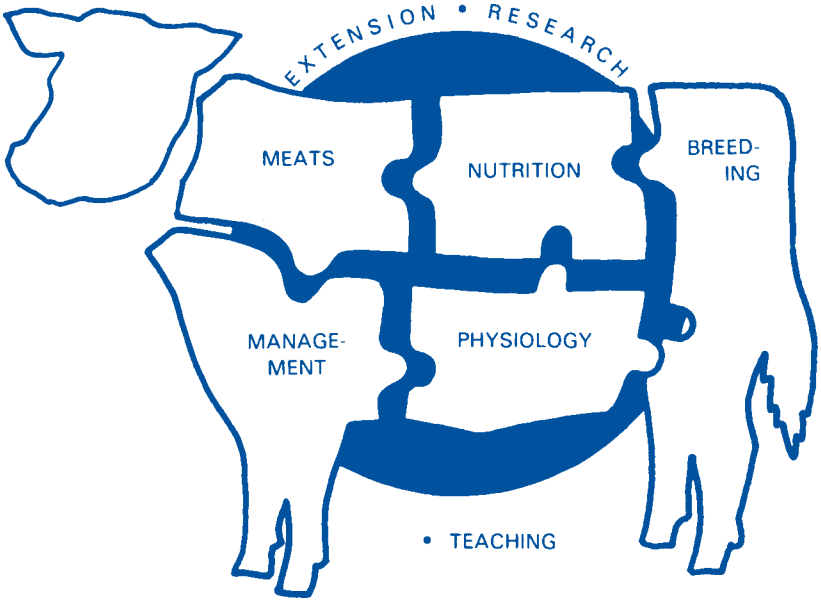
January 2005

Nebraska 2005 Beef Cattle Report (Complete volume)

NEBRASKA



MP 83-A

University of Nebraska Lincoln

2005 Beef Cattle Report

Table of Contents

Agricultural Research Division
University of Nebraska Cooperative Extension
Institute of Agriculture and Natural Resources
University of Nebraska-Lincoln

IANR

ACKNOWLEDGMENTS

Appreciation is expressed to the following firms, associations, or agencies who provided grant support for research in the beef cattle program.

Abengoa Bioenergy Corp., York, Nebraska
Bioniche Life Sciences, Bellville, Ontario
Cargill Corn Milling, Blair, Nebraska
Elanco Animal Health, Indianapolis, Indiana
Fort Dodge Animal Health, Overland Park, Kansas
Intervet, Millsboro, Delaware
Nebraska Corn Board, Lincoln, Nebraska
Beef Council, Kearney, Nebraska
Nutrition Physiology Corp., Amarillo, Texas
J.C. Robinson Seed Co., Waterloo, Nebraska
Soypass Royalty Funds, University of Nebraska, Lincoln, Nebraska

Appreciation is also expressed to the following firms who provided products or services.

Abengoa Bioenergy Corp., York, Nebraska
American Simmental Association, Bozeman, Montana
BK Giulini, Simi Valley, California
Cargill Corn Milling, Blair, Nebraska
Chief Ethanol Fuels, Hastings, Nebraska
Dakota Commodities, Scotland, South Dakota
Elanco Animal Health, Indianapolis, Indiana
Enzyme Valley Research, South Bend, Indiana
Fort Dodge Animal Health, Overland Park, Kansas
Hi Gain Inc., Cozad, Nebraska
Intervet, Millsboro, Delaware
Iowa Limestone, Des Moines, Iowa
Lignotech, Rothschild, Wisconsin
Liquid Feed Commodities, Fremont, Nebraska
Mead Cattle Co., Mead, Nebraska
Phoenix Scientific, St. Joseph, Missouri
Rex Ranch, Whitman, Nebraska
Schering Plough Animal Health, Kenilworth, New Jersey
Sigma Fine Chemicals, St. Louis, Missouri
Smithfield Beef Enterprise, Packerland Packing Co., Green Bay, Wisconsin
Trumark Inc., Linden, New Jersey
Tyson IBP Inc., Dakota City, Nebraska/Council Bluffs, Iowa
USDA Meat Grading and Certification Branch, Omaha, Nebraska

Appreciation is also expressed to the following Research Technicians, Unit Managers, and Crew involved in the Research Programs at our various locations.

Agricultural Research and Development Center, Ithaca
Justin Beam
Jeff Bergman
Andrew Cizek
Logan Dana
Scott Gotschall
Matt Greenquist
Allison Miller
Karl Moline
Tom Dreiling
Ken Rezac
Matt Sillivan
Doug Watson

Animal Science Department, Lincoln
Jeff Folmer
Jeryl Hauptman
Janet Hyde
Tommi Jones
Matt Luebbe
Jim MacDonald
Clyde Naber
Robert Peterson
Calvin Schrock
Candice Toombs
Kyle Vander Pol
Casey Wilson

Gudmundsen Sandhills Laboratory, Whitman
Andy Applegarth
Jackie Musgrave
John Nollette
Ryan Sexson
Troy Smith

Panhandle Research and Extension Center, Scottsbluff
Nabor Guzman
Paul McMillen

West Central Research and Extension Center, North Platte
Rex Davis
T. L. Meyer
Jim Teichert

Dalbey-Halleck Farm
Mark Dragastin

Northeast Research and Extension Center, Norfolk
Sheryl Colgan
Bob Frerichs
Kevin Heithold
Lee Johnson

Electronic copies of *Nebraska Beef Reports and Summaries* are available at: **http://animalscience.unl.edu**. Click on *Area of Interest; Beef Cattle;* then *Beef Reports*.

Comparison of Two Development Systems for March-born Replacement Beef Heifers

Kelly W. Creighton
Jacki A. Johnson-Musgrave
Terry J. Klopfenstein
Richard T. Clark
Don C. Adams[1]

Summary

A three-year study (2001-2003) was conducted to determine the effect of development system on reproductive performance of first-calf heifers. March-born heifers (n=261) were developed to reach either 55% of mature body weight (MBW) before a 45-day breeding season or 50% of MBW before a 60-day breeding season. Extending the breeding season 15 days for heifers developed to 50% of MBW prior to the first breeding season resulted in equal pregnancy, calving and weaning rates to heifers developed to 55% of MBW. Furthermore, the reduction in development costs in the 50% of MBW system more than offset the reduced income from lower weaning weights caused by later calving dates, resulting in decreased cost to produce one pregnant yearling heifer or 2-year old cow.

Introduction

Pregnancy rates in heifers are dependent upon the number exhibiting estrus early in the breeding season. The study of sexual maturity in a number of species provides evidence for the importance of diet during development or growth and suggests factors other than chronological age can control physiological changes necessary for puberty. Numerous studies indicate post-weaning growth rate is inversely correlated with age at puberty; however, previous work at the Gudmundsen Sandhills Laboratory (*2002 Nebraska Beef Report*, pp. 4-7) reported first- and second-calf conception rates were similar in heifers developed to reach either 55% or 60% of mature weight prior to breeding as yearlings.

Initial selection and management decisions are made at weaning under conditions of risk and uncertainty. Common practice is to select the oldest and heaviest heifers and feed at relatively high planes of nutrition. Although this practice increases the likelihood of heifers reaching puberty before or early in the breeding season, it results in higher feeding and development costs. Feeding lower levels of nutrition should result in lower development costs, but may decrease subsequent reproductive performance. The objectives of this study were: 1) to determine the effects of developing heifers to a pre-breeding target weight of 50% or 55% of MBW, and 2) to determine if extending the breeding season in heifers developed to a lower pre-breeding weight can offset possible reductions in reproductive performance expected in these heifers.

Procedure

Biological Data

Two hundred sixty-one MARC II (1/4 each of Angus, Hereford, Simmental, and Gelbvieh)-Husker Red (3/4 Red Angus, 1/4 Gelbvieh) crossbred heifers (505 lb; n = 88, 90 and 83 head in 2001, 2002 and 2003, respectively) were assigned randomly to one of two heifer development systems: 55% of mature body weight (MBW) before a 45-day breeding season (Intensive, INT; n=119) or 50% of MBW before a 60-day breeding season (Relaxed, RLX; n=142). The INT pre-breeding weight was established from previous research (*2002 Nebraska Beef Report*, pp. 4-7). To assure an adequate number of heifers would remain in the cow herd as 2-year olds, more heifers were developed in the RLX system each year because it was expected there would be a higher cull rate in that system due to a lower first calf conception rate.

At the initiation of the trial each year, heifers were weighed on two consecutive days and stratified to treatments by first day weight and birthdate. Treatments were initiated January 1, 2001, and December 1, 2002 and 2003. Heifers were placed in hay-feeding grounds, by treatment, for the winter feeding period and fed a diet consisting of meadow hay and protein supplement (INT also received whole corn in 2002 and 2003; Table 1). Heifers were weighed monthly and feed amounts adjusted to obtain desired gains.

At the end of the winter feeding period (May 15), all heifers were weighed and body condition score (BCS) was determined. A blood sample was collected from all heifers 10 days apart prior to start of the breeding season to determine cycling status before breeding. To eliminate the possibility of bull effects, all heifers were combined for breeding. Heifers were maintained on native Sandhills upland range for breeding, beginning May 20 of each year. INT heifers were removed from the breeding pasture

(Continued on next page)

after a 45-day exposure, while RLX heifers remained with the bulls for an additional 15 days. Sixty days after the end of the RLX breeding season (approximately September 10), all heifers were examined for pregnancy via rectal palpation and the number of days pregnant was estimated. All pregnant heifers were combined and maintained on sub-irrigated meadow regrowth during the fall grazing period (September-October). Non-pregnant heifers were sorted at time of palpation and sold.

During the second winter period, all pregnant heifers received 1.5 lb/head/day of supplement and were allowed ad libitum access to meadow hay. Heifer weights and BCS were recorded approximately February 15 of each year, prior to the start of calving. Heifers began calving approximately March 1. Calving date and calf birth weight were recorded within 24 hours of parturition. After calving, heifers were maintained on meadow hay and supplement until May 10, then placed on sub-irrigated meadow. Heifers remained on meadow until June 5 when they were placed on native Sandhills upland range. Two-year-old cows were exposed to bulls for 60 days beginning on June 5 for rebreeding. Calves from the 2-year-old cows were weaned in early September, and cows were examined for pregnancy (second calf) at that time. Calf weaning weights and cow body weights and BCS were also recorded at this time. Calf weaning rates, based on the number of heifers exposed to bulls during breeding and the number of heifers determined pregnant, and cows remaining in the herd as pregnant 2-year olds were then calculated.

Data were analyzed using the mixed model procedures of SAS. Year was treated as a random variable and differences between treatments were determined using Least Significant Differences (LSD), with a protected F-test. All pregnancy and cyclicity data were transformed to the logit scale and analyzed using the mixed model procedure. Initial analysis used overall means for each system; therefore, differences between systems are based on a 45- and 60-day breeding season for INT and RLX, respectively. Estimated breeding date was calculated from the number of days pregnant at pregnancy diagnosis to determine heifers that were pregnant within 30 and 45 days (only RLX means adjusted in the 45-day analysis) from the initiation of the breeding season. Data were then re-analyzed using only heifers pregnant within 30 or 45 days of the initiation of the breeding season to determine the effects of extending the breeding season in the RLX system.

Table 1. Winter feed rations for heifers developed in an intensive (INT; 55% MBW + 45-day breeding season) and relaxed (RLX; 50% MBW + 60-day breeding season) system.

	Feedstuff (lb/head/day)		
Item	Meadow Hay	Protein Suppl.[a]	Corn
RLX			
Year 1	10.8	3.5	—
Year 2	9.0	2.4	1.1
Year 3	9.5	2.9	2.0
INT			
Year 1	13.0	1.3	—
Year 2	11.9	0.7	—
Year 3	11.7	1.3	—

[a]Protein supplement consisted of 51.9% wheat middlings, 20.6% dried distillers grain, 10.0% soybean hulls, 12.8% cull beans and 2.5% cane molasses in year 1; 44.9% wheat middlings, 40% gluten feed, 10% soybean hulls and 2.5% cane molasses in years 2 and 3.

Economic Analysis

Each heifer development system was analyzed for economic feasibility to determine which strategy may be optimal for production of replacement heifers. For the analyses, 10-year average prices for feed and 5-year average prices for cattle were used. Pasture costs were determined from year 2003 values. Supplement costs were an average of the actual costs paid over the three-year period. A labor charge of $10 per ton of feed delivered was charged. Interest (10%) was charged on the entire animal costs and half the feed costs. Cost to produce a pregnant yearling and 2-year old cow were determined using overall, 30- and 45-day means for each system.

Results

Biological Data

Performance results from treatment initiation through second-calf pregnancy diagnosis are reported in Table 2. There was no difference in beginning weight between the two systems and averaged 505 lb for both systems. At pre-breeding, heifers in the INT system were 69 lb heavier ($P < 0.001$) and had a 0.5 unit greater ($P < 0.001$) BCS, due to the difference (0.46 lb/day; $P < 0.001$) in winter ADG. Target pre-breeding weight for both systems was based on an expected MBW of 1200 lb. Therefore, targeted pre-breeding weight was 600 and 660 lb for RLX and INT heifers, respectively. Both systems exceeded their targeted pre-breeding weight, which resulted in RLX heifers averaging 50.9% and INT averaging 56.5% of MBW prior to the initial breeding season.

The percentage of heifers determined to be pubertal before the breeding season (as indicated by serum progesterone level greater than 1ng/ml on at least one of two sample dates) did not differ between the two systems. Fifty-two percent of INT heifers were pubertal prior to initiation of the breeding season, while 33% of RLX heifers

Table 2. Biological and production results from treatment initiation through re-breeding of 2-year-old cows reared in an intensive (INT; 55% MBW) or relaxed (RLX; 50% MBW) heifer development system (overall means).

Item	RLX	INT	SEM	*P*-value
Cow data through 1st calving (3 years)				
No. of heifers	142	119		
Beginning wt.	505	505	6.6	0.99
Winter ADG, lb	0.71	1.17	0.04	<0.001
Pre-breeding wt	610	679	11.0	<0.001
Pre-breeding BCS	5.2	5.7	0.07	<0.001
Percent MBW	50.9	56.5	0.92	<0.001
Pubertal, %[a]	33.4	52.0	10.7	0.35
Pregnancy check wt.	829	864	10.1	<0.001
Pregnancy check BCS	5.6	5.9	0.07	<0.001
Pregnant, %	87.2	89.8	4.1	0.51
No. days pregnant	88	96	1.4	<0.001
Pre-calving wt.	980	1010	18.7	0.02
Pre-calving BCS	5.3	5.3	0.05	0.78
Cow data from 1st calving through 2nd calf pregnancy diagnosis (2 years)				
Pregnancy check wt.	903	926	9.3	0.11
Pregnancy check BCS	5.0	5.0	0.08	0.81
Pregnancy, %	90.5	92.2	3.2	0.70
Bred 2-year-old cows in herd, %	74.8	72.5	6.4	0.82
Calf performance				
3 years data				
Calf birth date	Mar 15	Mar 9	2.4	<0.001
Calf birth weight	75	75	0.9	0.61
Calving difficulty, %	32.0	26.9	4.9	0.46
Calving rate, per HE[b]	85.3	87.4	3.3	0.68
Calving rate, per PH[c]	95.6	98.6	1.1	0.15
2 years data				
Calf weaning wt.	190	197	2.7	0.04
Weight/day of age at weaning	2.40	2.38	0.07	0.38
Weaning rate, per HE[b]	80.8	77.6	6.7	0.67
Weaning rate, per PH[c]	90.7	87.7	6.4	0.47

[a]Percentage of heifers determined to have reached puberty (determined by a circulating serum progesterone level > 1ng/ml^{-1}) prior to the beginning of the initial breeding season.
[b]Percentage based on number of heifers exposed to bulls for breeding.
[c]Percentage based on number of heifers determined pregnant via rectal palpation 60 days following breeding.

were determined to have commenced estrous cycles by this same point. Weight at the time of pregnancy determination was greater ($P < 0.001$) for INT heifers; however, the difference was less than half of that seen at the initiation of the breeding season (69 vs. 35 lb difference between systems at the beginning of breeding and at pregnancy determination, respectively). This indicates that the heifers in the RLX system were able to partially compensate for weight differences created by the development system. A similar pattern was observed in BCS, with RLX heifers gaining more condition throughout the summer than INT heifers but the compensation was not sufficient to overcome existing differences. Therefore, RLX still maintained a lower average BCS ($P < 0.001$) than INT heifers at time of pregnancy diagnosis. Pregnancy rate following the initial breeding season was not different between the two systems and averaged 88.5% for both.

Weight change during the second wintering period (October-February) did not differ between systems, with heifers from both gaining an average of 152 lb. Therefore, weight differences created by the previous winter development protocol still existed before calving. The body weight difference at pre-calving (29 lb) was similar to that at the time of pregnancy determination. Body condition score change during the second winter did differ ($P = 0.002$) between systems, with INT heifers losing 0.5 units while the RLX lost only 0.2 units of condition score. This resulted in BCS at pre-calving to be similar ($P = 0.78$) between systems.

Average calving date did differ ($P < 0.001$) between systems, with INT calving approximately six days earlier than RLX heifers. This resulted primarily from the 15-day extended breeding season used in the RLX system. Calf birth weights were not different between systems. In conjunction, incidence of dystocia also did not differ between systems, with 32.0% and 26.9% of RLX and INT heifers requiring assistance at calving, respectively. The percentage of heifers that calved did not differ between systems when based on the number of heifers exposed to bulls during the initial breeding season; however, it did tend to differ ($P = 0.15$) when based on the number of heifers determined to be pregnant after the initial breeding season.

Calf weaning weights were different ($P = 0.04$) between systems with INT being heavier at weaning; however, when expressed as weight per day of age, no difference between systems exist. Weaning rates were also not different when expressed either on a per heifer exposed or per pregnant heifer basis. Cow body weights still tended ($P = 0.11$) to differ at calf weaning and second-calf pregnancy determination, with a 23 lb difference still evident at that time. Cow BCS, however, was similar between systems at weaning and pregnancy determination. Second-calf pregnancy rates were not different between systems and averaged 90.5% and 92.2% for RLX and INT systems, respectively. Additionally, the percentage of cows remaining in the herd as 3-year olds (bred 2-year olds) was similar, between systems averaging 74.8% and 72.5% for the RLX and INT systems, respectively.

Analysis of pregnancy and calving data using only heifers bred within 30 or 45 days of the start of the breeding season reveals the

(Continued on next page)

impact of extending the breeding season in the RLX system. First-calf pregnancy rate after 30 days from the initiation of the breeding season tend to differ ($P = 0.06$) between systems, with INT heifers having a 15.7% increase over RLX heifers at that point. By 45 days, the difference is reduced to 9.3%, which is no longer statistically significant. During the extended 15-day breeding period (from 45 to 60 days) for the RLX heifers, an additional 6.7% of heifers became pregnant. This caused the overall pregnancy rates between the two systems not to differ, with the RLX and INT systems averaging 87.2% and 89.8%, respectively. Second-calf conception rates did not differ at 30 or 45 days, nor did the overall means differ.

Average calving date remained different in the 30- ($P < 0.001$) and 45-day ($P < 0.001$) analyses, although the difference in the 30-day (4 days) and 45-day (3 days) analyses are numerically less than the difference in the overall means (6 days). Calf birth weight means and differences do not change across analyses. Weaning weight differences did vary across analyses, however. Weaning weights are not different in the 30-day analysis ($P = 0.42$) but tend to differ in the 45-day analysis ($P = 0.18$), while differences between the overall means is significant ($P = 0.04$). Calving rates, when expressed on a per heifer exposed basis, tend to differ (14.2% difference between systems; $P = 0.19$) in the 30-day analysis, a result of the lower first-calf pregnancy rate between the two systems at 30 days. By 45 days, the trend diminishes and calving rate at 45 days and overall are not different. Calving rate, expressed on a per pregnant heifer basis, tends to be different at 30 ($P = 0.15$) and 45 days ($P = 0.17$). Weaning rate does not differ between systems across all analyses, and is not affected by calculation method. Lastly, percent of heifers remaining in the herd as pregnant two-year old cows does not differ in any of the analyses; however, the RLX system does improve from a 8.3% deficit in the 30-day analysis to a 2.3% increase over the INT system in the overall analysis.

Table 3. Total and net costs within each of the first two production years for cows developed in an intensive (INT; 55% MBW) or relaxed (RLX; 50% MBW) heifer development system that were bred in either 30, 45 or 60 (RLX only) days of the initial breeding season.

	RLX			INT	
Item	30 day	45 day	60 day	30 day	45 day
1st year cost					
Total development cost	$ 659	$ 659	$ 659	$ 683	$ 683
Net cost per bred yearling heifer	$ 709	$ 703	$ 695	$ 727	$ 720
2nd year cost					
Total 2-year cost	$1039	$1031	$1022	$1062	$1055
Net cost per bred 2-year old cow	$ 700	$ 693	$ 693	$ 725	$ 714

Economic Analysis

Results from the economic analysis using 30-day, 45-day, and overall means for each system are summarized in Table 3. Net cost to produce one bred yearling heifer decreased $6.00 in the RLX by extending the breeding season from 30 to 45 days, with an additional $8.00 savings by extending the season to 60 days. These savings are still evident after the second breeding season, with a reduction in $7.00 for the first 15-day extension; however, due to differences in weaning weights between the 45- and 60-day analysis in the RLX system, the cost to produce one bred 2-year-old remained the same when extending the breeding season from 45 to 60 days. Similar trends occurred in the INT system, with a $7.00 per bred yearling heifer and an $11.00 per bred 2-year-old cow savings by extending breeding from 30 to 45 days.

[1]Kelly Creighton, former graduate student; Jacki Johnson-Musgrave, research technician, West Central Research and Extension Center, North Platte; Terry Klopfenstein, professor, Animal Science, Lincoln; Richard Clark, professor, Agricultural Economics, Lincoln; Don Adams, professor, Animal Science, West Central Research and Extension Center, North Platte.

Effects of Supplemental Protein During Gestation and Grazing Sub-irrigated Meadow During the Postpartum Interval on Pregnancy Rates of Spring Calving Cows and Calf Growth

L. Aaron Stalker
Don C. Adams
Terry J. Klopfenstein[1]

Summary

A two year experiment evaluated the influence of supplemental protein during the last trimester of gestation and grazing sub-irrigated meadow during the postpartum interval on pregnancy rates and calf growth in a March calving production system. Supplemental protein during the last trimester did not improve subsequent pregnancy rate but resulted in increased carcass weight. Allowing cows to graze sub-irrigated meadow during the postpartum interval improved pregnancy rates but did not change steer performance in the feedlot. Feeding supplemental protein during the last trimester of gestation and allowing cows to graze sub-irrigated meadow were both economical methods of improving production.

Introduction

One goal of cow/calf production systems is to optimize economic efficiency. A commonly recommended method of improving economic efficiency is to reduce cost of production. Integrated resource management data shows that the most profitable cow/calf producers are those with the lowest variable costs; however, incurring variable costs is justified if the increased cost yields returns of greater value.

Two key times in extended grazing cow/calf production systems are the last trimester of gestation and the postpartum interval. During the last trimester of gestation, nutrient requirements increase due to fetal growth and forage quality may not adequately meet requirements in spring calving systems. Additionally, postpartum conception is influenced by nutritional status at the start of the breeding season. Producers may choose to intervene by supplementing the diet with protein (the most limiting nutrient in dormant range) or allocating high quality forage resources to the cow/calf enterprise.

Our objectives were to determine if the additional costs of supplemental protein during the winter and high quality forage during the postpartum interval were justified by increased pregnancy rates and calf growth performance though out its life.

Procedure

This study was conducted at the Gudmundsen Sandhills Laboratory, near Whitman, Nebraska over two years. One-hundred-thirteen cows per year were divided into eight native upland pastures (80 + 15 acre) during the winter in equal stocking rates. Half the cows were fed the equivalent of 1 lb/head/day of supplemental protein (32% CP) three times per week from December 1 through February 28.

Cows were managed in a common group during the calving season (March 1 to April 30) and fed 28 lb cool season grass hay. Average calving date was March 23. During the interval between calving and start of breeding (May 1 to May 31), half the cows were fed cool season grass hay and half grazed sub-irrigated meadow. At the start of breeding (June 1), treatment groups were combined and cows were managed as a single group for the remainder of the production cycle.

Calves were weaned the first week of October and two weeks later all steers were shipped 104 miles to a feedlot. Steers were fed in eight pens that corresponded to the winter pasture until the average 12th rib back fat of all steers was 0.5 inches.

Data were analyzed as a 2X2 factorial. No winter by spring treatment interactions were observed, therefore only main effects are reported.

Partial budgets were employed to examine the economic efficiency of both production practices and included only costs that differed between treatments. For both production practices, two budgets were created. One used value at weaning and one used carcass value so that differences in returns between treatments could be assessed at both endpoints. Ten year average prices were used to value calves, hay

(Continued on next page)

(*Crop and Livestock Prices for Nebraska Producers, 2003*) and grazing fee (*Nebraska Farm Real Estate Market Developments, 2002-2003*). Actual delivered price was used to value supplemental protein.

Results

Effects of supplemental protein during the last trimester of gestation and plane of nutrition during the postpartum interval on cow body condition score throughout the year are presented in Figures 1 and 2, respectively. Feeding supplemental protein during the last trimester of gestation increased body condition pre-calving ($P = 0.02$) and pre-breeding ($P = 0.005$) but did not change pregnancy rates ($P = 0.87$; Table 1). Cows grazing sub-irrigated meadow during the postpartum interval had greater body condition pre-breeding ($P < 0.01$) which resulted in a tendency for increased pregnancy rates ($P = 0.13$; Table 1).

Calves born to cows fed supplemental protein during the last trimester of gestation were heavier at weaning ($P = 0.08$), and had heavier carcass weights ($P = 0.07$; Table 1). No differences were observed in ADG ($P = 0.41$), DMI ($P = 0.24$), efficiency of gain ($P = 0.20$) or carcass quality (data not shown). It is possible that the increased weaning and carcass weights resulted from permanently changing the endocrine system of

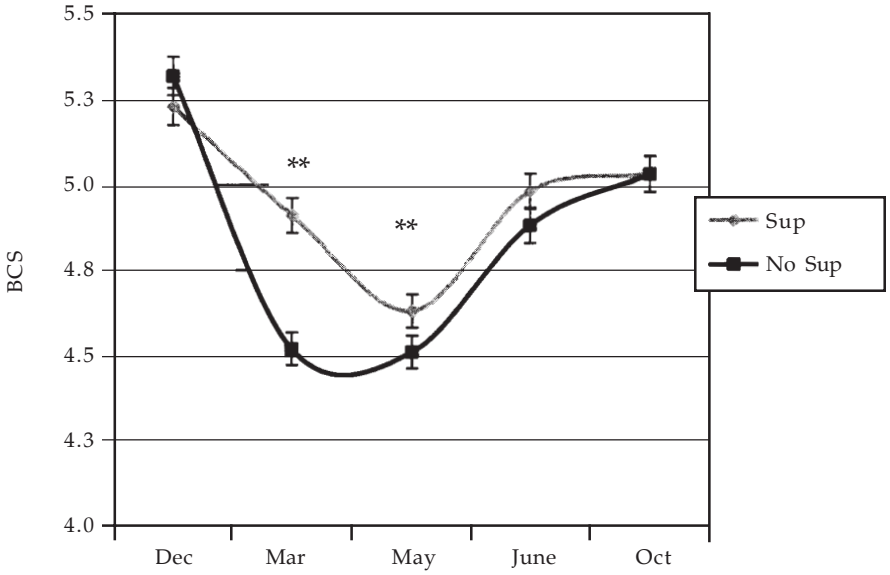


Figure 1. Effect of supplemental protein during the last trimester of gestation (December 1 to February 28) on cow body condition score (BCS).

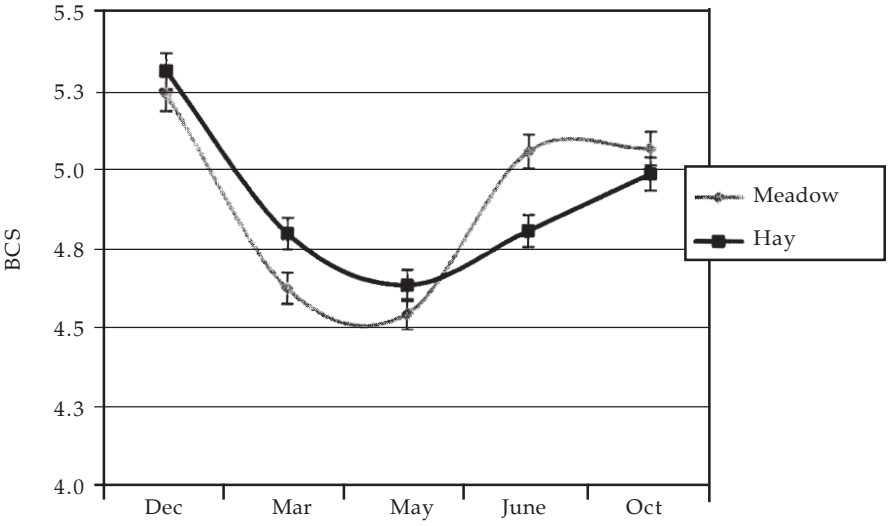


Figure 2. Effect of grazing sub-irrigated meadow or feeding grass hay during the postpartum period (May 1 to May 30) on cow body condition score (BCS).

Table 1. Effects of supplemental protein during the last trimester of gestation and grazing sub-irrigated meadow during the postpartum interval on pregnancy rates and calf growth.

	Treatment Main Effects[a]					Effect *P*-values	
Item	Supp	No Sup	Mead	Hay	SEM	Winter	Spring
Cow Performance							
Pregnancy Rate	0.906	0.901	0.928	0.880	0.021	0.87	0.13
Weaning Wt	469.6	455.0	469.5	455.0	5.28	0.08	0.08
Feedlot Performance							
Carcass Wt	810.5	788.8	802.2	797.1	9.83	0.14	0.72
ADG	3.51	3.46	3.47	3.49	0.06	0.41	0.74
DMI	18.8	18.0	18.5	18.4	0.43	0.24	0.87
Feed Efficiency	0.190	0.195	0.192	0.193	0.002	0.20	0.63

[a]No winter by spring treatment interactions were observed therefore only main effects are reported. Treatments were 1 lb/hd/day protein supplement vs. no supplement and grazing sub-irrigated meadow vs. feeding cool season grass hay.

the calf during gestation. The fetus is sensitive to the nutritional status of the mother and adjusts its development accordingly. Further research is addressing this issue. Weaning weight was increased ($P = 0.08$) but carcass weight was not different ($P = 0.72$) in calves that nursed cows grazing sub-irrigated meadow compared to calves nursing cows fed hay during the same time period. No differences were observed in ADG ($P = 0.74$), DMI (P = 0.87), efficiency of gain ($P = 0.63$) or carcass merit (data not shown).

Partial budget analysis showed that incurring both additional costs of feeding supplemental protein and grazing sub-irrigated meadow was profitable, regardless of endpoint. In the case of supplemental protein, returns were $4.66/head and $22.83/head greater at weaning and carcass endpoints, respectively. A dramatic increase in profit when calves were taken through the feedlot is a result of greatly increased carcass weight in steers born to cows fed supplement. The profit difference between endpoints shows that the majority of return on the investment in supplemental protein occurs in the feedlot. In the case of meadow grazing, returns were $30.48/head and $28.98/head greater at weaning and carcass endpoints, respectively. Increased returns were strictly a function of the increased pregnancy rate in meadow grazing cows.

Conclusion

Feeding supplemental protein during the last trimester of gestation to cows grazing dormant rangeland may be an economical method of increasing calf weight and the advantage is maximized when a carcass endpoint is used. Using sub-irrigated meadow to improve the nutritional plane of cows during the postpartum interval is an economical method of improving pregnancy rates in cows.

---

[1]Aaron Stalker, graduate student; Don Adams, professor, Animal Science, West Central Research and Extension Center, North Platte; Terry Klopfenstein, professor, Animal Science, Lincoln.

The Effects of Temperature and Temperature-Humidity Index on Pregnancy Rate in Beef Cows

Jamee L. Amundson
Terry L. Mader
Rick J. Rasby
Q. Steven Hu[1]

Summary

Ten years of records from a 150-head beef cow herd were used to determine the relationship of temperature and temperature-humidity index (THI) on pregnancy rate in beef cows. Pregnancy rate of the herd for the duration of the experiment averaged 92%. There was a linear relationship between average 30-day temperature and pregnancy rate during the first 30 days of the breeding season. Average THI greater than 65 for the first 30 days of the breeding season tended to decrease pregnancy rate in the first 30 days, but there was no effect on herd pregnancy rate. If the 60-day average THI was greater than 70, pregnancy rate for 60 days tended to decrease. Breeding season THI had no effect on pregnancy rate. High temperatures and high temperature-humidity index decrease the pregnancy rate during the first 30 days of the breeding season. Cows acclimate to environmental conditions and if the length of the breeding season is 60 days or more, pregnancy rate is not compromised.

Introduction

During the breeding season, conception, as well as embryo and fetal survival, are of concern in many cattle operations. Elevated ambient temperatures during the breeding season can decrease male and female fertility, reduce the duration of estrus, and lengthen the postpartum interval in multiparous cows. Heat stress also can delay puberty in heifers, cause anestrous in cows, depress estrus activity, induce abortions, and increase perinatal mortality. However, many studies evaluating environmental effects on conception rate are conducted using dairy cattle as the experimental unit. The reproductive response of dairy cows to heat stress may differ from that of beef cows due to differences in feed intake and genetics (Sprott et al., 2001 Prof. Anim. Scientist).

Many Nebraska cow herds are bred to calve in the spring. Consequently, breeding occurs in late spring through mid-summer when temperatures, combined with relative humidity, may reach levels that potentially affect reproductive performance. The objective of this study was to determine the effect of ambient temperature and humidity on reproductive performance of beef cows in a pasture setting.

Procedure

Ten years of calving records (1991-2000) from a spring-calving beef cow herd at the University of Nebraska Dalbey-Hallack Research Farm in Virginia, Nebraska were used to study the effects of temperature and humidity on reproductive performance. This research unit is located in southeast Nebraska. The herd consisted of about 150 commercial crossbred (1/2 Angus, 1/2 Continental) cows. All cows were managed similarly during the experimental period. Cows were bred using natural service while grazing mixed warm- and cool-season grasses. Length of the breeding season averaged 63 days for the ten years, beginning in late May and continuing through July. The bull to female ratio was maintained at 1:25.

Breeding date was estimated by subtracting 283 days from the recorded calving date. Pregnancy rate was determined by the number of cows bred during the breeding season divided by the total cows available to be bred. Pregnancy rates were totaled for the first 30 days, 60 days, and the entire breeding season and then regressed with average temperature and Temperature-Humidity Index (THI) for the corresponding time periods.

Weather data were compiled using the Great Plains Weather Archives for a station about 15 miles from the Dalbey-Hallack Farm. The weather history was downloaded in a daily format and included minimum and maximum temperature as well as average relative humidity. The average temperature and average relative humidity were used to calculate the THI for each day, using the following equation: $THI = Temperature - (.55 - (.55x (RH/100))) x (Temperature - 58)$. Average temperature and THI values were calculated for the first 30 days, 60 days, and entire breeding season and then correlated with pregnancy rate for each period.

The data were divided into four sets to evaluate temperature and THI effects on reproductive performance. The first data set consisted of all years and the general effects

Table 1. Mean of all 10 years and standard deviation (SD) of temperature, relative humidity, and THI for 30-day, 60-day, and the entire breeding season.

	30-day		60-day		Breeding Season	
	Mean	SD	Mean	SD	Mean	SD
Temp (°F)	68.3	7.9	71.9	7.7	72.1	7.7
Rel. Hum. (%)	71.1	14.1	72.6	12.2	72.7	12.1
THI	66.5	6.5	70.0	6.5	69.8	6.4

Table 2. Estimated influence of temperature (Temp, °F) on predicted change in pregnancy rate (PR) and their relationship.

Item	Predicted Change in PR (% per °F)	Relationship	
		R^2	*P*-value
30-day Temp and 30-day PR	-1.08	0.382	0.057
60-day Temp and 60-day PR	-0.70	0.169	0.238
Season Temp on Season PR	-0.18	0.016	0.728

Table 3. Estimated influence of temperature-humidity index (THI) on predicted change in pregnancy rate (PR) and their relationship.

Item	Predicted Change in PR (% per unit THI)	Relationship	
		R^2	*P*-value
30-day THI and 30-day PR	-1.38	0.437	0.037
60-day THI and 60-day PR	-0.90	0.169	0.238
Season THI on Season PR	-0.21	0.013	0.754

of temperature and THI on pregnancy rate for the first 30 days, 60 days, and entire breeding season were examined. The second data set examined effects in the first 30 days of the breeding season when the average THI for the 30 days was above a threshold of 65 and used six of the ten years of data. The third data set examined effects of a 60-day THI that averaged greater than 70 and used four of the ten years of data. The fourth data set evaluated effects of THI greater than 70 on pregnancy rate for the entire breeding season and used five of the ten years of data.

Results

Table 1 reports the average temperature, relative humidity, and THI for 30 days, 60 days, and the entire breeding season. The temperature and THI values increased as the breeding season progressed from May through July. This is a typical spring/summer climate trend for southeast Nebraska.

Table 2 shows the effect of temperature on pregnancy rate using all 10 years in the data set. Average 30-day temperature was correlated ($R^2 = 0.382$, $P = 0.057$) to pregnancy rate during the first 30 days of the breeding season and pregnancy rate decreased by 1.08% for every degree increase in temperature. Average temperature did not significantly affect pregnancy rate during the 60-day period or the entire breeding season.

Table 3 illustrates the effect of THI on pregnancy rate, using all 10 years in the data set. Pregnancy rate for the first 30 days was affected ($R^2 = 0.437$, $P = 0.037$) by 30-day THI. The 30-day THI decreased pregnancy rate by 1.38% per unit increase in THI. The 60-day and the entire breeding season THI model explained less than 20% of the variation in pregnancy rate. Even though the subsequent estrus occurred when THI values were greater than the previous values, the cows apparently acclimated and were able to become pregnant.

The effects of a 30-day pregnancy rate for those years in which the average 30-day THI exceeded 65 are illustrated in Table 4. During the four years in which the 30-day THI was less than 65, pregnancy rate was not affected by THI; however, during the six years in which the 30-day THI average was greater than 65, pregnancy rate tended to be reduced ($P = 0.078$). Cows appeared to be susceptible to heat stress during the first 30 days of the breeding season, when the THI average was greater than 65 for that period and resulted in a 1.60% decrease in pregnancy rate per unit increase in THI ($R^2 = 0.581$). However, when the first 30 days of the breeding season had a THI greater than 65, beef cows appeared to acclimatize to the environmental conditions and became pregnant in subsequent breeding opportunities that occur later in the breeding season. This became evident when the 60-day and entire breeding season THI model only explained 15% (60-day) and less than 1% (breeding season) of the variation in pregnancy rate.

These results suggest cows have the ability to physiologically adjust to the environmental changes throughout the breeding season. If the environmental changes are extreme and rapid, the cows may not be able to adapt to the conditions and reproductive performance is impaired. Producers considering shortening the breeding season in late spring to early summer may compromise pregnancy rates during hot, humid years. Allowing cows more estrous cycles and a chance to acclimate to gradual changes in weather conditions will not likely compromise reproductive performance.

(Continued on next page)

Table 5 shows the effects of a 60-day THI greater than 70. A breeding season THI greater than 70 had no effect ($P = 0.230$) on overall pregnancy rate. The breeding season was about 3 days longer than the 60-day period; therefore, the breeding season results resemble that of the 60-day data. These data suggest that even if the THI is high during the breeding season and the breeding season is at least 63 days in length, cows will acclimate and pregnancy rates will not be reduced.

It is important to note that no other treatments were induced on the cows included in this study, and all cows were managed in a similar manner throughout 10 years, so the correlations between pregnancy rate and weather parameters were not confounded by other treatments.

Table 4. Estimated influence of 30-day temperature-humidity index (THI) > 65 on predicted change in pregnancy rate (PR) and their relationship.

Item	Predicted Change in PR (% per unit THI)	Relationship	
		R^2	*P*-value
30-day THI and 30-day PR	-1.60	0.581	0.078
60-day THI and 60-day PR[a]	-0.91	0.152	0.445
Season THI on Season PR[a]	0.25	0.014	0.824

[a]For years when previous 30-day average THI was > 65.

Table 5. Estimated influence of 60-day temperature-humidity index (THI) > 70 on predicted change in pregnancy rate (PR) and their relationship.[a]

Item	Predicted Change in PR (% per unit THI)	Relationship	
		R^2	*P*-value
60-day THI and 60-day PR	-3.15	0.843	0.082
Season THI on Season PR[b]	-0.92	0.582	0.237

[a]Effects of breeding season THI > 70 were not significant (R^2 =0.430, P =0.230).
[b]For years when previous 60-day THI was greater than 70.

Implications

Date of breeding season

Producers may consider moving the breeding season earlier in the spring so the middle of the breeding season does not occur during the months that are hot and/or humid, such as July and August. By initiating an earlier breeding season, producers may avoid the negative effects of high THI conditions during the early part of the breeding season on reproductive performance. However, when moving the breeding season, producers must consider the additional costs of increased feed requirements when starting the breeding season before spring pastures are available.

Length of breeding season

The cows in this study had a reduced pregnancy rate for the first 30 days of the breeding season when the weather was hot and humid, but pregnancy rates for 60 days or greater were not affected by THI. These results indicate beef cows can acclimate to high temperatures and humidity if given enough time with the bull. In an effort to reduce the length of the calving season, some producers will shorten the breeding season to 45 days. These data suggest a 45-day breeding season may be too short and will reduce pregnancy rates, especially where the breeding season overlaps with hot, humid weather conditions.

[1]Jamee Amundson, graduate student; Terry Mader, professor, Animal Science, Haskell Ag Lab, Concord, Northeast Research and Extension Center; Rick Rasby, professor, Animal Science, Lincoln; Steve Hu, associate professor, Natural Resources, Lincoln.

Effects of Dried Distillers Grains Supplementation Frequency on Heifer Growth

L. Aaron Stalker
Terry J. Klopfenstein
Don C. Adams[1]

Summary

Dried distillers grains were fed as an energy source to growing heifers as a supplement to grass hay. Heifers were fed the equivalent of 3 lb/head daily, either three or six times per week of the same supplement. Heifers fed dried distillers grains six times per week gained more weight than heifers fed three times per week but those fed three times per week had greater allantoin to creatinine ratios. Better animal performance may result from more frequent supplementation of dried distillers grains.

Introduction

As the corn milling industries continue to expand, an increased availability of distillers grains is expected. Dried distillers grains (DDG) are appropriate for forage based production systems when forage quality is poor (winter) or quantity is limiting (drought). Dried distillers grains are considered a protein supplement when fed at less than about 15% of the diet DM and as an energy source when fed at levels greater than 15% of the diet. Energy supplied by DDG is in the form of digestible fiber and fat (*1996 Nebraska Beef Report*, pp. 65-66) making its energy value superior to corn in forage based diets (*2003 Nebraska Beef Report*, pp. 8-10). Dried distillers grains contain approximately 65% undegraded intake protein (% of CP), consequently forage based diets that include dried distillers grains fed as an energy source are commonly deficient in degradable intake protein (DIP) but contain excess metabolizable protein (MP). However, recent studies indicate adding urea to meet the degradable intake protein requirement is not necessary when dried distillers grains are fed as an energy source in forage based diets (*2004 Nebraska Beef Report*, pp. 20-21). The objective of this experiment was to determine the influence of supplementation frequency of dried distillers grains fed as an energy source without added urea on weight gain in heifers.

Procedure

Forty-eight crossbred heifers (425 + 44 lb) were stratified by weight then assigned randomly to one of eight pens. Pens were then assigned randomly to one of two supplement treatments. Heifers were fed for ad libitum consumption of grass hay (53% TDN, 6.6% CP) and supplemented with the daily equivalent of 3 lb (DM) DDG/head either three or six times per week. Supplement composition is listed in Table 1. Heifers were fed DDG Monday through Saturday or on Monday, Wednesday and Friday. Heifers were weighed on two consecutive days at the beginning and end of the 84-day trial without limiting intake prior to weighing. Beginning on day 55 of the experiment, approximately 50 mL of urine was spot collected from each heifer for three consecutive mornings. Urine samples were composited by animal and analyzed for allantoin and creatinine concentrations by high performance liquid chromatography. The ratio of allantoin to creatinine is indicative of the amount of microbial crude protein produced (*2004 Nebraska Beef Report*, pp. 20-21).

Feedstuffs used in the trial were analyzed for DM, OM, CP and IVDMD (Table 2).

Data were analyzed using pen as the experimental unit.

Results

Heifers fed distillers grains six times per week gained more weight than heifers fed three times per week (Table 3). One explanation for reduced gain in less frequently supplemented heifers is ruminal fat concentration. Distillers grains are approximately 10% fat and feeding three times per week at the levels used in this experiment would result in dietary fat concentration of 5.4% on the day of supplementation. High levels of fat in the diet depress fiber digestion via negative effects on ruminal microorganisms. Theoretically allantoin to creatinine ratios are indicative of microbial growth in the rumen and if fat content of the diet is the reason for decreased gains in the infrequently supplemented treatment a decreased allantoin to creatinine ratio would be expected. However, the ratio of allantoin to creatinine was greater in the infrequently supplemented group. This apparent inconsistency may be a result of the short (three day) urine collection period in relation to the supplementation schedule. Supplement was fed on Monday and Wednesday and urine was collected Tuesday through Thursday. Increased concentrations in the infrequently supplemented treatments would be expected if allantoin and creatinine concentrations in the urine were reflective of the previous day's diet.

(Continued on next page)

Table 1. Ingredient composition of supplement (%DM) used to determine the influence of dried distillers grain supplementation frequency.

Ingredient	% of Supplement[a]
Dry distillers grains	94.20
Molasses	2.90
Limestone	1.60
Salt	1.00
Trace mineral premix	1.16
Vitamin premix	0.06

[a]Supplement comprised 30% of the diet.

Table 2. Chemical composition (+ SD) of feedstuffs used in Experiment 1.

Item	Grass Hay	Dried Distillers Grains
DM, %	95.9 + 0.0003	92.1 + 0.0009
OM, %	90.2 + 0.0004	97.7 + 0.003
IVDMD, %	53.4 + 0.035	——
CP, %DM	6.7 + 0.002	34.1 + 0.265

Table 3. Performance and allantoin to creatinine ratios in urine of animals fed the daily equivalent of 3 lb (DM) dried distillers grains either 3 (3X) or 6 (6X) times per week.

	Treatment			
Item	3X	6X	SEM	*P*-value
Initial BW, lb	426	424	1.22	0.420
Final BW, lb	559	571	1.93	0.005
ADG, lb	1.58	1.74	0.031	0.010
Allantoin: creatinine	1.29	1.20	0.026	0.050

It is also possible that additional refinements to the technique of using allantoin to creatinine ratios need to be made before it can be used as an effective research tool. Other explanations for decreased gains in the infrequently supplemented treatment include decreased forage intake and inefficient nitrogen recycling. Decreased forage intake has been observed when high levels of distillers grains are fed in high forage diets (*2003 Nebraska Beef Report*, pp. 8-10). Also, efficiency of nitrogen recycling is inversely related to nitrogen intake. It is possible that inefficiency of nitrogen recycling in infrequently supplemented heifers created a degradable protein deficiency.

In conclusion, heifer gain was greater when dried distillers grains were fed six times compared to three times per week.

[1]Aaron Stalker, graduate student; Terry Klopfenstein, professor, Animal Science, Lincoln; Don Adams, professor, Animal Science, West Central Research and Extension Center, North Platte.

Reproductive Response in Heifers Fed Soybeans During Post Weaning Development

Heidi L. Harris
Andrea S. Cupp
Kelly W. Creighton
Rex L. Davis
Jim R. Teichert
Rick N. Funston[1]

Summary

Three experiments were conducted to determine effects of soybeans on reproduction in heifers. In Experiment 1, heifers received whole soybeans or control diet with wet corn gluten feed for 110 days. Heifers receiving soybeans had decreased synchronization rate and delayed estrous response. Diet did not affect AI conception, AI pregnancy, or final pregnancy rates. In Experiments 2 and 3, heifers received supplements of ground soybeans or dried distillers grains. Heifers in Experiment 2 were predominantly prepubertal and supplemented 161 days. Heifers in Experiment 3 were postpubertal and supplemented 30 days. Heifers fed soybeans had larger dominant follicles than those fed distillers grains.

Introduction

Fat supplementation has been shown to have positive reproductive effects independent from the energy contribution. In previous research conducted with pregnant and postpartum beef females, fat supplementation improved first service conception rates when fed prepartum, decreased the duration of the anestrous period, and increased circulating levels of reproductive hormones. Supplemental fat has been reported to increase the lifespan of an induced corpus luteum and increase the number and size of follicles on the ovary. Research on supplemental fat in heifer development diets is limited and results have been inconclusive. Soybeans are a locally produced crop high in fat. Therefore, the objectives of this study are 1) to determine the effects of supplemental fat (soybeans) on reproductive characteristics in developing heifers, and 2) to determine the effect of reproductive status (prepubertal vs. postpubertal) on response to fat supplementation.

Procedure

Experiment 1

The objective of the first experiment was to determine how soybeans in heifer development diets would affect 1) pubertal status 2) response to estrous synchronization 3) AI conception rate, and 4) overall pregnancy rate. One-hundred-four crossbred virgin beef heifers weighing 659 lb at 10 months of age were allotted by weight and randomly assigned to receive one of two diets (Table 1). Heifers received either 3 lb of whole raw soybeans (SB) as part of a total mixed diet (4% added fat) or a control diet containing wet corn gluten feed (WCGF; 2% fat). Diets were formulated to be isocaloric and isonitrogenous and fed for 110 days.

Two blood samples were taken 7 days apart before and during the feeding period and a single sample on day 110 to determine cycling status. Body weights were determined at the time of blood collection. Heifers in both groups were synchronized using 14-day melengestrol acetate (MGA, 0.5 mg/day) treatment 19 days before prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$) injection (25 mg) given on day 110 of the trial. Heifers were artificially inseminated (AI) 12 hours after visual detection of estrus. Bulls were placed with heifers 10 days after the last AI day for a 60-day breeding season. Pregnancy to AI was detected using ultrasonography 45 days after the last AI.

Experiment 2

The objective of Experiment 2 was to determine the effects of feeding soybeans to prepubertal heifers. Fifty crossbred virgin beef heifers weighing 463 lb at nine months of age were randomly assigned to one

(Continued on next page)

Table 1. Soybean and control diets, Experiment 1.

Ingredient, % of diet (DM)	Control Diet (2% added fat)	Soybean Diet (4% added fat)
Corn silage	48.7	54.5
Wheat straw	14.2	32.7
Whole soybeans	0	10.4
Wet corn gluten feed	13.4	0
Brome grass hay	21.4	0
Supplement	2.3	2.3
CP	11.2	10.8
TDN	65.3	64.2

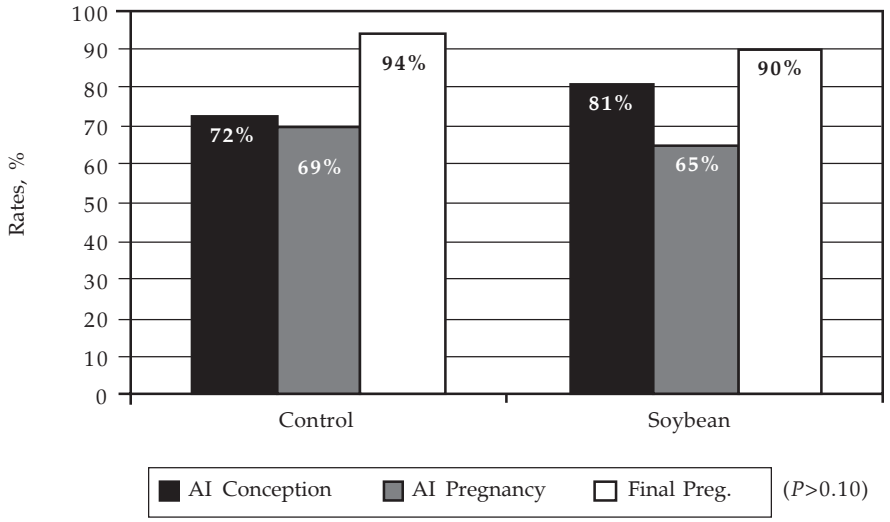


Figure 1. Artificial insemination (AI) conception, AI pregnancy, and final pregnancy rates, Experiment 1.

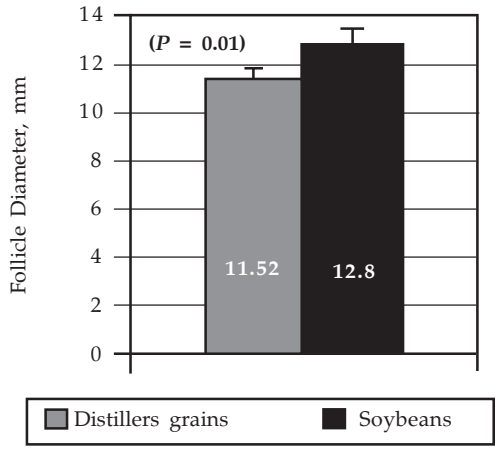


Figure 2. Follicle diameter, Experiments 2 and 3 combined.

of two treatment groups and to one of two pens per group. All heifers were fed ad libitum late harvested Sandhills meadow hay (9% CP) and supplemented with either 3 lb raw soybeans ground with 1 lb corn (SB; 17% fat) or 4 lb dried distillers grain (DDG; 11% fat) for 83 days. Both supplements were 31% CP and were approximately isocaloric. On day 84, heifers in both groups were put on native Sandhills pasture and supplementation continued for 78 days. Two blood samples were taken seven days apart before and during the feeding period to determine cycling status. Body weights were determined at the time of blood collection, and a final weight was taken on day 146.

Heifers were synchronized with two injections of $PGF_{2\alpha}$ 14 days apart. Blood samples were taken 48 and 60 hours after the second $PGF_{2\alpha}$ injection (given day 146). Sixty hours after the second injection of $PGF_{2\alpha}$, ovarian follicular aspirations were collected using an ultrasound-guided vaginal probe. The diameter of the dominant follicle was measured before aspiration. Granulosa cells were harvested from follicular fluid, follicular fluid and granulosa cells were then frozen until subsequent analysis. Fourteen days after aspirations were performed (day 161), supplements were discontinued and bulls were placed with all heifers for a 45-day breeding season. Pregnancy was determined by ultrasonography approximately 45 days after the end of the breeding season.

Experiment 3

The objective of Experiment 3 was to examine the effects of short-term soybean supplementation on ovarian follicle characteristics in postpubertal heifers. Twenty crossbred virgin beef heifers weighing 780 lb were randomly allocated to

one of two treatments and individually fed the same supplements as in Experiment 2. The experimental period was 30 days. Follicular aspirations were performed by the same procedure as in Experiment 2.

Results

Experiment 1

Heifers weighed 825 lb at the time of $PGF_{2\alpha}$ injection and ADG did not differ between groups throughout the experimental period (1.25 lb/day). Treatment did not affect cycling status at any time point measured. At the initiation of the feeding period, 82% of the heifers were cycling. Ninety-eight percent had reached puberty by day 55-62 of treatment, and all heifers had cycled at least once by the end of the experimental period. More ($P < 0.05$) heifers on the control diet (96%) exhibited estrus during the four-day breeding period compared to heifers fed soybeans (81%). Among the heifers fed soybeans and exhibiting estrus during the synchronization period, there was a delay in the average time of estrus compared to the control group (3.2 days vs. 2.9 days for SB and control, respectively; $P = 0.05$). Diet did not affect the percentage of synchronized heifers becoming pregnant to AI (AI conception rate), the percentage of heifers in each group becoming pregnant to AI (AI pregnancy rate), or the percentage of heifers in each group becoming pregnant to AI or natural service (final pregnancy rate; $P > 0.10$; Figure 1).

The reason for the reduced synchronization rate and delay in estrus is not known; however, upon analysis of soybeans by high performance liquid chromatography, three phytoestrogens were detected: 1) genistein at 1095 ppm, 2) daidzein at 940 ppm, and 3) glycitein at 100 ppm. The combination of these phytoestrogens may have altered reproductive response in heifers fed soybeans.

Experiment 2

Thirty-eight percent of the heifers were cycling at the beginning of the feeding period and 90% had become pubertal by day 80-87 of treatment. Diet did not affect pubertal status at this time. Heifers receiving DDG supplement were heavier than SB supplemented heifers at the end of the feeding period (775 lb vs. 738 lb, respectively; $P < 0.05$) and had a higher ADG throughout the experimental period (2.08 lb/day vs. 1.83 lb/day for DDG and SB, respectively; $P < 0.01$). Final pregnancy rates were not affected by treatment (80% and 88% for DDG and SB, respectively).

Follicle Diameter, Experiments 2 and 3

There was no treatment × experiment interaction for follicular diameter; therefore, data from Experiments 2 and 3 were combined. Follicle diameter was larger in SB heifers than DDG heifers (12.8 vs. 11.52 mm, respectively; $P = 0.01$). It is not known whether the increase in follicular diameter is a response to greater levels of fat in the soybean supplement or due to phytoestrogens in the soybeans. The ovulation of larger follicles may result in formation of larger corpora lutea and greater progesterone production, which has been associated with higher conception rates.

In conclusion, soybeans may be a viable protein and energy source in heifer development diets, depending on availability and price. There also may be direct positive effects on reproduction due to ovulation of a follicle with greater diameter.

---

[1]Heidi Harris, graduate student; Andrea Cupp, assistant professor, Animal Science, Lincoln; Kelly Creighton, former graduate student; Rex Davis, Jim Teichert, beef unit; Rick Funston, assistant professor, West Central Research and Extension Center, North Platte.

The Effects of Dried Distillers Grains on Heifers Consuming Low or High Quality Forage

Sarah E. Morris
Terry J. Klopfenstein
Don C. Adams
Galen E. Erickson
Kyle J. Vander Pol[1]

Summary

Two forage sources, high and low quality, were used to evaluate effects of five levels of dried distillers grains on forage intake. Ninety heifer calves were fed high or low quality forage, supplemented with 0, 1.5, 3, 4.5, or 6 lb DM dried distillers grains. Forage intakes linearly decreased as dried distillers grains increased. Average daily gain increased linearly with increased dried distillers grains indicating that dried distillers grains can be a protein and energy supplement source and a substitute for forage. Dried distillers grains are an economical supplement to cattle on either high or low quality forage diets.

Introduction

Traditionally, cereal grains have been used to supplement cattle on forage based diets; however, due to the amount of starch in these grains, a negative associative effect has been seen between starch and forage digestibility, leading to overall depressed forage utilization. This depressed level of forage utilization is due to competition between amolytic microbes and cellulolytic microbes. The production of ethanol, through fermentation of the starch in grain, results in a by-product known as distillers grains. This by-product is a viable alternative to cereal grains because the starch has been removed, eliminating the starch and forage digestibility issues. Dried distillers grains (DDG) and/or DDG plus solubles (DDGS) are a feasible supplement for cattle producers not near ethanol plants because the dried by-product is easily transported and can be stored for an extended time. With increasing supplies of DDGS and increasing cost of forage (*2004 Nebraska Beef Cattle Report*, p. 25) we hypothesize that DDGS can substitute for forage. The objectives of this trial were to determine effects of increasing levels of DDGS on forage intake, predict forage intakes of grazing animals supplemented with DDGS, and evaluate the economical worth of supplementing DDGS.

Procedure

Experimental design, animal performance and forage intake

Ninety head of heifer calves (631 lb) were stratified by weight and then assigned randomly to one of ten treatments in a 2 × 5 factorial design. The diets consisted of either smooth brome grass hay (BROME), a low quality forage source (53% TDN), or alfalfa hay and sorghum silage mix (ALSS 60% and 40% mix, respectively), a high quality forage source (65% TDN). The BROME was used to simulate winter range or hay feeding. The ALSS was used to simulate grazed summer forage. These two forage sources simulated the differences in nutritive values between growing and dormant range. Diets were supplemented with one of five levels of DDGS: 0, 1.5, 3, 4.5, or 6 lb DM DDGS. Heifers were individually fed forage in Calan electronic gates ad libitum with their respective amounts of DDGS. The forage and DDGS were weighed separately, mineral supplement was weighed separately and mixed with DDGS, and placed in the bunks with the DDGS on top of the forage. The DDGS were placed on top of the forage so the heifers would eat DDGS before eating forage. Five days before and at the end of the 84-day experiment, heifers were limit fed. At the end of the limit feeding periods, heifer weights were recorded for three consecutive days. Additional weights were obtained beginning on day 46 for three consecutive days. Orts were collected weekly. Total forage dry

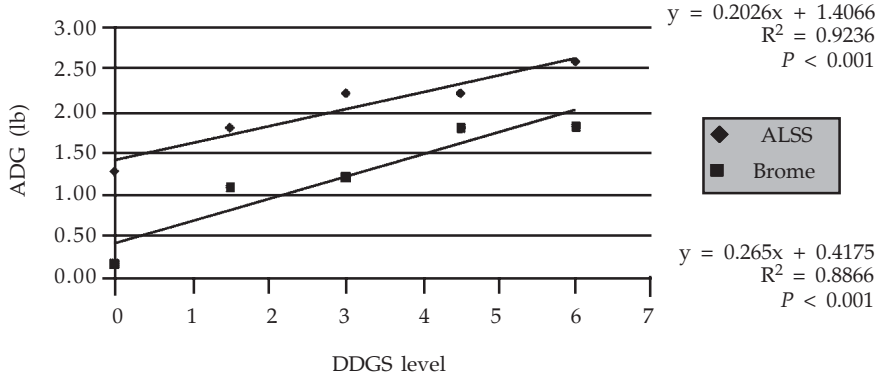


Figure 1. Average daily gain for both forage diets tested.

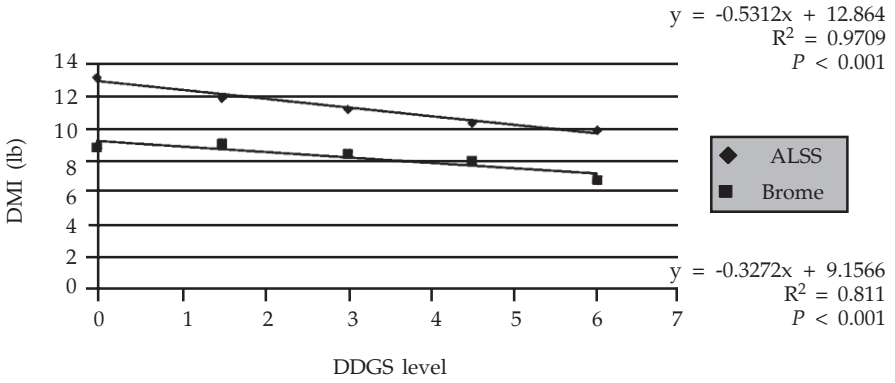


Figure 2. Dry matter forage intake for both diets tested.

matter intakes were determined from the trial based on dry matter offered (DMO) and orts, with the assumption that all DDGS were consumed. Impact of the five levels of DDGS on forage intakes was analyzed, as well as differences between the forage sources.

Economical analysis

The value of supplementing DDGS was determined by combining the values of the additional gain obtained and the decreased forage intake. The additional gain was valued by determining the income from selling the additional weight at the end of the grazing period. The selling price was estimated using the following regression equation $y = 0.00005x2 - 0.1071x + 127.3$ where y = price paid and x = animal weight. This equation was previously developed from the September-October average of feeder calf prices from 1992 to 1999. This equation relates well to actual prices (r = 0.987) and accounts for price slide of heavier cattle selling for less money per hundred weight. The forage replaced by DDGS was valued at the 10-year average for Nebraska, for brome hay ($64/ton dry matter) and alfalfa hay ($70/ton dry matter).

Results

Average daily gain and total forage intake

Average daily gain was significantly different ($P < 0.001$) between forage diets. Heifers on ALSS and BROME control diets gained 1.41 and 0.42 lb/day, respectively. Average daily gain for both diets linearly increased as level of DDGS increased (Figure 1). The rate of increase in gain was greater for the BROME diet (0.265 lb per lb DDGS) than for the ALSS diet (0.20 lb per lb DDGS). Forage intakes were significantly different between forage sources ($P < 0.001$). Control heifers on ALSS diets consumed 12.6 lb/day DM in contrast to controls on BROME diets consuming 9.5 lb/day DM. Forage intake linearly decreased as level of DDGS increased (Figure 2). The rate of decline was greater for the calves fed ALSS than those fed BROME (0.53 v 0.33 lb forage per lb of DDGS).

Both ADG and forage intake were significantly different ($P < 0.001$) for the two types of forage. The two qualities of forage were selected to simulate range-like conditions, so that intakes could be projected for cattle grazing range at different times of the year, for the spring/summer with the high quality forage and fall/winter with the low quality forage. The higher ADG and forage intake, seen with the controls on the ALSS, are similar to what would be observed on spring/summer range. Cattle can consume more of the higher quality forage and digest it more rapidly, resulting in increased animal performance. In contrast to the ALSS group, ADG and forage intake were lower ($P < 0.001$) for animals on the control for BROME. Decreased forage intake resulting in decreased animal performance is typical of animals grazing dormant or winter range. Cattle on winter range may perform poorly because they cannot consume enough of the highly lignified forage to meet their requirements.

Economical analysis

Supplementing DDGS to cattle on either high or low quality forage diets appears to be profitable through increased selling weight and decreased forage costs. Tables 1 and 2 show the values of all levels

(Continued on next page)

Table 1. Value of dried distillers grains and solubles (DDGS) due to improved animal performance (IAP) and reduced forage intake (RFI) with the high quality forage, alfalfa sorghum silage (ALSS).

Supplemental DDGS, lb per day (DM):	0	1.5	3.0	4.5	6
Beginning wt, lb[a]	631	631	631	631	631
End wt, lb[b]	749	775	800	826	851
Sale price, $ per 100 lb[c]	75.13	74.34	73.61	72.96	72.36
Revenue, $[d]	562.82	575.88	589.07	602.42	615.99
DDGS value from IAP, $ per ton[e]		207.39	208.34	209.54	211.01
DDGS value from RFI, $ per ton[f]		30.10	30.10	30.10	30.10
Total DDGS value, $ per ton[g]		237.49	238.44	239.64	241.11

[a]Average start weight for this trial.
[b]Expected weight after 84 days based on the equation $y = 0.20x + 1.41$ where y = ADG and x = DDGS intake.
[c]Sale price per 100 lb determined from the equation $y = 0.00005x2 - 0.1071x + 127.3$ where y = sale price and x = sale weight.
[d]Revenue determined by multiplying end weight and sale price/100.
[e]DDGS value (DM) due to improved animal performance. Calculated from additional revenue over 0 DDGS.
[f]DDGS value (DM) due to reduced forage intake assuming a forage cost of $70.00 per ton dry matter.
[g]Total DDGS value (DM) from IAP + RFI.

Table 2. Value of dried distillers grains and solubles (DDGS) due to improved animal performance (IAP) and reduced forage intake (RFI) with the low quality forage, smooth brome hay (BROME).

Supplemental DDGS, lb per day (DM):	0	1.5	3.0	4.5	6
Beginning wt, lb[a]	631	631	631	631	631
End wt, lb[b]	666	669	733	766	800
Sale price, $ per 100 lb[c]	78.15	76.85	75.67	74.59	73.63
Revenue, $[d]	520.51	537.54	554.51	571.55	588.77
DDGS value from IAP, $ per ton[e]		270.25	269.87	270.07	270.87
DDGS value from RFI, $ per ton[f]		27.52	27.52	27.52	27.52
Total DDGS value, $ per ton[g]		297.77	297.39	297.59	298.39

[a]Average start weight for this trial.
[b]Expected weight after 84 days based on the equation $y = 0.27x + 0.42$ where y = ADG and x = DDGS intake.
[c]Sale price per 100 lb determined from the equation $y = 0.00005x2 - 0.1071x + 127.3$ where y = sale price and x = sale weight.
[d]Revenue determined by multiplying end weight and sale price/100.
[e]DDGS value (DM) due to improved animal performance. Calculated from additional revenue over 0 DDGS.
[f]DDGS value (DM) due to reduced forage intake assuming a forage cost of $60.00 per ton dry matter.
[g]Total DDGS value (DM) from IAP + RFI.

of DDGS with the high- and low-quality forage diets, respectively. Supplementation of DDGS at any level with either high- or low-quality forage appears to be more profitable than not supplementing at all; however, the DDGS are valued higher with the low quality than with the high quality forage. Total DDGS value averaged over all levels was $298 and $237, respectively. These values depend on the values placed on the forage. Grazed forages would be somewhat less expensive and would lower the value of the DDGS; however, most of the value was from increased cattle gains.

In conclusion, dried distillers grains appear to be a viable supplement to cattle on forage-based diets, resulting in increased animal performance and decreased forage intakes. These results suggest supplementing DDGS does not adversely affect forage digestibility, although digestibility was not directly measured. Forage intakes can be predicted for cattle on either high or low quality forage diets supplemented with up to 6 lb DM DDGS. Economically it appears to be advantageous to supplement DDGS to cattle on either low or high quality forage diets; however, the value of the DDGS is higher when supplementing low quality forage diets.

---

[1]Sarah Morris, graduate student; Terry Klopfenstein, professor; Galen Erickson, assistant professor, Kyle Vander Pol, research technician, Animal Science, Lincoln; Don Adams, professor, Animal Science, West Central Research and Extension Center, North Platte.

Tree Growth and Cattle Weight Gain in a Ponderosa Pine System

Jim R. Brandle
Jeremy T. Hiller
Casey B. Wilson
Terry J. Klopfenstein[1]

Summary

Integrated timber and livestock systems (silvopastoral) are common in several regions of the United States. Grazing of three timber stands in eastern Nebraska showed no signs of tree damage due to rubbing or soil compaction. Steer gains were lower under the silvopastoral system compared to a typical pasture system (1.05 lb/day versus 1.70 lb/day). Growth of timber in silvopastoral stands was reduced (35.0 cubic feet per year versus 37.8 cubic feet per year); however, total productivity of the silvopastoral system (timber plus livestock) was greater ($20.98/acre) than with traditional timber systems.

Introduction

Silvopastoral systems are defined as the intentional integration of timber and livestock production. They are common in the pine forests of the southeastern United States, the conifer forests of the Pacific northwestern United States and are used in a number of situations in the Pine Ridge area of northwestern Nebraska. Several benefits are associated with the practice, foremost of which is the cash flow advantage of annual sale of cattle while the timber crop develops. In addition, there are direct benefits to tree growth due to the reduction in competition between the trees and understory vegetation for soil nutrients, water, and sunlight. Grazing is also a cost-effective method of control of the understory vegetation without the use of herbicides. From the forage perspective, shade and lower air temperatures tend to produce a higher quality forage. Cattle have the advantage of shade, reducing animal stress due to high temperatures. There are, however, several potential disadvantages of silvopastoral systems. Foremost is the concern of soil compaction and root damage due to grazing when the soils are wet. Cattle can damage trees by rubbing them, reducing the potential timber value, especially on fine hardwoods such as black walnut. If a forest system is overgrazed, forest reproduction may be damaged leading to a loss in forest diversity over the long term. However, with good management, cattle and timber production can be a profitable enterprise providing both short-term cash flow from livestock production and long-term capital gains from timber sales.

The purpose of this study was to demonstrate the interaction of cattle and trees in silvopastoral systems located in eastern Nebraska. Established initially as a demonstration site, our goal was to assess damage to two tree plantations — a scotch pine stand (*Pinus sylvestris L.*) and a green ash stand (*Fraxinus pennsylvanica Marsh.*) — by grazing livestock. As the study progressed, little damage was seen in either plantation. In 1999 the decision was made to conduct a preliminary study on a ponderosa pine (*Pinus ponderosa P. & C. Lawson*) stand to determine the effect of grazing on tree performance. The study objectives were redefined and data on tree growth and cattle performance were obtained and analyzed to determine the impact of grazing on tree and livestock performance. Only tree performance data from the ponderosa pine plantation are reported here. Cattle performance was based on the entire silvopastoral grazing period.

Procedure

Site Description

The study was conducted at the University of Nebraska Agricultural Research and Development Center (ARDC) Forestry Unit at Mead, Nebraska. The soil is a Sharpsburg silty clay loam with a 1% to 2% slope. The site is approximately nine acres and was planted to ponderosa pine (*Pinus ponderosa P. & C. Lawson*) in 1986 as part of a regional provenance test. The trees (one-year-old container grown seedlings) were planted in six replications on a 12-by-12-foot spacing in plots of 400 plants per replication (approximately 1.5 acres per replication). The site was sown to tall fescue in 1988. Since then, smooth brome grass has invaded the site and dominates most areas within the plantation. Replications 1 to 4 were thinned in the winter of 1997-98 following 10-year data

(Continued on next page)

collection for tree performance. Limited labor at the time restricted the ability to thin the remaining two replications, which were thinned in January 2001. The trees removed were selected based on tree performance and insect and disease resistance. The resulting stand is a savannah dominated by ponderosa pine and a mix of cool season grasses. Beginning in late April 2001, plots 1 to 4 were grazed by 6 head of steers for 52, 32, and 42 days in 2001, 2002, and 2003 respectively (Table 1). Cattle continued to be grazed on other silvopastoral sites, when not on ponderosa pine, from late April until early September of each year. Plots 5 and 6 were left ungrazed as a control.

Data Collection

Height and diameter at breast height (DBH; 4.5 feet above the ground) of the trees in all plots were measured following grazing in 2001, 2002 and 2003. If multiple stems occurred below 4.5 ft, the diameters of all stems were measured.

Silvopastoral grazing (SPG) steers were managed in the same system as control cattle in every year of this study. The only differences would be access to the SPG location during corn residue grazing and summer grazing. Control steers were a contemporary group utilized for grazing systems research in 2001 (*2003 Nebraska Beef Report,* pp. 65-68), 2002 and 2003 (*2005 Nebraska Beef Report,* pp. 68-72). Control steers grazed smooth brome grass from late April until mid May and warm season native range from mid May until September. Briefly, steers on the SPG study were received in November, weaned and placed on corn residue and allowed access to the SPG location from December until late February each year. Following corn residue grazing steers were placed in a drylot until SPG grazing was available. Following grazing, steers were placed in the feedlot and finished.

Table 1. Total grazing days for cattle on silvopastoral systems and the ponderosa pine silvopastoral plot.

Item	2001	2002	2003
Ponderosa pine (days)	52	34	42
Silvopastoral sites (days)	97	112	138

Table 2. Revenue generated with silvopastoral systems compared to trees alone.

	2001[a]		2002[a]		2003[a]	
	Gr[b]	UnGr[c]	Gr[b]	UnGr[c]	Gr[b]	UnGr[c]
Stem Vol. (ft^3/acre)[d]	152.0	201.3	186.1	235.4	222.0	276.9
Vol./year (ft^3/acre)[e]			34.1	34.1	35.9	41.5
Pulpwood ($/acre)[f]	23.16	30.67	28.35	35.86	33.82	42.18
Rev. Incr.($/acre/year)[g]			5.19	5.19	5.47	6.32
Cattle rev. ($/acre)	25.71		23.00		19.81	
Gr. Rev. Incr ($/acre)[h]	—		23.00		18.96	

[a]Tree measurements following grazing expressed as total amount.
[b]Gr (grazed) = Mean number of 66 Ponderosa pines per acre in the grazed plot
[c]UnGr (ungrazed) = Mean number of 98 Ponderosa pines per acre in the ungrazed plots
[d]Stem Vol. (volume) = stem only volumes calculated based on basal area and stem height
[e]Vol. (volume)/year = increase in tree volume from previous year.
[f]Pulpwood prices are the value of pulpwood per acre per year assuming a one time complete harvest, based upon volume per acre and pine pulpwood ($19.50/128 cubic feet) prices from the 2004 central timber market.
[g]Revenue increase per year from tree growth calculated as ((Vol./year/128 cubic feet) x $19.50).
[h]Gr. Rev. Incr. (Gross revenue increase) = revenue increase per year over timber alone; value based on differences in growth each year.

Table 3. Ponderosa pine stand characteristics[a].

Item	Gr[b]	SE	UnGr[c]	SE
			2001	
Trunk diameter (in)	7.2	0.8	6.8	0.9
Tree height (ft)	21.5	2.2	23.6	2.2
Basal Area (ft^2/acre)	20.9	5.0	25.8	7.1
Stem Vol. (ft^3/acre)[d]	152.0	29.9	201.3	41.6
			2002	
Trunk diameter (in)	7.7	0.9	7.1	1.0
Tree height (ft)	22.9	2.1	24.9	2.4
Basal Area (ft^2/acre)	24.1	6.1	28.6	7.7
Stem Vol. (ft^3/acre)[d]	186.1	41.1	235.4	56.6
			2003	
Trunk diameter (in)	8.17	1.0	7.6	1.1
Tree height (ft)	24.2	2.6	25.9	2.4
Basal Area (ft^2/acre)	27.2	6.8	32.3	9.0
Stem Vol. (ft^3/acre)[d]	222.0	46.4	276.9	61.2

[a]Tree measurements following grazing expressed as total amount.
[b]Gr (grazed), Mean number of 66 Ponderosa pines per acre in the grazed plot
[c]UnGr (ungrazed), Mean number of 98 Ponderosa pines per acre in the ungrazed plots
[d]Stem Vol. (volume) stem only volumes calculated based on basal area and stem height (Tree Volume = (Tree Basal Area × Tree Height ÷ 3)

Data Analysis

Data were analyzed to determine mean DBH, mean tree height, and basal area for each tree and for each replication. (Note: Basal area is the cross-sectional area of a tree at 4.5 ft. and is a common forestry measure of stand density.) In addition, stem volume per acre, stem volume increase per acre per year and

Table 4. Steer performance of silvopastoral and control cattle.

	2001		2002		2003	
	Silvopastoral	Control	Silvopastoral	Control	Silvopastoral	Control
Winter						
Days	154	154	141	141	135	135
Initial wt, lb	526	527	567	565	512	514
Daily gain, lb	1.61	1.41	1.74	1.50	1.79	1.83
Summer						
Days[a]	145	145	116	116	139	139
Initial wt, lb	774	740	813	777	762	761
Daily gain,lb	0.85	1.68	1.30	1.93	1.01	1.50
Finishing						
Days	86	86	92	92	82	82
Initial wt, lb	898	973	964	1002	903	970
Daily gain, lb	5.22	4.5	4.81	4.24	4.74	4.30
Final wt, lb	1351	1360	1418	1381	1292	1360
Economic analysis						
Break Even, $/cwt		64.11		64.97		63.26
Grazing value[b], $/hd	47.53		78.88		65.33	
P. Pine value[c], $/acre	25.71		23.00		19.81	

[a]Days grazed on the silvopastoral grazing location may be different due to steer management.
[b]Grazing value of the silvopastoral grazing location ((Silvopastoral final wt x Breakeven for control steers) - all cost, associated with silvopastoral system (not including grazing) = Grazing value for the silvopastoral area).
[c]P. Pine (Ponderosa Pine) value is the grazing value divided by total day on the ponderosa pine area.

approximate pulpwood value were calculated. The stem volume gains were compared within years and among treatments using 2001 tree measurements for each treatment as the starting value for comparisons. Additional revenue generated with the SPG steers was determined by evaluating the difference in economic value compared to the control cattle each year, using breakeven calculations as described in the *2001 Nebraska Beef Report*, pp. 29-34. Briefly, SPG final slaughter weights were multiplied by control cattle breakeven. This resulted in a steer value for SPG steers. Following this calculation, all costs associated with the SPG system except those associated with grazing were subtracted from steer value. The amount remaining after costs was then divided by total SPG days. This allocated a dollar value to the SPG area on a per steer basis.

Results

The analysis of tree response showed only small differences in stem volume increase between grazed and ungrazed plots (Table 2). While it is difficult to generalize these data to the long-term case, as most tree growth response studies typically run for a minimum of 10 years and usually 20 to 50 years, some observations are appropriate.

The initial differences (2001) in tree dimensions between grazed and ungrazed plots is likely not related to grazing. The differences in total tree growth (DBH, height and basal area) between grazed and ungrazed plots (Table 3) may be due to differences in thinning dates of ponderosa pine and may reflect a delayed response to drought conditions during the study period. However, the changes in stem volume in 2002 and 2003 are a valid evaluation of the impact on tree growth of cattle grazing in silvopastoral systems. The changes in stem volume per acre per year would suggest that grazing cattle in ponderosa pine has limited impact on total tree growth.

While there appears to be little difference in tree growth among the grazed and ungrazed plots, the effects upon the cattle were greater. Daily gains were lower during the summer grazing period when compared to control steers. The lower daily gains with the SPG system may be partially due to SPG pasture being dominantly cool season grasses. Cool season grass quality would decline during the warm summer months. The increased competition by the trees and grass for moisture during the summer months also may depress forage quantity and (or) quality. Control steers grazed warm season native range from late May until September. The improved forage quality during warm summer months with warm season grass may be responsible for the improved gain by control steers; however, the SPG steer gains were higher during the winter and feedlot periods when compared to control steers (Table 4). The SPG area may provide added protection that may benefit steer performance during the corn residue grazing portion of winter. Additionally, feedlot daily gains have been consistently higher following SPG. This increased gain may be compensation for the reduced summer gains. Breakeven averaged $64.11/cwt, giving grazing values of about $47 to $79 in the total silvopastoral grazing area. The value of the ponderosa pine area ranged from $20 to $26/acre.

The lower daily gains during summer grazing are offset by timber

(Continued on next page)

growth on the SPG area. When comparing SPG to grazing unfertilized smooth brome pastures, there is a 50% reduction in stocking rate. This reduction recognizes that unfertilized smooth brome pasture would supply 80 days grazing per steer per acre and that SPG supplies 43 days grazing per steer per acre on average. Fluctuating the stocking density utilized under SPG systems may be necessary depending on the stage of tree development. It may be beneficial to alter stocking rates as the tree stand density changes. As trees mature, the stocking rates may need to be reduced as tree canopy density increases, shading out the grass. However, as stands are thinned, grass production increases and stalking rate may be increased accordingly. Conducting grazing as it was in this study would not be recommended on trees less than five years old. Rapid grass removal may be conducted on tree stands as young as three years of age with minimal tree damage; however, tree species should be carefully evaluated prior to grazing.

Based on the average yearly volume increase of 37.8 cubic feet per acre with the ungrazed location and a value of $19.50 per cord of pulp wood (a cord is 128 cubic feet), we could expect an increase in gross return of $5.75 per acre per year (average increase in gross return over two years). However, combining the annual income from tree growth in the grazed areas and the additional return from livestock, the silvopastoral grazing system would provide $20.98 per acre per year additional income over timber stands alone (Table 3).

---

[1]Jim R. Brandle, professor; Jeremy T. Hiller, graduate student, AgroForestry, Lincoln; Casey B. Wilson, research technician, Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Determination of Undegradable Intake Protein Digestibility in Forages

Heather L. Haugen
Sarah K. Ivan
Terry J. Klopfenstein[1]

Summary

Digestibility of undegradable intake protein of smooth bromegrass, birdsfoot trefoil, and heat-treated alfalfa was determined using the mobile nylon bag technique. Undegradable intake protein (UIP) was determined using neutral detergent insoluble protein at 75% of the total mean retention time; 1.82 and 1.71 in June and July for brome and 1.30 and 1.94 in June and July for birdsfoot trefoil. Digestibility (%) of the UIP in brome was 38.6 and 27.1 in June and July and in birdsfoot trefoil 21.1 and 25.1. The UIP (% DM) of alfalfa dried to simulate dehydrated, sun-cured, and fresh alfalfa, was 3.13, 2.10, and 1.84. Digestibility (%) of UIP was highest for dehydrated (46.4) followed by sun-cured (25.6) and fresh alfalfa (14.7). The undegradable intake protein content and digestibility of the UIP of forages is low.

Introduction

Protein evaluation systems such as the NRC model for beef (1996) and dairy (2001) cattle recognize intestinal digestibilities of proteins may differ by source. Prior to the 2001 revision of the dairy NRC, a constant digestibility of 80% was used for the undegradable intake protein (UIP) of all feedstuffs. The 1996 beef NRC still uses a constant digestibility of 80% because of a lack of information available on UIP digestibility; however, the dairy NRC (2001) now uses variable digestibilities from 50% to 100%.

The length of incubation of forages in the rumen can significantly influence the measured intestinal digestibility of UIP because protein flowing from the rumen is greater at shorter incubation times and indigestible protein is the same. Many values reported in the literature for UIP and the digestibility of UIP in forages are based on ruminal incubations of 16 hours or less, which may not reflect true residence time of forage particles in the rumen. Digestibilities of UIP in forages might be overestimated when rumen incubations are too short. The objectives of the trial were: 1) to evaluate the protein characteristics of birdsfoot trefoil (BFT) and smooth bromegrass and 2) to determine the effect of heat treatment on the UIP content and digestibility in alfalfa.

Procedure

In the first experiment, birdsfoot trefoil and smooth bromegrass clip samples were collected from two fields on two dates (June and July, 2003) from a smooth bromegrass pasture interseeded with BFT at the University of Nebraska Agricultural Research and Development Center near Mead, Nebraska. Samples were frozen at -4ºC, freeze dried (–50ºC) for 72 hours, and ground through a 2 mm screen for in situ incubation and a 1 mm screen for laboratory analysis.

In vitro dry matter disappearance (IVDMD) was determined on samples and used to estimate the rate of passage (kp) of each of the forages using the following equation: $kp = 0.07 * IVDMD\ (\%) - 0.20$. The kp was then used to determine the mean retention time (MRT = 1/kp). A 10-hour passage lag was added to the MRT to yield the total mean retention time (TMRT).

Two ruminally cannulated heifers (1226 lb) were used to incubate 5 × 10 cm dacron bags with 50 µm pore size. Bags containing 1.25 g of air-dry forage ground through a 2 mm screen were heat-sealed. A mixed ration of 70% bromegrass hay and 30% concentrate was fed twice daily for a total intake of 1.5% BW. Duplicate bags were incubated at each time point and replicated over two days. Four 75% TMRT bags per heifer also were incubated on these two occasions for the intestinal incubation.

In vitro dry matter disappearance (%) of BFT in June and July was 74.5 and 64.4, respectively, which produced 75% TMRT incubation time points of 22.5 hours in June and 25.0 hours in July. Smooth bromegrass was incubated for 26.3 hours in June (59.9% IVDMD) and 28.9 hours in July (52.9% IVDMD), based on the calculated 75% TMRT. The 75% TMRT bags were washed in a washing machine for 0.25 hours using five rinse cycles consisting of a 1 minute agitation and a 2 minute spin following incubation in the rumen. Bags were subsequently refluxed in neutral detergent fiber solution to remove microbial contamination and determine the NDIN in the residue.

(Continued on next page)

Intestinal 75% TMRT bags were not washed but frozen until insertion into the duodenum. Ruminally incubated bags (75% TMRT) set aside for duodenal insertion were pre-incubated in a pepsin and HCl solution at 37ºC for 3 hours to simulate abomasal digestion. In Experiment 1, two duodenally cannulated steers (1305 lb) were used to incubate these bags over eight days. Steers were fed a mixed diet of 70% bromegrass hay and 30% concentrate twice daily at 1.5% of BW. Bags were inserted into the duodenum 2 hours post-feeding at a rate of 1 bag every 0.1 hour for a total of eight bags per steer per day. Bags were collected in the feces beginning 12 hours after insertion and frozen until all bags were collected. Bags were machine washed and refluxed in neutral detergent fiber solution to correct for microbial contamination of the forage residues. Residues were analyzed for N using a combustion method.

In a second experiment, alfalfa samples from plots fertilized with an average of 59 lb N/acre and 178 lb N/acre were used to evaluate effects of heat treatment and N fertilization on protein degradability in the rumen and the resulting digestibility of the UIP of alfalfa in the small intestine. Alfalfa was frozen at -4ºC until drying methods were applied. Drying methods were simulated in the laboratory and included sun-cured, dehydrated, and freeze-dried (fresh) alfalfa. Sun curing was simulated by drying the sample in a forced-air oven at 50ºC for 15 hours. The process of dehydration was simulated by drying the sample in a forced-air oven at 100ºC for 10 hours. Dry samples were ground through a 2 mm screen for in situ analysis and a 1 mm screen for lab analysis.

Two ruminally cannulated steers (1451 lb) fed a mixed ration of 65% alfalfa and 35% dry rolled corn twice daily for a total intake of 2% of BW were used to incubate quadruplicate 75% TMRT bags. Eight 75% TMRT bags were also incubated in the rumen in preparation for intestinal insertion. Dehydrated, sun-cured, and freeze-dried alfalfa averaged 70.0% IVDMD, and the calculated 75% TMRT point was 23.5 hours. Two duodenally cannulated steers (1451 lb) fed a mixed diet of 65% alfalfa hay and 35% dry rolled corn twice daily at 2% of BW were used to incubate bags over eight days. A total of 12 bags/steer were incubated each day at a rate of 1 bag every 0.1 hours. Bags were collected and handled as in Experiment 1.

Data were analyzed as a completely randomized design using the MIXED procedure of SAS with treatments set up in a 2 × 2 factorial arrangement with forage and date as fixed effects in Experiment 1. In Experiment 2, treatments were arranged in a 2 × 3 factorial with N level and heat treatment as fixed effects in the model. Animal, day, and week were treated as random effects in both experiments.

Table 1. Protein characteristics of smooth bromegrass and birdsfoot trefoil in June and July.

	Smooth Bromegrass		Birdsfoot Trefoil		
	June	July	June	July	SEM[a]
CP, % DM	15.9	9.9	24.7	16.1	
UIP, % DM[b]	1.82[f]	1.71[fh]	1.30[g]	1.94[fi]	0.08
TT IDP, % DM[c]	1.11[f]	1.24[g]	1.02[h]	1.45[i]	0.04
Digestibility of UIP, %[d]	38.6[f]	27.1[gj]	21.1[h]	25.1[ij]	1.8
DUIP, % DM[e]	0.70[f]	0.46[gj]	0.28[h]	0.47[ij]	0.04

[a]Standard error of the mean.
[b]Undegradable Intake Protein (UIP, % DM) = [NDIN at 75% total mean retention time (TMRT) * 6.25]/sample DM. Forage × Date $P < 0.01$.
[c]Total Tract Indigestible Dietary Protein (TT IDP, % DM) = (fecal NDIN * 6.25)/sample DM. Forage × Date $P < 0.01$.
[d]Digestibility of UIP = 1 - (TT IDP/UIP). Forage × Date $P < 0.01$.
[e]Intestinal Disappearance of UIP (DUIP, % DM) = UIP - TT IDP. Forage × Date $P < 0.01$.
[f,g,h,i,j]Means within a row with different superscripts differ ($P < 0.05$).

Table 2. Effect of heat treatment on the undegradable intake protein (UIP), total tract indigestible protein (TT IDP), and digestibility of UIP of alfalfa.

	Heat Treatment[a]			
	Dehydrated	Sun-cured	Freeze-dried	SEM[b]
CP, % DM	20.5	21.1	20.9	
UIP, % DM[c]	3.13[f]	2.10[g]	1.84[h]	0.08
TT IDP, % DM[d]	1.66[f]	1.54[g]	1.57[g]	0.04
Digestibility of UIP, %[e]	46.4[f]	25.6[g]	14.7[h]	1.8

[a]Heat Treatment applied: Dehydrated, 100ºC for 10 hours; Sun-cured, 50ºC for 15 hours; Freeze-dried, -50ºC for 72 hours.
[b]Standard error of the mean.
[c]Undegradable Intake Protein (UIP, % DM) = [NDIN at 75% total mean retention time (TMRT) * 6.25]/sample DM.
[d]Total Tract Indigestible Dietary Protein (TT IDP, % DM) = (fecal NDIN * 6.25)/sample DM
[e]Digestibility of UIP = 1 - (TT IDP/UIP).
[f,g,h]Means within a row with unlike superscripts differ $P < 0.05$.

Results

Protein characteristics of smooth bromegrass and BFT are shown in Table 1. There was a significant forage x date interaction ($P < 0.01$) for the UIP, IDP, digestibility of UIP, and DUIP in Experiment 1. Undegradable intake protein (% DM) of smooth bromegrass was similar

($P = 0.11$) in June (1.82) and July (1.71); however, the UIP (% DM) of BFT increased 49% from 1.30 in June to 1.94 in July ($P < 0.01$). Total tract IDP (% DM) of smooth bromegrass increased 12% from 1.11 in June to 1.24 in July ($P < 0.01$); however, the increase in IDP of BFT was greater (42%) as the IDP (% DM) in June and July were 1.02 and 1.45, respectively.

The tannin concentration of BFT in July may have protected a larger fraction of the CP later in the summer as the DUIP (% DM) was 0.47 percentage units in July but only 0.28 percentage units in June ($P < 0.01$). Tannins offer some protection from protein degradation in the rumen as a result of the tanning of proteins and inactivating enzymes. These tannin-protein complexes can potentially be digested in the lower tract. The increase in IDP in July for smooth bromegrass resulted in a reduction in DUIP (% DM) from 0.70 in June to 0.46 in July ($P < 0.01$). Digestibility (%) of the UIP in smooth bromegrass decreased from 38.6% in June to 27.1% in July, due to the increase in IDP. Even though the increase in IDP was larger in BFT in July, more UIP was flowing from the rumen, resulting in a tendency for the digestibility (%) of UIP to increase from 21.1 in June to 25.1 in July ($P = 0.07$).

Experiment 2

Adding heat during the drying process increased the flow of UIP from the rumen as the UIP of alfalfa increased with exposure to heat (Table 2). The UIP (% DM) of freeze-dried, sun-cured, and dehydrated alfalfa was 1.84, 2.10, and 3.13, respectively ($P < 0.01$). Indigestible protein (% DM) was not different in freeze-dried (1.57) and sun-cured alfalfa (1.56); however, the IDP of dehydrated alfalfa (1.66) was increased slightly above the other two drying methods ($P < 0.01$). There was a tendency ($P = 0.06$) for greater total tract IDP in alfalfa fertilized with high N (1.62) than with the low N level (1.57); however, this small increase in IDP did not adversely affect the digestibility of the UIP (data not shown).

The net effect of heat treatment on the digestibility of UIP was quite large as a result of the differences in UIP flowing to the small intestine. The digestibility (%) of the UIP in freeze-dried, sun-cured, and dehydrated alfalfa were 14.7, 25.6, and 46.4 ($P < 0.01$). The small increase in the IDP for dehydrated alfalfa was offset by the larger increase in the UIP flowing from the rumen and resulted in the higher digestibility of UIP. Compared to freeze-dried alfalfa, dehydrated alfalfa supplied 444% more protein in the small intestine.

Accurate UIP values of forages determined using appropriate incubation times of feeds in the rumen is a critical component in the determination of the digestibility of the UIP in forages. The heat-treated alfalfa used in the present study shows the effect of decreased ruminal degradability on lower intestinal tract digestibility values of the UIP fraction. The constant digestibilities used in current protein evaluation systems may be appropriate for concentrate feeds; however, these values appear to be too high for forages. The digestibility of the UIP in the forages in the current study was low, varying from 14.7% to 46.4%.

---

[1]Heather L. Haugen, graduate student; Sarah K. Ivan, former graduate student; Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Effects of Corn Moisture and Degradable Intake Protein Concentration on Finishing Cattle Performance

Josh R. Benton
Galen E. Erickson
Terry J. Klopfenstein
Casey N. Macken
Kyle J. Vander Pol[1]

Summary

A finishing trial was conducted to determine the effects of corn moisture and degradable intake protein level on cattle performance. Diets consisted of 65% processed corn, either dry-rolled, high-moisture at 24% or 30% moisture, or reconstituted dry corn at 28% or 35% moisture. Degradable intake protein levels were evaluated by adding 0%, 0.45% or 0.90% urea (DM basis). Supplementing 0.45% urea increased performance and sufficiently met degradable intake protein requirements. Diets containing high-moisture and reconstituted corn improved cattle performance compared to diets containing dry-rolled corn. Increasing the moisture of ensiled corn further enhanced the feeding value of corn by improving cattle performance.

Introduction

Feeding high-moisture corn (HMC) has been shown to be beneficial by improving cattle performance when compared to DRC in feedlot diets when byproducts are included. Previous beef finishing research (*2001 Nebraska Beef Report*, pp. 54-57) showed that intensive corn processing methods, such as high-moisture corn, increased degradable intake protein (DIP) requirements compared to DRC. Other Nebraska research has shown that including byproducts, such as wet corn gluten feed, increases the DIP requirement by increasing ruminal pH. Higher corn moisture and increased ensiling periods also may lead to increased digestion and DIP requirements by increasing the dry matter digestibility. Degradable intake protein is the fraction of crude protein available to the microbial population. A DIP deficiency can lead to limited microbial growth and reduced starch digestion. Therefore, a deficiency in DIP may result in reduced finishing cattle performance. Greater ruminal dry matter and starch digestion increases the DIP requirement. When the increased DIP requirements are met, cattle performance is improved.

The objectives of our research were to evaluate: 1) the feeding value of ensiled, high-moisture and ensiled, reconstituted corn at two moisture levels compared to DRC in a finishing diet, and 2) the effects of DIP concentration and DIP balance with the different corn treatments on cattle performance.

Procedure

Corn Harvest, Processing, and Storage

High-moisture corn was harvested at two times in September at 30% or 24% moisture (30HMC or 24HMC), coarsely rolled and stored in silo bags until feeding. Field-dried corn was harvested in mid-October. In late November, some of the dry corn was coarsely rolled and reconstituted (RECON) to 28% or 35% moisture (28RECON or 35RECON) and then stored in silo bags until feeding. The remaining dry corn was stored dry and coarsely rolled at time of feeding (DRC). The same hybrid was grown under irrigation in two similar fields at the Agriculture Research and Development Center near Mead, Nebraska.

The moisture at which HMC was harvested was lower than expected and that is why there is a difference in moisture between the HMC and RECON treatments. It is hard to meet the selected target for HMC with moisture equipment in the harvest machinery which is not well designed for higher moisture corns.

Feedlot Experiment

Four-hundred-and-eighty cross-bred yearling steers (743 lb) were used to compare the feeding value of HMC and RECON at two moisture levels and DRC. At the beginning of the feeding trial, HMC and RECON had been ensiled for at least 168 days. Cattle performance and DIP balance were evaluated. Steers were stratified by weight and assigned randomly to one of 60 pens (8 steers/pen) and the 60 pens were assigned randomly to one of 15 finishing diets (4 pens/diet). The treatment design was a 5 x 3 factorial with factors being corn type (24HMC, 30HMC, 28RECON, 35RECON or DRC) and DIP balance (NEG, ZERO or POS).

The three DIP balances were achieved by adding 0% (NEG), 0.45% (ZERO) or 0.90% (POS) urea

Table 1. Effects of moisture and harvest method on animal performance and carcass characteristics.

	Treatments[a]						
Item	DRC	24HMC	28RECON	30HMC	35RECON	SEM	*P*-value
Pens, n	12	12	12	12	12		
DMI, lb/day	24.4	24.4	24.2	23.9	23.5	0.2	0.06
ADG, lb	3.43[d]	3.53[de]	3.57[de]	3.68[e]	3.65[e]	0.06	0.02
Feed:gain[b]	7.14[d]	6.94[de]	6.77[e]	6.49[f]	6.45[f]		<0.01
Hot carcass, lb	767[d]	775[de]	779[de]	788[e]	786[e]	5	0.03
Marbling score[c]	492	486	491	490	504	6	0.36
Fat thickness, in	0.39[d]	0.44[e]	0.40[de]	0.44[e]	0.43[e]	0.01	0.04

[a]DRC = dry-rolled corn, 24HMC = 24% moisture, high-moisture corn, 28RECON = 28% moisture, reconstituted dry corn, 30HMC = 30% moisture, high-moisture corn, 35RECON = 35% moisture, reconstituted dry corn.
[b]Analyzed as ADG / DMI, reciprocal of feed conversion.
[c]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.
[d,e,f]Means within a row with different superscripts differ ($P < 0.05$).

Table 2. Effects of DIP balance on animal performance and carcass characteristics.

	Treatments[a]					
	NEG	ZERO	POS		*P*-value[b]	
Urea, % of DM	0	0.45	0.90	SEM	Linear	Quadratic
Pens, n	20	20	20			
DMI, lb/day	24.2	24.1	24.0	0.2	0.42	0.93
ADG, lb	3.42	3.64	3.66	0.04	<0.01	0.06
Feed:gain[c]	7.04	6.62	6.54		<0.01	0.02
Hot carcass, lb	766	785	785	4	<0.01	0.05
Marbling score[d]	492	488	498	5	0.40	0.26
Fat thickness, in	0.41	0.43	0.43	0.01	0.17	0.28

[a]NEG = diets formulated to have a negative DIP balance, ZERO = diets formulated to have a zero DIP balance, POS = diets formulated to have a positive DIP balance. DIP balance calculated using Level 1 of the NRC (1996) Model. DI*P* = degradable intake protein.
[b]Linear=linear response to urea supplementation, Quadratic = quadratic response to urea supplementation.
[c]Analyzed as ADG / DMI, reciprocal of feed conversion.
[d]Marbling score: 400 = Slight 0, 450 = Slight 50, 500 = Small 0, etc.

to the base diet (DM basis). The three DIP balances were calculated using the NRC (1996) model with the assumptions of a 743 lb steer with a DMI of 24 lb/day and an ADG of 4 lb. The final diets contained 65% test corn, 18% corn bran, 5% grass hay, 4% dry-rolled corn, 3% tallow and 5% dry supplement (DM basis). Rumensin® and Tylan® were included at 27 g/ton and 8 g/ton of diet DM, respectively. A commodity DRC was used in all diets at 4% (DM basis) because of limited supply of high-moisture and reconstituted corn.

Steers were weighed initially on two consecutive days after being limit-fed at 2.0% of body weight for five days in order to minimize differences in gut fill. Steers were implanted with Ralgro (Schering-Plough Animal Heath, Union, New Jersey) on day 1, reimplanted with Revalor®-S (Intervet, Millsboro, Delaware) on day 45, and fed for 138 days. Final weights were calculated using hot carcass weights adjusted to a common dress (63%). Steers were harvested at a commercial packing plant where carcass data were collected. Hot carcass weight was collected the day of harvest while fat depth, marbling score, and yield grade data were collected after a 24-hour chill.

Data were analyzed as a 5 x 3 factorial design using the Mixed procedure of SAS. The corn types were analyzed using the Least Significant Difference to separate means. The DIP balances were analyzed using linear or quadratic contrasts.

Results

There were no significant corn type x DIP level interactions for any of the variables observed, therefore, only main effects are presented. Within corn type (Table 1), no differences were detected between early harvested corn at 24% moisture and reconstituted dry corn at 28% moisture. There also were no differences between 30HMC and 35RECON. For both early harvested and reconstituted dry corn, the higher moisture treatment had improved ($P < 0.05$) feed conversion compared to the lower moisture treatment.

There was no difference in DMI ($P = 0.06$) between any of the corn types. There was a tendency for DMI to decrease as corn moisture increased. Steers fed diets containing DRC, 24HMC, and 28RECON had similar ADG and hot carcass weights. Steers fed diets containing 30HMC and 35RECON had a 9.4% improvement ($P < 0.01$) in feed conversion, gained 6.3% faster ($P = 0.02$), and had heavier

($P = 0.03$) hot carcass weights compared to steers fed diets containing DRC. Steers fed diets containing 24HMC and 28RECON had intermediate performance. There were no differences in marbling score among any of the corn types. For fat thickness, DRC and 28RECON were similar and 24HMC, 30HMC, and 35RECON had increased ($P = 0.04$) fat thickness compared to DRC.

Within DIP level (Table 2), no differences ($P > 0.05$) in DMI were observed among the treatments. Steers fed diets supplemented with urea had a 6.6% improvement (quadratic response, $P = 0.02$) in feed conversion, gained 6.1% faster (linear response, $P < 0.01$), and had increased (quadratic response, $P = 0.05$) hot carcass weights compared to steers fed diets with no supplemental urea. There were no differences ($P > 0.05$) among diets for marbling score or fat thickness.

For the DRC diets, the NRC model (1996, Level 1) predicts that the diets containing no urea supplementation had a DIP deficiency of -313 g/day and diets supplemented with 0.45% urea had a DIP balance of -173 g/day. For HMC and RECON diets, the NRC model (1996, Level 1) predicts that the diets containing no urea supplementation had a DIP deficiency of -157 g/day and diets supplemented with 0.45% urea had a balance of 22 g/day. Clearly the diets containing no urea were deficient in DIP. The diets containing 0.45% urea were close to a DIP balance of zero and cattle performance was improved compared to diets containing no urea. The diets that contained 0.90% urea had excess DIP and no improvement in cattle performance was observed compared to the diets with 0.45% urea supplementation.

In conclusion, increasing the moisture of high-moisture and reconstituted dry corn enhanced the feeding value. Increasing the moisture of ensiled corn improved cattle performance; however, higher moistures should only be fed with the inclusion of by-products or other mechanisms to control acidosis. The negative DIP diet with no urea supplementation reduced cattle performance. The zero DIP diet met the DIP requirements of the cattle and the positive DIP diet did not improve cattle performance. Therefore, current prediction models appear to be appropriate and protein (urea supplementation) above cattle requirements is not beneficial.

---

[1]Joshua R. Benton, graduate student; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor; Casey N. Macken, previous research technician; Kyle J. Vander Pol, research technician, Animal Science, Lincoln.

Effects of Corn Moisture and Length of Ensiling on Dry Matter Digestibility and Rumen Degradable Protein

Joshua R. Benton
Terry J. Klopfenstein
Galen E. Erickson[1]

Summary

An in situ trial was conducted to evaluate effects of corn moisture and length of ensiling on dry matter digestibility (ISDMD) and degradable intake protein (DIP). Corn treatments consisted of dry-rolled, high-moisture, and reconstituted dry corn. Corn samples were incubated in situ for 22 hours and ISDMD (%) and DIP (% of CP) values were calculated. Both high-moisture and reconstituted corn had higher ISDMD and DIP values than dry-rolled corn. Dry matter digestibility and degradable intake protein increased for high-moisture and reconstituted corn when either moisture or length of ensiling was increased.

Introduction

Research has shown that storing and feeding high-moisture corn (HMC) improves feed conversion 8% compared to feeding dry-rolled corn in feedlot diets containing by-products. It is not clear if the benefits are from increased moisture, the effects of early harvesting on the maturity of the corn kernel, or fermentation that occurs during the ensiling period. Previous Nebraska research has shown that a longer ensiling period, along with intensive processing and higher corn moisture, leads to an increase in dry matter and starch digestibility. The increase in ruminal digestion has been shown to increase the degradable intake protein (DIP) requirement. Degradable intake protein is the fraction of crude protein available to the microbial population. When the increased DIP requirements are met, cattle performance is improved.

In feedlots, acidosis causes physiological and biochemical stresses in cattle when they consume fermentable carbohydrates at a rapid rate. Ruminal pH drops below 5.6 and feed intake is reduced. Previous research shows that high-moisture corn is digested rapidly in the rumen and this can lead to acidosis (*1986 Nebraska Beef Report*, pp. 13-14). Therefore, when measuring dry matter or starch digestibility and protein degradability with in situ methods, animal diets must be considered. The animals should be on a finishing diet so that any effect of rumen pH on microbial digestion will be accounted for during in situ incubation. Particle size of in situ samples also may affect estimates of dry matter or starch digestibility and protein degradability.

The objectives of this study were to evaluate the effects of corn moisture and length of ensiling on in situ estimations of dry matter digestibility and degradable intake protein in cattle fed a finishing diet.

Procedure

Corn Samples

High-moisture corn was harvested at two times in September at 30% or 24% moisture (30HMC or 24HMC), coarsely rolled and stored in silo bags. Field-dried corn was harvested in mid-October. In late November, some of the dry corn was coarsely rolled, reconstituted to 28% or 35% moisture (28RECON or 35RECON), and then stored in silo bags. The remaining dry corn was stored dry and coarsely rolled at time of feeding (DRC). These five corn treatments were fed in a finishing trial from May to September the following year. All corn was of the same hybrid and grown in two University of Nebraska fields. All corn (except DRC) was sampled every 28 days throughout the ensiling period. The 30HMC and 24HMC treatments were ensiled for 372 and 358 days, respectively. The two reconstituted corn (RECON) treatments were both ensiled for 298 days. These corns were used in a feeding trial (*2005 Nebraska Beef Report*, pp. 28-30).

In Situ Procedure

Three ruminally cannulated steers were housed in individual pens and offered a diet that consisted of 68.5% DRC, 20% wet corn gluten feed, 7.5% alfalfa hay, and 4% dry supplement (DM basis). Rumensin® and Tylan® were included at 29 and 10 g/ton of diet DM, respectively. Dry matter digestibility and rumen degradability of protein were estimated for the five corn treatments by incubating duplicate 10 x 20 cm dacron bags filled with 5.0 g of corn in the rumen of each steer. The corn samples were ground through a Thomas-Wiley mill to produce a simulated masticate grind to have a particle size similar to masticated dry rolled corn (*2004 Nebraska Beef Report*, pp. 54-57). Samples were incubated for 75% of the mean retention time. Mean retention time is equal to the inverse of rate of passage using a passage rate of 3.44 %/hour for all samples, therefore

(Continued on next page)

Table 1. Regression analysis for 22-hour incubation.

	ISDMD			DIP (% of CP)		
Corn	day 0	Intercept[ab]	Slope[bc]	day 0	Intercept[ab]	Slope[bc]
24HMC	38.0	37.7[d] (1.2)	0.44[d] (0.06)	45.1	41.6[d] (0.9)	0.51[d] (0.05)
30HMC	45.4	61.3[e] (1.0)	0.38[d] (0.06)	48.8	68.1[e] (0.8)	0.40[e] (0.05)
28RECON	29.0	46.3[f] (1.0)	1.21[e] (0.05)	34.3	47.1[f] (0.7)	1.38[f] (0.04)
35RECON	29.0	68.8[g] (1.0)	0.70[f] (0.06)	34.3	64.9[g] (0.7)	0.95[g] (0.05)
DRC	29.0	——	——	34.3	——	——

[a]Intercept represents value after 28 days of ensiling.
[b]Values in parenthesis are standard error.
[c]Predicted ISDMD or DIP = Intercept + Slope (10 d of ensiling).
[d,e,f,g]Values within a column with different superscripts differ ($P < 0.10$).

samples were incubated for 22 hours. After incubation, samples were rinsed in a washing machine with 0.395 L of 39ºC water per in situ bag. There were five rinses consisting of one minute agitation and two minute spin each. Bags were then dried in a 60ºC forced-air oven for 18-24 hours, removed, weighed, and residues were analyzed for nitrogen.

Calculations

The residue weight of each sample was calculated by subtracting the original bag weight from the residue and bag weight obtained after drying. The ISDMD was calculated by dividing the residue weight by the original sample weight before incubation. The DIP was calculated by using the following equation: *DIP (% of CP) = {1 - [(Residue weight x Residue %CP) / (Sample weight x Sample %CP)]}x 100*.

The ISDMD and DIP values were regressed over ensiling days. From the regression equations *(y = mx + b)* given, the predicted ISDMD or DIP can be calculated. The intercept (b) represents the ISDMD or DIP after the first 28 days of ensiling and the slope (m) represents changes in ISDMD of DIP over time of ensiling after 28 days where x is equal to length of ensiling period in 10-day increments.

Results

Figures 1 and 2 show how the values for ISDMD and DIP for each corn changed over the ensiling

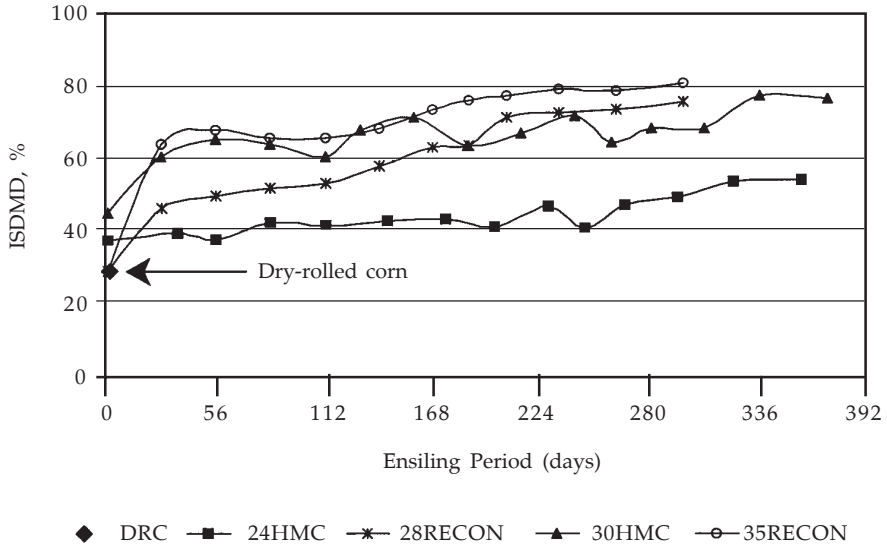


Figure 1. Changes for in situ dry matter digestibility (ISDMD, %) as length of ensiling increases.

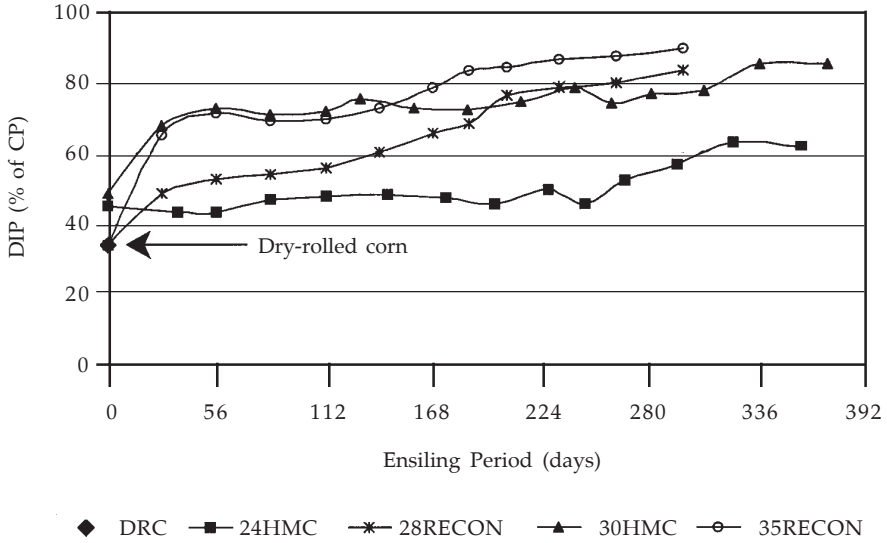


Figure 2. Changes for degradable intake protein (DIP) as length of ensiling increases.

period. When moisture was increased for HMC (from 24% to 30%) and RECON (from 28% to 35%), total ISDMD and DIP increased ($P < 0.10$). The greatest changes in ISDMD and DIP occurred in the first 28 days of ensiling, with the greatest increase for 35RECON followed by 30HMC and then 28RECON ($P < 0.10$). Compared to DRC, both HMC and RECON had greater total ISDMD and DIP. With increased moisture, ISDMD and DIP both increased and both continued to increase with more days of ensiling. The values presented are relative values which may be influenced by laboratory procedures. The values will give relative differences between the treatments and cannot be assumed to be the absolute values or differences.

Figures 1 and 2 show that after large changes in the first 28 days, further changes appeared to be linear. Therefore, the values after 28 days were regressed over time (Table 1). The slopes of RECON were greater ($P < 0.10$) than HMC. The slope of 24HMC was not different ($P > 0.10$) from 30HMC for ISDMD, while the slope of 24HMC was greater ($P < 0.10$) than 30HMC for DIP. The slope of 28RECON was greater ($P < 0.10$) than 35RECON for ISDMD and DIP.

As mentioned earlier, it has been shown that cattle performance is improved when increased requirements for degradable intake protein, due to increased ruminal digestion, are met. This study suggests that cattle performance may be improved by ensiling higher moisture corn resulting in increasing ISDMD and DIP of that corn. Reconstituted dry corn resulted in similar increases in ISDMD and DIP compared to HMC and these results would suggest that the changes in ISDMD and DIP are due to the effects of moisture and ensiling. There may be some initial improvement in the feeding value for HMC due to the effects of early harvesting, but it appears that after 28 to 56 days of ensiling, RECON and HMC are equivalent.

Based on this research, there appear to be two distinct phases to the changes that occur over time of ensiling. The first change occurs in the first 28 days of ensiling where there are significant increases in the ISDMD and DIP values of the corn. The second change occurs gradually after 28 days throughout the ensiling period where there are slight increases in the ISDMD and DIP values. In conclusion, as moisture and length of ensiling increase, the estimated values for dry matter digestibility and protein degradability will be increased.

---

[1]Joshua R. Benton, graduate student; Terry J. Klopfenstein, professor; Galen E. Erickson, assistant professor, Animal Science, Lincoln.

Influence of Corn Kernel Traits on Digestibility and Ruminal Fermentation

Matt K. Luebbe
Galen E. Erickson
Terry J. Klopfenstein
Wayne A. Fithian[1]

Summary

A metabolism trial was conducted to determine the influence of corn kernel traits on digestibility. The seven hybrids used in this study were the same as those fed in a feedlot performance trial where kernel traits were correlated to feed efficiency. These hybrids were selected to represent a range within and among kernel traits. There were no differences in total tract digestibility for hybrids that have softer endosperm. Ruminal pH parameters and intake behavior were not found to be different for animals in the metabolism trial. However, differences did exist among hybrids for volatile fatty acid production. VFA production over time was similar for all treatments with a peak in total VFA concentrations five to seven hours after feeding.

Introduction

Corn is the primary ingredient in feedlot diets due to its high energy value and subsequent animal performance. Cattle consuming starch from corn hybrids which are more rapidly degraded in the rumen are more efficient than those fed corn which is more slowly degraded (*Nebraska Beef Report, 2004* pp. 54). The interaction of many physical and chemical properties in the kernel can contribute to how starch is utilized. A softer endosperm kernel is generally thought to have more enzyme accessible space between the starch molecules. This increases the ability of bacteria to attach and degrade kernels to a greater extent.

Seven corn hybrids varying in chemical and physical properties were fed in a performance study to determine the impact of those properties on finishing cattle performance (Nebraska Beef Report, 2004 pp. 54). Larger, softer kernels were found to be significantly correlated to improved feed efficiencies when fed as dry-rolled corn. The results from the performance study suggest that kernel traits have an impact on starch utilization by feedlot cattle. Stenvert hardness tests from the previous study showed that hybrid 6 has the softest kernel traits followed by 1, 7, 2, 4, 5, and 3. Using these data, our hypothesis was that softer kernels are more digestible and total volatile fatty acid production would be greater for those kernels. The objective of this research was to examine total-tract nutrient digestibility, volatile fatty acid production, and monitor ruminal fermentation patterns of the same hybrids fed in the performance study.

Procedure

Seven ruminally cannulated cross-bred yearling heifers (avg. BW = 1130 lb) were used in a 7x7 Latin square designed experiment to determine the digestibility of seven hybrids varying in chemical and physical properties. The seven hybrids consisted of Golden Harvest H- 9164Bt (1), H-9235Bt/RR (2), H-9230Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7). All diets among treatment groups were identical except for the hybrid fed as dry-rolled corn. The final diet consisted of 68.5% dry-rolled corn, 20.0% wet corn gluten feed, 7.5% alfalfa, and 4.0% supplement. Heifers were fed for ad libitum intake once daily at 0700. Periods were 14 days in length with a 9-day adaptation to the diet and a 5-day collection period. Heifers were individually fed in pens on days 1-8 during the adaption and moved into stanchions for the collection period on day 9.

Individual feed bunks suspended from load cells were used to monitor feed intake patterns. Feed intake measurements (day 10 to 14) included DMI, number of meals per day, average meal size, total time spent eating, and average meal length. Continuous pH measurements were collected using submersible pH electrodes placed into the rumen during the collection period. Probes were suspended in a stationary position 4-6 inches above the ventral floor of the rumen prior to the collection period. Intake and pH measurements were recorded every six seconds and averaged for each minute.

Chromic oxide was used as an indigestible marker for estimating fecal output. Boluses were given via rumen cannula twice daily at 0700 and 1900 with each dose containing 7.5 grams chromic oxide. Fecal grab samples were collected three times daily on days 10 though 14 at 0, 6, and 12 hours post-feeding. Feed ingredients, feed refusals, and fecal samples were freeze-dried and analyzed to calculate nutrient digestibility. Ruminal fluid samples were collected on day 14 of each period prior to feeding, and every two hours post-feeding for a twelve-hour period to determine volatile fatty acid production.

Table 1. Effect of corn hybrid on ruminal pH.

	Hybrid[a]								
Parameter	1	2	3	4	5	6	7	SEM	*P*-value
Average pH	5.53	5.49	5.68	5.48	5.47	5.62	5.46	0.18	0.32
Maximum pH	6.28	6.30	6.48	6.21	6.17	6.32	6.07	0.12	0.36
Minimum pH	5.05	5.02	5.10	5.05	5.08	5.15	5.03	0.64	0.58
pH change	1.19	1.28	1.37	1.13	1.09	1.16	1.06	0.12	0.46
pH variance	0.28	0.25	0.26	0.23	0.22	0.26	0.21	0.02	0.12
Time < 5.6	913	899	630	935	954	761	1075	128	0.19
Area < 5.6	288	279	186	269	306	195	358	68	0.56

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).

Table 2. Effect of corn hybrid on total tract digestibility.

	Hybrid[a]								
Item	1	2	3	4	5	6	7	SEM	*P*-value
Dry Matter									
Intake, lb/day	20.9	21.3	22.5	20.8	21.5	21.5	22.3	1.41	0.91
Digestibility, %	78.4	76.1	74.6	79.3	78.0	77.8	75.1	2.13	0.19
Organic Matter									
Intake, lb/day	19.7	20.0	21.0	19.5	20.1	20.2	20.8	1.31	0.93
Digestibility, %	79.3	77.7	76.1	80.1	79.0	78.3	74.9	2.89	0.46
Starch									
Intake, lb/day	9.7[c]	11.9[de]	12.2[de]	11.2[cd]	11.5[de]	12.5[de]	13.1[e]	0.73	0.02
Digestibility, %	94.5	94.8	94.9	95.5	95.5	95.2	95.3	0.64	0.58

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b] F-test statistic for the effect of hybrid.
[c,d,e]Means within a row with unlike superscripts differ ($P < 0.05$).

Results

There were no differences in measured intake patterns among treatments. Heifers consumed an average of 3.4 lb of dry matter with 7.2 meals consumed per day. Total time spent eating was 600 minutes with each meal averaging 92 minutes (data not shown). Differences were found in starch intake among treatments with animals consuming the least amount of starch with hybrid 7 and the most with hybrid 1. These differences are due to the percent starch of the hybrid (63.8% and 80.3%, respectively).

Average pH, maximum pH, minimum pH, and pH change along with time and area below 5.6 are shown in Table 1. Ruminal pH measurements were not influenced by grain hybrid; however, some numerical differences in average pH were evident. Lower ruminal pH results would support a greater rate and extent of starch digestion, but could have been mediated in this study due to the inclusion of WCGF in the diet.

Total tract DM, OM and starch digestibilities were similar among treatments (Table 2). Dry matter, organic matter, and starch digestibilities averaged 77.1%, 77.9% and 95.1%, respectively. These results could be due to the intakes observed in the metabolism heifers. Intakes were lower as a percentage of body weight for the metabolism heifers (1.9%) compared to the finishing steers (2.3%). The lower intakes could have slowed the rate of passage of feed particles from the rumen and therefore increased the extent of degradation of starch from hybrids that have harder kernel characteristics.

Rumen fluid analysis indicates there were differences ($P < 0.01$) among hybrids for VFA production. Cattle consuming hybrid 3, the least efficient in the feedlot study, had the lowest propionate and total VFA concentrations along with a higher A:P ratio. Although starch digestion was not found to be different among hybrids, higher propionate and total VFA concentrations would suggest that the rate of starch fermentation plays a critical role in animals consuming more total DM, as discussed earlier. Interestingly, propionate production was not significantly correlated to F:G but was correlated to other physical measurements performed on the hybrids. The Stenvert time to grind was significantly correlated ($r = -0.84$) to propionate production. This would indicate that as the time

(Continued on next page)

Table 3. Effect of corn hybrid on VFA production.

	Hybrid[a]								
Item	1	2	3	4	5	6	7	SEM	*P*-value
Acetate, mM	41.9	43.8	44.2	41.8	44.1	44.6	42.6	2.9	0.53
Molar %	42.0^{c}	46.6^{de}	49.1^{e}	41.4^{c}	42.8^{cd}	44.6^{cd}	44.5^{cd}	1.8	<0.01
Propionate, mM	40.8^{c}	38.1^{c}	29.3^{d}	42.3^{c}	41.3^{c}	39.3^{c}	38.1^{c}	3.1	<0.01
Molar %	43.6^{c}	40.4^{cd}	33.7^{e}	42.2^{cd}	38.4^{cde}	38.6^{cde}	37.7^{de}	2.9	0.01
A:P	1.02^{cd}	1.29^{d}	1.67^{e}	0.97^{c}	1.25^{cd}	1.29^{cd}	1.29^{cd}	0.2	<0.01
Butyrate, mM	10.1	13.1	10.8	11.0	8.0	11.8	12.5	1.9	0.16
Total VFA, mM	97.7^{d}	94.6^{de}	89.7^{e}	100.1^{cd} 1	04.2^{c}	100.5^{cd}	98.9^{cd}	4.6	<0.01

[a]Hybrids consisted of Golden Harvest H-9164-Bt (1), H-9235Bt/RR (2), H-9230-Bt (3), Pioneer 33B51 (4), and 33P67 (5), and Golden Harvest H-8562 (6), and H-9533Bt (7).
[b]F-test statistic for the effect of hybrid.
[c,d,e]Means within a row with unlike superscripts differ ($P < 0.05$).

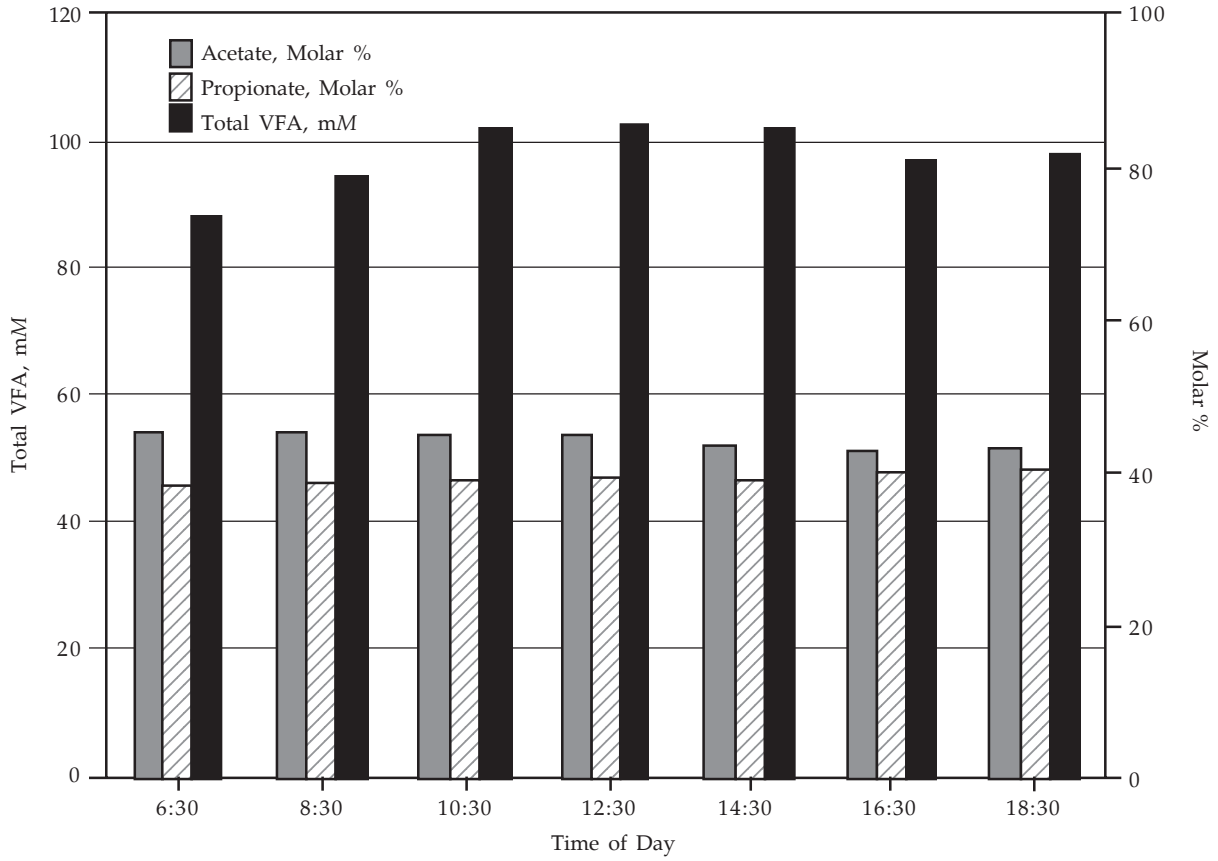


Figure 1. Schematic representing change over time across all treatments for total VFA concentration (m*M*) and molar proportions of acetate and propionate.

to grind harder kernels increases, propionate production decreases.

Because there were no interactions between hybrid and time of day, the main effects of time on VFA production are illustrated in Figure 1. Both acetate and propionate concentrations were lowest prior to feeding (0630) and increased throughout the sampling day with a peak production five to seven hours after feeding. These production patterns contributed to a peak in total VFA concentration five to seven hours after feeding. During this time, the propionate molar proportion increased from 38% to 40%, while the molar proportion of acetate decreased from 45% to 43%. The changes in acetate and propionate production across time reduced the A:P ratio from a high of 1.35 just prior to feeding to a low of 1.17 twelve hours post feeding.

[1]Matt K. Luebbe, research technician; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor; Animal Science, Lincoln; Wayne A. Fithian, JC Robinson Seed Co., Waterloo, Nebraska.

Effect of Different Corn Processing Methods and Roughage Levels in Feedlot Diets Containing Wet Corn Gluten Feed

Pablo L. Loza
Kyle J. Vander Pol
Galen E. Erickson
Terry J. Klopfenstein
Rick A. Stock[1]

Summary

Sixty steers were individually fed for a 101-day period to evaluate two corn processing methods, dry rolled (DRC) or 29% moisture reconstituted corn (HMC), in combination with two levels of alfalfa hay (0% and 7% DM) in finishing diets containing 25% wet corn gluten feed (WCGF). Final body weight was greater for the steers fed DRC compared to steers fed HMC diets. Steers receiving DRC treatments had a 16% higher DMI than HMC treatments. DMI was greater in the DRC 7% alfalfa treatment than DRC 0% alfalfa treatment, while there was no difference between the HMC treatments. There was a trend for a better feed conversion for DRC 0% alfalfa hay compared to HMC 0% alfalfa hay. The results indicate that 25% WCGF inclusion level was insufficient to overcome the subacute acidosis associated with diets based on high moisture corn in this study.

Introduction

Different rates of ruminal digestion have been observed due to corn processing. Higher rates of digestion can lead to subacute acidosis. Thus, different responses relative to the inclusion levels of milling by-product and forage in finishing rations would be expected. The use of corn milling by-products as energy sources in finishing diets could reduce the subacute acidosis problem associated with high-energy finishing diets and reduce the need for including forage. The objective of this trial was to compare cattle performance when two corn processing methods, reconstituted high moisture and dry rolled, and two levels of alfalfa are fed to finishing cattle. All diets included 25% wet corn gluten feed (WCGF).

Procedure

Sixty steer calves (initial BW 877 + 4.8 lb) were stratified by weight and assigned randomly to one of four treatments in a 2 x 2 factorial design. Treatments consisted of either dry rolled corn or high moisture corn in combination with 25% WCGF (Sweet Bran 60, Cargill corn milling) with two levels of forage inclusion (0% or 7% alfalfa hay, Table 1). Steers were individually weighed on three consecutive days under restricted feeding (DMI was 2% of BW) at the start of the experiment and two consecutive days at the end of the experiment. Starting on June 25, 2003, steers were individually fed for 101 days using Calan electronic headgates. Orts were collected when necessary to determine individual intake. At the end of the trial, steers were harvested at a commercial abattoir. Final weight was calculated from carcass weights using a common dressing percentage (63%). Hot carcass weight (HCW) was obtained the day of slaughter; fat thickness and rib eye areas (REA) were obtained after a 24-hour chill. Yield grades were calculated using REA, HCW and back fat, assuming a 2% kidney, pelvic and heart (KPH) fat. Statistical analysis was performed using mixed procedures of SAS. Data from two steers were removed from the analysis due to morbidity not related to treatments. Class

(Continued on next page)

Table 1. Diet composition (% DM).

	HMC 0% ALF	HMC 7% ALF	DRC 0% ALF	DRC 7% ALF
DRC	—	—	72	65
HMC	72	65	—	—
Wet corn gluten feed	25	25	25	25
Alfalfa hay (ALF)	0	7	0	7
Supplement	3	3	3	3

Table 2. Effects of corn processing method and alfalfa level in 25% WCGF diets

	DRC		HMC				
Alfalfa Level (% DM)	0	7	0	7	SEM	Corn Processing Method	Alfalfa
Final weight lb	1328	1323	1238	1276	12.5	<0.01	0.36
DMI lb/day	22.97	24.51	19.80	21.01	0.37	<0.01	0.01
ADG lb/day	3.76	3.69	2.99	3.24	0.11	<0.01	0.57
Yield Grade	2.30	2.35	1.53	1.91	0.08	<0.01	0.08
Fat, in 12th rib	0.433	0.453	0.303	0.400	0.02	<0.01	0.03
Marbling	554	482	510	510	19	0.18	0.75
REA	15.3	13.9	14.7	14.5	0.2	0.05	0.70

statements included corn source and alfalfa levels, and model statements included corn source, alfalfa levels and their interaction.

Results

There were no interactions on corn processing method by alfalfa level ($P>0.05$), except there was a trend in feed conversion. Dry matter intake was 16% higher ($P<0.05$) for cattle fed DRC than for cattle fed HMC. Final BW was 5% higher for the treatments with DRC. ADG was 19% higher ($P<0.05$) for cattle fed DRC than HMC, however, feed efficiency was not significantly different ($P>0.05$) between the two corn processing methods. Fat thickness and yield grades were greater ($P<0.05$) for cattle fed DRC and marbling scores tended ($P<0.18$) to be higher in the DRC treatments, but REA was larger in the HMC treatments. Alfalfa level influenced ($P=0.01$) DMI, being higher for the 7% alfalfa treatment compared to the 0% alfalfa treatment. However, including alfalfa did not significantly ($P>0.05$) influence ADG, final weight or F:G. Fat thickness was higher ($P<0.05$) for steers fed treatments with alfalfa, while alfalfa inclusion did not affect ($P>0.05$) marbling scores or REA.

A trend ($P=0.14$) for a corn processing method and alfalfa level was observed for F:G. Alfalfa decreased feed efficiency (6.58 vs 6.10 F:G) when fed in the DRC diets while alfalfa increased feed efficiency (6.45 vs 6.67) in the HMC diets. The ADG advantage of feeding DRC treatments compared to feeding HMC treatments contradicts previous research (*2001 Nebraska Beef Report* pp. 59-63). The difference with previous research might be due to the lower WCGF level used in the present trial (25%), compared with previous trials, but also may be related to the type of experiment. In this experiment, cattle were individually fed whereas previous research (*2001 Nebraska Beef Report* pp. 59-63; *2003 Nebraska Beef Report* pp 25-27) was conducted in research pens (8 steers/pen). The WCGF inclusion level in this trial may not have been sufficient to overcome the higher acidotic challenge with the HMC diet. These data suggest that the value of forage in feedlot diets may depend on the corn processing method when diets contain WCGF.

[1]Pablo L. Loza, graduate student; Kyle J. Vander Pol, research technician; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Rick A. Stock, adjunct professor, Animal Science, Lincoln.

Effect of Corn Bran and Corn Steep Inclusion in Finishing Diets on Diet Digestibility and Fiber Disappearance

Kristi M. Sayer
Galen E. Erickson
Terry J. Klopfenstein
Tim W. Loy[1]

Summary

Eight ruminally cannulated heifers were used in a replicated 4 x 4 Latin square to determine the effects of replacing dry rolled corn with corn bran or a combination of corn bran and corn steep, on diet digestibility and rumen environment. Heifers received diets including 0% bran, 30% bran, 30% bran/15% steep and 45% bran/15% steep. Byproduct diets were effective in reducing acidosis and had lower dry matter and organic matter digestibilities than the control diet, regardless of steep inclusion. Fiber digestion and microbial efficiency may have been promoted with the inclusion of corn bran and steep in the diet. Feeding a diet containing corn bran and steep may be valuable for improving nutrient utilization in the rumen.

Introduction

Providing options to decrease ammonia emissions is essential for future progress of the feedlot industry. Feeding corn bran, which is a source of highly digestible fiber, is an effective means of reducing N losses from the feedlot pen surface. When 30% bran replaced dry rolled corn (DRC), N losses were reduced by 38% in the winter months (*2003 Nebraska Beef Report*, pp 54-58). The reduction in N lost was achieved by reducing diet digestibility, increasing fecal N output, and increasing OM on the pen surface.

Fecal N is more stable than urinary N. Increasing the amount of fermentable carbohydrates to the hind gut, via feeding a lower digestible diet, is an effective means to increase fecal N (*1996 Nebraska Beef Cattle Report*, pp 74-77). The consequence of reducing diet digestibility is reduced feed efficiency in cattle (*2002 Nebraska Beef Cattle Report*, pp 54-57; *2003 Nebraska Beef Report*, pp 54-58).

Corn steep is a by-product of the wet corn milling industry that is a combination of both distillers solubles and steep liquor. It has a higher energy value than DRC (*1998 Nebraska Beef Cattle Report*, pp 69-71). The objective of the following metabolism study was to evaluate the effect of corn bran and steep inclusion in finishing diets on diet digestibility and rumen environment.

Procedure

Eight ruminally cannulated crossbred heifers were used in a replicated 4 x 4 Latin square design. All diets included 15% corn silage, 5% supplement and DRC. Treatments included a 0% corn bran control (CON), 30% bran (30/0), 30% bran/15% steep (30/15), and 45% bran/15% steep (45/15), with by-products replacing DRC and molasses (Table 1). These diets were similar in composition to those fed in two finishing trials used to evaluate cattle performance and N mass balance (*2005 Nebraska Beef Cattle Report*, pp 54-56). Periods included 16-day adaptation and 5-day collection. Chromic oxide was used as a marker to determine total tract digestibility, dosed 7.5 g, twice daily through the rumen cannula. The chromic oxide was dosed 72 hours before the first collection day, to ensure it was equally concentrated throughout the digesta. Fecal samples were taken three times during each collection day, dried in a 60ºC oven for 48 hours, and composited. Intake was continuously measured similar to the system described by Cooper et al., (*1997 Nebraska Beef Report*, pp 49). Ruminal fluid was collected prior to feeding and at 2, 4, 6, 8, 10 and 12 hours after feeding on each of the 5 days during a collection period.

An in-situ trial also was conducted during the final collection period. Corn bran and DRC were incubated as-is at time points of 0, 12, 24, 48, and 96 hours, with corn bran extent of 96 hours and DRC at a 48-hour extent. Each time point used two steers per diet and two replications per sample, with an empty dacron bag incubated for a control. Both bran and DRC were evaluated for DM disappearance

(Continued on next page)

rate; corn bran also was evaluated for NDF disappearance rate within each of the four diets. Potential digestible fractions were calculated by subtracting the extent hour value from the 0 hour value. A log transformation calculation was used to calculate DM and NDF disappearance rates (%/hour).

Results

Dry matter intake was similar among all treatments, averaging 25 lb/day ($P > 0.10$; Table 1). By-product diets had higher ruminal pH (5.96) than CON (5.75), averaged across all time points ($P < 0.01$; Table 2). The lower ruminal pH supports the concept that feeding by-products helps minimize the effects of acidosis. Acetate: propionate ratios were 2:09, 2:25, 2:30, and 2:52 for the CON, 30/0, 30/15, and 45/15 diets, respectively (P<0.05). When diets had a higher fiber content (i.e. bran included in the diet), acetate concentrations were higher and propionate concentrations were lower.

Total tract DM digestibility (Table 2) was higher in CON than by-product diets (79% vs 73.0%, $P < 0.01$), as was OM digestibility (80.2% vs. 74.6%, $P < 0.01$). Steep provided no improvement in DM or OM digestibility of the 30/15 diet. This is somewhat different from previous research that evaluated 15% corn bran and 15% corn bran plus 15% steep (15/15). Scott et al. (*1998 Nebraska Beef Report*, pp 69-71) reported the DM digestibility of a 15% bran diet to be 80%, while the 15/15 diet was 83% digestible. Although there was no statistical difference in the data from Scott et al., (1998) steep did tend to improve total tract digestibility.

In-Situ Results

DM disappearance (%/hour) of DRC was lower in CON diet than by-product diets ($P < 0.01$; Table 3), suggesting that because the rumen pH was higher in the byproduct

Table 1. Composition of dietary treatments for metabolism and in situ trials (% DM basis).

Ingredient	CON	30/0	30/15	45/15
Dry Rolled Corn	75	45	35	20
Corn Silage	15	15	15	15
Corn Bran	—	30	30	45
Steep	—	—	15	15
Molasses	5	5	—	—
Dry Supplement[a]	5	5	5	5
Nutrient Composition (%)				
CP[b]	13.7	13.4	14.0	14.2
Calcium[c]	0.70	0.70	0.70	0.70
Phosphorus[c]	0.32	0.26	0.47	0.44

[a]Supplement formulated to provide 28g/ton Rumensin® and 10 g/ton Tylan®.
[b]Calculated based on CP analysis of feedstuffs.
[c]Calculated using tabular values for ingredients.

Table 2. Effect of dietary treatment on DM intake, total tract digestibility, and ruminal pH.

	Treatment[a]					
Item	CON	30/0	30/15	45/15	SE[b]	F-Test[c]
Avg pH[d]	5.75[g]	5.95[h]	5.94[h]	5.98[h]	0.06	<0.01
DM Intake, lb/d	23.8	25.8	25.4	25.2	1.4	0.56
DM Digested, lb/d	18.8	19.0	18.5	18.3	1.0	0.90
DMD,%[e]	79.0[g]	73.7[h]	72.8[h]	72.6[h]	1.5	0.03
OM Intake, lb/d	22.1	24.0	23.6	23.4	1.3	0.56
OM Digested, lb/d	17.7	18.0	17.6	17.4	1.0	0.95
OMD,%[f]	80.2[g]	75.0[h]	74.4[h]	74.4[h]	1.5	0.03

[a]CON = dry rolled corn based diet with no by-product inclusion; 30/0 = dry rolled corn replaced with 30% bran and 0% steep; 30/15 = dry rolled corn and molasses replaced with 30% bran and 15% steep; 45/15 = dry rolled corn and molasses replaced with 45% bran and 15% steep.
[b]Standard error of the mean.
[c]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[d]Avg pH = average pH.
[e]DMD = DM digestibility.
[f]OMD = OM digestibility.
[gh]Means within row with unlike superscripts have differing values.

Table 3. Disappearance rates (%/hour) of corn bran and dry rolled corn incubated within each dietary treatment.

	Treatment[a]					
Item	CON	30/0	30/15	45/15	SE[b]	F-Test[c]
DMd (corn)[d]	2.36[f]	2.71[g]	2.99[g]	2.89[g]	0.22	<0.01
DMd (bran)[d]	0.76[f]	2.18[g]	1.70[g]	1.92[g]	0.22	<0.01
NDFd (bran)[e]	0.82[f]	1.71[g]	1.79[g]	2.08[h]	0.05	<0.01

[a]CON = dry rolled corn-based diet with no by-product inclusion; 30/0 = dry rolled corn replaced with 30% bran and 0% steep; 30/15 = dry rolled corn and molasses replaced with 30% bran and 15% steep; 45/15 = dry rolled corn and molasses replaced with 45% bran and 15% steep.
[b]Standard error of the means.
[c]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[d]DMd = Dry matter disappearance rate calculated as%/hour.
[e]NDFd = NDF disappearance rate calculated as%/hour for corn bran.
[fgh]Means with unlike superscripts within row have differing values.

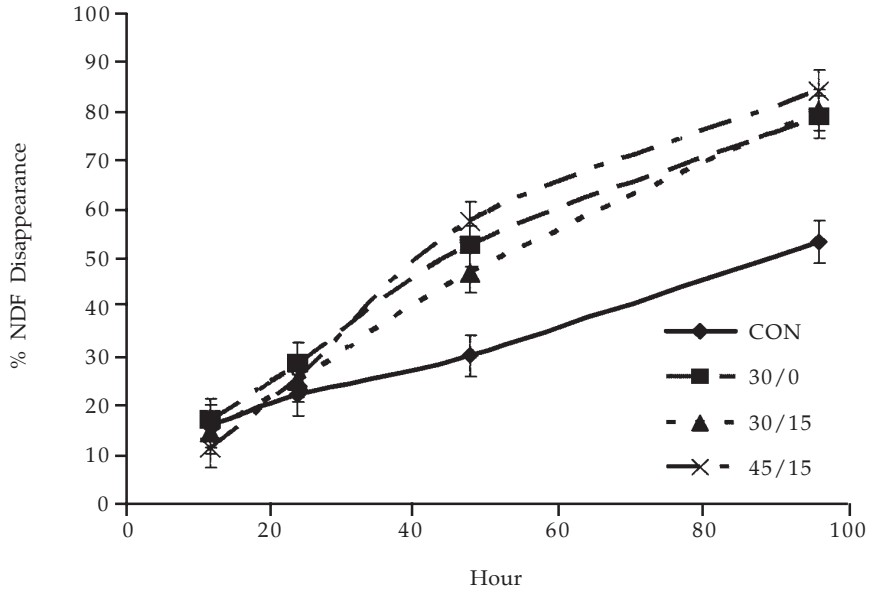


Figure 1. Corn bran NDF disappearance (%), reported at 12, 24, 48, and 96 hours, incubated within each dietary treatment.

diets, the microbial population was more efficient at digesting the DRC. The NDF content of corn bran was 72.9%. NDF disappearance rates (%/hour) were highest for the 45/15, similar for 30/0 and 30/15, and lowest for CON ($P < 0.01$; Table 3). This suggests that when corn bran is increased in the diet, the microbial population has more cellulolytic bacteria. A higher cellulolytic bacteria population would promote an increase in the acetate: propionate ratio, as well as an increase in ruminal fluid pH.

The percentage of NDF disappearance was not different among diets at 0, 12 and 24 hours; however, at 48 and 96 hours (Figure 1), the NDF disappearance for bran was lower for CON than by-product diets ($P < 0.01$). Digestion of corn bran occurred to a further extent when bran was incubated in 30/0, 30/15, and 45/15 diets, compared to incubation in the CON diet. These data support the theory that because of a higher ruminal pH and an altered microbial population, digestion of both dry rolled corn and bran occurs to a greater extent.

While adding steep to the diet did not improve total tract digestibility, it did improve cattle performance (*2005 Nebraska Beef Report*, pp 54-56). By-product diets are effective in reducing acidosis, and have lower dry matter and organic matter digestibilities than typical corn-based diets, regardless of steep inclusion. Rate of corn bran digestion and extent is greater in by-product-based diets. Feeding corn bran and steep in combination is an effective means of promoting fiber digestion, and maintaining a healthier rumen environment.

---

[1]Kristi M. Sayer, graduate student, Galen E. Erickson, assistant professor, Terry J. Klopfenstein, professor, Tim W. Loy, former research technician, Animal Science, Lincoln.

Degradable Intake Protein In Finishing Diets Containing Dried Distillers Grains

Kyle J. Vander Pol
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

An experiment evaluated the effects of finishing diets containing dried distillers grains supplemented with degradable intake protein on performance and carcass characteristics of yearling heifers. Diets contained 10% or 20% dried distillers grains (DDG) with or without 0.80 or 0.63% urea. Degradable intake protein balances were -192 (10% DDG no urea), 58 (10% DDG + urea), -111 (20% DDG), and 81 (20% DDG + urea) grams/day. No response in performance or carcass characteristics were observed among treatments. The results indicate sufficient amounts of urea were recycled to the rumen to meet the degradable intake protein requirement. Therefore, supplemental degradable intake protein is not necessary in finishing diets containing dried distillers grains at 10% or 20% of diet DM.

Introduction

A recent USDA report indicated U.S. ethanol production grew from a few million gallons in the mid-1970s to over 3.3 billion gallons projected in 2004. Corn dry milling is the primary mechanism for producing fuel ethanol, however, ethanol can be produced from the dry milling of other cereal grains (sorghum, wheat, etc.) or from wet milling corn. Approximately two-thirds of the grain being milled is recovered as ethanol or carbon dioxide, the other one-third is referred to as distillers by-products. Therefore, nutrients within distillers by-products are concentrated three-fold compared to the cereal grain from which it was produced.

Distillers grains are well utilized in feedlot diets, however, diets being formulated to contain a fixed amount of dried distillers grains (DDG) often indicate a deficiency in degradable intake protein (DIP). Past research with growing heifers concluded supplemental DIP in high forage diets containing fixed amounts of DDG was not necessary (*2004 Nebraska Beef Report,* pp. 20-21).

The objective of this research trial was to determine if supplemental DIP is necessary for performance optimization of heifers consuming finishing diets containing DDG.

Procedure

Fifty-eight crossbred yearling heifers (844 lb) were individually fed one of four diets in a 2 x 2 factorial arrangement of treatments. Factors consisted of two levels of DDG (10% and 20% of DM) and presence or absence of urea (Table 1). Supplemental urea was provided at 0%, 0.8% (10% DDG diet), or 0.63% (20% DDG diet) of diet DM. Bromegrass hay and molasses were included in all diets at 5% of diet DM, while dry supplement was included in all diets at 4% of DM. Dry-rolled corn made up the balance of the diets. Rumensin® and Tylan® were fed at a rate of 320 and 90 mg/head/day, respectively. Dietary treatments (Table 1) consisted of 10% DDG (10DG), 20% DDG (20DG), or 10% DDG with urea (10DG+U), and 20% DDG with urea (20DG+U). All diets were evaluated using the NRC, 1996 computer model to determine both DIP and metabolizable protein (MP) balances. All diets were sufficient in MP (Table 1), while the 10DG and 20DG diets were deficient in DIP (Table 1). Initial weights were based on a five-day limit fed weight, where heifers were fed a 50% alfalfa hay:50% wet corn gluten feed diet (DM basis) at 2% of body weight, with weights taken for three consecutive days. Dietary adaptation consisted of limit feeding, whereby DM offered increased 0.50 lb/day from 12 lb/day DM (1.4% BW) until ad libitum intakes were achieved (~21 days). Heifers were implanted on day 26 with Revalor-H®, and were weighed on days 26-28, 70-72, and 100 (final live weight). An aliquot (20 ml) of blood was collected on days 28, 72, and 100, via jugular venipuncture into vacutainers, for subsequent blood urea nitrogen analysis, using the automated procedure outlined by Marsh et. al (1965). Heifers were slaughtered on day 100 at a commercial packing plant (Tyson Fresh Meats, West Point, Nebraska)

Table 1. Ingredient composition for finishing diets containing dried distillers grains with or without supplemental urea (values presented as a percentage of dietary DM)[a].

	10DG	10DG+U	20DG	20DG+U
Dry-Rolled Corn	76.0	76.0	66.0	66.0
Dried Distillers Grains	10.0	10.0	20.0	20.0
Brome Hay	5.0	5.0	5.0	5.0
Molasses	5.0	5.0	5.0	5.0
Dry Supplement	4.0	4.0	4.0	4.0
Supplement [b]				
Fine Ground Corn	1.77	0.95	1.77	1.12
Limestone	1.34	1.34	1.32	1.32
Urea	—	0.80	—	0.63
Salt	0.30	0.30	0.30	0.30
Ammonium Sulfate	0.22	0.22	0.27	0.27
Tallow	0.15	0.15	0.15	0.15
Potassium Chloride	0.13	0.13	0.11	0.11
Mineral Premix	0.05	0.05	0.05	0.05
Rumensin™	0.018	0.018	0.018	0.018
Tylan™	0.01	0.01	0.01	0.01
Vitamin ADE	0.01	0.01	0.01	0.01
Diet Crude Protein, %	11.2	13.4	13.4	15.1
DIP Balance, g/day	-192	58	-111	81
MP Balance, g/day	268	277	367	367

[a]10 DG = 10% DDG no urea, 10DG+U = 10% DDG with urea, 20DG = 20% DDG no urea, 20DG+U = 20% DDG with urea.
[b] Values presented as a percentage of diet (DM basis).

Table 2. Performance measurements and carcass characteristics for finishing diets containing dried distillers grains with or without supplemental urea[a].

	10DG	10DG+U	20DG	20DG+U	SE
Performance Parameters					
Initial BW, lb	844	842	846	845	15
Final BW, lb [b]	1192	1206	1196	1203	19
DMI, lb	24.5	24.9	23.9	24.6	0.5
ADG, lb	3.51	3.68	3.55	3.60	0.11
Feed:Gain	7.02	6.79	6.82	6.95	0.20
Carcass Characteristics					
Hot Carcass Weight, lb	744	753	747	752	12
12th Rib Fat Thickness, in	0.45	0.43	0.40	0.45	0.03
Ribeye Area, in^2	12.7	12.4	12.5	12.3	0.1
Marbling Score [c]	536	522	548	536	16

[a]10 DG = 10% DDG no urea, 10DG+U = 10% DDG with urea, 20DG = 20% DDG no urea, 20DG+U = 20% DDG with urea.
[b]Calculated from carcass weight, adjusted to a 62% common dressing percentage.
[c]Where 400 = Slight 0, 500 = Small 0.

where livers were scored for abscesses and hot carcass weights were recorded. Fat thickness, ribeye area, USDA called yield grade, and marbling score were recorded after a 72-hour chill. Performance was calculated based on hot carcass weights adjusted to a common dressing percentage (62%).

Heifer was the experimental unit, and data from each individual were analyzed using the mixed procedures of SAS for performance, carcass, and blood variables. Blood urea nitrogen was analyzed as a repeated measurement over time, using the mixed procedures of SAS, with heifer as a random effect. Treatments containing 10% DDG were replicated 15 times, while treatments containing 20% DDG were replicated 14 times.

Corn distillers dried grains were procured from a commercial ethanol plant (Abengoa Bioenergy, York, Nebraska) as one lot, delivered all at one time, and utilized as needed.

Results

Performance variables are presented in Table 2. Dry matter intake increased numerically with the addition of urea, however, no significant differences ($P > 0.10$) were detected for the interaction or main effects. Similarly, carcass adjusted final live weight was numerically higher for heifers receiving supplemental urea. Further, as with DMI and carcass adjusted BW, average daily gain (ADG) improved numerically when urea was incorporated into the diet, however, the response was not significant ($P > 0.35$). Feed:gain ratio were slightly different. The ratio was numerically improved by adding urea to the 10% DDG diet and was not impacted by adding urea to the 20% DDG diet. The urea x level interaction, however, was not significant ($P = 0.37$).

These data suggest sufficient recycling of nitrogen to the rumen to meet the DIP requirement occurred. Further, there was sufficient MP available to supply the needed urea for recycling. The numerical data for feed efficiency clearly show that recycling occurred on the 20% DDG treatment, however, the deficiency of DIP was less and the MP excess was greater than that for the 10% DDG treatment. The conservative application of these results may be to incorporate a small amount of urea into a 10% DDG diet; however, no added benefit of supplemental urea will occur when greater than 10% DDG is fed. In this experiment, DDG was used instead of wet distillers grains, primarily due to the relatively small amount of distillers grains needed in an individual feeding experiment. However, total protein and DIP are similar

(Continued on next page)

Table 3. Blood urea nitrogen values for heifers on finishing diets containing dried distillers grains with or without supplemental urea[a].

	10DG	10DG+U	20DG	20DG+U	SE	urea	level	urea*level
Day 28, mg/100 ml	9.2	10.9	11.6	14.1	0.58	< 0.01	< 0.01	0.49
Day 72, mg/100 ml	11.2	15.0	16.0	17.4	0.74	< 0.01	< 0.01	0.12
Day 100, mg/100 ml	14.1	16.1	17.5	18.5	0.67	0.03	< 0.01	0.44
Average, mg/100 ml [b]	11.5	14.0	14.9	16.7	0.52	< 0.01	< 0.01	0.48

[a]10 DG = 10% DDG no urea, 10DG+U = 10% DDG with urea, 20DG = 20% DDG no urea, 20DG+U = 20% DDG with urea.
[b]Average blood urea nitrogen for all time points.

between wet and dry distillers grains. Therefore, we could predict similar responses in diets containing wet distillers grains.

Carcass characteristics were similar between treatments (Table 2). The mean fat thickness was 0.43 inches, indicating heifers on all treatments were equally finished; however, heifers not supplemented with urea had numerically higher marbling scores than heifers supplemented with urea.

Blood urea nitrogen (BUN) values are presented in Table 3. Within each sampling date, as well as with the average of each heifer's BUN across all sampling dates, there were significant differences for the main effect of both level and urea. Interactions were not significant. Heifers receiving urea had significantly higher BUN values than heifers not supplemented with urea. Similarly, heifers fed the 20DG diets had significantly higher BUN values than heifers receiving the 10DG diets. Published data indicate that a minimum BUN value of about 7.0 mg/100 ml is necessary for optimum performance, with performance leveling off when BUN values exceed the minimum requirement (Marini and Van Amburgh, 2003, in Journal of Animal Science 81:545-552). The values observed in this trial all exceed the published minimum by at least 50%. Therefore, these data indicate excess metabolizable protein in the diets deficient in DIP was adequate enough to provide the additional DIP needed in the rumen and maintain performance.

Heifers on all treatments had significantly higher BUN values as time on feed increased. The higher circulating urea amounts later in the feeding period (Table 3) reflect the decreasing protein requirement of the finishing animal with time on feed.

In conclusion, providing supplemental urea to meet the DIP deficiency generated by diets containing either 10% or 20% DDG had no effect on performance or carcass characteristics of finishing heifers. Further, BUN values indicate adequate nitrogen was available for recycling in cattle receiving diets containing DDG to maintain performance similar to that of cattle supplemented with enough urea to meet the DIP requirement.

---

[1]Kyle J. Vander Pol, research technician; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Effect of Feeding a By-product Combination Consisting of Wet Distillers Grains and Wet Corn Gluten Feed to Feedlot Cattle

Pablo L. Loza
Kyle J. Vander Pol
Galen. E. Erickson
Terry J. Klopfenstein
Rick A. Stock[1]

Summary

Two-hundred-and-eighty yearling steers were used to evaluate effects of increasing levels of a corn milling by-product combination (Blend) (50% wet corn gluten feed, 50% wet distillers grains; DM basis) and different alfalfa hay levels on feedlot performance and carcass characteristics. Levels of Blend were 0%, 25%, 50% or 75% diet DM. Alfalfa level was either kept constant at 7.5% of DM or the forage level decreased, i.e., 7.5%, 5.0%, 2.5%, and 0% alfalfa for the 0%, 25%, 50%, and 75% Blend, respectively. Steer DMI, ADG, and F:G responded quadratically (P<0.05), with the greatest ADG and improved at 25% and 50% blend. These results suggest that feeding a 50:50 combination of wet corn gluten feed and wet distillers grains for up to 50% of a diet will enhance cattle performance.

Introduction

Current corn milling by-product utilization in commercial feedlot diets is usually up to 30% of diet DM. The expected growth of the corn milling industry will increase the by-product supply in the future, providing opportunity to increase the amount used. The levels used also may interact with roughage levels in the diet. Traditionally roughage level is fed to manage acidosis in feedlot cattle. Because corn milling by-products also help with acidosis control, an opportunity may exist to lower roughage levels in diets with higher levels of the by-products. The objectives of this trial were 1) to evaluate the effects of inclusion levels of a by-product mixture of wet corn gluten feed (WCGF) and wet corn distillers grains plus solubles (WDGS), and 2) to evaluate forage inclusion level in feedlot diets on animal performance and carcass characteristics.

Procedure

Two-hundred-and-eighty yearling steers (initial BW = 815 + 1 lb) were blocked by weight, stratified within block, and assigned to 35 pens (8 steers/pen). Pens were assigned randomly to one of seven treatments (five pens/treatment). Treatments consisted of beef finishing diets containing different inclusion levels of a 50:50 blend (DM basis) of wet distillers grains plus solubles (WDGS) and wet corn gluten feed (WCGF) and alfalfa hay levels (Table 1). The 50:50 by-products blend (Blend) was included at 75%, 50%, 25% and 0% (DM basis). Alfalfa was included using two scenarios. In the first scenario, all diets (levels of Blend) included 7.5% alfalfa hay. In the second scenario, the level of alfalfa decreased as Blend level increased to supply alfalfa hay at levels of 5%, 2.5% and 0% for the 25%, 50% and 75% Blend levels respectively. Wet distillers grains (Abengoa Bioenergy, York, Nebraska) were delivered weekly and every truckload was sampled. Alfalfa hay, corn and WCGF (Sweet Bran, Cargill, Blair, Nebraska) were sampled weekly. Samples were analyzed for lipid and mineral content. Steers were limit-fed for five days prior to day 1 of the experiment (September 30, 2003), and then weighed on two consecutive days to determine the initial BW. Steers were adapted to treatment diets over 21 days and the finishing diets were fed until the end of the trial. Steers were implanted with Revalor-S® on day 21. On day 105

(Continued on next page)

Table 1. Diets containing different levels of a by-product blend[a] fed to finishing steers.

	Treatments[b]						
Ingredients	Control	25/7.5	50/7.5	75/7.5	25/5	50/2.5	75/0
Corn[c]	87.5	62.5	37.5	12.5	65.0	43.0	20.0
Wet Distillers Grains	0.0	12.5	25.0	37.5	12.5	25.0	37.5
Sweet Bran®	0.0	12.5	25.0	37.5	12.5	25.0	37.5
Supplement	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Alfalfa Hay	7.5	7.5	7.5	7.5	5.0	2.5	0.0
CP	13.0	14.6	18.9	23.3	14.4	18.6	22.8
eNDF	0.91	1.39	1.87	1.87	1.09	1.26	1.44
Ether Extract	2.67	3.76	5.13	5.57	3.24	5.13	5.57

[a]50:50 blend of wet distillers grains and wet corn gluten feed (DM basis).
[b]Expressed as blend/alfalfa hay levels.
[c]50:50 blend of high moisture corn (71% DM): dry-rolled corn (DM basis).

Table 2. Effect of different inclusion levels of a by-product blend[a] fed to yearling steers.

Blend	0	25		50		75			
Alfalfa Hay	7.5	5	7.5	2.5	7.5	0	7.5	SEM	F Test
DMI, lb/day	24.3[a]	26.3[bc]	26.5[b]	25.4[c]	26.1[bc]	23.0[d]	23.6[ad]	0.30	<0.05
ADG, lb/day	3.99[a]	4.70[b]	4.57[b]	4.55[b]	4.56[b]	3.86[a]	3.93[a]	0.11	<0.05
F/G	6.10[a]	5.60[c]	5.80[bc]	5.59[c]	5.73[bc]	5.97[bc]	6.01[ab]	0.13	<0.05

[a]Blend is a 50:50 blend of wet distillers grains and wet corn gluten feed (DM basis).
[a,b,c]Different superscripts within a row are different ($P < 0.05$).

Table 3. Main effect of a by-product blend[a] fed to yearling steers.

	0	25	50	75	SEM	Li	Quad
DMI, lb/day	24.3	26.4	25.8	23.3	0.2	<0.05	<0.05
ADG, lb/day	3.99	4.63	4.56	3.90	0.07	0.34	<0.05
F/G[b]	6.25	5.55	5.55	5.88	—	0.32	<0.05
Final BW lb	1277	1352	1345	1264	8.75	0.34	<0.05
Calculated YG	1.85	2.37	2.08	2.10	0.08	0.27	<0.05
Marbling Score[c]	532	521	518	473	8.71	<0.05	0.08
12th rib fat, in.	0.37	0.45	0.46	0.38	0.02	0.60	<0.05
REA, sq. in.	14.5	14.4	14.1	14.2	0.2	0.32	0.66

[a]Blend is a 50:50 blend of wet distillers grains and wet corn gluten feed (DM basis).
[b]Analyzed as G/F.
[c]450=Slight[50], 500=Small[0], 550=Small[50], etc.

or 121, steers were harvested at a commercial abattoir. Carcass data were collected after a 24-hour chill. Data were evaluated using Proc Mixed procedure of SAS. Pen was the experimental unit. Model effects were Blend, alfalfa levels, and the interactions. Linear and quadratic effects were analyzed using orthogonal polynomials.

Results

Interactions between alfalfa and Blend levels were observed only on marbling score and calculated yield grade. There were no effects ($P>0.05$) of alfalfa levels on any of the variables measured within each by-product level (Table 2). For F/G, no differences were observed within a Blend level; however, steers fed less roughage with either 25% or 50% Blend had lower F/G although the difference was not significant. Because little differences were observed by decreasing roughage as the by-product blend increased, our conclusion is that roughages can be decreased from conventional feeding levels as by-product inclusion increases. Due to little effect across different roughage levels, Blend level was tested as a main effect. Quadratic responses ($P<0.05$) to Blend level were observed for ADG, DMI and feed conversion (Table 3). Feedlot performance was not significantly different between the steers fed the 25% and 50% Blend diets. Steers fed the diets with a by-product inclusion of 25% or 50% had higher DMI, ADG, and better feed conversion than steers fed the 75% Blend and the control (0% Blend) diets. When the Blend was included at 75%, ADG, DMI, and feed conversion were not different from the control, corn-based diet (0% Blend).

Hot carcass weights were 5% heavier for the 25% and 50% Blend inclusion levels compared with the 0% (control) and the 75% Blend. Calculated yield grade, back fat and rib eye area showed a quadratic response to Blend levels in the diets, while marbling scores showed a trend ($P=0.08$) for a quadratic response.

Feeding Blend up to 50% of diet DM improved animal performance. Above the 50% Blend inclusion level, feedlot performance did not differ from the control corn-based diet. Alfalfa level in the diets could be reduced when Blend levels are increased without affecting feedlot performance. Wet distillers grains and wet corn gluten feed may be complementary based on their nutrient compositions. Distillers grains are higher in fat and undegradable intake protein while WCGF is higher in effective fiber. The combination was very effective in this experiment; at the 25% Blend level the energy value was 50% greater than the corn replaced by the Blend. A summary of past research has shown that wet distillers grain has 52% more energy value than corn at 17.4% of the diet. Wet corn gluten feed had 5.1% more energy than corn fed at an average of 35% of the diet. Based on these past studies, we predicted 29% higher values for the blend in this experiment at the 25% and 50% levels. In this experiment, cattle fed 25% Blend performed 44.8% better compared to corn in the control and cattle fed 50% Blend performed 22.4% better than corn in the control. The increased apparent energy value, especially for cattle fed the 25% Blend, is likely due to acidosis control and the complementary effect of the WDGS and WCGF.

[1]Pablo L. Loza, graduate student; Kyle J. Vander Pol, research technician; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Rick A. Stock, adjunct professor, Animal Science, Lincoln.

Ethanol Distiller By-product Phosphorus Concentration as Influenced by Corn Hybrid

Bahman Eghball[1]

Summary

Analysis of commercial corn hybrids indicated grain phosphorus concentrations ranged from 0.19% to 0.39%. This range of P concentration provides an opportunity to reduce P in the distiller's by-products. Based on 90% starch conversion efficiency, the estimated P concentrations of ethanol by-product were 0.52% and 1.04% when using grain with P concentrations of 0.19% and 0.39%, respectively. This is a reduction of 50% when using low P instead of high P corn hybrids.

Introduction

Ethanol production plants are using a significant amount of corn produced in the United States each year. In 2002, about 800 million bushels of corn were used to produce ethanol (Agricultural Statistics, 2002). In the ethanol production system, the starch is converted to ethanol and CO_2 and the remaining grain material is called distiller by-product (wet distiller grain plus soluble or dry distiller grain plus soluble). This by-product is high in energy, protein and P content and is usually fed to feedlot cattle in Nebraska. Removing starch from grain concentrates P in the by-product. When this high P material is added to a ration, it increases P concentration of the ration and subsequently increases manure P concentration.

Corn hybrids have different concentrations of P in grain. Results of a two-year field study conducted by the author in 1999 and 2000 indicated grain P concentration ranged from 0.21% to 0.33% among 12 commercial corn hybrids. Analysis of other commercial hybrids in 2003 indicated that high P hybrids have P concentrations that can be more than double those for low P hybrids. These low P grain hybrids can be used in rations to reduce P content or used in ethanol production to reduce P content of the by-product and hence make it a more environmentally friendly feedstuff. The starch conversion efficiency is usually greater than 90% with either dry or wet milling. Some of the starch is associated with phytate (P compound in the grain) and that would prevent the associated starch from being converted to ethanol (H. Noureddini, personal communication). The low P corn would have the advantage of containing less starch associated with P in grain and hence may increase starch conversion efficiency. The objective of this study was to determine the effects of corn hybrids with different grain P concentrations on the P content of ethanol by-products. By reducing P concentration of the by-product, the P concentration of manure also will be reduced, addressing concerns about soil P accumulation in the soil.

Procedure

Commercial corn hybrids (Pioneer Hi-Bred and NC+ brands) grown in Nebraska and Iowa in 2003 and the B73 X Mo17 hybrid were tested for grain P concentration differences. The grain samples (at least two replications except the NC^+ samples) were tested for total P using the X-ray method at the University of Nebraska Soil Testing Laboratory. The grain P concentration of each hybrid was used to estimate the P concentrations of the ethanol production by-products.

Ethanol distiller by-product P concentrations were estimated based on grain starch content and starch conversion efficiency. Starch recovery for the low temperature dried, elevator, and export corn during five years of milling ranged from 89 to 94% (average 92% + 0.5) (U.S. Grain Council, 2001). When calculating the expected P concentrations of the ethanol by-product, an assumption of 90% starch conversion efficiency was used. Corn grain total starch concentration was determined using the chemical solubilization method.

Results

There was a wide range of grain P concentrations among the corn hybrids (Table 1). Grain P concentration ranged from 0.19% to 0.39%, indicating that P concentrations varied more than 100% across the

(Continued on next page)

range of hybrids included in the study. The average grain P concentration for the hybrids was 0.27% and that was 42% higher than Pioneer 33B50, which had the lowest grain P concentration.

When grain from these hybrids is used for ethanol production, the P concentrations of the byproduct would be expected to range from 0.52% to 1.04%. Using Pioneer 33B50 instead of NC+ 3709 (the hybrids with the least and greatest P concentrations in the study; Table 1) for ethanol production would reduce the by-product P concentration by 50%. The low P content by-product should reduce the amount of P excreted in manure when it is fed to cattle.

In ethanol production facilities, corn from a number of farms and likely a mixture of hybrids with different P concentrations are used. The average P concentration of the hybrids reported in Table 1 was 0.27%, which may be similar to the mix used by ethanol plants. Using Pioneer 33B50 hybrid as compared with the average concentration can result in 27% reduction in the by-product P concentration. Phosphorus concentrations of by-products in eight new ethanol plants in Minnesota and South Dakota (118 samples) ranged from 0.70% to 0.99% (average 0.89% and CV=11.7%) (Spiehs et al., 2002, *Journal of Animal Science* 80:2639-2645). The P concentration of the by-product from the low P corn hybrid (0.19% P) was expected to be 42% less than the average of those from these eight plants.

Table 1. Grain phosphorus and starch concentrations (dry weight basis) of selected commercial corn hybrids and the estimated ethanol by-product P concentrations assuming 90% starch conversion efficiency.

Hybrid	Grain P Concentration	Grain Starch Concentration	Estimated Ethanol By-product P Content
	%		
Pioneer 33B50	0.190	70.8	0.52
Pioneer 34M94	0.197	69.6	0.53
Pioneer 35Y65	0.211	70.6	0.58
Pioneer 33R77	0.212	68.7	0.56
Pioneer 34N43	0.212	70.0	0.57
Pioneer 34B97	0.227	68.7	0.59
B73 X Mo 17	0.235	68.7	0.62
Pioneer 31N27	0.248	69.7	0.67
Pioneer 33P66	0.260	69.6	0.70
Pioneer 34H31	0.266	70.4	0.73
NC+ 3672	0.285	69.5	0.76
Pioneer 34G82[a]	0.295	69.6	0.79
Pioneer 33R87[a]	0.315	69.6	0.84
Pioneer 34D34[a]	0.322	69.6	0.86
NC+ 4771	0.386	69.5	1.03
NC+ 3709	0.394	68.8	1.04
Average	0.266	69.6	0.71

[a]Grain P concentrations taken from Eghball et al. (2003) and starch concentrations are the average of the other 13 hybrids reported in the table (the mean starch concentration of 69.6% had a standard error of 0.2).

Corn hybrids have a wide range of grain P concentrations. Using those with low P concentrations provides a great opportunity to reduce the P content in ethanol distiller byproducts. Using the low P hybrid can result in as much as a 50% reduction in the P concentration of the by-product. Additional research is needed to confirm the effects of P concentration in corn grain on ethanol quality and quantity and distiller by-product. In addition, other commercial corn hybrids need to be tested for grain P concentration differences and whether the P concentration trait is stable under various soil P levels or environmental conditions. Low grain P concentration corn removes less P from soil at the same grain yield level as high grain P corn, resulting in longer period when corn production is used to lower soil P level.

---

[1]Dr. Bahman Eghball passed away July 26, 2004. He was a soil scientist with the USDA-ARS and adjunct associate professor in the Department of Agronomy and Horticulture, Lincoln.

Effects of Field Peas in Beef Finishing Diets

Erin M. Fendrick
Ivan G. Rush
Dennis R. Brink
Galen E. Erickson
David D. Baltensperger[1]

Summary

Feeding field peas was compared to using corn in beef finishing diets. Diets containing field peas at 0%, 20%, 40%, and 59% replacement of corn in ration DM were fed to 129 steers. Dry matter intake increased from the 0% to 40% diets, but decreased when 59% peas replaced corn compared to 40%. No significant differences in ADG and G:F were observed. Field peas can replace 59% of the corn DM in beef finishing diet with no significant differences in animal gain or feed efficiency.

Introduction

Acreages of field peas (*Pisum savitum*) have increased markedly in recent years as field peas have become a valuable part of dryland crop rotations. Most field peas are grown for human consumption, however, the peas must meet strict quality grade standards for the human market. The rejected peas are much lower in dollar value and consequently are available for livestock consumption. Field peas contain 20-28% CP and one-third less starch than corn, which would indicate possibly a lower feeding value when protein needs are met. The objectives for our study were to determine the optimum level of field pea inclusion in a corn-based finishing diet and to compare the feeding of peas to corn.

Procedure

One-hundred-and-twenty-nine crossbred yearling steers weighing 799 lb were stratified by weight and randomly assigned to 16 pens with four pens randomly assigned to four treatments. Two consecutive day weights were taken for an initial weight. Single day weights were taken at 28-day intervals. Final weights were calculated from hot carcass weight by dividing carcass weight by 63%. Periodic feed and bunk samples were collected. The steers were on feed 143 days (5/24/03 to 10/13/03). Field peas replaced corn in the diet at 0%, 20%, 40%, and 59% (Table 1). The field peas were fed unprocessed. Two supplements were used with different levels of protein as the level of peas increased. One of the supplements contained 58% protein (38% from non protein nitrogen) (NPN) while the other was 10% protein with no NPN. The peas provided all the required protein in the diet of 40% and 59% field peas. Diets were calculated to contain 12.5%, 14.0%, 15.5%, 17.0% protein for 0%, 20%, 40%, and 59% diets, respectively. In the 20% pea diet a combination of two supplements was used to meet the required protein and monensin levels. Levels of monensin, vitamins, and trace minerals were constant in all experimental diets. The cattle were started on a 50 NEg diet and three steps were made to the final ration. The full level of peas (40% and 59%) was not achieved until the cattle were on the final finishing diet. All cattle were implanted with Synovex Plus® at the initiation of the trial plus treated for internal and external parasites. The data were analyzed in SAS using the Proc Mixed procedure with linear and quadratic contrasts. Mean with $P < 0.05$ were considered significantly different.

(Continued on next page)

Table 1. Experimental dry matter composition of rations containing four levels of peas[a].

	Peas			
Ingredient	0%	20%	40%	59%
Corn Silage	10.80	10.80	10.60	10.00
Dry Rolled corn	82.00	64.77	46.12	27.72
Peas		20.00	40.00	59.00
Supp A[b]	7.20	2.10		
Supp B[c]		1.80	2.60	2.60
Limestone		0.53	0.68	0.68

[a]Treatments are the percent of peas replacing corn on a DM basis.
[b]Supp A contained 58% crude protein.
[c]Supp B contained 10% crude protein.

Results

Cattle performance data is shown in Table 2. Dry matter intakes were significantly different (quadratic effect $P < .0001$). Intakes increased from 0% to 40% and decreased from 59% to 40%. It is not clear why intakes were higher at the low level pea diets yet dropped off at the higher levels. There did not appear to be any separation in the bunk so it is doubtful that palatability was greatly different between peas and corn. Because the level of starch is lower in peas than in corn, the higher intake of the pea diets may be explained by a possible increase in rumen pH as peas increased in the diet. This of course does not explain the peak intake at 40% peas rather than 59%, however, the intake at the high level of pea diet was still 1.5 lb higher than the corn control diet. The high level pea diets contained very high levels of protein which could have possibly moderated intake at the highest level. Bunk analysis of the diets found 12.7%, 14.3%, 16.2%, and 19.6% crude protein for the respective diets containing 0%, 20%, 40%, and 59% peas. Also, even though the NDF in all rations were relative low, if rumen pH was higher in the pea rations, NDF digestion could have been higher in the higher pea rations which would allow for greater intake.

There were no significant treatment differences among ADG and G:F ratios (Table 2). Numerically the control cattle were the most efficient because they had the lowest intake and the highest daily gain. In this experiment the control ration had 13.8% greater efficiency and although not statistically significant, it does suggest that further studies are needed to see if pea inclusions do lower efficiency and, if so, at what level.

Another factor suggesting that peas are of lower feeding value than corn, from an energy standpoint, was when the net energy value was estimated (Fred Owens Pioneer Brand Excel spreadsheet) in the overall diet and for peas. It was found that the value for peas was considerably lower than that for corn (Table 3). This was especially true with the lower level of inclusion. The estimated NEg level of the peas increased as the level in the diet increased. It is unclear why the estimates are greatly different at the different levels, but perhaps peas are influencing the overall diet digestion. Because the numerical differences in efficiency of the pea diets were nearly equal but greatly differed when compared to the corn diet, it is logical that the net energy value will be lowest at the lowest inclusion level. Reasons for the apparent negative associated effect are unclear, however, due to the fact that the feed efficiency means were not significantly different, it is probable the pea net energy values are estimated lower than actual values. It appears that when all factors are considered, the energy value of peas is somewhat lower than corn but the exact level is not clear in this experiment. No significant differences among treatments were observed for carcass variables (Table 4).

Replacing up to 59% of the diet DM with field peas produced similar animal gain, efficiency, and carcass quality with increased consumption to compensate for lower NEg content of the peas. Field peas have potential agronomic benefits for crop rotation in western Nebraska and the peas rejected from the human market can be fed with satisfactory results at high levels in finishing rations.

Table 2. Performance of finishing steers fed different levels of field peas[a].

	Peas				*P*-value	
Item	0%	20%	40%	59%	Linear	Quad
Initial wt, lb	810	799	806	799	0.8419	0.7891
Final wt, lb	1320	1288	1297	1294	0.1300	0.8447
DMI lb/day	21.0	22.9	23.1	22.5	0.0489	< .0001
ADG, lb	3.63	3.50	3.50	3.45	0.8719	0.4256
G:F	0.173	0.152	0.151	0.154	0.6002	0.2867

[a]Treatments are the percentage of peas replacing corn on a DM basis.

Table 3. Calculated net energy values Mcal/lb (Fred Owens, Pioneer Brand Excel Spreadsheet) for overall diets and peas in the diet[a].

	Peas			
Item	0%	20%	40%	59%
Diet NEg	.65	.57	.55	.58
Field Pea NEg	—	.17	.44	.56

[a]Treatments are the percentage of peas replacing corn on a DM basis.

Table 4. Carcass data of finishing steers fed different levels of peas[a].

	Peas				*P*-value	
Item	0%	20%	40%	59%	Linear	Quad
Hot wt, lb	831.8	811.4	816.8	815.3	0.3821	0.3968
Marbling score[b]	5.34	5.13	5.39	5.12	0.6825	0.8857
Fat, in.	0.51	0.47	0.48	0.52	0.6328	0.2063
Rib eye area, sq. in.	13.45	12.97	12.95	12.92	0.0748	0.2876

[a]Treatment is the amount of peas replacing the corn in the diet.
[b]Marbling score, 5.0 = small 0.

[1]Erin M. Fendrick, graduate student; Ivan G. Rush and David D. Baltensperger, professors, Animal Science and Agronomy, Panhandle Research and Extension Center, Scottsbluff; Dennis R. Brink, professor, Animal Science, Lincoln; Galen E. Erickson, assistant professor, Animal Science, Lincoln.

Effects of Dietary Phosphorus Level in Beef Finishing Diets on Phosphorus Excretion Characteristics

Bobbi Gene Geisert
Galen E. Erickson
Terry J. Klopfenstein
Matt K. Luebbe[1]

Summary

Five ruminally fistulated steers were fed five finishing diets containing varying levels and sources of phosphorus (P). Diets consisted of 3 brewer's grits-based diets consisting of one with no supplemental P (0.12) and two supplemented with mineral P (0.27%, and 0.42% P), one corn-based diet (0.30% P), and one diet containing dry distillers grains (0.36% P). As P intake increased, P excretion increased and was positively correlated (r = 0.67; P < *0.01) to P intake. Most of the P excretion was fecal P averaging 88.7% of total excretion. With the exception of steers fed the 0.12% P diet with very little (0.50 g/day) urinary P, steers fed the other treatment diets excreted an average 2.1 g/day via the urine. These data suggest that P intake is positively correlated to P excretion and diet P concentration may impact route of excretion.*

Introduction

There is a growing interest in reducing P excretion from finishing cattle. One way to lower the amount of P excreted is by reducing the amount of P fed. Previous research suggests as dietary P increases, amount of fecal P excretion increases from cattle fed roughage-based diets (Valk et. al. 2002). The effects of dietary P levels on P excretion have not been well documented in feedlot diets, therefore the objective of this study was to evaluate the effects of dietary P concentrations on amount and route P excretion when cattle are fed finishing diets.

Procedure

Five ruminally fistulated steers (initial BW = 850 lb + 87 lb) were utilized in a 5 x 5 Latin square experiment. Diets (Table 1) consisted of three brewers grits-based diets formulated for 0.12% P (LOWP) with monosodium phosphate added to increase P level to 0.27 (MEDP) and 0.42% P (HIGHP). Diets consisted of 50% coarse brewers grits, 20% dry-rolled corn (DRC), 15% corn bran, 5% grass hay, 5% molasses, and 5% supplement and were similar to those in a P requirement study previously reported (*2004 Nebraska Beef Report*, pp. 49-51). The remaining two diets were a DRC-based diet (CORN) and a dry distillers grain diet (DDGS). The CORN diet consisted of 85% DRC, 5% grass hay, 5% molasses, and 5% supplement. The DDGS diet contained 57% DRC, 30% dry distillers grains, 5% grass hay, 5% molasses, and 3% supplement. Diets contained 0.12%, 0.27%, 0.42%, 0.30% and 0.36% P (DM basis) for

(Continued on next page)

Table 1. Diet composition for finishing rations (% DM basis).

Ingredient	Treatments				
	LOWP[a]	MEDP[a]	HIGHP[a]	CORN[b]	DDGS[c]
Brewers Grits	50	50	50	—	—
DRC[d]	20	20	20	85	57
DDGS[e]	—	—	—	—	30
Corn Bran	15	15	15	—	—
Grass Hay	5	5	5	5	5
Molasses	5	5	5	5	5
Supplement	5	5	5	5	3

[a]Monosodium phosphate replaced fine ground corn in the supplement. Diets contained 0.12%, 0.27% and 0.42% P for LOWP, MEDP, and HIGHP, respectively.
[b]CORN contained 0.30% P.
[c]DRC replaced fine ground corn in the supplement. Diet contained 0.36% P.
[d]DRC means dry rolled corn.
[e]DDGS means dry distillers grains.

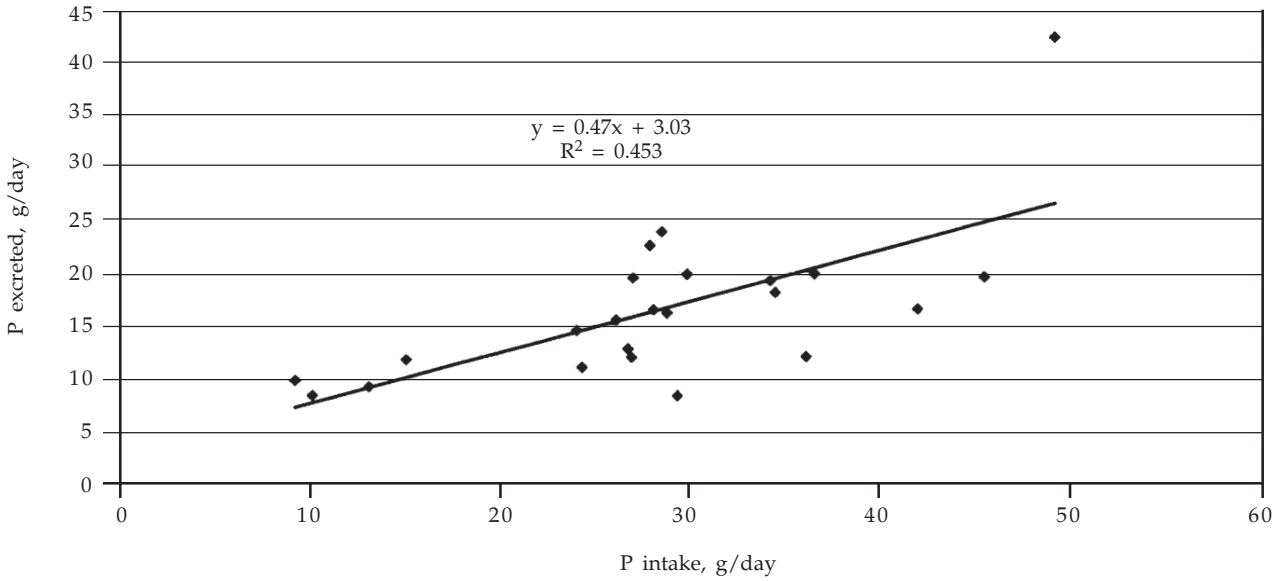


Figure 1. Relationship between P intake and P excretion for steers fed varying concentrations of dietary P.

Table 2. Intake and excretion of P from steers consuming different levels of dietary phosphorus.

	Treatments[a]					Statistics	
Item	LOWP	MEDP	HIGHP	CORN	DDGS	SEM	F-Test
Diet P, %	0.12	0.27	0.42	0.30	0.36		
DMI, lb/day	20.7	23.2	21.5	21.1	20.9	1.5	0.16
P Intake, g/day	10.5 [d]	26.7 [e]	37.9 [h]	29.5 [f]	34.6 [g]	0.7	<0.01
P Excreted, g/day	9.5 [d]	16.3 [de]	25.0 [f]	14.2 [de]	18.0 [ef]	2.9	0.04
Urine P, g/day	0.50 [d]	2.18 [e]	1.78 [e]	2.17 [e]	2.26 [e]	0.52	0.03
Fecal P, g/day	9.2 [d]	14.2 [de]	23.2 [f]	12.1 [de]	15.8 [ef]	3.1	0.07
% Urine [b]	4.1	14.2	9.5	16.7	12.3	3.5	0.22
% Feces [b]	95.9	85.8	90.5	83.4	87.7	3.5	0.22
% of Intake [c]	85.2[a]	60.9[b]	65.5[bc]	47.8[bd]	54.2[bcd]	7.6	0.04

[a]Treatments include three brewers grits diets with varying levels of supplemental mineral P (LOWP, MEDP, and HIGHP), a corn-based diet (CORN), and a distillers by-product diet (DDGS).
[b]Phosphorus excreted in either urine or feces as a percentage of total phosphorus excreted.
[c]Percentage of phosphorus excreted as a percentage of phosphorus intake.
[d,e,f,g,h]Means within a row with different superscripts are different ($P < 0.10$).

Table 3. Diet digestibility of finishing diets with different levels of P.

	Treatments[a]					Statistics	
Item	LOWP	MEDP	HIGHP	CORN	DDGS	SEM	F-Test
DMD, %[b]	75.4	69.8	74.4	64.9	75.3	2.7	0.07
OMD, % [c]	76.4	71.6	75.6	65.8	76.7	2.7	0.07
PD, % [d]	11.1[e]	39.1[f]	33.3 [f]	52.2 [f]	45.8 [f]	7.5	0.04

[a]Treatments include three brewers grits diets with varying levels of supplemental mineral P (LOWP, MEDP, and HIGHP), a corn-based diet (CORN), and a distillers by-product diet (DDGS).
[b]Dry matter digestibility.
[c]Organic matter digestibility.
[d]Phosphorus digestibility
[e,f]Means within a row with different superscripts differ ($P < 0.05$).

LOWP, MEDP, HIGHP, CORN and DDGS, respectively. In the MEDP and HIGHP diets the P source was inorganic phosphate which was supplied with the substitution of monosodium phosphate for fine ground corn as part of the supplement. The source of P in the LOWP, CORN, and DDGS diets was organic in the form of phytate. Steers were fed ad libitum once daily at 0700 and were allowed to adapt to diets for 16 days followed by a 5-day collection period. Chromic oxide was dosed (10g/day) directly into the rumen using gel capsules, twice daily (0600 and 1700) for the final eight days of every collection period.

A funnel system was used to collect total urine for the final five days of the collection period. Urine collection containers were drained three times daily (0600, 1200, and 1700 hours), urine volume was recorded and a 45 ml sub-sample was taken. Urine samples were frozen and later analyzed for urine P concentration using a commercial kit (Diagnostic Chemicals Limited).

Fecal samples were collected three times daily (0600, 1200, and 1700 hours) and dried in a 60°C forced air oven. They were composited by collection period and ground through a 1 mm screen using a Wiley mill. They were stored and later analyzed for chromium, nitrogen, and P concentration. Diet and ingredient samples were taken daily during the last eight days of the collection period and composited by collection period for analysis. Composite samples were dried using a 60°C forced air oven and ground, then analyzed for P concentration.

Results

Dry matter intake and phosphorus excretion data are shown in Table 2. There were no significant treatment differences in DMI ($P > 0.10$). Average intake for all treatments was 21.5 lb/day. The P intakes were 10.5, 26.7, 37.9, 29.5 and 34.6 g/day for LOWP, MEDP, HIGHP, CORN, and DDGS diets, respectively.

Route of excretion did appear to be related to P intake. Steers fed the LOWP excreted very little urinary P and less ($P < 0.01$) than all other treatments. However, urinary P excretion was variable, but similar on the other treatments. Based on previous research, only small amounts of P are excreted in the urine; however, an average of 2.1 g/day was excreted by steers on all other treatments except LOWP. Fecal excretion of P was significantly different ($P = 0.07$) among treatments. Therefore, total P excretion (fecal and urinary P combined) was different ($P = 0.04$) across treatments.

Figure 1 depicts the relationship between P intake and P excretion. As expected, when more P is fed, more is excreted. P intake and P excretion were significantly and positively correlated (r = 0.67). From Figure 1, the intercept (3.1 g/day) depicts the predicted maintenance requirement or the P excreted when no P is consumed by cattle. Comparing this calculated maintenance requirement to 1996 NRC equations for 850 lb steers, the estimated maintenance requirement is greater (6.2 g/day) than calculated values in this study. One point, however, is quite high with an animal consuming 50 g/day of P and excreting 42 g/day. If that data point is removed, the calculated maintenance requirement is 7.5 g/day; however, the relationship is not as strong with this animal removed.

Digestibility data are shown in Table 3. There were no differences ($P > 0.10$) in either organic matter digestibility (OMD) or dry matter digestibility (DMD). Phosphorus digestibility was influenced by diet with the lowest digestibility with steers fed LOWP. The remaining treatments were not different and averaged 42.6% P digestibility. Surprisingly, P digestibility was not depressed at higher P intakes.

As the P concentration of the diet increased, so did the amount of P that was excreted. Most of the P excreted is in the feces whereas little P is excreted in the urine. Reducing the dietary P in feedlot rations by eliminating supplemental P can reduce the amount of P excreted. This will increase the N:P ratio and reduce the amount of P entering fields. Eliminating P supplementation is supported by previous research (*2004 Nebraska Beef Report,* pp. 49-51; *2002 Nebraska Beef Report,* pp. 45-48) which has shown that feeding levels as low as 0.17% P (DM basis) to calf-fed heifers and steers has no adverse effects on cattle performance. Feeding P levels as low as 0.14% P to yearling steers (*1996 Nebraska Beef Report*, pp. 78-80) did not affect performance. Eliminating supplemental P from corn or corn/by-product diets will reduce the amount of P excreted while maintaining cattle performance. It is still unclear how amount or route of excretion may influence solubility of P. Recent research in dairy cattle suggests that soluble P may be increased as dietary P (and P excretion) is increased. Presumably, the greater the solubility of P, the greater the potential for manure P challenges in runoff. This experiment will be analyzed in the future to assess solubility of P with these different diets.

---

[1]Bobbi Gene Geisert, graduate student, Galen E. Erickson, assistant professor, Terry J. Klopfenstein, professor, and Matt K. Luebbe, research technician, Animal Science, Lincoln.

Effects of Corn Bran and Corn Steep Inclusion in Finishing Diets on Cattle Performance and Nitrogen Mass Balance

Kristi M. Sayer
Galen E. Erickson
Terry J. Klopfenstein
Kyle J. Vander Pol
Casey N. Macken[1]

Summary

Two experiments were conducted to evaluate the effects of decreasing digestibility of a finishing diet by replacing dry rolled corn (DRC) with corn bran, or a combination of corn bran and steep, on cattle performance and nitrogen mass balance in open feedlots. Replacement of DRC with bran had no impact on performance when steep was included in the finishing diets at 15% DM. Feeding bran and steep, in combination, was an effective means of reducing N losses in winter, as well as maintaining cattle performance throughout the year.

Introduction

Less than 15% of dietary nitrogen (N) is retained by feedlot cattle (*1996 Nebraska Beef Cattle Report*, pp 74-77). The other 85% is excreted and can be lost by volatilization. By increasing the amount of carbon in the manure, it is possible to trap more N in manure and thus volatilize less N.

One way to increase the amount of organic matter (OM) in the manure is to increase the amount of hind gut fermentation by lowering diet digestibility (*1996 Nebraska Beef Report*, pp 74-77). Corn bran is a highly digestible fiber source that is effective in increasing the amount of OM and trapping more N in manure. N losses were reduced by 20.4% in winter, when bran was included at 30% diet DM; however, feed efficiency was reduced by 10.6% (*2002 Nebraska Beef Report*, pp 54-57).

Corn steep is a by-product of the wet corn milling industry and has been shown to have a higher energy value than dry rolled corn (DRC). It is a combination of both distillers solubles and steep liquor. The optimal inclusion level of steep in finishing diets was determined to be 15% of diet DM, when bran was also included in the diet at 15% or 30% (*1998 Nebraska Beef Report*, pp 69-71). Feed efficiency was improved 9.3% when steers were fed a combination of bran and steep. Steep and bran are normally combined in the production of wet corn gluten feed, which is becoming a common feed in feedlot diets. The objectives of this study were to evaluate the effect on cattle performance and N mass balance of replacing DRC with corn bran and corn steep in finishing diets.

Procedure

Cattle Performance

In the first experiment (WINTER), 128 steer calves (693 + 29 lb) were fed 167 days, from November 2002 to April 2003, and in the second experiment (SUMMER), 256 yearling steers (806 + 31 lb) were fed for 126 days, from May to September 2003. Steers were stratified by weight and assigned randomly to one of four dietary treatments.

The control (CON) diet was formulated to provide a typical dry rolled corn-based diet (Table 1). Corn bran then replaced DRC at 30% diet DM (30/0), similar to previous studies (*2002 Nebraska Beef Report*, pp 54-57, *2003 Nebraska Beef Report*, pp 54-58). Bran and steep replaced DRC and molasses at 30% and 15% (DM basis), respectively

Table 1. Composition of dietary treatments for WINTER and SUMMER trials (% DM basis).

Ingredient	CON	30/0	30/15	45/15
Dry rolled-corn	75	45	35	20
Corn Silage	15	15	15	15
Corn Bran	—	30	30	45
Steep	—	—	15	15
Molasses	5	5	—	—
Dry Supplement				
Limestone	1.56	1.65	1.66	1.66
Urea	1.50	0.99	0.10	—
Blood Meal	0.15	0.75	—	—
Feather Meal	0.15	0.75	—	—
Fine Ground Corn	1.08	0.27	2.70	2.80
Salt	0.30	0.30	0.30	0.30
Tallow	0.15	0.15	0.15	0.15
Beef Trace Mineral	0.05	0.05	0.05	0.05
Potassium Chloride	0.02	0.05	0.05	0.05
Rumensin Premix	0.018	0.018	0.018	0.018
Tylan Premix	0.013	0.013	0.013	0.013
Vitamin Premix	0.01	0.01	0.01	0.01
Nutrient Composition (%)				
CP[a]	13.7	13.4	14.0	14.2
DIP[b]	8.9	9.8	9.5	10.4
Calcium[c]	0.70	0.70	0.70	0.70
Phosphorus[c]	0.32	0.26	0.47	0.44

[a]Calculated based on average CP analysis of feedstuffs for WINTER and SUMMER trial.
[b]DIP = degradable intake protein.
[c]Calculated based on tabular values.

Table 2. Effects of dietary treatment on steer performance during WINTER trial.

	Treatment[a]					
Item	CON	30/0	30/15	45/15	SEM[b]	F-Test[c]
DMI, lb/day	23.2	24.3	25.1	23.7	0.43	0.06
ADG, lb	3.70	3.80	3.90	3.70	0.08	0.22
Feed:Gain[d]	6.27	6.39	6.42	6.44	0.14	0.56
Hot Carcass Weight, lb	826	835	848	824	9.18	0.27
12th rib fat, in	0.59	0.53	0.55	0.56	0.03	0.67
Marbling score[e]	539	512	535	551	16.93	0.46

[a]Treatments: CON = dry rolled corn-based diet with no byproduct inclusion; 30/0 = dry rolled corn replaced with 30% bran and 0% steep; 30/15 = dry rolled corn and molasses replaced with 30% bran and 15% steep; 45/15 = dry rolled corn and molasses replaced with 45% bran and 15% steep.
[b]Standard error of the mean.
[c]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[d]Analyzed as Gain:feed.
[e]Marbling score: 400 = slight^0; 450 = slight^{50}; 500 = small^0; 550 = small^{50}; etc.

Table 3. Effects of dietary treatment on steer performance during SUMMER trial.

	Treatment[a]					
Item	CON	30/0	30/15	45/15	SEM[b]	F-Test[c]
DMI, lb/day	24.0[e]	25.6[f]	26.0[f]	25.4[f]	0.24	<0.01
ADG, lb	3.50	3.46	3.76	3.63	0.08	0.07
Feed:Gain	6.89[e]	7.43[f]	6.92[e]	7.02[e]	0.14	0.05
Hot Carcass Weight, lb	788	784	806	799	7.21	0.15
12th Rib Fat,in	0.48	0.52	0.50	0.49	0.03	0.74
Marbling Score[e]	500	501	515	484	8.51	0.11

[a]CON = dry rolled corn based diet with no byproduct inclusion; 30/0 = dry rolled corn replaced with 30% bran and 0% steep; 30/15 = dry rolled corn and molasses replaced with 30% bran and 15% steep; 45/15 = dry rolled corn and molasses replaced with 45% bran and 15% steep.
[b]Standard error of the means.
[c]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[d]Marbling score: 400 = slight^0; 450 = slight^{50}; 500 = small^0; 550 = small^{50}; etc.
[ef]Means within row with different superscripts differ.

(30/15), to evaluate the effect of steep. The final treatment included 45% bran and 15% steep (45/15) on a DM basis, to try and further increase the amount of OM in the manure. Cattle were adapted to diets over a 21-day step up period. During the first 67 days of the WINTER trial, cattle were fed diets containing 6% supplement. Diets were balanced for metabolizable protein. WINTER calves were implanted with Synovex S® and re-implanted with Revalor S®, and SUMMER yearlings were implanted with Revalor-S®.

Following harvest, data were recorded on hot carcass weight, 12th rib fat, marbling and yield grade. Final weights were calculated based on a 63% common dressing percentage. DM intake, ADG, and feed/gain were calculated.

Nutrient Balance

The WINTER experiment was conducted using 16 open feedlot pens with a stocking density of 344 ft^2 per steer and 8 steers per pen. When rainfall occurred, runoff was collected in retention ponds below the pens. Precipitation amount was measured using a rain gauge, and the effluent was drained and quantified using an air bubble flow meter (ISCO, Lincoln, Nebraska). Samples of the effluent were collected and analyzed for DM, OM, and total N content.

The SUMMER experiment was conducted using 24 open feedlot pens. Sixteen of the pens were the same pens used in the WINTER experiment. The other 8 pens had 16 steers per pen, with a stocking density of 328 ft^2 per steer. Runoff collection was similar to the WINTER trial.

For both trials, feed refusals were collected and sampled. Pens were cleaned approximately every 28 days during the WINTER and every 42 days during the SUMMER. Manure was piled on the cement apron, sampled, weighed and then piled in windrows in the compost yard.

Feed sources were sampled monthly and analyzed for ash, CP, and DM content. N intake was calculated based on analyzed dietary N sources, multiplied by DMI and corrected for feed refusals. Retained steer N was calculated using the energy and protein equation found in the NRC (1996). N excretion was determined by subtracting N retention from N intake. The DM digestibility of the CON diet was 79% and the by-product diets were reported as 73.7%, 72.8%, and 72.6% DM digestibility for the 30/0, 30/15, and 45/15 diets respectively in the *2005 Nebraska Beef Cattle Report*, pp 39-41.

Total N loss was calculated on a lb/steer basis. Excreted N minus runoff N and manure N equals total N lost. The percentage of N lost was calculated as N lost divided by N excreted. All data were analyzed using the PROC MIXED procedures in SAS.

Results

Feedlot Performance

Cattle were finished to similar endpoints, with no differences in hot carcass weight or 12th rib fat (Table 2). In WINTER, cattle fed CON diets tended to eat less than cattle on byproduct diets (23.2 lb/day vs. 24.3 lb/day, $P = 0.06$), however, no differences in final weight or feed conversions were detected ($P > 0.05$; Table 2). These data tend to contradict previous research where cattle on 30/0 diets had lower feed conversions.

Cattle fed during the SUMMER (Table 3) were also finished to

(Continued on next page)

similar endpoints, with no differences detected in final weight or 12th rib fat. Cattle on the CON diet had lower DMI then those on the by-product diets (24.0 lb/day vs. 25.7 lb/day, P<0.01). Cattle fed the 30/0 diet had lower ($P < 0.05$) feed conversions than other treatments (Table 3); however, when corn steep was added to the diet, feed conversions were similar to the CON. These data support the theory that steep helps cattle maintain performance when bran is included in the diet, possibly because of the additional energy provided by steep.

Nutrient Balance

Manure N content was higher from cattle on the 30/0, 30/15, and 45/15 diets ($P < 0.05$) than manure N from the CON fed cattle (Table 4). The 45/15 treatments had the lowest ($P < 0.05$) percentage of N lost and had the highest amount of OM removed from the pen floor. This is similar to what has been observed in previous research (*1996 Nebraska Beef Cattle Report*, pp 74-77). The 45/15 treatments reduced N losses by 43.9%, when compared to the CON diet ($P < 0.05$).

During the SUMMER trial (Table 5), no differences were detected in the percentage of N lost among treatments (averaging 60.1%). Manure N content and the amount of OM removed from the pen were higher for the by-product diets than the CON diet ($P < 0.05$).

Temperature and moisture both affect the amount of N volatilized. During the WINTER trial, the temperature averaged 33.9ºF, with only 3.74 inches of rainfall; however, the SUMMER trial averaged 69.4ºF, with 12.20 inches of rainfall. The higher N losses during the SUMMER can be attributed to these higher temperatures and possibly to the higher rainfall. As with other studies (*2003 Nebraska Beef Report*, pp 54-58, *2002 Nebraska Beef Report*, pp 54-57), reducing N losses through feeding corn bran and increasing OM on the pen floor surface was only effective in the WINTER.

Feeding bran and steep, in combination, was an effective means of reducing N losses in winter, as well as maintaining cattle performance throughout the year.

Table 4. Effects of dietary treatment on nitrogen mass balance during WINTER expressed in lb/steer.

	Treatment[a]					
Item	CON	30/0	30/15	45/15	SEM[b]	F-Test[b]
N intake	91.2[g]	89.5[g]	97.6[h]	93.5[gh]	1.5	0.02
N retention[c]	12.5	12.8	13.2	12.4	0.2	0.24
N excretion[d]	78.8[g]	76.6[h]	84.4[i]	81.2[gi]	1.3	0.01
Manure N	28.6[g]	37.8[h]	40.7[h]	52.0[i]	3.5	<0.01
Run-off	0.20	0.05	0.12	0.01	0.06	0.20
N lost[e]	50.0[g]	38.8[hi]	43.7[gh]	29.2[i]	5.1	0.01
N loss, %[f]	63.7[g]	50.7[h]	51.8[h]	35.8[i]	9.0	0.01
DM removed	2379[g]	2523[g]	2732[g]	3859[h]	302	0.02
OM removed	605[g]	928[h]	935[h]	1269[i]	70	<0.01

[a]CON = dry rolled corn-based diet with no by-product inclusion; 30/0 = dry rolled corn replaced with 30% bran and 0% steep; 30/15 = dry rolled corn and molasses replaced with 30% bran and 15% steep; 45/15 = dry rolled corn and molasses replaced with 45% bran and 15% steep.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c] Calculated using the NRC net protein and net energy equations.
[d]Calculated as N intake - N retention.
[e]N lost = N excretion - Manure N - Runoff N.
[f]Calculated as N lost divided by N excretion.
[ghi]Means within row with different superscripts differ.

Table 5. Effects of dietary treatment on nitrogen mass balance during SUMMER, expressed as lb/steer.

	Treatment[a]					
Item	CON	30/0	30/15	45/15	SEM	F-Test[b]
N intake	75.2[g]	83.3[h]	81.3[hi]	80.1[i]	0.7	<0.01
N retention[c]	11.2[g]	10.9[g]	12.0[h]	11.5[gh]	0.2	0.05
N excretion[d]	64.1[g]	72.4[h]	69.3[i]	68.6[i]	0.7	<0.01
Manure N	22.3[g]	29.8[h]	28.7[h]	29.2[h]	1.5	0.01
Run-off	2.29	1.65	3.25	1.47	0.5	0.09
N lost[e]	40.7	41.8	39.0	38.6	2.2	0.69
N loss, %[f]	63.5	57.8	56.2	56.4	6.6	0.13
DM removed	1844	2346	2221	2489	200	0.16
OM removed	395[g]	593[h]	575[h]	615[h]	29	<0.01

[a]CON = dry rolled corn-based diet with no by-product inclusion; 30/0 = dry rolled corn replaced with 30% bran and 0% steep; 30/15 = dry rolled corn and molasses replaced with 30% bran and 15% steep; 45/15 = dry rolled corn and molasses replaced with 45% bran and 15% steep.
[b]Data were analyzed using a protected F-test where numbers represent P-value for variation due to treatment.
[c]Calculated using the NRC net protein and net energy equations.
[d]Calculated as N intake - N retention.
[e]N lost = N excretion - Manure N - Runoff N.
[f]Calculated as N lost divided by N excretion.
[ghi]Means within row with different superscripts differ.

[1]Kristi M. Sayer, graduate student, Galen E. Erickson, assistant professor, Terry J. Klopfenstein, professor, Animal Science, Lincoln, Kyle J. Vander Pol, research technician, Casey N. Macken, former research technician, Lincoln.

Composting of Feedlot Manure: Compost Characteristics, Crop Yields and Application Rates

Casey B. Wilson
Galen E. Erickson
Terry J. Klopfenstein
Walker Luedtke
Mark A. Schroeder[1]

Summary

Crop yields were measured using no-compost check strips in large-scale production fields to determine the impact of a one-time compost application. Adding compost to irrigated corn, irrigated soybeans and dryland corn acres significantly increased yields. Altering the application rate from 0 to 20 to 40 ton per acre did not significantly increase grain yield. However, all yields made biological improvements under irrigated conditions when compost was added.

Introduction

Managing manure and its nutrient content is increasingly important for agricultural producers. Numerous projects have been initiated at the University of Nebraska to help producers handle the challenges of managing manure, and also the costs associated with nutrient management. The primary focus of this article is to summarize compost characteristics and average yield responses from a one-time compost application to irrigated corn and soybeans or dryland corn and soybeans.

Procedure

Composting was initiated in 1993 (Study 1) to handle manure from the 1500-head research beef feedlot at the University of Nebraska Agricultural Research and Development Center near Ithaca, Nebraska. Subsequently, compost as a waste management system has been evaluated by determining costs of composting and spreading, nutrient recoveries during composting and yield impacts from compost amendment to soil. Research progress reports have been provided in previous beef reports (*1996 Nebraska Beef Report*, pp 77-79; *1997 Nebraska Beef Report*, pp. 88-91; *2001 Nebraska Beef Report*, pp 92-95).

Composting occurred in windrows during the summer months (May to October) and was dependent on manure supply and timing. After windrows were formed, samples were collected from random locations. Compost was considered finished when windrows no longer produced heat two to seven days after turning. After complete composting, windrows were again sampled. Samples were composited by time and by windrow and analyzed for DM, OM, N (nitrogen), P (phosphorus), K (potassium) and most mineral elements. Nitrogen recoveries were calculated using total ash as an internal marker and the following equation: Nitrogen recovery = *100 x [(% ash before ÷ % ash after) x (% N after ÷ % N before)]*. The reductions in manure weight with composting also were evaluated in a similar manner using total ash as a marker for DM. Weight reduction percentage was the reduction in as-is weight over the entire composting period divided by the as-is weight before. Weights before composting were calculated as follows: As-is weight before = *[((DM weight after (lb) x % ash after) ÷ % ash before)) ÷ %DM before]*. Ash and N concentrations on a DM basis were used in both calculations.

Since 1993, approximately 1600 acres received compost. Fields were chosen based on a Bray P-1 soil phosphorus test result less than 15 ppm as the critical soil test value and the availability of compost. In 1999 compost application was increased to 20 tons/acre (as is). Check strips were maintained in large scale production fields by GPS/GIS technology to ensure strip identity and integrity. No-tillage cropping systems were utilized in all research and compost was not incorporated.

Yield data have been collected and summarized for compost produced from 1999 to 2003. Total weight from check strips was collected in a 550-bu Brent (model 672) grain cart equipped with J-star load cells or measured by truck scale.

(Continued on next page)

When weighing capability was unavailable, yields were determined by calibrated yield monitors from grain combines. Fields were managed similarly in terms of crop, variety or hybrid, irrigation , N fertilization and planting/harvesting dates. No commercial P was applied. Compost was applied in winter after soybean harvest and before corn planting.

To account for variation from field to field, field and compost treatments were included in the yield model for all compost treatments. All fields were maintained on either an irrigated, no-till corn-soybean rotation or a non-irrigated, no-till corn-soybean rotation. Yield differences were analyzed within each crop by year from application time, whether one, two or three years from compost amendment, using the MIXED procedure in SAS.

An additional study was initiated in 1999 (Study 2) to evaluate applying compost at different rates to evaluate yield response in an irrigated corn-soybean rotation. Compost was applied at one of three rates: 0, 20 or 40 ton/acre (as is). Treatments in the rate study were applied to 16-row strips in large production fields with five replications per application rate. Compost application and grain yield were conducted in the same manner as described above. Data were analyzed within each crop by year from application time and predetermined contrasts were made to compare application rates using the MIXED procedure of SAS.

Table 1. Feedlot compost nutrient composition for 2000 to 2003.

Year[a]	DM In,%[b]	DM Out,%[c]	Lb per ton of DM N	P	K	N recovery	% Reduction[d]
2000	82.4	76.6	15.7	7.5	23.9	72	4.0
2001	62.6	73.6	20.6	12.9	27.9	79	23.6
2002	76.2	77.7	19.9	10.8	24.7	73	12.9
2003	69.2	80.6	17.2	14.5	29.5	83	20.1
Average	72.6	77.1	18.4	11.4	26.5	76.8	15.2

[a]Year represents the summer that composting occurred.
[b]Manure DM entering the compost process.
[c]DM of finished compost.
[d]% reduction in weight from manure to finished compost.

Table 2. Yield response (bu/acre) from compost on irrigated corn and soybeans.

Year[a]	crop[b]	No Compost	Compost	diff(bu)	diff(%)	strip	SEM	*P*=
1	IC	224.2	232.6	8.4	3.7	18	2.2	0.01
3	IC	231.8	246.5	14.7	6.3	6	3.6	<0.01
Overall average		228.0	239.6	11.6	5.0			
2	ISB	60.8	61.9	1.1	1.8	15	0.5	0.05
3	ISB	58.9	58.8	-0.1	-0.2	3	1.9	0.97
Overall average		59.9	60.4	0.5	0.8			

[a]Year is the number of years following a one-time compost application, differences in bushels and percentage calculated as compost minus no compost divided by no compost treatment, strip is a measure of replication, SE is the standard error of the mean, and *P*= is the probability that the compost and no compost treatments are equal when variation due to fields is accounted for.
[b]Crop designated as IC (irrigated corn) or ISB (irrigated soybeans).

Results

Compost Characteristics

Nitrogen concentration is usually an indicator of compost quality and soil contamination. Nitrogen content of feedlot compost is generally lower in years accompanied by muddy and wet conditions (*1996 Nebraska Beef Cattle Report*, pp 77-79); however, the four years reported here were accompanied by minimal soil contamination.

Compost analyses are reported in Table 1. Averaged across four years, finished feedlot compost contained 18.4 lb of N, 11.4 lb of P and 26.5 lb of K per ton of DM. Dry matter concentration averaged 77.1%. Therefore, 14.2 lb of N, 8.8 lb of P and 20.4 lb of K were produced per ton of as-is compost. Converting P to P_2O_5 basis leads to 20.2 lb of P_2O_5 per ton of as-is compost from the feedlot. Converting K to K_2O basis leads to 31.9 lb of K_2O per ton of as-is compost from the feedlot. Using the average N concentration of 14.2 lb of N, the value of N is $3.02 per ton (as-is) assuming N is priced at $0.212 per lb ($NH_3$ = $350 per ton equivalent, based on 2004 prices). Similar calculations for P suggest the value of P is $5.92 per ton (as-is) assuming $0.293 per lb P_2O_5 (18-46-0 = $270 per ton equivalent).

During composting, energy is required in the form of carbon (organic matter) to maximize N recovery. Therefore, a critical measure in manure is the carbon to nitrogen (C:N) ratio. Feedlot manure is usually 12:1 whereas optimal C:N ratios are 25:1 or greater. The consequences of low C:N ratios are greater N losses. Table 1 contains N recovery ranges for feedlot compost in these studies. N recovery was variable but ranged from 60% to 90%, which suggests that the majority of N is transformed from inorganic N to organic N. Once applied, organic N should be more stable than that in manure and eventually will be used by the growing crops.

Calculated weight reduction percentages show an average reduction of 15.5% of initial manure weight. This is a sizeable reduction in weight to be handled and

Table 3. Yield response (bu/acre) from compost treatment on dryland corn and soybeans.

Year[a]	crop[b]	-comp	+comp	diff(bu)	diff(%)	strip	SEM	*P*=
1	DLC	140.5	158.1	17.6	12.5	6	1.5	<0.01
2	DLC	103.0	106.1	3.1	3.0	3	2.1	0.19
3	DLC	119.5	118.5	-1.0	-0.8	3	2.1	0.65
Overall Average		120.9	127.6	6.6	5.5			
1	DLSB	51.5	51.1	-0.4	-0.7	12	0.9	0.71
2	DLSB	48.7	47.6	-1.1	-2.3	6	1.3	0.40
3	DLSB	44.4	44.4	0	0	3	1.8	0.97
Overall Average		48.2	47.7	-0.5	-1.0			

[a]Year is the number of years following a one-time compost application, differences in bushels and percentage calculated as compost minus no compost divided by no compost treatment, strip is a measure of replication, SE is the standard error of the mean, and *P* is the probability that the compost and no compost treatments are equal when variation due to fields is accounted for.
[b]Crop designated as DLC (dryland corn) or DLSB (dryland soybeans).

Table 4. Rate response (bu/acre) from compost treatment on irrigated corn and soybeans.

		Yield[c]			0 versus 20			0 versus 40		
Year[a]	crop[b]	0	20	40	diff(bu)	SE	*P*=	diff(bu)	SE	*P*=
1	IC	141.2	143.9	143.7	2.7	6.8	0.69	2.5	6.8	0.71
2	ISB	66.5	67.5	68.8	1.0	2.3	0.67	1.3	2.3	0.59
3	IC	196.8	203.5	208.2	6.7	6.8	0.33	11.4	6.8	0.11
4	ISB	66.2	68.8	68.9	2.6	2.3	0.27	2.7	2.3	0.24

[a]Year is the number of years following a one-time compost application.
[b]Crop designated as IC (irrigated corn) or ISB (irrigated soybeans).
[c]Represents grain yield with different compost application rates 0 ton/acre, 20 ton/acre and 40 ton/acre.

improves transportation efficiency for field application.

Crop Yields and Benefits

Irrigated

Adding compost to irrigated acres improved ($P < 0.10$) yields in the first, second and third years following application (Table 2). Yields were increased by 8.4 bushels, which was 3.7% the first year with irrigated corn, 1.1 bushels or 1.8% for soybeans in year 2 and 14.7 bushels or 6.3% with irrigated corn in year 3. The improvements in yield in the first two years following application are in agreement with previous Nebraska research (*2001 Nebraska Beef Report*, pp 92-95) when 10 ton/acre (as-is) compost was applied. The response with irrigated corn in the third year is unexpected. Further research including more replications is necessary to validate the increase in year 3.

Assuming a 11.6 bushel increase in corn yield in year 1 and 3 (based on overall average response) and a 1.1 bushel increase in soybean yields in year 2, the compost treatment increased gross returns by $59.74. This assumes an average (10-year) corn price of $2.30 per bushel and a soybean price of $5.80 per bushel. If application costs average $2.50 per ton (based on previous calculations; *1997 Nebraska Beef Report*, pp 88-91), then total spreading costs are $50 per acre if 20 ton per acre is applied. In this situation the increased return over three years covered the application costs.

Non-Irrigated

Adding compost to non-irrigated corn acres increased ($P > 0.001$) yields by 17.6 bushels or 12.5% in the first year after application. In subsequent years, the impact of adding compost was not statistically significant. Based on the results in Table 3, compost treatment numerically increased dryland corn yields in the first and third years; however, variation from year to year was probably due to precipitation differences. With variable yields due to weather effects during different years, benefits due to compost application were not distinguishable. Biologically, a 5.5% average yield increase (Table 3) with dryland corn over three years would be important. If yield is increased 6.6 bushels due to compost treatment, then gross income is increased by $45.50 *(6.6 bushels x 3 yrs x 2.30 per bushel)*.

With non-irrigated soybeans, compost treatment did not result in statistical differences in yield (Table 3) when compared with the no-compost treatment. Overall, compost application to dryland soybeans showed reduced yields of 1% (0.51 bushels). Only five fields were used to measure dryland soybean yields in the three years following application. Yield variation with dryland soybeans was greater than with irrigated soybean. The increased variation in dryland situations is presumably related to precipitation differences and the subsequent impact of weather on yields. This variation is similar when corn is grown on dryland acres.

Level of Application

Applying compost at 20 or 40 ton/acre showed no significant yield response with irrigated corn or soybeans (Table 4). However, both corn and soybeans show a numerical increase in yield in all four years following compost addition. Average yield increase over no-added-compost for years one and three for irrigated corn was 2.8% and 4.0% for 20 and 40 ton/acre respectively. Similar increases

(Continued on next page)

were measured for soybeans in years two and four with 2.7% and 3.0% for 20 and 40 ton/acre respectively. The potential benefit from compost addition with increased rates from 20 and 40 ton/acre may be the yield increase in subsequent years. The increase in gross income from the first four years with the irrigated corn and soybean rotation in this study is $42.62 with an application rate of 20 ton/acre.

In summary, yields were significantly increased when compost was applied to irrigated corn, irrigated soybeans and dryland corn in Study 1. Because N fertilization was not reduced in the compost treated strips, the increases in yields and income were over and above the yields from crops receiving the recommended N fertilizer rates based on soil tests. The economic returns were greatest for corn, however, in our calculations application costs were only recovered at the 20 ton/acre rate with irrigated crops in Study 1. Furthermore, costs associated with composting or the value of nutrients in compost were not included in these studies nor were the costs associated with manure disposal. Compost N availability is slow, releasing 20%, 20%, 10%, and 5% in the first, second, third and fourth year after application (*2001 Nebraska Beef Report*, pp 89-92). This slow release of N may be one of the potential benefits of compost application and aid in long-term economic returns.

Because N fertilization was held constant, we conclude that the yield response is probably due to P, but other nutrients may have influenced yield. Whether yield improvements resulted from added P, OM, K, or other nutrients is not known, only that there is a benefit from one or a combination of these.

The continued yield response with compost addition in Study 2 demonstrates the need to evaluate compost addition over a longer time. The continued nutrient payout of compost and increased application rates may improve long-term yields, however, further research is needed to document the benefit.

---

[1]Casey B. Wilson, research technician, Galen E. Erickson, assistant professor, Terry J. Klopfenstein, professor, Animal Science, Lincoln; Walker Luedtke, research technician; and Mark A. Schroeder, farm operations manager, Agricultural Research and Development Center, Mead.

Vaccination for *Escherichia coli* O157:H7 in Market Ready Feedlot Cattle

Robert E. Peterson
David R. Smith
Rodney A. Moxley
Terry J. Klopfenstein
Susan Hinkley
Galen E. Erickson[1]

Summary

A clinical trial was conducted in summer 2003 to evaluate effects of vaccinating feedlot cattle against Type III secretory proteins of enterohemorrhagic Escherichia coli on prevalence of E. coli *O157:H7 in feces. Treatments included: 1) no vaccination; 2) vaccinated once at re-implant (day 42); 3) vaccinated upon arrival (day 0) and again at re-implant (day 42); and 4) vaccinated on arrival (day 0), at day 21, and again at re-implant (day 42). Vaccination effectively reduced the proportion of feedlot cattle shedding O157 in the feces, the effect was dose-responsive, and vaccination within a pen conferred protection to unvaccinated pen-mates (herd-immunity).*

Introduction

Escherichia coli O157:H7 has been a pathogen of concern to the beef industry for two decades. Because cattle represent a significant reservoir of *E. coli* O157:H7, a great deal of research has been conducted at the University of Nebraska to determine the ecology of *E. coli* O157:H7 in Nebraska beef feedlots. Most recently, research has focused on identifying and scientifically testing easily implemented on-farm intervention strategies to control the carriage and shedding of *E. coli* O157:H7 in feces of feedlot cattle. Previous research at Nebraska (Potter et al., Vaccine 2004) found that vaccinating feedlot cattle against Type III secretory proteins of *Escherichia coli* O157:H7 reduced the probability of fecal shedding of the organism by 59%. In that study cattle were vaccinated three times at three-week intervals. Current feedlot practices make a three-vaccination treatment protocol challenging to implement. However, vaccinating cattle once at reimplant, or twice, once at initial processing and again at reimplant, would be much easier to implement into current feedlot practices. Therefore, an experiment was conducted to evaluate the effects of varying the number of doses of a commercially prepared vaccine on the probability that cattle shed *E. coli* O157:H7 in feces.

Procedure

The clinical trial was conducted during summer (May - September) of 2003 at the University of Nebraska Beef Research Feedlot at Ithaca, Nebraska. Four-hundred-eighty medium-weight steers were stratified by weight and assigned randomly to 60 pens (8 head/pen) and to one of four vaccination treatments (2 head/treatment) within a pen. Steers were blocked into four groups based on replication of dietary treatment. Dietary treatments are summarized in a separate report (*2005 Nebraska Beef Report,* pp. 28-30). Vaccine (2 ml/dose) was administered subcutaneously in the neck using an 18 ga x 5/8-inch needle. Vaccination treatments included: 1) no vaccination; 2) vaccinated once at re-implant (day 42); 3) vaccinated upon arrival (day 0) and again at re-implant (day 42); and 4) vaccinated on arrival (day 0), at day 21, and again at re-implant (day 42). An additional 128 steers were assigned to 12 pens and two study blocks within the same feedlot to serve as unvaccinated external controls. Blocking criteria for external controls was steers per pen (8 head in 8 pens; 16 head in 4 pens). Steers were fed for an average of 138 days and each steer was sampled by rectal fecal grab every three weeks of the feeding period, resulting in one pre-treatment period (day 0), two interim periods (day 21, day 42), and four test-period samplings (days 63, 84, 105, and 126). Feces from these cattle were collected for culture in two sample blocks within

(Continued on next page)

the same test period on consecutive days for vaccinated and external control pens.

All fecal samples were taken immediately to the UNL *E. coli* lab and analyzed for presence of *E. coli* O157:H7 using procedures previously described (*2004 Nebraska Beef Report*, pp. 67-68) with modifications.

The odds of a treated animal shedding *E. coli* O157:H7 was compared to that of unvaccinated control cattle within the pen and control cattle in the external pens, accounting for repeated measures, block, and pen using the GENMOD procedure of SAS. Adjusted odds ratios (OR) were converted to relative risk (RR) using marginal probabilities for prevalence and vaccination. Vaccine efficacy was calculated as (1-RR). Feedlot performance was evaluated using the MIXED procedure of SAS accounting for block and pen. Because treatments were assigned to animals within a pen, only weights and average daily gain (ADG) can be reported for the direct effect of vaccination treatment.

Results

E. coli Results

In total, *E. coli* O157:H7 was recovered from 845 of 4253 culture observations (20%) from cattle in treated and external control pens. During the pre-treatment sampling period, the proportion of cattle shedding *E. coli* O157:H7 within the 60 treated pens was 45% and was not different ($P > 0.10$) for animals allocated to different vaccine treatments. The proportion of cattle shedding *E. coli* O157:H7 among the external control pens was 30.5% during the same test period and was significantly lower ($P < 0.05$) than treated pens; however, the proportion of cattle shedding *E. coli* O157:H7 among the external control pens was higher ($P < 0.05$) than treated pens throughout the remainder of the study (Figure 1).

Table 1. Finishing performance and carcass merit for steers receiving 0,1, 2, or 3 doses of vaccine within vaccinated pens.

	Treatment[a]					
Item	0	1	2	3	SEM[a]	VAC[b]
Steers	120	120	120	120		
Initial BW, lb	745	742	742	745	2.32	0.59
Final BW, lb[c]	1242	1233	1229	1244	6.26	0.27
ADG, lb	3.60	3.56	3.53	3.62	0.41	0.45
HCW, lb	782	777	774	784	3.94	0.27
12th rib fat, in.	0.37	0.32	0.36	0.34	0.04	0.67
Marbling [d]	489	503	485	487	5.51	0.09

[a]Standard error of the mean
[b]Main effect of vaccination treatment.
[c]Calculated from carcass weight, adjusted to a 63% common dressing percentage.
[d]Marbling = Marbling score = 400 = Slight^{0}, 450 = Slight^{50}, 500 = Small^{0}, etc.

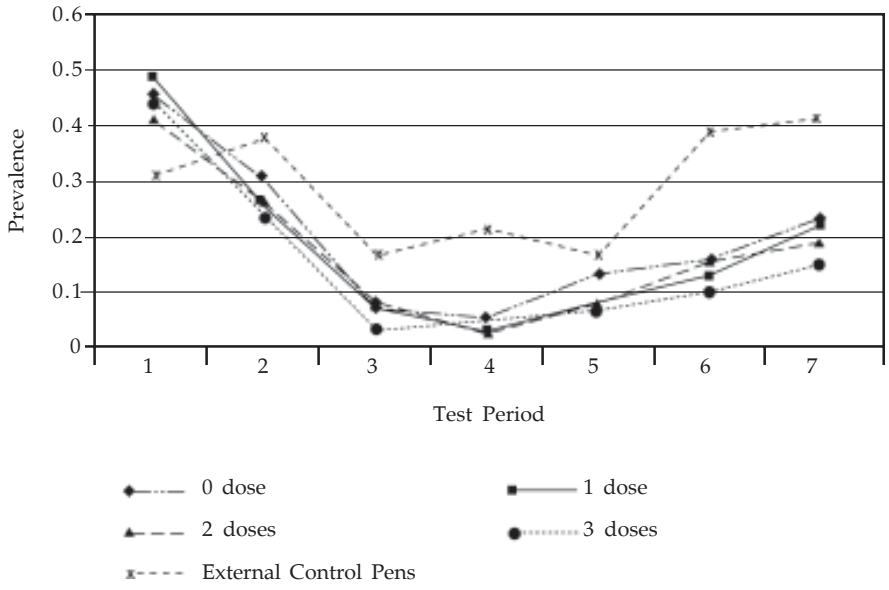


Figure 1. The proportion of steers shedding *E. coli* O157:H7 by test period and treatment (0, 1, 2, or 3 doses of vaccine) within treated pens compared to untreated pens.

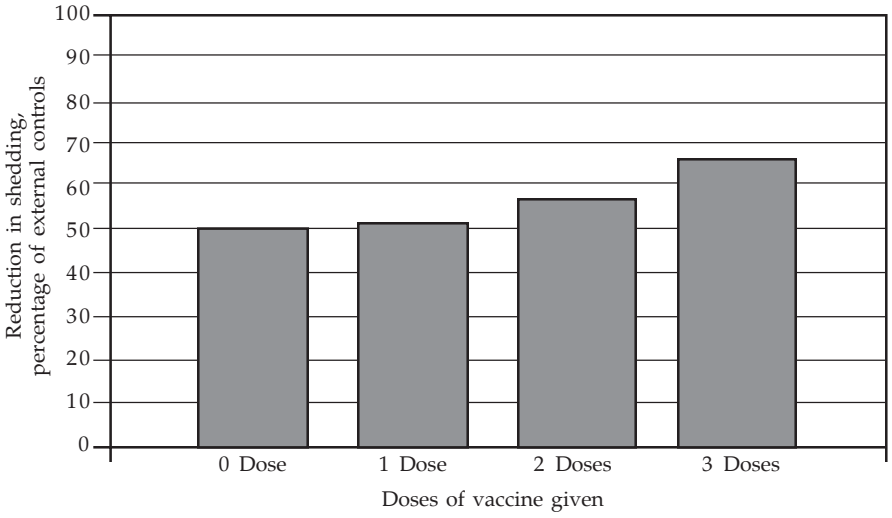


Figure 2. Percentage reduction in *E. coli* O157:H7 shedding (vaccine efficacy) by steers receiving 1, 2, or 3 doses of vaccine within treated pens compared to pens receiving no vaccine (21-84 days post treatment).

The proportion of cattle shedding *E. coli* O157:H7 in both treated and control pens during test periods four to seven differed significantly by test period ($P < 0.05$, Figure 1). There was no interaction between vaccination and test periods four to seven. During test periods four to seven cattle in pens receiving one, two, or three doses of vaccine were less likely to shed *E. coli* O157:H7 than cattle in pens not receiving vaccine (OR=0.33; P=0.0008) — a vaccine efficacy of 59%. Vaccine efficacy of receiving one, two, or three doses of vaccine was 52%, 58%, and 68%, respectively ($P < 0.01$ for each, Figure 2), compared with cattle in pens not receiving vaccine. Unvaccinated cattle in pens receiving vaccine treatments were also less likely to shed *E. coli* O157:H7 than cattle in pens not receiving vaccine (OR=0.42, P=0.02). Compared to unvaccinated cattle within the pens receiving vaccine treatments, the odds of shedding *E. coli* O157:H7 decreased as cattle received one, two, or three doses of vaccine (OR=0.94, 0.82, and 0.59 respectively). Cattle receiving three doses of vaccine were 35% less likely to shed *E. coli* O157:H7 than unvaccinated cattle in the same pen (P=0.06) during the post-treatment period.

Finishing Performance

Least squares means for finishing performance measures are presented in Table 1. There were no differences ($P > 0.10$) in finishing performance for steers receiving one, two, or three doses of vaccine compared with unvaccinated steers within the same pen. These data suggest vaccinating feedlot cattle against Type III secretory proteins of enterohemorrhagic *Escherichia coli* will have no measurable impact on finishing performance.

In conclusion vaccine efficacy improved with the number of doses administered, and vaccinating a majority of cattle within a pen offered a significant protective effect (herd immunity) to non-vaccinated cattle within the same pen. Furthermore, vaccinating feedlot cattle against Type III secretory proteins of enterohemorrhagic *Escherichia coli* had no detrimental effects on finishing performance. Vaccination appears to be a promising pre-harvest intervention strategy for the control of *E. coli* O157:H7.

---

[1]Robert E. Peterson, research technician; Dave R. Smith, Rod Moxley, professors, Veterinary and Biomedical Sciences; Terry J. Klopfenstein, professors; Galen E. Erickson, assistant professor, Animal Science; Susan Hinkley, assistant professor, Veterinary and Biomedical Sciences.

Direct-fed Microbial Products for *Escherichia coli* O157:H7 in Market Ready Feedlot Cattle

Robert E. Peterson
Terry J. Klopfenstein
David R. Smith
Jeffrey D. Folmer
Galen E. Erickson
Susan Hinkley
Rodney A. Moxley[1]

Summary

A clinical trial was conducted during the summers of 2002 and 2003 to evaluate the effect of a direct-fed microbial product (DFM) on the prevalence of E. coli O157:H7 in feces of feedlot steers. The DFM consisted of Lactobacillus acidophilus (NPC 747) fed at the rate of $1x10^9$ colony forming units (CFUs) per head per day. Treatments included supplemental DFM or no supplemental DFM. Feedlot steers supplemented with DFM were 35% less likely to shed E. coli O157:H7 in the feces compared with steers that were not supplemented with the DFM. Finishing performance was not affected by adding a DFM into the ration.

Introduction

Bacteria used as direct-fed microbial products (DFM) have been defined as single or mixed cultures of live organisms, which, when fed to animals, beneficially affect the host (Krehbiel et al., 2003). Additionally, preliminary research from Nebraska, as well as other institutions, has shown that feeding a *Lactobacillus*-based DFM will decrease fecal shedding of *E. coli* O157:H7 without detrimental effects on performance (*2004 Nebraska Beef Report*, pp. 67-68, Brashers et al., *2003 J. Food Prot.*, Younts-Dahl et al., *2004 J. Food Prot.*). Because *E. coli* O157:H7 has emerged as an important food borne pathogen, and beef cattle represent an important reservoir for human exposure, there has been an increased interest in using DFMs as a pre-harvest intervention strategy to control the carriage and shedding of *E. coli* O157:H7 in the feces. Folmer et al. (*2004 Nebraska Beef Report*, pp. 67-68) reported that over five test periods the probability for control steers to shed *E. coli* O157:H7 averaged 21.3%; whereas, the probability for steers treated with the DFM (NPC 747; Nutrition Physiology Corp.) to shed *E. coli* O157:H7 was only 13.3%. However, this response, though seemingly meaningful, was not statistically significant ($P = 0.21$). The purpose of this study was to continue evaluating the effects of feeding a DFM by extending the trial another year to increase the power of the study by doubling the total number of observations.

Procedure

Four-hundred-forty-eight medium-framed steer calves were used in a feedlot finishing experiment during the summers (May-September) of 2002 and 2003. In 2002, steers were blocked into three weight groups and stratified by weight within block and assigned randomly into 24 pens (8 steers/pen). Pens within each block were assigned randomly to one of two treatments. Treatments included DFM supplementation (NPC 747; Nutrition Physiology Corp.) and no DFM supplementation. The finishing diet dry matter composition was 55% high moisture corn, 35% wet corn gluten feed, 5% corn silage, 2% alfalfa hay, 2% supplement, and 1% water (used to mix the direct-fed microbial). In 2003, steers were blocked into two groups, stratified by weight and assigned randomly to 24 pens and one of four dietary treatments (*2005 Nebraska Beef Report*, pp. 54-56). The two DFM treatments were assigned randomly within dietary treatments. Again, DFM treatments included DFM supplementation and no DFM supplementation. In both years of the study DFM product was mixed with water and applied to the feed truck mixing box and fed at a rate of $1x10^9$ colony forming units (CFUs)/steer/day. Steers were fed once daily. The control steers were fed with a control feed truck; DFM-treated steers were fed with a separate feed truck to prevent cross contamination. Steers were weighed on two consecutive days at the start of the experiment after a three-day period of limit-feeding to equalize gut fill. In 2002 and 2003, steers were fed for an average of 121 and 127 days, respectively. In 2002, steers were sampled one block per week in three-week experimental periods, resulting in one pre-treatment sampling and five experimental periods. In 2003, steers were sampled in one block per day on two consecutive days every three weeks, resulting in one pre-treatment sampling and six experimental periods. Rectal fecal grab samples were obtained from each steer in each period.

All fecal samples were taken immediately to the UNL *E. coli* lab and analyzed for the presence of *E. coli* O157:H7 using procedures previously described (*2004 Nebraska Beef Report*, pp. 67-68) with modifications.

Pen was considered the experimental unit, and ADG, DMI, F:G and the proportion of culture-positive animals per pen during the period were the outcomes of

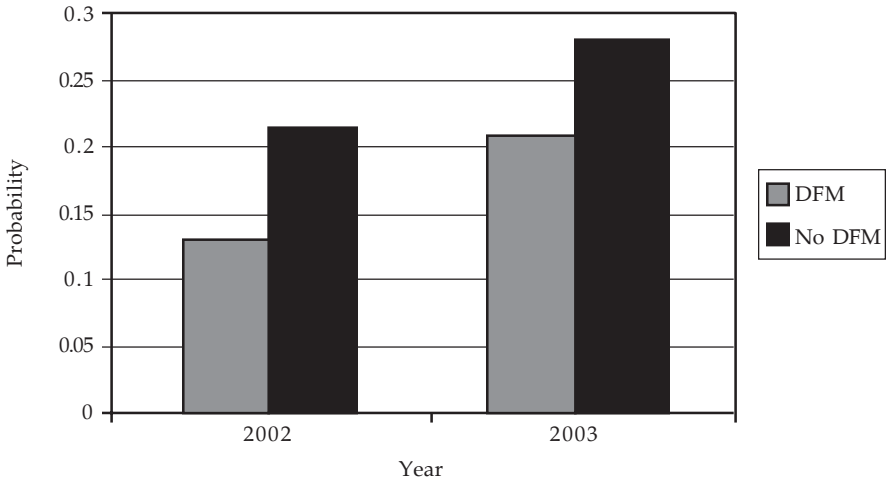


Figure 1. Probability of *E. coli* O157:H7 shedding, by direct-fed microbial treatment and year.

Table 1. Feedlot performance by direct-fed microbial treatment.

Item	No DFM	DFM	SEM[a]	DFM	DFM*Year
Steers	224	224	—	—	—
Pens	24	24	—	—	—
Performance					
ADG, lb	3.76	3.81	0.09	0.43	0.88
DMI, lb/day	25.12	24.93	0.46	0.38	0.92
ADG:DMI,	0.150	0.153	0.002	0.13	0.82

[a]Standard error of the mean.

interest. For proportion of culture positive animals per pen, the odds for a DFM-supplemented pen of cattle was compared with pens of cattle that were not supplemented with the DFM, accounting for repeated measures, year, and block. Odds ratios (OR) were converted to relative risk (RR) using marginal probabilities for prevalence and DFM treatment. Treatment efficacy was calculated as (1-RR). Feedlot performance was evaluated statistically using the MIXED procedure of SAS accounting for year and block. Average daily gain (ADG), dry matter intake (DMI), and ADG:DMI is reported by DFM treatment.

Results

E. coli Results

The probability of recovering *E. coli* O157:H7 from the feces of steers, by treatment and year is summarized in Figure 1. In 2002, the probability of recovering *E. coli* O157:H7 from the feces of steers supplemented with DFM was 13%. The probability of recovering *E. coli* O157:H7 from feces of steers not supplemented with DFM was 21%. In 2003, the probability of recovering *E. coli* O157:H7 from feces of steers supplemented with DFM was 21%. The prevalence of *E. coli* O157:H7 in the feces of steers not supplemented with the DFM product was 28%. The probability of recovering *E. coli* O157:H7 from the feces differed ($P < 0.05$) between 2002 and 2003, however there was no interaction ($P > 0.10$) between DFM treatment and year. The DFM treated steers were 35% less likely ($P = 0.002$) to shed *E. coli* O157:H7 in the feces than steers in untreated pens over the course of the feeding periods of the two years. These results confirm the benefits of using this DFM product as a pre-harvest food safety intervention tool.

Finishing Performance

There was no interaction between DFM treatment and year for any of the finishing performance outcomes; therefore, only effects of DFM treatment on performance are presented (Table 1). Supplementation of the DFM product had no effect ($P > 0.10$) on ADG, DMI, or ADG:DMI. We observed a 2% improvement in ADG:DMI ($P = 0.13$) when cattle were supplemented with the DFM product. Although not significant, a 2% improvement in ADG:DMI might be expected, and meaningful, when supplementing a DFM product in the ration. The true effect of DFM on cattle performance is unclear. In a review of six research trials (n=1,249 cattle), Krehbiel et al., (2003, *Journal of Animal Science*) reported that feeding combinations of lactic acid- and propionic acid-producing bacteria in diets of growing/finishing cattle might improve growth rate by 2.6%. However, in a large scale commercial finishing study (n=3,539 steers and heifers), Greenquist et al. (K-state Cattlemen's Day 2004) reported supplementation of *Lactobacillus acidophilus* and *Propionibacterium freudenreichii* had no measurable impact on growth performance. In our clinical trial only the *Lactobacillus acidophilus* was fed.

In conclusion, supplementing feedlot cattle with $1x10^9$ CFUs/steer/day of *Lactobacillus acidophilus* significantly reduced fecal shedding of *E. coli* O157:H7. Additionally, we observed a non-significant improvement (2%) in ADG:DMI. These data suggest feeding a *Lactobacillus acidophilus* product is an effective pre-harvest intervention control for reducing *E. coli* O157:H7 and further research should be conducted to determine the product's effects on growth performance.

---

[1]Robert E. Peterson, Jeffrey D. Folmer, research technicians; Terry J. Klopfenstein, professor; Galen E. Erickson, assistant professor, Animal Science; David R. Smith, associate professor; Rodney A. Moxley, professor; Susan Hinkley, assistant professor, Veterinary and Biomedical Sciences.

Performance and Economics of Sorting Yearling Steers by Feedlot Initial Body Weight

Jeffrey D. Folmer
Casey N. Macken
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

Four groups of long yearling steers were used to evaluate the effect of sorting by feedlot initial body weight on performance and feedlot economic variables during the feeding period. Steers were sorted into the lightest 25%, middle 50%, and heaviest 25%, along with a non-sorted control. Steers were marketed by sort treatment: heavy two weeks prior, middle one week after, and light three weeks after the unsorted control steers. Sorting did not affect dry matter intake, average daily gain, marbling, 12th rib fat thickness, USDA yield and quality grades, or economic analysis; however, sorting did increase days on feed, feedlot final BW, and hot carcass weight.

Introduction

Yearling production systems can be plagued with overweight carcasses because cattle are larger at arrival and perform well during finishing. MacDonald et al. (*2003 Nebraska Beef Report,* pp.65-68) utilized a two-way sorting system to sort yearling steers to decrease overweight carcasses and increase carcass uniformity. While in their study, overweight carcasses were not reduced, sorting did result in increased carcass uniformity. However, there was no increase in overall carcass weight or profitability. In addition, MacDonald et al. (*2003 Nebraska Beef Report*, pp. 61-65) found the best correlation (r = .83) to predict the final BW of long yearling feedlot fed steers was feedlot initial BW compared to winter initial BW and grass initial BW.

Cooper et al. (*1999 Nebraska Beef Report*, pp. 57-59) found re-implant BW to be a good indicator of carcass weight for long-fed steers. In addition, Cooper et al. (*2000 Nebraska Beef Report*, pp. 43-45) analyzed data from individually fed animals. Ranking these animals from leanest to fattest at slaughter, they found leaner animals to be lighter but gaining well at the time of slaughter, which suggests light animals may benefit from additional days on feed.

In terms of carcass finish, Brethour (*2000 Journal of Animal Science*, 78:2005) utilized serial ultrasound measurements to estimate development of 12th rib back-fat thickness. Results indicated 25% of cattle were fed too long and another 25% were not fed long enough.

Objectives of this research were to compare the performance and feedlot economics of sorting steers by feedlot initial BW to an unsorted control in a long yearling production system.

Procedures

Yearling Steer Development

Two experiments were conducted over a two-year period. In the fall of each year 200 steer calves were purchased. One hundred steers each were placed into one of two different long yearling steer production systems. The systems are described in another article (Folmer et al., *2005 Nebraska Beef Report*, pp. 68-72).

Sorting

In both systems, after their respective summer grazing periods, steers were weighed and stratified into two BW groups of 50 steers, with equal average initial BW, variation, and standard deviation. Then steers in the sorting treatment were assigned to a group by dividing the steers into one of two replications. Steers were then put into one of three sort groups: heavy sort treatment contained 12 steers or 6 steers per replication, middle sort treatment contained 26 steers or 13 steers per replication, light sort treatment contained 12 steers or 6 steers per replication, and the unsorted control contained 50 steers or 25 steers per replication. Steers in the unsorted control were fed for an average of 91 days. Steers in the heavy sort group were fed for an average of 77 days and were marketed two weeks prior to the unsorted control steers. Because the heaviest steers were removed, the middle sort group were fed an average of 98 days and marketed one week after unsorted controls. Steers in the light sort group were fed for an average 112 days and were marketed three weeks later than the unsorted controls.

Economic Analysis

Feedlot finishing economics were based on a finishing diet cost of $115.38/ton (DM; using 10-year average prices for ingredients) and days on feed. Feedlot in price was $76.21/cwt for 900-1000 lb steers and was calculated from 7-year average prices for July to September (Feuz and Burgener, *2004 University of Nebraska Cooperative Extension Bulletin*, PHREC 04-21). Live sale price ($70.08/cwt) was calculated from 7-year averages for the months of September through December (Feuz and Burgener, *2004 University of Nebraska Cooperative Extension Bulletin*, PHREC 04-21). Feedlot break-even was calculated by dividing total cost by the final live BW. Live profit or loss was calculated by subtracting the live break-even from

Table 1. Feedlot performance of sorted and unsorted steers.

Item	Control	Sorted	Difference	SE	*P*-value
Initial BW, lb	971	9798.0	16.6	0.39	
Final BW, lb	1352	1378	26.0	6.06	0.01
DMI, lb	28.6	28.2	0.4	0.63	0.18
Daily gain, lb	4.16	4.09	0.07	0.13	0.49
Feed/gain	6.91	6.93	0.02	0.35	0.86
Days fed	92	98	6.0	2.73	0.12

Table 2. Carcass characteristics of sorted and unsorted steers.

Item	Control	Sorted	Difference	SE	*P*-value
Carcass wt., lb	852	868	16.0	3.81	0.01
Yield grade	2.43	2.41	0.02	0.07	0.73
Fat thickness, in.	0.42	0.46	0.04	0.03	0.14
Marbling[a]	491	498	7.0	6.95	0.50
Longissmus, sq. in.	14.3	14.1	0.2	0.40	0.45
% Choice	43.9	44.1	0.2	5.86	0.97
% Select	56.3	55.9	0.4	5.87	0.96
% Yield grade 4+	1.0	0.9	0.1	0.77	0.91
% Heavy	9.1	1.5	7.6	2.48	< 0.01

[a]Marbling score = 400 = Slight[0], 500 = Small[0] etc.

Table 3. Feedlot economics of sorted and unsorted steers.

Item	Control	Sorted	Difference	SE	*P*-value
Live break, $[ab]	73.58	73.69	0.1	0.42	0.76
Live p/l, $[c]	-37.76	-39.93	2.17	5.51	0.66
Carcass break, $	116.78	116.97	0.19	0.67	0.75
Quality p/l, $d	-39.78	-37.37	2.41	5.87	0.77
Yield p/l, $	-28.53	-26.70	1.83	6.46	0.79
Commodity p/l, $	-38.98	-37.14	1.84	5.69	0.81

[a]All prices on a cwt basis.
[b]Calculated from an initial price of 7-year average price of $76.21/cwt for 900-1000 lb steers, and $115.38 /ton (DM) ration cost.
[c]Live sale price $70.08/cwt; p/l = profit or loss.
[d]Carcass Base Price of $112.27/cwt.

the 7-year average price.

In addition to live sale economics, a marketing grid profitability analysis was performed. Based on three different carcass grid-pricing scenarios, profit or loss for each treatment on each grid was calculated. The analysis used three different grids, consisting of a quality-rewarding grid, a yield-rewarding grid, and a commodity grid, as proposed by Feuz (*2002 Nebraska Beef Report* pp.39-41). Premiums and discounts for each grid are reported in another article (Folmer et al., *2005 Nebraska Beef Report,* pp. 68-72). Profitability was calculated from a 7-year average (Feuz and Burgener, *2004 University of Nebraska Cooperative Extension Bulletin,* PHREC 04-21) dress base price ($112.27 /cwt) with individual grid premiums and discounts applied. Grid profit or loss was calculated from a carcass breakeven calculated as with live breakeven, with hot carcass weight instead of final BW as the multiplier.

Results

Performance

Steer performance results are presented in Table 1. Initial BW for the feedlot phase was not different ($P = 0.39$), however feedlot final BW was significantly greater ($P < 0.01$) for sorted steers (1378 lb) compared to unsorted control steers (1352 lb). Dry matter intake ($P = 0.18$), feed conversion ($P = 0.49$), and daily gain ($P = 0.86$) did not differ between sorting treatments. Due to the nature of the marketing strategy, days on feed increased from 92 days for the unsorted control compared to 98 days for sorted steers.

Steer carcass characteristics are presented in Table 2. Carcasses of steers in the unsorted control and sorted treatments did not differ in USDA yield grade ($P = 0.50$), 12th rib fat thickness ($P = 0.78$), marbling score ($P = 0.60$), or ribeye area ($P = 0.45$). However, due to the increases in ADG and final BW, hot carcass weight was significantly ($P < 0.01$) increased by 16 lb for the sorting treatment. Sorting steers also had no effect on the percentage of USDA choice, select, or yield grade 4 and 5 carcasses. However, sorting steers by feedlot initial BW and marketing them accordingly, significantly ($P < 0.01$) reduced heavy weight carcasses from 9.1% for the unsorted control steers to 1.5% for the sorting treatment.

Economics

Feedlot economics are summarized in Table 3. Due to increased days on feed, feedlot yardage and feed costs increased for the sorted treatment. Increased costs for the sorting treatment resulted in no differences in live breakeven ($P = 0.70$) or live feedlot profitability ($P = 0.62$). In addition, the increased costs of the sorting treatment, along with no differences in carcass characteristics, resulted in no differences in carcass breakeven ($P = 0.70$) and no differences in profitability when marketed on the quality rewarding ($P = 0.78$), yield rewarding ($P = 0.80$), or the commodity ($P = 0.80$) marketing grids.

Results of this experiment indicate sorting long yearling steers by initial feedlot BW may allow for increased average days on feed, and increased sale weights, while avoiding discounts. However, due to an increase in days on feed, and costs incurred with increased days on feed, sorting did not translate into an economic advantage in this study.

---

[1]Jeffrey D. Folmer, Casey N. Macken, research technicians; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Performance and Economics of Yearlings Developed with Intensive Winter Management, and Partial Season Grazing

Jeffrey D. Folmer
Casey N. Macken
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

Two experiments were conducted over two years to evaluate effects of two developmental systems on performance and economics of long yearling steer production. Steers were wintered in the normal system with corn residue grazing and dry lot hay feeding, with 5 lb per day wet corn gluten feed as a supplement. Intensively managed steers were given 6 lb per day wet corn gluten feed and implanted with Ralgro® at the beginning of the wintering period and Synovex S® at the beginning of the dry lot phase. In addition, intensively managed steers were removed from summer pasture early. Intensive system steers were marketed in October and normal system steers were marketed in November following a finishing period. Economic analysis indicated a performance and economic advantage to the intensive system, when marketing the steers after the wintering period or after the summer grazing period; however, if steers were marketed after feedlot finishing, profitability estimates were not different.

Introduction

Nebraska research has developed a wintering system that develops long yearlings. Jordan et al. (*2002 Nebraska Beef Report*, pp. 25-29) found steers wintered at 1.5 lb daily gain had lower slaughter breakevens than steers wintered at 0.5 lb daily gain. The lower breakeven was produced by providing steers daily supplements of 5 lb (DM) of wet corn gluten feed during the corn residue grazing and drylot period in the winter/spring. In addition, Jordan et al. (*2001 Nebraska Beef Report*, pp. 41-49) fed seven levels of wet corn gluten feed to steers grazing corn residue. Using breakpoint analysis, steers began replacing grazed corn residue with wet corn gluten feed when fed more than 6 lb (DM) daily.

Increasing both weight gain and weight at sale should increase the profitability of the beef production system. In order to accomplish this, intensive management of steers may be needed. Increased levels of supplementation, growth promoting implants, short season grazing, and ionophores increase weight gain and ultimately final sale weight.

The objectives of this research were 1) to compare animal performance with our normal yearling steer production system to a more intensive shorter season production system, and 2) to compare the economic effects of our normal yearling steer production system to the more intensive, shorter season production system.

Procedure

Yearling Steer Development

Two experiments were conducted over a two-year period. In the fall of each year, 200 steers were purchased at weaning and received according to normal protocols. They were then stratified by weight and assigned to one of two yearling steer production systems, each containing one hundred steers. System one was the normal University of Nebraska yearling production system. System two was the experimental system of intensive winter management and partial season summer grazing.

Wintering Period

Steers were weaned and managed in two groups. Both groups were allowed to graze corn residue for about 89 days, from approximately December 1 until March 1. Groups were then placed in drylot for hay feeding for 49 days until approximately April 20. Steers in the normal system were supplemented daily with 5 lb (DM) of wet corn gluten feed during the entire winter production cycle, whether grazing corn residue or being fed hay.

In order to achieve increased rates of gain, steers in the intensive system were supplemented daily with 6 lb (DM) of wet corn gluten

feed. Included in this supplemental wet corn gluten feed was an ionophore, (Bovatec) fed at 170 mg/head/day. In addition, intensive steers were implanted at the beginning of the winter phase with Ralgro® and at the beginning of the hay-feeding phase with Synovex S®, while normal steers were not implanted.

Summer Period

After the wintering period, steers in both groups were weighed, implanted with Revalor®-G, and allowed to graze brome grass pasture from approximately April 20 to May 15, and then moved to native Nebraska Sandhills range to graze until their appropriate time of removal from pasture.

Normal system steers were allowed to graze the entire summer season until approximately September 1 when they were placed on feed for finishing. To increase summer grazing rates of gain and take advantage of higher summer feeder cattle markets, intensively managed steers were removed from summer pasture approximately July 1 when they were placed on feed for finishing.

Feedlot

In both years, steers were adapted to the final finishing diet in 17 days using four step-up diets containing 45%, 35%, 25%, and 15% roughage. Diets were fed for three, four, five, and five days. The final diet (7% roughage; Table 2) was formulated to contain a minimum of 13% CP, 0.7% Ca, 0.35% P, 0.6% K, 30 ay,g/ton Monensin, and 10g/ton, Tylan (DM basis). The final finishing diet contained, on a dry matter basis, 40% wet corn gluten feed, 48% high moisture corn, 7% alfalfa hay, and 5% supplement. Our goal in these experiments was to feed steers in either management system to the same degree of finish.

Initial and final weight for all periods of the system were based on two-day consecutive weights following five days of limit feeding 50% alfalfa and 50% wet corn gluten feed fed at 2% of body weight (DM basis). Slaughter weight was calculated assuming a constant dressing percent (63%). Steers were harvested at the same commercial abattoir where hot carcass weight, 12th rib fat thickness, rib eye area, USDA yield and quality grade, and marbling score, were collected following a 48-hour carcass chill.

Economic Analysis

Due to interest charges increasing over time, a separate analysis for each period was necessary. Differences between systems in input costs will be noted; otherwise it should be assumed that inputs were similar. For all sale prices including initial steer cost, winter ending price, grass ending price, and feedlot live marketing price, average weight of a pen was multiplied by the USDA western Nebraska-eastern Wyoming 10-year average price (Feuz and Burgener, *2004 University of Nebraska Cooperative Extension Bulletin,* PHREC 04-21). Initial steer cost for 500-600 lb steers was $87.04/cwt for the month of October (Feuz and Burgener, *2004 University of Nebraska Cooperative Extension Bulletin,* PHREC 04-21). Health and processing for the winter period were charged at $25 for each system plus $2 for implants, and $1 for the ionophore feed additive in the intensive system. Simple interest was charged on initial animal cost and health for the entire ownership period. All interest charges discussed herein were based on a simple 8.9% rate.

The two systems were charged a corn residue-grazing fee of $0.24/head/day during the corn residue-grazing period. Interest was charged for half of the residue grazing period plus the remainder of ownership. Wet corn gluten feed was charged to each system at a cost of $103.00/ton (DM basis; equal to a corn price of $2.44/bu [as-is]) and a mineral supplement ($406.00/ton; DM basis) at the rate of 0.11 lb/head/day (DM basis). Interest was charged on wet corn gluten feed and mineral supplement for half of the corn residue grazing period and the remainder of the ownership.

Grass hay was priced at $40.00/ton (as-is) and interest was charged on hay for half of the feeding period plus the remainder of ownership. Steer sale price for the end of the wintering period was based on winter end weight for the respective systems in the month of April. Intensive system steers were priced at $72.38/cwt for 800 to 900 lb steers, and normal steers were priced at $77.38/cwt for 700 to 800 lb steers (Feuz and Burgener, *2004 University of Nebraska Cooperative Extension Bulletin,* PHREC 04-21). Winter profit or loss was calculated by multiplying price by the respective winter final weight minus total winter costs for the appropriate treatment.

Grazing period economics were calculated on a grazing day basis. Each group of steers was charged $0.50 per head per day grazing fee which would include all supplemental grazing and water costs. Steer sale price for the end of the summer grazing period was based on grazing end weight for the respective system and the month the steers would have been marketed. Intensive steers would have been marketed in July and were assigned a sale price of $75.32/cwt for 900-1000 lb steers, and normal treatment steers were assigned a sale price of $76.98/cwt for 900-1000 lb steers for September. Since there are only seven years of pricing data for 900-1000 lb steers, these figures were used (Feuz and Burgener, *2004 University of Nebraska Cooperative Extension Bulletin,* PHREC 04-21). Grazing profit or loss was calculated by multiplying price by the respective grazing final weight minus total costs

(Continued on next page)

including the wintering costs and summer grazing costs.

Feedlot finishing economics were based on a finishing diet cost of $115.38/ton (DM; using 10-year average prices for ingredients) and individual system days on feed. Final selling price was adjusted for the appropriate time of marketing. Feedlot breakeven was calculated by dividing total cost by the live final weight. Live profit or loss was calculated by subtracting the live breakeven from the appropriate sale price for the month of marketing for the particular system. Intensive system steers were marketed in October with a 10-year average price of $70.09/cwt, and normal steers were marketed in December with a 10-year average price of $70.07/cwt (Feuz and Burgener, *2004 University of Nebraska Cooperative Extension Bulletin*, PHREC 04-21).

In addition to live sale economics, a marketing grid profitability analysis was performed. Based on three carcass grid-pricing scenarios (Table 1), profitability for each system on each grid was calculated. The three grids used in this analysis, as proposed by Feuz (*2002 Nebraska Beef Report*, pp. 39-41), were a quality-rewarding grid, a yield-rewarding grid, and a commodity grid. Premiums and discounts for each grid are summarized in Table 1 and profitability was calculated with a base price of $110.40/cwt of hot carcass weight for steers marketed in September and $112.29/cwt of hot carcass weight for steers marketed in December. Premiums and discounts were applied to these base prices. Grid profit or loss was calculated from a carcass breakeven calculated similar to live breakeven with hot carcass weight instead of final weight as the multiplier.

Table 1. Premiums and discounts for three alternative grids.

Item	Commodity	Yield Rewarding	Quality Rewarding
Prime, $[a]	6.00	3.00	10.00
Choice, $	0.00	0.00	0.00
Select, $	-7.00	-5.95	-8.05
Standard, $	-17.00	-8.95	-$23.05
Yield Grade 1, $	2.00	3.00	1.00
Yield Grade 2, $	1.00	2.00	1.00
Yield Grade 3, $	0.00	-1.00	0.00
Yield Grade 4, $	-15.00	-20.00	-12.00
Yield Grade 5, $	-20.00	-25.00	-17.00
Light & Heavy, $	-15.00	-15.00	-15.00

[a]All prices on 100 lb of carcass basis.

Table 2. Steer development performance[a].

Item	Intensive[b]	Normal	Difference	SE	*P*-value
Purchase BW, lb	543	540	3	5.7	—
Corn grazing, days	89	89	—	—	—
Dry-lot, days	49	49	—	—	—
Winter daily gain, lb	1.96	1.66	0.30	0.15	0.05
Grass BW, lb	813	769	44.0	10.2	0.06
Grass daily gain, lb	1.98	1.72	0.27	0.17	0.26
Summer grazing, days	78	128	50.0	—	—
Grass end date	July 2	August 25	—	—	—
Grass end BW, kg	968	986	18.0	14.2	0.15

[a]Steers were developed during winter, spring and summer and managed in intensive and normal yearling production systems.
[b]Intensive system = 6 lb (DM) wet corn gluten feed daily, plus Ralgro® (during corn residue grazing), and Synovex S® (during drylot feeding); Normal system = 5 lb (DM) wet corn gluten feed daily.

Table 3. Feedlot performance for intensive and normally developed steers.

Item	Intensive[b]	Normal	Difference	SE	*P*-value
Initial BW, lb	968	986	18	14.2	0.151
Dry matter intake, lb	27.8	28.8	1.0	0.60	0.04
Daily gain, lb	3.96	4.27	0.31	0.06	0.10
Days on feed	102	90	12.0	3.2	0.20
Feed/gain	7.04	6.75	0.29	0.25	0.20
Final BW, lb	1372	1371	1.0	12.6	0.97

Table 4. Carcass characteristics for intensive and normally developed steers.

Item	Intensive[b]	Normal	Difference	SE	*P*-value
Carcass wt., lb	864	864	—	7.91	0.97
Yield Grade	2.43	2.41	0.03	0.04	0.50
Fat thickness, in.	0.45	0.45	—	0.02	1.00
Longissmus, sq. in.	14.7	13.8	0.9	0.50	0.32
Marbling[a],	482	510	28	10.2	0.20
% Choice	34.5	54.0	19.5	5.53	0.13
% Select	65.5	46.0	19.5	5.53	0.13
% Yield Grade 4+	1.5	0.5	1.0	1.11	0.59
% Heavy	4.5	2.5	2.0	1.11	0.30

[a]Marbling score = 400 = Slight^0, 500 = Small^0 etc.

Table 5. Steer winter economics for intensive and normally developed steers.

Item	Intensive[b]	Normal	Difference	SE	*P*-value
Steer cost + int., $[ab]	495.30	495.40	0.10	0.85	0.88
Winter yardage + int., $	22.79	22.79	—	—	—
Winter feed + int., $	69.30	62.80	6.50	2.14	0.01
Health + int., $	10.89	8.81	2.08	<0.01	<0.01
Total cost + int., $	603.66	595.14	8.52	3.45	0.03
Winter breakeven, $[c]	74.49	77.69	3.20	0.80	0.08
Winter p/l, $	+8.20	-17.29	25.49	1.34	0.04

[a]Interest rate = 8.9%.
[b]Initial steer cost 10-year average price of $87.04/cwt for 500-600 lb steers.
[c]Intensive system sale price, 10-year average of $72.38/cwt for 800-900 lb steers; normal system sale price 10-year average of $77.38/cwt for 700-800 lb steers.

Table 6. Steer summer economics for intensive and normally developed steers.

Item	Intensive[b]	Normal	Difference	SE	*P*-value
Steer cost + int., $[ab]	498.91	505.42	6.51	7.23	0.05
Winter yardage + int., $	22.62	22.78	0.16	0.64	0.02
Winter feed + int.,$	69.84	64.12	5.72	3.04	0.02
Health + int., $	17.64	17.42	0.22	0.23	<0.01
Grazing cost + int., $	38.86	64.16	25.30	3.43	0.08
Total cost + int., $	656.08	682.75	26.68	8.27	0.07
Grazing breakeven, $[c]	67.81	69.25	1.44	0.34	0.10
Grazing p/l, $	53.88	26.32	27.56	8.48	0.05

[a]Interest rate = 8.9%.
[b]Initial steer cost 10-year average price of $87.04/cwt for 500-600 lb steers + interest cost for winter and summer periods.
[c]Intensive system sale price, 7-year (July) average of $75.32/cwt for 900-1000 lb steers; normal system sale price 7-year (September) average of $76.98/cwt for 900-1000 lb steers.

Results

Wintering and Summer Performance

Winter and summer performance are summarized in Table 2. Steers managed in the intensive system had significantly greater daily gains ($P = 0.05$) and grass weights ($P = 0.058$). Intensively managed steers gained 1.96 lb per day, producing a grass weight of 813 lb. Normally managed steers gained 1.66 lb per day which produced a grass weight of 769 lb.

Over the two-year period intensively managed steers grazed for an average of 78 days and gained 1.98 lb per day during the summer. Daily gain was not significantly different for the normally managed steers, but was numerically lower (1.72 lb per day) while the steers grazed for an average of 128 days. In addition, normally managed steers had a numerically greater, but not significantly ($P = 0.15$) greater feedlot in weight of 986 lb versus 968 lb for the intensively managed steers.

Feedlot Performance

Feedlot performance for the two systems is summarized in Table 3. Summer-fed, intensively managed steers had significantly ($P = 0.04$) reduced daily dry matter intakes, consuming 27.8 lb/day (DM), compared to normally managed steers who consumed 28.8 lb per day. This may be a result of decreased feedlot in weight, but more likely is a result of increased summer temperatures reducing feed intake. Summer-fed, intensively managed steers were fed for an average of 103 days, while fall fed normally managed steers were fed for an average of 91 days.

Intensively managed steers gained 3.94 lb per day versus 4.25 lb per day for the normally managed steers ($P = 0.08$). Fall fed, normally managed steers had a numerically ($P = 0.17$) lower feed conversion ratio of 6.78 versus a 7.08 ratio for the summer fed intensively managed steers. No differences were present in feedlot final weight, which averaged 1372 lb for the intensively managed steers versus 1371 lb for the normally managed steers.

Carcass Characteristics

Carcass characteristics for the two groups of steers are summarized in Table 4. Equal feedlot final weight between treatments resulted in equal average hot carcass weights for the two treatment groups of 864 lb. Steers in the two systems had an average of 0.45 inches of 12th rib fat thickness. In addition USDA yield grade did not differ between treatments with intensively managed steers having an average yield grade of 2.43, with normally managed steers averaging 2.41. Summer fed intensively managed steers had an average marbling score of 482 and fall fed normally managed steers had an average of 510 (400 = Select^0; 500 = Choice^0; $P = 0.19$).

Steer Development Economics

Economics of winter and summer periods are summarized in Tables 5 and 6. Winter feed and health costs were significantly greater for the intensive system steers ($P = 0.01$). This resulted in a significant ($P = 0.03$) increase in the total costs. Differences in costs and weights at winter's end resulted in a tendency for a difference ($P = 0.08$) in the winter breakeven for the two systems. Normal system steers had a winter breakeven of $77.69 versus $74.49 for the intensive system. This led to significantly ($P = 0.04$) greater profitability

(Continued on next page)

for the intensive system. Intensive system steers showed a profit of $8.20 per head while normal system steers showed a loss of $17.29 per head.

Due to the effect of time on interest costs, significant increases were present for normal system steer cost ($P = 0.05$) and winter yardage cost ($P = 0.02$). In addition, normal system grazing costs were greater ($P = 0.08$) at $64.14 per head versus $38.86 for the intensive system. This resulted in a decreased ($P = 0.10$) breakeven at the end of the grazing period for the intensive system despite the increased weight at the end of the grazing period for the normal system. Normal system grazing breakeven was $69.25 versus $67.81 per head for the intensive system. This decreased breakeven for the intensive system resulted in a significant ($P = .05$) increase in intensive system profitability ($53.88 versus $26.32) for the normal system.

Feedlot Economics

Feedlot finishing economics are summarized in Table 7. Feedlot feed ($P = 0.09$), yardage ($P = 0.20$), and total health costs ($P < 0.01$), increased in the intensive system due to the increased days on feed and winter implants. However, due to decreased summer grazing days, days of ownership were less in the intensive system. Increased ownership days caused increased steers costs ($P = 0.06$) and increased winter yardage cost ($P = 0.01$) for the normal system. However, total costs were not different between the two systems. Intensive steers had a total cost of $897.02 versus $902.79 for the normal system ($P = 0.40$).

Similar total steer costs coupled with similar live final weights resulted in a similar ($P = 0.55$) feedlot breakeven of $65.85 for the normal system and $65.40 for the intensive system. As can be expected, similar breakevens and similar live final weight produced similar ($P = 0.56$) live feedlot profitability.

As could be expected with similar hot carcass weight and costs, carcass breakeven price was similar ($P = 0.55$) between treatments. Analyzing the carcass data and marketing the steers on a grid basis, normal system steers showed numerically greater profitability. If steers were marketed on a quality-rewarding grid, normal steers returned a profit of $78.76 versus $49.55 per head for the intensively managed steers ($P = 0.27$). In addition, if steers were sold on a yield-rewarding grid, normal system steers showed a profit of $87.32 versus $62.54 per head for the intensive system ($P = 0.27$). If steers were sold on a commodity grid, the result was the same. Normal system steers resulted in a profit of $77.89 versus $51.16 for the intensive system ($P = 0.27$). These numerical differences in grid profitability are most likely a direct result of the tendency ($P = 0.12$) for an increase in the percentage choice in the normal system.

Results of this study indicate intensive management of long yearling steers can produce greater profitability if a producer is going to market the steers after the wintering or grazing periods. However, if the producer is going to finish the steers in the feedlot, differences in profitability disappear when selling on a live or carcass basis. Increases in profitability may be achieved with the normal system if marketed on a grid due to slight differences in carcass quality.

Table 7. Feedlot economics for intensive and normally developed steers.

Item	Intensive[b]	Normal	Difference	SE	*P*-value
Steer cost + int., $[a]	518.39	524.52	6.13	0.89	0.06
Winter yardage + int., $	23.87	24.16	0.29	0.50	0.01
Winter feed + int.,$	73.35	67.33	6.02	1.49	0.01
Grazing cost + int., $	40.48	66.80	26.32	4.29	0.09
Feedlot yardage + int., $[b]	31.02	27.37	3.65	0.99	0.20
Feedlot feed + int., $[c]	165.92	151.51	14.41	3.27	0.09
Total health + int., $	30.39	27.45	2.94	0.03	< 0.01
Total cost + int., $	897.02	902.79	5.77	3.52	0.40
Live breakeven, $[d]	65.40	65.86	0.46	0.45	0.55
Live p/l, $	64.37	57.84	6.53	6.72	0.56
Carcass breakeven, $[e]	103.81	104.54	0.73	0.72	0.55
Quality p/l, $	49.56	78.76	29.21	3.6	0.27
Yield p/l, $	62.53	87.32	24.81	1.6	0.27
Commodity p/l, $	51.16	77.89	26.71	2.5	0.27

[a]Interest rate = 8.9%.
[b]Yardage $0.30/day.
[c]Ration cost $115.38/ton (DM).
[d]Calculated from total system cost and a live sale price $70.09/cwt.
[e]Carcass Base Price of $112.27/cwt.

[1]Jeffrey D. Folmer, Casey N. Macken, research technicians; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Effect of High Roughage and High Energy Diets on Body Temperature

Sheryl L. Colgan
Terry L. Mader[1]

Summary

Four heifers were used in two trials comparing the effect of high energy and high roughage diets on three body temperature measurements. Body temperatures were measured in the vagina, in the ear canal near the tympanic membrane, and in the rumen. The high roughage diet lowered all three measures of body temperatures as compared with the high energy diet. Vaginal, tympanic, and ruminal temperature all appeared to effectively measure body temperature as they followed the same diurnal cycle; however, ruminal temperatures were, on average, 0.5 to 1.4°F higher than other body temperature measures.

Introduction

Contradictory opinions have evolved on temporarily increasing roughage levels in the diet to help manage short periods of cold stress. Roughages are assumed to have a higher heat increment than concentrates, and often are recommended to improve cold stress tolerance of cattle. However, this practice may not be beneficial, as higher roughage levels reduce metabolizable energy (ME) intake and increase the rate of passage through the rumen, thus potentially reducing fermentative heat production in the rumen.

Body temperature measurements are traditionally used in diagnosing sick animals, but they also may be used as an indication of heat or cold stress. A healthy, unstressed animal will have a core body temperature in the range of 100.4 to 103.1°F, that generally follows a diurnal pattern. Acceptable measures of core body temperature can be taken in the rectum, vagina, or ear canal near the tympanic membrane. Technologies are being developed for continuously monitoring body temperatures via radiotelemetry, which would allow earlier detection of sick cattle for treatment and could even be used to identify time of ovulation in cows and heifers.

The objectives of this trial were to determine the effect of feeding high roughage and high energy diets on body temperature, and to compare body temperature measurement taken in the rumen with the traditionally used vaginal, rectal, and tympanic temperature measures.

Procedure

Trial 1

Tympanic, vaginal, and ruminal temperatures were obtained from four crossbred heifers (mean weight = 911 lb) over four-day periods while being fed the high energy or high roughage diet (Table 1). The heifers were initially fed the high energy diet, then switched to the high roughage diet and allowed a 10-day acclimation period before temperatures were monitored.

Table 1. Diet composition (% dry matter basis).

Ingredients	High Energy	High Roughage
Alfalfa hay	5.0	26.0
Brome hay	—	10.0
Corn silage	5.0	60.0
Dry rolled corn	80.0	—
Rumensin/Tylan	2.2	1.0
Soybean meal	3.5	—
Liquid supplement	4.3	3.0
Dry matter, %	80.86	40.06
Metabolizable energy, Mcal/lb	1.42	1.13

Tympanic temperatures (TT) were recorded using a Stowaway XTI® data logger (Onset Corporation, Pocasset, MA) and thermistor. The thermistor was inserted approximately four to five inches into the ear canal until the tip was near the tympanic membrane. The loggers recorded temperatures at 15-minute intervals.

Vaginal (VT) and ruminal (RT) temperatures were recorded using the ETD Bolus™ (CowTek, Inc., Santa Clarita, CA). The ruminal boluses were inserted using a balling gun and remained in place until removal at slaughter. Vaginal temperatures were recorded using the same type of bolus. The bolus was hand-placed inside the vagina, immediately behind the cervix, during periods when temperatures

(Continued on next page)

were recorded. All boluses were activated via wireless signal to record temperatures at one-hour increments.

Due to problems receiving data from the boluses, primarily caused by bolus orientation and distance of the bolus to the signal receiver, approximately two-thirds of the VT and RT observations were missing from the first set of data during the high energy feeding period. Therefore, the receiver was moved and the heifers were observed for a second four-day period while being fed the high energy diet. (Approximately 60% of VT and RT observations were missing from the second period.) Data from both four-day high energy diet collections were pooled. The heifers were switched to the high roughage diet and the receiver was moved again to improve reception, resulting in only 8% of VT and RT observations missing from the high roughage feeding period.

Before analyzing the data, VT and RT observations were matched with TT occurring at the nearest hour. The remaining TT measurements were not used in the analysis. Because there was not a complete set with all three temperature observations for every hour, time of day was divided into six-hour (h) quarters as follows: Quarter 1 = 0000h to 0559 h; Quarter 2 = 0600 h to 1159 h; Quarter 3 = 1200 h to 1759 h; and Quarter 4 = 1800 h to 2359 h, with results reported accordingly. Also, any time that more than one observation occurred on the same date in the same quarter on the same heifer, a mean was taken for that quarter and heifer. This aided in balancing the data set for quarter and diet. For the entire study, 178 and 167 data points were obtained for heifers on high energy and high roughage diets, respectively, with approximately one-third of the points occurring for each temperature location. Additionally, 90-105 data

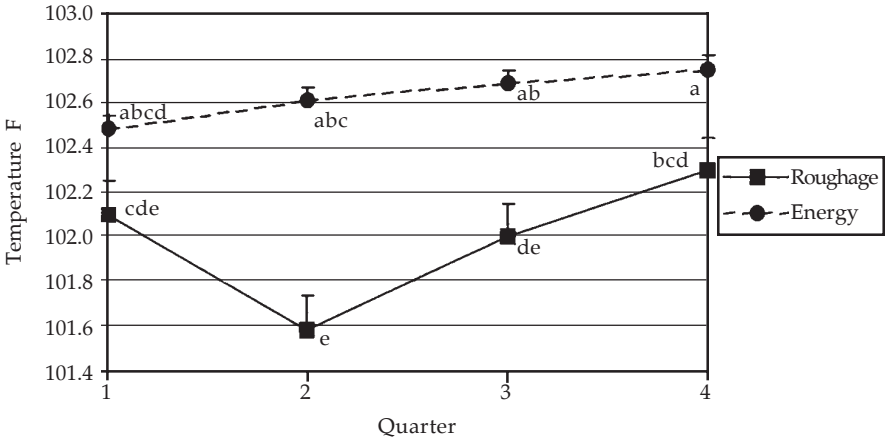


Figure 1. Mean temperature (pooled across vaginal, ruminal, and tympanic temperatures) by quarter for heifers fed high roughage and high energy diets.

Quarter: 1 = 0000 h to 0559 h; 2 = 0600 h to 1159 h; 3 = 1200 h to 1759 h; 4 = 1800 h to 2359 h. Diet by quarter interaction ($P = 0.082$); significant diet effect ($P < 0.0001$).
[abcde]Temperature means differ by $P < 0.05$.

Table 2. Weather conditions during periods and trials.[a]

Diet	Mean (SD)	Mean Min (SD)	Mean Max (SD)
Trial 1			
Energy Feeding Period			
Temperature (°F)	18.0 (6.3)	9.8 (5.2)	27.1 (9.7)
Relative humidity(%)	78.9 (9.4)	59.8 (20.2)	91.3 (2.9)
Wind speed (mph)	9.2 (1.8)	4.8 (2.8)	14.8 (2.8)
Solar radiation (langleys)	162 (58)	——	——
Roughage Feeding Period			
Temperature (°F)	35.3 (5.5)	26.8 (5.5)	45.7 (4.8)
Relative humidity(%)	61.6 (3.2)	38.9 (7.9)	82.2 (4.5)
Wind speed (mph)	14.6 (2.8)	7.8 (4.0)	22.4 (3.4)
Solar radiation (langleys)	265 (48)	——	——
Trial 2[b]			
Energy diet			
Temperature (°F)	43.2 (9.7)	——	——
Relative humidity (%)	56.6 (17.1)	——	——
Wind speed (mph)	14.4 (5.2)	——	——
Solar radiation (langleys)	384 (157)	——	——

[a]As reported by High Plains Research and Climate Center for site near Concord, Nebraska, approximately 1 mile north and 1/2 mile west of the feedlot.
[b]Means for April 1 - 10.

Table 3. Mean temperatures by recording location.

	Tympanic	Rectal	Vaginal	Ruminal	SEM
Trial 1	101.8[a]	——	101.9[a]	103.2[b]	0.16
Trial 2[c]	103.0[a]	103.7[ab]	103.8[ab]	104.3[b]	0.51

[ab]Means within a row differ (P<0.10).
[c]Temperatures were taken in order, left to right.

points were obtained in every quarter, except quarter 1 (0000h to 0559 h), when only 49 measures were recorded. Observations were analyzed using Proc Mixed analysis of variance procedures (SAS; SAS Institute, Inc. Cary, NC). The model included diet, temperature location, quarter, and all interactions as fixed effects with animal nested in the quarter by temperature location interaction (since vaginal and ruminal temperatures were only recorded at times when the animal was within receiver range) as random effects.

Trial 2

On a separate date, the same four heifers were moved into the working facilities. Tympanic, rectal, vaginal, and ruminal temperatures were taken in that order within a two-minute time frame while each animal was in the chute. The ruminal temperature was recorded using the ETD Bolus^{TM} that was already in place, while the other three were recorded with a digital thermometer (Deltatrak, Pleasanton, CA). All heifers were on the high energy diet (Table 1) during this trial.

These observations were analyzed using the Proc Mixed analysis of variance procedures (SAS; SAS Institute, Inc., Cary, NC). The model included temperature location as fixed effect with animal as a random effect.

Results

Overall, feeding the high roughage diet reduced body temperature when compared with feeding the high energy diet. Figure 1 shows the effect of diet and quarter on temperature, as pooled across temperature location. Diet by quarter interaction is significant ($P = 0.082$), which indicates that diet may have a tendency to alter the diurnal temperature rhythm. For all quarters except the first one, temperature means were significantly higher ($P<0.05$) for high energy than high roughage diets, even though weather conditions were slightly warmer during the roughage feeding period. Average weather conditions during both trials are shown in Table 2. Cattle were near or within the thermoneutral zone for the duration of the trial.

Temperatures recorded at each location are presented in Table 3. In Trial 1, ruminal temperature was significantly higher than both tympanic and vaginal temperatures ($P<0.05$); however, in Trial 2, tympanic temperature was the only temperature significantly different from ruminal temperature ($P<0.10$) with rectal and vaginal temperature intermediate. Temperature location by diet interaction is not significant ($P = 0.1824$).There are several reasons that Trial 2 temperatures may have had a tendency to run higher than Trial 1. All of the Trial 1 data was used (both diet treatments) while Trial 2 observations only occurred while heifers were on the high energy diet. Additionally, Trial 2 involved moving the animals into working facilities, utilized different devices, and occurred two months after Trial 1.

There was no quarter interaction between temperature recording and location ($P = 0.998$). This indicates that all three temperature locations followed the same trends and may be effective measurements of body temperature. Further research needs to be done to enhance and maintain constant receiver/signal communication, so that temperatures can be statistically analyzed as measured on an hourly basis to ascertain the similarity of RT to VT and TT.

Feeding a high roughage diet lowered all measures of core body temperature when compared to feeding a high energy diet. Ruminal temperature may be an effective way to measure body temperature, as it follows a similar diurnal rhythm as vaginal and tympanic temperature measurements, although water and feed intake effects need to be evaluated. In addition the nature of the ruminal diurnal pattern should be evaluated hourly.

---

[1]Sheryl L. Colgan, research technician, Terry L. Mader, professor, Animal Science, Haskell Ag Lab, Northeast Research and Extension Center, Concord.

Effect of Clinoptilolite Zeolite on Cattle Performance and Nitrogen Volatilization Loss

Dawn M. Sherwood
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

A winter feeding experiment evaluated effects of adding clinoptilolite zeolite clay at 1.2% of the diet on steer performance and nitrogen (N) volatilization loss. No differences were found in steer performance, removed manure composition or N balance; however, small numeric improvements were observed in ADG and F:G for steers fed zeolite. Adding zeolite clay to feedlot diets did not affect N loss in open feedlots using mass balance techniques.

Introduction

With increasing environmental regulations, producers will need to incorporate efficient, cost effective methods to reduce N losses from feedlots without negatively affecting cattle performance. Numerous options have been researched which include decreasing diet digestibility by adding corn bran (*2004 Nebraska Beef Report*, pp. 69-71, *2003 Nebraska Beef Report*, pp. 54-58, *2002 Nebraska Beef Report*, pp. 54-57), feeding less total protein (*1999 Nebraska Beef Report*, pp. 60-63) and cleaning pens more frequently (*2004 Nebraska Beef Report*, pp. 72-73).

Zeolite clay, a proposed new treatment to reduce N volatilization, is capable of ion exchange and may be effective in adsorbing ammonia. Most zeolite clays are mined from volcanic ash deposits which form alkaline lakes. One hypothesis for this research is that adding zeolite clay to cattle feedlot diets will bind the ammonia (NH_3), reducing the amount of N lost into the air. The second hypothesis is that steer ADG, feed efficiency and intake will not be negatively impacted by adding zeolite clay to the diet.

Procedure

Ninety-six crossbred steer calves (741 + 26 lb) were fed for 168 days from November to April. Steers were stratified by weight and assigned randomly to twelve pens and one of two treatments (eight head per pen, six pens per treatment). Treatments were 1) control diet with 0% zeolite clay or 2) treatment diet with 1.2% zeolite clay. Clinoptilolite zeolite clay was used in this experiment.

Steers were weighed initially on two consecutive days following a five-day limit-feeding period. Steers were weighed again on days 28, 84 and 168. The cattle were implanted on day 1 and day 84 with Synovex-Choice®. Diets were formulated to meet the steers' metabolizable protein requirement according to the 1996 Beef NRC. Steers were fed on a four-week step-up program to the finishing diet shown in Table 1. The supplement used a ground corn carrier and for the treatment diet, 1.2% of the ground corn carrier was replaced with zeolite clay.

At slaughter, hot carcass weights and liver scores were recorded. Following a 24-hour chill, fat thickness at the 12th rib, quality grades, yield grades and rib-eye areas were recorded. Final weights were calculated as hot carcass weight divided by the dressing percentage of 63.

Table 1. Composition of finishing diets (% DM basis).

Ingredient	Control	Zeolite
High moisture corn	62.5	62.5
Wet corn gluten feed	25	25
Alfalfa hay	7.5	7.5
Supplement[a]	5	5

[a]Control supplement: ground corn (3.14%), Rumensin® (320 mg/head/day), Tylan® (90 mg/head/day), limestone, salt, tallow, vitamins and minerals. Treatment supplement: ground corn (1.94%), zeolite clay (1.2%), Rumensin® (320 mg/head/day), Tylan® (90 mg/head/day), limestone, salt, tallow, vitamins and minerals.

The N balance experiments were conducted in 12 open feedlot pens with retention ponds to collect run-off. Run-off amounts were measured using an ISCO 4230 flow meter (Lincoln, Nebraska). Samples were collected during draining of the retention ponds and analyzed for dry matter, organic matter and total N.

Prior to the steers entering the pens, 16 core samples (top 6 inches) were taken at equally spaced intervals throughout the pen. Following removal of the steers at slaughter, pens were cleaned and 16 cores were taken once again at similar locations. Six cores per pond were taken at the same time as the pen cores. All cores were analyzed for dry matter, organic matter and N.

On day 168, following the removal of the steers, pens were cleaned. Total pounds of manure removed were recorded. As manure was loaded, samples were obtained for analysis of dry matter and N.

Table 2. Growth performance and carcass characteristics.[a]

Item	Control	Zeolite	SEM	*P*-value
Initial BW, lb	742	742	1	0.87
Final BW, lb	1378	1400	14	0.30
DMI, lb	22.2	22.3	0.3	0.95
ADG, lb	3.79	3.92	0.08	0.30
Feed/gain [b]	5.85	5.68	0.01	0.37
Hot carcass weight	868	882	9	0.30
Marbling score [c]	548	531	8	0.15
Fat thick, in [d]	0.63	0.60	0.03	0.56

[a] Adjusted using hot carcass weight.
[b]Analyzed as gain:feed.
[c]Marbling score: 500 = Small^{0}, 550 = Small^{50}
[d]12th rib fat thickness.

Table 3. Nitrogen mass balance in the feedlot for steer calves fed from November to April (values expressed as lb/steer over entire feeding period unless noted).

Item	Control	Zeolite	SEM	*P*-value
N intake	85.8	86.3	1.3	0.77
N retention [a]	12.6	13.1	0.3	0.30
N excretion [b]	73.2	73.2	1.1	0.95
Manure N [c]	43.9	42.7	2.4	0.64
N lost [d]	29.2	30.6	4.0	0.82
% N lost [e]	40.1	41.8	5.7	0.84

[a]Calculated using NRC (1996) net protein and net energy equations.
[b]Calculated as N intake - N retention.
[c]Manure N includes soil core balance before the experiment and after cleaning.
[d]Calculated as N excretion - manure N - core N.
[e]N lost expressed as % of N excreted.

Table 4. Manure composition.

Item	Control	Zeolite	SEM	*P*-value
DM weight removed	3573	3637	213	0.84
% DM	68.1	69.2	0.9	0.40
OM weight removed	692	657	42	0.57
% OM	19.7	18.0	0.9	0.19
N weight removed	37.0	35.3	2.4	0.64
% N	1.04	0.97	0.03	0.16

Nitrogen intake was calculated using analyzed dietary N concentration for each feedstuff and total DMI. Individual steer N retention was calculated using the NRC (1996) net protein and net energy equations. Nitrogen excretion was determined by the difference between N intake and N retention. Manure N was calculated from weight of manure hauled and N composition. Manure N was corrected for inherent cleaning differences by adjusting for soil core N before and after the feeding period. Total N lost was calculated by subtracting soil corrected manure N from excreted N. All N values are reported on a per steer basis fed for 168 days. All data were analyzed by variance using the Mixed Procedure of SAS.

Results

There were no statistical differences in steer performance between control and zeolite treatments (Table 2). Numerically, the zeolite steers had a 3.4% increase in ADG over the control group. The zeolite group had a 2.9% decrease in feed:gain.

Nitrogen mass balance was not affected by adding zeolite clay. No statistical differences were found in manure composition removed or N balance (Tables 3 and 4).

Previous research suggests zeolite clay is able to adsorb N, thus having the ability to reduce N volatilization loss. In this trial, however, no differences in volatilization were seen. The percent of N lost during this trial (Table 3) was consistent and within the 38-74% N lost during winter months as reported in previous studies. Over the 168-day feeding period, 73.2 lb of N was excreted and about 45 lb of zeolite clay was consumed per steer. The steers were excreting 162% more N than zeolite consumed. About 30 lb of N was lost, so the amount potentially retained by the zeolite clay did not have a significant impact. The amount of N supplied by feedlot diets may be greater than the potential for zeolite clay to adsorb and therefore N balance and losses may not be impacted.

Based on previous estimates of NH_3 binding in soils by Kithome et al. (*1998 Soil Science Society of America Journal*), zeolite clay retained 1 g per lb of zeolite. Using that estimate, only 0.1 lb of N would be trapped in manure from the 45 lb of zeolite fed to each steer over the 168 days.

In this experiment, mass balance techniques were used in open outdoor pens which is different than previous research. Manure is being composted to determine if any differences would be observed between treatments.

[1]Dawn M. Sherwood, graduate student; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Evaluation of Initial Implants for Finishing Steers

Jeffrey D. Folmer
Travis B. Farran
Galen E. Erickson
Terry J. Klopfenstein
Chris D. Reinhardt
Bill D. Dicke
Jim S. Drouillard[1]

Summary

A commercial feedlot experiment utilizing 12 pens and 1038 steers evaluated initial implant strategies for feedlot steers. Steers were administered either Revalor-IS® or Synovex S® at initial processing. Both treatment groups received Revalor-S® as a terminal implant. Revalor-IS® as an initial implant improved hot carcass weight and carcass adjusted final weight; however, there was no effect on any other measure of performance or carcass characteristics. Selling steers on a carcass merit basis resulted in a similar return per head for both implant strategies. Reduced-dose combination implants may improve hot carcass weight and carcass adjusted final weight with no impact on carcass merit.

Introduction

Growth-promoting implants increase growth rate (i.e. daily gain), improve feed conversion, and increase final weight of cattle by as much as 40 to 90 lb (Guiroy et al., 2002; *Journal of Animal Science*) compared to non-implanted cattle. If implanted cattle are marketed at weights comparable to non-implanted cattle, the increase in growth rate and lean deposition may occur at the expense of meat quality (reduction in marbling score), suggesting implanted cattle should be fed to higher body weights in order to achieve comparable quality grades.

New reduced-dose initial implant combinations of estradiol and trenbolone acetate are available for steers and may have different effects on animal performance and carcass quality when compared to the more traditional estrogen-based implants. Recently, Hutcheson et al. (2003, *Journal of Animal Science* Vol. 81 Suppl. 1, p112) reported estradiol and trenbolone acetate implants, used in either the full or reduced dosage form, improved gain, feed efficiency, and hot carcass weight while maintaining carcass quality in short-fed yearling steers when compared to a traditional estrogen implant. Also, Farran et al. (*2004 Nebraska Beef Report*, pp. 58-60) observed improvements in gain, feed efficiency, marbling score, and the percentage of carcasses grading upper two-thirds Choice when reduced dosage estradiol and trenbolone acetate implants were compared to initial implants of estrogen plus testosterone in long-fed heifers. Our objectives were: 1) to determine whether a reduced-dose combination of estradiol and trenbolone acetate is effective in maintaining animal performance, and 2) to measure the impact of reduced dosage of estrogen in an estradiol and trenbolone acetate initial implant on carcass quality, yield grade and feeding economics of feedlot steers.

Procedure

Crossbred steers (593 lb. initial BW) were received at a commercial feedlot in Western, Nebraska and were allotted randomly to one of two implant regimens at initial processing (within 72 hours after arrival). Each group of incoming cattle represented a treatment replication for a total of six replications per treatment (12 pens total; 1,077 steers). Steers were kept separate by arrival date and assigned randomly to pens by sorting every other animal as they exited the processing chute during initial processing. Within a replication, all steers were from the same source and arrived to the feedlot at the same time. At initial processing, steers were individually weighed, vaccinated, treated for internal and external parasites, and given a lot-tag for individual and pen identification. The initial implant treatment was either Revalor-IS (16 mg estradiol, 80 mg trenbolone acetate) or Synovex S (20 mg estradiol benzoate, 200 mg progesterone). After processing, animals were weighed by pens for a starting pen weight just prior to being moved into their home pen. Number of animals in a pen ranged from 70 to 120 head and was equal across treatments and replications.

Steers were fed (twice daily) a common finishing diet containing

62.3% steam-flaked corn, 10.6% dry-rolled corn, 9.0% wet distillers grains, 3.0% alfalfa hay, 4.0% mixed hay, 5.0% liquid supplement, 3.5% corn steep liquor, and 2.6% tallow. The finishing diet was formulated to contain 14.7% CP, 0.7% Ca, and 0.4% P, 28 g/ton Rumensin, and 9 g/ton Tylan. Cattle were adapted to the finishing diet over an 18- to 21-day step-up period starting with 45% roughage and progressively replacing roughage with concentrate.

Replications of steers were reimplanted with Revalor-S (24 mg estradiol 17beta, 120 mg trenbolone acetate) as the common terminal implant an average of 78 days (range 71 to 84) prior to slaughter. At re-implant time, steers were removed from their pens and immediately weighed to obtain a pen weight. Steers were then re-vaccinated, poured, individually weighed, and re-implanted prior to being sent back to their home pen for the remainder of the feeding period. Initial implants also were evaluated at this time to identify defects, including abscessed, bunched, missing, crushed, partial, or cartilage-placed implants. Steers were fed an average of 180 days (range 170 to 191). All pens within a replication were marketed under identical conditions at the same commercial abattoir (National Beef Packing; Dodge City, Kansas). Hot carcass weights were recorded on the day of harvest. Carcass fat thickness, longissimus muscle area, and USDA called marbling score and yield grades were recorded following a > 24-hour chill. Empty body fat was calculated from the equations of Guiroy et al. (2002, *Journal of Animal Science*), where empty body fat = 17.76207 + (4.68142 × fat thickness in cm) + (0.01945 × hot carcass weight in kg) + (0.81855 × quality grade) - (0.06754 × longissimus muscle area in cm^2). Calculated yield grade was estimated with the formula from the American Meat Science Association, 2001 *Meat Evaluation Handbook* where Yield Grade = 2.5 + (2.5 × fat thickness in inches) + 0.2 × (% kidney, pelvic, and heart fat; estimated at 2%) + (0.0038 × hot carcass weight in lb) - (0.32 × longissimus muscle area in $in.^2$). Marbling score was recorded on a scale of 450 = Slight ^{50}; 500 = Small ^{0}; 550 = Small ^{50}; 600 = Modest ^{0}.

The economic influence of the initial implant treatment on profit/loss of steers sold on a value-based pricing grid was determined based upon the commodity grid proposed by Feuz (*2002 Nebraska Beef Report,* pp. 39-41). Carcass value was calculated based on USDA quality and yield grade, carcass weight, and nonconformance (i.e., dark cutters and heavy carcasses). A carcass base price of $109.84/cwt (10-year average dressed weight price) was used for low Choice, Yield Grade 3 carcasses weighing 550 to 950 lb. Discounts were calculated on a hundred weight of carcass basis as: $7/cwt Select; $17/cwt Standard; $25/cwt dark cutters; $15/cwt for light (<550 lb) and heavy (>950 lb) carcasses; and $15/cwt for yield grades of 4 and 5. Premiums were calculated as: $6/cwt Prime; $1.50/cwt upper 2/3 Choice; $1/cwt Yield Grade 2; and $2/cwt Yield Grade 1. Ration cost was calculated using 10-year average corn and alfalfa hay price. Non-feed costs were $0.28/head daily yardage, $30/head miscellaneous (medicine, processing, shipping, etc.), and 7% animal and feed interest. Initial implant cost was $1.95/implant for Revalor-IS and $0.80/implant for Synovex S. Initial animal cost was based upon the 10-year average 600- to 700-lb feeder steer price of $83.76/cwt (Feuz et al., *2002, University of Nebraska, Cooperative Extension Bulletin,* PHREC 02-21, p.16).

Animal performance, carcass data and economics were analyzed using the Mixed procedure of SAS for a randomized complete block design where pen served as the experimental unit. Model effects were initial implant treatment, while arrival date was termed a blocking factor, thus placed into the random statement. Least squares means were separated using the PDIFF statement of SAS.

Results

Data are presented with deads and railers removed from the analysis. Fifteen and thirteen head were removed from the Revalor-IS and Synovex S treatments, respectively. Feed intake and head days were adjusted accordingly for the time of removal from the pen. Feed intake was calculated from feedlot closeout information on each pen of cattle. Because all steers received a common terminal implant, initial implant treatment will be referred to when comparing treatment differences.

There were no differences in initial implant defects for either treatment. One animal in the Revalor-IS and three animals in the Synovex S treatments possessed abscessed implants. Additionally, thirteen animals in the Revalor-IS and fifteen in the Synovex S treatment had identifiable defects in the initial implant. Therefore, 2.5% of steers administered Revalor-IS and 2.8% of steers administered Synovex S were found to have implants that fell within the defective criteria. This indicates that initial implants were properly administered.

There were also no differences in morbidity and mortality of steers. Deads and railers were combined as they were all removed from their pens and the data analysis. Deads and railers averaged 3.6% and 3.2% for the Revalor-IS and Synovex S treatments, respectively. Total pulls averaged 56.8% and 52.8% for the Revalor-IS and Synovex S treatments, respectively. Of those pulls, steers treated for respiratory disease on one occurrence were 38.1% and 38.8%, and steers treated for respiratory disease two or more times were 15.0% and 11.9% for the Revalor-IS and Synovex S treatments, respectively. Pulls for other

reasons were 3.7% and 2.0% for the Revalor-IS and Synovex S treatments, respectively.

Steer performance is presented in Table 1 and is expressed on a live and carcass adjusted basis using a common dressing percentage (63%). Dry matter intake was similar between treatments. Steers implanted initially with Revalor-IS had 8 lb. greater ($P = 0.07$) carcass adjusted final weight than steers initially implanted with Synovex S. Implanting steers initially with Revalor-IS improved feed efficiency by 2% in the live category (5.41 vs. 5.53) and 3% in the carcass adjusted calculation (5.31 vs. 5.48); however, neither difference was significantly different from the Synovex S treatment with P-values of 0.30 and 0.23, respectively. Live average daily gain (P = 0.31) and carcass adjusted average daily gain (P = 0.22) were not significantly different and only slightly increased with the initial Revalor-IS treatment.

Carcass merit is shown in Table 2. Revalor-IS implanted steers had 5 lb heavier ($P = 0.07$) hot carcass weights, with similar dressing percentages, 12th rib fat thickness, calculated empty body fat, and longissimus muscle area when compared to Synovex S implanted steers. USDA called yield grade and calculated yield grade were similar between treatments indicating that steers were fed to a similar compositional end-point. Marbling score, carcasses grading upper two-thirds Choice, and total carcasses grading Choice were not different between initial implant treatments. Steer carcass yield grade breakdowns also are presented in Table 5. There were no differences between treatments when analyzed in single numerical categories or when combined as is illustrated when yield grade one and two were combined. These data suggest that reduced-dose combina-

Table 1. Effects of Revalor-IS or Synovex S as initial implants for feedlot steers on live and carcass adjusted performance.

	Initial Implant[a]			
Item	Revalor-IS	Synovex S	SEM	*P*-value
Number of pens	6	6		
Number of steers	518	520		
Initial weight, lb	592	593	4.3	0.80
Dry matter intake, lb	20.0	20.3	0.3	0.45
Carcass performance				
Final weight, lb[b]	1269	1261	3.5	0.07
Daily gain, lb[c]	3.77	3.72	0.04	0.22
Feed:gain[c]	5.31	5.48	0.15	0.23
Live performance				
Final weight[d]	1258	1253	3.4	0.20
Daily gain, lb[e]	3.70	3.67	.03	0.31
Feed:gain[e]	5.41	5.53	0.11	0.30

[a]All steers implanted with Revalor-S as the common terminal implant.
[b]Calculated as hot carcass weight ÷ 63%.
[c]Calculated using carcass-adjusted final weight.
[d]Calculated from live pen weights and shrunk 4%.
[e]Calculated from live final weight.

Table 2. Effects of Revalor-IS or Synovex S as initial implants on steer carcass characteristics.

	Initial Implant[a]			
Item	Revalor-IS	Synovex S	SEM	*P*-value
Hot carcass weight, lb	800	795	2.24	0.07
Dressing percentage	63.6	63.4	0.12	0.26
12th rib fat, in.	0.48	0.48	0.05	1.00
Empty body fat, %[b]	28.8	28.8	0.14	0.74
Longissimus muscle area, sq. in.	13.6	13.5	0.11	0.24
Dark cutters, %	1.12	2.73	0.87	0.14
USDA yield grade, %				
1	7.6	8.3	0.99	0.53
2	52.8	46.5	4.26	0.20
3	32.5	39.4	5.59	0.28
4	6.0	4.8	1.1	0.35
5	1.1	1.0	0.7	0.82
Calculated yield grade[c]	2.9	2.9	0.04	0.37
Marbling score[d]	516	516	4.34	0.97
USDA Quality grade, %				
Prime	1.2	0.2	0.51	0.11
Upper 2/3 Choice	18.8	19.8	3.14	0.76
Low Choice	36.8	39.2	2.06	0.31
Select	40.7	38.8	1.1	0.14
Standard	2.5	2.0	1.38	0.73
Total Choice carcasses	55.6	58.2	1.36	0.15

[a]All steers implanted with Revalor-S as the common terminal implant.
[b]Calculated from Guiroy et al., 2002 (*Journal of Animal Science*), where empty body fat = 17.76207 + (4.68142 × 12th rib fat thickness) + (0.01945 × hot carcass weight) + (0.81855 x quality grade) - (0.06754 × longissimus muscle area).
[c]Calculated YG = 2.5 + (2.5 × 12th rib fat thickness) + (0.2 x kidney, pelvic, and heart fat) + (0.0038 × hot carcass weight) - (0.32 × longissimus muscle area).
[d]Marbling score: 450 = Slight 50; 500 = Small 0; 550 = Small 50; 600 = Modest 0; etc.

Table 3. Feeding economics of steers implanted with Revalor-IS or Synovex S.

Item	Initial Implant[a]		SEM	*P*-value
	Revalor-IS	Synovex S		
Initial animal cost, $/cwt[b]	83.76	83.76	—	—
Ration cost, $/ton DM	126.00	126.00	—	—
Initial implant cost, $/head	1.95	0.80	—	—
Total misc. cost, $/head[c]	103.81	102.72	—	—
Carcass base price, $/cwt	109.84	109.84	—	—
Commodity grid profit(loss), $/head[d]	1.06	-3.89	8.07	0.57

[a]All steers implanted with Revalor-S as the common terminal implant.
[b]10-year average price feeder steers weighing 600 to 700 lb.
[c]Includes $0.28/day yardage, 7% animal and feed interest, and $30/head miscellaneous cost (processing, health, terminal implant, shipping, etc.)
[d]Discounts/cwt = $7 Select, $17 Standard, $15 yield grade 4&5, $25 dark cutter, $15 light & heavy carcasses; premiums/cwt = $6 Prime, $1.50 Upper 2/3 Choice, $2 Yield grade 1, $1 Yield grade 2.

tion (E + TBA) implants used initially may improve carcass weight compared to traditional higher dose implants, when cattle are fed the same number of days. Additionally, implant treatment did not affect the degree of finish of the steers.

The simulated economic analysis of marketing cattle on a value-based carcass merit basis is presented in Table 3. Using 10-year average prices, ration cost was calculated to be $126/ton (DM basis). The added cost of Revalor-IS over that of Synovex S implants also was included in the analysis. Initial animal cost and total miscellaneous costs were similar between treatments. Steers implanted initially with Revalor-IS returned $4.95/head more ($P = 0.57$) than those steers initially implanted with Synovex S. The 5 lb heavier hot carcass weights translate into greater returns for steers implanted with Revalor-IS.

This study provides evidence that Revalor-IS as an initial implant for feedlot steers appears to provide equal performance and slightly better carcass weight than traditional steer initial implants (Synovex S), without affecting carcass characteristics or feeding economics when steers are sold on a value-based grid marketing system. Farran et al. (*2004 Nebraska Beef Report*) found significant increases in gain, feed efficiency, and marbling score when Revalor-IH was used as an initial heifer implant compared to Synovex-H. They observed a 2.5% increase in carcass adjusted feed efficiency. In our study with steers, we observed no differences in gain or marbling score. However, we did find slight increases in hot carcass weight and carcass adjusted final weight. In addition, we observed a 2% decrease in live, and 3% decrease in carcass adjusted feed conversion; however, due to a larger amount of variation or differences in physiology between heifers and steers, the improvements we observed were not statistically significant.

[1]Jeffrey D. Folmer, Travis B. Farran, graduate students; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln; Chris D. Reinhardt, Intervet, Inc.; Bill D. Dicke, Cattlemen's Consulting, Lincoln, NE. Jim S. Drouillard, professor, Animal Science, Kansas State University.

Effect of Injecting Modified Connective Tissue Solutions on Quality of Beef Roasts

Oscar Esquivel
Roger W. Mandigo[1]

Summary

Soluble collagen from enzymatically treated beef tendons was used in an enhancement brine to inject and tumble USDA select grade semitendinosus muscles. Similar samples injected only with water, salt and phosphates and non-injected ST roasts were used as controls. No treatment differences were found for package purge loss and shear force. Color of collagen injected samples was either similar to non-injected or salt/phosphate injected pieces. Sensory evaluation indicated that samples injected with enzyme treated collagen were tenderer, juicier, and more flavorful. Tendons can be modified and successfully used for injection of whole muscle products in model systems.

Introduction

Important amounts of connective tissue such as tendons, membranes, cartilages and ligaments are generated from beef fabrication and grinding operations. This material is usually of low value and rendered for protein and fat. Previous research has described modification and use of connective tissue in meat systems like ground beef, patties, sausages, frankfurters, bologna and restructured products, where it was successfully included for cost reduction, texture modification and fat substitution. However, applications in whole muscle products have not been reported. Injection and marination of beef cuts have proved to enhance overall eating quality and reduce palatability variations of the finished product. This enhancement technology is now common practice in the meat industry. Our objective was to improve connective tissue functionality so that it could be used as an ingredient for injection, marination and enhancement of beef whole muscle products.

Procedure

Beef Tendon Solutions

Beef chuck tendons were either cooked to 167ºF in a solution containing salt (5% w/w), phosphate (2% w/w) and bromelin (a pineapple derived proteolytic enzyme) or just salt and phosphate as a control. The resulting product was filtered through cheesecloth to obtain two types of solutions: heat solubilized collagen (C-collagen) and enzyme-degraded collagen (B-collagen), which were used as ingredients for injection.

Injection of Beef Roasts

Six USDA select grade semitendinosus (ST) muscles were cut in half to obtain 12 ST roasts. Three roasts were randomly assigned to each of the following injection treatments: 1) C-collagen, 2) B-collagen, 3) salt and phosphate (SP) and 4) no injection (NI).

All the solutions to be injected were adjusted to have the same level of salt (5% w/w) and phosphate (2% w/w). The eye of round pieces were injected to 15% weight increase, bagged and tumbled for 30 minutes. After tumbling the pieces were cut into six 0.75-inch steaks which were randomly assigned in groups of two steaks per three time periods: day 1, day 8 and day 15 post injection. The steaks were weighed, vacuum packaged and stored in the darkness at 41ºF.

Purge, Color and pH

At every time period, a two-steak package per experimental unit was opened and the steaks were blotted

(Continued on next page)

Table 1. Least square means[e] for lightness value (L*) by treatment and time.

Main Effect	L*value
Treatment[f]	
B	40.81[a]
C	50.85[a]
SP	44.35[b]
NI	51.49[a]
Std error	1.90
Time[g]	
Day 1	45.62[d]
Day 8	46.05[d]
Day 15	48.94[c]
Std error	1.11

[e]Means within a column lacking a common superscript letter are different ($P < 0.05$).
[f]Injection treatments B, C, SP, NI refer to samples injected with: bromelin degraded collagen, heat-treated collagen, salt/phosphate only and non-injected, respectively.
[g]Time refers to day 1, 8 and 15 post injection.

Table 2. Least square means[c] for package purge by time.

Time[d]	Purge (%)
Day 1	3.72[a]
Day 8	5.46[b]
Day 15	4.95[b]
Std error	0.403

[c]Means within a column lacking a common superscript letter are different ($P < 0.05$).
[d]Time refers to day 1, 8 and 15 post injection.

Table 3. Least square means[d] for cooking losses by injection treatment.

Treatment[e]	Cooking Loss (%)	Std error[f]
B	30.41[ab]	0.923
C	32.75[a]	0.923
SP	27.37[c]	0.923
NI	29.03[bc]	1.002

[d]Means within a column lacking a common superscript letter are different ($P < 0.05$).
[e]Injection treatments B, C, SP, NI refer to samples injected with: bromelin degraded collagen, heat-treated collagen, salt/phosphate only and non-injected, respectively.
[f] Injection treatments have different standard errors due to missing data.

Table 4. Least square means for Warner-Bratzler shear (WBS) force by treatment.

Treatment[a]	WBS (kg)
B	4.13
C	4.26
SP	3.92
NI	3.63
Std error	0.221

[a]Injection treatments B, C, SP, and NI refer to samples injected with: bromelin degraded collagen, heat-treated collagen, salt/phosphate only and non-injected, respectively.

Table 5. Least square means[d] for sensory flavor, tenderness, juiciness and overall acceptability scores.

	Treatment[e] Means				
Attribute[f]	B	C	SP	NI	Std error[g]
Flavor	8.6[a]	6.8[b]	7.6[b]	7.3[b]	0.40
Tenderness	8.9[a]	7.7[b]	7.5[b]	6.8[b]	0.45
Juiciness	9.0[a]	7.0[b]	8.2[a]	7.0[b]	0.39
Overall acceptability	8.5[a]	6.8[c]	7.7[ab]	7.2[bc]	0.38

[d]Means within a row lacking a common superscript letter are different ($P < 0.05$).
[e]Injection treatments B, C, SP, NI refer to samples injected with: bromelin degraded collagen, heat-treated collagen, salt/phosphate only and non-injected, respectively.
[f]Attributes scored on a 15 cm hedonic scale (n=45 panelists).
[g]Injection treatments have different standard errors due to missing data.

with a paper towel to remove excess moisture and weighed to determine purge loss. The samples were allowed to bloom for 30 minutes and lightness (L*), redness (a*) and yellowness (b*) and pH were measured. The steaks were then vacuum packed again and stored under refrigeration.

Cooking Losses, WBS and Sensory Analysis

Steaks were cooked to 130°F internal temperature for Warner-Bratzler shear force determination (WBS) and sensory evaluation. Forty-five panelists scored the samples for tenderness, juiciness, flavor and overall acceptability. Cooking losses were calculated by weight difference.

Statistical Analysis

A regression and an analysis of variance using Proc Mixed from the Statistical Analysis System (SAS) were performed. Least significant differences were calculated for mean separation and Bonferroni confidence bands were constructed for the regression parameter estimates.

Results

The NI steaks were lighter and redder while b* value trends were not significantly different among treatments. C-collagen samples were as light as NI product and as red as SP-injected steaks. B-collagen injected samples were similar in color characteristics to SP-injected product. Over time, all samples became lighter and both a* and b* decreased in a quadratic fashion (Table 1, Figures 1 and 2). As expected, purge increased as a function of time, but no treatment differences were observed (Table 2). Collagen injection slightly increased cooking losses compared to SP-injected samples, but was not different than NI steaks (Table 3).

(Continued on next page)

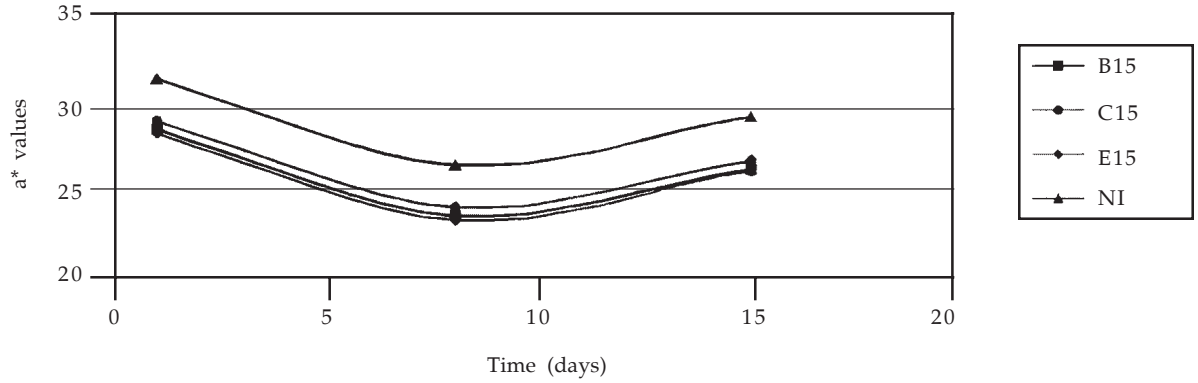


Figure 1. Predicted a* values by injection treatment.

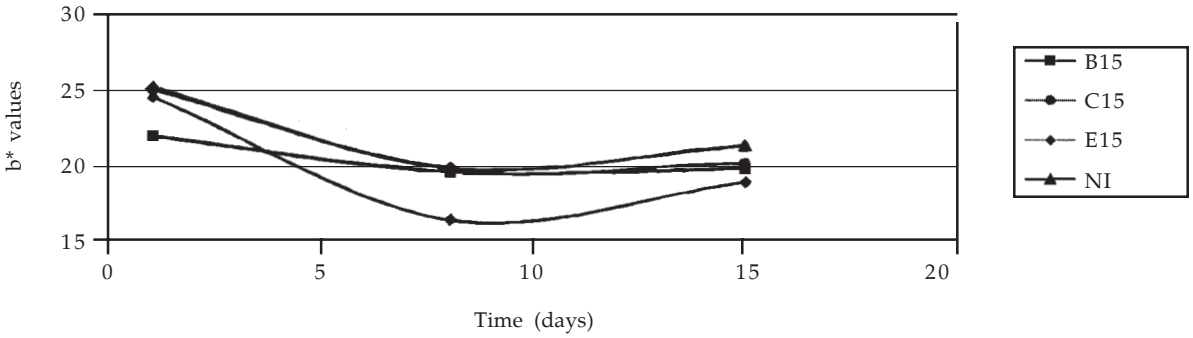


Figure 2. Predicted b* values by injection treatment.

Shear forces, however, were similar among samples (Table 4). Panelists perceived B-collagen steaks as being more flavorful and tender than any other treatment, and as juicy and acceptable as SP-injected steaks (Table 5). Injection of beef roasts with bromelin-degraded collagen improved palatability without significant changes to appearance and yield. Beef tendons can be upgraded through enzymatic hydrolysis and successfully utilized to inject beef cuts, adding value to both the raw materials and the finished product.

---

[1]Oscar Esquival, graduate student; Roger W. Mandigo, professor, Animal Science, Lincoln.

Packaging Effects on Shelf-Life and Sensory Traits of Enhanced Beef

Chris R. Calkins
Mike L. Buford[1,2]

Summary

Beef strip loins and top sirloins were enhanced and steaks were stored in one of three packaging systems: high-oxygen barrier trays, low-oxygen peelable trays, or vacuum packages. After dark storage for 8 or 15 days, simulating distribution time, steaks were displayed up to 3 days in a retail case. Steak discoloration and sensory traits were rated. Extended dark storage and retail display were detrimental to flavor and color. In this study, the best packaging systems were those that minimized opportunities for oxidation — vacuum packaging and, as long as dark storage was limited to eight days, high oxygen packaging.

Introduction

Recent innovations with packaging films and equipment technology require careful consideration of packaging options for a given beef product. High-oxygen packaging allows for a bright red color of beef, but accelerates conversion of fresh beef from bright red to a more brownish color. Low-oxygen packaging systems do not impart a bright red color of beef, but maintain the color in retail display if the package remains intact. There is a strong interest in the marketplace for beef products enhanced with ingredients designed to improve texture, flavor, and consistency. The objectives of this study were to determine the effects of commercial case-ready packaging systems on sensory, shelf-life, color, and color stability characteristics of enhanced beef.

Procedure

USDA select grade beef strip loins and top sirloin butts were selected at a commercial meat processing facility. At the plant, each primal was weighed, pumped with a commercial enhancement solution (water, salt and phosphate), and sliced into 1-inch thick steaks using a commercial slicer. Steaks were randomly packaged using one of three packaging systems: 1) a Ross 3320 and a high-oxygen barrier tray with approximately 20% carbon dioxide and 78% oxygen, 2) a Ross Junior model S3180 and a peelable tray with approximately 22% carbon dioxide, 78% nitrogen and 223 ppm of oxygen, or 3) vacuum packaged into oxygen-impermeable bags. The sirloin steaks were lightly misted with a rosemary extract to minimize oxidation.

Packaged steaks were allocated to one of two periods of dark storage (8 or 15 days), to be followed by up to 3 days of retail display. During display a team of trained evaluators rated the steaks' surface discoloration using a scale where 1 = 0% discoloration, 2=1-10% discoloration, 3=11-20% discoloration and so on. After one or three days of retail display, steaks were frozen and held for evaluation by a trained, 10-member sensory panel.

A trained sensory panel evaluated juiciness, tenderness, flavor intensity, intensity of off-flavor, and flavor desirability. The panel was not trained on flavor desirability, so the extent to which preference result can be applied to the general population is limited. These data were obtained as an indicator of panelist reaction to the products. All sensory traits were evaluated on 8-point rating scales, where 1=extremely dry, extremely tough, extremely mild flavor, no detectable off-flavor, extremely undesirable flavor, and 8=extremely juicy, extremely tender, extremely intense flavor, extremely intense off-flavor, and extremely desirable flavor. Panelists also identified off-flavors. Steaks were cooked to 158°F on Farberware Open Hearth broilers.

Results

Steak Discoloration

There were no differences among packaging and storage treatments for strip steaks at the start of the retail display period (Figure 1). Beginning one day of retail display, greater discoloration was detected for the low oxygen, peelable packages, regardless of storage time, and for the high oxygen packages stored in the dark for 15 days. For the duration of retail display, these differences continued to diverge from the vacuum packaged steaks and the high oxygen steaks stored in the dark for just eight days. These data suggest the low oxygen, peelable packages retained sufficient residual oxygen to catalyze myoglobin oxidation to the metmyoglobin state, thereby increasing the brown appearance. Presumably, a low oxygen, peelable package without residual oxygen would have lower levels of discoloration. Under high oxygen, storage of strip steaks for

(Continued on next page)

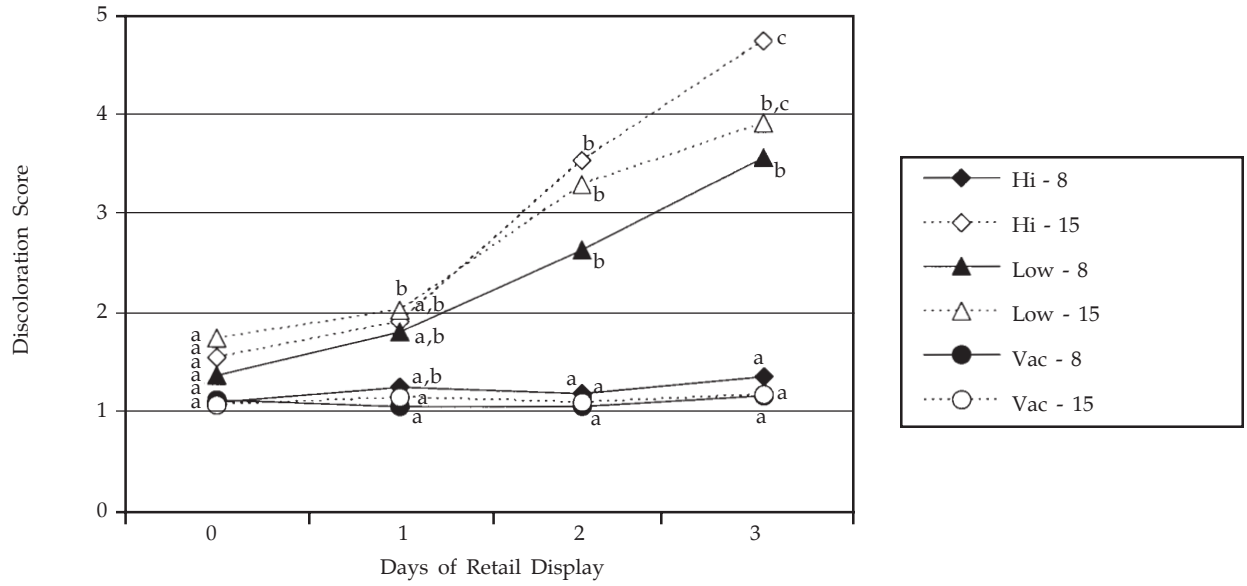


Figure 1. Discoloration scores for strip steaks during retail display in different packaging systems following 8 or 15 days of dark storage.

[a,b,c]Means within a day with no common letters differ ($P < 0.05$).
Rated on a scale where 1 = 0% discoloration, 2 = 1 - 10%, 3 = 11 - 20% and so on.

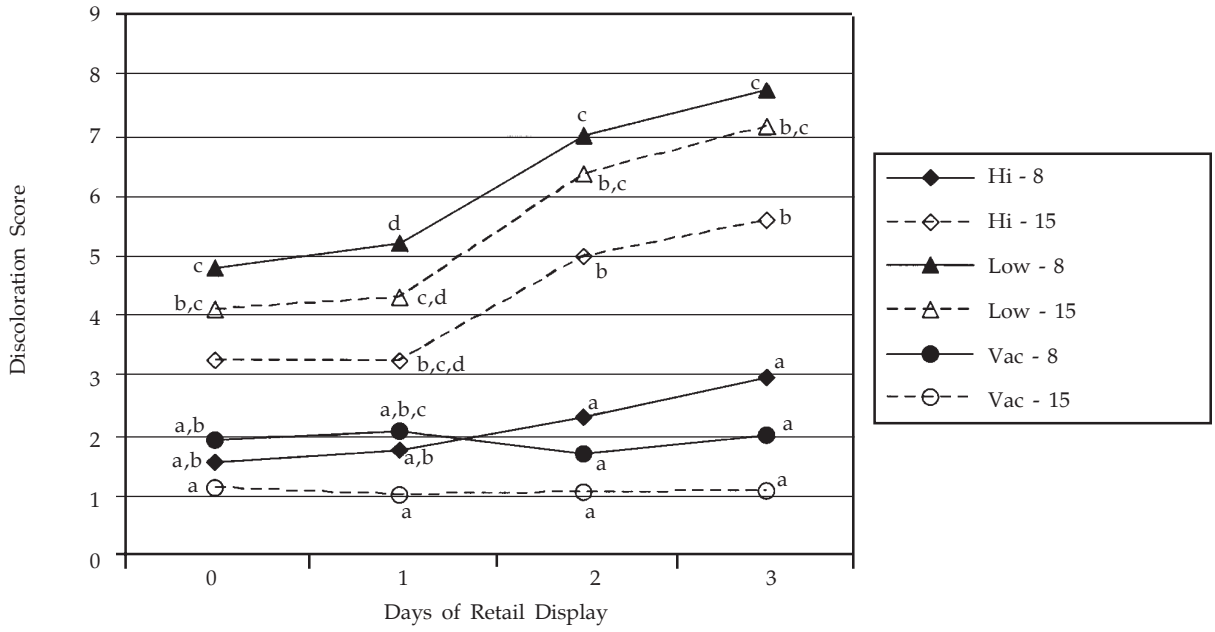


Figure 2. Discoloration scores for top sirloin steaks during retail display in different packaging systems following 8 or 15 days of dark storage.

[a,b,c]Means within a day with no common letters differ ($P < 0.05$).
Rated on a scale where 1 = 0% discoloration, 2 = 1 - 10%, 3 = 11 - 20%, and so on.

15 days is sufficient to promote discoloration. Minimizing the length of dark storage prior to retail display appears to avoid brown color development.

A nearly identical pattern of discoloration was observed with the sirloin steaks (Figure 2) in that low oxygen peelable packages, regardless of storage time, and high oxygen packages stored in the dark for 15 days had greater discoloration than the other treatments beginning at one day of retail display. The most notable difference among steak types was the greater extent of discoloration in the sirloin steaks. Differences in muscles

suggested this might occur and the sirloin steaks were misted with an antioxidant (rosemary extract) to minimize the effect. In this study, the antioxidant treatment was not successful in preventing the discoloration during retail display.

Sensory Properties

Tenderness was not affected by storage or retail display periods (Table 1). A difference in tenderness was perceived by the panelists for the different packaging systems. The steaks from the high-oxygen packages were perceived to be less tender than the steaks from the vacuum packages in the top sirloin steaks and less tender than the strip steaks packaged in vacuum packages and low-oxygen packages. The mean scores for all treatments were still considered to be at least "slightly tender". Recent data in the literature suggests the enzymes responsible for tenderization are diminished in activity under oxidizing conditions. Perhaps the greater oxidation created by high oxygen levels contributed to reduced enzyme activity.

Extended dark storage was detrimental to off-flavor intensity and flavor preference for both steak types (Table 1). The same was true for extended retail display. This pattern was consistent across all packaging systems for strip steaks. In top sirloin steaks, the high oxygen packages were judged least desirable in off-flavor intensity and flavor preference. A trained panel was used to evaluate the samples, which might explain the uncommonly low flavor preference scores. It is clear, however, that modified atmosphere packaging of enhanced beef steaks creates the potential for undesirable flavors to develop.

Similarly, a greater number of panelists detected oxidized flavors in both steak types following extended dark storage (Tables 2 and 3). The same was true for the longer retail display period in the strip steaks.

Table 1. The influence of main treatment effects on sensory traits of enhanced beef steaks.

Steak Type	Trait[a]	Dark Storage 8 Day	Dark Storage 15 Day	Packing Type High Oxygen	Packing Type Low Oxygen	Packing Type Vacuum Packaged	Display Time 1 Day	Display Time 3 Day
Strip	Juiciness	4.82[b]	4.47[c]	4.88	4.48	4.57	4.66	4.63
	Tenderness	5.69	5.63	5.23[c]	5.87[b]	5.80[b]	5.73	5.59
	Flavor intensity	4.99[b]	5.47[c]	5.10	5.36	5.23	5.09	5.37
	Off-flavor intensity	4.04[b]	4.98[c]	4.39	4.90	4.25	4.21[b]	4.81[c]
	Flavor preference	3.35[b]	2.67[c]	3.10	2.69	3.23	3.20[b]	2.82[c]
Top Sirloin	Juiciness	4.65	4.79	4.84	4.46	4.86	4.71	4.72
	Tenderness	4.37	4.77	4.17[c]	4.55[b,c]	4.99[b]	4.44	4.69
	Flavor intensity	4.98[b]	5.43[c]	5.55[c]	4.94[b]	5.12[b]	4.97[b]	5.43[c]
	Off-flavor intensity	4.01[b]	4.80[c]	5.29[c]	3.91[b]	4.00[b]	4.12[b]	4.70[c]
	Flavor preference	3.03[b]	2.62[c]	2.26[c]	3.07[b]	3.16[b]	3.01[b]	2.65[c]

[a]Evaluated on 8-point rating scales where 1 = extremely dry, extremely tough, extremely weak flavor, extremely weak off-flavor, and extremely undesirable and 8 = extremely juicy, extremely tender, extremely strong flavor, extremely strong off-flavor, and extremely desirable, respectively.
[b,c]Means in the same row within a main effect bearing different superscripts differ ($P < 0.05$).

Table 2. Top sirloin butt: percentage of panelists detecting off-flavors.

Off-flavor	Storage Days 8	Storage Days 15	Packaging Hi-ox	Packaging Low-ox	Packaging Vacuum	Retail Days 1	Retail Days 3
Oxidized	50.7[a]	60.2[b]	69.2	52.7	44.4	55.5	55.3
Sour/Acidic	27.6[a]	39.7[b]	27.1	37.0	36.8	31.4	35.9
Metallic	15.2[a]	20.8[b]	16.1	18.7	19.0	17.0	18.9
Salty	5.6	7.3	10.5	2.1	6.8	5.3	7.6

[a,b]$P < 0.05$.

Table 3. Strip loin: percentage of panelists detecting off-flavors.

Off-flavor	Storage Days 8	Storage Days 15	Packaging Hi-ox	Packaging Low-ox	Packaging Vacuum	Retail Days 1	Retail Days 3
Oxidized	50.2[a]	63.7[b]	59.5	61.1	50.3	51.3[a]	62.6[b]
Sour/Acidic	37.3	43.6	32.6	44.9	43.8	35.1[a]	45.8[b]
Metallic	11.8	9.4	9.0	9.3	13.7	9.8	11.5
Salty	6.0	6.0	3.4	4.7	10.0	7.5	4.6

[a,b]$P < 0.01$.

Implications

Conditions that promote oxidation, like extended dark storage or retail display, result in the development of off-flavors in enhanced beef. Accordingly, retailers who seek to merchandise enhanced beef would be advised to minimize time in the marketing chain for the product.

[1]Chris R. Calkins, professor, Animal Science, Lincoln; Mike L. Buford, former graduate student.

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

Benchmarking the Differences Between Cow and Beef Muscles

Laura B. Mink
Chris R. Calkins
D. Dwain Johnson
Alex M. Stelzleni
Bucky L. Gwartney[1,2]

Summary

Some muscles from the different populations of cows evaluated have similar chemical and physical properties to muscles from A-maturity, USDA Select grade cattle. Perhaps those muscles from cows could be utilized in a manner that would increase their value. Fifteen carcasses were selected from five populations (fed beef cows, non-fed beef cows, fed dairy cows, non-fed dairy cows, and Select grade beef) and nine muscles per carcass were characterized. Most muscles from cows were darker in color, had higher pH values, and had greater heme iron content than muscles from younger cattle, which may be undesirable to consumers. Supplemental technology may be needed to upgrade muscles from cow carcasses.

Introduction

In recent years, utilization of under-valued muscles has been influenced by beef muscle profiling and cow muscle profiling projects. These studies, however, did not make direct comparisons between populations of young and old cattle. Such information would help the industry determine if there are muscles from different populations of cows that are comparable to A-maturity, Select grade beef and could be used in a way that would upgrade their value.

This study was designed to analyze chemical and physical properties of nine different muscles (gluteus medius, infraspinatus, longissimus, psoas major, rectus femoris, tensor facia latae, teres major, triceps brachii-lateral head, and triceps brachii-long head) from five populations of cattle (fed beef cows, non-fed beef, fed dairy cows, non-fed dairy cows, and A-maturity, USDA Select grade beef). The objective of this study was to document similarities and differences in the physical and chemical characteristics of the nine muscles from the five populations of cattle studied.

Procedure

Sample collection took place at Packerland Packing Co. in Green Bay, Wisconsin. Based on visual evaluation, live cattle were separated into four populations of cows (fed beef, non-fed beef, fed dairy, non-fed dairy) and A-maturity, USDA Select grade beef by experienced plant personnel. Seventy-five carcasses, fifteen from each of the five populations of cattle, were selected. Selected carcasses had at least 0.1 inch of 12th rib fat and medium or greater muscling. Hot carcass weight, ribeye area, lean and bone maturity, kidney/pelvic/heart fat percent, marbling score, fat color (1=white, 2=creamy white, 3=slightly yellow, 4=moderately yellow, 5=yellow), and lean color (1=extremely dark red, 2=dark red, 3=moderately dark red, 4=slightly dark cherry-red, 5=slightly bright cherry-red, 6=moderately bright cherry-red, 7=bright cherry-red, 8=extremely bright cherry-red) were recorded. Nine muscles were removed from each carcass for further analysis. Objective color [L* (measure of lightness), a* (measure of red), and b* (measure of yellow)] was measured with Illuminant A using a Hunter Lab Mini Scan XE Plus colorimeter with a 1-inch port. Water holding capacity was determined as expressible moisture and was measured as the percentage of moisture loss due to centrifugation. A pH meter with a spear tip combination electrode was used to determine muscle pH. Total heme iron is a measurement of pigment (myoglobin and hemoglobin) in a muscle sample. Pigments were extracted using acetone and hydrochloric acid. The total heme iron content was quantified using a spectrophotometer and reported in parts per million. Muscle total collagen content was measured by assaying for hydroxyproline content using a spectrophotometer. Muscle is composed of moisture, protein, fat, and ash. Moisture and ash were measured using a LECO thermogravimetric analyzer. Fat was measured by Soxhlet ether extraction and protein was determined by difference. Data were analyzed using Proc Mixed procedures of Statistical Analysis System (SAS). Means were separated using the Least Square Means procedure of SAS.

Results

Although muscle composition, total collagen, water holding capacity, and objective color (a* and b*) were measured, these results will

Table 1. Least square means of carcass characteristics from five groups[a] of beef .

Characteristic	Groups				
	B-NF	B-F	D-NF	D-F	SEL
Hot carcass weight, lb	676^{i}	841^{h}	813^{h}	945^{g}	812^{h}
Lean maturity	D^{40i}	C^{74h}	D^{23gh}	D^{09gh}	A^{42i}
Bone maturity	E^{07g}	D^{37h}	D^{33h}	D^{72gh}	A^{45i}
Overall maturity[b]	D^{74g}	D^{05h}	D^{28gh}	D^{41gh}	A^{44i}
Fat color[c]	4.5^{g}	3.3^{i}	4.0^{h}	3.5^{hi}	2.1^{j}
Lean color[d]	3.5^{i}	4.7^{h}	3.6^{i}	3.8^{i}	6.3^{g}
Fat thickness, in	0.3^{i}	0.6^{g}	0.2^{i}	0.3^{i}	0.4^{h}
Muscling[e]	5.2^{i}	6.6^{h}	4.2^{j}	4.7^{ij}	8.1^{g}
Marbling[f]	Sl^{85i}	Mt^{09h}	Sm^{81h}	Md^{08g}	Sl^{56i}
Ribeye area, in^2	11.1^{j}	12.8^{h}	11.3^{ij}	12.3^{hi}	14.1^{g}
% kidney, pelvic, heart fat	2.6^{i}	3.6^{hi}	4.4^{h}	5.5^{g}	3.1^{i}
Yield grade	2.7^{i}	4.0^{g}	3.4^{h}	4.1^{g}	2.7^{i}

[a]Groups: B-NF = Non-fed beef cows, B-F = Fed beef cows, D-NF = Non-fed dairy cows, D-F = Fed dairy cows, SEL = A-maturity, Select grade beef
[b](Lean maturity + Bone maturity)/2
[c]1 = white, 2 = creamy white, 3 = slightly yellow, 4 = moderately yellow, 5 = yellow
[d]1 = extremely dark red, 2 = dark red, 3 = moderately dark red, 4 = slightly dark cherry-red, 5 = slightly bright cherry-red, 6 = moderately bright cherry-red, 7 = bright cherry-red, 8 = extremely bright cherry-red
[e]1 = light^{-}, 2 = light^{0}, 3 = light^{+}, 4 = medium^{-}, 5 = medium^{0}, 6 = medium^{+}, 7 = heavy^{-}, 8 = heavy^{0}, 9 = heavy^{+}
[f]Sl = slight, Mt = modest, Sm = small, Md = moderate,
[g,h,i,j]Means in the same row having different superscripts are significant at $P < 0.05$ level.

Table 2. Least square means of objective color (L*) for nine muscles[a] from five groups[b] of beef.

Muscles	Groups				
	B-NF	B-F	D-NF	D-F	SEL
GLM	34.52^{d}	34.35^{d}	34.66^{d}	34.38^{d}	38.13^{c}
INF	34.94^{e}	37.06^{cd}	35.76^{de}	36.19^{de}	38.72^{c}
LOD	35.34^{d}	35.73^{d}	34.96^{d}	35.59^{d}	38.86^{c}
LTB	33.21^{e}	35.37^{d}	32.98^{e}	33.74^{de}	37.80^{c}
MTB	34.55^{d}	35.67^{d}	35.26^{d}	34.33^{d}	38.77^{c}
PSO	35.41^{d}	36.47^{d}	35.17^{d}	34.20^{d}	38.88^{c}
REF	33.54^{e}	36.36^{d}	35.24^{de}	34.98^{de}	43.04^{c}
TER	34.77^{e}	37.46^{cd}	35.21^{de}	34.99^{de}	39.31^{c}
TFL	34.94^{e}	38.29^{d}	35.28^{e}	37.34^{de}	41.80^{c}

[a]Muscles: GLM = gluteus medius, INF = infraspinatus, LOD = longissimus, LTB = triceps brachii long-head, MTB = triceps brachii lateral-head, PSO = psoas major, REF = rectus femoris, TER = teres major, TFL = tensor facia latae
[b]Groups: B-NF = Non-fed beef cows, B-F = Fed beef cows, D-NF = Non-fed dairy cows, D-F = Fed dairy cows, SEL = A-maturity, Select grade beef
[c,d,e]Means in the same row having different superscripts are significant at $P < 0.05$ level.

not be discussed in this report because there were very few differences.

Carcass Characteristics

Hot carcass weights (Table 1) from the population of Select were lighter ($P < 0.05$) than carcass weights of fed dairy cows and heavier than carcass weights of non-fed beef cows, but similar to fed beef and non-fed dairy cows. As expected, the overall maturity of Select was younger than the other populations. A-maturity, USDA Select grade cattle had whiter fat color and higher lean color scores than the other populations. These cattle may have been fed a high concentrate diet for a longer time, resulting in whiter fat color. Younger animals display lighter and brighter lean color. With the exception of the fed beef cow population, Select had less external fat measured at the 12th rib and Select had less kidney, pelvic, and heart fat than fed and non-fed dairy. Carcasses from fed beef, non-fed dairy, and fed dairy cows had more marbling than Select. However, Select carcasses were heavier muscled (1 = light and 8 = heavy) and had larger ribeye areas than the other populations. Muscling scores can be influenced by the nutritional status of the animal. If cattle are on a low plane of nutrition, they may be forced to metabolize muscle tissue to maintain energy, thereby reducing muscle scores. Yield grades were lower ($P < 0.05$) for Select than fed beef, non-fed dairy and fed dairy cows.

Although a feeding trial was not conducted as part of this experiment, it is obvious that different populations of cows exist. Carcass data indicate beef cows were more like A-maturity, USDA Select grade cattle than dairy cows for many carcass characteristics. In many cases, there were apparent differences between the populations of cows selected for additional feeding and those not selected for additional feeding. For example, non-fed beef cattle were older, leaner, and lighter in weight than fed beef cows. Perhaps those cows were not selected for additional feeding out of concern they would not benefit enough to make it worth the additional costs.

Objective Color

Seven of nine muscles from Select cattle were significantly ($P < 0.05$) lighter (higher L*) than the same muscles from each of the cow populations (Table 2). The infraspinatus and teres major from fed beef cows did not differ from Select. In general, as animals advance in age the muscle tissue becomes a darker red.

(Continued on next page)

Table 3. Least square means of pH for nine muscles[a] from five groups[b] of beef.

	Groups				
Muscles	B-NF	B-F	D-NF	D-F	SEL
GLM	5.52^{de}	5.47^{e}	5.58^{cd}	5.62^{c}	5.49^{de}
INF	6.01^{c}	5.90^{cd}	5.95^{cd}	5.96^{c}	5.84^{d}
LOD	5.57^{c}	5.52^{c}	5.57^{c}	5.56^{c}	5.53^{c}
LTB	5.63^{de}	5.60^{e}	5.74^{cd}	5.76^{c}	5.54^{e}
MTB	5.64^{d}	5.61^{d}	5.79^{c}	5.77^{c}	5.56^{d}
PSO	5.62^{cd}	5.59^{cd}	5.73^{c}	5.72^{c}	5.56^{d}
REF	5.79^{c}	5.72^{cd}	5.83^{c}	5.83^{c}	5.57^{d}
TER	5.73^{cd}	5.73^{cd}	5.78^{cd}	5.82^{c}	5.63^{d}
TFL	5.67^{cd}	5.59^{de}	5.68^{c}	5.73^{c}	5.53^{e}

[a,b,c,d,e] See footnotes in Table 2.

Table 4. Least square means of heme iron (ppm) for nine muscles[a] from five groups[b] of beef.

	Groups				
Muscles	B-NF	B-F	D-NF	D-F	SEL
GLM	28.92^{de}	32.44^{cd}	36.66^{c}	33.76^{cd}	25.33^{e}
INF	32.32^{c}	33.31^{c}	32.04^{cd}	34.61^{c}	26.71^{d}
LOD	29.43^{c}	30.05^{c}	34.64^{c}	30.35^{c}	21.19^{d}
LTB	29.22^{de}	33.86^{cd}	34.17^{cd}	37.29^{c}	25.94^{e}
MTB	33.94^{c}	28.00^{de}	32.87^{cd}	36.36^{c}	24.67^{e}
PSO	27.69^{cd}	31.97^{c}	31.00^{c}	32.17^{c}	23.52^{d}
REF	26.77^{cd}	31.05^{c}	32.38^{c}	33.08^{c}	20.85^{d}
TER	26.89^{cd}	25.29^{de}	31.09^{c}	29.38^{cd}	20.85^{cd}
TFL	27.46^{cd}	24.71^{d}	29.74^{c}	28.84^{cd}	18.18^{e}

[a,b,c,d,e]See footnotes in Table 2.

Muscle pH

Muscle pH differed ($P < 0.05$) from Select for eight of nine muscles (Table 3). The most noticeable differences were from the populations of fed and non-fed dairy cows. For thirteen of eighteen observations, pH values of muscles from the dairy cow populations were higher than the Select. The infraspinatus, rectus femoris and tensor facia latae from non-fed beef cows also had significantly ($P < 0.05$) higher pH values than Select. Muscle pH is dependent on the amount of glycogen present in the muscles at the time of slaughter. Muscle glycogen content may be influenced by the animal's diet and stress prior to slaughter. If glycogen stores are depleted prior to slaughter, pH decline is slowed and a higher than normal ultimate pH will occur. The role of pH is very broad and affects many characteristics of meat. Muscles with a high ultimate pH will be very dark in color and very dry in appearance on the exposed surface because water is tightly bound to the proteins.

Heme Iron Concentration

All muscles from Select had significantly ($P < 0.05$) lower heme iron concentrations (Table 4) than the cow muscles tested. Studies have shown that heme iron content of muscles from A-maturity cattle are lower than the same muscles from market cows. Others have reported an increase in myoglobin content as animals increased in maturity and the pigment content of steers and cows were double and triple the concentrations of pigment found in veal calves, respectively.

Seven of thirty-six observations from the four cow populations had heme iron concentrations that did not differ from Select. Most of these observations were of beef cows, indicating muscle color from beef cows more closely matches muscle color from Select than do muscles from dairy cows.

Most muscles from cows were darker in color, had higher pH values, and had greater heme iron content than muscle from younger cattle, which may be undesirable to some consumers. Supplemental technology may be needed to upgrade muscles from cow carcasses.

---

[1]Laura B. Mink, graduate student; Chris R. Calkins, professor, Animal Science, Lincoln; D. Dwain Johnson, professor, Animal Science, University of Florida, Gainesville; Alex M. Stelzleni, graduate student; Bucky L. Gwartney, National Cattlemen's Beef Association, Denver, CO.

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

Pre-rigor Water Injection and Post-rigor Sodium Citrate Treatment on Beef Tenderness

Bethany M. Sitz
Pennapa Matayompong
Christian D. Perversi
Chris R. Calkins[1,2]

Summary

Thoracic limbs from 20 beef steers were used as post-rigor controls, pre-rigor controls (removed pre-rigor), or treated with combinations of sodium citrate and/or water to evaluate the effect of citrate on meat tenderness. Shear force values on steaks from the infraspinatus, supraspinatus and triceps brachii muscles revealed citrate-treated muscles were more tender than water and post-rigor control treatments. It appears sodium citrate can tenderize meat independent of water injection.

Introduction

Tenderness is the most important factor for consumers in determining acceptability of meat, especially beef. Consumers are willing to pay a premium for meat that is more tender. Brooks et al. (2000) concluded from the 1998 National Beef Tenderness Survey that muscle from the round and chuck are in particular need of improvement in tenderness. Treatments to improve tenderness of chuck and round muscles would add value to the whole carcass.

Previous research in our laboratory indicated beef chucks injected pre-rigor with water were less tender than control samples while those injected pre-rigor with 200 and 400 mM sodium citrate, a glycolytic inhibitor, improved tenderness over the controls. Some muscles injected with water had longer sarcomeres (less contraction). Since calpains are the calcium-dependent protease responsible for postmortem meat tenderization, we hypothesized that pre-rigor water injection diluted intramuscular calcium to the point that contraction and calpain activities were minimized, and that sodium citrate would enhance tenderness independent of this effect. The current study was conducted to determine the effect of pre-rigor water injection and post-rigor sodium citrate treatment on chuck muscle tenderness.

Procedure

Animals

Left and right thoracic limbs of 20 steers were randomly assigned after evisceration to one of five treatments: 1) left on the carcass to enter rigor (post-rigor control), 2) removed pre-rigor and otherwise untreated (pre-rigor control), 3) removed pre-rigor and left untreated for 24 hours, when they were injected to 15% of muscle weight with a solution of 4% sodium citrate (0/citrate), 4) removed pre-rigor, injected to 10% of muscle weight with tap water, then injected post-rigor with 5% more tap water (water/water) and 5) removed pre-rigor and injected to 10% of muscle weight with tepid tap water, then injected post-rigor to 5% of muscle weight with a solution of 12% sodium citrate (water/citrate). Injection of water and solution was done by hand throughout the infraspinatus, supraspinatus and triceps brachii using a five-needle ham injection unit. Pre-rigor and post-rigor injections were done at 2 hours and 24 hours postmortem, respectively. After 48 hours of chilling at 4ºF, the infraspinatus, supraspinatus and triceps brachii were excised from the limbs and sampled for sarcomere length (muscle contraction) determination. At 5 and 12 days post mortem, a one-inch thick steak from each muscle was cut and frozen for Warner-Bratzler shear force determination.

Sarcomere Length

Sarcomere length was measured at 48 hours postmortem on fresh muscle samples (total of 20 fibers per observation) using the neon laser diffraction method.

Warner-Bratzler Shear Force

A one-inch thick steak from each muscle was broiled on a tabletop broiler to a final internal temperature of 158ºF. Temperature was monitored at the geometric center of each steak using a thermocouple thermometer. Cooked steaks were chilled 2 hours at 4ºF, and then eight cores (1/2-inch in diameter) were removed parallel to the muscle fiber orientation. Cores were sheared once each on an Instron

(Continued on next page)

Table 1. Effect of treatments on shear force values (lbs) of infraspinatus, supraspinatus and triceps brachii muscles at 5 and 12 days post mortem.

		Treatments					
Muscle	Aging	Post-rigor Control	Pre-rigor Control	0 / Citrate	Water / Water	Water / Citrate	SEM
Infraspinatus	5 d	6.65^{c}	5.55^{a,b}	5.70^{a,b,c}	6.56^{b,c}	5.48^{a}	0.33
Infraspinatus	12 d	6.64^{b}	5.46^{a}	5.07^{a}	6.74^{b}	5.24^{a}	0.37
Supraspinatus	5 d	11.52^{b}	10.11^{a}	9.71^{a}	11.52^{b}	9.16^{a}	0.73
Supraspinatus	12 d	11.28^{b}	9.45^{a,b}	8.57^{a}	11.06^{b}	8.02^{a}	0.73
Triceps brachii	5 d	8.63^{c}	8.06^{b,c}	6.67^{a}	8.92^{c}	6.92^{a,b}	0.40
Triceps brachii	12 d	8.14^{b}	8.15^{b}	6.21^{a}	8.57^{b}	5.77^{a}	0.34

^{a,b,c} Within a row, means without a common superscript letter differ ($P < 0.05$)

Table 2. Effect of treatments on sarcomere length (µm) of infraspinatus, supraspinatus and triceps brachii muscles at 48 hours post mortem.

	Treatments					
Muscle	Post-rigor Control	Pre-rigor Control	0 / Citrate	Water / Water	Water / Citrate	SEM
Infraspinatus	1.63	1.92	1.68	2.11	2.01	0.14
Supraspinatus	1.62	1.93	1.66	1.73	1.48	0.12
Triceps brachii	2.01	1.95	1.84	2.19	2.33	0.15

Universal Testing Machine with a Warner-Bratzler attachment and a 250 mm/min crosshead speed.

Statistical Analysis

Data were analyzed by analysis of variance using the MIXED procedures of SAS for a completely randomized design. The model included the main effects of carcass side, animal, and treatment. When the treatment main effect was significant ($P < 0.05$), least squares means were separated using the PDIFF procedure.

Results

For each muscle at each aging time (Table 1), except infraspinatus 0/citrate versus water/water at five days postmortem, citrate-treated muscles (0/citrate and water/citrate, which were not different from each other) were significantly more tender than the water/water and the post-rigor control treatments (which were not different in tenderness from each other). Post-rigor injection with sodium citrate may increase pH and ionic strength of muscles to a level where increased solubilization of myofibrillar proteins occurs. This would be similar to the effect of potassium chloride. The mechanism by which sodium citrate increased meat tenderness may not involve calpain enzymes because sodium citrate is a calcium chelator and calcium is required for calpain activty. Additionally, the concentration of sodium citrate used in this study may inactivate calpains since increased ionic strength decreases calpain activity. The results of this study suggest that citrate can overcome some limits to tenderization caused by pre-rigor injection of water.

There were no differences in sarcomere length ($P > 0.05$) among treatments within muscles (Table 2). Pre-rigor removal of the thoracic limb increased tenderness in the infraspinatus and supraspinatus when compared to the post-rigor control ($P < 0.05$), which likely occurred as a result of altered muscle position. Thus, sodium citrate can tenderize meat independent of water injection. Further research is needed to understand the role of sodium citrate in meat tenderization and its application to low-value muscles.

[1]Bethany M. Sitz, former graduate student; Pennapa Matayompong, graduate student; Christian D. Perversi, former graduate student; Chris R. Calkins, professor, Animal Science, Lincoln.

Evaluation and Composition of Beef *Semitendinosus* Utilizing a Novel Cooking System

Betsy L. Booren
Joe L. Baumert
Roger W. Mandigo[1]

Summary

The effects of cooking dwell time on chemical and physical properties of cooked meat and cook-out purge were examined. Cooked meat yields were not affected among cooking dwell times for samples with 12% added enhancement solution. Increasing cooking dwell time resulted in increased cooked meat tenderness. No differences were demonstrated among cook-out purge samples for moisture, ash, fat, and total collagen values regardless of cooking dwell time, pump level, and endpoint temperature of the sample. This may be beneficial to meat processors in creating an ready-to-eat product that utilizes cook-out purge.

Introduction

Cook-out purge is an everyday occurrence for a meat processor, yet little is understood about the production of cook-out purge and how to utilize it. The term "cook-out purge" describes an aqueous solution, which includes water and water-soluble proteins, found after a meat product has been thermally processed in a cook-in bag. The ready-to-eat (RTE) market is an ideal opportunity for meat processors to find a method of utilizing cook-out purge. Many factors must be considered during the development of a meat RTE product such as meat tenderness, product flavor profile, ability to be re-heated or fully cooked within consumers' homes, and how other non-meat ingredients interact within the meat system. Since raw muscle, cooked meat, and cook-out purge of the meat system are related, the chemical composition of each must be examined to better understand these relationships. The focus of this research was to study how cooking dwell time affected the chemical and physical properties of beef *semitendinosus* during thermal processing. The objectives were to determine if length of dwell time during thermal processing affected chemical properties of cooked meat and cook-out purge, and to determine if altering the length of cooking dwell time affected cooked meat tenderness.

Procedure

Beef *semitendinosus* (ST) muscles (n=48) were delivered to the Loeffel Meat Laboratory at the University of Nebraska-Lincoln. The ST muscles were trimmed of external fat and connective tissue. Each ST muscle was randomly assigned a cooking dwell time (0, 60, 90, or 120 minutes) within a level of added enhancement solution (0% or 12%) and internal endpoint temperature (140°F or 150°F) combination. Cooking dwell time was defined as the time (in minutes) each sample was held at a designated endpoint temperature. Each sample was injected with either 0% or 12% of an enhancement solution containing 2% salt and 0.3% sodium phosphate. Each roast was then sealed in a plastic bag and tumbled for one hour in a vacuum tumbler. To ensure separation and isolation of the muscle from the cook-out purge during thermal processing, cook-in bags were modified to contain a one quart plastic bottle at the bottom of the bag to collect the cook-out purge. A stainless steel ham hook was inserted in the distal end of the muscle. A long string loop was secured to the ham hook. The meat, hook, and loop were placed into a modified cook-in bag. Each cook-in bag was sealed by clipping twice with a pneumatic clipper and hung on a cooking cart by the hook. The cook-in bags were placed in an Alkar hot water cooker that continuously showered the products with hot water. The water temperature was raised to 100°F initially and allowed to shower samples for 30 minutes. After each 30-minute increment, the water temperature was increased 43°F until water temperature was 160°F. The water temperature was held at 160°F until the first sample reached its designated internal endpoint temperature. The water temperature was then decreased to 140°F or 150°F, depending on designated endpoint temperature to prevent overcooking. As each sample reached its designated endpoint temperature, the cooking dwell time was initiated and monitored. Samples reaching the designated endpoint temperature and cooking dwell time were removed from the cooker and the modified cook-in bags containing the roast were placed into a stainless steel sausage truck. The bags were packed in ice and allowed to cool for a minimum of 12 hours. Following cooling, the roasts were prepared for tenderness analysis utilizing Warner-Bratzler shear force. Chemical analyses to determine moisture, ash, fat, protein, and total collagen content were conducted on the roasts and cook-out purge. Total collagen content was determined by analyzing the hydroxyproline content (mg of collagen/g). Cooking yield was

(Continued on next page)

Table 1. Cooking yields (%) for cooked beef *semitendinosus* with 0% or 12% added enhancement solution and cooked to an internal endpoint temperature of 140°F and 150°F

Endpoint	0% Enhancement Solution Dwell Time (minutes)				12% Enhancement Solution Dwell Time (minutes)			
Temperature	0	60	90	120	0	60	90	120
140°F	83.54[a]	68.45[b]	76.49[a]	76.16[a]	84.75	84.30	82.94	82.49
150°F	77.11[a]	73.79[b]	74.65[ab]	70.08[c]	81.06	78.01	77.71	78.32

[abc]Within each pump level, means within a row having different superscripts are significantly different (P <0.05).

Table 2. Warner-Bratzler shear force values (lb) for beef *semitendinosus* with 0% or 12% added enhancement solution and cooked to internal endpoint temperature of 140°F or 150°F.

Endpoint	0% Enhancement Solution Dwell Time (minutes)				12% Enhancement Solution Dwell Time (minutes)			
Temperature	0	60	90	120	0	60	90	120
140°F	7.21[ab]	8.14[a]	6.04[b]	6.70[b]	8.86[a]	6.24[b]	5.71[b]	6.68[b]
150°F	6.61	6.61	6.55	6.39	7.29	6.83	6.70	6.42

[ab]Within each pump level, means within a row having different superscripts are significantly different (P <0.05).

Table 3. Chemical composition of cooked beef *semitendinosus* with 0% or 12% added enhancement solution and cooked to an internal endpoint temperature of 140°F or 150°F.

Trait	0% Enhancement Solution Dwell Time (minutes)				12% Enhancement Solution Dwell Time (minutes)			
	0	60	90	120	0	60	90	120
Moisture (%)								
140°F	69.44[a]	68.67[a]	67.23[b]	67.39[b]	72.23	71.53	71.75	70.81
150°F	68.63[a]	67.44[b]	67.41[b]	65.82[c]	71.03	70.94	69.93	71.02
Ash (%)								
140°F	1.17	1.11	1.07	1.31	2.64	2.52	2.45	2.34
150°F	1.30[b]	1.36[a]	1.44[a]	1.50[a]	2.66[a]	2.78[a]	2.54[b]	2.63[a]
Fat (%)								
140°F	3.14	3.28	2.33	3.77	3.36[a]	1.96[b]	2.67[ab]	2.22[b]
150°F	2.33[ab]	3.29[a]	1.81[b]	1.79[b]	3.00	4.01	2.90	2.92
Protein (%)								
140°F	27.62[b]	29.30[a]	29.90[a]	29.32[a]	24.13[b]	24.49[ab]	24.07[b]	25.72[a]
150°F	29.37[b]	29.84[b]	29.83[b]	31.86[a]	24.35[b]	24.78[b]	26.23[a]	25.05[ab]
Total Collagen (mg/g)								
140°F	6.50	7.09	5.11	7.34	4.65	5.74	5.62	4.55
150°F	6.75	9.06	5.62	6.97	5.78	5.78	5.04	6.95

[abc]Within each pump level, means within a row having different superscripts are significantly different (P <0.05).

measured and calculated as the difference in roast weight before and after cooking and was expressed as the percentage weight remaining.

Results

Cooked meat yields decreased for samples with an internal endpoint temperature of 150°F and 0% enhancement pump level (P <0.05) as cooking dwell times increased (Table 1). There were no differences in cooked meat yields among samples treated with the enhancement solution. The similar yields indicate that adding an enhancement solution maintains the cooking yield of meat samples over a two-hour dwell time.

Product tenderness was evaluated utilizing Warner-Bratzler shear force. Roasts cooked to an internal endpoint temperature of 150°F, regardless of added enhancement solution, did not differ among cooking dwell times (Table 2). Among enhanced samples with an endpoint temperature of 140°F, extending the dwell time to 60 minutes or more resulted in lower WBS values than samples with 0 minutes of dwell time. A similar trend was noted for 0% added enhancement at 140°F, with dwell times beyond 60 minutes.

Moisture values for cooked meat samples with 0% added enhancement solution decreased as cooking dwell time increased (Table 3). For samples with an endpoint temperature of 140°F, a significant decrease (P <0.05) in moisture levels was seen between samples with cooking dwell times 60 minutes and lower compared to those 90 minutes or greater. Moisture levels for samples with 12% added enhancement solution were not affected by cooking dwell time (P >0.05) regardless of internal endpoint temperature (Table 3). As seen in Table 1, cooked meat samples with 12% added enhancement solution had higher overall cooking yields than the 0% added enhancement solution samples, which indicates less moisture loss. Altering the ionic strength of the meat protein by adding salt and sodium phosphate likely allowed better water binding.

Ash levels for samples cooked to an endpoint temperature of 140°F, regardless of level of added enhancement solution, were unaffected (P >0.05) by cooking dwell time (Table 3). Samples with 0% added enhancement solution held for 0 minutes at 150°F had the lowest (P <0.05) ash level. As expected, ash levels were approximately twice as great for samples with 12% enhancement solution compared to those with 0%. The enhancement solution contained sodium phosphate and salt, which would increase ash levels. The ash

level may appear to be increased or concentrated, when in actuality the loss of moisture during thermal processing may have changed the percentage of ash within each cooked meat sample.

The effect of moisture loss on percentage of other chemical components of cooked muscle also may be true for cooked meat fat levels. Samples containing 12% added enhancement solution and cooked to 140ºF had a range of 1.4% fat among cooking dwell times with samples held for 60 minutes having the lowest fat value (Table 3). Levels of fat did not consistently decrease as cooking dwell time increased. It was expected fat levels would decrease as cooking dwell time increased, but the varying levels of fat among dwell times can not be explained.

Protein composition of cooked meat with 0% enhancement solution increased as dwell time increased (Table 3). Samples containing 12% enhancement solution did not have a consistent increase in protein content as dwell time increased. The increased protein level among cooking dwell time may have been affected, similar to the change in ash and fat values, by the loss of moisture within the cooked meat sample.

The levels of total collagen were not affected ($P > 0.05$) by cooking dwell time for any treatment combination (Table 3). Reports in the literature indicate that collagen solubility may occur with increased temperature and cooking dwell time, however, this was not seen in our study. Previous research has suggested that other factors besides temperature contribute to meat tenderness. Endogenous proteolytic and collagenolytic enzymes also might affect collagen solubility.

The chemical composition of cook-out purge is shown in Table 4. No differences ($P > 0.05$) were demonstrated for moisture, ash, fat, and total collagen values regardless of cooking dwell time and treatment combination of added enhancement solution and endpoint temperature of the sample. A difference ($P < 0.05$) of cook-out purge protein level was seen among purge samples from roasts containing 0% added enhancement solution, cooked to an endpoint temperature of 140ºF, and a dwell time of 60 minutes. The significant decrease in protein levels cannot be explained within this study. Purge samples from roasts with an endpoint temperature of 150ºF, 12% added enhancement solution, and held for 0 minutes had the lowest cook-out purge protein values among cooking dwell times within that treatment combination. The overall range of absolute protein levels was lower among purge samples from roasts containing 12% added enhancement level compared to 0%. Adding salt and sodium phosphate to cooked meat may have affected the level of protein expressed during thermal processing. Altering ionic strength within the meat and the combination of cooking dwell time and endpoint temperature may affect levels of cook-out protein levels within purge.

Table 4. Chemical composition for cook-out purge of beef *semitendinosus* with 0% and 12% added enhancement solution and cooked to an internal endpoint temperature of 140ºF and 150ºF.

	0% Enhancement Solution Dwell Time (minutes)				12% Enhancement Solution Dwell Time (minutes)			
Trait	0	60	90	120	0	60	90	120
Moisture (%)								
140ºF	95.62	96.69	95.86	95.48	95.46	98.08	96.78	95.51
150ºF	95.12	95.58	96.26	95.36	96.43	94.83	96.83	96.82
Ash (%)								
140ºF	1.09	0.97	1.31	1.34	2.47	2.25	2.51	2.54
150ºF	1.30	1.23	1.30	1.17	2.27	2.51	2.03	2.11
Fat (%)								
140ºF	0.22	1.53	0.05	0.06	1.31	0.00	0.47	0.75
150ºF	0.30	0.06	0.14	0.00	0.80	1.01	0.15	0.00
Protein (%)								
140ºF	4.46[a]	2.16[b]	4.72[a]	5.02[a]	2.26	2.83	3.39	3.47
150ºF	5.04	4.52	4.56	4.19	2.02[b]	2.35[a]	2.95[a]	2.70[a]
Total Collagen (mg/g)								
140ºF	0.71	0.04	0.72	2.31	0.53	2.12	1.94	1.78
150ºF	0.56	1.40	1.20	0.49	0.94	0.83	1.31	1.47

[ab]Within each pump level, means within a row having different superscripts are significantly different ($P < 0.05$).

As the moisture levels of cooked meat samples decreased among cooking dwell times, the levels of other chemical components were affected. Although the differences in total collagen were not significant in this study, collagen content may be important to consumer meat quality and deserve further evaluation. No differences were demonstrated among cook-out purge samples for moisture, ash, fat, and total collagen values regardless of cooking dwell time, pump level, and endpoint temperature of the sample. This may be beneficial to meat processors in creating an RTE product that utilizes cook-out purge as the only component affected by cooking dwell time is the level of protein. The amount of protein found in cook-out purge may be affected by altering the components and levels within the enhancement solution.

[1]Betsy L. Booren and Joe L. Baumert, former graduate students; Roger W. Mandigo, professor, Animal Science, Lincoln.

The Effects of Phosphate Type and Potassium Lactate Level on Quality Characteristics of Enhanced Beef Steaks

Joe L. Baumert
Roger W. Mandigo[1]

Summary

Beef semitendinosus steaks were used to evaluate the effects of sodium phosphate and potassium lactate on quality characteristics of enhanced beef steaks. Sodium phosphate decreased the amount of package purge and cook loss and gave the beef product a darker, redder appearance. Potassium lactate gave the product a darker, redder appearance, while increasing levels of lactate decreased total psychrotrophic (bacterial) plate counts, and decreased package purge and cook loss. Sodium phosphate and potassium lactate aid in extending shelf-life and improving quality attributes of enhanced beef steaks.

Introduction

Changes in consumer buying trends and lifestyles have required the meat industry to look for new technologies that allow meat products to be prepared quickly and easily by the consumer while improving overall product quality and consistency. The use of sodium phosphate in meat has been shown to increase moisture retention and reduce oxidative rancidity. Sodium lactate has long been used as a shelf-life extender in meat products. Research has shown that increasing sodium lactate levels decreases bacterial counts in cooked beef roasts. A recent study also indicated that sodium lactate in frankfurter formulations controlled growth of *Listeria monocytogenes*. Although extensive research has been conducted on the use of sodium lactate and sodium phosphate in meat products, limited research has been conducted to evaluate the use of potassium lactate in conjunction with particular sodium phosphate types. The desire by some consumers to lower sodium intake has led to increased use of potassium lactate in some meat products to accommodate the low sodium diet without losing the antimicrobial benefits of lactate. The objective of our study was to evaluate the effects of potassium lactate levels and sodium phosphate types on quality characteristics of enhanced beef steaks.

Procedure

Thirty-six U.S. Select beef *semitendinosus* (ST) muscles were purchased from Swift and Company, Grand Island, Nebraska, and delivered to the Loeffel Meat Laboratory at the University of Nebraska. The ST muscles were trimmed of external fat and connective tissue. Three sodium phosphate types [no phosphate, Brifisol® 85 Instant (BK85), and sodium tripolyphosphate (STP)] were used to evaluate sodium phosphate functionality. Brifisol® 85 Instant is a blended phosphate containing hexameta-, pyro-, and poly-phosphates. Blended phosphates are formulated to balance the phosphate pH for increased functionality in specific applications, however, they are slightly more expensive than STP. Three potassium lactate (KL) levels were evaluated in this study (0%, 2%, and 4% lactate). Four replications were used in this project. Following trimming and denuding, each ST muscle was injected to 112% of the green weight of the roast with enhancement solutions containing 0.35% sodium chloride, 0% or 0.35% sodium phosphate (no phosphate, BK 85, or STP), and 0%, 2%, or 4% potassium lactate. Following injection, each roast was sliced into 3/4-inch thick steaks. Each steak was individually packaged in a modified atmosphere package containing 80% food grade oxygen and 20% carbon dioxide. Steaks were placed on a table in a 38ºF cooler under simulated lighted retail display conditions where they remained for 0, 3, 6, 9, 12, or 15 days. When the display time was completed, packages were aseptically opened for microbial sampling. Total psychrotrophic (bacteria) plate counts were used to evaluate microbial growth. Color traits were measured using a HunterLab colorimeter. A 1-inch port was used with Illuminant A and 10º standard observer settings. L* (lightness to darkness), a* (red to green color), and b* (yellow to blue color) were used to objectively define color in a three-dimensional color space. Package purge loss (the

amount of moisture lost from the steak while in the package) and cooking loss were measured. Warner-Bratzler shear force was measured on each steak following cooking.

Results

Adding sodium phosphate and potassium lactate in enhanced beef steaks increased the pH of the steaks (Table 1). The use of alkaline phosphates in meat products to increase the pH has been well documented. By increasing the pH, the product can bind more water, resulting in decreased purge and cooking loss. The decrease in cooking loss produces a juicier, more desirable product. In our study, adding sodium phosphate increased ($P < 0.05$) steak pH. Use of STP should increase the pH of meat more than BK85 because it is more alkaline, however, there was no difference between the two phosphate types ($P > 0.05$). Increasing levels of lactate significantly increased steak pH ($P < 0.05$). The ability of potassium lactate to increase product pH also should increase moisture retention in the product. Research indicates lactate has the ability to delay microbial growth, which will have an effect on the product pH. The ability of potassium lactate to increase pH and delay microbial growth over the 15-day storage period may have allowed the product pH to remain higher than steaks containing 0% potassium lactate.

Table 1. Effect of phosphate type or lactate level on the pH of beef *semitendinosus* steaks.

		Steak pH	
		Mean	S.E.
Phosphate Type	No Phosphate	5.70[b]	0.018
	BK85	5.97[a]	
	ST	5.93[a]	
Lactate Level	0% KL	5.75[z]	0.018
	2% KL	5.90[y]	
	4% KL	5.99[x]	

[ab]Means within a column with different superscripts are significantly different ($P < 0.05$).
[xyz]Means within a lactate level with different superscripts are significantly different ($P < 0.05$).
BK85 = Brifisol® 85 Instant (BK Giulini Corporation, Simi Valley, CA); pH of ~ 8.5.
STP = Sodium tripolyphosphate (BK Giulini Corporation, Simi Valley, CA); pH of ~ 9.5.
KL = Potassium lactate (Ultra-Pure PL-85®,Trumark Inc., Linden, NJ); 60% solution, pH of 7.65.

Increasing levels of potassium lactate delayed bacterial growth and held the total bacterial plate counts lower over the 15-day refrigerated storage period as compared to bacterial counts from steaks containing 0% lactate (Figure 1). Steaks containing 0% KL had higher microbial counts by day 15 as compared to steaks containing 2% and 4% KL ($P < 0.05$). Increasing the level of lactate from 2% to 4% reduced the bacterial count over the 15-day storage period ($P < 0.05$). The addition of potassium lactate in meat products has been shown to increase the shelf-life of the product by delaying bacteria growth. A decrease in bacterial load also may have an effect on other quality characteristics. As bacteria grow, they

(Continued on next page)

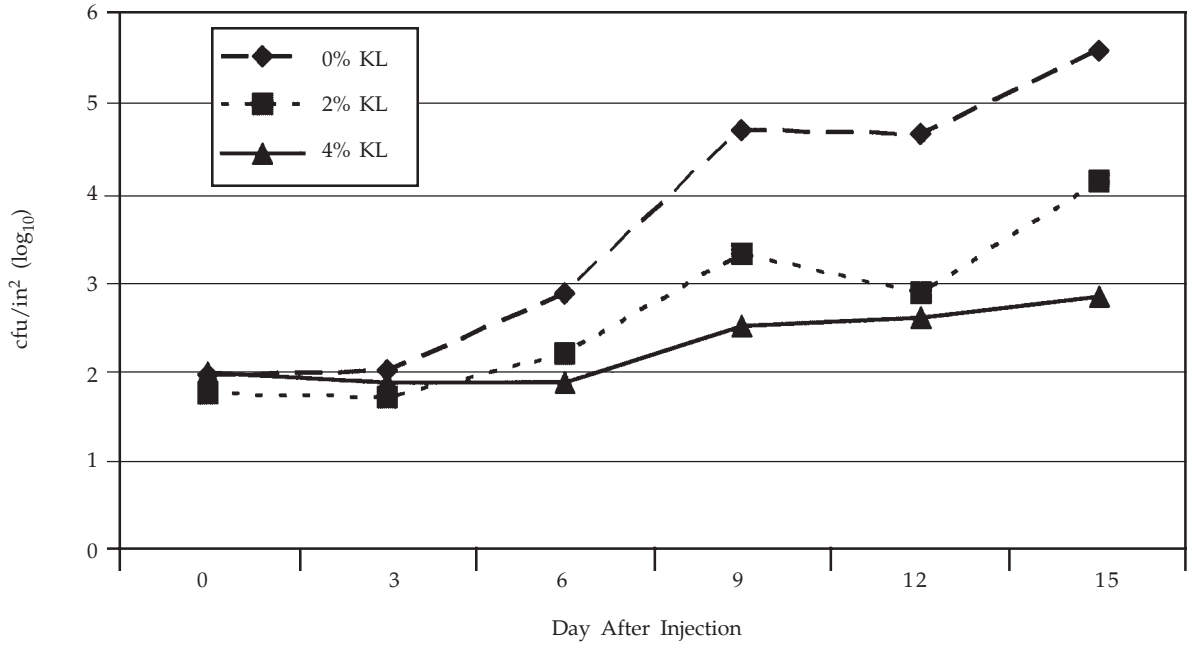


Figure 1. Effect of potassium lactate on psychrotrophic plate counts (log_{10} cfu/in^2) of enhanced beef *semitendinosus* steaks.

Table 2. Effect of phosphate type or lactate level on color values of beef *semitendinosus* steaks.

		L* Value		a* Value		b* Value	
		Mean	S.E.	Mean	S.E.	Mean	S.E.
Phosphate Type	No Phosphate	45.37[a]	0.644	26.06[b]	0.542	20.31[a]	0.297
	BK85	42.17[b]		28.73[a]		20.89[a]	
	STP	43.14[b]		28.05[a]		20.88[a]	
Lactate Level	0% KL	45.84[x]	0.644	26.12[y]	0.542	20.22[y]	0.297
	2% KL	42.51[y]		28.49[x]		21.06[x]	
	4% KL	42.33[y]		28.22[x]		20.80[xy]	

[ab]Means within phosphate types with different superscripts are significantly different ($P < 0.05$).
[xy]Means within lactate levels with different superscripts are significantly different ($P < 0.05$).
BK85 = Brifisol® 85 Instant (BK Giulini Corporation, Simi Valley, CA); pH of ~ 8.5.
STP = Sodium tripolyphosphate (BK Giulini Corporation, Simi Valley, CA); pH of ~ 9.5.
KL = Potassium lactate (Ultra-Pure PL-85®,Trumark Inc., Linden, NJ); 60% solution, pH of 7.65.

Table 3. Effect of phosphate type or lactate level on percent package purge of beef *semitendinosus* steaks.

		% Package Purge	
		Mean	S.E.
Phosphate Type	No Phosphate	5.91[a]	0.283
	BK 85	2.92[b]	
	STP	2.95[b]	
Lactate Level	0% KL	6.19[x]	0.283
	2% KL	3.85[y]	
	4% KL	2.23[z]	

[ab]Means in a column with different superscripts are significantly different ($P < 0.05$).
[xyz] Means within lactate levels with different superscripts are significantly different ($P < 0.05$).
BK85 = Brifisol® 85 Instant (BK Giulini Corporation, Simi Valley, CA); pH of ~ 8.5.
STP = Sodium tripolyphosphate (BK Giulini Corporation, Simi Valley, CA); pH of ~ 9.5.
KL = Potassium lactate (Ultra-Pure PL-85®,Trumark Inc., Linden, NJ); 60% solution, pH of 7.65.

Table 4. Effect of phosphate type or lactate level on percent cooking loss of beef *semitendinosus* steaks.

		% Cooking Loss	
		Mean	S.E.
Phosphate Type	No Phosphate	31.62[a]	0.429
	BK85	29.93[b]	
	STP	30.04[b]	
Lactate Level	0% KL	33.71[x]	0.429
	2% KL	29.77[y]	
	4% KL	28.10[z]	

[ab]Means within phosphate type with different superscripts are significantly different ($P < 0.05$).
[xyz]Means within a lactate level with different superscripts are significantly different ($P < 0.05$).
BK85 = Brifisol® 85 Instant (BK Giulini Corporation, Simi Valley, CA); pH of ~ 8.5.
STP = Sodium tripolyphosphate (BK Giulini Corporation, Simi Valley, CA); pH of ~ 9.5.
KL = Potassium lactate (Ultra-Pure PL-85®,Trumark Inc., Linden, NJ); 60% solution, pH of 7.65.

produce acidic, metabolic by-products that will lower product pH. Lower product pH reduces moisture retention and the stability of myoglobin resulting in decreased shelf-life due to the development of a brown surface appearance. Sodium phosphate did not significantly reduce ($P > 0.05$) microbial growth (data not shown).

Steak color utilizing HunterLab L*, a*, and b* was monitored over the 15-day refrigerated storage period. Adding sodium phosphate or potassium lactate resulted in a darker, redder steak appearance (Table 2). Steaks enhanced with sodium phosphate had significantly lower L* values (darker appearance) and higher a* values (redder appearance) as compared to steaks containing no phosphate ($P < 0.05$). No differences in b* values (yellowness to blueness) were seen between the steaks ($P > 0.05$). Adding potassium lactate significantly decreased the lightness of the product (lower L* values) while giving the product a redder appearance (higher a* values). The ability of sodium phosphate and potassium lactate to increase the product pH may be aiding color stability. Research has shown that myoglobin is more stable at higher pH values. The results in this study indicate that adding phosphate and lactate can help increase product shelf-life because the product maintains a more desirable appearance for a longer time.

Both sodium phosphate and potassium lactate decreased the amount of package purge loss (Table 3). Adding sodium phosphate decreased the amount of package purge ($P < 0.05$), however, no differences were seen between the two phosphate types. Increasing levels of potassium lactate decreased the amount of package purge loss ($P < 0.05$).

Adding phosphate and lactate also decreased the amount of cooking loss (Table 4). Adding sodium phosphate decreased the amount of

cooking loss ($P < 0.05$), however, no differences were seen between the two phosphate types. Increasing levels of potassium lactate decreased the amount of cooking loss ($P < 0.05$). The ability of sodium phosphate and potassium lactate to decrease package purge and cooking loss may be due to their ability to increase product pH, allowing muscle proteins to bind and hold more water. The decrease in moisture loss should result in a juicier product.

Adding BK85 decreased ($P < 0.05$) the Warner-Bratzler shear force values (increased the tenderness) of the enhanced beef steaks (Table 5). Research indicates the use of phosphate in meat products will increase product tenderness. It was expected that STP would also increase product tenderness, however, this was not the case in our study. Potassium lactate did not aid in increasing product tenderness.

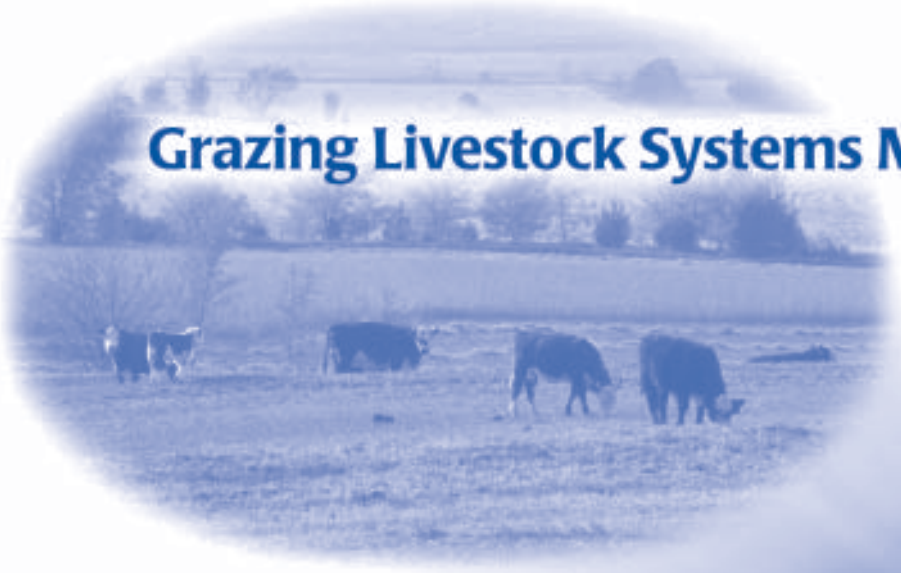
Results of this study indicate that the use of sodium phosphate and potassium lactate can enhance product quality. Sodium phosphate decreased the amount of package purge and cook loss and gave the beef product a darker, redder appearance. Potassium lactate gave the product a darker, redder appearance, while increasing levels of lactate decreased total psychrotrophic (bacteria) plate counts and decreased package purge and cook loss. Sodium phosphate and potassium lactate aid in extending product shelf-life from a bacterial and color standpoint while improving moisture retention of enhanced beef steaks.

Table 5. Effect of phosphate type or lactate level on Warner-Bratzler shear force values of beef *semitendinosus* steaks.

		Warner-Bratzler shear force (pounds of force)	
		Mean	S.E.
Phosphate Type	No Phosphate	9.72[a]	0.117
	BK85	8.71[b]	
	STP	9.77[a]	
Lactate Level	0% KL	9.74[x]	0.117
	2% KL	9.19[x]	
	4% KL	9.26[x]	

[ab]Means within phosphate type with different superscripts are significantly different ($P < 0.05$).
[x]Means within a lactate level with different superscripts are significantly different ($P < 0.05$).
BK85 = Brifisol® 85 Instant (BK Giulini Corporation, Simi Valley, CA); pH of ~ 8.5.
STP = Sodium tripolyphosphate (BK Giulini Corporation, Simi Valley, CA); pH of ~ 9.5.
KL = Potassium lactate (Ultra-Pure PL-85®,Trumark Inc., Linden, NJ); 60% solution, pH of 7.65.

[1]Joe L. Baumert, former graduate student; Roger W. Mandigo, professor, Animal Science, Lincoln.



Grazing Livestock Systems Major

Two Programs- One Industry

http://gls.unl.edu
http://feedlot.unl.edu/intern

Feedlot Management Internship Program

Beef... Built on Partnerships