incubated in modified *E. coli* broth overnight, followed by streaking onto selective agar plates. This enrichment procedure was used to detect very low counts of surviving organisms and injured cells that would not normally be detected by direct sample plating.

Results and Discussion

The *E. coli* O157:H7 inoculation rates for meat batters were approximately 12 and 10 million colony forming units per gram for all-beef and venison-containing beef, respectively. Smokehouse heating to 148 and 155°F internal sausage temperature resulted in 99.8% and 99.9% reductions in *E. coli* O157:H7, respectively, for all-beef sticks. Similar reductions for venison-containing beef sticks were 99.3% for both heating temperatures. These reductions (99.9%, or 3 log reductions) would not meet the five-log (99.999%) USDA/FSIS pathogen control guidelines for this product group. After the specified drying process for the products had been completed, however, counts had been further reduced to very low surviving numbers, or not detected at all. Therefore, the complete manufacturing process (acidification, thermal processing, and drying) for this product did meet USDA/FSIS guidelines.

The pH of both control and inoculated samples for all-beef and venison-containing beef snacks were very similar for all treatments and sampling times. The final pH range for all products at the end of the drying cycle was 4.7 to 5.3. When comparing between citric and lactic acid treatments, however, pH was higher for products with lactic acid. In addition, the venison-containing beef snack sticks demonstrated higher pH than the all-beef snack sticks did. Similar bacterial reductions were observed for treatments having differing fat contents (10 vs. 25%).

EVALUATION OF EXTERIOR SANITARY GARMENTS FOR MEAT PLANT EMPLOYEES FOR CONTROL OF MICROBIAL CONTAMINATION

G. V. Hickey, J. M. Bieker, J. L. Marsden, R. K. Phebus, E. J. Harvey, L. J. Franken, and C .L. Kastner

Summary

Disposable frocks, manufactured by Precise Systems, LLC, and made of an innovative clothing material formed by an inner layer of a spun-bond polypropylene material reinforced by an outer layer of polyethylene, were compared with the cotton/polyester materials used in frocks typically worn in food plants today. The growth and absorption of bacteria on these materials were compared as an indicator of the sanitary conditions of the disposable frocks. These materials were cut into 2 x 2-inch pieces and were inoculated with generic *Escherichia coli*, *E. coli* O157:H7, *Listeria monocytogenes*, and *Salmonella* spp. Samples were collected after allowing microorganisms to attach for 0, 1, 2, 4, 6 and 8 hours. In most instances, the cotton/polyester absorbed and maintained the initial inoculation rate over the sampling times. Polypropylene was somewhat absorbent, but contamination rates were slightly lower than on cotton/polyester. Polyethylene material was non-absorbent and performed the best, especially with *Listeria monocytogenes*. The data indicate that the non-absorbent property of polyethylene does not provide a reservoir for microorganisms, allows run-off, and therefore potentially reduces the opportunity for cross-contamination of food products.

Introduction

Cleaning and sanitation in food plants is the most important aspect in obtaining a wholesome product. Plant employees have the potential to spread contamination in a food processing plant. Their personal hygiene practices and sanitation awareness (i.e., clean outer garments and regular cleaning of personal protective equipment) can greatly improve or reduce the overall sanitation of a plant and its products. Every tool and garment of plant employees that come into contact with food or food contact surfaces increases the likelihood of food contamination if sanitation protocols are not properly met. Outer garments of plant employees are subjected to continual contact with fat, blood, and other organic matter that are a source of microorganisms. The loading of garments with a mixture of organic material and water, plus the body temperature of the worker, helps provide an appropriate environment for organisms to survive, or possibly replicate, throughout the working day.

It has proven difficult, if not impossible, to maintain clean outer garments during meat processing. Most food plants distribute one frock per employee during every shift because of cleaning costs and time constraints of distribution. Outer garments possess another potential problem; cotton, the material most frocks are made from, can carry contamination through the laundering process, and it quickly absorbs moisture (water, blood, fat). The cuff, forearm, thigh, chest, and abdomen are the areas most frequently soiled among food plant workers, especially in slaughter and fabrication areas.

Precise Systems, LLC, has developed a new spun-bond, disposable frock with an outer polyethylene layer to provide protection

against absorption of moisture and organic materials, and possibly against microbial contamination. These frocks were microbiologically analyzed and compared with cotton frocks after inoculation with microorganisms and loading with meat purge.

Procedures

Four different bacterial mixtures were used to perform side-by-side testing in the laboratory on disposable and cotton frocks: generic *Escherichia coli, E. coli* O157:H7, *Salmonella*, and *Listeria monocytogenes*.

A clean frock made of cotton/polyester material was cut into 2 x 2-inch pieces and sterilized before inoculation. The polypropylene spun-bond and the polyethylene materials from the disposable frocks were separated and individually cut into 2 x 2-inch pieces with a scalpel while wearing sterile gloves. Pieces of the disposable frock were sampled for bacteria before and after inoculation.

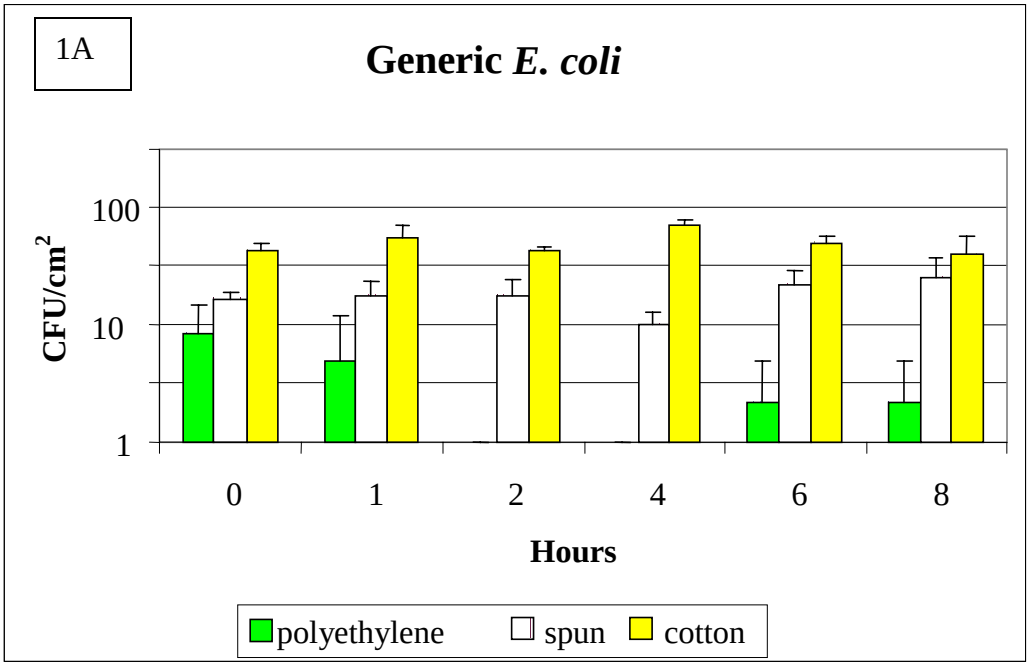
Frock pieces from all materials were suspended on metal hooks inside a spray chamber and then misted with two sprays of inoculum and two sprays of meat purge. To replicate the continual soiling of frocks in a food processing plant, frock pieces were misted every 30 minutes with either one spray of inoculum and one spray of meat purge, or deionized water only (for control), until the designated sampling time.

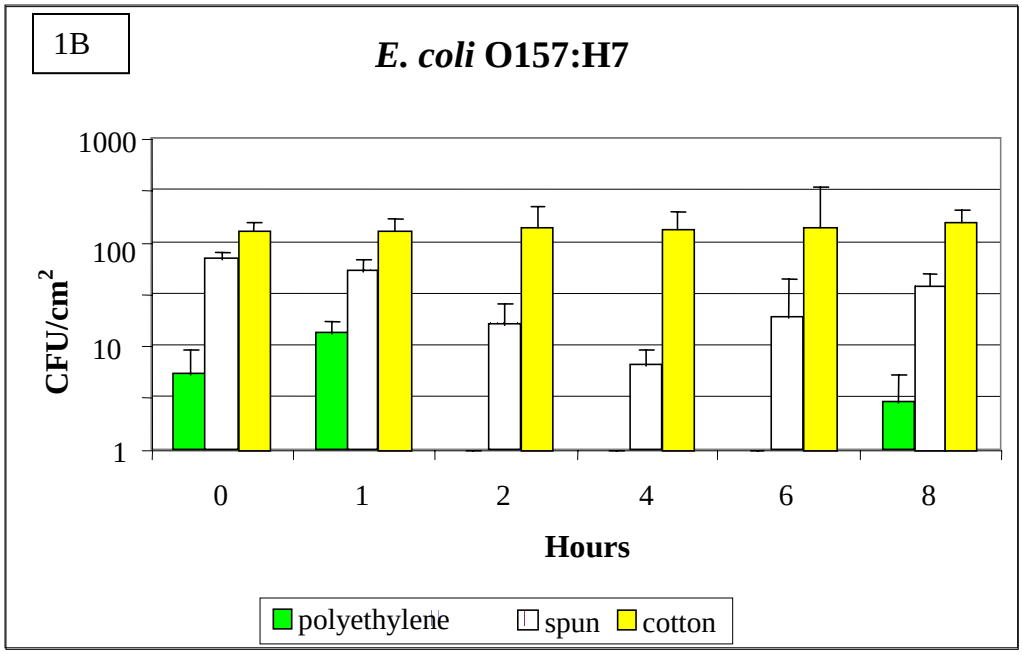
Microbes on frock material samples were enumerated at 0, 1, 2, 4, 6 and 8 hours to determine amount of pathogen on each material. The entire sample was placed into a sample bag with sterile diluent and mixed thoroughly to dislodge the bacteria from the frock material. Aliquots of the diluent were then plated onto selective agar plates to enumerate each pathogen population.

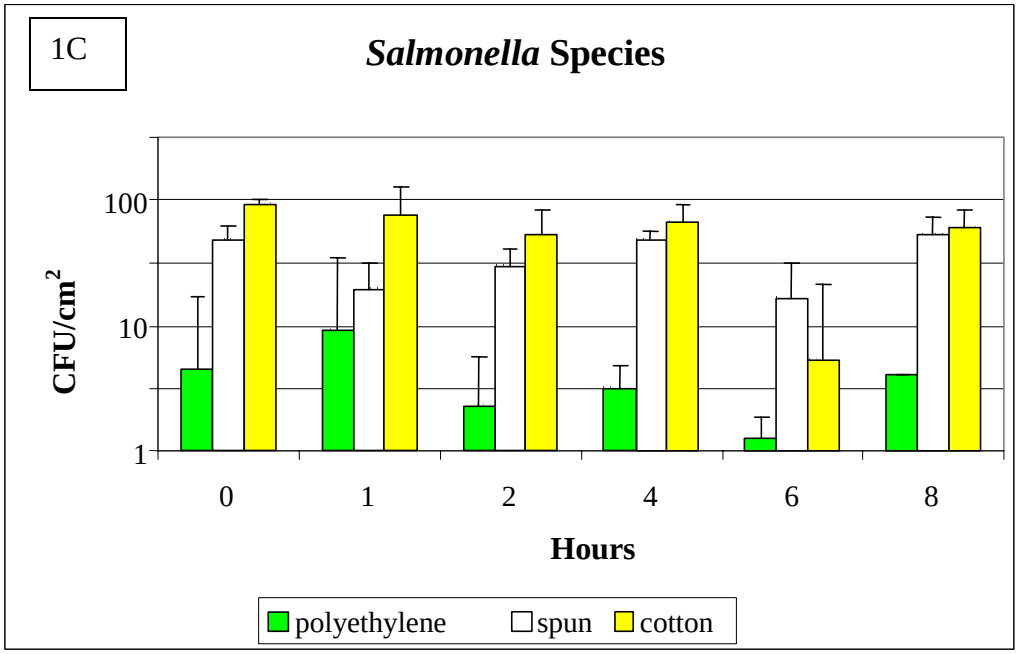
Results and Discussion

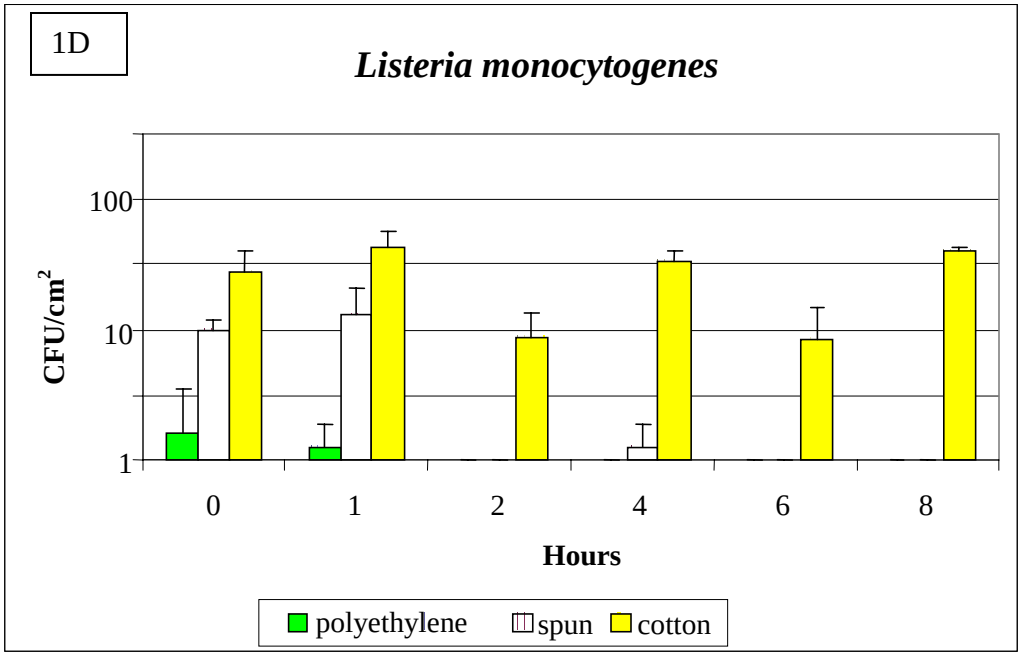
The cotton/polyester pieces demonstrated high absorption, and in most instances inoculation rates were maintained throughout the entire sampling period (Figure 1). No microorganisms were detected on any fresh, disposable frock taken directly from vacuum packaging. The polypropylene spun-bond material was less absorbent to moisture than the cotton/polyester material was, but it was not able to resist continued wetting over time. Microbial counts were slightly smaller for spun-bond samples than for cotton/polyester material for each of the four types of organisms. The polyethylene material showed superior performance in resisting both initial microbial contamination and prolonged contamination over time. Polyethylene is non-absorbent and, therefore, does not allow contamination to penetrate the garment like cotton/polyester or spun-bond materials would. Microbial counts were much smaller for the polyethylene material than for the polypropylene spun-bound and the cotton/polyester materials.

Results indicate that disposable frocks made from polyethylene (exterior) and polypropylene spun-bound material (interior) are superior to cotton frocks with respect to resistance to microbial contamination on the garment. Our data also agree with that generated from the health industry, in which these disposable garments are widely used. Data from other researchers have indicated that disposable gowns made of polypropylene showed less blood absorption and bacterial passage than cotton gowns did.


1A
Generic E. coli
100
10
1
CFU/cm2
0
1
2
4
6
8
Hours
polyethylene
spun
cotton


1B
E. coli O157:H7
1000
100
10
1
CFU/cm2
0
1
2
4
6
8
Hours
polyethylene
spun
cotton





Figures 1A-D. Numbers of Target Organisms Recovered after Inoculation and Extended Storage of Different Frock Materials Worn during Meat Manufacturing.

BIOLOGICAL VARIABILITY AND STATISTICAL EVALUATION OF DATA

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

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

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

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

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

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

ACKNOWLEDGMENTS

Listed below are individuals, organizations, and firms that have contributed to this year's beef research program through financial support, product donations, or services. We appreciate your help!

Abengoa Bioenergy
Alpharma Inc., Animal Health Division, Fort Lee, New Jersey
American Angus Association, St. Joseph, Missouri
American-International Charolais Association, Kansas City, Missouri
American Shorthorn Association, Omaha, Nebraska
BASF Corp., Wilmington, North Carolina
Beef Checkoff, Centennial, Colorado
Lee Borck, Larned, Kansas
Cargill Inc., Minneapolis, Minnesota
Costco Wholesale Corporation
Cryovac Sealed Air Corporation, Duncan, South Carolina
Dow Agrosciences, Indianapolis, Indiana
E.I. duPont de Nemours, Wilmington, Delaware
Elanco Animal Health, Indianapolis, Indiana
Excel Corporation, Wichita, Kansas
Felton International, Lenexa, Kansas
FiL Agritech, LLC
Fink Beef Genetics, Manhattan, Kansas
Fort Dodge Animal Health, Fort Dodge, Iowa
Gardiner Angus Ranch, Ashland, Kansas
Bernie Hanson, Alma, Kansas
Hoffmann-LaRoche, Inc., Nutley, New Jersey
Hutchinson Technologies Inc., Hutchinson, Minnesota
InterAg, Hamilton, New Zealand
Intervet Inc., Millsboro, Delaware
Iowa Limestone Company, Des Moines, Iowa
Irsik & Doll Feedlots, Cimarron, Kansas
Kamar, Inc.
Kansas Artificial Breeding Service Unit, Manhattan, Kansas
Kansas Beef Council, Topeka, Kansas
Kansas Livestock Assn., Topeka, Kansas
Kenny Knight, Lyons, Kansas
Livestock and Meat Industry Council (LMIC), Manhattan, Kansas
Merial Limited, Iselin, New Jersey
MMI Genomics, Salt Lake City, Utah
Mohrlang Manufacturing, Brush, Colorado
National Cattlemen's Beef Association, Centennial, Colorado
North American Meat Processors Assn., Reston, Virginia
North Dakota Oilseed Council, Bismark, North Dakota
Novartis Animal Vaccines, Bucyrus, Kansas
Pfizer Animal Health, Exton, Pennsylvania
Pharmacia Animal Health, Kalamazoo, Michigan
Phoenix Scientific, Inc., St. Joseph, Missouri
Pioneer Hi-Bred International, Des Moines, Iowa
Pratt Feeders, Pratt, Kansas
Precise Systems, LLC
Ross Industries, Midland, Virginia
SAF Agri USA, Milwaukee, Wisconsin
Schering-Plough Animal Health, Kenilworth, New Jersey
SDK Labs, Hutchinson, Kansas
Select Sires, Plain City, Ohio
Stork Division, Townsend Engineering, Des Moines, Iowa
Tailgate Ranch, Tonganoxie, Kansas
Tyson Fresh Meats, Rogers, Arkansas
Tyson/IBP, inc., Emporia, Kansas
USDA Food Safety Consortium, Washington, DC
USDA, Cooperative State Research Education and Extension Service, Washington, DC
VetLife, Inc., Overland Park, Kansas
Ward Feedyard, Larned, Kansas
Western Point, Inc.

The Livestock and Meat Industry Council, Inc.

The Livestock and Meat Industry Council, Inc. (LMIC) is a non-profit charitable organization supporting animal agriculture research, teaching and education. This is accomplished through the support of individuals and businesses that make LMIC a part of their charitable giving.

Tax deductible contributions can be made through gifts of cash, appreciated securities, real estate, life insurance, charitable remainder trusts, bequests, as well as many other forms of planned giving. LMIC can also receive gifts of livestock, machinery or equipment. These types of gifts, known as gifts-in-kind, allow the donor to be eligible for a tax benefit based on the appraised value of the gift.

Since its inception in 1970, LMIC has provided student scholarships, research assistance, capital improvements, land, buildings, and equipment to support students, faculty and the industry of animal agriculture. If you would like to be a part of this mission or would like additional information, please contact the Livestock and Meat Industry Council/Animal Sciences and Industry, Weber Hall, Manhattan, Kansas 66506 or call 785-532-1244.

LMIC Board Members:

Max Deets	Dell Allen	Andrew Murphy
Kenny Knight	Raymond Adams, Jr.	Tom Perrier
Henry Gardiner	Gina Miller	Duane Walker
Sam Hands	Phil Phar	Pat Koons
Lyle Gray	Mikel Stout	Lee Reeve
Bernie Hansen	Jerry Bohn	Randy Fisher
Larry Jones	Steve Hunt	Craig Good
Jan Lyons	Steve Irsik, Jr.	Greg Henderson
Galen Fink	Ken Stielow	Warren Weibert

Royal Board Members:

Bill Amstein	Richard Chase	Stan Fansher
Calvin Drake	Don Good	Harland Priddle
Don Smith	Fred Germann	

Auxiliary Board Members:

Fred Cholick	Janice Swanson

Photo Captions*

Front cover—clockwise starting from upper left.

White Star, Grand Champion Market Steer at the 1936 American Royal, was owned and shown by K-State. Held by Dr. A D "Dad" Weber, he is pictured with the 1936 Women's Meat Judging Team and their coach. From left to right, David Mackintosh, coach, Francis (Aicher) Lewis, Norma (Holshouser) Holm, Ellen (Brownlee) Musil, and Dr. Weber.

The show herd leaving for the American Royal. Picture was taken on November 11, 1913, and shows them parading past Anderson, Denison, and Holton halls.

Registered Hereford cows owned by K-State. Stone barn number 3 is in the background. The barn, built for draft horses, was later used as a show barn for cattle until it was destroyed by fire in the mid 1950s.

Crowd at Feeder's Day viewing research cattle at the beef research unit. Probably taken late 1930s or early 1940s.

Lines formed to get lunch at Livestock Feeder's Day, May 24, 1930.

The crowd at Livestock Feeder's Day, March 26, 1919.

Three Shorthorn show steers pictured November 23, 1906, standing on the approximate location of West Hall.

Back cover—clockwise starting from upper left.

Show steers, pictured November 20, 1911, stand on the approximate location of Waters Hall parking lot.

Ranch hands in their bunk house enjoying the evening.

Digestion trial in the old nutrition barn which stood on the approximate location of Trotter Hall. These steers were involved in a study that required the collection of urine in the basement.

Lining up for chow at Livestock Feeder's Day, March 26, 1919.

Eating lunch in the new pavilion at Livestock Feeder's Day. Picture taken March 26, 1919.

Show steers, pictured November 17, 1908, stand on the approximate location of West Hall. Stone barn number 2, which stood on the approximate location of Shellenberger Hall, can be seen on the left.

Ranch hands. Picture taken sometime in the early 1900s.

Crowd at Livestock Feeder's Day March 26, 1919.

Appreciation is expressed to Miles McKee and Chris Wallace for making these pictures available for this publication.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service, Manhattan, KS 66506

SRP 943 February 2005