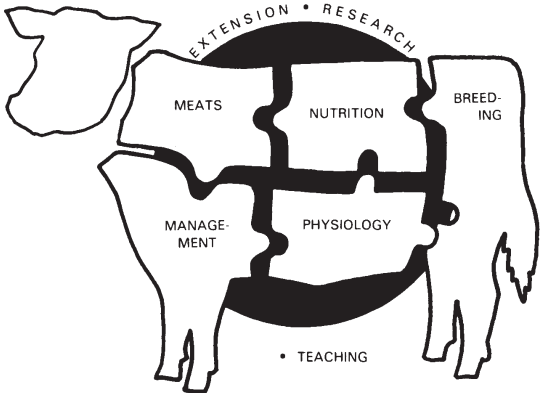
University of Nebraska Lincoln EXTENSION

MP 88-A



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

2006 Beef Cattle Report

Table of Contents

IANR

ACKNOWLEDGMENTS

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

Abengoa Bionergy Corp., York, Nebraska
Beef Board, Centennial, Colorado
Bioniche Lifes Services, Belleville, Ontario, Canada
Cargill Corn Milling, Blair, Nebraska
Elanco Animal Health, Indianapolis, Indiana
Intervet, Millsboro, Delaware
J.C. Robinson Seed Co., Waterloo, Nebraska
Montana State University, Boseman, Montana
Nebraska Cattlemen, Inc., Lincoln, Nebraska
Nebraska Corn Board, Lincoln, Nebraska
Nutrition Physiology Corp., Amarillo, Texas
Pfizer Inc., New York, New York
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
Boehringer Ingelheim Vetmedica, St. Joseph, Missouri
Cargill Corn Milling, Blair, Nebraska
Chief Ethanol Fuels, Hastings, Nebraska
Dakota Gold, Sioux Falls, South Dakota
Elanco Animal Health, Indianapolis, Indiana
Fort Dodge Animal Health, Overland Park, Kansas
Greater Omaha Pack, Omaha, Nebraska
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
Pfizer Animal Health, New York, New York
Pharmacia Upjohn, Kalamazoo, Michigan
PharmAgra Labs, Inc., Brevard, North Carolina
Premium Protein Products, Hastings, Nebraska
Rex Ranch, Whitman, Nebraska
Schering Plough Animal Health, Kenilworth, New Jersey
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 & Development Center, Ithaca
Jeff Bergman
Logan Dana
Tom Drieling
Matt Greenquist
Allison Miller
Chuck Rezac
Ken Rezac
Matt Sillivan
Darren Vinton
Doug Watson

Animal Science Department, Lincoln
Josh Benton
Deb Clopton
Ruth Diedrichsen
Jeryl Hauptman
Janet Hyde
Tommi Jones
Matt Luebbe
Jim MacDonald
Clyde Naber
Robert Peterson
Calvin Schrock
Joseph Schulz
Candice Toombs
Kyle Vander Pol

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

Panhandle Research & Extension Center, Scottsbluff
Nabor Guzman
Paul McMillen
Doug Pieper

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

Dalbey-Halleck Farm
Mark Dragastin

Northeast Research & 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; Beef Reports.

Effects of Supplementing Beef Cows with Lipid from Whole Corn Germ

Jeremy L. Martin
Rick J. Rasby
Dennis R. Brink
Ron U. Lindquist
Duane H. Keisler
Steve D. Kachman
Mark Dragastin[1]

Summary

A two-year study was conducted with crossbred beef cows to determine whether supplementation with fat from whole corn germ either pre- or postpartum influenced ovarian activity before the breeding season, pregnancy rates, calving interval, calf performance, or serum leptin concentration. Supplements were fed for approximately 45 days before or 45 days after calving. Cows supplemented prepartum with fat from whole corn germ had shorter calving intervals. Ovarian activity before the breeding season, pregnancy rate, calf growth, and serum leptin were not different between groups.

Introduction

Profitability in the cow/calf sector of the beef industry is driven by reproduction. A cow must become pregnant within approximately 80 days of calving to maintain a 365-day calving interval. Leptin is a hormone produced by adipose tissue that is closely related to body condition. Cows with greater body condition have higher blood leptin concentrations. Leptin influences gonadotropin secretion, especially in nutrient-restricted cows. Dietary fat may influence leptin secretion and postpartum reproduction.

Supplemental feedstuffs are a necessity in most beef cow operations. When supplementing energy to beef cows, it is important to consider the possibility of negative associative effects on forage digestibility. Supplemental fat or starch may inhibit fiber digestibility if fed at high levels. However, previous research indicates there is potential for moderate levels of supplemental fat to elicit a favorable reproductive response compared to control supplements equal in energy.

The objectives of this study were to determine if supplementing cows with fat from whole corn germ for 45 days before or after calving affected cows exhibiting ovarian activity before the breeding season, pregnancy rate, calving interval, calf performance, or blood leptin concentrations.

Procedure

Composite MARC II (1/4 each Hereford, Angus, Simmental, and Gelbvieh) beef cows and cows sired by Hereford x Angus bulls and MARC II dams were used in a two-year experiment at the University of Nebraska–Lincoln Dalbey-Halleck experiment station. In each year cows (n=172 yr 1; n=170 yr 2) were assigned randomly to one of three treatments: control (CON; n=118) supplemented before and after calving with dry rolled corn, whole corn germ pre-calving (PRE; n=115), or whole corn germ post-calving (POST; n=109). Supplements were nearly equal in CP and TDN but divergent in lipid content (Table 1); and consisted of 4 lb DM dry rolled corn or 2.5 lb DM whole corn germ supplement daily. Whole corn germ is a by-product of the wet-milling industry that contains the corn oil. Whole corn germ is approximately 12.5% CP, 140% TDN, and 45% fat. Supplements were group-fed daily with at least three linear feet of bunk space per cow. Cows were fed a mixture of approximately one-third alfalfa hay and two-thirds bromegrass hay (as-fed basis) and were allowed *ad libitum* intake, such that minimal hay remained prior to the subsequent daily feeding.

Supplementation periods averaged approximately 45 days, and began January 29, 2002, in year 1 and January 20, 2003, in year 2. Corn germ was fed to PRE cows for 42 days from January 29 to March 11, 2002, and for 52 days from January 20 to March 12, 2003. During the period when PRE cows were supplemented with whole corn germ, CON and POST cows were managed as a single group and supplemented dry rolled corn. Whole corn germ was fed to POST cows for 42 days from March 12 to April 23, 2002 and for 50 days from March 12 to April 30, 2003. Average calving date in year 1 was March 12 $\pm$ 1.4 days and in year 2 was March 20 $\pm$ 1.5 d. During the period when POST cows were supplemented with whole corn germ, CON and PRE cows were fed the control supplement as a single group. From the end of the post-calving supplementation period to the beginning of the subsequent pre-calving supplementation period, cows and calves were managed together.

Body weight and condition score change were used as predictors of nutritional status. Cows were weighed in January at the initiation of supplementation, in April after the supplementation period, immediately prior to the breeding season, and at

(Continued on next page)

Table 1. Supplement and nutrient intake for cows fed control or whole corn germ supplement.

	Control	Whole Corn Germ
Supplement Intake, lb DM/day[a]	4.0	2.5
Ether Extract, lb/day[a]	0.15	0.88
Total Digestible Nutrients, lb/day[b]	3.60	3.53

[a]Calculated lab analysis of corn and whole corn germ supplements.
[b]Calculated using 1996 NRC value for dry rolled corn and commercial laboratory analysis for whole corn germ.

weaning. Weaning dates were September 24, 2002, and October 7, 2003. Body condition scores were assigned independently by two technicians on each of these dates and between supplementation periods. Calf birth weights and weaning weights were recorded. Weaning weight was adjusted to 205 days of age. No adjustment was made for age of dam because cow ages were equally distributed across treatments. Cows were exposed to fertile bulls for 62 days beginning May 23rd each year. Pregnancy was diagnosed via rectal palpation. Calving interval was calculated as the number of days between consecutive calving dates.

Blood samples were taken during the treatment periods to determine leptin concentrations. Samples were cooled immediately and serum was harvested and frozen at -20°C until further analysis. Two additional blood samples were collected 10 days apart immediately prior to the breeding season to determine ovarian activity. Cows with serum progesterone concentrations greater than 1 ng/mL in either sample had initiated estrous cycles. Leptin concentrations were assayed using a double-antibody radioimmunoassay validated for use in bovine serum.

Table 2. Effects of pre- or postpartum lipid supplementation on cow body condition score and weight from late gestation until weaning.

Date	Body Condition Score[c]			Weight, lb[c]		
Con	Pre	Post	Con	Pre	Post	
January	5.39	5.40	5.30	1189	1178	1189
March	5.36	5.21	5.29			
April	5.10	5.02	4.91	1033	1024	1015
May	5.38	5.28	5.32	1108	1095	1099
Calving[a]	5.36	5.21	5.24			
Weaning[b]	5.25	5.31	5.27	1150	1141	1143

[a]Body condition score measurement taken closest to calving date.
[b]Weaning measurements were taken September 24, 2002, and October 7, 2003.
[c]Con = control; Pre = supplemented with corn germ 45 days prepartum; Post = supplemented with corn germ 45 days postpartum.

Table 3. Effects of pre- or postpartum lipid supplementation on calf growth and cow reproductive performance.

	Treatment[c]		
Calf Performance	Con	Pre	Post
Calving Date, Day of Year	73[d]	79[e]	78[de]
Birth Weight, lb	88	88	84
Actual Weaning Weight, lb[a]	503	488	495
Adjusted Weaning Weight, lb[b]	516	516	516
Weaning Age, day	199[f]	193[g]	194[fg]
Cow Performance			
Cyclic at initiation of breeding, %	72.3	65.0	63.1
Pregnant, %	90.7	91.6	91.6
Calving Interval, day	373[h]	362[i]	371[h]

[a]Unadjusted weaning weight.
[b]Weaning weight adjusted for calf age.
[c]Con = control; Pre = supplemented with corn germ 45 days prepartum; Post = supplemented with corn germ 45 days postpartum.
[de]Within a row, means without common superscripts differ at $P = 0.12$.
[fg]Within a row, means without common superscripts differ at $P = 0.13$.
[hi]Within a row, means without common superscripts differ at $P = 0.07$.

Results

Treatment did not influence BCS nor weight at any sampling time, nor was there an effect of treatment by age interaction on BCS or weight (Table 2).

Calf growth and cow reproductive data are shown in Table 3. Birth weight, actual weaning weight, and weaning weight adjusted for calf age were similar among treatments. There was no difference among treatments for proportion of cows exhibiting ovarian activity prior to the breeding season or for pregnancy rate. There was a tendency ($P = 0.07$) for a treatment effect on calving interval. PRE cows had shorter calving intervals than POST or CON cows (CON = 373 $\pm$ 5.9 d, POST = 371 $\pm$ 6.2 d, PRE = 362 $\pm$ 5.9 d).

Circulating leptin concentration was not influenced by supplement at any time during the study and averaged 2.15 $\pm$ 0.75 ng/mL for CON, 1.88 $\pm$ 0.76 ng/mL for POST, and 1.91 $\pm$ 0.75 ng/mL for PRE groups.

In summary, supplementing cows with whole corn germ for 45 days prior to calving reduced calving interval. Cow weight and BCS, calf growth, proportion of cows exhibiting ovarian activity prior to the start of the breeding season, and pregnancy rate were not affected. Furthermore, supplementing cows with fat did not influence leptin concentrations.

[1] Jeremy Martin, graduate student; Rick Rasby, professor, Animal Science, Lincoln; Dennis Brink, professor, Animal Science, Lincoln; Ron Lindquist, Archer Daniels Midland, Columbus, Neb.; Duane Keisler, professor, Animal Science, University of Missouri-Columbia, Columbia, Mo.; Steve Kachman, professor, Biometry, Lincoln; Mark Dragastin, Dalbey-Halleck unit manager, Va.

Effects of Supplementing Lactating, June-calving Cows on Second-calf Pregnancy Rates

L. Aaron Stalker
Kelly W. Creighton
Jacki A. Musgrave
Don C. Adams
Terry J. Klopfenstein[1]

Summary

A two year experiment evaluated the influence of supplementation pre-breeding on second-calf pregnancy rates in June-calving heifers. For 60 days before start of the breeding season, heifers were assigned to one of two treatments: supplementation of dried distillers grains (1.5 lb/day) to meet energy and metabolizable protein requirements or unsupplemented control. Supplementation improved body condition score during the supplementation period and resulted in increased body condition score at weaning. In year 1, feeding supplement to the dam did not change calf weight gain but feeding supplement increased calf weight in year 2. Pregnancy rates were 90% and not changed by supplementation.

Introduction

In the Nebraska Sandhills, calving in June matches the cow's nutrient requirements with grazed forage nutrient supply and reduces the need for feeding of harvested forage. Reducing the amount of harvested forage fed improves net returns compared to the traditional March-calving system.

Reproductive performance of mature June-calving cows is comparable to March-calving cows but rebreeding rate of June-calving, two-year-old cows with their second calf is low (*2000 Nebraska Beef Report,* pp. 13-16). Poor reproduction of young cows would negatively impact economic efficiency in the June-calving system.

Nutrient status of lactating, first-calf heifers during the postpartum period has dramatic impacts on subsequent reproduction. Nutrient content of upland native range in the Nebraska Sandhills declines rapidly in late summer and early fall. Objectives of this research were to determine if supplementation to meet energy and protein requirements would improve second-calf conception rates in lactating, first-calf heifers when calving occurs in June.

Procedure

This study was conducted at the Gudmundsen Sandhills Laboratory, near Whitman, Neb., over two years. In each year, 2-year-old, primiparous, June-calving heifers (n= 41, year 1; n = 40, year 2; average calving date June 1, year 1; May 28, year 2) were stratified by calving date and assigned randomly to one of two prebreeding treatments: supplementation to meet net energy and metabolizable protein requirements or non-supplemented control. Loose dried distillers grains was used as the supplement to which an ionophore (equivalent of 150 mg/day rumensin) was added. Cows grazed upland range during the treatment (July 15 to August 30), breeding (September 1 to October 15) and post-breeding to weaning (October 16 to November) periods.

In year 1 diet samples were collected using esophageally fistulated cows before initiation of the trial and results were used to balance diets of cows in the supplement treatment according to NRC (1996) requirements (Tables 1 and 2).

At the beginning and end of the treatment period, cows and calves were weighed and body condition score of cows was determined. On Monday, Wednesday and Friday, cows in the supplement treatment were group fed the daily equivalent of 1.5 lb/cow.

On September 1 of each year, treatment groups were combined for the breeding season and 1.5 lb/day supplement was fed to all cows through the end of breeding (October 15). Weaning occurred the first week of November and heifer pregnancy status was determined by rectal palpation in January.

Significant year by treatment interaction occurred for calf growth, therefore calf weight data are presented by year.

Results

Heifer body weights were similar between treatments upon initiation

(Continued on next page)

Table 1. Nutrient Requirements of Beef Cattle (NRC, 1996) model inputs

Item	
Animal inputs[a]	
Age, mo	25
BW, lb	1000
Body condition score	5.0
Mature BW, lb	1200
Days in milk	90
Peak milk production, lb/day	15
Diet Inputs	
Forage CP, %	9.4
Forage DIP, %CP	82.0
Forage TDN, %	59.0
Microbial efficiency, % TDN	13

[a]Breed composition: Gelbvieh x Angus x Angus.

Table 2. Average nutrient balance for supplemented (S) and nonsupplemented (NS) lactating, primiparous, June-calving cows during the 45 day period (Jul. 15 to Aug. 30) prior to the breeding season for second calf.

Item	NS	S
Forage intake, lb[a]	22.7	22.5
Supplement intake, lb/day	—	1.4
NEm balance, Mcal[b]	-0.77	0.08
MP balance, g/day[c]	28	191
DIP balance, g/day[d]	1	-123
Days to lose 1 condition score	185	1814

[a]Estimated by NRC (1996) model.
[b]Net energy for maintenance.
[c]Metabolizable protein.
[d]Degraded intake protein.

and termination of the treatment period (Table 3). Body weights were similar at weaning even though heifers in both treatments lost body weight from the end of the supplementation period to weaning.

Heifer body condition score did not differ between treatments upon initiation of the treatment period. Heifers receiving supplement gained condition while heifers not receiving supplement lost body condition during the supplementation period. Heifers in both treatments lost body condition during lactation and overall body condition score loss was not different between treatments.

In year 1, calf weight was not different between treatments at any point during the experiment (Table 4). However, in year 2, calves nursing dams fed supplement were heavier at the end of the supplementation period and tended to be heavier at weaning. This discrepancy in calf growth between years may result from differences in forage quality dynamics.

Dried distillers grains are high in undegraded intake protein. Past research has shown an increase in milk production in cows fed protein supplements containing undegraded intake protein. The increase in milk production in response to undegraded intake protein supplementation is variable and appears to interact with nutrient plane (i.e. forage quality). It is possible that forage quality differences between years altered response to supplementation and increased milk production in year 2 leading to increased calf weight.

Pregnancy rates were similar between heifers fed supplement to meet energy and protein requirements and nonsupplemented heifers. Pregnancy rates of non-supplemented, 2 year old, June-calving heifers averaged 92.5% over two years. These results are markedly better than past observations (*2002 Nebraska Beef Report*, pp. 4-7). Feeding supplement in an effort to improve already acceptable pregnancy rates may not be economical.

Table 3. Effect of prebreeding protein supplementation on body weight, body condition score (BCS) and subsequent pregnancy rate in primiparous heifers

Item	No Supplement	Supplement	SE	*P*-value
Initial wt., lb	1012	1028	12	0.35
Final wt., lb	1021	1041	11	0.22
Wt. at Weaning, lb	981	1009	14	0.16
Initial BCS	5.6	5.6	0.1	0.50
Final BCS	5.4	5.7	0.1	0.001
BCS at Weaning	5.0	5.2	0.1	0.05
Pregnancy rate, %	92.5	88.0	0.4	0.50

Table 4. Effect of prebreeding protein supplementation on body weight of calves born to primiparous heifers

Item	No Supplement	Supplement	SE	*P*-value
Year 1				
Initial wt., lb	165	158	6	0.39
Final wt., lb	249	241	7	0.45
Weaning wt, lb	372	367	9	0.72
Year 2				
Initial wt., lb	149	154	6	0.57
Final wt., lb	270	292	7	0.03
Weaning wt, lb	413	433	8	0.08

[1]Aaron Stalker, graduate student; Kelly Creighton, former graduate student; Jacki Musgrave, research technologist; Don Adams, professor, Animal Science, West Central Research and Extension Center, North Platte; Terry Klopfenstein, professor, Animal Science, Lincoln.

Effects of Pre- and Postpartum Nutrition on Reproduction in Spring Calving Cows and Calf Feedlot Performance

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

Summary

Crossbred, spring calving cows were used in a three-year experiment to evaluate the influence of supplemental protein prepartum and grazing sub-irrigated meadow postpartum on pregnancy rates and calf feedlot performance. Feeding supplement prepartum improved body condition score pre-calving and pre-breeding and increased the percentage of live calves at weaning but did not affect pregnancy rate or steer calf feedlot performance. Grazing sub-irrigated meadow did not change pregnancy rates or feedlot performance.

Introduction

Beef production systems are comprised of a series of segments with potential for complex interactions. Management changes in one segment may influence the entire system.

Body condition score is a good measure of energy reserves and BCS at calving is among the most important factors affecting pregnancy rate. However, postpartum nutrition also may influence reproduction. Increased nutritional plane both pre- and postpartum has been shown to increase growth rate of calves in many but not all cases. Whether this increased growth rate persists beyond weaning is not known.

Objectives of this study were to determine the effects of pre- and postpartum nutrition and their interaction within an applied production setting on productivity of the entire system, especially cow reproductive performance and calf growth performance through the feedlot.

Table 1. Causes for cows being removed from study.

			Injured/died during							
			Prepartum		Parturition		Lactation			
Treatment[a]		n	Cow	Calf	Cow	Calf	Cow	Calf	Late[b]	Total
Supplement	Meadow	90	0	0	0	0	1	2	1	4
Supplement	Hay	91	0	0	0	0	0	0	1	1
No Supplement	Meadow	90	2	2	0	2	1	2	1	10
No Supplement	Hay	91	0	1	0	2	0	2	4	9

[a]Supplement = Cows fed the equivalent of 1 lb/day supplement (42% CP) prepartum;
No Supplement = Cows not fed supplement prepartum;
Meadow = Cows grazed meadow for 30 days postpartum;
Hay = Cows fed hay for 30 days postpartum.
[b]Cows were removed from the study if calving did not occur by April 20.

Procedure

In year 1, 136 pregnant, MARC II (four-breed composite:1/4 Angus, 1/4 Gelbvieh, 1/4 Hereford, 1/4 Simmental), spring calving cows age 3 to 5 years were stratified by age and weaning weight of previous calf then assigned randomly to 1) supplement or no supplement prepartum and 2) sub-irrigated meadow or hay postpartum. In year 2 cows were switched to the opposite treatment and switched back to their original treatment in year 3. Cows remained in the experiment unless removed because of injury, reproductive failure, or if calving did not occur by April 20 (Table 1). In year 2 and 3 only 113 cows were used because of reduced forage availability caused by drought.

On December 1, cows were divided into eight pastures of similar size and grazed native upland range at the University of Nebraska, Gudmundsen Sandhills Laboratory, near Whitman, Neb. Either 0 or 1 lb daily of supplement was provided to cows on a pasture basis, three times per week, from December 1 to February 28. On a DM basis, supplement ingredients were: 50.0% sunflower meal, 47.9% cottonseed meal, 2.1% urea; and composition was: 42.0% CP and 73.3% TDN.

Cows were managed in a common group during the calving season (March 1 to April 30) and fed grass hay in a dry lot. Amount of hay fed was adjusted daily in an effort to satisfy appetite but minimize waste and averaged 30.9 lb/cow daily (DM basis). Hay quality was determined by near infrared reflectance spectroscopy at a commercial laboratory (Table 2). Average calving date was March 27. During the period between calving and start of breeding (May 1 to May 31), half the cows were fed grass hay and half grazed sub-irrigated meadow. At the beginning of breeding season (June 1) treatment groups were combined and cows grazed upland range as a single group for the remainder of the production cycle. The breeding season lasted 60 days with a 1:20 bull: cow ratio. Diet quality (Table 2) was estimated from masticate samples obtained from esophageally fistulated cows. Weight and body condition score (BCS) of all cows were recorded at beginning (December 1) and end (February 28) of the prepartum supplementation period, at beginning (May 1) and end (May 30) of the postpartum meadow grazing period, and at weaning (first week of October). Cows were examined for pregnancy via rectal palpation by a veterinarian in October.

Calves were weighed within 24 to 48 hours of birth and at weaning. Between 24 and 48 hours of birth, a blood sample was collected from

(Continued on next page)

each calf in year 2 and 3. Serum was analyzed for Immunoglobulin G concentration by single radial immunodiffusion. Bull calves were castrated at branding (May).

At weaning, steers (yr 1 n = 61, yr 2 n = 65, yr 3 n = 45) received two doses of PRISM 4 14 days apart and a single dose of One Shot vaccine. Steers were fed for ad libitum intake of grass hay in a dry lot during a two week preconditioning period before being shipped to a feedlot at the West Central Research and Extension Center in North Platte, Neb. (100 mi). Upon arrival steers were fed grass hay at 2.5% of BW for 7 days. After the 7-day adaptation period, steers were weighed on two consecutive days and implanted with Synovex S and dewormed with Cydectin on the second day. Steers were reimplanted with Revelar S about 100 days prior to slaughter. The starting diet contained 35% alfalfa and steers were adapted over 14 days to a finishing diet that contained 48% dry rolled corn, 40% wet corn gluten feed, 7% alfalfa and 5% supplement (DM basis) by replacing alfalfa with corn. Steers were fed in 8 pens corresponding to the prepartum pasture of their dam until it was visually estimated the average 12th rib back fat of all steers was 0.5 in.

Hot carcass weight was obtained at harvest. Dressing percentage was calculated using the unshrunk weight obtained at the feedlot prior to shipment to the abattoir. Following a 24-hour chill, marbling score, fat thickness at the 12th rib, percentage of KPH, longissimus muscle area, yield grade and quality grade were determined.

Table 2. Upland and sub-irrigated meadow diet and hay quality (mean ± SD).

Item	Year 1	Year 2	Year 3
Upland range diet			
CP, % DM	6.4 ± 0.6	4.7 ± 1.4	5.1 ± 0.1
TDN, % DM	50.8 ± 5.4	49.0 ± 0.8	50.6 ± 0.8
Hay			
CP, % DM	8.6 ± 1.2	8.7 ± 0.7	6.3 ± 0.6
TDN, % DM	56.0 ± 1.8	54.2 ± 2.1	57.9 ± 1.3

Table 3. BW, BCS, reproductive performance and milk production of cows fed 0 or 1 lb/day supplement December 1 to February 28 (prepartum) and allowed to graze sub-irrigated meadow or fed grass hay May 1 to May 31 (postpartum).

	Supplement		No Supplement			Effect *P*-value[b]		
Item	Meadow	Hay	Meadow	Hay	SEM[a]	Sup	Mead	SxM
Cow BW, lb								
December 1	1081	1074	1088	1093	29	0.16	0.95	0.52
February 28	1078	1082	1008	1048	43	0.001	0.13	0.20
May 1	986	990	955	987	42	0.14	0.13	0.22
May 30	1028	999	1008	994	55	0.24	0.06	0.52
October 8	1071	1050	1054	1061	22	0.81	0.55	0.23
Cow BCS								
December 1	5.2	5.2	5.3	5.3	0.1	0.11	0.67	0.91
February 28	5.1	5.2	4.5	4.8	0.2	<0.001	0.16	0.35
May 1	4.8	4.9	4.5	4.7	0.2	<0.001	0.08	0.60
May 30	5.2	4.9	5.1	4.8	0.2	0.01	<0.001	0.97
October 8	5.2	5.1	5.1	5.1	0.1	0.21	0.39	0.96
Pregnancy Rate, %	94.8	91.5	89.2	91.3	5.8	0.46	0.88	0.49
Calves weaned, %	95.2	99.0	90.1	89.9	3.7	0.03	0.56	0.51
Calving, day of year	87	88	84	85	2	0.01	0.16	0.80

[a]Pooled standard error of treatment means, n = 12 pastures per treatment.
[b]Sup = Prepartum treatment main effect; Mead = postpartum treatment main effect; S x M = prepartum x postpartum treatment interaction.

Results

Cows fed protein supplement prepartum had greater BCS at the end of the supplementation period ($P < 0.001$), at start of postpartum treatment period ($P < 0.001$) and at start of the breeding season ($P = 0.01$) than cows not fed supplement (Table 3). Feeding supplemental protein did not result in increased pregnancy rates ($P = 0.46$). Similarly, cows that grazed sub-irrigated meadow had greater BCS ($P < 0.001$) at start of breeding but pregnancy rates were not affected ($P = 0.88$). It is likely that pregnancy rates were similar because nonsupplemented and hay fed cows were in acceptable body condition at calving and at start of breeding. Research has shown a BCS of 5 at calving is the critical level affecting subsequent reproduction and cows in all treatments were near a BCS of 5 at calving.

Cows fed supplement calved three days later ($P = 0.01$) than cows not fed supplement but birth weight was similar ($P = 0.29$). Weaning weight and ADG from birth to weaning were greater for calves born to cows fed supplement. Several studies report increased weaning weight of calves born to cows fed supplement prepartum.

The percentage of live calves at weaning was greater ($P = 0.03$) for cows fed supplement prepartum but was not different ($P = 0.56$) between cows that grazed meadow or were fed hay (Table 3). Since only pregnant cows were included in the study each year, differences in percentage of live calves at weaning cannot be attributed to failure to conceive. Potentially, failure of passive transfer of immunity could explain differences in weaning rate and weaning weight. In year 2 and 3, IgG titers of calves between 24 and 48 hours after birth were similar ($P = 0.98$; Table 4). These results agree with the finding that BCS at calving, ranging from 4 to 7, does not influence IgG titers of calves.

Steers born to cows fed supplement prepartum that grazed subirrigated meadow were heavier ($P < 0.05$) upon entry into the feedlot than steers born to cows in the other treatment combinations (Table 5). Feedlot ADG ($P = 0.89$), DMI ($P = 0.78$), feed ef-

Table 4. Growth performance and serum immunoglobulin G concentration of calves born to cows fed 0 or 1 lb/day supplement December 1 to February 28 (prepartum) and allowed to graze sub-irrigated meadow or fed grass hay May 1 to May 31 (postpartum).

	Supplement		No Supplement			Effect *P*-value[b]		
Item	Meadow	Hay	Meadow	Hay	SEM[a]	Sup	Mead	SxM
Ig G, mg/100ml[c]	3262	3068	3224	3115	600	0.98	0.47	0.84
Calf birth wt, lb	80	81	79	80	2	0.29	0.20	0.95
Calf wean wt, lb	489	469	470	462	15	0.02	0.01	0.27
ADG to wean, lb/day[d]	2.14	2.06	2.02	1.99	0.03	0.002	0.04	0.32
Steer 205d wt, lb[e]	531	511	505	506	15	0.13	0.35	0.30

[a]Pooled standard error of treatment means, n = 12 pastures per treatment.
[b]Sup = Prepartum treatment main effect; Mead = postpartum treatment main effect; S x M = prepartum x postpartum treatment interaction.
[c]Immunoglobulin G concentration in calves between 24 to 48 h after birth measured by radial immunodiffusion.
[d]Average daily gain from birth to weaning.
[e]Weaning weight of steer calves adjusted to 205 d of age.

Table 5. Finishing performance and carcass characteristics of steer calves born to cows fed 0 or 1 lb/day supplement December 1 to February 28 (prepartum) and allowed to graze sub-irrigated meadow or fed grass hay May 1 to May 31(postpartum).

	Supplement		No Supplement			Effect *P*-value[b]		
Item	Meadow	Hay	Meadow	Hay	SEM[a]	Sup	Mead	SxM
Finishing period (222 days)								
Start BW, lb	488	461	462	461	5	0.01	0.01	0.01
ADG, lb/day	3.4	3.4	3.4	3.5	0.1	0.89	0.45	0.45
DMI, lb/day	18.9	18.7	18.5	18.9	0.4	0.78	0.71	0.44
Life ADG, lb/day[c]	2.7	2.7	2.6	2.7	0.04	0.32	0.94	0.23
Carcass data								
HCW, lb	821	805	796	805	10	0.23	0.67	0.23
Dressing, %	64.8	65.0	64.6	64.5	2.4	0.13	0.96	0.49
Marbling score[d]	482	476	467	467	9	0.23	0.76	0.74
LMA, in^2[e]	13.7	13.6	13.4	13.5	0.2	0.27	0.76	0.48
Choice, %	94.2	89.5	87.7	83.0	4.2	0.16	0.29	0.99
Yield Grade	2.95	3.03	2.91	3.02	0.11	0.81	0.44	0.91
Fat thickness, in[f]	0.52	0.54	0.50	0.53	0.03	0.81	0.26	0.92

[a]Pooled standard error of treatment means, n = 8 pens per treatment.
[b]Sup = Prepartum treatment main effect; Mead = postpartum treatment main effect; S x M = prepartum x postpartum treatment interaction.
[c]Average daily gain from birth to shrunk live weight at slaughter.
[d]Marbling score: 400 = Small[00], 500 = Modest[00].
[e]Longissimus muscle area.
[f]Fat thickness measured at the 12th rib.

ficiency ($P = 0.39$) and carcass weight ($P = 0.23$) were similar for steers born to supplemented and non-supplemented cows. Likewise, feedlot ADG ($P = 0.45$), DMI ($P = 0.71$), feed efficiency ($P = 0.71$) and carcass weight ($P = 0.67$) were similar for steers born to cows that grazed meadow and cows fed hay. Carcass characteristics were not influenced by either prepartum or postpartum treatment.

Implications

Results of this study indicate feeding supplement to spring calving cows grazing dormant forage may have benefits beyond impacting reproduction. Feeding supplement to spring calving cows did not improve pregnancy rates but increased percentage of live calves at weaning. These data demonstrate that changes in management have ramifications beyond the segment in which they occur and may influence the entire production system. In this study, prepartum nutrition had a greater affect on subsequent productivity than did postpartum nutrition.

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

Effects of Dam Nutrition on Growth and Reproductive Performance of Heifer Calves

Jeremy L. Martin
Kim A. Vonnahme
Greg P. Lardy
Don C. Adams
Rick N. Funston[1]

Summary

A 3-year experiment evaluated the effects of maternal nutrition on growth and reproductive performance of heifer calves. Supplementing cows with protein during late gestation resulted in heifers that were heavier at weaning and breeding, had higher pregnancy rates, and calved earlier. Allowing cows to graze meadows after calving improved calf weaning weight but not heifer reproductive performance. Heifers from cows that were fed hay after calving had reduced DMI and improved residual feed intake if their dams were supplemented with protein during gestation, but ADG and G:F were not affected by dam supplementation or spring feeding strategies.

Introduction

The nutritional requirements of spring-calving beef cows grazing dormant Sandhills range during late gestation exceed the nutritional value of the forage. In order to maintain cow body condition, protein supplements are often fed during the last trimester of gestation. These supplements are expensive and do not improve subsequent reproductive performance (*2005 Nebraska Beef Report*, pp. 7-9). However, the additional cost of protein supplementation is recovered in improved calf performance at weaning and feedlot endpoints (*2005 Nebraska Beef Report*, pp. 7-9). Additionally, nutrient requirements of the cow are highest during early lactation, which coincides with the beginning of the breeding season. Allowing cows to graze cool-season meadows during this time improves reproductive performance and calf weaning weight compared to cows fed cool-season grass hay (*2005 Nebraska Beef Report*, pp. 7-9).

The effects of dam nutrition during late gestation and early life on future performance of their heifer calves are not well characterized. Therefore, the objectives of the current study were to determine if supplemental protein during late gestation or postpartum plane of nutrition of cows influences future growth or reproductive performance of their heifer calves.

Procedure

A 3-year study was conducted with heifers produced at Gudmunsen Sandhills Laboratory (GSL), Whitman, Neb. The heifers were born to cows used in a 2x2 factorial treatment design to determine effects of late gestation and postpartum nutrition on reproductive performance and calf growth (*2005 Nebraska Beef Report*, pp 7-9). During the last trimester of gestation (December 1 through February 28) cows received either the equivalent of 1 lb/head/day of a 42% CP supplement fed three times per week or no protein supplement. The cows were managed as a single group during the calving season, March 1 to April 30. From May 1 until May 31, half the cows were fed cool-season grass hay while the other half grazed sub-irrigated meadow. On June 1, cows were again combined and were managed in a common group throughout the breeding season and remainder of the production cycle.

During year 1 and year 3, heifers were managed as a single group from June 1 until the end of data collection. Data available from year 1 is limited to birth and weaning records. In year 2, additional reproduction and calving data was collected. The proportion of heifers cycling before the beginning of the breeding season in year 2 was determined by progesterone concentration in two blood samples collected 10 days apart. Progesterone concentration greater than 1 ng/mL in either sample was interpreted to indicate ovarian luteal activity. Heifers from year 2 were exposed to bulls for breeding, and first service pregnancy rate was determine using transrectal ultrasonography approximately 30 days after the end of the breeding season.

Heifers born in year 3 remained at GSL for 109 days after weaning and were then transported to the North Dakota State University Animal Nutrition and Physiology Center, Fargo, ND. After an adaptation and training period, heifers from year 3 were individually fed for 84 days using Calan gates. Heifers were housed in a climate-controlled facility with the light cycle being 14 hours light, 10 hours dark. All heifers were allowed ad libitum consumption of hay (7.5% CP, 71% NDF, 52 % ADF) fed in the morning and supplemented daily with 2 lb of 16% CP pellets in the afternoon. Orts were collected twice weekly and analyzed for DM to determine DMI. Two-day consecutive weights were taken at the beginning and end of the feeding period, with interim weights recorded every 14 d. Following completion of the individual feeding period on May 17, 2005, heifers were transported to the West Central Research and Extension Center, North Platte, Neb. and pre-breeding weights were recorded.

Performance data were analyzed as a 2x2 factorial using PROC MIXED of SAS. Reproductive and calving difficulty data were analyzed using Chi-square procedures in PROC GENMOD of SAS. The model included dam treatment during late gestation and dam treatment during the spring. The interaction between gestation and spring treatments were

Table 1. Effects of dam protein supplementation during the last trimester of gestation and grazing sub-irrigated meadow during early lactation on growth performance of heifer calves[a].

	Treatment[b]					*P*-values	
Item	Prot	NoProt	Meadow	Hay	SEM	Gest	Spring
Birth date, Julian day	86	84	85	86	1.4	0.29	0.67
Birth wt, lb	79	77	77	79	2.2	0.25	0.15
Act wn wt, lb	467	456	468	455	15	0.14	0.09
Adj 205 day wt, lb	498	481	496	483	15	0.02	0.07
Pre-breeding wt, lb	608	586	599	595	20	0.04	0.70

[a]Includes birth and weaning (wn) data from 170 heifer calves born from year 1 to year 3 , and pre-breeding weights from 91 heifers born in year 2 and year 3.
[b]No gestation by spring treatment interactions were detected, therefore only main effects are reported. Prot = dams supplemented three times pre week with the equivalent of 1 lb/hd/d 42% CP cake during the last trimester of gestation; NoProt = no protein supplement fed to dams during gestation; Meadow = dams grazed sub-irrigated meadows between the end of calving and the breeding season; Hay = dams fed cool-season grass hay from the end of the calving season until initiation of the breeding season.

Table 2. Effects of dam protein supplementation during the last trimester of gestation and grazing sub-irrigated meadow during early lactation on reproductive and calving performance of heifers[a].

	Treatment[b]					*P*-values	
Item	Prot	NoProt	Meadow	Hay	SEM	Gest	Spring
Cycling at beginning of breeding season, %	47	50	45	53		0.91	0.66
First service pregnancy rate, %	88	45	64	65		0.003	0.59
Overall pregnancy rate, %	94	73	82	82		0.06	0.76
Calving date, Julian day	63	71	68	66	3.3	0.07	0.71
Calf birth wt, lb	75	74	73	76	2.2	0.61	0.29
Unassisted births, %	69	38	56	50		0.08	0.92

[a]Includes reproductive data from 39 heifers born in year 2 and calving data from 32 heifers that became pregnant.
[b]No gestation by spring treatment interactions were detected, therefore only main effects are reported. Prot = dams supplemented three times pre week with the equivalent of 1 lb/hd/day 42% CP cake during the last trimester of gestation; NoProt = no protein supplement fed to dams during gestation; Meadow = dams grazed sub-irrigated meadows between the end of calving and the breeding season; Hay = dams fed cool-season grass hay from the end of the calving season until initiation of the breeding season.

Table 3. Effects of dam protein supplementation during the last trimester of gestation and grazing sub-irrigated meadow during early lactation on growth, BCS, and residual feed intake of heifers individually-fed for 84 days.[a]

	Treatment Effects[b]						*P*-values	
Item	P/M	P/H	NP/M	NP/H	SEM	G	Sp	G*Sp
Initial wt, lb	607	574	564	571	19	0.19	0.45	0.26
Initial BCS	5.53	5.54	5.43	5.54	0.10	0.62	0.53	0.65
Final wt, lb	684	656	646	631	18	0.08	0.22	0.71
Final BCS	5.13	4.96	4.96	4.92	0.09	0.20	0.23	0.42
ADG, lb/day	0.81	0.93	0.92	0.85	0.14	0.86	0.75	0.15
DMI, lb/day	14.49[de]	15.25[d]	14.98[de]	13.67[e]	0.63	0.37	0.65	0.09
G:F	0.057	0.062	0.060	0.067	0.007	0.40	0.27	0.88
RFI, lb/day[c]	-0.30[de]	0.61[d]	0.40[de]	-0.90[e]	0.62	0.50	0.74	0.07

[a]Includes data from 50 heifers born in year 3.
[b]P/M = dams supplemented with the equivalent of 1 lb/hd/d of 42% CP cake during gestation and grazed meadows from the end of the calving season until the breeding season; P/H = dams supplemented with the equivalent of 1 lb/hd/d of 42% CP cake during gestation and were fed cool-season grass hay from the end of the calving season until the breeding season; NP/M = dams not supplemented with protein during gestation, grazed meadows between in the interval between the end of calving and initiation of the breeding season; NP/H = dams not supplemented with protein during gestation, fed cool-season grass hay between in the interval between the end of calving and initiation of the breeding season.
[c]Residual feed intake, the difference between observed DMI and predicted DMI.
[de]Within a row, means without a common superscript differ.

included for data sets when significant. In multiyear analyses, year was included as a random variable. Pen was included in the random statement for heifers in the individual feeding trial.

For year 3, residual feed intake (RFI) was calculated by regressing DMI on mid-test weight and ADG using PROC REG of SAS. The slope coefficients (b_m and b_g, respectively) from these analyses were then used to predict DMI using the following equation: Predicted DMI = Average DMI of the group + b_m(mid-test weight) + b_g(ADG). Residual feed intake was calculated as the difference between observed and predicted DMI; therefore, lower values indicate increased efficiency.

Results

Birth and weaning data are summarized in Table 1. Dam nutrition did not affect ($P > 0.10$) heifer birth date or birth weight. Supplementing cows with protein during late gestation tended ($P = 0.14$) to increase subsequent heifer weaning weight, and increased ($P = 0.02$) adjusted 205 day weight. Cows that grazed sub-irrigated meadows during the spring produced heifer calves with increased actual ($P = 0.09$) and adjusted ($P = 0.07$) weaning weight compared to heifers from cows fed hay. Pre-breeding weight was greater ($P = 0.04$) for heifers from protein-supplemented dams than heifers from unsupplemented dams, but spring treatment did not affect ($P > 0.10$) heifer pre- breeding weight. Overall ADG between weaning and the first breeding season was not affected by dam treatment ($P > 0.10$; data not shown).

There was no effect ($P > 0.10$) of dam nutrition on the proportion of heifers from year 2 exhibiting ovarian luteal activity prior to the breeding season (Table 2). Furthermore, there was no difference ($P > 0.10$) for pregnancy rates or calving data between heifers whose dams grazed sub-irrigated meadows and heifers whose

(Continued on next page)

dams were fed hay in the spring. However, first service pregnancy rate was 88% for heifers from protein-supplemented dams and 45% for heifers born to unsupplemented cows ($P = 0.003$). Overall pregnancy rate was 94% versus 73% ($P = 0.06$) for heifers from protein-supplemented or unsupplemented dams, respectively. Heifers born to cows supplemented with protein during late gestation calved earlier ($P = 0.07$; Table 2) and had a greater proportion of unassisted births (69% vs 38%; $P = 0.08$) than heifers whose dams were not supplemented with protein during late gestation. However, no differences ($P = 0.61$) in birth weight were detected. Weight and BCS prior to the second breeding season were not affected by maternal nutrition ($P > 0.10$; data not shown).

Data from the individual feeding trial (yr 3) are presented as simple effects (Table 3). Heifers from protein-supplemented cows were heavier ($P = 0.08$) at the end of the 84-day trial but had similar initial weights ($P > 0.10$), and similar BCS at both time points ($P > 0.10$) compared to heifers from cows that were not supplemented during gestation. Dam nutrition after calving did not affect weight nor BCS ($P > 0.10$). Neither ADG nor the ratio of gain to feed was affected ($P > 0.10$) by maternal nutrition.

Dry matter intake and RFI were affected ($P = 0.09$, $P = 0.07$, respectively) by the interaction of maternal nutrition during late gestation and after the calving season. Heifers born to protein supplemented dams had greater DMI ($P = 0.09$) if their dams were fed hay in the spring, but not if their dams grazed meadows after calving ($P > 0.10$). Similarly, heifers from protein supplemented dams had higher RFI ($P = 0.07$) if their dams were fed hay in the spring, but not if their dams grazed meadows during the postpartum period ($P > 0.10$). Higher RFI values indicate that heifers from protein supplemented cows fed hay were less feed efficient than heifers from unsupplemented cows fed hay after calving. In this data set, it appears that selecting for feed efficiency based on RFI would result in reduced DMI, but not improved ADG. In fact, the heifers with more favorable RFI also had numerically lower ADG, but the differences were not statistically significant. Gain to feed ratio was not affected by treatment.

Conclusion

Supplementing cows with protein during late gestation not only affects the nutritional plane of the cow, but has lasting effects on their heifer calf weight and reproductive performance. Heifers from protein-supplemented cows were heavier at weaning and maintained this advantage through the beginning of the breeding season, but postweaning rate of gain was similar. These same heifers tended to have higher pregnancy rates, calved earlier, and had a higher proportion of unassisted births. Cows grazing subirrigated meadows also weaned heavier calves but this weight advantage was not maintained, and reproductive performance of the heifers was not improved. In young cattle, RFI is a measure of feed efficiency correlated to reduced mature cow feed intake but not mature cow size (Arthur et al, 2004 J. Anim. Sci. Suppl. 1:449). Heifers from cows receiving protein supplement during gestation that were fed hay after calving had more favorable RFI and reduced DMI, although G:F was not influenced by maternal nutrition.

---

[1]Jeremy Martin, graduate student; Kim Vonnahme, assistant professor, Animal Science, North Dakota State University, Fargo, N.D.; Greg Lardy, professor, Animal Science, North Dakota State University, Fargo, N.D.; Don Adams, professor, Animal Science, West Central Research and Extension Center, North Platte; Rick Funston, assistant professor, Animal Science, West Central Research and Extension Center, North Platte.

A System for Wintering Beef Heifers Using Dried Distillers Grains

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

Summary

A two-year experiment compared two systems for wintering pregnant heifers. The standard system used by the ranch served as the control (CON) and the treatment system (TRT) included a dried distillers grains based supplement. Heifers in the TRT system were heavier and had greater body condition score at end of supplementation. Calving difficulty, percentage of live calves weaned and subsequent pregnancy rate were similar between systems. Calves born to heifers in the TRT system were heavier at birth and weaning. The TRT system cost $10.47/heifer less than the CON system and resulted in equivalent or improved heifer and calf growth performance.

Introduction

Purchased and harvested feeds represent a major component of the annual operating costs in cow-calf operations. Mechanically harvesting and feeding of forage is expensive and significant improvements in economic efficiency may be gained by extending the grazing season (*2001 Nebraska Beef Report*, pp.10-12). However, effective supplementation programs are required if optimal animal performance is to be achieved in extended grazing production systems.

Previous research has demonstrated the value of meeting animal nutrient requirements in extended grazing heifer wintering systems (*2004 Nebraska Beef Report*, pp. 7-9). This study showed feeding a dry corn gluten feed based supplement in an extended grazing system reduced winter costs by $6.91 compared to a conventional wintering system dependent upon hay feeding.

We hypothesized dried distillers grains (DDG) would be an acceptable supplement in an extended grazing heifer wintering system. The nutrient profile of DDG makes it attractive in forage based production settings. Dried distillers grains is an excellent source of total digestible nutrients, containing digestible fiber and relatively high levels of fat. Dried distillers grains is also high in crude protein (approximately 32%), the majority of which (65%) is undegraded in the rumen. Additionally, DDG is a good source of phosphorus (0.6%), a nutrient commonly deficient in forage based diets.

The objective of this experiment was to reduce costs in an extended grazing heifer wintering system using a DDG based supplement without decreasing heifer reproductive or calf growth performance compared to a conventional system.

Procedure

Spring-calving, crossbred heifers (n = 657, yr 1; n = 696, yr 2) were used in a two-year experiment at a commercial ranch (Rex Ranch, Abbott Unit) near Ashby, Neb. In August of each year (Aug. 21 yr 1; Aug. 26 yr 2) pregnant heifers were assigned randomly to control or treatment systems. The standard system used by the ranch for wintering pregnant heifers served as control and included access to native upland range, dry corn gluten based supplement (Table 1), and meadow hay. Hay feeding in the CON system began in December and amount fed increased as gestation advanced such that hay completely replaced range as calving approached. The treatment system included access to native range and a DDG based supplement with no hay fed. In the TRT system heifers had ad libitum access to native upland range for the entire treatment period.

Table 1. Composition of supplements.

	Composition, %DM	
Ingredient	CON[a]	TRT[a]
Dry gluten feed	72.0	—
Dried distillers grains	—	60.0
Sunflower meal	22.4	5.0
Wheat middlings	—	20.0
Milk, NFD-USDA	—	11.0
Molasses	2.5	4.0
Binder[b]	3.1	—

[a]CON is ranch standard wintering system; TRT is extended grazing system using dried distillers grains based supplement.
[b]Included to improve pellet quality.

Systems were designed to supply similar amounts of energy and meet degraded intake protein and metabolizable protein requirements. Data collected from previous research (*2004 Nebraska Beef Report*, pp. 7-9) served as a guide for predicting forage intake. Predicted forage intake, changes in forage quality and historic hay feeding records were used as inputs into the NRC (1996) model to create a supplement feeding schedule. Supplement feeding schedules (Table 2) were designed to begin in October of each year but actual starting dates were at the discretion of the ranch manager and depended on weather and forage availability. Supplement feeding was terminated at onset of calving. Average calving date was March 22. Upon termination of treatments, heifers were managed in a common group during calving and the subsequent summer grazing season.

Heifer weight and body condition score (scale 1= emaciated, 9 = obese), evaluated independently by two technicians, were recorded upon initiation of the experiment (August 21 year 1; August 26 year 2), termination of treatments (February 26, year 1; March 1, year 2), and the subsequent fall (October 14, year 1). Calves born to heifers following application of treatments were weighed at birth and

(Continued on next page)

weaning (August 28, year 1). To evaluate carry over effects of treatments on subsequent pregnancy rate, heifers were examined for pregnancy by rectal palpation in the fall (October 14, year 1). The second year of this study is still in progress; therefore, weaning weight of calves and fall weight and BCS of heifers from year 2 are not included.

Diet quality was estimated at the beginning, middle and end of the treatment period in both systems (Table 3) from masticate samples obtained from esophageally fistulated cows external to the experiment.

Costs associated with both systems in year 2 were compared using partial budget analysis. Costs from year 2 were used because management in year 1 did not closely match the prescribed feeding schedule. Actual amount of hay and supplement fed was used in the budget. Amount of grazed forage consumed was calculated from intake predictions. Hay was valued using a 10-year average price (Crop and Livestock Prices for Nebraska Producers, 2005) and winter range valued at half the current average rate for a summer AUM, according to published data (Nebraska Farm Real Estate Market Developments, 2003-2004), while actual purchase price of supplements was used in the budget. Labor costs associated with feeding were obtained from historic ranch records.

Results

Body weight ($P < 0.001$) and BCS ($P < 0.001$) were greater at the end of the supplementation period for heifers in the TRT system (Table 4). This was because ADG ($P < 0.001$) was greater and less BCS ($P = 0.03$) was lost for heifers in the TRT system. Systems were designed to result in similar performance. Heifers in the TRT system performed similarly to designed objectives. Observed differences between systems may be a result of deviations by the ranch manager from the prescribed feeding schedule for CON heifers and because forage and hay quality were different than predicted

Table 2. Predicted intakes and feeding schedules for two systems of wintering pregnant heifers in the Nebraska Sandhills

	DMI, lb/day					
	CON			TRT		
Period	Range[a]	Supplement	Hay	Range[a]	Supplement	Hay
November 1 to 30	19.0	0.9	0.0	19.0	0.9	—
December 1 to 31	13.2	1.5	5.0	18.2	1.5	—
January 1 to 31	4.8	3.0	12.0	16.9	2.9	—
February 1 to 14	—	3.5	17.0	15.0	4.2	—
February 15 to 28	—	3.5	19.0	14.2	5.6	—

[a]Predicted from NRC (1996).

Table 3. Nutrient composition of grazed forage collected by esophageally fistulated cows and hay fed in two systems for wintering pregnant heifers (mean ± standard deviation)[a]

	Year 1		Year 2	
Item	CP	IVDMD	CP	IVDMD
Range				
October	8.6 ± 0.6	63.0 ± 0.04	7.1 ± 0.7	51.2 ± 0.03
December	6.8 ± 0.6	57.9 ± 0.06	6.2 ± 0.4	52.3 ± 0.02
February	6.7 ± 0.7	49.8 ± 0.11	6.0 ± 1.8	48.0 ± 0.05
Hay	10.2 ± 0.1	56.5 ± 0.01	10.9 ± 0.1	50.6 ± 0.02

[a]Standard deviations are computed for the mean nutrient content of samples obtained from multiple esophageally fistulated cows, not across laboratory duplications; n = 3.

Table 4. Weight, body condition and subsequent reproductive and calf growth performance of heifers from two wintering systems

	Treatment			
Item	CON	TRT	SE	P-value
Heifer				
Aug. BW, lb	832	831	3	0.91
Feb. BW, lb	950	989	3	<0.001
Oct. BW, lb[a]	981	993	4	0.06
ADG, Aug to Feb., lb/day	0.63	0.83	0.01	<0.001
ADG, Feb to Oct., lb/day	0.02	0.01	0.006	<0.001
ADG, Aug to Oct, lb/day	0.07	0.08	0.004	0.003
Aug. BCS	5.5	5.5	0.02	0.39
Feb. BCS	5.1	5.2	0.01	<0.001
Oct. BCS[a]	5.0	5.2	0.1	0.30
Calving day of year	82	82	0.3	0.87
Calving difficulty[b]	1.3	1.4	0.03	0.16
Pregnancy rate, %[c]	97.1	96.5	2.3	0.64
Wean, %[d]	92.7	93.0	0.2	0.91
Calf				
Birth wt, lb	81	84	0.4	<0.001
Wean wt, lb	387	394	3	0.07
Adj. wean wt, lb[e]	386	394	2	0.03
ADG, lb/day	1.94	1.97	0.01	0.06

[a]Measured in October following application of treatments the previous winter.
[b]Calving difficulty score; 1 = no assistance, 2 = easy pull.
[c]Percentage of heifers pregnant with second calf; P-value represents chi-square analysis.
[d]Percentage of live calves at weaning; P-value represents chi-square analysis.
[e]Weaning weight adjusted to 205 days of age.

Table 5. Feed and labor costs associated with two systems for wintering pregnant heifers.

	Treatment			
	CON		TRT	
Item	$/heifer	% total	$/heifer	% total
Feed Costs				
Supplement[a]	24.29	30.6	28.44	41.2
Grazing[b]	21.67	27.3	39.70	57.8
Hay[c]	25.85	32.5	—	—
Labor Costs[d]				
Supplement	0.53	1.0	0.60	1.0
Hay	6.87	8.6	—	—
Total	79.21	100.0	68.74	100.0

[a]Delivered price to the ranch
[b]Standing winter forage valued at $13.83/AUM
[c]Hay valued at $60.87 per ton as-fed
[d]Includes ranch values of costs associated with feed delivery

values. The CON system was the standard management system employed by the operation and involved subjective management decisions made by an experienced manager. These results indicate knowledge of forage quality dynamics and application of advancements in understanding of nutrition requirements, such as the NRC (1996) model, are of value in designing management systems.

During the interval between end of supplementation and pregnancy determination, heifers in the CON system gained more weight ($P < 0.001$) than heifers in the TRT system. However, weight gain from initiation of treatments to the following October was greater ($P = 0.003$) for TRT heifers.

Calving date ($P = 0.68$) was not affected by system. Calves born to heifers in the TRT system were ($P < 0.001$) heavier at birth but calving difficulty was not different ($P = 0.16$).

Actual weight ($P = 0.07$) and ADG ($P = 0.06$) of calves tended to be greater and weaning weight adjusted to 205 d of age was greater ($P = 0.03$) for calves born to heifers in the TRT system. Several studies have shown an increase in weaning weight of calves born to cows in better nutrient status during gestation (*2005 Nebraska Beef Report*, pp. 7-9). These results suggest the increased weight may persist beyond weaning.

Subsequent pregnancy rate ($P = 0.64$) and percentage of live calves at weaning ($P = 0.91$) were similar between systems. Pregnancy rates of heifers in both treatments averaged 97%.

Analysis of costs associated with wintering heifers in both systems indicated costs were reduced by $10.47/heifer in the TRT system (Table 5). Hay and labor associated with feeding hay comprised nearly 41% of costs in the CON system. Grazed forage was the major cost in the TRT system. Labor costs account for approximately half the difference in costs between the two systems. On cow/calf operations were labor could be devoted to other enterprises the TRT system may be more attractive compared to operations were labor is not limiting.

Conclusion

These results indicate extended grazing systems for wintering pregnant heifers can result in reduced costs without sacrificing heifer and calf performance. Opportunity exists to incorporate by-products from corn milling into forage based production systems as a method of reducing costs.

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

Feeding Melengestrol Acetate to Bulls Prior to and at Puberty Alters Body Weight, and Hormone Concentration

April J. Tepfer
Ryann M. McFee
Rebecca C. Bott
Joseph S. Schulz
Debra T. Clopton
Jeffrey W. Bergman
Karl V. Moline
Kathryn J. Hanford
Andrea S. Cupp[1]

Summary

Melengestrol acetate (MGA), which is commonly used in the beef industry to manipulate ovarian activity of females, was fed to bulls at two times during development, prepubertal (5.5 to 7.5 months) and peri-pubertal (6.5 to 9.5 months), to determine effects on testes size, scrotal circumference, body weight, and/or hormone production. We can conclude that feeding bulls MGA during the prepubertal and peri-pubertal time can alter body weight and testosterone production.

Introduction

Previous studies feeding bulls 0.5 to 2.0 mg/hd/day MGA at 317 days of age for 99 days resulted in no effects on LH or testosterone concentrations or male sexual behavior. However, no experiments have determined the effects of feeding MGA prior to 9 months on testis function in bulls. In the current study MGA was fed at two critical times during development; 1) prepubertal (5.5 to 7.5 months) and; 2) peri-pubertal (6.5 to 9.5 months), to determine the effects on testes size and hormone concentration in bulls. If MGA caused an increase in either testes weight or scrotal circumference this should result in an increase in sperm production. Bulls with increased sperm production would be beneficial to those in the cattle industry raising seedstock or purebred bulls for natural mating or collection of semen for artificial insemination.

In contrast, if MGA caused decreased testis weight or scrotal circumference then this may decrease testosterone production which would be beneficial to producers that castrate bulls later in age. Testosterone has positive effects on increased lean muscle growth. However, testosterone also induces aggressive male behavior, and causes off flavor in carcasses (especially in intact males). Therefore, a reduction in testosterone production may provide the benefits of lean muscle growth while reducing the unfavorable effects associated with behavior and meat flavor.

Procedure

Experiment 1 Prepubertal

Bull calves were given a supplement of 56% soybean hulls, 40 % fine ground corn at 6 lbs/hd/day either containing MGA (1 mg/hd/day, n=12) or without MGA (n=11) while on a roughage diet from 5.5 to 8.5 months. The roughage diet included pasture, containing smooth brome grasses, during the summer months and alfalfa hay fed ad libitum during the winter months. Blood samples, scrotal circumference and body weight were collected at 7.5, 8.75, 9.5, and 11 months. In addition, two bulls were castrated at each collection time to determine individual testis weight and combined testis weight. Blood samples were evaluated for LH and testosterone concentrations (Figure 1). Data were analyzed using SAS with repeated measures and weaning weight as a covariate.

Experiment 2 Peri-pubertal

Bull calves were given a supplement of 56% soybean hulls, 40 % fine ground corn at 6 lbs/hd/day either containing MGA (1 mg/hd/day, n=12) or without MGA (n=10) while on a roughage diet from 6.5 to 9.5 mo. The roughage diet included pasture, containing smooth brome grasses, during the summer months and alfalfa hay fed ad libitum during the winter months. Blood samples, scrotal circumference and body weight were collected at 9.5, 10.5, 11.5, and 12.5 months. In addition, at least two bulls were castrated at each collection time to determine individual testis weight and combined testis weight. Blood samples were evaluated for LH and testosterone concentrations (Figure 2). Data were analyzed using SAS with repeated measures and weaning weight as a covariate.

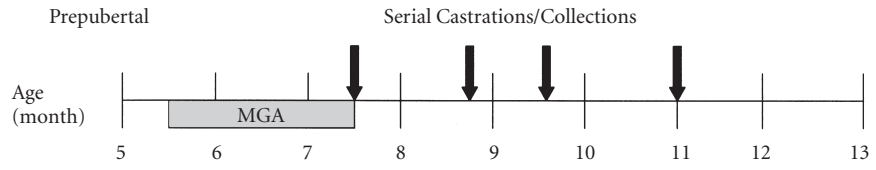


Figure 1.

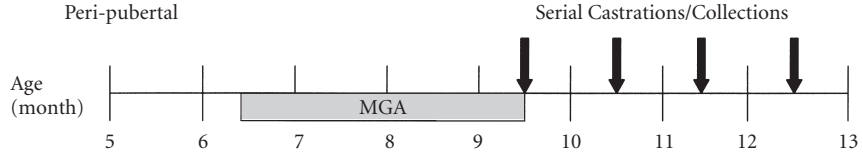


Figure 2.

Table 1. Feeding MGA during the prepubertal period.

	Bull Age							
	7.5 mo		8.75 mo		9.5 mo		11.0 mo	
	C[a]	MGA[b]	C	MGA	C	MGA	C	MGA
TW[c] (g)	102.9	180.7	222.1	206.6	306.3	190.5	416.0	301.6
CTW[d] (g)	207.0	356.9	451.8	422.6	577.9	372.0	826.7	606.2
N[e] =	2	2	2	2	2	2	2	2
SC[f] (cm)	25.1	24.2	30.8	28.4	32.1	30.0	33.0	32.0
BW[g] (lb)	504	513	552	554	606[i]	588[j]	730	755
LH (ng/mL)	0.16	0.11	0.18	0.16	0.19	0.27	0.28	0.26
Testosterone (ng/mL)	3.95	2.31	9.04	6.62	5.70[k]	4.40[l]	10.37	9.66
N[h]=	12	11	10	9	8	7	6	5

[a]C = Control
[b]MGA = Melengestrol acetate
[c]TW = Testis weight
[d]CTW = Combined testis weight
[e]N = Number of bulls castrated at each time for each group
[f]SC = Scrotal circumference
[g]BW = Body weight
[h]N =Number of bulls at each collection that were collected to determine SC, BW, LH and testosterone.
[i,j]Different letters within collection for each measurement are different at $P < 0.05$.
[k,l]Different letters within collection for each measurement are different at $P = 0.1$.

Table 2. Feeding MGA during the peri-pubertal period.

	Bull Age							
	9.5 mo		10.5 mo		11.5 mo		12.5 mo	
	C[a]	MGA[b]	C	MGA	C	MGA	C	MGA
TW[c] (g)	260.57	230.37	156.60	132.47	334.95	388.83	361.80	418.87
CTW[d] (g)	531.43	470.33	292.77	312.43	683.65	789.03	761.90	864.83
N[e]=	3	3	3	3	2	3	2	3
SC[f] (cm)	31.10	30.88	33.24	33.41	34.68	35.48	34.50	36.60
BW[g] (lb)	725.60	719.00	779.00	765.33	863.75[i]	854.33[j]	846.00	885.33
LH (ng/mL)	0.25	0.36	0.16	0.16	0.17	0.24	0.18	0.22
Testosterone (ng/mL)	8.87	5.19	4.39	5.76	7.54	8.68	5.02	13.27
N[h]=	10	12	7	9	4	6	2	3

[a]C = Control
[b]MGA = Melengestrol acetate
[c]TW = Testis weight
[d]CTW = Combined testis weight
[e]N = Number of bulls castrated at each time for each group
[f]SC = Scrotal circumference
[g]BW = Body weight
[h]N =Number of bulls at each collection that were collected to determine SC, BW, LH and testosterone.
[i,j]Different letters within collection for each measurement are different at $P < 0.05$.

Results

Experiment 1 Prepubertal

MGA treated bulls were lighter than control bulls ($P < 0.05$) at collection 3 (9.5 mo; Table 1). There was also a tendency ($P = 0.1$) at collection 3 for testosterone concentration to be lower in the MGA treated than control group (9.5 months; Table 1). Testis weight, combined testes weight, and scrotal circumference were not different between the treatment and control groups. Histological sections from bulls at each castration collection are being evaluated to determine the effects of MGA prior to puberty on testis composition.

Experiment 2 Peri-pubertal

Control bulls were heavier ($P < 0.05$) than MGA treated bulls at collection 3 (11.5 mo; Table 2). Testis weight, combined testis weight, and scrotal circumference were not statistically different between the two groups (Table 2). Further analysis of histology from testes from both experiments will determine if MGA treatments affected populations of cells within the testis or sperm maturation.

From these experiments, we can conclude that feeding MGA during the pre- and peri-pubertal period can alter testosterone production and body weight. Thus, feeding MGA during different stages of bull development may be good method to alter testis function. Further experiments with larger numbers of bulls are being conducted to provide more information on MGA's effect on testis development.

---

[1]April Tepfer, graduate student; Ryann McFee, former research technician; Rebecca C. Bott, graduate student; Joseph Schulz, laboratory manager; Debra T. Clopton , research analyst; Jeff Bergman, animal technician; Karl Moline, cow/calf manager; Kathy Hanford, research assistant professor, Andrea S. Cupp, assistant professor, Animal Science, Lincoln.

Vascular Endothelial Growth Factor mRNA Isoforms 120 and 164 are Differentially Regulated Prior to Ovulation

Robin A. Ten Broeck
Debra T. Clopton
Jeremy L. Martin
Rebecca C. Bott
Karl V. Moline
Jeff W. Bergman
Andrea S. Cupp[1]

Summary

Vascular Endothelial Growth Factor (VEGF) is produced by cells surrounding the egg in the follicle prior to ovulation. If VEGF is inhibited, ovulation does not occur. The VEGF gene can be spliced to produce different protein isoforms which have specific functions. Our objective was to determine if VEGF 120 and 164 mRNA isoforms are differentially regulated in the preovulatory follicle. From our studies, VEGF isoforms are differentially regulated during both CL regression and after a simulated LH surge. Differences observed in VEGF isoform regulation may allow for manipulation of ovulation in the beef cow.

Introduction

Follicular development within the bovine ovary is a dynamic process. It begins prior to birth and continues throughout the cow's reproductive lifespan. Angiogenesis, the formation of new blood vessels, is crucial in the ovulatory follicle. The blood vessels supply the follicle with necessary nutrients for development and growth prior to ovulation. VEGF is expressed by granulosa cells (cells surrounding the egg) prior to ovulation in the bovine follicle and is an important factor in the regulation of normal angiogenesis in the developing follicle and corpus luteum. Several VEGF isoforms exist, the most common isoforms are VEGF 164 and VEGF 120. In other tissues such as the heart and lung VEGF isoforms have specific functions in vascular development. VEGF 120 is highly diffusible and recruits endothelial cells (precursor to blood vessel cells) in the establishment of blood vessels. VEGF 164 recruits endothelial cells that form the large blood vessels. However, it is not known how these isoforms function in the ovarian preovulatory follicle nor how inhibition of VEGF might alter ovulation. The objective of the current study is to determine if the two major VEGF mRNA isoforms, 120 and 164, are differentially regulated prior to ovulation in the granulosa cells of the dominant follicle.

Procedure

Trial 1

Two injections of $PGF_{2\alpha}$ (5mg/cow) were administered 14 days apart. $PGF_{2\alpha}$ induces regression of the corpus luteum initiating the LH surge and ovulation. A vaginal probe with needle attachment was used to collect follicular fluid and granulosa cells from the dominant follicle. Follicular aspirates were collected at 12, 18, 24, 30, 36, 48, 54, 60, 66, and 72 hours (n=average of 8) after the second injection of $PGF_{2\alpha}$. Messenger RNA was extracted from granulosa cells and samples were reversed transcribed to cDNA. Progesterone and estrogen concentrations were measured in follicular fluid. A ratio greater than 1 of estrogen to progesterone indicated that the follicle was still dominant. The mRNA expression of VEGF isoforms 120 and 164 were determined using real-time quantitative polymerase chain reaction (PCR) at each follicular aspirate time point. Data were analyzed using an ANOVA with SAS. Comparisons of means were analyzed using a Tukey-Kramer test. In 12 animals, blood samples were collected after the second injection of $PGF_{2\alpha}$ at two-hour intervals from 0 to 72 hours to determine when the LH surge occurred. The LH surge was detected in six of the 12 cows and occurred between 54 and 72 hours. Due to this variation, a second trial was conducted to obtain follicle aspirates after a simulated surge of LH by injecting GnRH (0.1mg/cow).

Trial 2

Two injections of $PGF_{2\alpha}$ (5mg/cow) were administered 14 days apart with an injection of GnRH (0.1mg/cow) administered 48 hours after the second injection of $PGF_{2\alpha}$. Follicular aspirates were collected via vaginal probe with needle attachment at 3, 6, 12, and 24 hours after GnRH (n=average of 3). Messenger RNA was extracted as described previously and expression of VEGF mRNA isoforms 120 and 164 were analyzed using quantitative real time PCR. Data were analyzed using an ANOVA with SAS. Comparisons of means were tested using a Tukey-Kramer test.

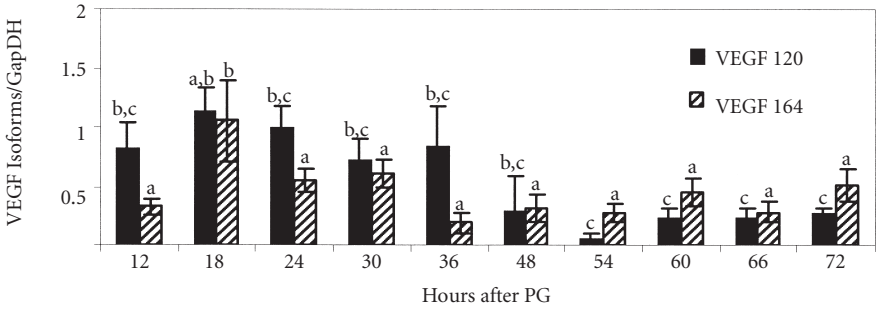


Figure 1. VEGF mRNA isoforms expression of 120 and 164 at different time points after second injection of PG. Different letters within each isoform at collection time points denote differences of $P < 0.01$.

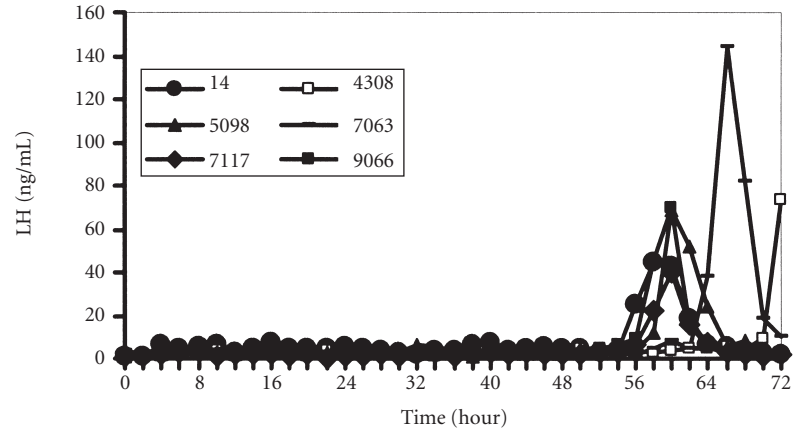


Figure 2. A subset of 12 cows were bled every two hours for 72 hours to determine timing of LH surge. This graph represents cows that displayed an LH surge within 72 hours.

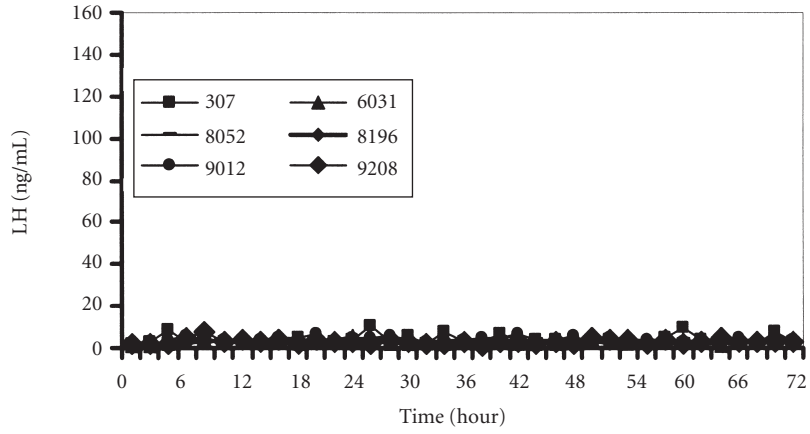


Figure 3. A subset of 12 cows were bled every two hours for 72 hours to determine timing of LH surge. This graph represents cows that did not display an LH surge within 72 hours.

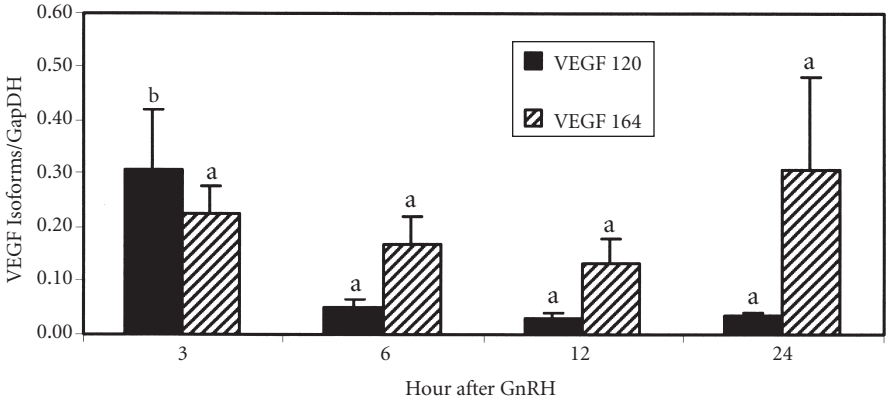


Figure 4. VEGF mRNA isoforms expression of 120 and 164 after injection of GnRH. Different letters within each isoform at collection time points denote differences of $P < 0.05$.

Results

In the first trial, the greatest concentration of VEGF 164 mRNA was observed at 18 hours post second injection of $PGF_{2\alpha}$ ($P < 0.01$; Figure 1). VEGF 164 is the predominant VEGF isoform responsible for the formation of large blood vessels. A peak in 164 isoform at 18 hour post-$PGF_{2\alpha}$ may contribute to the development of vasculature in the theca layer of the largest follicle on the ovary to establish its dominance. At 18 hours there also was an increase of VEGF 120 ($P < 0.01$) compared to time points 54, 60, 66, and 72 hour, but not compared to all other time points (Figure 1).

In the 12 cows bled to determine timing of the LH surge, 50% of the cows had an LH surge between 54 and 72 hours (Figure 2). In the other half of the cows, the LH surge did not occur within the 72-hour time period and presumably had occurred after 72 hours (Figure 3). Due to this variation in occurrence of the LH surge, data collected after the 54-hour time point was deemed not representative of all cows in the study. Luteinizing hormone has been shown to affect VEGF mRNA expression, therefore cows that had LH surges would have different VEGF mRNA expression profiles when compared to cows that did not have an LH surge at the 54 to 72 hour period. Thus a second trial was conducted to more accurately synchronize the LH surge by an injection with GnRH to determine how the LH surge would affect VEGF mRNA isoforms.

In trial 2, an increase in VEGF 120 mRNA expression ($P < 0.05$) was detected at 3 hours post GnRH (Figure 4). VEGF 120 is responsible for recruiting endothelial cells to develop initial blood vessels. The increase in VEGF 120 mRNA at 3 hours may represent recruitment of endothelial cells to develop blood vessels in the developing corpus luteum. There was no difference in VEGF 164 at any of the collections after GnRH. Thus, it appears that VEGF 164 and 120 isoforms maybe independently regulated at corpus luteum regression (trial #1) and after the LH surge (trial #2). Determining the role of VEGF isoforms during the preovulatory period may allow for better 1) synchronization of ovulation for timed-AI; and 2) corpus luteum formation which may reduce embryonic mortality in beef cattle.

[1]Robin A. Ten Broeck, graduate student; Debra T. Clopton, research technician; Jeremy L. Martin, graduate student; Rebecca C. Bott, graduate student; Karl V. Moline, cow/calf manager; Jeff W. Bergman, agriculture technician; Andrea S. Cupp, assistant professor, Animal Science, Lincoln.

Bull Exposure, When Combined With a Seven-day MGA Synchronization, Does Not Enhance Conception Rates in Cows

Michelle M. Baltes
Rebecca C. Bott
Ryann M. McFee
Joseph S. Schulz
Candice F. Toombs
Jeff W. Bergman
Karl V. Moline
Andrea S. Cupp[1]

Summary

The purpose of the current experiments was to determine if cows exposed to sterile bulls (epididyectomized) in combination with a 7-day MGA treatment would have an advantage in conception rates to cows not exposed to bulls. Bull exposure increased percentage of cows cycling prior to synchronization and reduced the time from calving to initiation of cycling. Overall there was not an increase in conception rates to timed TAI or in total pregnancy rates in bull exposed MGA treated cows when compared to cows not exposed to bulls.

Introduction

Shortening the postpartum interval for beef cows has been a difficult task for cattle producers. Although the scientific explanation is not clear, researchers have demonstrated bull exposure may reduce the postpartum anestrous interval. Cows that have been exposed to bulls early in the postpartum period resumed cyclicity sooner than nonexposed cows. Synthetic progestins, such as MGA, also have been used to induce cyclic activity in heifers and mature cows and to synchronize estrous cycles. Therefore, the objectives of this experiment were to determine if bull exposure and a 7-day MGA feeding period would increase conception rates, compared to cows administered MGA without bull exposure.

Procedure

The objectives of the following experiments were to determine the effects of bull exposure and/or 7-day MGA treatment on the following variables 1) percentage cycling at the beginning of the trial (first blood sample taken approximately 60 days before breeding); 2) percentage cycling at the time of synchronization; 3) calving to initiation of cyclic activity; 4) percentage conceived to TAI; and 5) final pregnancy rate.

In a 2002 trial, cows were exposed (n= 88) or not exposed (n= 97) to surgically sterilized bulls (epididyectomized) at least 30 days prior to breeding at a bull to cow ratio of 1:20 (Figure 1). Blood samples were taken at four different time points before the synchronization protocol was initiated. Progesterone assays were analyzed and a female was considered cycling if serum progesterone concentration was at least 1 ng/ml or greater at blood collection. The females were given a $PGF_{2\alpha}$ injection (5 mg/cow) before starting on a 7-day treatment of MGA (.5 mg/kg/day). After the MGA feeding period, the cows were again injected with prostaglandin (5 mg/cow). The females were artificially inseminated 70 hours after the second prostaglandin injection (Figure 1). Fertile bulls were placed with cows two weeks after TAI.

In a second trial, which was conducted over two years (2003-2004), a similar procedure was followed. Cows were allotted to bull exposed (n= 170) or non-bull exposed (n=176) groups and bled at regular intervals to determine cyclicity. Cows in the bull exposure group were exposed to sterile bull (epididyectomized but has libido) for at least 30 days prior to breeding at a bull to cow ratio of 1:20 (Figure 2). In this trial, cows were given an injection of GnRH (0.1 mg) before a 7-day MGA treatment. On the last day of MGA treatment, the cows were given an injection of $PGF_{2\alpha}$ and artificially inseminated 55 to 60 hours after the $PGF_{2\alpha}$ injection (Figure 2). Fertile bulls were placed with cows two weeks after TAI. All data were analyzed using SAS. Effects of treatment were determined with a one-way ANOVA and treatment means were analyzed using a Dunnett's test. Percentage of cows

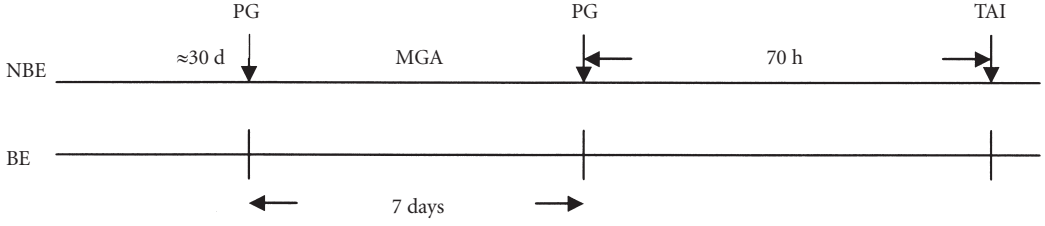


Figure 1. Experimental protocol for Trial 1.

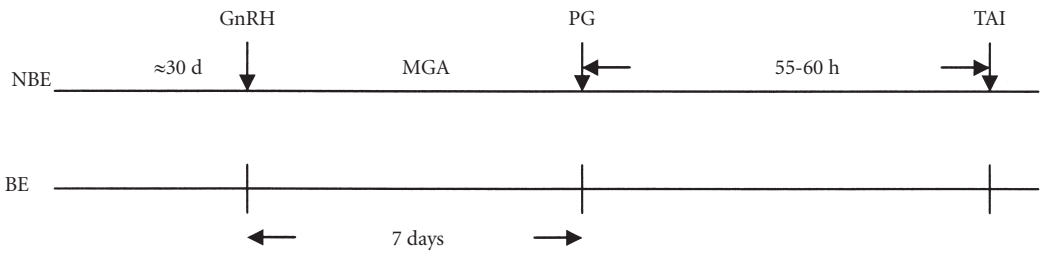


Figure 2. Experimental protocol for Trial 2.

Table 1. Results of Trial 1 conducted in 2002.

	AGE					
	First calf cows		2nd calf cows (2-3 yr of age)		Mature cows (> 3 yr of age)	
Treatment	NBE[a]	BE	NBE	BE	NBE	BE
n	26	24	21	20	50	44
Cycling at beginning of trial, %	19.2[b]	33.3[b]	19.1[b]	50.0[c]	18.0[b]	9.3[b]
Cycling after bull exposure, %	65.4[b]	75.0[b]	61.6[b]	95.0[c]	78.0[b]	95.4[c]
Calving (or birth) to start of cycling, days	412[b]	407[b]	85[b]	71[c]	50[b]	43[b]
Conceived to TAI, %	42.3[b]	50.0[b]	14.3[b]	20.0[b]	18.0[b]	16.3[b]
Final pregnancy rate, %	80.8[b]	75.0[b]	85.7[b]	95.0[b]	84.0[b]	90.7[b]

[a]NBE = No bull exposure; BE = Bull exposure.
[b,c]Different letters between columns within age depict significant differences, ($P < 0.05$).

Table 2. Results of Trial 2 conducted in 2003.

	AGE					
	First calf cows, age		2nd calf cows (2-3 yr of age)		Mature cows (> 3 yr of age)	
Treatment	NBE[a]	BE	NBE	BE	NBE	BE
n	23	24	18	19	53	50
Cycling at beginning of trial, %	52.5[b]	45.8[b]	0.0[b]	0.0[b]	3.8[b]	4.0[b]
Cycling after bull exposure, %	73.9[b]	87.5[b]	5.6[b]	36.8[c]	81.1[b]	80.0[b]
Calving (or birth) to start of cycling, days	398[b]	385[b]	112[b]	92[c]	59[b]	62[b]
Conceived to TAI, %	30.4[b]	50.0[b]	38.9[b]	42.1[b]	26.4[b]	46.0[c]
Final pregnancy rate, %	91.3[b]	87.5[b]	88.9[b]	89.5[b]	88.7[b]	94.0[b]

[a]NBE = No bull exposure; BE = Bull exposure.
[b,c]Different letters between columns within age depict significant differences, ($P < 0.05$).

cycling, pregnancy rate to TAI and final pregnancy rates were analyzed using Chi Square analysis.

Results

Trial 1

In the first trial there were more mature cows and second-calf cows cycling after bull exposure (Table 1; $P < 0.05$) compared to cows not exposed to bulls. However, there were greater numbers of second-calf cows cycling before initiation of the experiment in the bull exposed group compared to the non-exposed group. Calving to initiation of cyclic activity was reduced in the second-calf cows exposed to bulls (71 days) compared to the non-bull exposed group (85 days; Table 1; $P < 0.05$). There were no effects of treatment on percentage conceived to TAI or final pregnancy rates.

Trial 2

In 2003, 36.8% of second-calf cows exposed to bulls were cycling after bull exposure compared to the non-bull exposed (5.6%; Table 2; $P < 0.05$). The second-calf cows exposed to bulls had reduced calving to initiation of cyclic activity (92 days) compared to the non-bull exposed (112 days; Table 2; $P < 0.05$). The mature cows exposed to bulls had a significant increase in the percentage of females that conceived to TAI (46.0 %) compared to the non-bull exposed females (26.4%; Table 2; $P < 0.05$) but this was not repeated as significant in the second year.

(Continued on next page)

In 2004, both the second-calf cows and mature cows exposed to bulls had a higher percentage of females cycling after bull exposure (Table 3). The second-calf cows exposed to bulls had a reduced calving to initiation of cyclic activity (68 days) compared to the non-bull exposed (85 days; Table 3; $P < 0.05$). The second-calf cows exposed to bulls also had a higher rate of pregnancy (95.0%) compared to the control (76.2%). Mature cows exposed to bulls had a reduced calving to initiation of cycling (52 days) compared to non-bull exposed (61 days). Interestingly, the bull exposed mature cows had a lower final pregnancy rate compared to the non-bull exposed mature cows (Table 3; $P < 0.05$).

In conclusion, bull exposure in combination with a 7-day MGA feeding period does not consistently enhance conception rates to TAI or total pregnancy rates compared to cows treated for 7 days with MGA. The year to year differences may be due to body condition scores of cows in the herd prior to breeding. However, it does appear that the combination of a 7-day MGA administration with a GnRH injection on day 1 and $PGF_{2\alpha}$ on day 7 and TAI at 55 to 60 hours is a viable synchronization protocol to obtain 40-50% conception rates to TAI in cows of all ages.

Table 3. Results of Trial 2 conducted in 2004.

	AGE			
	2nd calf cows (2-3 yr of age)		Mature cows (> 3 yr of age)	
Treatment	NBE[a]	BE	NBE	BE
n	21	20	61	57
Cycling at beginning of trial, %	0.0[b]	0.0[b]	0.0[b]	0.0[b]
Cycling after bull exposure, %	38.1[b]	90.0[c]	80.0[b]	93.5[c]
Calving to start of cycling, days	85[b]	68[c]	61[b]	52[c]
Conceived to TAI, %	42.9[b]	40.0[b]	40.0[b]	51.6[b]
Final pregnancy rate, %	76.2[b]	95.0[c]	96.7[b]	87.1[c]

[a]NBE = No bull exposure; BE = Bull exposure.
[b,c]Different letters between columns within age depict significant differences, ($P < 0.05$).

[1]Michelle M. Baltes, graduate student; Rebecca C. Bott, graduate student; Ryann McFee, former technician; Joseph S. Schulz, laboratory manager; Candice F. Toombs, former laboratory manager; Jeff Bergman, agricultural research technician; Karl Moline, cow-calf manager; Andrea S. Cupp, assistant professor, Animal Science, Lincoln.

Digestibility of Undegradable Intake Protein of Feedstuffs

Josh R. Benton
Jim C. MacDonald
Galen E. Erickson
Terry J. Klopfenstein
Don C. Adams[1]

Summary

Digestibility of undegradable intake protein of subirrigated meadows, upland native range, smooth bromegrass, and other feedstuffs used in several growing trials was measured using the mobile nylon bag technique. In general, as the grazing season progressed, undegradable intake protein (UIP) digestibility of grazed forages decreased. Also, UIP digestibility was highly variable among feedstuffs. Compared to the constant 80% digestibility of UIP used by the 1996 Beef NRC, grazed and harvested forages tend to have much lower UIP digestibility values while the supplemental protein sources evaluated tend to have higher UIP digestibility values.

Introduction

The amount of protein available for absorption in the small intestine of cattle depends on the amount of microbial protein and ruminally undegradable intake protein (UIP) flowing to the small intestine as well as the digestibility of these protein sources in the small intestine. Current protein evaluation systems acknowledge that intestinal digestibility of proteins may differ between feedstuffs, but the NRC (1996) model for beef cattle still uses a constant, true digestibility of 80% for UIP, due to a lack of available data on UIP digestibility (UIPDIG). Research conducted at the University of Nebraska (*2005 Nebraska Beef Report,* pp. 25-27) showed UIP content and UIPDIG of forages is low which suggests the values used by the NRC (1996) model for the UIP content and UIPDIG of feedstuffs may be overestimated. The objectives of our study were: 1) to determine effects of season on UIP content and UIPDIG of forage samples collected from subirrigated meadow or upland native range during a grazing trial and 2) to evaluate protein characteristics of feedstuffs used in four growing trials.

Procedure

In the first experiment, meadow and range samples from a previous study (*2002 Nebraska Beef Report*, pp. 7-9) were further analyzed to determine the UIP content, UIPDIG, and total tract indigestible dietary protein (TTIDP). In the previous study, forage samples were collected from two subirrigated meadow sites and two upland native range sites at the Gudmunsen Sandhills Laboratory near Whitman, Neb. Subirrigated meadow samples consisted of warm and cool-season grasses and upland native range samples consisted of warm season grasses. Collections were made using esophageally-fistulated cows in May, June, July, August, and September of 2000. Forage samples were freeze-dried and later analyzed for IVDMD. The IVDMD was used to estimate the rate of passage (kp) using the following equation: $kp = 0.07 * IVDMD\ (\%) - 0.20$. The kp was then used to determine the mean retention time (MRT = 1/kp) and a 10-hour passage lag was added to the MRT to yield the total mean retention time (TMRT).

In the present experiment, two ruminally and duodenally cannulated steers were used to incubate 5 x 10 cm dacron bags with 50 μm pore size. Bags contained 1.25 g of forage ground through a 2 mm screen. A mixed ration of 70% smooth bromegrass hay and 30% concentrate was fed twice daily for a total intake of 1.8% BW. Four bags per steer were ruminally incubated for 75% of the TMRT determined using the IVDMD. The 75% TMRT incubation time points of the meadow and range samples are shown in Table 1. After ruminal incubation, all bags were frozen. Two bags per sample were later thawed and prepared for duodenal insertion. Bags were first pre-incubated in a pepsin and HCl solution at 37°C for 3 hours to simulate abomasal digestion. Bags were inserted into the duodenum 2 hours post-feeding at a rate of 1 bag every 0.1 hour for a total of 12 to 13 bags/steer/day. Bags were recovered in the feces beginning 12 hours after insertion and frozen until all bags had been collected. After all bags had been intestinally incubated, the ruminally incubated bags and intestinally incubated bags were thawed and washed in a washing machine for 0.25 hours. This was done using five rinse cycles consisting of a 1 minute agitation and a 2-minute spin per cycle. Bags were subsequently bulk refluxed in neutral detergent solution to remove microbial contamination of the residue. Residues were then analyzed for NDIN using a combustion method.

In the second experiment, feed ingredients and forage diet samples from four previous growing trials were analyzed for UIP, TTIDP, and UIPDIG. Three of these previous trials were grazing studies from 2002, 2003, and 2004 where animals rotationally grazed smooth bromegrass pastures. In each of these three studies, two ruminally cannulated heifers per pasture were used to collect forage diet samples of the grazed forage throughout the grazing season, but collection strategies differed each year. In 2002, all pastures in the rotation were sampled at two time points and samples were composited by time. In 2003, diet samples were collected at three times during the trial from the pasture where cattle were grazing at that time. In 2004, cattle grazed each pasture for one day. Two pastures were sampled at the start of each rotation, one was a pasture the cattle had grazed the previous day and the other was the pasture they would graze that

(Continued on next page)

Table 1. Protein characteristics of subirrigated meadows and upland native range from May to September.

	May		June		July		August		September		
Item	M[a]	R	M	R	M	R	M	R	M	R	SEM[b]
CP, %DM[c]	14.1[h]	12.2[i]	11.9[i]	9.4[j]	12.3[i]	9.6[j]	11.8i	9.0[j]	8.5[j]	9.4[j]	0.6
IVDMD, %[d]	70.2[h]	67.7[h]	67.3[h]	63.6[i]	59.0[jk]	61.6[ik]	57.2[jl]	55.8[l]	50.4[m]	52.5[m]	1.2
UIP, %DM[e]	1.65[hj]	1.88[hj]	1.87[hj]	1.87[hj]	1.60[hi]	1.48[hi]	1.44[hi]	2.05[j]	1.26[i]	2.44[k]	0.29
TTIDP, %DM[f]	0.91[h]	1.08[hi]	1.06[hi]	1.19[i]	1.09[hi]	1.20[i]	1.14[hi]	1.70[j]	1.11[hi]	2.18[k]	0.15
UIPDIG, %UIP[g]	43.3[h]	40.2[hi]	43.0[hi]	36.1[hi]	30.1[ij]	21.2[jk]	16.1[jkl]	10.9[kl]	6.5[l]	13.1[kl]	6.3

[a]M = subirrigated meadow, R = upland native range.
[b]SEM = standard error of the mean.
[c]Forage x Month ($P < 0.01$).
[d]Forage x Month ($P = 0.02$).
[e]UIP = Undegradable intake protein, calculated as follows: UIP (% DM) = (NDIN at 75% total mean retention time * 6.25) / sample DM. Forage x Month ($P < 0.01$).
[f]TTIDP = total tract indigestible dietary protein, calculated as follows: TTIDP (% DM) = (fecal NDIN * 6.25) / sample DM. Forage x Month ($P < 0.01$).
[g]UIPDIG = UIP digestibility, calculated as follows: UIPDIG (% of UIP) = 1 - (TTIDP / UIP). Forage x Month ($P = 0.57$). Forage ($P = 0.24$). Month ($P < 0.01$).
[h, i, j, k, l, m]Means within a row with unlike superscripts differ ($P < 0.05$).

day. Those diet samples were averaged to obtain an average diet sample for that time. Samples were collected at eight times in 2004. The other nongrazed feed ingredients analyzed in Experiment 2 were: the commercially available methionine source Smartamine M™ (MET), corn cobs (COB), bloodmeal (BM), corn gluten meal (CGM), SoyPass™ (SP), feathermeal (FM), two sources of dry distillers grains (DDGA and DDGB), sorghum silage (SS) and corn bran ruminally incubated for 21 or 30 hours (BRAN21 or BRAN 30). The grazed forage samples and SS were freeze-dried and then all samples were ground through a 2 mm screen for the in situ incubations or a 1 mm screen for lab analysis. In vitro dry matter disappearance (IVDMD) was determined on the forage samples (COB, SS and grazed forage samples) and used to estimate TMRT as described in Experiment 1.

Two ruminally and duodenally cannulated steers were used to incubate 5 x 10 cm dacron bags with 50 μm pore size containing 1.25 g of sample. Steers were fed smooth bromegrass hay twice daily at ad libitum intake. Four bags per steer of each sample were ruminally incubated during one of two incubation periods. The forage samples (COB, SS and grazed forage diet samples) were ruminally incubated for 75% of their TMRT. All other feed ingredients were ruminally incubated for 16 hours except for the BRAN21 and BRAN30.

Table 2. Protein characteristics of smooth bromegrass diet samples collected in 2002 and 2003.

Year:	2002			2003			
Item	May 30	June 10	SEM[a]	May 14	June 4	July 1	SEM[a]
CP, %DM[bc]	19.9	15.1	0.50	25.3	13.3	20.4	0.82
IVDMD, %[bc]	61.5	51.9	0.81	69.5	51.3	53.9	0.41
UIP, %DM[bcd]	3.70	2.10	0.14	2.05	2.50	3.55	0.04
TTIDP, %DM[bef]	1.80	0.95	0.08	0.83	1.30	2.08	0.17
UIPDIG, %UIP[g]	49.0	54.3	1.82	58.1	48.3	41.3	5.40

[a]SEM = standard error of the mean.
[b]In 2002, collection times differ ($P < 0.05$).
[c]In 2003, quadratic effect of time ($P < 0.05$).
[d]UIP = Undegradable intake protein, calculated as follows: UIP (% DM) = (NDIN at 75% total mean retention time * 6.25) / sample DM.
[e]In 2003, linear effect of time ($P < 0.05$).
[f]TTIDP = total tract indigestible dietary protein, calculated as follows: TTIDP (% DM) = (fecal NDIN * 6.25) / sample DM.
[g]UIPDIG = UIP digestibility, calculated as follows: UIPDIG (% of UIP) = 1 - (TTIDP / UIP).

Two incubation times were used because it is unclear how long corn bran remains in the rumen. These two time points represent 75% of the expected total mean retention time (21 hours) and a hypothetical maximum retention time (30 hours). After ruminal incubations, all bags were frozen. Four bags per sample were later thawed and prepared for duodenal insertion. A total of 12 to 16 bags/steer were intestinally incubated each day. All bags were inserted, collected, and handled as in Experiment 1.

In Experiment 1, data were analyzed as repeated measures using the MIXED procedures of SAS. The UIP, TTIDP, and UIPDIG was analyzed with animal as a random effect. For Experiment 2, data were analyzed with the MIXED procedures of SAS. For grazed forage diet samples, the animal used to collect the diet sample was the experimental unit and repeated measures were used when samples were collected more than three times. For nongrazed samples, the animal in which the bags were inserted was the experimental unit. Means were separated using the pdiff option in SAS and contrasts were developed to make more precise comparisons for DDGA versus DDGB and BRAN21 versus BRAN30. Animal was considered to be random for both sample types.

Results

Protein characteristics and IVDMD of subirrigated meadows and upland native range are shown in Table 1. There was a forage x

Table 3. Protein characteristics of smooth bromegrass diet samples collected in 2004.

Item	1[a]	2	3	4	5	6	7	8	SEM[b]
CP, %DM[c]	21.2	21.9	19.7	20.4	20.1	19.5	22.5	21.4	0.63
IVDMD, %	68.7	67.7	62.9	67.5	63.6	62.6	69.1	63.5	2.08
UIP, %DM[d]	2.14	2.14	2.10	2.02	2.10	2.28	2.01	2.53	0.17
TTIDP, %CP[ef]	—	1.00	1.15	1.03	1.20	1.40	1.17	1.37	0.08
UIPDIG, %UIP[eg]	—	50.0	44.9	47.4	42.3	43.9	42.1	45.7	4.75

[a]Collection dates: 1=May 4; 2=May 12; 3=May 20; 4=May 28; 5=June 5; 6=June 13; 7=June 25; 8=July 9.
[b]SEM = standard error of the mean.
[c]Quadratic effect of time ($P < 0.05$).
[d]UIP = Undegradable intake protein, calculated as follows: UIP (% DM) = (NDIN at 75% total mean retention time * 6.25) / sample DM.
[e]Linear effect of time ($P < 0.05$).
[f]TTIDP = total tract indigestible dietary protein, calculated as follows: TTIDP (% DM) = (fecal NDIN * 6.25) / sample DM.
[g]UIPDIG = UIP digestibility, calculated as follows: UIPDIG (% of UIP) = 1 - (TTIDP / UIP).

Table 4. Protein characteristics of harvested forages and supplement ingredients used in four growing trials.

Item	MET[a]	BM	FM	SP	CGM	DDGA	DDGB	BRAN21	BRAN30	SS	COBS	SEM[b]
CP, %DM	47.4	84.7	85.8	49.7	70.1	29.7	31.0	14.4	14.4	8.89	3.78	—
IVDMD, %	—	—	—	—	—	—	—	—	—	61.6	47.0	—
UIP, %CP[c]	101[f]	89.5[g]	60.4[j]	65.3[i]	69.7[h]	55.7[k]	51.3[k]	18.6[l]	16.6[l]	19.9[l]	91.1[g]	1.98
TTIDP, %CP[d]	34.5[f]	11.8[hi]	16.4[i]	2.20[j]	3.55[j]	5.52[jk]	5.70[jk]	12.7[hi]	10.6[hk]	12.6[hi]	44.1[g]	1.84
UIPDIG, %UIP[e]	65.9[f]	89.6[h]	72.9[i]	96.6[h]	94.9[h]	90.0[h]	88.9[h]	31.3[j]	35.4[j]	36.3[j]	51.6[g]	3.38

[a]Samples: MET=Smartamine M™; BM=bloodmeal; FM=feathermeal; SP=SoyPass™; DDGA and DDGB=dried distillers grains from two sources; BRAN21 and BRAN30=corn bran ruminally incubated for 21 and 30 hours, respectively; SS=sorghum silage; COBS=corn cobs.
[b]SEM = standard error of the mean.
[c]UIP = Undegradable intake protein, calculated as follows: UIP (% CP) = (residue CP * residue wt) / (sample CP * sample wt) where residue is the remaining sample after ruminal incubation for 75% total mean retention time for SS and COBS, 21 h and 30 h for BRAN21 and BRAN30, respectively, or 16h for all other samples.
[d]TTIDP = total tract indigestible dietary protein, calculated as follows: TTIDP (% CP) = (fecal CP * fecal wt) / (sample CP * sample wt).
[e]UIPDIG = UIP digestibility, calculated as follows: UIPDIG (% of UIP) = 1 - (TTIDP / UIP).
[fghijkl]Superscripts within row differ ($P < 0.05$).

month interaction ($P < 0.03$) for CP, IVDMD, UIP, and TTIDP in Experiment 1. From May to September, the CP and IVDMD values decreased($P < 0.05$) 39.8 and 28.2% , respectively, for meadow. For range, the CP and IVDMD values decreased ($P < 0.05$) 22.7 and 22.4%, respectively, from May to September. Meadow had higher ($P < 0.01$) CP values compared to range from May to August and meadow also had a higher ($P < 0.01$) IVDMD value in June compared to range. Undegradable intake protein (% DM) of meadow was similar ($P > 0.07$) from May to August, and UIP was also similar ($P > 0.12$) in July, August, and September. From June to September, UIP decreased 32.9% for meadow. For range, UIP was similar ($P > 0.05$) in May, June, and July and from July to September, UIP increased 64.6%. For meadow, TTIDP was similar ($P > 0.10$) from May to September. For range, TTIDP was similar ($P > 0.38$) from May to July and then there was an 81.5% increase from July to September. In August and September, UIP and TTIDP were higher ($P < 0.02$) for range than for meadow. There was not a forage x month interaction ($P = 0.57$) for UIPDIG and there was also no main effect ($P = 0.24$) of forage which would suggest that meadow and range have similar UIPDIG from May to September. There was, however, a main effect ($P < 0.01$) of month. From May to September, UIPDIG decreased 85.1% and 67.5% for meadow and range, respectively.

Characteristics for diet samples collected from animals grazing smooth bromegrass in 2002, 2003, and 2004 are shown in Tables 2 and 3, respectively. In 2002 and 2003, CP and forage quality, measured as IVDMD, declined ($P < 0.05$) from May to June. In 2003, both the CP and IVDMD increased from June to July. In 2004, CP and IVDMD were generally high and did not change much. The fact that forage quality did not decline in 2004 as it did in 2002 and 2003 is likely related to the amount of precipitation and heat in June. The UIP content declined ($P < 0.05$) from May to June in 2002, however; in 2003 and 2004, there was an increase ($P < 0.05$) in the UIP content from May to July. The TTIDP content decreased ($P < 0.05$) in 2002 from May to June, while in 2003 and 2004, there was an increase ($P < 0.05$) in TTIDP from May to July. This resulted in an increase ($P < 0.05$) in UIPDIG from May to June in 2002. From May to July, UIPDIG tended to decrease ($P = 0.12$) in 2003 and did decrease ($P < 0.05$) in 2004.

The protein characteristics of harvested forages and supplement ingredients used in growing trials is shown in Table 4. This data set represents feedstuffs with a wide range of CP and UIP contents. Several protein sources such as BM, SP, CGM and distillers grains had UIPDIG values which were

(Continued on next page)

greater than 80%, while samples used as amino acid sources (FM and MET) had UIPDIG values slightly lower than 80%. Harvested forages (SS and COBS) and corn bran had UIPDIG values that fit within the range of the grazed forage samples tested in this data set; UIP content and digestibility were low.

These data suggest there is large variation in UIPDIG among feedstuffs. Compared to the constant 80% UIP digestibility currently used by the 1996 Beef NRC, forages tend to have lower UIPDIG values and several protein sources tend to have higher UIPDIG values. The protein characteristics tended to act similar across the grazed forages tested. With the exception of smooth bromegrass collected in 2002, both UIP and TTIDP content increased and UIPDIG decreased as grazing season progressed and forage quality declined. The UIPDIG is highly variable across grazed forages and is likely related to forage quality and CP content. The UIPDIG ranged from 58.1% of UIP for smooth bromegrass that was 69.5% IVDMD and 25.3% CP in May of 2003 to 6.5% for mature subirrigated meadow in September of 2000 that was 50.4% IVDMD and 8.5% CP.

All UIPDIG measured in grazed forages were much lower than the 80% currently used by the 1996 Beef NRC model. Our data suggest forages supply little MP in the form of UIP because of low UIP and UIPDIG values and MP supply may be overestimated using current prediction models. Using a simple model to estimate total MP supply with the option to change UIP digestibility from 80%, we calculated the total MP for two forage samples from this study. In our model, microbial efficiency was reduced with lower forage quality. For smooth bromegrass that had 58.1% UIP digestibility, total MP supply was reduced 6.4% by using 58.1% instead of 80% UIP digestibility in the model. For subirrigated meadow that had 6.5% UIP digestibility, total MP supply was reduced 33.8% by using 6.5% instead of 80% UIP digestibility. From the modeling, it appears that using a constant 80% UIP digestibility is more of a problem for lower quality forages where the true UIP digestibility may be much lower. While 80% may be an appropriate value on average, more specific data for different feedstuffs is needed if accurate metabolizable protein (MP) balances are to be determined for different classes of cattle.

---

[1]Joshua R. Benton, graduate student; Jim C. MacDonald, research technician; Galen E. Erickson, assistant professor, Animal Science, Lincoln; Terry J. Klopfenstein, professor, Animal Science, Lincoln; Don C. Adams, professor, West Central Research and Extension Center, North Platte.

Effect of Fat and Undegradable Intake Protein in Dried Distillers Grains on Performance of Cattle Grazing Smooth Bromegrass Pastures

Jim C. MacDonald
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

Growing heifers grazing smooth bromegrass pastures were supplemented daily with dry distillers grains, corn bran + corn oil, or corn bran + corn gluten meal to determine the relative contributions of fat and undegradable intake protein in dried distillers grains to animal performance. For cattle supplemented from 0 to 0.75% body weight with dried distillers grains, ADG was improved by 0.14 lb for every 0.10% BW increase in dried distillers grains supplementation. Cattle supplemented with corn bran + corn gluten meal gained 38% as much as cattle supplemented with dry distillers grains while cattle supplemented with corn bran + corn oil showed no improvement in ADG over cattle supplemented with a corn bran control supplement. Neither fat nor undegradable intake protein account for all the observed improvement in ADG from supplementing dry distillers grains.

Introduction

Dried distillers grains (DDG) have been shown to increase ADG in animals consuming both low and high quality forages (*2005 Nebraska Beef Cattle Report,* pp. 18-20) yet the reason for increased gain is unproven. It has long been recognized that cattle consuming actively growing forages will respond to undegradable intake protein (UIP) supplementation because the protein in the forage is highly degraded in the rumen causing a metabolizable protein (MP) deficiency (*1990 Nebraska Beef Cattle Report,* pp. 65-67). Dried distillers grains consist of approximately 15 to 20% UIP (DM), thus it is likely that UIP is responsible for the additional gain. However, DDG also contains 8 to 12% fat (DM) and 40 to 45% fiber (DM). The relative contributions of these nutrients to the performance of cattle grazing forages remains undocumented and are important because DDG nutrient compositions will change as the milling industry continues to alter the manner in which it processes corn. The purpose of the present study was to determine the relative contributions of UIP and fat to the performance of growing cattle grazing high quality forage.

Procedure

One hundred twenty crossbred heifers (811 lb, SD=86) were used to determine the relative contributions of UIP and fat measured as ether extract (EE) in DDG to animal performance. Heifers were blocked by previous gain and randomly received one of ten treatments in a 3 x 3 + 1 factorial arrangement with three supplements, three levels, and a control. Heifers rotationally grazed six smooth bromegrass pastures (IVDMD=65.7%, CP=20.8% DM, UIP=2.17% DM) which were nine acres each. Supplements were provided individually using a Calan gate system and refusals for each animal were collected weekly. Heifers were limit fed for 5 days at the beginning and end of the trial and weights were measured for three consecutive days to minimize variation in gut fill.

Supplements are shown in Table 1 and included DDG (15.8% UIP, 9.67% EE), corn gluten meal (CGM; 31.6% UIP, 0.83% EE) to provide UIP, or corn oil (OIL; 0.74% UIP, 19.3% EE) to provide fat. Corn gluten meal and corn oil were selected as sources of UIP and fat, respectively, because like DDG, they are derived from corn and therefore their amino acid and fatty acid profiles, respectively, should be similar to DDG. Levels of daily DDG supplementation were 1.65, 3.30, and 4.95 lb DM per head while CGM and OIL were supplemented daily with 0.83, 1.65, and 2.48 lb DM per head. While heifers supplemented with CGM and OIL were offered half the DM compared to heifers supplemented with DDG, their respective concentrations of UIP and fat were doubled such that the levels of these

(Continued on next page)

Table 1. Composition of supplements.

	Composition, %DM									
	DDG[a]			CGM			OIL			CONT
Ingredient/level	1[b]	2	3	1	2	3	1	2	3	
Dry distillers grains	96.8	98.4	98.9	—	—	—	—	—	—	—
Corn gluten meal	—	—	—	53.8	55.5	56.1	—	—	—	—
Corn oil	—	—	—	—	—	—	17.3	17.8	18.0	—
Corn bran	—	—	—	32.5	33.6	33.9	69.0	71.3	72.0	81.8
Molasses	—	—	—	7.4	7.7	7.8	7.4	7.7	7.8	7.1
Salt[c]	3.2	1.6	1.1	6.3	3.2	2.2	6.3	3.2	2.2	11.1

[a]DDG contained 15.8% undegradable intake protein (UIP), 9.67% ether extract (EE); CGM contained 31.6% UIP, 0.83% EE; OIL contained 0.74% UIP, 19.3% EE; CONT contained 2.07% UIP, 1.23% EE.
[b]Levels of DDG: 1=1.65 lb/hd/day, 2=3.30 lb/hd/day, 3=4.95 lb/hd/day; Levels of CGM and OIL: 1=0.83 lb/hd/day, 2=1.65 lb/hd/day, 3=2.48 lb/hd/day; CONT=0.55 lb/hd/day.
[c]Included to provide 25g/hd/day salt.

nutrients matched those found in DDG. Control heifers were each offered daily 0.55 lb of a supplement containing corn bran and molasses to serve as a carrier for salt. For CGM and OIL, corn bran was used as a carrier and molasses was included to bind the supplement and improve palatability. Salt was included in all supplements at levels that provided 25 g per head per day.

Forage intake for cattle consuming DDG was predicted from animal performance using TDN values for DDG and forage samples. Forage TDN was estimated from IVDMD values that were adjusted to In vivo digestibility values. This was accomplished by including five hay samples which had known In vivo digestibility values as standards in the In vitro run. The In vitro values were regressed on the known In vivo values for the five standards and the resulting equation was used to adjust the forage samples of interest. The TDN for DDG was set at 108% based on its comparison to corn fed in forage diets (*2003 Nebraska Beef Cattle Report,* pp. 8-10). Animal performance was used to predict TDN intake using the following equation by Winchester: TDN = 0.0553 $BW^{2/3}$ (1+0.805 ADG) where ADG and BW are expressed in pounds. This product was adjusted using the following equation that more accurately reflects forage intake in the current situation based on a study where cattle consuming forage diets were supplemented DDG and forage intake was directly measured (*2005 Nebraska Beef Cattle Report,* pp. 18-20): adjusted TDN intake = (predicted TDN intake - 2.07) / 0.94. The TDN from DDG intake was subtracted from TDN required to meet animal performance and the remaining TDN requirement was divided by TDN of the forage to yield forage intake.

Statistical analysis was conducted using the mixed procedures of SAS with block considered to be a random effect. Many heifers consumed less supplement than was offered such that it was not logical to analyze the data based on treatment allotments. Therefore, actual average daily UIP and fat intake as %BW were used as a covariate for regression analysis comparing DDG vs. CGM and DDG vs. OIL. Regression equations were developed using the solutions option in SAS with the highest order polynomials included in the equation that were significant at P<0.05. The statistical model and estimate statements were developed so it could be determined if each slope was different from 0 and if slopes were different from one another. The intercept was forced through the response of control cattle.

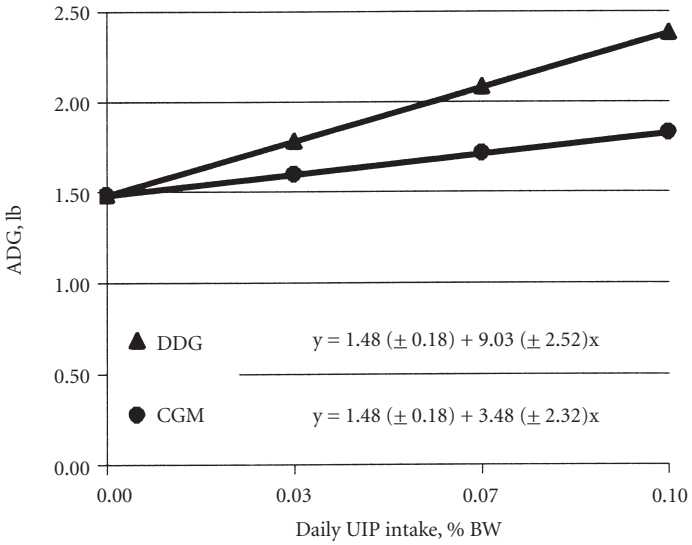


Figure 1. Effect of undegradable intake protien (UIP) intake from dry stillers grains (DDG) or corn gluten meal (CGM) on ADG. DDG slope > 0 ($P < 0.01$). CGM slope > 0 ($P = 0.14$). DDG slope > CGM slope ($P = 0.10$).

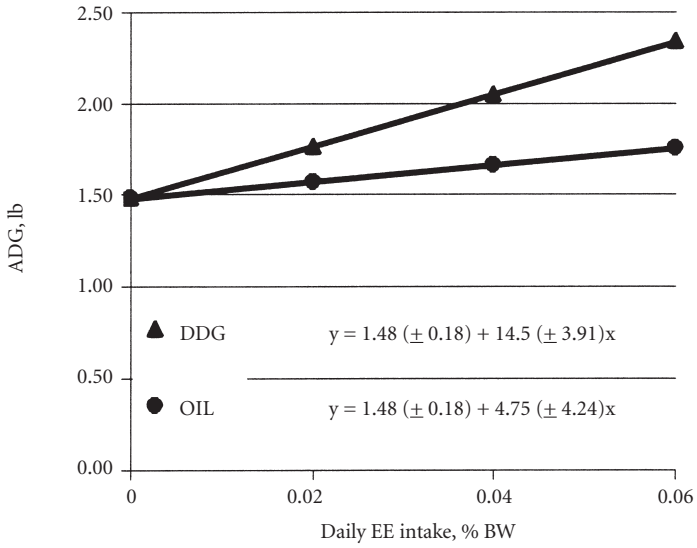


Figure 2. Effect of ether extract (EE) intake from dry stillers grains (DDG) or corn oil (OIL) on ADG. DDG slope > 0 ($P < 0.01$). OIL slope > 0 ($P = 0.26$). DDG slope > CGM slope ($P = 0.09$).

Results

Figure 1 and Figure 2 shows the response of ADG to UIP and fat supplementation, respectively. Animal performance was improved (P<0.01) from DDG supplementation when expressed either as UIP or EE intake as %BW. When expressed as DM intake as %BW (data not shown), the DDG slope was 1.42 (±0.39) and was significantly different from 0 (P<0.01). This equates to an 0.14 lb increase in ADG for every 0.10 %BW

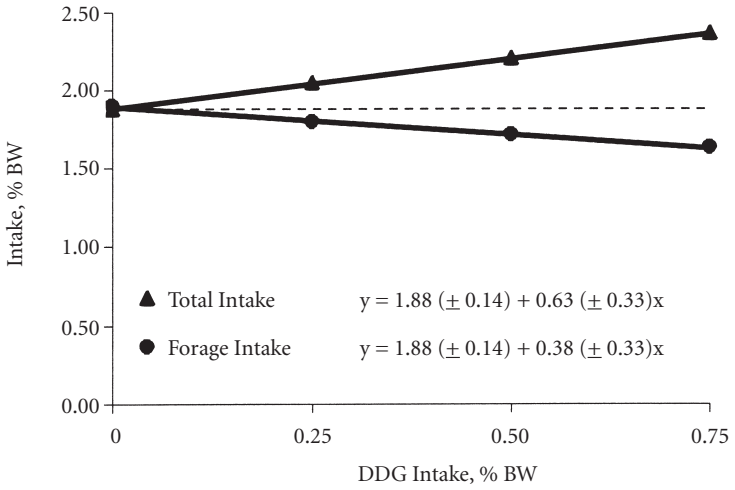


Figure 3. Effect of dry distillers grains supplementation on forage intake and total intake. Total intake slope > 0 ($P < 0.07$). Forage intake slope < 0 ($P = 0.27$). Dashed line represents intake of controls.

increase in DDG supplementation within the range of DDG supplemented in this study. Cattle in this study consumed DDG from 0 to 0.75% BW. Using these data, a 700 lb steer consuming 3.5 lb DDG (0.50% BW) would be expected to gain 0.70 lb/day more than the same animal not consuming DDG. This response matches closely with a previous gain response with high quality forages observed at the University of Nebraska (*2005 Nebraska Beef Cattle Report,* pp. 18-20), which measured a 0.13 lb increase in ADG for every 0.10 %BW increase in DDG supplementation.

Performance tended to be improved (P=0.14) from CGM supplementation, while the slope for OIL was not different from 0 (P=0.26). The response from DDG tended to be greater than the response from both CGM (P=0.10) and OIL (P=0.09). The slope for CGM was 38.5% the slope for DDG which may represent the proportion of the response of DDG that is due to meeting a MP deficiency. The fact that the response of CGM is linear rather than quadratic may indicate cattle used excess protein for energy. The lack of response from adding energy from OIL supplementation is not surprising considering MP is first limiting in these cattle and ruminal microbes yield essentially no microbial crude protein from fat. Therefore, supplying additional energy without protein should not be expected to improve gain. However, the added response of DDG over CGM and OIL suggests that adding energy and protein in combination may allow for additional gain. Other nutrients provided in DDG, such as phosphorus may also contribute to the additional gain, but we are unable to separate their relative contributions with these data.

The effects of DDG supplementation on forage intake and total intake are shown in Figure 3. There tended to be an increase in total DMI (P<0.07), but no significant decrease in forage intake (P=0.27) due to DDG supplementation. We have previously reported that one pound of DDG replaces from 1.72 (*2004 Nebraska Beef Cattle Report,* pp. 25-27) to 0.53 (*2005 Nebraska Beef Cattle Report,* pp. 18-20) pounds of forage in grazing cattle. The replacement rate for the current study was 0.38 lb forage replaced per lb DDG supplemented, but this small change was not significantly different from 0 when accounting for the variation in this study. Forage replacement may be inversely related to ADG because cattle in the current study showed the greatest gain response with no significant change in forage intake, while cattle in the afore mentioned study with the largest reduction in forage intake showed the smallest improvement in ADG. This issue needs to be developed further in the future because forage replacement is an important factor in determining the value of DDG in grazing situations.

Dry distillers grains significantly increase ADG in cattle grazing high quality forages. The response to CGM and lack of response to OIL in this data set suggests a portion of the increased ADG is due to meeting a MP deficiency. An associative effect of providing a combination of protein and energy from UIP and fat may be responsible for the additional gain observed from DDG supplementation. Other nutrients such as phosphorus may also play a role, but cannot be separated from these data.

---

[1]Jim C. MacDonald, graduate student; Galen Erickson, assistant professor, Animal Science, Lincoln; Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Effects of Supplementing Dried Distillers Grains to Steers Grazing Summer Sandhill Range

Sarah E. Morris
Jim C. MacDonald
Don C. Adams
Terry J. Klopfenstein
Rex L. Davis
Jim R. Teichert[1]

Summary

Yearling steers continuously grazed summer native Sandhill range, with supplementation of varying levels of dried distillers grains with solubles (DDGS): 0.26, 0.51, 0.77, and 1.03% BW. Forage intakes were predicted using an equation based on TDN. Forage intakes linearly decreased as level of DDGS increased. Average daily gain linearly increased as level of DDGS increased. Steers were finished and slaughtered. No significant differences were found in feedlot performance or carcass data. Economical analyses were conducted and suggest supplementing DDGS is profitable. Increased gain from supplementing yearling steers DDGS while grazing summer range did not affect feedlot performance and can be economical.

Introduction

Increased production of ethanol in Nebraska is increasing the availability of distillers by-products for producers. Distillers grains plus solubles (DGS), is an excellent supplement for cattle in grazing situations, due to its high energy, protein, and phosphorus levels. In grazing situations or for producers not in close proximity to an ethanol plant, dried DGS (DDGS) are easier to transport, store, and handle than the wet product. The cost of grazing forages is increasing, while the cost of DDGS is decreasing. This increased cost of grazing may encourage producers to look for a substitution or supplemental source for their forages, in which DDGS may be a good fit. The objectives of this trial were to predict forage intake, determine rate of replacement of forage, and determine effects on animal performance by increasing supplemental DDGS, as well as evaluate economics of supplementing DDGS.

Procedure

Grazing

Fifty-six yearling steers (686 ± 54 lb) were stratified by weight and randomly assigned to one of five treatments in a completely randomized design. Treatments were supplementing varying levels of DDGS to steers continuously grazing native summer Sandhill range. Trial duration was 88 days, divided into three periods. Weights were obtained at the beginning and end of the trial. Levels of DDGS were on a percent BW basis. To determine DDGS levels the highest level was set at 7.5 lbs (DM), with the intention steers would consume 7.5 lbs (DM) during days 31-60. The four remaining lower levels were determined as a percent, 0, 25, 50, and 75%, of the highest level. Treatment levels were 0, 0.26, 0.51, 0.77 and 1.03 %BW. Weights were projected at the beginning of each period, and DDGS offered adjusted to account for weight gain. Steers continuously grazed except during supplementation six days/week. Steers were gathered in the morning (six days/week) and individually supplemented, in feeding crates, their respective amount of DDGS. Distillers grains offered and any refusals were weighed out daily to determine DDGS intake.

Feedlot and Carcass

All steers were placed into a feedlot at West Central Research and Extension Center at North Platte, where they were fed for 113 days. Steers were placed into two pens per treatment, for a step up period of 21 days and a period of 37 days on finisher to estimate individual intakes. All animals were combined into one pen for the remaining 55 days. Three animals were removed from the feedlot study due to death or sickness. The animals were slaughtered and carcass data were collected.

Prediction of Individual Intakes

Three esophageally fistulated cows were used to collect monthly diet samples to determine TDN of the pasture. To predict forage intake, total TDN intake was calculated using an equation developed by Winchester, based on ADG and BW, $TDN = 0.0553\ BW^{2/3}(1 + 0.805GAIN)$. The predicted total TDN intake was adjusted using a regression equation obtained from a previous growing trial (*2005 Nebraska Beef Report*, pp 18-20) where TDN intake, BW, and ADG were known. This regression equation was acquired by predicting total TDN intake using Winchester's equation and regressing it against known total TDN intake; without nonsupplemented cattle. The resulting equation is as follows, where $adjusted\ TDN\ intake = (known\ TDN\ intake - 2.069) \div 0.936$ ($R^2 = 0.754$). The adjusted total TDN intake establishes the total TDN consumed by the animal. Total DDGS TDN intake was subtracted from the adjusted total TDN intake. The remaining TDN value was divided by the known diet TDN (57.22% TDN), resulting in forage DMI.

Economical Analysis

Two economical analyses were conducted. The first analysis, estimated the added value of supplementing DDGS to animals on pasture, accounting for value in both added gain and reduced forage intake. The additional gain was valued by determining the income from selling the

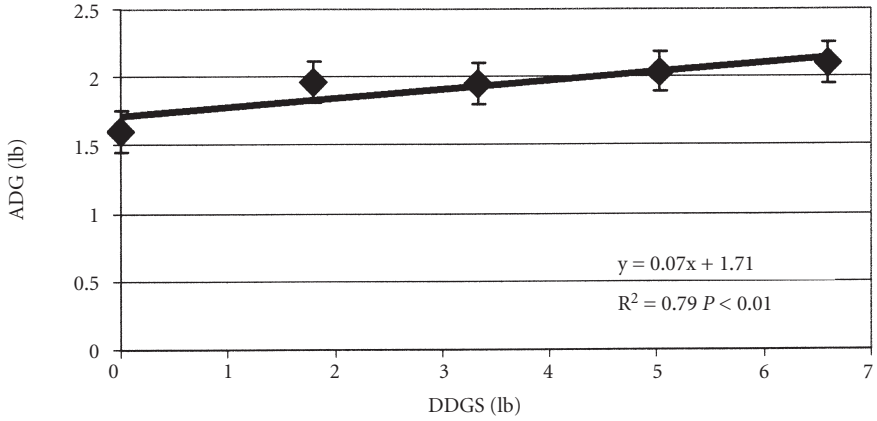


Figure 1. Effect of supplemental dried distillers grains on average daily gain.

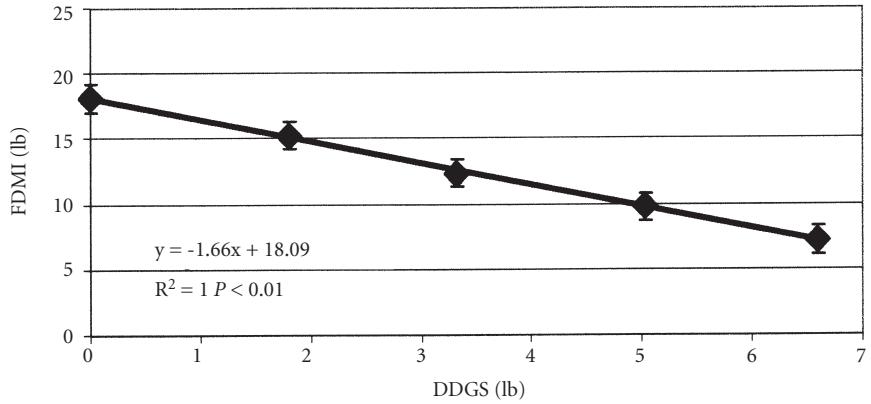


Figure 2. Effect of supplemental dried distillers grains on predicted forage dry matter intake.

Table 1. Feedlot performance; treatment applied during grazing.

	Treatment (%BW)						
	0	0.26	0.51	0.77	1.03	SE	*P*-value
Avg DDGS intake, lb/day (DM)	0	1.80	3.33	5.03	6.60	0.19	
Initial BW, lb	836	867	872	875	876	31.96	0.64
Final BW, lb	1265	1314	1305	1284	1306	45.50	0.79
DMI, lb	23	23	23	23	22	0.46	0.12
ADG, lb	3.79	3.95	3.83	3.62	3.80	0.19	0.52
F:G	6.20	5.99	6.00	6.51	5.95	0.33	0.42

additional weight at the end of the grazing period. The selling price was estimated using the following regression equation, *y = -0.0498x + 136.15* where y = price paid and x = animal weight (lb). This equation was developed using the five year average of feeder calf prices for September, and accounts for lower prices at heavier weights. The forage replaced by DDGS was valued at the 2004 grazing price (animal unit month) in Nebraska.

The second analysis evaluated the profitability of selling the animals after the summer grazing period versus the feedlot period. The purchase price was based off of the five-year average for feeder calf prices at 700 lb during April ($98.44/cwt). Price of DDGS was based on $110/ton (as-is) with labor and delivery costs accounted for. Feedlot diet costs were based off 10-year averages for corn and alfalfa, $2.27/bushel and $62.50/ton (as-is) respectively, wet corn gluten feed was priced at the cost of corn. Handling costs for all ingredients were accounted for in the analysis. Yardage was set at $0.30/day, and interest at 9%. Break even prices were calculated on $/cwt basis.

Statistical Analysis

All data were analyzed using the mixed procedure in SAS.

Results

Summer and Feedlot Performance

Summer ADG linearly increased ($P < 0.01$) as level of DDGS increased (Figure 1). Controls gained 1.71 lb per day with the rate of increased gain at 0.07 lb per lb of DDGS. Predicted forage DMI decreased linearly ($P < 0.01$) as level of DDGS increased (Figure 2). Forage intake for control steers was 18.09 lb per day, with the rate of decline in forage intake at 1.66 lb per pound of DDGS. These results suggest that supplementing DDGS replaces forage while increasing animal performance.

Feedlot ADG, DMI, and F:G (Table 1) were not significantly different. In addition, no significant differences were found in any carcass data collected. These results suggest additional gain attained from DDGS supplementation during the summer does not affect cattle performance in the feedlot or carcass traits.

Economical Analyses

Supplementing DDGS to cattle in grazing situations appears to be profitable through increased selling weight and decreased forage costs. Table 2 shows the value of supplementing all levels of DDGS. Total DDGS value averaged over all levels of supplementation was $163.51. The systems approach of evaluating the economics of supplementing DDGS during the summer versus through the feedlot (Table 3) suggests that if

(Continued on next page)

cattle were sold off pasture, lowest breakeven would be at the highest level of supplementation (1.03%BW) at $90.03/cwt. In contrast if the cattle were retained through the feedlot, breakeven costs would decrease, with lowest breakeven at the third level (0.51%BW) of supplementation at $78.62/cwt. These results suggest supplementing DDGS is profitable for either selling cattle off grass or retaining ownership through the feedlot.

In conclusion, DDGS appear to be a viable supplement to cattle in grazing situations with increased animal performance and decreased forage intake, with no adverse effects in feedlot performance or carcass traits. Economical analysis evaluating added value of DDGS, suggest supplementing DDGS is economical in grazing situations. Evaluation of economics from a systems standpoint, suggest supplementation of DDGS is economically advantageous during both the grazing and feedlot periods.

[1]Sarah Morris and Jim MacDonald, graduate students; Terry Klopfenstein, professor, Animal Science, Lincoln; and Don Adams, professor; Rex Davis, beef unit, Jim Teichert, beef unit, Animal Science, West Central Research and Extension Center, North Platte.

Table 2. Value of dried distillers grains and solubles (DDGS) due to improved animal performance (IAP) and reduced forage intake (RFI).

	Treatment (% BW)				
	0	0.26	0.51	0.77	1.03
Supplemental DDGS, avg lb per day (DM)	0	1.80	3.33	5.03	6.60
Beginning wt, lb[a]	689	687	688	682	683
End wt, lb[b]	832	840	850	853	863
Sale Price, $ per 100 lbs[c]	94.70	94.30	93.84	93.65	93.15
Revenue, $[d]	788.22	792.48	797.29	799.23	804.28
DDGS value from IAP, $ per ton[e]	—	56.49	64.97	52.12	58.02
DDGS value from RFI, $ per ton[f]	—	105.61	105.61	105.61	105.61
Total DDGS value, $ per ton[g]	—	162.09	170.58	157.73	163.63

[a]Average start weight for each treatment.
[b]Expected weight after 84 days based on the equation $y = 0.07x + 1.71$ where y = ADG and x = DDGS intake.
[c]Sale price per 100 lb determined from the equation $y = -0.0498x + 136.15$ where y = sale price and x = sale weight (lbs).
[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/ level/day (84).
[f]DDGS value (DM) due to reduced forage intake assuming a forage cost of $21.65 per animal unit month.
[g]Total DDGS Value (DM) from IAP + RFI.

Table 3. Economic evaluation using systems approach calculating breakeven costs for selling cattle after supplementation of distillers grains off grass or after retaining ownership through the feedlot.

	Treatment (% BW)				
	0	0.26	0.51	0.77	1.03
Avg DDGS intake, lb/d (DM)	0	1.80	3.33	5.03	6.60
Breakeven selling off grass[a]	95.26	91.61	91.11	90.05	90.03
Breakeven selling after feedlot[b]	81.53	78.81	78.62	80.12	79.81

[a]Selling price can be calculated using the equation used in Table 2 to determine selling price.
[b]Selling price can be calculated using the 5-year average for fat cattle in December at $78.26/cwt live weight basis.

Influence of Dried Distillers Grains Supplementation Frequency on Forage Digestibility and Growth Performance

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

Summary

Two experiments evaluated the influence of dried distillers grains supplementation frequency on forage digestibility and growth of yearling steers. In Exp. 1, treatments were dried distillers grains fed at 16.7% of the diet either daily, every other day or every third day. Diet DM, OM and NDF digestibility decreased linearly as dried distillers grains supplementation occurred less frequently. In Exp. 2, 48 crossbred steers were used in a two-year study to compare corn/soybean meal with dried distillers grains as winter supplements. Steers performed similarly when supplements were fed 6 days/week but performance was decreased when dried distillers grains was fed 3 days/week. Better animal performance may result from more frequent supplementation of dried distillers grains.

Introduction

In many forage-based production systems, supplemental protein is provided during periods of limited forage quality and/or quantity to increase animal weight gain and improve forage intake and digestibility. Supplemental feeds comprise a significant portion of variable costs of beef production and providing protein supplements less frequently may reduce costs without negatively impacting performance.

In situations where forage energy content does not support desired productivity, energy supplementation may be necessary. Energy supplements containing nonstructural carbohydrates, such as cereal grains, often depress forage intake and digestibility. However, balancing the diet for degraded intake protein requirements may alleviate this problem. Dried distillers grains (DDG) is an excellent source of energy that does not contain nonstructural carbohydrates. Additionally, the high undegraded intake protein and phosphorus content make DDG an ideal supplement for growing cattle consuming forage based diets.

Objectives of these experiments were to determine the influence of DDG supplementation frequency on intake, digestibility and growth performance of beef cattle consuming forage based diets.

Procedure

Experiment 1: Digestion Trial

Eight crossbred steers (818 ± 66 lb) were assigned randomly to treatment in a replicated 3 X 3 Latin square design with three periods. Treatments were DDG fed either daily, every other day or every third day. Dried distillers grains comprised 16.7% of the diet dry matter for all treatments. Steers were housed in individual pens (6 x 3 m) in a semi-enclosed barn with unrestricted access to fresh water. Periods lasted 21 days and total tract diet digestion was assessed from day 16 to 21 of each period. On day 1 through 9 of each period, cool season grass hay, chopped to a 15-cm particle size, was provided ad libitum, with orts from the previous day determined before feeding. Beginning on day 10 of each period, amount of hay fed was reduced to 90% of the average hay intake on day 1 through 9. Limiting amount of hay offered resulted in elimination of orts during the fecal collection period.

Before hay feeding, DDG was provided to those steers receiving DDG every day at 16.7% of the previous day's DMI. For steers assigned to every other day and every third day treatments, DDG was fed at 33.3% of the average DMI for the previous two day and 50.0% of the average DMI for the previous three days, respectively, on the appropriate supplementation day. Nutrient content of hay and DDG is listed in Table 1.

Table 1. Digestion trial feedstuff nutrient content (Exp 1).

Item	Grass Hay	Dry Distillers Grains
DM, %	95.9	92.1
OM, %	90.2	97.7
NDF, %	67.2	43.5
IVDMD, %	53.4	—
CP, %DM	6.7	34.1
Fat, %DM	—	10.2

Steers were fitted with fecal bags on day 16, with bags changed once every 12 hours, for a total fecal collection period of 6 days. Digestibility of DDG NDF was assumed to be 80%.

Experiment 2: Steer Performance Trial

Each year for two years, 48 crossbred steers (470 ± 49 lb) were stratified by weight and assigned randomly to replicated supplementation groups, with 6 steers per group. Steers in the same supplementation group were identified by a colored ear tag. Two supplementation groups (ear tag colors) were assigned randomly to treatments. Treatments were designed to result in similar ADG using 1996 NRC software. The control (CON) treatment consisted of ad libitum access to grass hay in a drylot and the daily equivalent of 4.4 lb/steer (DM) corn-soybean based supplement (Table 2) fed 6 days/week. Steers in all other treatments grazed upland winter range in a common pasture and were sorted into one of 6 pens 6 days/week according to ear tag color and fed the daily equivalent of either 6.0 lb/steer (DM) corn-soybean based supplement 6 days/week (SBM), 4.2 lb/steer (DM) DDG based supplement 6 d/week (DDG6) or 4.2 lb/steer (DM) DDG based supplement 3 days/week (DDG3). Steers in the DDG3 treatment were offered twice the amount

(Continued on next page)

offered to DDG6 on alternate supplementation days however DDG3 fed steers only consumed the daily equivalent of 3.9 lb/steer (DM) supplement over the course of the experiment. Treatments were designed to supply similar amounts of energy and meet metabolizable protein and degraded intake protein requirements according to NRC (1996). Previous research has shown dried distillers grains has about 125% the energy of corn. Therefore, calves were supplemented with 70% as much dry matter to provide equivalent energy intake.

Steers were weighed on two consecutive days upon initiation and termination of the 62-day trial without limiting intake prior to weighing. Hay used in the trial was subsampled and analyzed for DM, CP and IVDMD, while supplements fed were analyzed for CP.

A partial budget was used to compare costs and calculate cost of gain associated with each treatment. Hay, corn and soybean meal were valued using a 10 year average price (*Crop and Livestock Prices for Nebraska Producers, 2005*; $60.87/ton, $2.22/bu, and $9.68/cwt respectively) while a price of $75/ton was used for dried distillers grains. Costs included $11.79/ton for labor and equipment associated with feeding hay and $35/ton for delivery of corn, soybean meal and distillers grains. Winter range valued at half the current average rate for a summer AUM, according to published data (*Nebraska Farm Real Estate Market Developments, 2003-2004*). It was assumed cattle were checked daily, therefore costs associated with delivering supplement were the same for all treatments.

Table 2. Supplement composition and feedstuff nutrient content (%DM; Exp. 2).

	Treatment[a]			
Ingredient	Hay	CON	CSM	DDG
Dry distillers grains	—	—	—	97.80
Dry rolled corn	—	53.67	65.64	—
Soybean meal	—	43.31	32.16	—
Molasses	—	—	—	—
Limestone	—	1.67	1.22	1.22
Salt-	1.13	0.82	0.82	
Trace mineral premix[b]	—	0.17	0.12	0.12
Vitamin premix[c]	—	0.05	0.04	0.04
Nutrient content				
CP, %	6.6	27.8	25.7	32.0
IVDMD, %	53.4	—	—	—

[a]Steers fed a corn/soybean based supplement in a dry lot (CON) or while grazing native winter range (CSM) or fed dried distillers grains while grazing range either 6 (DDG6) or 3 (DDG3) days per week.
[b] Contained (g/kg of premix): 130 Ca; 10 Co; 15 Cu; 2 I; 100 Fe; 80 Mn; and 120 Zn.
[c]Contained 29.9 million IU of vitamin A, 6.0 million IU of vitamin D, and 7,000 IU of vitamin E/kg of premix.

Table 3. Effect of dried distillers grains supplementation frequency on DM, OM, and NDF intake and OM and NDF digestibility by steers (Exp 1).

	Treatment[a]				*P*-value[c]	
Item	D	2D	3D	SEM[b]	L	Q
Daily DMI, % BW						
Hay	2.36	2.22	2.22	0.04	0.03	0.13
Total	2.67	2.50	2.51	0.05	0.04	0.14
Daily OM intake, % BW						
Hay	1.93	1.80	1.81	0.03	0.03	0.13
Total	2.37	2.22	2.23	0.04	0.04	0.15
Daily NDF intake, % BW	1.69	1.58	1.59	0.03	0.04	0.13
Diet digestibility, %						
DM	58.1	56.0	55.0	0.4	0.001	0.32
OM	62.3	60.3	59.1	0.5	0.001	0.53
NDF	58.8	57.8	57.4	0.6	0.12	0.73
Hay digestibility, %						
DM	51.4	50.1	50.4	0.7	0.33	0.32
OM	55.4	54.4	54.7	0.7	0.45	0.44
NDF	58.8	57.8	57.4	0.6	0.12	0.73

[a]D = daily supplementation; 2D = supplementation every other day; 3D = supplementation every third day.
[b]Standard error of the mean, n = 18.
[c]L = linear effect of supplementation frequency; Q = quadratic effect of supplementation frequency.

Results

Experiment 1: Digestion Trial

Hay ($P = 0.06$) and total ($P = 0.08$) DMI decreased linearly as supplementation frequency decreased (Table 3). Similarly, as DDG supplementation frequency decreased so did hay ($P = 0.07$) and total ($P = 0.08$) organic matter intake. Daily NDF intake decreased linearly ($P = 0.07$) as supplementation frequency decreased.

Apparent total-tract DM ($P = 0.002$), OM ($P = 0.002$) and NDF ($P = 0.07$) disappearance of the diet decreased linearly as supplementation frequency decreased.

Among other possibilities, decreased digestibility as a consequence of less frequent feeding may be related to the fat content of distillers grains (10.2 %). On the day of supplementation dried distillers grains comprised 50% of the diet in steers supplemented every third day, adding 5% fat to the diet. Hay has 2.0 to 2.5% ether extract. Feeding fat at these levels may be enough to depress digestibility.

Table 4. Weight and average daily gain of steers fed a corn/soybean based supplement in a dry lot (CON) or while grazing native winter range (CSM) or fed dried distillers grains while grazing range either 6 (DDG6) or 3 (DDG3) days per week (Exp. 2)

	Treatment					
Item	CON	CSM	DDG6	DDG3	SE[a]	*P*-value
Initial BW, lb	468	468	470	470	1	0.98
Final BW, lb	585[b]	594[b]	581[b]	560[c]	1	0.004
ADG, lb/day	2.0[b]	2.0[b]	1.8[b]	1.4[c]	0.1	0.004

[a]Standard error of the mean, n = 16.

Table 5. Costs associated with feeding a corn/soybean based supplement to steers in a dry lot (CON) or grazing native winter range (CSM) or feeding dried distillers grains either 6 (DDG6) or 3 (DDG3) days per week to steers grazing range (Exp. 2).

Item	CON	CSM	DDG6	DDG3
Supplement cost, $/hd	25.05	31.37	15.57	14.78
Hay cost, $/hd	20.27	—	—	—
Range cost, $/hd	—	8.60	11.11	11.38
Total cost, $/hd	45.32	39.97	26.68	26.16
Cost of gain, $/cwt	37.29	31.76	23.78	29.30

Experiment 2: Steer Performance Trial

Steers receiving CON, CSM and DDG6 treatments had similar ADG but gain was reduced in the DDG3 treatment. Decreased gain in DDG3 steers is likely due to reduced forage digestibility as observed in Exp. 1. Other research has demonstrated reduced gain in animals fed DDG less frequently (*2003 Nebraska Beef Report*, pp. 8-10). Incomplete consumption of supplement may also have contributed to reduced performance. Steers in the DDG3 treatment consumed the equivalent of 0.3 lb per day less supplement than DDG6 steers.

These results agree with past research (*2004 Nebraska Beef Report*, pp. 22-24) and indicate balancing diets for degradable intake protein requirements when feeding supplements containing non-structural carbohydrates may reduce effects of starch on fiber digestibility. Cost of gain was greatest for CON treated steers primarily because of costs associated with feeding hay (Table 5). Total costs were least but gain was also least for DDG3 steers making cost of gain greatest among steers grazing range. Feeding dried distillers grains six days per week resulted in the lowest cost of gain.

Conclusion

Forage digestibility and animal performance were reduced and cost of gain increased when DDG were fed less frequently. These results may be related to the fat content of DDG. Previous research has shown DDG has about 125% the energy of corn. Therefore, calves were supplemented with 70% as much DM to provide equivalent energy intake. This concept is validated by the equal gains of calves fed CSM and DDG6 primarily because of lower amount fed.

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

Dried Distillers Grains Supplementation of Calves Grazing Corn Residue

Kristin H. Gustad
Terry J. Klopfenstein
Galen E. Erickson
Kyle J. Vander Pol
Jim C. MacDonald
Matt A. Greenquist[1]

Summary

Dried distillers grains (DDGS) were fed to weanling steer calves grazing nonirrigated corn residue to determine daily gain response and residue intake response to increasing levels of DDGS (from 1.5 to 6.5 lb/day in 1 lb increments). The DDGS was fed individually using Calan electronic gates. Daily gain increased from 0.9 (1.5 lb DDGS) to 1.8 (6.5 lb DDGS) lb/day . Forage intake decreased from 11.3 (1.5 lb DDGS) to 8.3 (6.5 lb DDGS) lb/day . Results provide information for selecting a DDGS supplementation level to achieve a target gain.

Introduction

Due to their high energy (108% TDN) and high protein content (30.1%) dried distillers grains (DDGS) fit well as a protein and (or) energy supplement in many grazing situations. Corn residues are a relatively inexpensive feed resource, but are low in protein and energy, especially for growing calves, backgrounded for entry into the feedlot or for summer pasture, or for replacement heifers. Beef producers often target a specific ADG so it is important to know the amount of DDGS to supplement to calves grazing corn residues in order to achieve a desired level of daily gain. The objectives of our experiment were to determine the effects on ADG of incremental DDGS supplementation to calves grazing corn residue, and predict the effect of supplementation on forage intake.

Procedure

One hundred and twenty steers (512 ± 37 lb) were stratified by weight and assigned randomly to incremental levels of DDGS treatments. Steers were limit fed a 47.5% alfalfa, 47.5% WCGF 5% supplement diet for five days at the beginning and end of the trial and weighed for three consecutive days to minimize variation due to gut fill. Treatments included 1.5, 2.5, 3.5, 4.5, 5.5, and 6.5 lb DDGS/head daily adjusted to a percentage of body weight (.29, .49, .69, .88, 1.08, and 1.27 % respectively.) The DDGS contained 12.4% fat and 30.1% CP. Calves were weighed on consecutive days biweekly to adjust the amount of DDGS offered. Minerals and vitamins were added to the DDGS supplements to meet NRC requirements.

All steers were individually fed supplement using Calan electronic gates. Thirty calves were selected as a control group and fed a diet of 70.9% brome hay, and 29.1% sorghum silage with DDGS treatments assigned randomly within the group. Diet intake was directly measured for individual steers in the control group. Ninety calves grazed 90 acres of corn residue for 95 days. Grazing calves were gathered every morning at 6:30 and allowed three hours to consume supplement, then returned to the field for grazing.

Corn residue samples were collected biweekly using two ruminally canulated heifers and IVDMD was determined.

Results

Average daily gain increased ($P < .001$) with increasing levels of DDGS, with grazing calves ranging from .9 to 1.8 lbs/day (Figure 1). Some calves fed the two highest levels of DDGS (5.5 and 6.5 lb/day) did not consume all of the DDGS offered. Actual DDGS intakes are used in Figure 1 to determine ADG response to level of DDGS. The quadratic effect of DDGS levels on ADG suggests that gains didn't increase much above 1.1% of body weight of DDGS (Figure 2). Because there were some refusals of DDGS at the highest level of feeding (6.5 lb/day), we suggest a practical limit of 1.1% BW of DDGS supplementation (5.5 lb/day). Obviously, the amount (lb/day) would be greater for larger calves.

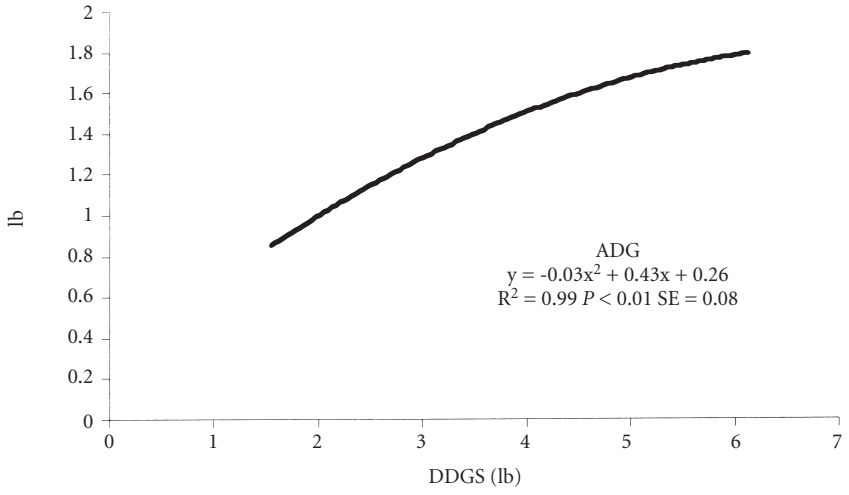


Figure 1. Grazing cattle average daily gain and predicted forage dry matter intake response due to increased levels of DDGS.

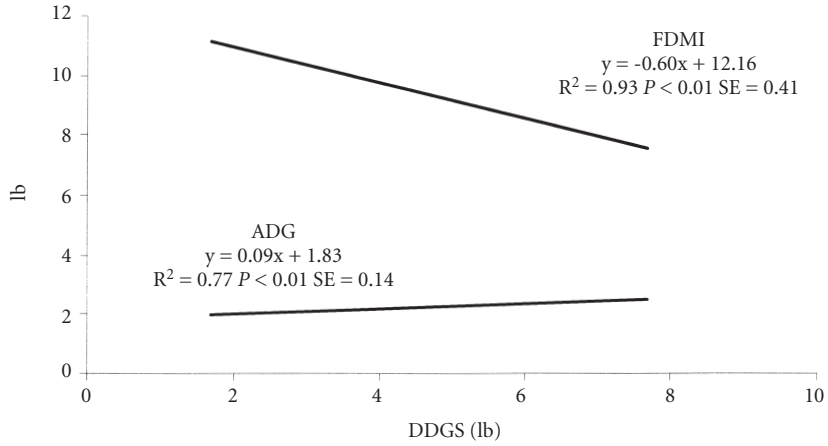


Figure 2. Control cattle group average daily gain and forage dry matter intake response due to increased levels of DDGS.

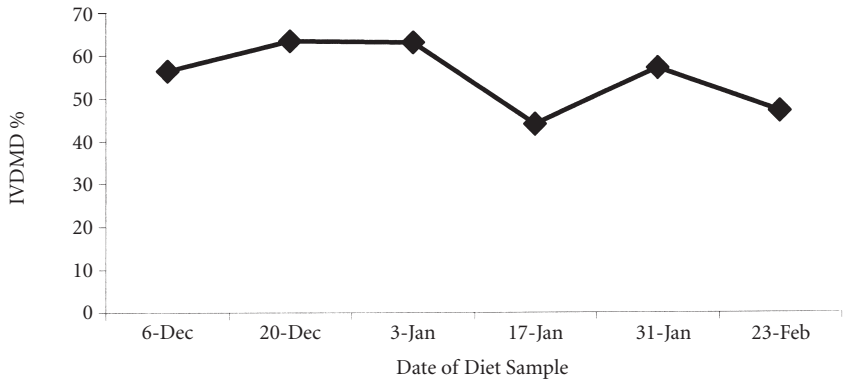


Figure 3. In vitro dry matter digestibility of corn residue over time.

Calves fed hay had ADG ranging from 1.9 to 2.4 lb (Figure 2). Differences in gain were due to differing TDN of corn residue and hay diet (55% and 59% respectively). Forage intake in the hay-fed calves (Figure 2) decreased linearly (P<.001) with DDGS supplementation. Values ranged from 11.3 lb at 1.5 lb DDGS supplementation to 8.3 at the high supplementation level. Figure 3 depicts the digestibility of the corn residue which varied from 56.4% early in the grazing period to 46.9% at the end of the period with an average of 55.1%. Animal selectivity is the logical explanation to an overall decrease in quality with time. The low point fell at 44.0% during a period of snow cover. Intake of the control, hay-fed calves decreased by about 27% as DDGS level increased from 1.5 to 6.5 lb/day. We therefore assume a similar decrease in intake of the corn residue. This could provide a feasible option to extend the stocking rates of corn stalks, while still improving ADG. Theoretically, one could increase stocking rate by 27%.

Figure 1 provides information necessary for a producer to determine the DDGS supplementation level necessary to achieve a targeted gain. For example, if 1.5 ADG is desired, then 4 lb of DDGS would be fed. The calves would consume 73% as much residue. We estimate cornstalk grazing cost at $.12 per calf daily. With reduced consumption of corn residue (73%) the cost would be $.09 per day. We estimate delivered price of DDGS to be about $110 per ton. the 4 lb of DDGS (4.3 lb air dry) would cost $.24 per day for a total feed cost of $.33 per day or $.213 per lb gain at 1.5 lb ADG.

---

[1]Kristin H. Gustad, graduate student; Terry J. Klopfenstein, professor; Galen E. Erickson, assistant professor; Kyle J. Vander Pol, Jim C. MacDonald and Matt A. Greenquist, technicians, Animal Science, Lincoln.

Effect of Corn Hybrid and Processing Method on Site and Extent of Nutrient Digestibility Using the Mobile Bag Technique

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

Summary

The influence of corn hybrid and processing method onsite and extent of DM, starch, and protein digestibility was determined using the mobile bag technique. Samples consisted of three hybrids with known digestibility and feeding value processed as either dry-rolled corn (DRC) or high-moisture corn (HMC). Ruminal and total tract nutrient digestibilities were greater for HMC compared to DRC. Differences among hybrids existed for all variables measured except ruminal starch digestibility and degradable intake protein. Undegradable intake protein (UIP) digestibility was greater for HMC compared to DRC (77.8 and 73.7%, respectively). However, UIP was lower for HMC than DRC. Differences among processing methods and hybrids exist for site and extent of nutrient digestibility.

Introduction

The site of digestion (i.e., rumen or intestinal) is critical to understanding the impact on performance. More intense corn processing methods or selection of hybrids with desirable kernel traits has been shown to improve the extent of starch digestion by increasing the amount digested in the rumen. Previous research also shows that degradable intake protein (DIP) for high moisture corn increases as moisture and length of ensiling increases. However, the effects of high-moisture ensiling on undegradable intake protein (UIP) digestibility are unknown. The current NRC Beef Cattle Nutrient Requirement model assumes UIP digestibility is 80% for all feedstuffs. Because UIP from corn provides a large amount of metabolizable protein (MP) to finishing cattle, small changes in UIP digestibility can have a large impact on MP. The objectives of this research were to determine site and extent of DM and starch digestibility, and to determine undegradable intake protein digestibility of three hybrids processed as either dry-rolled corn (DRC) or high-moisture corn (HMC).

Procedure

Two ruminally and duodenally cannulated steers were used to incubate 5 x 10 cm dacron bags with a 50 um pore size. Bags were filled with 1.75 g of DM sample ground through a 0.25 in screen to simulate masticated corn. Dry rolled corn samples were ground as-is and HMC samples were ground frozen. The samples consisted of three hybrids: H-8562 (1), 33P67 (2), and H-9230 Bt (3), processed either as DRC or reconstituted HMC. Dry corn was coarsely rolled, reconstituted to 28% moisture and ensiled to mimic early harvested HMC. These hybrids were also fed in previous feedlot and metabolism studies (*2004 Nebraska Beef Reports,* pp. 54; *2006 Nebraska Beef Reports*, pp. 40). A concentrate diet consisting of 68.5% DRC, 20% wet corn gluten feed, 7.5% alfalfa, and 4% supplement was fed at 1.8% BW. Particle size analysis was performed using a wet sieving method to determine the geometric mean diameter and geometric standard deviation. An incubation time of 22 hours was used representing 75% of the mean retention time calculated from the inverse of a passage rate at 3.44%/hour. Fifty-eight bags/sample were ruminally incubated in each animal and frozen. Eight bags/sample were used to measure ruminal digestibility, the remaining 50 bags/sample were thawed and prepared for duodenal insertion. To simulate abomasal digestion, bags were incubated in a pepsin and HCl solution (1 g pepsin/L of 0.01 N HCl) at 37°C for 3 hours. Fourteen bags were inserted daily into the duodenum and subsequently frozen after being recovered in the feces. After intestinal incubation, the ruminally incubated bags and intestinally incubated bags were thawed and machine rinsed along with four bags/sample that were not incubated. The nonincubated bags were used to determine the percentage residue that was washed out without incubation. Residue from twenty bags was composited within animal for the intestinal samples to determine degradable intake protein, undegradable intake protein digestibility, and starch digestibility.

Results

Particle size analysis indicated there were differences among hybrids and processing methods for geometric mean diameter (GMD), and geometric standard deviation (GSD). The GMD was greater ($P < 0.01$) for DRC compared to HMC (2193 μ and 1184 μ, respectively). The differences among processing methods for GMD are comparable to true masticated samples with HMC having a smaller GMD than DRC. Hybrid 2 had the largest GMD, followed by hybrids 1 and 3. There was no attempt to change the particle size among hybrids by altering the knives on the mill. The percent washout for the 0 h samples were 2.4 times greater ($P < 0.01$) for HMC compared to DRC (data not shown). The percent washout for hybrids 1 and 3 were approximately 50% greater ($P = 0.01$) than hybrid 2. There was an inverse relationship (r = -0.94) between GMD and % washout. As the GMD increased, the percent of sample washed out of the bag decreased due to less surface area of the endosperm exposed.

Table 1. Effect of corn hybrid and processing method on nutrient digestibility and particle size.

	Dietary Treatment[a]									
	DRC			HMC				*P*-value[c]		
Item	1	2	3	1	2	3	SEM[b]	Process	Hybrid	Inter
Dry Matter Digestibility										
Ruminal	51.3	44.2	49.8	64.7	59.8	68.7	4.9	< 0.01	0.01	0.54
Postruminal[d]	76.3^{gh}	71.9^{f}	74.9^{g}	74.8^{g}	77.9^{h}	71.9^{f}	1.1	0.49	0.02	< 0.01
Total-tract	88.5^{h}	84.3^{f}	87.4^{g}	91.0^{i}	91.0^{i}	91.4^{i}	0.5	< 0.01	< 0.01	< 0.01
Starch Digestibility										
Ruminal	56.1	44.8	52.3	68.9	66.0	75.2	1.7	< 0.01	0.48	0.85
Postruminal[d]	93.6	91.0	93.1	97.0	93.7	96.1	2.6	< 0.01	< 0.01	0.99
Total-tract	97.1	95.1	96.7	99.0	97.7	99.0	0.3	< 0.01	< 0.01	0.52
Protein Digestibility										
DIP (%CP)	57.0	49.1	56.5	72.8	68.0	74.6	4.9	< 0.01	0.12	0.90
UIP (%CP)	43.0	50.9	43.5	27.2	32.0	25.4	4.9	< 0.01	0.12	0.90
Total-tract CP	90.5^{gh}	84.2^{f}	88.6^{g}	94.0^{i}	92.7^{hi}	94.2^{i}	1.2	< 0.01	<0.01	0.02
UI*P* Digestibility[d]	78.2	69.0	73.8	80.1	76.7	76.5	3.0	0.03	0.02	0.35
Particle Size[e]										
GMD	2184	2648	1747	1131	1380	1039	143	< 0.01	< 0.01	0.08
GSD	2.98	2.43	3.42	4.73	4.34	4.89	0.14	< 0.01	< 0.01	0.16

[a]Hybrids consisted of Golden Harvest H-8562 (1), Pioneer 33P67 (2), and Golden Harvest H-9230Bt (3); processed as dry-rolled corn (DRC) or high-moisture corn (HMC).
[b]SEM = Standard error of the mean for the hybrid by processing method interaction.
[c]Process = Main effects of dry-rolling versus high-moisture ensiling; Hybrid = main effect of hybrid; Inter = interaction of processing method and hybrid.
[d]Postruminal digestibility expressed as a percent entering the duodenum.
[e]GMD= Geometric mean diameter, GSD = geometric standard deviation.
[f,g,h,i]Significant hybrid by processing method interaction. Means within row with unlike superscripts differ ($P < 0.05$).

Dry-matter digestibility

Ruminal dry-matter digestibility (RDMD) was influenced by both hybrid and processing method. The RDMD for HMC was 33% greater compared to DRC. Ruminal DMD for hybrids 1 and 3 were greater compared to hybrid 2. A significant hybrid by processing method interaction existed for postruminal DMD expressed as a percent entering the duodenum. Postruminal DMD for hybrids 1 and 3 processed as DRC were greater compared to hybrid 2. When processed as HMC, postruminal digestibility was greater for hybrid 2 compared to hybrids 1 and 3. A greater postruminal DMD for hybrids 1 and 3 processed as DRC might be due to simply less residue entering the duodenum because of a greater ruminal DMD for these hybrids. However, this does not account for the differences among hybrids when processed as HMC. One explanation might be that after a greater extent of RDMD for HMC, the residue inserted into the duodenum is less digestible. A hybrid by processing method interaction also existed for total-tract DMD. When processed as DRC, DMD for hybrid 1 was 1% greater ($P < 0.01$) than hybrid 3, and 5% greater than hybrid 2. However, when processed as HMC there were no differences among hybrids. Ruminal DMD trends were similar to total tract DMD, but not statistically different due to the smaller number of bags used for ruminal DMD (n = 8) compared to total-tract DMD (n = 50).

Starch digestibility

There were no differences among hybrids for ruminal starch digestibility (SD). Ruminal SD was 37% greater for HMC compared to DRC (70.1, and 51.1%, respectively). Postruminal SD was greater for hybrids 1 and 3 compared to hybrid 2. Total-tract SD was also greater for hybrids 1 and 3 compared to hybrid 2. Postruminal and total-tract SD were also greater ($P < 0.01$) for HMC compared toDRC. Because starch is more digestible than the total residue entering the duodenum for postruminal DMD, postruminal SD (expressed as a percentage entering duodenum) is greater for samples that are digested more in the rumen.

Protein digestibility

Degradable intake protein (DIP) was greater for HMC samples compared to DRC similar to results found in a previous study (*2005 Nebraska Beef Report, pp.31*). Undegradable intake protein digestibility was greater for HMC compared to DRC (77.8 and 73.7%, respectively). Digestible UI*P* among hybrids was greatest for hybrid 1, intermediate for hybrid 3, and lowest for hybrid 2. A hybrid by processing method interaction also existed for total-tract C*P* digestibility. Total-tract C*P* digestibility was greater for hybrids 1 and 3 processed as HMC compared to hybrid 2. Crude protein digestibility for hybrid 2 processed as HMC was similar to hybrid 1 processed as DRC. When processed as DRC, total-tract C*P* digestibility was lowest for hybrid 2, intermediate for hybrid 3, and greatest for hybrid 1.

The values presented are not absolute values but do show relative differences for nutrient digestibility among hybrids and processing methods. The lower UIP digestibility for DRC may have an impact on metabolizable protein due to a greater proportion of UIP for DRC compared to HMC. Differences among processing methods and hybrids exist for site and extent of nutrient digestibility.

[1] Matt Luebbe, research technician; Galen Erickson, assistant professor; Terry Klopfenstein, professor, Animal Science, Lincoln; Wayne Fithian, agronomy systems manager, Golden Harvest Seed Co., Waterloo, Neb.

Influence of Corn Hybrid and Processing Method on Digestibility and Ruminal Fermentation

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

Summary

Three hybrids with different kernel traits and feeding value were selected from a previous study to determine effects of corn hybrid and processing method (high-moisture corn (HMC), or dry-rolled corn DRC)) on nutrient digestibility and ruminal fermentation. DMI, intake rate, and total time spent eating were greater for HMC than DRC. Changes in ruminal pH and pH variance were also greater for HMC compared to DRC. Total-tract nutrient digestibility was influenced by processing method and hybrid. Nutrient digestibilities were greatest for hybrid 1, and greater for HMC compared to DRC. There was a hybrid by processing method interaction for molar proportions of propionate and the acetate: propionate (A:P) ratio. The magnitude of change for propionate molar proportions and the A:P ratio were different among hybrids when fed as HMC compared to DRC. Selection of hybrids with softer kernel traits and use of HMC will result in greater digestibility and favorable ruminal fermentation end products such as propionate.

Introduction

A greater extent of starch digestion is ideal for feedlot producers to maximize efficiency if acidosis can be controlled. The primary way to increase the extent of starch digestion for high-moisture and dry-rolled corn is to increase the rate of degradation in the rumen. Another way producers can maximize efficiency is by selecting hybrids with kernel traits that are associated with improved digestibility when fed as dry-rolled corn (*2004 Nebraska Beef Report,* pp. 54-57). Altering kernel traits of hybrids using more intense processing methods such as high-moisture ensiling, fine grinding, or steam-flaking may take away the advantage of selecting hybrids with more desirable kernel traits (*2003 Nebraska Beef Report,* pp. 32-34). However, a more intense processing method may also increase the incidence of acidosis and reduce feed efficiency if starch fermentation is too rapid. Therefore, the objectives of our research were to 1) determine total-tract nutrient digestibility, 2) monitor intake patterns and ruminal pH, and 3) determine ruminal volatile fatty-acid concentrations of steers fed three hybrids with varying kernel traits and feeding value processed as either dry-rolled or high-moisture corn.

Procedure

Six ruminally cannulated steers (BW= 960 lb) were used in a 6x6 Latin square to determine digestibility of hybrids fed as dry-rolled (DRC) or high-moisture corn (HMC) . Treatments consisted of three hybrids: H-8562 (1), 33P67 (2), and H-9230Bt (3); processed either as DRC or HMC in a 3x2 factorial arrangement. Dry-rolled corn was coarsely rolled and reconstituted to 28% moisture to mimic early harvested HMC. Diets consisted of 68.5% corn, 20% wet corn gluten feed, 7.5% alfalfa, and 4% supplement. In a previous study (*2004 Nebraska Beef Report,* pp. 54-57), F:G was 5.45 for hybrid 1, 5.62 for hybrid 2, and 5.95 for hybrid 3. Laboratory analyses indicate hybrid 1 has the largest/softest kernels, hybrid 3 the hardest/smallest kernels, and hybrid 2 was intermediate for both kernel hardness and size. Steers were fed for ad libitum intake once daily at 0730.

Periods were 14 days in length with a 9-day adaptation to the diet, and a 5-day collection period to measure digestibility, ruminal fermentation, pH, and intake. Steers were individually fed in pens during the adaptation on days 1-8 and moved into stantions for the collection period on day 9. Feed intake patterns and ruminal pH measurements were collected (days 10 to 14) as described in the *1998 Nebraska Beef Report,* pp. 71-75 . Feed intake measurements included DMI, intake rate, number of meals per day, and total time spent eating. The ruminal pH parameters measured were average pH, pH change, pH variance, and maximum and minimum pH.

Chromic oxide was used as an indigestible marker for estimating fecal output. Boluses were administered 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 through 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 12-hour period to determine volatile fatty acid (VFA) concentrations.

Results

Dry matter, organic matter, and starch intake were similar among hybrids. Interestingly, nutrient intake was greater ($P < 0.02$) for animals consuming HMC compared to DRC (Table 1). Total time spent eating and intake rate were also greater ($P < 0.05$) for animals consuming HMC compared to DRC. Average meal size and number of meals/day were not different ($P > 0.05$) among processing methods or hybrids and averaged 3.9 lb/meal and 7.2 meals/day, respectively.

Total tract nutrient digestibilities were influenced by both hybrid and

Table 1. Effect of corn hybrid and processing method on intake and nutrient digestibility.

	Dietary Treatment[a]									
	DRC			HMC				*P*-value[c]		
Item	1	2	3	1	2	3	SEM[b]	Process	Hybrid	Inter
Nutrient Digestibility										
Dry Matter										
Intake, lb/day	20.8	22.7	22.2	23.3	23.5	23.2	0.8	< 0.01	0.19	0.28
Digestibility, %	79.8	74.1	76.5	80.5	77.7	78.3	2.1	0.10	0.03	0.63
Organic Matter										
Intake, lb / day	16.7	19.2	18.0	20.3	19.7	19.2	1.2	0.02	0.45	0.18
Digestibility, %	79.9	74.4	76.3	82.5	78.4	79.0	2.5	0.05	0.04	0.91
Starch										
Intake, lb/day	9.2	9.7	9.3	10.8	10.6	10.3	0.6	< 0.01	0.68	0.67
Digestibility, %	96.1	95.1	95.3	97.0	96.0	95.8	0.5	0.02	0.02	0.80
Intake Patterns										
No. Meals/day	7.5	6.2	7.0	7.6	7.2	7.4	0.5	0.12	0.15	0.50
Total time (min)	566	533	558	613	631	647	37	< 0.01	0.72	0.58
Rate, %/hour	12.7	13.5	15.1	17.4	15.2	17.4	2.3	0.04	0.51	0.63

[a]Hybrids consisted of Golden Harvest H-8562 (1), Pioneer 33P67 (2), and Golden Harvest H-9230Bt (3); processed as dry-rolled corn (DRC) or high-moisture corn (HMC).
[b]SEM = Standard error of the mean for the hybrid by processing method interaction.
[c] Process = Main effects of dry-rolling versus high-moisture ensiling: Hybrid = main effect of hybrid; Inter = interaction of processing method and hybrid.

Table 2. Effect of corn hybrid and processing method on ruminal pH and VFA concentration.

	Dietary Treatment[a]									
	DRC			HMC				*P*-value[c]		
Item	1	2	3	1	2	3	SEM[b]	Process	Hybrid	Inter
Ruminal pH										
Average	5.58	5.59	5.78	5.65	5.66	5.53	0.12	0.58	0.91	0.10
Maximum	6.24	6.20	6.36	6.49	6.32	6.25	0.13	0.24	0.53	0.15
Minimum	5.13	5.13	5.31	5.03	5.15	4.89	0.16	0.08	0.83	0.15
pH change	1.11	1.07	1.05	1.46	1.17	1.36	0.15	< 0.01	0.31	0.45
pH variance	0.048	0.044	0.043	0.098	0.068	0.082	0.003	< 0.01	0.38	0.62
Ruminal VFA										
Acetate, mM	50.6	52.9	52.0	49.8	49.1	48.1	2.1	0.02	0.79	0.47
Molar %	48.5	48.6	50.2	44.2	46.5	45.5	1.4	< 0.01	0.25	0.33
Propionate, mM	38.0	36.1	30.1	48.0	41.9	46.4	3.2	< 0.01	0.07	0.06
Molar %	36.2[ef]	33.5[f]	28.6[g]	46.2[d]	39.7[e]	44.5[d]	2.4	< 0.01	< 0.01	< 0.01
A:P	1.41[f]	1.45[f]	2.06[g]	0.76[d]	1.20[ef]	1.08[e]	0.1	< 0.01	< 0.01	< 0.01
Butyrate, mM	9.2[de]	12.8[fg]	15.8[g]	7.4[de]	10.2[ef]	6.7[d]	1.8	< 0.01	0.02	< 0.01
Total VFA, mM	104.8	108.8	105.5	104.4	110.5	106.0	3.9	0.69	0.57	0.23

[a]Hybrids consisted of Golden Harvest H-8562 (1), Pioneer 33P67 (2), and Golden Harvest H-9230Bt (3); processed as dry-rolled corn (DRC) or high-moisture corn (HMC).
[b]SEM = Standard error of the mean for the hybrid by processing method interaction.
[c]Process = Main effects of dry-rolling versus high-moisture ensiling: Hybrid = main effect of hybrid; Inter = interaction of processing method and hybrid.
[d,e,f,g]Significant hybrid by processing method interaction. Means within row with unlike superscripts differ ($P < 0.05$).

processing method (Table 1). DM and OM digestibility for hybrid 1 were greater ($P < 0.04$) than for hybrid 2, and tended ($P = 0.07$) to be greater than hybrid 3. Starch digestibility was also greater (P = 0.02) for hybrid 1 compared to hybrids 2 and 3. DM digestibility tended ($P = 0.10$) to be greater for HMC than DRC. OM and starch digestibility were greater ($P = 0.05$ and $P = 0.02$, respectively) for HMC than DRC.

There was a tendency ($P = 0.10$) for a hybrid by processing method interaction for average pH (Table 2). Animals consuming hybrids 1 and 2 as HMC had a higher average pH than for those fed the same hybrid as DRC. Conversely, average pH for animals consuming hybrid 3 had a lower pH when fed as HMC. Overall, the average pH for HMC and DRC was 5.61, and 5.65, respectively. The change in pH (maximum to minimum) and pH variance were greater ($P < 0.05$) for HMC than DRC, indicating that a more intense processing method has a more rapid fermentation rate than DRC. There was also a tendency ($P = 0.08$) for minimum pH to be lower for HMC than DRC. One explanation for ruminal pH to be similar for animals consuming HMC and DRC could be due to more total time spent eating, and a tendency ($P = 0.12$) for animals consuming HMC to eat more meals/day. The intake behavior could be due to the animal regulating its intake so they do not experience acidosis. Consuming a smaller quantity of feed more often and allowing

(Continued on next page)

ruminal pH to recover between meals could contribute to a similar average pH for both processing methods. Even though the addition of WCGF to these diets mediated the pH, there is enough fermentable starch in the DRC diets for animals to experience acidosis. These animals also regulate intake similar to those consuming HMC diets but do not experience the changes in ruminal pH as rapidly (variance) or to the same extent (pH change).

Ruminal fluid analyses indicate differences existed among hybrids and processing methods for VFA concentrations (Table 2). There was a hybrid by processing method interaction for molar proportions (%) of propionate, and the acetate: propionate (A:P) ratio. The increase in molar% of propionate for HMC compared to DRC for hybrid 3 was greater than the increase for hybrids 1 and 2. The larger increase in the molar % of propionate suggests the harder kernel traits for hybrid 3 could have limited rumen degradation when fed as DRC. These data are similar to the VFA measurements taken in a previous study (*2005 Nebraska Beef Report,* pp. 34-36) where propionate concentrations were the lowest for hybrid 3 (H-9230Bt) when fed as DRC. Through high-moisture ensiling, these kernel traits were altered allowing for a greater increase in propionate concentrations. The decrease in the A:P ratio from DRC to HMC for hybrids 1 and 3 were greater than the decrease for hybrid 2. The smaller decrease in the A:P ratio for hybrid 2 is due to the smaller change found for the concentration of propionate when fed as HMC compared to DRC.

A processing method by time interaction ($P < 0.01$) existed for molar % of propionate and the A:P ratio. Molar % of propionate for animals consuming DRC averaged 32.8% and did not change throughout the sampling day (data not shown). The molar % of propionate for animals consuming HMC were 34.6% prior to feeding and increased throughout the sampling day to 46.3% 12 hours after feeding.

Nutrient digestibility data show hybrid 1 maintained an advantage over hybrids 2 and 3 even though a more intense processing method was used. The differences found for total-tract nutrient digestibility and VFA concentrations for hybrids fed as either DRC or HMC may have efficiency implications for hybrid selection and processing method. Producers feeding corn as DRC may want to consider selecting hybrids with larger, softer kernels. If a more intense processing method is used such as high-moisture ensiling, hybrid selection may not be as important.

---

[1]Matt Luebbe, research technician; Galen Erickson, assistant professor; Terry Klopfenstein, professor; Animal Science, Lincoln; Wayne Fithian, agronomy systems manager, Golden Harvest Seed Co., Waterloo, Neb.

Influence of Corn Hybrid on Kernel Traits

Flint W. Harrelson
Galen E. Erickson
Terry J. Klopfenstein
Lenis A. Nelson
David S. Jackson[1]

Summary

Sixty commercially available corn hybrids were used to identify kernel traits that may be used as an indicator of feeding value to cattle. Three separate tests were conducted and 12 traits were evaluated for each hybrid. Most production traits were negatively correlated or not correlated to physical traits making them less indicative of cattle performance compared to some lab techniques. Based on the dry matter disappearance in the rumen, a harder kernel will be more efficiently digested. An approximately 10% change in dry matter disappearance is shown between the most and least digestible hybrid. Physical kernel traits can be helpful in determining corn hybrids used for feeding cattle.

Introduction

A large amount of research has been devoted to corn processing and the feeding value of corn for feedlot cattle. Considerably less research has been conducted to see the effect of the corn hybrid type on feeding value. Chemical and physical traits of the corn kernel are similar within a hybrid even across years, but can vary greatly among hybrids. Using seven commercially available corn hybrids, a feedlot trial showed differences are present and can influence cattle performance (*2004 Nebraska Beef Report,* pp.54 - 57). In that study many different factors were used to distinguish differences between these hybrids, using chemical and physical characteristics. In the following experiment many of these same tests, on 60 commercially available hybrids which had been entered in hybrid performance tests by the Department of Agronomy and Horticulture, were investigated. The objective of our experiment was to identify factors that would give an indication of feeding performance, allow us to evaluate differences in feeding value present among corn hybrids, and determine if common grain marketing tests could distinguish those differences.

Procedure

Corn Production

Sixty hybrids were grown in four field replicates and used to determine hybrid differences. At harvest, approximately 2 lb of grain was collected, placed in nylon bags, and stored dry. After approximately two months of storage, each sample was cleaned, by sieving, to obtain a sample of whole kernels for analysis.

1,000 Kernel Weight

Following cleaning, 1,000 kernels were separated using an automated seed counter. Kernels were then weighed and a 1,000 kernel weight was recorded for each sample on an air-dry basis. A DM analysis was performed on each sample and the kernel weights were adjusted to a DM basis and represented the dry kernel weight.

Stenvert Hardness Test

Twenty grams of each whole corn sample were ground through a micro hammer mill. The softer particles grind first and fall to the bottom of the collection tube, while the harder particles grind slower and remained on top. The mill was attached to a tachometer which measured the revolutions per minute (rpm) of the machine. The machine started at 3600 RPM and the lowest RPM reached during grinding was recorded. A test tube placed at the bottom of the machine collected the ground sample and was also used to determine the grinding time. The grinding time was the time from placing the whole sample into the machine until 17 mL, represented by a line on the tube, of ground sample was obtained. The total height of sample in the tube and height of the soft material were measured, after the entire sample was ground. The soft height was measured by identifying the change in color between the soft powder and the harder pericarp near the top of the tube. After these measures were taken, the ground sample was placed in a 425 μm sieve which was placed on a Strand shaker for three minutes. The hard pericarp remained on top of the screen and was weighed to determine the kernel's hard percentage.

In Situ

Based on 1,000 kernel weight and Stenvert grinding, 20 hybrids were selected for an *in situ* trial to measure the dry matter disappearance (DMD) as an indication of feeding value. The 20 hybrids represented a range in kernel weights, as well as hard percentage and grinding time. The four replicates from each hybrid were ground using a Wiley Mill to simulate a masticate grind. After being ground, 5 g of each sample was weighed and placed in an *in situ* bag to be incubated. The samples were replicated twice per animal per day, for a total of eight replications of each of the four field replications per hybrid. The procedure was conducted during a five day period using two ruminally cannulated steers, an incubation period of 24 hours, and one day between the two incubation periods. Upon removal of the bags from the steers, they were washed and placed in a 60° C oven for 48 hours to dry. After drying, each sample bag was weighed back to determine amount of residue left. The residue which remained was divided by the original sample, corrected for DM, to determine the DMD of each hybrid.

Results

(Continued on next page)

Kernel characteristics averaged across hybrid are presented in Table 1. With a few exceptions, the production traits of yield and test weight had no correlation or were negatively correlated ($P < 0.05$) to the Stenvert and *in situ* traits. Yield was correlated to the soft height and soft height percentage, ($P = 0.04$ and $P < 0.01$ respectively), but negatively correlated to dry kernel weight ($P = 0.02$). Test weight (volume weight usually in lb/bu) was correlated to RPM ($P < 0.01$), but was negatively correlated to total height, hard percentage, and 24 hour DMD ($P < 0.01$, $P < 0.01$, and $P = 0.02$ respectively). These observations would seem to suggest that our most common market time quality measurement, test weight, is not related to laboratory tests which correlate with the feeding value of the corn. An important observation is an insignificant negative correlation ($P = 0.22$) was observed between test weight and kernel weight. Previous studies (*2004 Nebraska Beef Report,* pp.54-57), have shown a positive correlation between kernel weight and feeding performance. This suggests that higher weight kernels result in better performance. However since test weight is based on density more than solid weight, these two measures do not result in similar relationships to feeding performance. Revolutions per minute was the only Stenvert observation that had a correlation with the in situ procedure. RPM was negatively correlated to the DMD ($P < 0.01$), which indicates a hybrid with a harder kernel has a higher DMD. These data are contrary to previous data. Previous studies indicated softer kernels have a higher DMD compared to harder kernels (*2003 Nebraska Beef Report,* pp.32-34; and *2004 Nebraska Beef Report,* pp. 54-57). Another current study (*2006 Nebraska Beef Report,* pp. 45-47) also indicates that a softer kernel is more digestible though the relationship between the two was rather weak (r = 0.27). The overall change in DMD between the highest and lowest percentage was 9.33 %, which indicates that although the hybrids were chosen using some extremes from the Stenvert and 1,000 kernel weight data, overall differences in feeding value were less than 10%. The current study reaffirms hybrid testing as important, because hybrid feeding performance differences are present and significant. Through further research we will find the general characteristics of corn grains used more efficiently by feedlot cattle.

For more information about the Department of Agronomy and Horticulture's hybrid performance tests visit http://varietytest.unl.edu/corntst/2004/index.htm. For more information about the specific hybrids used in this study visit the Lancaster county tab on that Web site.

Table 1. Kernel characteristics of all 60 hybrids.

Trait	Mean	Standard Dev.	Range	r[b]
Yield, bu/ac	185	13.0	156-210	- 0.35
Test wt., lb/bu	59.2	1.16	56.8-62.6	- 0.53
1,000 Kernel wt., g	328	22.9	273-365	0.27
Stenvert Hardness				
RPM	2390	53.2	2280-2520	- 0.70
Soft Height, %	75.4	2.19	70.1-80.3	- 0.25
Grind Time, s	6.90	0.56	5.50-8.25	- 0.43
Hard, %	81.6	1.93	74.2-83.7	0.18
24 Hr DMD[a],%	50.5	1.50	47.5-52.4	

[a]24 Hr DMD = Percentage dry matter disappearance over 24 hours of incubation.
[b]Correlation coefficient to DMD; test wt, and rpm significant at $P < 0.05$.

[1]Flint W. Harrelson, graduate student; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln; Lenis A. Nelson, professor; Agronomy and Horticulture, Lincoln; David S. Jackson, professor, Food Science and Technology, Lincoln.

Influence of Corn Hybrid, Kernel Traits, and Dry Rolling or Steam Flaking on Digestibility

Flint W. Harrelson
Galen E. Erickson
Terry J. Klopfenstein
Wayne A Fithian
Patrick M. Clark
David S. Jackson[1]

Summary

Seventy-two commercially available corn hybrids were used to quantify the existing range in kernel characteristics shown to correlate with improved feeding value to cattle. Twelve hybrids were steam flaked at two different bulk densities. Hybrids were tested for kernel size, hardness, in situ digestibility, and starch use. For dry rolled corn, a 27% difference in dry matter disappearance was found across hybrids. For flaking, a 6% to 29% improvement over dry rolled corn was observed. An 8% to 36% advantage for flaking in starch digestibility was also found. The results of this trial suggest there can be an interaction between hybrid value and whether fed as dry-rolled or steam-flaked corn.

Introduction

Recent research has begun to explore corn hybrid testing as an important way to improve cattle performance in the feedlot. Previous hybrid testing data showed how corn hybrid interacts with processing methods. A previous study comparing dry rolled corn with high moisture corn (*2003 Nebraska Beef Report,* pp. 32-34) illustrated that a harder (flinty) endosperm had improved performance when processed as high moisture corn compared with dry rolled corn. Another study using HMC (*2006 Nebraska Beef Report,* pp. 40-42) indicates that processing corn hybrids can increase the feeding performance of harder kernels. Evaluating hybrids when processed differently is critical because some poorer performing hybrids fed as dry rolled corn, may be greatly improved when fed as steam flaked corn. Our objective for the first trial was to identify kernel traits that indicate feeding value and how these traits are influenced by hybrid as dry rolled corn. Our objective for the second trial was to identify how hybrid kernel characteristics affect the flaking process and feeding value of the resulting flakes.

Procedure

Dry Corn Trial

Whole grain samples of 72 commercially available corn hybrids were used for Stenvert Hardness tests and *in situ* analysis. A duplicate analysis was run for the Stenvert Hardness test (procedure detailed in *2006 Nebraska Beef Report*, pp. 43-44) since only one sample of each hybrid was present. After the Stenvert analysis, 24 hybrids were selected for *in situ* analysis to include a wide range of kernel characteristics. A sample of each hybrid was ground through the Wiley Mill to simulate a masticate grind for the *in situ* analysis. This grind produces a particle size equivalent to a masticated, rolled corn. A 10 g sample of ground corn was weighed and placed in an *in situ* bag for incubation. Each hybrid was replicated six times in two ruminally cannulated steers using an incubation period of 24 hours. After the incubation period each sample was removed, machine washed using five three minute cycles, and placed in a 60ºC oven to dry for 48 hours after which it was weighed and dry matter disappearance (DMD) was calculated. Feed value was measured for each hybrid using an *in situ* procedure; disappearance was correlated with measured kernel traits. Correlation results were compared to previous investigations comparing kernel characteristics with feed efficiency using *in situ* disappearance and a feedlot pen study.

Steam Flaked Corn Trial

Twelve hybrids, which were used in the dry corn *in situ* trial, were sent to the Department of Grain Science and Industry's Feed Processing Center at Kansas State University (KSU), Manhattan, Kan., to determine the hybrid effect on flaking characteristics. Characteristics measured included: bulk density at two levels (light and heavy, 27 lb/bu and 32 lb/bu, respectively); electrical consumption of the steam flaking motor to determine kilowatt hours/ton (kWh/ton); and production rates. Corn hybrids were steam flaked on a Roskamp flaker equipped with a 25 HP motor and 16"x 12"(diameter x width) rolls at 16 grooves/in. A 12"x15"x72" stainless steel steam chamber was used to steam condition all corn before entering the flaking rolls. The feeder was set at a constant rate to allow for any electrical differences to be measured. For the drive motor, voltage and amperage across each electrical phase was measured using a recording volt-amp meter (Model DM-II Pro, Amprobe, Miami, FL). Electrical consumption was determined by relative (gross) and specific (net) energy. Gross energy was defined as the total amount of energy required while the machine was used under a load. Net energy was defined as the energy required to operate the machine under a load, minus the energy required to operate the machine empty. Retention time of the corn in the steam chest before flaking was eight minutes with a steam conditioning temperature of 98.8°C (210°F) for all corn hybrids.

After the flaking was conducted at KSU, approximately 30 lb of each hybrid and flake density (n=24) were returned for *in situ* analysis. The samples were placed in feed bags to cool and dry to prevent spoilage before being shipped. A sub sample

(Continued on next page)

of the 24 samples was ground in the Wiley Mill without a screen. For the *in situ* procedure each hybrid was tested as ground dry corn, whole flaked corn, and ground flaked corn. Each flake density for each hybrid was analyzed to compare the densities; as well as flaking versus dry corn. A 5 g sample was placed in an *in situ* bag for incubation. Each sample was replicated in each of two animals per day over two days (eight total bags), with an incubation period of 24 hours. Starch analysis was conducted on the original unincubated samples, and the *in situ* residue samples which were composited across animals within days.

Results

Dry Corn Trial

A wide range was observed within each kernel trait across hybrid (Table 1). Production related traits of 1,000 kernel weight and test weight were correlated ($P < 0.05$) to each other and to a few of the Stenvert observations. Kernel weight was negatively correlated ($P < 0.01$) to test weight, indicating that a higher volume weight does not necessarily indicate heavier kernels. Test weight was positively correlated to the Stenvert grind time ($P < 0.01$), which indicates that a higher volume weight causes the sample to grind slower. Dry matter digestibility is believed to be the best measure of value to the hybrid for finishing cattle. Therefore, kernel traits that relate to DMD are of primary interest. Test weight was the only kernel trait correlated to DMD ($P = 0.07$) and the relationship was not strong ($r = 0.4$). Previous research showed that softer kernels were more digestible based on Stenvert soft height percentage. The relationship ($r = 0.27$) between DMD and the percentage soft particles in the kernel was weak and not significant ($P = 0.27$). We can contrast some findings from this study with the feedlot trial from 2004. In that trial the relationship ($r = 0.85$) between gain:feed and soft height percentage was strong and would directly relate to feedlot performance. We did not use these hybrids in a feedlot trial, but did use DMD as an equivalent measure for this analysis. It is also important to note that our *in situ* process is designed to mimic what would occur in a feedlot; however, we are only testing a small amount of feed, and for a short period, so though helpful, it cannot be evaluated on the same scale as a feedlot trial.

Table 1. Kernel characteristics of 72 single replicate Golden Harvest hybrids.

Trait	Mean	Standard Dev.	Range	r[b]
Test Wt., lb/bu	58.7	1.71	55.2-62.5	- 0.38
Dry Kernel Wt., g	341	27.4	259-407	0.23
RPM	2470	98.0	2240-2720	< 0.01
Soft Height %	80.2	2.11	67.9-84.2	- 0.27
Grind Time, s	6.27	0.67	5.00-8.00	- 0.11
Hard %	82.4	2.81	72.9-89.3	- 0.27
24 Hr DMD[a]	53.8	5.98	44.7-71.0	

[a]24 Hr DMD = Percentage dry matter disappearance over 24 hours of incubation.
[b]Correlation coefficient to DMD; no significance at $P < 0.05$, but test weight was at $P < 0.1$.

Table 2. Flaking characteristics of 12 Golden Harvest hybrids.

	Bulk density(lb/bu)		Amperage			kWh/ton	
Hybrid	Light	Heavy	Light	Heavy	Prod. Rate [a]	Light	Heavy
9430	26.0	30.6	17.8	16.7	2200	2.71	2.11
9485	26.1	30.3	17.9	17.2	2020	3.02	2.58
9494	26.8	30.6	17.7	16.6	2120	2.79	2.12
8803	26.1	30.5	18.0	17.0	1940	3.19	2.57
8906	25.8	30.3	18.3	17.2	2200	3.04	2.39
8700	27.4	30.1	17.2	16.6	2340	2.24	1.94
9507	26.8	31.3	17.5	16.7	1760	3.21	2.62
8562	27.8	31.5	17.6	17.1	1890	3.04	2.69
9164	26.9	32.2	18.1	16.9	1940	3.26	2.53
9248	26.5	31.9	18.1	17.1	2090	3.07	2.45
9209	27.3	30.3	17.3	16.8	2160	2.49	2.22
9360	27.2	30.3	17.4	16.7	2480	2.23	1.86

[a]Production Rate in lb/hour.

Steam Flaking Characteristics

Flaked corn production rates fluctuated by corn hybrid (Table 2). Although there were differences in the production rates, an adjustment was made when calculating kWh/ton to accurately assess the effect of hybrid on kWh/ton. As expected, there was a difference in kWh/ton between light and heavy flakes. The steam flaker consumed more electricity as flaking became more rigorous in creating a lighter flake. There also appeared to be differences among hybrids within each bulk density treatment. For example, hybrid 8700 had an electrical consumption of 2.243 kWh/ton and hybrid 9164 had an electrical consumption of 3.258 kWh/ton. This is a difference of 1.1 kWh/ton. A feedlot with 4 flakers operating at 50 ton/hour each, operating 16 hours/day and six days a week, at a $0.07/kW charge has a potential savings of $1,478.40 per week in electrical costs. Replications were not conducted, so statistical differences could not be calculated.

Dry Matter Disappearance

A comparison of the mean dry matter disappearances between dry rolled corn and steam-flaked corn is shown in Table 3. Since no effect of grinding on the flakes was present, data are pooled and reported on the basis of bulk density and compared to the dry rolled corn samples for each hybrid. There was a hybrid* processing interaction ($P < 0.01$) for DMD. The bulk densities of flakes ($P < 0.01$)

Table 3. *In situ* **DM disappearance and hybrid rank for steam flaked and dry rolled corn from 12 hybrids.**[a]

Hybrid	DRC[b]	Rank	Light Flake[c]	Rank	Heavy Flake[b]
9430	38.5	1	49.5	2	38.0
9485	42.2	2	59.7	10	45.4
9494	43.4	3	52.3	3	41.1
8803	43.4	4	54.3	5	48.0
8906	43.8	5	58.6	9	46.8
8700	43.9	6	52.5	4	41.6
9507	44.9	7	56.4	6	45.8
8562	45.1	8	47.9	1	38.4
9164	45.2	9	56.9	7	40.3
9248	45.9	10	58.6	9	41.2
9209	47.5	11	57.9	8	49.5
9360	49.4	12	56.9	7	45.9
LSD[d]	6.00		4.23		4.17

[a]Main effect of hybrid , Main effect of processing, Main effect of hybrid*processing.
[b]DRC not different from heavy flakes, except hybrid 8562.
[c]Light flakes different from both DRC and heavy flakes except hybrid 8562 was not different between DRC and light flakes.
[d]Least Significant Difference.

Table 4. *In situ* **starch digestibility and hybrid rank for steam flaked and dry rolled corn from 12 hybrids.**[a]

Hybrid	DRC	Rank	Light Flake	Rank	Heavy Flake
8700	42.2[b]	1	66.2[c]	5	55.8[d]
9485	46.4[b]	2	68.7[c]	8	59.7[d]
9430	48.2[b]	3	63.7[c]	3	54.6[d]
8562	52.4[b]	4	56.8[b]	1	52.9[b]
8803	53.3[b]	5	59.5[c]	2	58.4[bc]
9209	53.8[b]	6	69.2[c]	9	67.3[c]
8906	54.0[b]	7	68.5[c]	7	56.0[b]
9494	54.1[b]	8	68.2[c]	6	52.4[b]
9248	55.3[b]	9	69.5[c]	10	46.5[d]
9360	56.4[b]	10	65.4[c]	4	47.6[d]
9164	57.5[b]	11	73.9[c]	11	46.3[d]
9507	57.9[b]	12	68.5[c]	7	48.0[d]
LSD[e]	5.31		4.50		5.40

[a]Main effect of hybrid, Main effect of processing, Main effect of hybrid*processing.
[b,c,d]Means within a row with unlike superscripts differ ($P < 0.05$).
[e]Least Significant Difference.

influenced DMD, while the lighter flakes were more digestible than the heavier flakes. The lighter flakes were also more digestible than the dry rolled corn ($P < 0.01$), which supports performance data on comparing flaked corn with DRC. The second poorest hybrid (DMD) when fed as dry rolled corn, turned out to be the best hybrid using a light flake, with a 29% improvement in DMD. The hybrid with the least improvement for light flakes over dry rolled corn had a 5% improvement. Another interesting observation was that the two hardest hybrids based upon all of the Stenvert tests, responded the best to flaking with the lighter flakes from these hybrids having the greatest change in DMD. This observation suggests that harder kernels perform better when processed as steam flaked corn than when fed as dry-rolled corn. Clearly, hybrids responded differently to flaking. The range in DMD values for DRC is 10.9 percentage units. The range in DMD for light flakes was 11.8 percentage units. This information could be very useful in identifying hybrids for feeders with steam flakers.

Starch Digestibility

Hybrid starch digestibility for DRC, light flakes, and heavy flakes is represented in Table 4, with the means being 52.6%, 66.5%, and 63.8% respectively. A lighter flake resulted in a significantly higher ($P < 0.01$) digestibility. There was a significant hybrid*process interaction ($P < 0.01$) as was also seen with DMD. The ranking of hybrid efficiency changed somewhat, however a strong relationship ($r = 0.79$) between DMD and starch digestibility still exists. Hybrid 8562, which in previous studies had been a good performing hybrid, showed some interesting properties in the flaking trial. It was the only hybrid in which the starch digestibility of the DRC, light, and heavy flakes were not significantly different.

[1] Flint W. Harrelson, graduate student; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor; Animal Science, Lincoln; Wayne A. Fithian, Golden Harvest Seed Co., Waterloo, Neb.; Patrick M. Clark, graduate student, Grain Science and Industry, Kansas State University, Manhattan, Kan.; David S. Jackson, professor; Food Science and Technology, Lincoln.

Effect of Corn Processing in Finishing Diets Containing Wet Distillers Grains on Feedlot Performance and Carcass Characteristics of Finishing Steers

Kyle J. Vander Pol
Galen E. Erickson
Matt A. Greenquist
Terry J. Klopfenstein
Thomas Robb [1]

Summary

An experiment evaluated the effects of six corn processing methods in feedlot diets containing 30% (DM basis) wet distillers grains plus solubles (WDGS). Treatments consisted of whole corn, dry-rolled corn, a dry-rolled/high-moisture corn mix, high-moisture corn, steam flaked corn, and fine ground corn. The ADG was highest for steers receiving dry-rolled corn, high-moisture corn, or a 50:50 blend of dry-rolled and high-moisture corn. Feed conversion was best for steers receiving high-moisture corn. Interestingly, cattle fed finely ground corn or steam-flaked corn did not gain or convert as well as expected. Results indicate that there is a performance advantage obtained by processing corn as either dry-rolled or high-moisture when included with WDGS in finishing diets.

Introduction

Recently, the increased availability of wet distillers grains plus solubles (WDGS) has led to a greater number of feedlot producers and nutritionists incorporating this feed into finishing diets. According to past research, incorporating WDGS into feedlot diets results in better performance, with optimum feed conversion observed when included between 30% and 40% of the diet (DM basis); (Vander Pol et al., *2006 Nebraska Beef Report*). Steam-flaked corn is 12% and high-moisture corn is 2% higher in energy than dry-rolled corn (Cooper et al., *2001 Nebraska Beef Report*, pp. 54-57). However, in diets containing wet corn gluten feed, high-moisture corn is 8% higher in energy and steam-flaked corn is 14% higher in energy than dry-rolled corn based on feed conversion (Macken et al., *2003 Nebraska Beef Report*, pp. 25-27).

The objective of this trial was to determine effects of six different corn processing methods as the primary concentrate in diets containing 30% WDGS (DM basis) on feedlot performance and carcass characteristics of finishing calf-fed steers.

Procedure

Three-hundred sixty large-framed, crossbred (British x Continental) steer calves (BW = 701 ± 34 lb) were used in a completely randomized design. Upon arrival to the feedlot, steers were identified, vaccinated, and weaned on smooth bromegrass pastures for approximately three weeks. Five days before the initiation of this trial, steers were limit fed a diet consisting of 50% wet corn gluten feed and 50% alfalfa hay (DM basis) at 2% of BW. Steers were weighed individually on day 0 and day 1 to obtain an accurate initial BW, and all steers were implanted with Synovex-C (*Fort Dodge Animal Health, Fort Dodge, IA*). Utilizing BW obtained on day 0, steers were stratified by weight and assigned randomly to pen (10 steers/pen). Pen was assigned randomly to dietary treatment and served as the experimental unit. The overall experimental design used six dietary treatments which were replicated six times, for a total of 36 feedlot pens.

The six dietary treatments (Table 1) consisted of six different corn processing methods or combinations fed at 62% of diet DM, which were: whole corn (WC), dry-rolled corn (DRC), dry-rolled/high-moisture corn fed at a 1:1 ratio DM basis (DRC:HMC), high-moisture corn (HMC), steam-flaked corn (SFC), and fine-ground (FGC). Basal dietary ingredients consisted of 30% WDGS, 5% alfalfa hay fed, and 3% dry meal supplement (DM basis). Dry matter determinations were conducted weekly on all ingredients by drying samples in a 60° C forced air oven for 48-hr. Diets were formulated to meet or exceed the NRC (1996) requirements for metabolizable protein, Ca, and K. Step-up procedure consisted of a 21-day period and four steps fed for 3, 4, 7, and 7 days, respectively, where corn replaced alfalfa hay starting at

Table 1. Composition of dietary treatments and formulated nutrient analysis.

Ingredient [a]	% of diet DM
Corn [a,b]	61.4
WDGS	30.0
Alfalfa hay [b]	5.6
Dry supplement [c]	3.0
Limestone	1.42
Fine ground corn	0.65
Potassium chloride	0.47
Salt	0.30
Tallow	0.08
Trace mineral premix [d]	0.05
Rumensin-80 premix [e]	0.018
Vitamin A-D-E premix [f]	0.01
Tylan-40 premix [g]	0.01
Formulated Nutrient Analysis	
Crude protein, %	16.1
Calcuim, %	0.65
Phosphorus, %	0.48
Potassium, %	0.65
Sulfur, %	0.39
Ether extract, %	6.5

[a]Either fine-ground corn, steam-flaked corn, high-moisture corn, dry-rolled/high-moisture corn combination, dry-rolled corn, or whole corn.
[b]Weighted average based on days fed finishing ration and corresponding inclusion.
[c]Supplement formulated to be fed at 3% of diet DM.
[d]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, 0.05% Co.
[e]Premix contained 80 g/lb^{-1} monensin.
[f]Premix contained 1500 IU vitamin A, 3000 IU vitamin D, 3.7 IU vitamin E per g.
[g]Premix contained 40 g/lb Tylosin.

Table 2. Performance of steers fed 30% WDGS and corn from six different processing methods.

Treatment:[a]	FGC	SFC	HMC	DRC:HMC	DRC	WC	SEM
Pens, n	6	6	6	6	6	6	
Steers, n	60	60	60	60	60	60	
Days on feed	168	168	168	168	168	168	
Performance							
Initial BW, lb	704	700	700	700	700	700	1
Live final BW, lb[b]	1292[f]	1315[f]	1353[gh]	1351[gh]	1377[g]	1347[h]	9
Adjusted final BW, lb[c]	1271[f]	1303[g]	1352[hi]	1356[hi]	1381[h]	1347[i]	11
DMI, lb/day	20.4[f]	20.4[f]	21.0[fh]	21.5[h]	22.6[i]	23.1[i]	0.2
ADG, lb/day[d]	3.38[f]	3.59[g]	3.89[hi]	3.91[hi]	4.05[h]	3.85[i]	0.06
Feed:gain lb/lb [de]	6.15[fi]	5.76[g]	5.46[h]	5.61[gh]	5.68[gh]	6.07[i]	0.09

[a]Where FGC = fine ground corn, SFC = steam-flaked corn, HMC = high-moisture corn, DRC:HMC = dry-rolled and high-moisture corn combination, DRC = dry-rolled corn, WC = whole corn.
[b]Final live BW shrunk 4%.
[c]Calculated from HCW divided by a common dressing percentage of 63.
[d]Calculated from adjusted final body weight.
[e]Calculated as total feed intake (DM basis) divided by total gain.
[f,g,h,i]Means in a row with unlike superscripts differ $P < 0.05$.

Table 3. Carcass characteristics of steers fed 30% WDGS and corn from six different processing methods.

Treatment:[a]	FGC	SFC	HMC	DRC:HMC	DRC	WC	SEM
HCW, lb	801[f]	821[g]	852[hi]	854[hi]	870[h]	849[i]	7
Dressing %	62.0	62.4	63.0	63.2	63.2	63.0	0.3
Liver score [b]	0.02	0.03	0.04	0.00	0.02	0.05	0.02
12th rib fat, in	0.45[f]	0.51[fg]	0.58[hi]	0.55[gh]	0.62[i]	0.59[hi]	0.02
KPH fat, %	1.87[f]	1.92[fg]	1.98[gh]	1.98[h]	2.08[h]	2.08[h]	0.04
Ribeye area, in^2	12.5	12.6	13.2	13.1	13.0	12.8	0.2
Marbling score[c]	487[f]	496[f]	544[g]	528[g]	540[g]	534[g]	10
% Choice	46.1	48.3	65.0	62.4	63.5	60.0	5.3
% Upper 2/3 Choice	10.4[fi]	6.7[f]	28.0[g]	19.6[fg]	29.4[gh]	23.3[ghi]	5.1
PYG[d]	3.11[f]	3.26[fg]	3.45[hi]	3.36[gh]	3.55[i]	3.45[hi]	0.05
Yield grade[e]	3.06[f]	3.22[f]	3.37[g]	3.30[g]	3.62[h]	3.49[gh]	0.08

[a]Where FGC = fine ground corn, SFC = steam-flaked corn, HMC = high-moisture corn, DRC:HMC = dry-rolled and high-moisture corn combination, DRC = dry-rolled corn, WC = whole corn.
[b]Where 1 = A-, 2 = A, 3 = A+.
[c]Where 400 = Slight 0, 500 = Small 0.
[d]Preliminary yield grade measured between 12th and 13th rib.
[e]Where Yield grade = 2.50 + (2.5*fat thickness, in.) - (0.32*ribeye area, in^2) + (0.2*KPH, %) + (0.0038*HCW, lb.)
[f,g,h,i]Means in a row with unlike superscripts differ $P < 0.05$.

45% of DM for step 1 and decreasing by 10% for each subsequent step. After 107 days on the finishing diet, alfalfa hay was increased to 7.5% of diet DM and corn reduced to 59.5% of diet DM. Steers were fed once daily at 0830 by means of a single axle truck equipped with a Roto-Mix® model 420 (*Roto-Mix®, Dodge City, Kan.*) mixer/delivery box.

Steers were re-implanted on day 66 with Revalor-S® (*Intervet, Millsboro, Del.*) and fed for a total of 168 days. Before shipping, all pens were weighed separately on a pen scale to determine final live weight and dressing percentage. All final live weight values were shrunk 4%. Steers were slaughtered on day 169 at a commercial packing plant (*Greater Omaha Pack, Omaha, Neb.*) where hot carcass weights and liver scores were recorded. Following a 48-hour chill, fat thickness/preliminary yield grades, ribeye areas, kidney pelvic heart fat percentages, and USDA called marbling scores were recorded. Yield grade was calculated using the equation (YG=2.50 + (2.5*FT, in.) - (0.32*REA, in2) + (0.2*KPH, %) + (0.0038*HCW, lb.)) published in the Meat Industry Handbook. Carcass adjusted final body weight, ADG and feed:gain were calculated using hot carcass weight divided by an average dressing percentage of 63, which was done to minimize error associated with gastrointestinal fill, and to provide an accurate estimate of individual final body weight.

With the exception of the SFC, all corn used was produced from the same seed-corn hybrid (Pioneer 33B51, *Pioneer Hybrid International, Johnston, IA*) and grown in similar fields under irrigation to reduce the effect of corn hybrid on feeding performance. Dry-rolled corn was processed through a single-roll roller mill. Fine-ground corn was processed through a hammermill to pass through a 0.95-cm screen. High-moisture corn was harvested in one day at approximately 32% moisture and ensiled in a plastic silo bag for a minimum of 55-days before air exposure. Steam-flaked corn was produced at a commercial feedlot (*Mead Cattle Company, Mead, Neb.*), targeted a flake density of 26 lb/bushel, and delivered bi-weekly. Wet distillers grains plus solubles were procured from a commercial ethanol plant (*Abengoa Bioenergy, York, Neb.*), and delivered on an as needed basis to the research facility (approximately 1X/week). Based on information obtained from the ethanol plant, the ratio of distillers grains to distillers solubles was 65:35 (DM basis) and contained on average; 32.6% DM, 30.6% CP, and 12.0% crude fat.

Data were analyzed using the mixed procedures of SAS (*Version 9.1, SAS Inc., Cary, N.C.*) as a completely randomized design, with pen serving as the experimental unit.

Results

Cattle receiving the DRC or WC treatments had significantly higher DMI than cattle receiving the FGC, SFC, HMC, and DRC:HMC treatments (Table 2, $P < 0.05$).

The ADG was highest ($P < 0.05$) for cattle fed DRC, HMC, and 50:50 DRC:HMC treatments. Feed:gain, was lowest for cattle receiving the HMC treatment and highest for cattle receiving the FGC treatment ($P < 0.05$). Cattle receiving the HMC treatment

(Continued on next page)

had better ($P < 0.05$) feed:gain ratio than cattle fed FGC, SFC, and WC treatments, with a trend ($P = 0.09$) for the HMC treatment to be better than the DRC treatment (5.46 vs 5.68). The HMC treatment was lower in feed conversion because of lower DMI and similar ADG relative to the DRC treatment.

Liver abscess score (Table 3) was not different among treatments ($P = 0.47$) which can potentially indicate cattle did not experience a higher incidence of acidosis due to different corn processing methods, or that Tylan® inclusion controlled abscesses. Cattle with the least amount of 12th rib fat were on the FGC treatment, which measured 0.45 in, which indicates that regardless of dietary treatment, cattle achieved a minimum fat thickness indicative of adequate finish. Fat thickness was greatest for cattle receiving the DRC treatment (0.62 in), which was greater ($P < 0.05$) than cattle on the FGC, SFC, WC, and DRC:HMC treatments.

Ribeye area was not different among treatments ($P = 0.16$), however, marbling score was significantly different ($P < 0.01$). Cattle receiving the HMC treatment had the highest marbling score (544) while cattle on the FGC and SFC treatments had the lowest ($P < 0.05$).

There were no significant differences ($P = 0.07$) among treatments for percentage of cattle grading USDA Choice or better. However, only 6.7% of cattle on the SFC treatment graded upper 2/3 Choice or better, which was lower than every other treatment except the FGC treatment. Cattle receiving the DRC treatment had a significantly higher ($P < 0.05$) calculated yield grade than cattle receiving the FGC, SFC, HMC, and DRC:HMC treatments. The carcass characteristics support the performance data, with cattle fed FGC and SFC being less finished and lower in fat than the other treatments.

In summary, high concentrate finishing diets containing 30% (DM basis) WDGS are influenced by corn processing method. More specifically, cattle fed 30% WDGS and DRC yielded higher final body weights, ADG, fat thickness, KPH, and calculated yield grade than cattle fed 30% WDGS and either FGC, SFC, HMC, DRC:HMC, or WC. However, cattle fed 30% WDGS and HMC as the concentrate source yielded better feed conversion, and higher marbling scores than cattle fed the same amount of WDGS and either FGC, SFC, DRC:HMC, DRC, or WC. Overall, WDGS is an excellent feed ingredient for finishing diets. It appears that steam-flaking and fine grinding or not processing corn at all (whole corn) are not as favorable as dry-rolling and high-moisture corn processing methods in diets containing 30% WDGS.

---

[1]Kyle J. Vander Pol, research technician; Galen E. Erickson, assistant professor; Matt A. Greenquist, research technician; Terry J. Klopfenstein, professor, Animal Science, Lincoln; Thomas Robb, Abengoa Bioenergy, York.

Effect of Dietary Inclusion of Wet Distillers Grains on Feedlot Performance of Finishing Cattle and Energy Value Relative to Corn

Kyle J. Vander Pol
Galen E. Erickson
Terry J. Klopfenstein
Matt A. Greenquist
Thomas Robb [1]

Summary

An experiment evaluated the effects of six dietary inclusions of wet distillers grain plus solubles (WDGS) on feedlot performance and carcass characteristics of yearling steers, and also evaluated the energy value of WDGS relative to corn. Treatments consisted of 0, 10, 20, 30, 40, and 50% (DM basis) dietary inclusion of WDGS. Final BW, DMI, and ADG increased quadratically, while feed: gain decreased quadratically as WDGS inclusion increased from 0 to 50% of DM. No differences in carcass characteristics were observed among treatments. Energy value of WDGS relative to corn was above 100% for all inclusion levels and decreased (178 to 121%) as dietary WDGS inclusion increased, (10 to 50% of DM). Results indicate that WDGS can be used effectively in finishing diets, with optimum performance being observed at 30 to 40% dietary inclusion.

Introduction

As the U.S. ethanol industry continues to expand, the availability of by-products generated from milling processes will increase. It is estimated that in 2005, U.S. production of fuel grade ethanol may reach 4 billion gallons and will continue to grow. Therefore, it appears that there is a tremendous opportunity for cattle feeders to take advantage of and use these by-products in their current operations.

Along with the positive availability of distillers by-products, past research has indicated a higher energy value of feeding distillers by-products compared to dry-rolled corn when fed to cattle. However, the higher energy value appears to be inclusion level dependent and the response is variable. Therefore, knowing that the potential exists to use more wet distillers by-products in feedlot diets than what is currently being used opens up an avenue that many nutritionists, and ethanol companies are interested in.

The objective of this trial was to determine the effects of increasing dietary inclusion of wet distillers grains plus solubles (WDGS) on feedlot performance and carcass characteristics of finishing yearling steers, and to determine the energy value of WDGS relative to a high-moisture/dry-rolled corn combination as level of WDGS increases from 0 to 50% (DM basis) in 10% increments.

Procedure

A 126-day finishing trial used 288 crossbred yearling steers (BW = 773 ± 24 lb) with predominately British breed influences in a completely randomized design. Five days before the initiation of the trial, steers were limit fed a high fiber ration consisting of a 1:1 ratio (DM basis) of alfalfa hay and wet corn gluten feed at 2.0% of BW. Steers were weighed individually on day 0 and day 1, to obtain an accurate initial weight, and poured with Elector[C] (*Elanco Animal Health, Greenfield, IN)* on d 1. Steers were stratified by weight, and assigned randomly to pen (eight steers/pen). Pen was assigned randomly a dietary treatment and served as the experimental unit. In total there were six treatments and six replications/treatment, resulting in 36 pens.

The six dietary treatments (Table 1) consisted of a control (CON) with no WDGS, 10% WDGS (10DG), 20% WDGS (20DG), 30% WDGS (30DG), 40% WDGS (40DG), and 50% WDGS (50DG) all included in the ration as a percentage of DM. Alfalfa hay was included in all diets at 5.0% of DM, and high-moisture corn (HMC) and dry-rolled corn (DRC) were fed at a 1:1 ratio (DM basis). WDGS replaced this blend of HMC:DRC so all diets had a constant ratio of HMC to DRC. Dry matter determinations were conducted weekly on all ingredients by drying samples in a 60° C forced air oven for 48 hours. Diets were formulated to meet or exceed the NRC (1996) requirements for metabolizable protein, Ca, and K. Dietary adaptation consisted of a step-up procedure where alfalfa hay replaced corn starting at 45% of DM, and was reduced by 10%, with the step durations being 3, 4, 7, and 7 days, for steps 1, 2, 3, and 4, respectively. Steers were fed once daily at 0800 by means of a single axle truck equipped with a Roto-Mix® model 420 (*Roto-Mix®, Dodge City, Kan.*) mixer/delivery box.

Steers were implanted on day 28 with Revalor-S® (*Intervet, Millsboro, DE*). Dietary ingredients were sampled once weekly, analyzed for DM (AOAC,1965), frozen, composited by month, and analyzed for N and ash (AOAC, 1965).

Steers were slaughtered on day 127 at a commercial abattoir (*Tyson Fresh Meats, West Point, NE*). Hot carcass weight and liver scores were recorded on day of slaughter. Ribeye area and fat thickness were measured after a 24-hour chill. Further, marbling score and yield grade were called by a trained USDA grader. Final BW, ADG, and feed efficiency were calculated based on hot carcass weights adjusted to a common dressing percentage of 63. This was done to minimize error associated with gut fill, and to provide an accurate estimate of final weight.

The energy value of each level

(Continued on next page)

of WDGS (Table 2) was calculated using feed efficiency. The difference between each WDGS treatment and the CON was calculated, divided by the feed efficiency value of the CON treatment, as well as the percentage of WDGS in the corresponding diet to give an energy value of WDGS relative to the CON treatment (see Table 2).

Wet distillers grains plus solubles were produced at a commercial ethanol plant (*Abengoa Bioenergy, York, NE*), and delivered once weekly to the research facility. Based on information obtained from the ethanol plant, the ratio of distillers grains to distillers solubles was 65:35 (DM basis), and contained on average; 32.6% DM, 30.6% CP, and 12.0% crude fat.

Data were analyzed using the mixed procedures of SAS (*Version 9.1, SAS Inc., Cary, NC*) as a completely randomized design, with pen as the experimental unit. Orthogonal contrasts were used to test significance for the highest order polynomial.

Results

Performance and carcass variables are presented in Table 2. Carcass adjusted final body weight followed a significant ($P < 0.01$) quadratic increase as WDGS inclusion increased. Similarly, DMI increased quadratically ($P < 0.01$) as WDGS inclusion increased, with cattle on the 30DG treatment achieving the highest intake. Additionally, ADG increased quadratically (Figure 1) as WDGS inclusion increased from 0 to 50% of DM, with cattle fed the 30DG having the highest ADG. Feed conversion followed a significant ($P < 0.01$) quadratic decrease (Figure 1) as WDGS inclusion increased from 0 to 50% of the diet. However, optimum feed conversion was achieved when WDGS was incorporated into the diet at 40% of DM.

Calculated energy value of WDGS relative to HMC/DRC, resulted in energy values greater than 100% regardless of WDGS inclusion. The 10DG treatment yielded the highest energy value relative to corn, and the overall response was a significant

Table 1. Composition of dietary treatments and formulated nutrient analysis.[a]

Ingredient	CON	10DG	20DG	30DG	40DG	50DG
High-moisture corn	45.0	40.0	35.0	30.0	25.0	20.0
Dry-rolled corn	45.0	40.0	35.0	30.0	25.0	20.0
WDGS	—	10.0	20.0	30.0	40.0	50.0
Alfalfa hay	5.0	5.0	5.0	5.0	5.0	5.0
Dry supplement[b]	5.0	5.0	5.0	5.0	5.0	5.0
Fine ground corn	1.04	1.78	2.07	2.35	2.61	2.66
Limestone	1.45	1.55	1.57	1.55	1.53	1.51
Urea	1.29	0.66	0.44	0.21	—	—
Potassium chloride	0.45	0.42	0.39	0.36	0.33	0.31
Salt	0.30	0.30	0.30	0.30	0.30	0.30
Calcium sulfate	0.24	0.06	—	—	—	—
Tallow	0.13	0.13	0.13	0.13	0.13	0.13
Trace mineral premix[c]	0.05	0.05	0.05	0.05	0.05	0.05
Rumensin-80 premix[d]	0.016	0.016	0.016	0.016	0.016	0.016
Thiamine[e]	0.013	0.013	0.013	0.013	0.013	0.013
Vitamin A-D-E premix[f]	0.01	0.01	0.01	0.01	0.01	0.01
Tylan-40 premix[g]	0.009	0.009	0.009	0.009	0.009	0.009
Formulated Nutrient Analysis						
Crude protein, %	13.0	13.6	15.3	16.9	18.7	21.0
DIP balance, g/day	123	11	21	28	43	110
MP balance, g/day	37	171	301	431	560	693
Calcium, %	0.70	0.70	0.70	0.70	0.70	0.70
Phosphorus, %	0.29	0.34	0.39	0.44	0.49	0.54
Potassium, %	0.60	0.60	0.60	0.60	0.60	0.60
Sulfur, %	0.20	0.20	0.23	0.27	0.31	0.35
Ether Extract, %	4.17	5.02	5.85	6.68	7.51	8.33

[a]Values presented on a DM basis, dietary treatment levels (DM basis) of WDGS, CON = 0% WDGS, 10DG = 10% WDGS, 20DG = 20% WDGS, 30DG = 30% WDGS, 40 DG = 40% WDGS, 50DG = 50% WDGS.
[b]Supplement formulated to fed at 5% of diet DM.
[c]Premix contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, 0.5% Cu, 0.3% I, 0.05% Co.
[d]Premix contained 80 g/lb^{-1} monensin.
[e]Premix contained 40 g/lb^{-1} thiamine.
[f]Premix contained 1500 IU vitamin A, 3000 IU vitamin D, 3.7 IU vitamin E per g.
[g]Premix contained 40 g/lb^{-1} tylosin.

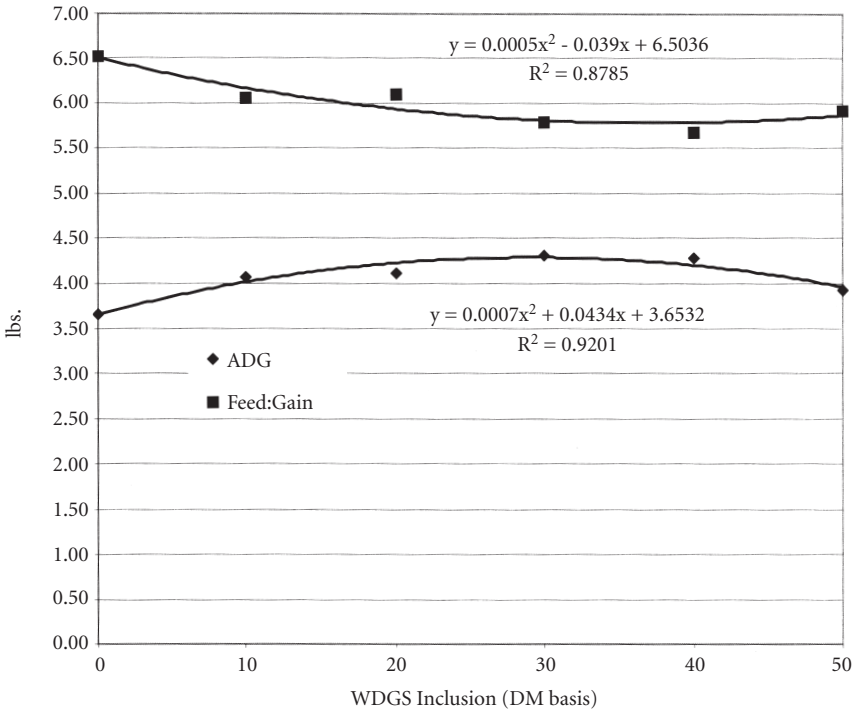


Figure 1. Graphical depiction of ADG and F:G relative to WDGS inclusion.

Table 2. Cattle performance when fed different levels of WDGS to finishing yearlings.[a]

WDGS level:	CON	10DG	20DG	30DG	40DG	50DG	SEM	Lin [b]	Quad [c]	Cubic [d]
Pens, n	6	6	6	6	6	6				
Steers, n	48	48	48	48	48	48				
Days on Feed	126	126	126	126	126	126				
Performance										
Initial BW, lb	774	772	772	772	774	772	0.7	0.60	0.52	0.81
Final BW [e], lb	1234	1285	1291	1313	1313	1267	12	0.01	< 0.01	0.43
DMI, lb/day	24.0	24.6	25.1	26.0	24.4	23.3	0.3	0.09	< 0.01	0.81
ADG, lb/day	3.65	4.07	4.11	4.31	4.27	3.92	0.09	0.01	< 0.01	0.45
Feed:Gain [f], lb/lb	6.52	6.06	6.10	5.78	5.68	5.92	0.02	< 0.01	< 0.01	0.43
Energy Value [g], %		178	138	144	137	121	7	0.81	< 0.01	<0.01
Carcass Characteristics										
HCW, lb	777	801	807	827	825	796	8	< 0.01	< 0.01	0.18
Liver Score [h]	0.23	0.24	0.23	0.29	0.31	0.33	0.11	0.40	0.87	0.90
12th Rib Fat, in	0.45	0.54	0.49	0.52	0.46	0.50	0.03	0.80	0.08	0.10
Ribeye Area, in^2	12.4	12.8	12.8	12.5	12.4	12.6	0.2	0.36	0.09	0.13
Marbling Score [i]	515	538	520	523	501	505	12	0.11	0.29	0.22
Yield Grade [j]	2.40	2.77	2.63	2.73	2.75	2.65	0.10	0.13	0.07	0.48

[a]Dietary treatment levels (DM basis) of WDGS, CON = 0% WDGS, 10DG = 10% WDGS, 20DG = 20% WDGS, 30DG = 30% WDGS, 40 DG = 40% WDGS, 50DG = 50% WDGS.
[b]Contrast for the linear effect of treatment P-Value.
[c]Contrast for the quadratic effect of treatment P-Value.
[d]Contrast for the cubic effect of treatment P-Value.
[e]Calculated from hot carcass weight, adjusted to a 63% common yield.
[f]Calculated as total gain over total dry matter intake.
[g]Calculated from feed efficiency relative to control, divided by WDGS inclusion.
[h] Where 1 = A-, 2 = A, 3 = A+.
[i]400 = Slight 0, 500 = Small 0.
[j]Called by U.S.D.A. grader.

($P < 0.01$) cubic decrease in energy value as WDGS inclusion increased from 10 to 50% of DM.

In terms of carcass characteristics, with the exception of HCW, there were no significant differences observed for any carcass characteristic. The observation of no difference in 12th fat thickness is a good indication all steers achieved similar feeding endpoints, regardless of treatment.

In summary, regardless of dietary inclusion, feeding WDGS in finishing diets generated higher energy values than a high-moisture/dry-rolled corn mixture. Because of the DMI response and maximum DMI observed at 30% WDGS, ADG increased as WDGS increased to 30%. However, ADG was similar for cattle fed either 30 or 40% WDGS. Therefore, for optimum (lowest) feed conversion, 40% WDGS should be used. Further, regardless of dietary inclusion, cattle fed WDGS achieved similar carcass characteristics as cattle not fed WDGS.

[1] Kyle J. Vander Pol, research technician; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor; Matt A. Greenquist, research technician, Animal Science, Lincoln. Thomas Robb, Abengoa Bioenergy, York.

Economic Optimum Use of Wet Distillers Grains in Feedlots

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

Summary

An economic analysis was conducted using feedlot performance, current feed ingredient prices, trucking, and cost of feeding inputs to determine economics of feeding wet distillers grains plus solubles (WDGS) at five dietary inclusions. The analysis also incorporated positive corn basis into the model. Cattle returns are greatest when incorporated WDGS is fed at 30 to 40% of DM at feedlots located between 0 and 60 miles from the plant. As distance of the feedlot increases from 60 to 100 miles from the plant, optimum inclusion is between 20 and 30% of dietary DM. Either a 5 or 10 cent positive corn basis decreases net returns on cattle by approximately $2 for each $0.05 increase in corn bushel price, but optimum inclusion amounts do not change based on distance from the plant. Results indicate more than just the cost of the product influence the economics of feeding WDGS.

Introduction

It is well documented that incorporating wet distillers grains plus solubles (WDGS) into feedlot diets yields energy values greater than corn (Ham et al., *1994 Nebraska Beef Report*, pp. 38-40; Vander Pol et al., *2006 Nebraska Beef Report,* pp. 51-53). As a result, WDGS popularity has increased especially in close proximity to ethanol plants. Another contributing factor leading to increased use is the rapid expansion of the ethanol industry, resulting in a relatively stable price.

The energy value of WDGS relative to corn is 120 to 180% depending on inclusion amount of 10 to 50% of diet DM (Vander Pol et al., *2006 Nebraska Beef Report,* pp. 51-53). However, WDGS is typically priced at 90 to 95% the price of corn at the ethanol plant. Therefore, the relatively high value compared to price has encouraged WDGS use by feedlots. However, WDGS is a relatively wet product, with average DM between 30 and 35%. WDGS typically replaces corn in feedlot diets. Due to the higher moisture content, the price is presumably greater to deliver WDGS to the bunk compared to corn. Therefore, in order for WDGS feeding to be profitable, the higher energy value associated with WDGS has to be able to make up for the increase in delivery cost at the bunk associated with feeding WDGS relative to corn.

Therefore, the objectives of this research were to determine the economic benefit of feeding WDGS relative to feeding a typical high concentrate corn based finishing diet. Energy value, inclusion rate, distance from the plant, increased feeding cost and corn price sensitivity impact on the economics were also evaluated.

Procedure

Performance Inputs

Twenty-one treatment means from 11 published research trials conducted in Illinois, Iowa, and Nebraska that involved feeding WDGS across a range of inclusions from 10 to 50% of DM were compared to develop an equation to predict the energy response (energy relative to corn) of feeding WDGS compared to corn. Because the energy value changes with inclusion amount, an equation was developed and was a linear relationship of $y = -0.84x + 164.2$ ($R^2 = 0.28$), where x equals percentage dietary inclusion of WDGS and y is the energy value relative to corn. For the economic modeling, inclusions of 10, 20, 30, 40, and 50% (DM basis) were evaluated.

The energy value of WDGS relative to corn for all 21 treatment means used was calculated utilizing feed efficiency values from each treatment comparison. The equation was based on comparing the WDGS treatment to that experiment's control performance. Therefore, WDGS energy value relative to corn was calculated as: ((WDGS feed efficiency - control feed efficiency)/control feed efficiency)/WDGS inclusion (DM basis). Therefore, using a published control value (Vander Pol et al., *2006 Nebraska Beef Report,* pp. 51-53) and calculated energy values for each inclusion level, allowed calculation of an adjusted feed efficiency value for each of the five WDGS inclusions.

For ADG, one data set was used that evaluated all the theoretical inclusions of 10, 20, 30, 40, and 50% (Vander Pol et al., *2006 Nebraska Beef Report,* pp. 51-53). The observed quadratic ADG equation as WDGS increased was used to develop an ADG prediction equation across WDGS inclusion levels. The equation was $y = -0.0007x^2 + 0.04x + 3.66$ ($R^2 = 0.91$), where x equals dietary inclusion of WDGS and y equals predicted ADG at that inclusion. Using this equation and the five WDGS inclusions to be evaluated (10, 20, 30, 40, and 50% of DM) allowed calculation of an adjusted ADG for each inclusion. The estimate for DMI was calculated using adjusted ADG divided by adjusted feed efficiency.

After adjusted ADG values were determined for each inclusion, these values were used to determine the number of days on feed a typical feedlot animal would need to be fed to achieve the same final body weight as a feedlot animal fed 0% WDGS for 153 days. For example, the control cattle gained 3.66 lb/d for 153 days (560 lb). Because cattle fed WDGS have greater ADG, less days are required to gain 560 lb. Therefore, days on feed were necessary for yardage calculations, and for appropriate DMI at each inclusion amount.

Feed Ingredient Prices and Return

WDGS are typically priced between 90 and 95% the price of corn at the plant, therefore, we assumed WDGS was priced at 95% of the corn

Table 1. Cost of feeding, adjusted days on feed, and yardage adjustments for cattle fed 10, 20, 30, 40, or 50% WDGS relative to an animal fed 0% WDGS for 153 days.

WDGS Inclusion[a]	10%	20%	30%	40%	50%
DMI, lb/day[b]	24.9	25.3	25.3	24.8	23.9
Adjusted DOF, day[c]	139.3	132.1	129.6	131.4	137.9
Yardage adjustment, $/head[d]	4.25	6.49	7.25	6.68	4.68
Total DMI, lb[e]	3469	3346	3280	3265	3298
DM of diet, %	70.6	63.5	57.7	52.9	48.8
Total feed (as is), lb[f]	4917	5273	5685	6175	6761
Feeding cost, $/head[g]	13.86	14.86	16.02	17.41	19.06

[a]WDGS inclusion as a percentage of diet DM.
[b]Calculated from adjusted ADG divided by adjusted gain:feed ratio.
[c]Adjusted days on feed equal total weight gain of control animal divided by adjusted ADG for each WDGS inclusion.
[d]Calculated from 153 days on feed minus adjusted days on feed multiplied by yardage cost ($0.31).
[e]DMI lb/d multiplied by adjusted days on feed.
[f]Total DMI divided by ration DM percentage.
[g]Feeding cost equal total as-is feed for each WDGS inclusion minus total as-is feed for control, divided by total as is feed for control multiplied by $13.00.

Table 2. Return ($/head) above cattle fed a conventional corn based diet with no WDGS, utilizing 10-year average corn price at the plant, adjacent to and three distances from the ethanol plant.[a,b,c,d]

WDGS Inclusion[e]	10%	20%	30%	40%	50%
Adjacent to plant	16.10	24.99	29.49	29.79	25.38
30 miles from plant	14.62	22.12	25.27	24.20	18.30
60 miles from plant	13.13	19.25	21.05	18.59	11.23
100 miles from plant	11.14	15.42	15.43	11.12	1.79

[a]Ten-year average corn price = $2.30/bushel.
[b]Values account for adjusted days on feed.
[c]Values account for increased costs of feeding.
[d]Trucking cost equal $2.50/mile.
[e]WDGS inclusion as a percentage of diet DM.

price, FOB (i.e., at the plant). Prices for corn and alfalfa hay were 10-year averages, equating to $2.30/bushel and $54.54/ton, respectively (*www.feuzmarketanalysis.com*). Current prices at the time of analysis were utilized for other basal ingredients, which were primarily micro ingredients totaling 5% of DM, or typical of a dry supplement.

Returns ($/hd) for feeding a steer 10, 20, 30, 40, or 50% WDGS relative to a steer fed 0% WDGS (i.e., 80% corn alone) for 153 days were calculated by determining the break even price of WDGS, or the price you could pay for WDGS when profits were equivalent to the control cattle. This was the cost of the control diet minus the cost of the basal ingredients in the five different WDGS diets divided by the amount (ton equivalent) of WDGS used in that diet. The difference between the break even cost and actual cost of WDGS for the amount of WDGS fed determined the $/head return for WDGS at each of the five dietary inclusions.

Corn Basis, Trucking Cost, Distance from the Plant, and Feeding Costs

It has been postulated that the presence of an ethanol plant will increase the demand for corn within close proximity of the plant, thus increasing the basis (cash price minus futures price) of corn in the immediate area. To account for this potential increase in corn price, price was increased either 0, 5, or 10 cents/bushel at the plant. Given these scenarios, and WDGS priced at 95% that of corn, a positive corn basis at the plant would result in a higher price paid for WDGS and corn remaining in the diet. In addition, a sensitivity component was included in the model to determine at what price feeding WDGS is more or less profitable. Inputs for this component were $1.80, $2.30, and $2.80/bushel corn at the plant.

Trucking costs at the time of analysis were assumed to be $2.50/loaded mile based on a 25 ton (as is) load. Since all feedlots are not immediately adjacent to the ethanol plant, we evaluated the economics for a feedlot 0, 30, 60, and 100 miles from the ethanol plant.

The cost of feeding WDGS in feedlots is greater than corn since WDGS has a much higher moisture content relative to corn, and there is a cost associated with hauling wet feed (more total weight) to a given feedlot pen. Therefore, we assumed the cost of feeding 0% WDGS was approximately 1/4 of yardage ($0.32/steer/d) giving a cost of feeding of $13.00 for a control (corn only) steer for 153 days. The increased feeding cost would account for equipment, labor, fuel, etc. To calculate the increase in feeding cost for diets utilizing WDGS we multiplied the percentage increase in as-fed amount of feed hauled to a pen by the $13.00 cost of feeding 0% WDGS for each WDGS inclusion we evaluated.

Results

The increased costs of feeding WDGS at five inclusions, adjusted days on feed, and corresponding yardage adjustments are presented Table 1. Days on feed, which are derived using the ADG values calculated for the five different dietary inclusions follows a quadratic pattern as dietary inclusion increases. Days on feed is lowest for cattle fed 30% WDGS (130 days), and highest for cattle fed 10% WDGS (139 days) assuming control cattle are fed 153 days. The reduced days on feed equates to a savings of $7.25 for an animal fed 30% WDGS. As mentioned previously, the cost of feeding a diet containing 0% WDGS for 153 days (153 days = industry average) is estimated to be $13.00 per animal. Because WDGS is a relatively wet product, the cost of feeding increases from $13.86/hd at a 10% inclusion, to $19.06/hd at a 50% dietary inclusion.

Assuming that feeding WDGS does not effect corn price, return ($/hd) near the plant, as well as 30, 60, and

(Continued on next page)

100 miles from the plant are presented in Table 2. These results suggest that feedlots at or near the plant have the greatest economic advantage to use a 40% WDGS dietary inclusion. However, as distance from the plant increases to 30 miles, the return is highest for WDGS inclusions between 30 and 40%. The economic optimum inclusion is decreased as the distance from the plant reaches 100 miles. Between 60 and 100 miles from the ethanol plant it is most economically favorable to utilize between a 20 and 30% dietary inclusion of WDGS.

Data evaluating a 5 cent/bushel positive corn basis at the ethanol plant are presented in Table 3. As with the ten-year average corn price, a 5 cent/bushel increase in corn price favors a 40% WDGS inclusion at or near the plant. At a distance up to 30 miles away the economic advantage of feeding WDGS is highest between a 30 and 40% inclusion. As distance from the plant and subsequent trucking cost increase up to 100 miles away from the plant, the economic advantage to feeding WDGS is highest between 20 and 30% dietary inclusion.

If corn basis at the ethanol plant is increased to 10 cent/bushel, the trends for the economic optimum inclusions do not change (Table 4). However, the overall return above cattle fed a conventional corn diet is decreased compared to a $0.05 basis or 0 basis. Therefore, as corn basis increases with ethanol plant construction, there is a lower return than if the plant had no impact on corn price. However, even if corn price increases, the feedlot has larger net returns with WDGS than without the by-product feed. The only scenario that is negative return was feeding 50% WDGS at a feedlot 100 miles from the ethanol plant. Further, the sensitivity analysis using either $1.80, $2.30, or $2.80/bushel corn generated similar trends as the corn basis data. A key to these results is the conventional corn comparison is cheaper because this assumes the ethanol plant was not built. Therefore, both the corn and the WDGS (priced relative to corn) are higher priced.

Table 3. Return ($/head) above cattle fed a conventional corn based diet with no WDGS, assuming a 5 cent/bushel increase above the 10-year average corn price at the plant, adjacent to and three distances from the ethanol plant.[a,b,c,d]

WDGS Inclusion [e]	10%	20%	30%	40%	50%
Adjacent to plant	14.64	21.86	26.44	26.78	22.34
30 miles from plant	13.17	18.99	22.22	21.18	15.26
60 miles from plant	11.70	16.12	18.00	15.58	8.19
100 miles from plant	9.73	12.29	12.37	8.11	-1.25

[a]Ten-year average corn price = $2.30/bushel.
[b]Values account for adjusted days on feed.
[c]Values account for increased costs of feeding.
[d]Trucking cost equal $2.50/mile.
[e]WDGS inclusion as a percentage of diet DM.

Table 4. Return ($/head) above cattle fed a conventional corn based diet with no WDGS, assuming a 10 cent/bushel increase above the 10-year average corn price at the plant, adjacent to and three distances from the ethanol plant.[a,b,c,d]

WDGS Inclusion [e]	10%	20%	30%	40%	50%
Adjacent to plant	9.57	19.73	23.39	23.75	19.31
30 miles from plant	8.08	15.86	19.17	18.16	12.23
60 miles from plant	6.60	12.99	14.95	12.56	5.15
100 miles from plant	4.61	9.16	9.32	5.09	-4.28

[a]Ten-year average corn price = $2.30/bushel.
[b]Values account for adjusted days on feed.
[c]Values account for increased costs of feeding.
[d]Trucking cost equal $2.50/mile.
[e] WDGS inclusion as a percentage of diet DM.

A primary driver for the use of WDGS in finishing diets has been the improved feed efficiency associated with the product. From an economic standpoint, it appears that the improved feed efficiency drives the economic advantage when using the product at specific levels. However, certain scenarios such as increased trucking and feeding costs can significantly reduce the economic benefit associated with the use of WDGS. It is important also to note that feeding a product high in moisture and phosphorus can impact the costs associated with shrink and manure handling which were not evaluated in this model. Other research (Kissinger et al., *2006 Nebraska Beef Report,* pp. 94-97) evaluating the cost of managing feedlot manure phosphorus suggest that the cost of handling the additional manure phosphorus generated by feeding by-products such as WDGS is roughly $0.75 to $1.00/hd going from 0 to 30 or 40% DM inclusion.

In conclusion feedlot managers and nutritionists should evaluate more than just the price of WDGS when determining an optimum dietary inclusion level. Based on these results, it appears that returns have been good for feedlots in close proximity to ethanol plants using wet by-products. The performance data, along with these economic data, suggest that up to 40% WDGS (DM basis) can be fed, which is probably more than is commonly used today.

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

Evaluation of a Low Protein Distillers By-product for Finishing Cattle

Virgil R. Bremer
Galen E. Erickson
Terry J. Klopfenstein
Matthew L. Gibson
Kyle J. Vander Pol
Matthew A. Greenquist[1]

Summary

An experiment was conducted to evaluate the effect of level of a low protein distillers by-product, Dakota Bran Cake (DBRAN), on feedlot performance and carcass characteristics of yearling steers. Diets contained 0, 15, 30, 45% DBRAN, or 30% dried distillers grains plus solubles (DDGS), replacing corn (DM basis). Final BW, ADG, and F:G improved linearly and daily DMI had a quadratic positive response as level of DBRAN in the diet increased. With the exception of HCW, there were no significant differences for carcass characteristics. The DBRAN had feeding performance similar to DDGS at the same inclusion level. Feeding DBRAN in this trial, up to 45% of the diet, resulted in improved performance compared to feeding high-moisture/dry-rolled corn, suggesting DBRAN has 100 - 108% of the energy value of corn.

Introduction

The growing ethanol industry is continually developing innovative ways to increase ethanol production and, in turn, market by-products derived from the milling process. Feeding some by-products as a significant portion of dietary intake presents challenges with managing various nutrient concentrations in the feed. Dakota Bran Cake (DBRAN) contains less highly fermentable starch than corn and lower levels of protein than other by-product feeds. Although DBRAN shows potential for widespread feedlot use based on composition analysis, animal performance of the product has not been evaluated.

The objectives of this research trial were to determine the effect of level of DBRAN on feedlot performance and carcass characteristics and to calculate the energy value of DBRAN relative to corn in feedlot cattle.

Procedure

Three hundred crossbred long yearling steers (BW = 837 $\pm$ 44 lb) were used in a randomized complete block design experiment. Dietary treatments (Table 1) consisted of 0, 15, 30, and 45 % DBRAN and 30% dried distillers grains plus solubles (DDGS), replacing corn (DM basis). Basal ingredients consisted of high-moisture corn and dry-rolled corn, fed at a constant 1:1 ratio (DM basis), plus ground alfalfa hay and dry supplement each fed at 5% of diet (DM basis). Rumensin®, thiamine, and Tylan® were fed at a rate of 320, 140, and 90 mg/head/day, respectively. Steers were weighed for two consecutive days (day 0 and day 1) to determine initial weight following a 5-day limit feeding period. The weights from day 0 were used to assign the cattle. Steers were blocked by weight into three blocks, stratified by weight within block, and assigned randomly to pen. Pens were assigned randomly to treatment within block with five pens per treatment and 12 steers per pen. The steers were implanted with Revalor-S® at the end of the step-up phase on day 21. In addition, one steer was removed from trial due to poor health unrelated to the study. Steers were fed for 116 days and slaughtered on day 117 at a commercial abattoir (Greater Omaha Pack, Omaha, Neb.) where livers were scored and hot carcass weights recorded. Fat thickness, ribeye area, and USDA marbling score were recorded after a 46-hour chill. Hot carcass weight, fat thickness, and ribeye area were used to calculate yield grade assuming a common kidney, heart, and pelvic fat of 2%. Performance was calculated based on hot carcass weights adjusted to a common dressing percentage (63%). Net energy value of diets was estimated using an iteration process for net energy calculation based on animal performance (Owens et al., 2002).

(Continued on next page)

Table 1. Ingredient composition and diet and ingredient analysis for diets (values presented as a percentage of dietary DM).[a]

	Treatments				
Ingredient	0 DBRAN	15 DBRAN	30 DBRAN	45 DBRAN	30 DDGS
Dry-Rolled Corn	45.0	37.5	30.0	22.5	30.0
High Moisture Corn	45.0	37.5	30.0	22.5	30.0
Dakota Bran Cake	—	15.0	30.0	45.0	—
DDGS	—	—	—	—	30.0
Alfalfa Hay	5.0	5.0	5.0	5.0	5.0
Dry Supplement	5.0	5.0	5.0	5.0	5.0
Ingredient Analysis[b]	DBRAN	DDGS	HMC	DRC	ALF
DM	52.1	93.5	70.3	87.0	86.0
Starch	26.9	8.5	72.0	72.0	
NDF	39.4	42.3	10.0	10.0	59.3
CP	14.9	30.8	9.6	10.0	17.6
Ether Extract	10.4	11.4	4.1	4.1	1.1
Minerals					
Phosphorus	0.65	0.74	0.27	0.29	0.25
Sulfur	0.35	0.76	0.14	0.14	0.27

[a]DBRAN = Dakota Bran Cake, DDGS = dried distillers grains plus solubles, HMC = high moisture corn, DRC = dry rolled corn, ALF = alfalfa, 0 DBRAN = 0% DBRAN, 15 DBRAN = 15% DBRAN, 30 DBRAN = 30% DBRAN, 45 DBRAN = 45% DBRAN, 30 DDGS = 30% DDGS.
[b]Values presented as a percentage of ingredient DM.

Table 2. Performance measurements and carcass characteristics for treatments.[a]

Item	0 DBRAN	15 DBRAN	30 DBRAN	45 DBRAN	30 DDGS	SE	*P* Value		
							Lin.	Quad.	30 DDGS vs. 30 DBRAN
Initial BW, lb	837	836	838	836	836	0.8	0.73	0.20	0.71
Final BW[b], lb	1273	1302	1315	1331	1301	8	<0.01	0.46	0.87
DMI, lb	25.1	26.8	27.1	26.9	26.3	0.3	<0.01	<0.01	0.19
ADG, lb	3.76	4.02	4.10	4.27	4.01	0.07	<0.01	0.54	0.90
Feed:Gain, lb/lb	6.74	6.72	6.68	6.37	6.62	0.09	0.01	0.08	0.33
Diet NE_m[c], Mcal/cwt	98.21	97.91	98.58	102.04	99.18	1	0.01	0.06	0.36
By-product NE_m, %[d]	—	98	101	108	103	4	0.14	0.28	0.39
Diet NE_g[c], Mcal/cwt	58.52	58.29	58.80	61.47	59.7	0.7	0.01	0.07	0.36
By-product NE_g, %[d]	—	98	101	107	102	3	0.14	0.28	0.39
Hot Carcass Weight, lb	809	828	835	846	827	5	<0.01	0.45	0.84
Marbling Score[e]	567	567	561	550	544	15	0.49	0.71	0.69
Ribeye Area, in^2	13.7	13.7	13.7	13.9	13.6	0.2	0.39	0.71	0.27
12^{th} Rib Fat Thickness, in	0.39	0.42	0.44	0.40	0.44	0.01	0.78	0.06	0.34
Calculated Yield Grade[f]	2.55	2.68	2.77	2.63	2.77	0.07	0.36	0.12	0.45

[a]DBRAN = Dakota Bran Cake, DDGS = dried distillers grains plus solubles, 0 DBRAN = 0% DBRAN, 15 DBRAN = 15% DBRAN, 30 DBRAN = 30% DBRAN, 45 DBRAN = 45% DBRAN, 30 DDGS = 30% DDGS.
[b]Calculated from carcass weight, adjusted to a 63% common dressing percentage.
[c]Calculated with iteration process for net energy calculation based on performance (Owens et al., 2002).
[d]Value relative to corn, calculated by difference of net energy, divided by by-product inclusion.
[e]400 = Slight ^{0}, 500 = Small ^{0}.
[f]Calculated as 2.5 + (2.5*Fat Depth) + (0.2* 2% KPH) + (0.0038* Hot Carcass Wt.) – (0.32*Ribeye Area) from Meat Evaluation Handbook, 2001.

All feed samples were oven dried at 60°C for 48 hours to calculate accurate DMI, feed energy analysis, and nutrient composition of ingredients.

Pen was the experimental unit, and data from each pen were analyzed as a randomized complete blocked design with the Mixed procedure of SAS for performance and carcass variables. Weight block was considered random in the model. Orthogonal polynomial contrasts were designed to test for significance of the highest order polynomial.

Results

A linear increase ($P < 0.01$) in carcass adjusted final live weight as the level of DBRAN in the diet increased (Table 2) occurred. Similarly, ADG increased linearly ($P < 0.01$) as the level of DBRAN in the diet increased. Further, G:F improved linearly ($P = 0.01$) as level of DBRAN in the diet increased. A quadratic response ($P < 0.01$) was observed for DMI as the level of DBRAN in the diet increased. Diet NE_m and NE_g values, based on performance, increased linearly ($P = 0.01$) as level of DBRAN in the diet increased. The energy value of DBRAN as a percentage of corn increased numerically as level of DBRAN in the diet increased. With the exception of hot carcass weight, there were no differences ($P > 0.05$) for carcass characteristics across treatments.

These results indicate the low protein distillers by-product has feeding performance similar to DDGS at the same inclusion level across all variables measured. Feeding DBRAN in this trial, up to 45% of the diet, resulted in improved performance compared to feeding high-moisture/dry-rolled corn, suggesting it has 100-108 % the energy value of corn depending on its inclusion level in the diet.

The energy value of DDGS in this trial was 103 % the energy value of corn at 30 % dietary DM inclusion. This number concurs with past research (2004 Nebraska Beef Report, pp. 45-48) showing similar performance of DDGS to a high-moisture corn/wet corn gluten feed control ration at 20 and 40 % DM inclusions of DDGS. In this study, WDGS was not fed. No comparison can be made between Dakota Bran Cake and WDGS.

[1]Virgil R. Bremer, graduate student; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor; Kyle J. Vander Pol, research technician; Matthew A. Greenquist, research technician, Animal Science, Lincoln. Matthew L. Gibson, Dakota Gold Research Association, Sioux Falls, S.D.

Effect of MIN-AD Ruminal Buffer and Roughage Level on Ruminal Metabolism and Extent of Digestion in Steers

**Grant I. Crawford,
Matt K. Luebbe,
Terry J. Klopfenstein,
Galen E. Erickson,
Clinton R. Krehbiel
Greg A. Nunnery[1]**

Summary

Six ruminally and duodenally cannulated steers were used in a metabolism experiment to determine effects of adding a ruminal buffer to diets containing increasing levels of roughage. Steers were fed high-concentrate diets containing 4.5, 9.0, or 13.5% alfalfa hay with or without 1.0% MIN-AD ruminal buffer. There were no differences observed in feed intake, ruminal metabolism, or total tract digestibility due to MIN-AD inclusion in the diet. Average pH increased and time below pH 5.6 and pH 5.3 decreased with increasing alfalfa level. Total tract digestibility decreased with increasing alfalfa level. Addition of MIN-AD to high-concentrate diets did not produce a response similar to increasing the roughage level in the diet.

Introduction

Modern beef cattle finishing diets routinely contain in excess of 85% concentrate. Feeding high levels of concentrate which contains rapidly fermentable starch increases energetic efficiency of a feedlot ration, but also predisposes cattle to metabolic disorders such as ruminal acidosis. Decreased DMI and ADG may result from mild acidosis, while more severe acidosis may cause prolonged reductions in DMI and ADG and possibly even death.

Roughages are included in high-grain finishing diets to reduce digestive and metabolic disorders. However, on an energy basis, roughages are one of the most expensive ingredients in the ration, and are therefore included in finishing diets at low levels. Ruminal buffers are added to beef feedlot diets in an attempt to prevent ruminal pH depression and fluctuation and ultimately acidosis. By providing for a more constant ruminal pH, buffers decrease fluctuations in DMI, and also allow for replacement of a portion of the dietary forage with a higher-energy feedstuff. The avoidance of intake-depressing digestive disorders should ultimately result in fewer days on feed.

The objective of this experiment was to determine effects of MIN-AD ruminal buffer and forage level on feed intake, ruminal metabolism, and extent of digestion in steers fed a high-concentrate diet.

Procedure

Six ruminally and duodenally cannulated Holstein steer calves (initial BW = 500 lb) were assigned randomly to one of six treatments in a 3 x 2 factorial, arranged in a 6 x 6 Latin square. Following a 21-day adaptation to a high-concentrate diet, steers were assigned to a treatment and received a different treatment in each period and received every treatment once over the course of the experiment for a total of six replications per treatment. Steers received either 4.5, 9.0, or 13.5% roughage with or without MIN-AD ruminal buffer (calcium magnesium carbonate; MIN-AD, Inc., Amarillo, Tex.) which was provided at 1.0% of the diet DM (Table 1). The concentrate portion of each treatment contained an 80:20 ratio of high-moisture corn and dry-rolled corn, and the roughage was provided as alfalfa hay. MIN-AD was provided as part of a dry supplement. All diets contained 0.25% Mg, 30.8 mg/kg Rumensin, and 11 mg/kg Tylosin. Steers did not receive an implant in this experiment.

Periods were 21 days in length (12-day diet adaptation and 9-day data collection) and all animals were fed for ad-libitum intake. Bunks were read once daily throughout each period at 0730 and feed offerings were adjusted accordingly for feeding at 0800. All feed refusals were removed, quantified, and sampled. Steers were individually fed in free stalls from days 1-12 and days 18-21 of each period. In the afternoon of day 12, steers were moved and tethered to individual metabolism stalls and were allowed to acclimate to these stalls overnight. Beginning on day 13, steers were fed in individual feed bunks suspended from load cells connected to a computer equipped with software allowing for continuous data acquisition. Feed weight in each bunk was recorded once every minute and continuously stored for each steer throughout the day. Feed intake measurements (days 13-18 of each period)

(Continued on next page)

Table 1. Composition of diets (% of diet DM).

	No MIN-AD			1.0% MIN-AD		
Ingredient[a]	4.5% Alf.	9% Alf.	13.5% Alf.	4.5% Alf.	9% Alf.	13.5% Alf.
High-moisture corn	65.2	61.6	58.0	65.2	61.6	58.0
Dry-rolled corn	16.3	15.4	14.5	16.3	15.4	14.5
Alfalfa hay	4.5	9.0	13.5	4.5	9.0	13.5
Limestone	1.45	1.29	1.14	0.91	0.75	0.59
Urea	1.05	0.93	0.80	1.05	0.93	0.80
MIN-AD	—	—	—	1.00	1.00	1.00
Potassium Chloride	0.48	0.36	0.23	0.49	0.36	0.24
Fine ground corn	0.36	0.78	1.20	0.03	0.44	0.85
Magnesium Oxide	0.13	0.12	0.11	—	—	—

[a]All diets included molasses (5.0%), Soypass (5.0%), salt (0.3%), tallow (0.13%), trace mineral (0.05%), Rumensin (0.02%), Tylan (0.01%), and Vitamin A,D,E (0.01%).

Table 2. Simple effects of MIN-AD ruminal buffer and alfalfa level on feed intake.

	No MIN-AD			1.0% MIN-AD				*P* Value		
Alfalfa (% of DM):	4.5	9.0	13.5	4.5	9.0	13.5	SEM	Alfalfa	MIN-AD	A*M
DMI, lb	14.0	15.4	14.9	14.9	14.0	15.1	0.8	0.55	0.94	0.12
Meals/day	6.19	5.62	5.89	5.75	6.57	5.32	0.46	0.18	0.99	0.13
DMI/meal, lb	2.26[b]	2.74[ab]	2.53[ab]	2.59[ab]	2.13[b]	2.84[a]	0.22	0.21	0.95	0.01
Time eating/day, min	503	603	537	572	564	557	42	0.23	0.61	0.12
Time/meal, min	81.2[c]	107.3[a]	91.1[abc]	99.4[ab]	85.8[bc]	104.7[a]	7.7	0.42	0.48	0.01

[abc]Means within a row with uncommon superscripts differ ($P < 0.05$).

Table 3. Main effects of alfalfa level and MIN-AD ruminal buffer on ruminal pH.

	Alfalfa, % of DM			MIN-AD, % of DM			*P* Value[a]		
Item	4.5	9.0	13.5	0	1.0	SEM	Alf. Linear	Alf. Quad.	MIN-AD
Average pH	5.41	5.52	5.58	5.53	5.48	0.04	0.01	0.70	0.31
Maximum pH	6.25	6.39	6.41	6.36	6.33	0.07	0.09	0.43	0.70
Minimum pH	4.92	4.95	5.02	4.97	4.96	0.03	0.05	0.56	0.72
pH change	1.33	1.44	1.39	1.39	1.37	0.08	0.53	0.36	0.86
pH variance	0.10	0.11	0.10	0.11	0.10	0.01	0.60	0.27	0.52
Time < 5.6	1015.4	853.0	778.0	834.3	930.0	62.5	0.02	0.56	0.20
Area < 5.6	360.8	276.3	252.2	269.6	323.3	35.3	0.05	0.48	0.20
Time < 5.3	613.7	450.9	393.3	439.8	532.1	65.3	0.03	0.49	0.22
Area < 5.3	114.2	76.2	74.8	77.1	99.7	18.6	0.12	0.37	0.26

[a]No differences ($P > 0.10$) due to MIN-AD inclusion x alfalfa level interaction.

included DMI, number of meals per day, average meal size, total time spent eating, and average meal length.

Also on day 13 of each period, submersible pH electrodes were placed into the rumen of each steer through the ruminal cannula and remained in place through the morning of day 18. Each pH electrode was encased in a weighted, four-wire metal shroud to keep the electrode in a stationary suspended position approximately 4 to 6 inches above the ventral floor of the rumen. Electrodes were linked directly to a computer equipped with data acquisition software to record ruminal pH every six seconds and average ruminal pH every minute throughout the pH data collection phase. On day 18 of each period the ruminal pH electrodes were removed and steers were returned to their respective free stalls. Ruminal pH measurements included average, maximum, and minimum pH, time spent below pH 5.3 and 5.6, area of pH below 5.3 and 5.6 (time below x magnitude below), pH variance, and magnitude of pH change. Ruminal samples were collected from each steer immediately before feeding on day 21, and 3, 6, 9, 12, 18, and 24 hours after feeding for VFA analyses.

Chromic oxide was used as an indigestible marker for estimating fecal output. Boluses containing 7.5 g chromic oxide were inserted through the ruminal cannula twice daily (0700 and 1900 h) from days 8-16. Fecal grab samples were collected 0, 6, and 12 hours post-feeding on days 14-17.

Data were analyzed as a 3 x 2 factorial treatment arrangement and Latin square experimental design using the Mixed procedure of SAS. Model effects were period, forage level, MIN-AD level, forage x MIN-AD interaction, and steer. Steer was considered a random effect. Least squares means were separated using the PDIFF statement in SAS when protected by a significant ($P < 0.10$) *F*-test. Forage level was analyzed for linear and quadratic responses.

Results

Intake Behavior

Intake data presenting the simple effects of MIN-AD inclusion, alfalfa level, and their interaction are presented in Table 2. An interaction between alfalfa level and MIN-AD inclusion was observed for DMI/meal as steers consuming the 13.5% alfalfa, 1.0% MIN-AD treatment had greater ($P < 0.05$) DMI/meal than those consuming either the 4.5% alfalfa, no MIN-AD treatment or the 9.0% alfalfa, 1.0% MIN-AD treatment. A similar interaction ($P < 0.05$) was observed with time spent eating per meal, as the steers consuming the 13.5% alfalfa, 1.0% MIN-AD treatment and the 9.0% alfalfa, no MIN-AD treatment spent more time eating per meal than steers consuming the 4.5% alfalfa, no MIN-AD treatment. This suggests the 4.5% alfalfa, no MIN-AD treatment produced some digestive disturbances that altered the normal intake behavior of these steers. There were no alfalfa level x MIN-AD inclusion responses ($P > 0.10$) for any other intake variable. Neither the main effect of alfalfa level nor the main effect of MIN-AD inclusion were significant ($P > 0.10$) for any of the measured intake variables. Dry matter intake ranged from 14.0 to 15.4 lb/day. Intakes were numerically higher with 1.0% MIN-AD and 4.5% alfalfa compared with no MIN-AD and 4.5% alfalfa; however, the opposite response was observed at the 9.0% alfalfa level with a 1.4 lb numerical decrease in intake when 1.0% MIN-AD was included in the diet.

Table 4. Main effects of alfalfa level and MIN-AD ruminal buffer on total tract digestibility and VFA production.

	Alfalfa, % of DM			MIN-AD, % of DM			*P* Value[a]		
Item	4.5	9.0	13.5	0	1.0	SEM	Alf. Linear	Alf. Quad.	MIN-AD
Total Tract Digestibility, %									
DM Digestibility	84.6	83.9	80.8	82.7	83.4	1.0	0.01	0.30	0.53
OM Digestibility	86.5	85.8	83.0	84.7	85.4	0.9	0.01	0.33	0.54
VFA Production									
Acetate, mM	47.5	49.7	52.0	49.0	50.5	3.4	0.17	0.97	0.58
Propionate, mM	34.3	40.3	30.3	33.3	36.7	3.6	0.30	0.03	0.29
Butyrate, mM	11.2	9.3	10.4	9.8	10.8	1.3	0.47	0.16	0.27
Total VFA, mM	100.0	105.1	99.3	98.4	104.6	7.3	0.92	0.36	0.27
Acetate:Propionate	1.38	1.23	1.72	1.47	1.38	0.24	0.08	0.02	0.62

[a]No differences ($P > 0.10$) due to MIN-AD inclusion x alfalfa level interaction.

Ruminal pH and VFA Production

There were no effects on ruminal pH due to either MIN-AD inclusion or MIN-AD x alfalfa level interaction; therefore all ruminal pH data are presented showing the main effects of alfalfa level and MIN-AD inclusion (Table 3). Ruminal pH averaged 5.53 and 5.48 with 0 and 1.0% MIN-AD, respectively, and ranged from 4.97 to 6.36 for the no MIN-AD treatments and from 4.96 to 6.33 for the 1.0% MIN-AD treatments. Average ruminal pH responded linearly ($P < 0.05$) to increasing alfalfa level, with the lowest ruminal pH observed at the 4.5% alfalfa level and the highest at the 13.5% alfalfa level. Maximum and minimum ruminal pH exhibited a response similar to that observed with average pH. The difference between the maximum and minimum pH (pH change) was fairly constant across alfalfa level, as was pH variance. A linear response ($P < 0.05$) due to alfalfa level was observed for time below pH 5.6 and time below pH 5.3. For both variables, the impact was greatest when steers consumed the 4.5% alfalfa treatments. Subacute acidosis is generally defined as a ruminal pH below 5.6. In this study, when steers consumed the 4.5% alfalfa treatments, they had a ruminal pH below 5.6 for 1,015 minutes per day, and ruminal pH below 5.3 for 614 minutes per day. This represents nearly 17 hours of the day that these steers experienced subacute acidosis, and over 10 hours per day were spent at a pH of less than 5.3. Time spent below pH 5.6 was reduced 16 and 23% when steers consumed diets containing 9.0 or 13.5% alfalfa, respectively. Area below pH 5.6 responded ($P = 0.05$) similarly to time below pH 5.6, while area below pH 5.3 exhibited a similar decline with increasing alfalfa level; however, the response was not significant ($P > 0.10$). The area measurements represent the magnitude of pH depression multiplied by the time spent below the selected pH level.

There was little impact on VFA production due to alfalfa level, MIN-AD inclusion, or their interaction (Table 4). Total VFA measured 101.5 mM when averaged across all treatments. MIN-AD inclusion did not impact ($P > 0.10$) any measured VFA variable. Acetate production averaged 49.0 and 50.5 mM for the 0 and 1.0% MIN-AD treatments, respectively, while propionate production averaged 33.3 mM with no MIN-AD inclusion and 36.7 mM with 1.0% MIN-AD inclusion. A quadratic response ($P < 0.05$) due to alfalfa level was observed for propionate production, with the highest propionate levels observed when steers consumed the 9.0% alfalfa treatments. This quadratic response ($P < 0.05$) was also present with the acetate:propionate ratio, with the lowest ratio observed with the 9.0% alfalfa level.

Total Tract Digestibility

Total tract digestibility of DM and OM was calculated from estimated fecal output as measured by dosing of chromic oxide. There were no differences ($P > 0.10$) observed for either DM or OM total tract digestibility due to MIN-AD inclusion or MIN-AD inclusion x alfalfa level interaction (Table 4), with DM digestibility averaging 82.7 and 83.4% and OM digestibility averaging 84.8 and 85.4% for the 0 and 1.0% MIN-AD treatments, respectively. Total tract DM digestibility decreased linearly ($P < 0.05$) from 84.6 to 80.6% with increasing alfalfa level. Organic matter digestibility exhibited the same response ($P < 0.05$), with total tract digestibilities of 86.5, 85.8, and 83.0% when alfalfa was included in the diet at 4.5, 9.0, and 13.5%, respectively. The increase in alfalfa level in this experiment was in place of corn, which would explain the digestibility response.

In summary, ruminal metabolism and eating behavior were not impacted by the addition of MIN-AD ruminal buffer to steer diets. An increase in alfalfa level increased ruminal pH and decreased time spent at subacute pH levels, but also decreased OM digestibility. Additional analyses are yet to be completed to further evaluate the impact of MIN-AD in this study. Ruminal buffers are occasionally added to feedlot rations to mediate digestive disturbances without having to add roughage to the diet. In this study, however, the addition of MIN-AD to high concentrate diets did not produce responses similar to those produced by increasing the roughage level in the diet.

[1]Grant Crawford, graduate student; Matt Luebbe, research technician; Terry Klopfenstein, professor; Galen Erickson, assistant professor, Animal Science, Lincoln; Clint Krehbiel, associate professor, Oklahoma State University, Stillwater; and Greg Nunnery, MIN-AD Inc., Amarillo, Tex.

Sodium Chloride and Soybeans in Feedlot Diets

Sheryl L. Colgan
Terry L. Mader[1]

Summary

Two trials were conducted to evaluate feeding sodium chloride salt (NaCl) and soybeans to feedlot cattle in summer and winter seasons. The treatments were 1) control; 2) 1% added salt; 3) 5% added whole soybeans; and 4) the combination of 1% added salt and 5% added whole soybeans. Added salt had a tendency to decrease dry matter intake and increase water intake. Additional salt and soybeans elevated tympanic temperatures. Treatment did not have an effect on performance, carcass quality grade, or dressing percentage.

Introduction

In recent years, the low price that producers received for soybeans allowed soybeans to become a competitively priced source of fat in cattle rations. Supplemental fat may have beneficial effects under both hot and cold environmental conditions. Fat is an energy dense energy source, which could enhance available digestible energy and feed efficiency of cattle exposed to cold stress. However, fat has a lower heat increment than proteins and carbohydrates, which could be beneficial during hot weather, and a disadvantage in cold weather.

During hot weather, increased dietary mineral concentration due to declining feed intake and the potential depletion of key cations from heat stress may be required. Potassium and sodium (Na) are the primary cations involved in the maintenance of acid-base chemistry. Salt (NaCl) is a common feed ingredient, which can be used to regulate feed intake, particularly at levels of 5% or more of the total diet dry matter. However, at levels less than 1% of the diet dry matter, cattle do have an appetite for salt, which tends to stimulate intake. Levels of salt that stimulate or restrict feed intake may vary depending on feeding conditions and type of environmental stress to which cattle are exposed. Effects of switching from low-salt, low-fat diets to diets containing elevated levels of salt and/or fat is unknown. The objectives of this study were to assess effects of switching cattle from a normal feedlot diet to higher salt and/or added fat from soybeans diets during summer and winter feeding periods.

Procedure

Summer Trial

Ninety-six crossbred heifers and forty-eight crossbred steers were used for this trial. Prior to trial initiation, cattle were vaccinated (Bar-Vac 7/Somnus and Express 4; Boehringer Ingelheim Vetmedica Inc., St. Joseph, Mo.) and weighed. Weight and sex were used to allot animals to 18 pens. At trial initiation, heifers and steers were implanted with Revalor-H or Revalor-S (Intervet Inc., Millsboro, Del.), respectively, weighed (mean BW = 878 lb) and sorted into allotted pens. A 3 x 3 Latin square design was utilized in which diet treatments were compared during three nine-day treatment periods. Between each treatment period, the control diet was fed to all cattle during a five-day adjustment period. Diet treatments (Table 1) were: 1) control; 2) 1% added sodium chloride (salt); and 3) 1% added sodium chloride (salt) and 5% added whole soybeans. All cattle were on control diet prior to trial initiation and started on treatment diet on day 1. Following completion of the third period, cattle remained on the last period treatment diet for 39 days, until slaughter.

Dry matter (DMI) and water (DWI) intakes were recorded daily. Body weights were obtained following completion of the latin square (day 43) and the day before slaughter (day 92). Hot carcass weight, yield grade, and marbling score were obtained at slaughter. Tympanic temperatures (TT) were recorded using Stowaway XTI[7] data loggers and thermistors (Onset Corporation, Pocasset, Mass.). 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 1-hour intervals in 20 animals from eight pens (five animals total/treatment) during the last 6 days of the second period. Treatments for the second period were imposed in late July.

Table 1. Composition of diets fed in summer trial (DM basis).

	Treatment		
	Control	Salt	Salt-soybean
Ingredient, %			
Alfalfa	8.0	6.0	7.0
Dry rolled corn	86.0	87.0	81.0
Rumensin/Tylan supplement	2.0	2.0	2.0
Liquid supplement	4.0	4.0	4.0
Salt (NaCl)	—	1.0	1.0
Whole soybeans	—	—	5.0
Nutrient Composition (estimated NRC)			
Crude protein, %	13.0	12.8	14.4
NEg, mcal/lb	0.65	0.65	0.65
Fat, %	3.8	3.8	4.5
Calcium, %	0.63	0.60	0.63
Phosphorus, %	0.32	0.32	0.34
Potassium, %	0.68	0.65	0.74
Sodium, %	0.10	0.50	0.50
DCAD, meq/100g[a]	7.6	8.0	8.7

[a]DCAD = meq (% in diet/equivalent weight) of [(Na + K) – (CL + S)].

Table 2. Composition of diets fed in winter trial (DM basis).

	Treatment			
	Control	Salt	Soybean	Salt-soybean
Ingredient, %				
Alfalfa	6.0	4.0	4.0	3.8
Corn silage	4.0	4.0	8.0	8.0
Dry rolled corn	82.7	83.7	78.0	78.0
Rumensin/Tylan supplement	2.0	2.0	2.0	2.0
Liquid supplement	3.3	3.3	3.0	3.0
Soybean meal	2.0	2.0	—	—
Salt (NaCl)	—	1.0	—	1.0
Whole soybeans	—	—	5.0	5.0
Nutrient Composition (estimated NRC)				
Crude protein, %	13.3	13.0	13.5	13.4
NEg, mcal/lb	0.65	0.65	0.66	0.66
Fat, %	3.81	3.79	4.61	4.59
Calcium, %	0.53	0.51	0.49	0.48
Phosphorus, %	0.33	0.33	0.34	0.33
Potassium, %	0.71	0.68	0.75	0.73
Sodium, %	0.09	0.48	0.08	0.47
DCAD, meq/100g[a]	8.3	7.5	9.1	8.7

[a]DCAD = meq (% in diet/equivalent weight) of [(Na + K) – (CL + S)].

Table 3. Climatic conditions during periods tympanic temperature measurements were obtained.[a]

	Mean Ta, F	Max Ta, F	Min Ta, F	RH, %	THI	WSPD, mph
Summer	78.9	93.3	69.3	69.7	74.4	5.97
Winter	26.8	37.6	16.7	64.7	31.25	4.76

[a]Ta = Ambient temperature; RH = relative humidity; THI (temperature humidity index) = (meanTa-(0.55-(0.55*(RH/100)))*(meanTa-58); WSPD = wind speed.

All data was analyzed using the Proc Mixed procedures of SAS. Carcass data was analyzed with final diet treatment in the model. Dry matter intake and DWI were analyzed using repeated measures in a 3 x 3 Latin square design. The model included the effects of square, period, diet treatment, period day, and the interaction of period day by diet. The specified term for the repeated statement was pen within period. Tympanic temperatures were analyzed using a repeated measures model that included diet treatment, time of day, day, and the interaction of diet treatment by time of day. The specified term for the repeated statement was animal.

Winter Trial

One-hundred sixty-eight crossbred steers were used for this trial. Prior to trial initiation, cattle were vaccinated (Vision 7/Somnus and Titanium 5 PHM Bac 1; Intervet Inc., Millsboro, Del.), dewormed (Safe-Guard; Intervet Inc., Millsboro, Del.), treated for external parasites (Saber; Schering Plough Animal Health, Union, N.J.), and weighed. This weight was used to allot animals to 24 pens. At trial initiation, cattle were implanted (Revalor-S; Intervet Inc., Millsboro, Del.), weighed (mean BW = 895 lb), and sorted to their allotted pens. A 3 x 4 incomplete latin square design was utilized with 10-day treatment periods in which diet treatments were compared. Between each treatment period, an 11-day adjustment period was used in which the control diet was fed to all cattle. Diet treatments (Table 2) were: 1) control diet; 2) 1% added sodium chloride (salt); 3) 5% added soybean diet; and 4) 1% added sodium chloride (salt) and 5% added soybeans. The control diet was fed to all cattle nine d prior to imposing the first treatment period. Following completion of the third period of the latin square, cattle remained on respective diets for an additional 38 days, and were then slaughtered. When including the 10 days from the final period of the latin square, the cattle were on the final diet for 48 days.

Dry matter intake and DWI were recorded daily. Body weights were obtained the day before slaughter. Animals were observed at 0800 during the last four days of each period and the number of animals in each pen showing signs of shivering was recorded. Tympanic temperatures were recorded at 1-hour intervals in three animals from each of two pens (six animals total/treatment) of each treatment for the last eight days of the Periods 1 and 2. Treatment periods were imposed in early January, late January, and mid-February. The TT data were obtained from the same animals in each period.

All data were analyzed using the Proc Mixed procedures of SAS. Dry matter and water intakes were analyzed using repeated measures for an incomplete 3 x 4 Latin square design. The model included the effects of soybeans, salt, period day, period, and all possible interactions. The specified term for the repeated statement was pen within period. Tympanic temperatures were analyzed using a repeated measures model that included soybeans, salt, and time of day with all possible interactions. The specified term for the repeated statement was animal within period.

Results

Mean ambient temperatures (Table 3), during the period TT were obtained were above 10-year normal in both the summer (78.9 vs 72.1°F) and winter (26.8 vs 23.2°F). Based on THI values (mean = 74.4 summer and 31.3 winter), conditions were sufficient to produce moderate stress in both seasons. Generally, a THI outside of the range of 35-74 is considered sufficient to elicit stress responses in beef cattle.

In the winter, the addition of salt (salt and salt-soybean treatments) decreased DMI ($P < 0.10$), increased DWI ($P < 0.05$), and decreased the DMI per DWI ratio ($P < 0.05$). The

(Continued on next page)

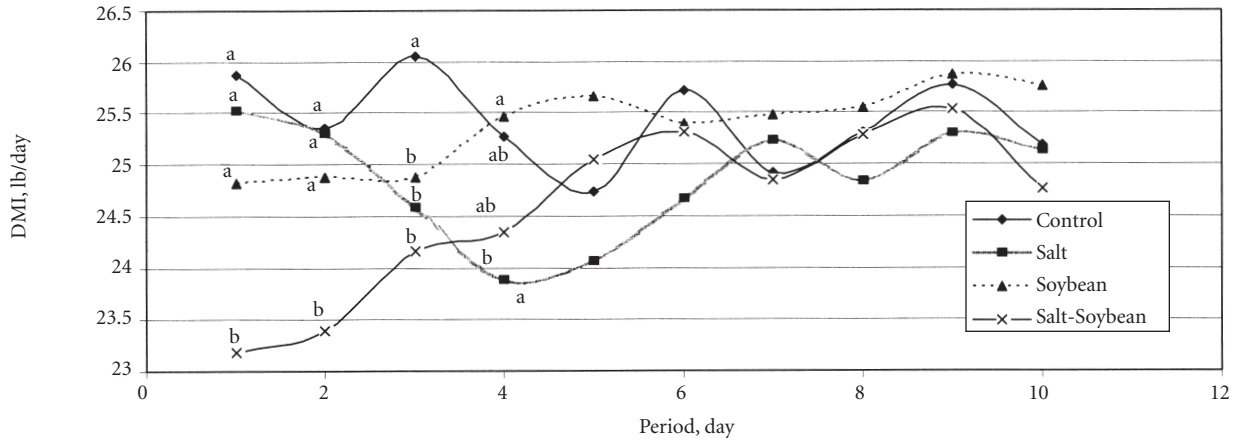


Figure 1. Winter trial daily dry matter intake. Diet treatment * period day interaction ($P = 0.07$)
[ab]Means within a day with unlike superscripts differ ($P < 0.10$).

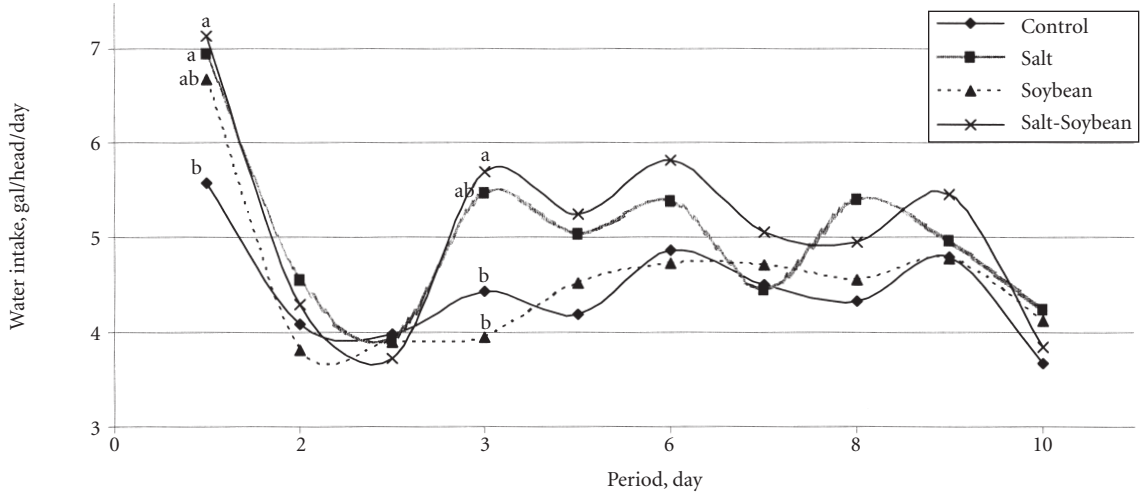


Figure 2. Winter daily water intake. Diet treatment * period day interaction ($P = 0.01$).
[ab]Means within a day with unlike superscripts differ ($P < 0.05$).

combined feeding of salt and soybeans also elevated TT in the winter (Table 4) when compared to the control treatment. In the summer, the addition of salt or soybeans did not affect DMI or DWI (Table 5). However, feeding salt and soybeans in combination still elevated ($P < 0.05$) TT. Even though dietary treatment effects were not observed in intakes during the summer, the addition of salt produced similar trends in DMI, DWI, and DMI per DWI ratio in both seasons. The lack of significance in the summer trial may be partially due to differences in DMI between the two trials. Winter DMI was 3.5 lb greater than summer intakes. This difference would indicate that the winter cattle consumed nearly 0.6 oz more salt per day than the summer cattle.

Table 4. Dry matter intake, water intake (DWI), and tympanic temperature (TT) — Winter latin square trial.

	Treatment				
	Control	Salt	Soybean	Salt-soybean	SEM
DMI[1], lb	25.42[b]	24.85[a]	25.37[b]	24.58[a]	0.383
DWI[1], gal	4.45[d]	5.05[c]	4.55[d]	5.19[c]	0.129
DMI/DWI[1]	6.06[d]	5.53[c]	6.19[d]	5.17[c]	0.102
TT[g]	101.9[a]	101.7[b]	101.8[c]	102.0[d]	0.01

[ab]Means within a row with unlike superscripts differ ($P < 0.10$).
[cdef]Means within a row with unlike superscripts differ ($P < 0.05$).
[g]Salt * soybean interaction ($P < 0.0001$).
[1]DMI = dry matter intake; DWI = daily water intake.

Table 5. Daily dry matter intake, water intake and tympanic temperature (TT) — Summer Latin square trial.

	Treatment			
	Control	Salt	Salt-soybean	SEM
DMI[1], lb	21.43	21.31	21.17	0.198
DWI[1], gal	8.40	8.68	8.41	0.172
DMI/DWI[1], lb/gal	2.69	2.67	2.71	0.098
TT, °F	101.4[a]	101.3[a]	101.9[b]	0.26

[ab]Means within a row with unlike superscripts differ ($P < 0.05$)
[1]DMI = dry matter intake; DWI = daily water intake.

Table 6. Forty-nine day performance data, carcass data, and daily water intake (DWI) — Summer performance trial.[a]

	Treatment			
	Control	Salt	Salt-soybean	SEM
Initial weight, lb	1012	1011	1006	11.0
Final weight, lb	1179	1196	1178	19.9
ADG, lb	3.41	3.77	3.50	0.215
DMI[1], lb	21.31	21.81	21.33	0.479
DWI[1], gal	7.33	7.20	6.82	0.465
DMI/DWI[1]	2.92	3.03	3.25	0.202
F/G	6.35	5.88	6.13	0.270
G/F	0.160	0.172	0.165	0.008
Quality grade[b]	18.50	18.41	18.25	0.283
Yield grade	2.07	1.96	1.98	0.079
Dressing percentage	61.5	61.6	61.5	0.32

[a]Diets provided for 49 d from end of latin square to slaughter.
[b]18 = high select; 19 = low choice.
[1]DMI = dry matter intake; DWI = daily water intake.

Table 7. Carcass data of steers in winter trial after 48 days on respective diets.

	Treatment				
	Control	Salt	Soybean	Salt-soybean	SEM
Quality grade[a]	19.31	19.27	19.29	19.31	0.161
Yield grade	2.64[c]	2.44[b]	2.48[bc]	2.41[b]	0.070
Dressing percentage	62.0	61.5	61.6	62.0	0.78

[a]Quality grade: 19 = low choice, 20 = average choice, 21 = high choice.
[bc]Means within a row with unlike superscripts differ ($P < 0.10$).

The winter trial showed a diet treatment by period day interaction ($P < 0.10$) for DMI (Figure 1). The control and soybean treatment DMI remained fairly level throughout the period, while DMI for the salt treatment group declined over the first four d and then increased to the control DMI level. By day 5, DMI was similar among treatment groups ($P > 0.05$). This indicates that the treatment differences in DMI may be due to switching and then adapting to the new treatment diet. Diet ingredients or combination of ingredients, which can be used to control or regulate DMI, may also be used to limit large increases in DMI and possibly minimize variation in DMI during adverse weather events.

The winter trial also showed a diet treatment by period day interaction ($P < 0.05$) for DWI (Figure 2). On day 1 of the period, DWI was greater for all cattle fed salt and soybean diets when compared to cattle fed the control diet. However, DWI declined for salt-fed cattle on days 2 and 3, but stabilized and became similar to control cattle by day 5 and remained similar for the duration of the period.

No significant differences were found for any treatment in performance data for the summer trial (Table 6). However, in the winter, the addition of salt tended to lower ($P < 0.10$) USDA yield grade (Table 7).

These data suggest that switching to diets containing the combination of added salt and soybeans may elevate body temperature in the summer and winter seasons, even though dry matter intake is depressed. However, added salt, by itself, tends to lower DMI and body temperature, while increasing DWI. Added soybeans by itself did not have an effect on DMI, DWI, or body temperature. Added salt or soybeans had no effect on carcass quality grade or dressing percentage.

[1]Sheryl Colgan, research technologist; Terry Mader, professor, Animal Science, Northeast Research and Extension Center, Concord.

Effects of Field Pea Level and Processing in Finishing Diets

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

Summary

Cattle were fed coarse rolled or whole field peas in a finishing diet to determine impact on finishing performance. The peas were included in the diet DM at 0%, 15%, and 30%. There were no significant differences in ADG, F:G, or carcass characteristics among processing methods or field pea level. DMI was significantly different due to level and not processing of peas. The DMI increased as the field peas inclusion increased to 30% the diet DM Field peas can be fed whole and replace corn in the diet up to 30%.

Introduction

Field pea production has increased in the United States as well as western Nebraska. The majority of the field peas are grown under contract for human consumption. Field peas must meet a strict quality guidelines to enter the human market. The peas that are not eligible for human consumption are then available for livestock feed. Field peas can be used as a protein source since they contain 20-28% CP. However, large quantities are available and producers prefer to feed large quantities or higher inclusion rates to utilize the peas as an energy source as well as protein. Often, field peas are grown by producers that own some livestock, but do not have grain processing equipment and the question arises as to the benefits of processing the peas before feeding. The objectives of this trial were to compare coarse rolled to whole peas in a finishing diet; and inclusion of 15% or 30% in dry-rolled corn finishing diets.

Table 1. Diet composition (DM basis) of rations containing whole or coarsely-rolled field peas.

	Treatments				
	DRC	15DRP	15WP	30DRP	30WP
Corn Silage	18.2	18.2	18.2	18.2	18.2
Corn	73.5	58.5	58.5	43.5	43.5
Peas	--	15	15	30	30
Supp[b]	8.3	8.3	8.3	8.3	8.3
Nutrient Content (NRC,1996)					
NEg	63.6	61.0	61.0	58.5	58.5
CP	13.5	13.5	13.5	13.6	13.6
Ca	0.81	0.77	0.77	0.72	0.72
P	0.34	0.35	0.35	0.35	0.35
K	0.55	0.63	0.63	0.72	0.72

[a]DRC = dry rolled corn; DRP = dry rolled peas; and WP = whole peas.
[b]Supplement contained: Protein content for control supplement was 58% CP, 9% calcium, 80 grams of Rumensin/ton, and 190 grams of Tylan/ton. Supplement for 15 and 30% peas were similar except protein was 12 and 18% respectively.

Procedure

Two hundred and five crossbred yearlings steers (average weight = 1068 lb) were randomly assigned to 20 pens and then pens were assigned randomly to five treatments. Initially cattle were weighed and implanted with Synovex Plus. Cattle were in pens with 10-11 head per pen, and four pens per treatment. Cattle were fed whole or coarse-rolled peas at 15 and 30% of the diet DM or a dry rolled corn diet (Table 1). The peas were rolled through a roller mill with the objective of breaking the seed coat of the peas and breaking into two or more pieces. Combinations of two supplements were fed due to the protein content of the peas. Each supplement contained equal amounts of vitamins, trace minerals, and monensin, but the CP was 10% and 58%. Therefore, peas replaced corn and protein. The cattle were transitioned between the growing ration and a finishing ration in 21 days; using three steps with 10% concentrate replacing forage in each step to the final diet (fed for 7 days each). The cattle were fed an inclusion of field peas at 0%, 15%, and 30%; the peas were either fed whole or course rolled. It was assumed the corn silage was 45% grain and 55% roughage giving 10% roughage DM in the final finishing diets. Cattle were fed a total 75 days to harvest and carcass data collected 18 hr after harvest. The data were analyzed in SAS using Proc Mixed with means separated with contrast statements testing level, processing and their interaction. Treatment means with ≤ 0.05 were considered significant.

Results

Cattle performance data are shown in Table 2. There were significant differences in DMI due to level, but not processing. The processing did not show an effect on intake, but as the field pea inclusion increased to 30% the DMI increased. However, there were no significant differences for ADG, or F:G between coarse rolled and whole peas or between levels. No significant differences in carcass data were detected. Numerically there appears to be several benefits in processing when 30% peas were fed; however, in this trial the differences were not great enough to be statistically different. In conclusion, finishing cattle fed

Table 2. Performance of finishing cattle fed whole and coarsely cracked field peas.

	Treatments					*P*-value[b]		
	CON	15DRP	15WP	30DRP	30WP	Proc	Level	Interaction
DMI	24.5	24.5	24.5	25.2	25.0	0.457	0.0029	0.7449
ADG	3.69	3.94	3.82	4.06	3.75	0.1721	0.8597	0.5262
F:G	6.69	6.24	6.43	6.21	6.72	0.1784	0.593	0.5247

[a]DRC = dry rolled corn; DRP = dry rolled peas; and WP = whole peas.
[b]Proc=Processing, Level= 0%, 15%, or 30% field inclusion, and interaction between the processing and levelof peas fed.

whole or coarse rolled peas at 15 or 30% of DM gain similar to cattle fed corn and produce similar carcasses. In conclusion, cattle could be fed whole peas up to 30% of diet DM with good finishing performance.

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

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 during the summer of 2004 to evaluate the effects of vaccinating cattle against Escherichia coli *on the probability of detecting* E. coli *O157:H7 in feces and colonization at the terminal rectum. The probability for vaccinated or nonvaccinated cattle to shed* E. coli *O157:H7 in feces was not significantly different. However, the probability for steers to be colonized by* E. coli *O157:H7 in the terminal rectum was greatly reduced for vaccinated (0.3%) compared with nonvaccinated (20.0%) steers. We concluded that the vaccine was effective at reducing colonization of* E. coli *O157:H7 at the terminal rectum of cattle.*

Introduction

Beef cattle represent an important reservoir for *E. coli* O157:H7 and, in cattle, the mucosal cells 3-5 cm proximal to the terminal rectum are an important site of colonization. Previous research at Nebraska found that vaccinating feedlot cattle against Type III secretory proteins of *Escherichia coli* reduced the probability that cattle shed *E. coli* O157:H7 in the their feces (*2005 Nebraska Beef Report*, pp. 61-63); however, no research documenting the effects of the vaccine on colonization of *E. coli* O157:H7 in the terminal rectum has been reported. Intervention strategies aimed at reducing colonization in the terminal rectum could aid beef industry efforts to reduce *E. coli* O157:H7 contamination of beef products. Therefore, a clinical trial was conducted to evaluate the effects of vaccination on the probability that cattle shed *E. coli* O157:H7 in the feces, and that of animals colonized by this organism in the terminal rectum when the treatment is applied at the pen level.

Procedure

The clinical trial was conducted during the summer months (May - September) of 2004 at the University of Nebraska Beef Research Feedlot at Ithaca, Neb. Two hundred eighty eight medium-weight steers were stratified by weight and assigned randomly to 36 pens (eight head/pen) and pens were assigned randomly to vaccination treatment. Cattle were stratified by weight so the heaviest 36 cattle could be systematically assigned to 1 of 36 pens using a random number generator. This process was repeated seven more times so that each pen would have a total of eight animals per pen.

Treatments included vaccinated and nonvaccinated pens of steers. Steers in vaccinated pens received three doses of the vaccine at 21-day intervals. Steers in nonvaccinated pens received 3 doses of the adjuvant (placebo) at the same 21-day intervals. Researchers and feedlot personnel were blinded to the actual vaccination treatments.

Each steer was sampled by rectal fecal grab on day 0 and every 14 days of the feeding period following administration of the treatment, resulting in 1 pre-treatment period (day 0), and 4 test-period samplings (14, 28, 42, and 56 days post treatment). Feces from all steers were collected for culture on the same day within the same test period. 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.

A terminal rectum mucosal (TRM) sample was collected from each steer by scraping mucosal cells 3-5 cm proximal to the rectoanal juncture at harvest. The TRM samples were cultured using standard methods involving selective enrichment, immunomagnetic separation, agar plating, biochemical and immunological testing, and PCR confirmation as previously described (*2004 Nebraska Beef Report*, pp. 67-68) with modifications.

The effect of vaccine treatment on the probability to detect *E. coli* O157:H7 from feces was tested by modeling the probability of detecting *E. coli* O157:H7 from feces using the logit link function in a multivariable generalized estimation equation (GEE) model (Proc GENMOD, SAS Institute, Cary, N.C.). Least squared means of the parameter estimates from the multivariable logistic models were used to estimate adjusted probabilities for class variables (vaccine treatment). Relative risk (RR) values for levels of vaccine treatment were calculated from the adjusted probabilities and vaccine efficacy was calculated as (1-RR).

Results

E. coli

In total, *E. coli* O157:H7 was recovered from 86 of 1,419 culture observations (6.1%) from feces collected from steers in vaccinated and nonvaccinated pens. During the pre-treatment sampling period, the average proportion of steers shedding *E. coli* O157:H7 within the treated pens was 6.3% and was 1.4% in nonvaccinated pens ($P = 0.07$).

In this study an association between test period and the probability for cattle to shed *E. coli* O157:H7 approached statistical significance ($P = 0.07$; Figure 1). Other studies suggest test period was significantly associated with fecal shedding of *E. coli* O157:H7 (Potter et al., Vaccine 2004; *2005 Nebraska Beef Report*, pp. 61-63, Khaitsa et al, 2003), The odds of detecting *E. coli* O157:H7 in the feces increased as the time between the last vaccination and sampling occurred. After adjusting for dietary and vaccination treatment, and using day 56 posttreatment as the referent,

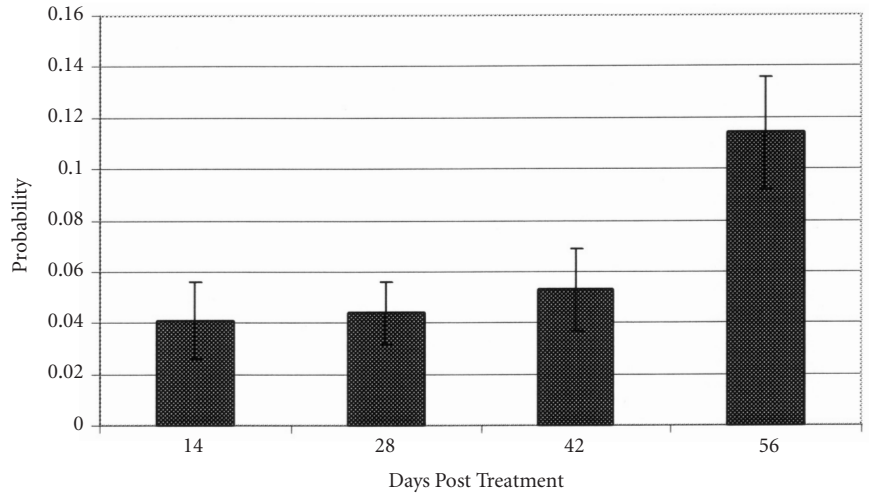


Figure 1. Probability of steers shedding *E. coli* O157:H7 in the feces 14, 28, 42, and 56 days post treatment adjusted for dietary and vaccination treatment.

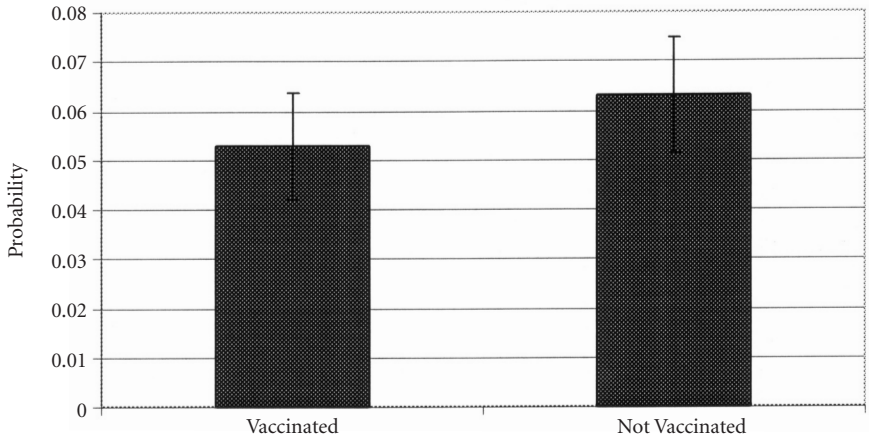


Figure 2. Probability of steers shedding *E. coli* O157:H7 in the feces by vaccination treatment adjusted for sample and dietary treatment.

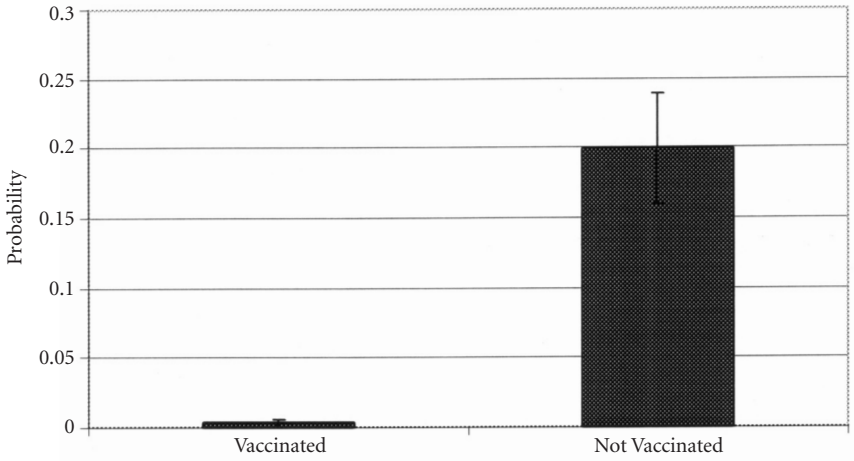


Figure 3. Probability of steers to be colonized by *E. coli* O157:H7 in TRM at harvest by vaccination treatment adjusted for dietary treatment.

the odds of detecting *E. coli* O157:H7 in the feces on d 14, 28, and 42 were 0.33, 0.60 and 0.44, respectively. In contrast to previous reports (*2004 Nebraska Beef Report*, pp. 67-68; *2005 Nebraska Beef Report*, pp. 61-63), vaccination was not associated ($P = 0.51$) with the probability for cattle to shed *E. coli* O157:H7 in the feces (Figure 2). However, the relatively low probability to detect *E. coli* O157:H7 in feces during this study compared with studies conducted in previous years may explain the lack of association between vaccination and test period and the probability to detect *E. coli* O157:H7 in feces. The probability to detect *E. coli* O157:H7 in feces during the summers of 2002 and 2003 was 0.15 and 0.20, respectively (*2004 Nebraska Beef Report*, pp. 67-68; *2005 Nebraska Beef Report*, pp. 61-63). The probability to detect *E. coli* O157:H7 in feces over the course of this study was 0.06. After adjusting for sample and dietary treatment, the odds for vaccinated cattle to test positive for *E. coli* O157:H7 in the feces were 0.83 times the odds for nonvaccinated cattle to test positive for *E. coli* O157:H7 in the feces.

Terminal Rectum Mucosa

The factors explaining the probability for steers to test positive for *E. coli* O157:H7 in TRM samples in the multivariable logistic regression model were diet and vaccination treatment. Dietary treatment did not interact with vaccination. Vaccination was significantly ($P < 0.001$) associated with the probability for cattle to be colonized by *E. coli* O157:H7 1-2 inches proximal to the rectoanal juncture (Figure 3). After adjusting for dietary treatment, the odds of vaccinated steers to be colonized by *E. coli* O157:H7 1-2 inches proximal to the rectoanal juncture was 0.01 times the odds of nonvaccinated steers to be colonized by *E. coli* O157:H7 at the same location, a vaccine efficacy of 98.5%.

Although we were unable to detect a significant difference in the probability to detect *E. coli* O157:H7 in feces due to vaccination treatment, results from this study suggest vaccination effectively reduced the probability for cattle to become colonized by *E. coli* O157:H7 3-5 cm proximal to the rectoanal juncture.

---

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

Large-scale Clinical Trial to Evaluate an Experimental *Escherichia coli* Vaccine

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

Summary

A clinical trial was conducted within 19 Nebraska feedlots to evaluate effects of an E. coli *vaccine on the probability to detect* E. coli *O157:H7 on ROPES or for cattle to be colonized by* E. coli *O157:H7 at the terminal rectum. Vaccinated pens of cattle were less likely to test ROPE-positive than nonvaccinated pens of cattle and a lower probability for* E. coli *O157:H7 colonization among vaccinated cattle compared with nonvaccinated cattle was observed. The vaccine was effective at reducing* E. coli *O157:H7 in the feedlot pen environment and colonization at the terminal rectum of cattle.*

Introduction

Research reported in the previous article of this report indicates several benefits of vaccination for *E. coli* O157:H7 in market ready beef cattle (*2006 Nebraska Beef Report*). However, vaccination has not been evaluated in a large-scale study that accounted for multiple factors known to influence the probability to detect *E. coli* O157:H7 in the feedlot environment. For example, time of year, pen condition, and feedlot have all been identified as factors that explain the variability in the prevalence of *E. coli* O157:H7 associated with feedlot cattle. Therefore, there was a need to evaluate vaccination as a pre-harvest intervention strategy in a large-scale commercial feedlot study.

Procedure

The study was a large-scale clinical trial designed to test the effect of a two-dose vaccination regimen on the probability to detect *E. coli* O157:H7 on pen-test devices (ROPES) and from mucosal cells of the rectoanal junction of cattle at harvest. Commercial feedlots were classified as either feeding or not feeding a direct-fed microbial (DFM) product. Pens of vaccinated and nonvaccinated cattle within feedlots were matched by time of sampling, reprocessing schedule, and estimated days to finish weight. Vaccine was given to all cattle within treated pens at initial processing and again at reimplant. Pair-matched nonvaccinated pens of cattle were sampled on the same days. Research personnel responsible for vaccinating cattle and collecting samples and other data from the cattle were blinded to microbiological results. Research personnel working in the microbiological laboratory were blinded to treatment assignments.

Each pen of cattle enrolled in the study was sampled for *E. coli* O157:H7 starting at least one week after the second dose of vaccine was given (untreated pens of cattle were sampled on the same day as the pair-matched vaccinated pen) and continued every three weeks for four test period samplings. Pens were tested for *E. coli* O157:H7 by hanging seven ropes from the neckrail of the feedbunks where cattle could easily lick, chew, or rub on them. Pens were classified ROPES-positive if *E. coli* O157:H7 was recovered from at least one rope-device. *E. coli* O157 was isolated and identified by standard methods involving selective enrichment, immunomagnetic separation, agar plating, biochemical and immunological testing and PCR confirmation.

The outcome variable (Yes/No) defined if pens tested ROPES-positive for *E. coli* O157:H7. The binomial probability of detecting *E. coli* O157:H7 from at least one ROPES within a pen was modeled with a Generalized Estimating Equations (GEE) model using the GENMOD procedure of SAS accounting for a correlated data structure with repeated measure of pens (test periods), and clustering of matched pairs of pens within feedlot.

The variable of interest was vaccination (Yes/No). Additional specific contrasts were vaccination versus not vaccinated and short revaccination period (13-45 days) versus long revaccination period (45-100 days). Potential confounders tested in the GEE model were feeding a DFM, region of the state (defined as East or West of a North/South line extending through Grand Island, Neb.), month of sampling, the condition of the pen floor (dry and dusty, wet and muddy, ideal condition), number of cattle in the pen (145 cattle or less, greater than 145), cleanliness of the cattle, and test period. An interaction between vaccination and test period was tested. Additionally, the variable representing direct-fed microbial feeding was forced in the model as a fixed effect because of its importance as a potential confounder. Other variables remained in the model if they contributed to the model fit and significantly explained the probability for ROPES-positive pens ($\alpha \leq 0.05$).

Twenty one pens of cattle on the study (11 vaccinated, 10 not vaccinated) were followed to the packing plant so samples could be collected to test effect of the vaccine on probability for colonization of mucosal cells of the terminal rectum. Cattle were systematically selected for sampling from within each pen. The sample size for each pen was calculated so that we would be 95% confident to estimate EC prevalence at 50% with a 15% precision. Terminal rectum mucosal cells (TRM) were collected by scraping the mucosa of the terminal rectum 1-2 inches proximal to the rectoanal juncture. The TRM were cultured using standard methods involving selective enrichment, immunomagnetic separation, agar plating, biochemical and immunological testing, and PCR confirmation as previously described.

The outcome of interest was the probability of detecting *E. coli* O157:H7 from TRM, analyzed using a generalized linear mixed model. Differences in the mean days from reprocessing to slaughter for vaccinated and not vaccinated pens was tested by the Student's t test assuming equal variances.

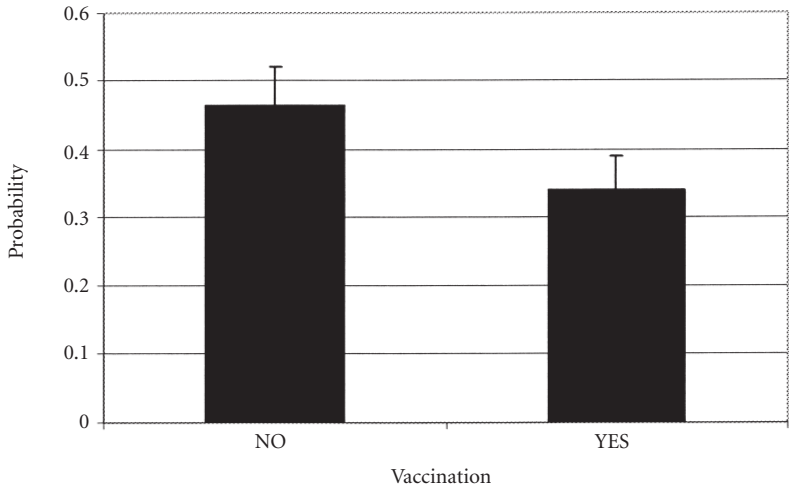


Figure 1. Adjusted probabilities for vaccinated and unvaccinated pens to test ROPES-positive for *E. coli* O157:H7.

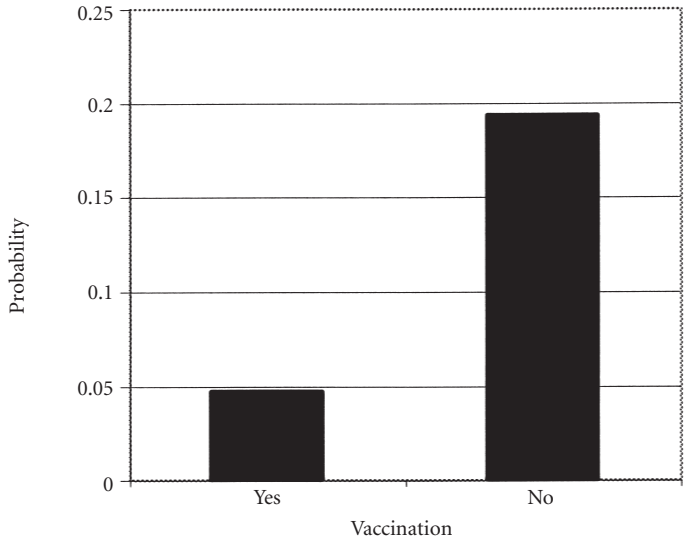


Figure 2. Probabilities for *E. coli* O157:H7 colonization of the rectoanal junction at slaughter for vaccinated and unvaccinated cattle.

Results

One-hundred forty eight pens of cattle (n=21,691 hd of cattle) within 19 commercial feedlots in Nebraska were enrolled in this study. However, two matched pairs of cattle pens were not reprocessed until October and November leaving no usable observations during the study period ending October 31 and cattle from two pairs of pens were not revaccinated; therefore, the data analyzed were from 140 pens of cattle within 19 feedlots representing 20,566 cattle.

Data were not collected from all four periods for all pens of cattle either because some pens of cattle were marketed before all four test periods were completed, or because some test periods fell outside of the study period (after October 31). In total, 86 pair- matched pens of cattle were in feedlots feeding a direct-fed microbial (DFM) and 54 pair- matched pens of cattle were in feedlots not feeding a DFM. The time interval between initial process (vaccination) and reprocessing (revaccination) averaged 54.2 (13-104) days. There were 485 pen observations and each observation had complete dependent and independent data. The number of cattle per pen averaged 146.8 (53-300) head.

ROPES

Nonvaccinated pens of cattle were more likely to test ROPES-positive than matched vaccinated pens of cattle (OR (odds ratio) =1.68, $P = 0.0035$), accounting for other variables in the model (Figure 1). There was no significant interaction between vaccination treatment and test period ($P = 0.94$), demonstrating efficacy of the vaccine did not change over time after revaccination.

The variables representing month of the year, region of the state, and the number of cattle within the pen remained in the model because they significantly explained the probability for pens of cattle to test ROPES-positive. Condition of the pen floor was retained in the model because the variable approached significance and has previously been demonstrated to explain the probability for pens of cattle to test ROPES-positive.

Terminal Rectum Mucosa

Terminal rectum mucosal (TRM) samples were collected from 720 cattle; 382 vaccinated cattle from within 11 pens and 338 nonvaccinated cattle from 10 pens. Four-hundred forty-one cattle were from within 13 pens fed DFM and 279 cattle were from within 8 pens of cattle not fed DFM.

Probability for *E. coli* O157:H7 colonization of the mucosal cells of the terminal rectum at slaughter among vaccinated cattle was lower (4.7%) compared with nonvaccinated cattle (19.5%). Vaccination reduced the probability for cattle within a feedlot to be colonized with *E. coli* O157:H7 at slaughter (OR=0.20; $P = 0.03$). Vaccine efficacy was 76% (Figure 2).

Vaccination of cattle within commercial feedlots was effective for reducing the probability of detecting *E. coli* O157:H7 from ROPES and the vaccine reduced, at slaughter, *E. coli* O157:H7 colonization of the terminal rectum mucosal cells of cattle fed in a commercial system.

Acknowledgments

The authors of this report would like to express their sincere appreciation to the feedlots that so graciously participated in the study. Without the outstanding cooperation from these feedlots this study would not have been possible.

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

Effect of Optaflexx Dosage and Duration of Feeding Prior to Slaughter on Feed Conversion and Carcass Characteristics

Grant I. Crawford
Galen E. Erickson
Kyle J. Vander Pol
Matt A. Greenquist
Jeffrey D. Folmer
Michael T. Van Koevering[1]

Summary

Finishing steer calves were fed 0, 100, or 200 mg/head/day of Optaflexx for the final 28, 35, or 42 days of the finishing period. Steers were started on Optaflexx treatment at one-week intervals and marketed as a single group. Feeding Optaflexx to feedlot steers increased ADG, improved F:G, and increased carcass weight. Feeding 200 mg/head/day of Optaflexx improved feed conversion by 8.1% without impacting carcass characteristics. Feeding Optaflexx at 200 mg/head/d for 28 to 42 days appears beneficial when compared with feeding diets without Optaflexx.

Introduction

Optaflexx is a feed additive approved for use in feedlot cattle during the final 28 to 42 days of the feeding period. Optaflexx can be fed at a rate of 70 to 430 mg/head/day and 9.1 to 27.3 g/ton (100% DM basis) in the final mixed diet to improve rate of weight gain and feed efficiency.

While some information is available on effects of Optaflexx dosage and feeding duration from research prior to F.D.A. approval of Optaflexx, post-approval data are limited. Because of the wide range of approved inclusion rates, research to predict response at various doses and durations is warranted. The objective of this experiment was to evaluate F:G and carcass characteristics when steers were fed 0, 100, or 200 mg/head/day of Optaflexx for the final 28, 35, or 42 days prior to slaughter.

Procedure

Crossbred (English x Continental) steer calves were received at the Agricultural Research and Development Center near Mead, Neb. in the fall of 2003. Calves were received on a common program and adapted to grain over a 21-day period by replacing alfalfa with high-moisture corn. Prior to initiation of Optaflexx treatment all cattle were fed 58.5% high-moisture corn, 30% wet corn gluten feed (SweetBran, Cargill, Blair, Neb.), 7.5% alfalfa hay, and 4% dry supplement (DM basis).

In late January, steers were re-implanted and weighed individually on two consecutive days. At this time, steers were assigned to one of nine treatments, arranged as a 3 x 3 factorial with factors including Optaflexx feeding duration (final 28, 35, or 42 day of the finishing period) and Optaflexx dosage (0, 100, or 200 mg/head/day). Steers were separated into two blocks based on two-day re-implant weights. The heavy block consisted of 360 steers assigned randomly to 36 pens (10 steers/pen), while the light block consisted of 495 steers assigned randomly to 45 pens (11 steers/pen). Pens within a block were assigned randomly to one of nine treatments in the 3 x 3 factorial. An additional 69 steers were assigned randomly into six pens creating three baseline marketing groups. The baseline marketing cattle were fed the same diet as the heavy and the light block, and two pens (23 head) were slaughtered at initiation of each Optaflexx duration treatment (light block, 28, 35, 42 days) to determine carcass characteristics for later estimation of carcass changes during the Optaflexx feeding period. Carcass ADG and efficiency of weight transfer were calculated by regressing dressing percentage on days after initial weight using the baseline marketing cattle (day 0, 7, and 14; n=69) and all control cattle in the light block (day 42; n=164). This allowed for observations of dressing percentage at 0, 7, 14, and 42 days after initial weights were measured. From this regression, a theoretical dressing percentage was determined by multiplying the duration of feeding after initiation of treatment with the slope generated from the regression and then subtracting this value from final dressing percentage. The slope represents gain in dressing percentage for each day after initiation of treatment. An initial carcass weight was then calculated by multiplying the theoretical initial dressing percentage with live weight at the time of treatment initiation.

Steers were implanted with Synovex-S initially and re-implanted with Revalor-S 100 and 104 days prior to marketing for the heavy and light block, respectively. The baseline marketing cattle received the same implant treatments, and therefore were implanted 62, 69, and 76 days prior to slaughter for the 42, 35, and 28 day treatments, respectively.

During the Optaflexx feeding period, a new Optaflexx dry supplement consisting of fine-ground corn was added to all diets to provide 0, 100, or 200 mg/head/day of Optaflexx. These diets included 55.4% high-moisture corn, 30.0% wet corn gluten feed, 7.5% alfalfa hay, 4% supplement, and 3.1% of the Optaflexx supplement (DM basis). Cattle were fed twice daily throughout the entire experiment at approximately 0800 and 1300 hours. Steers received 60% of their daily DM during the A.M. feeding and 40% during the P.M. feeding. To determine actual Optaflexx concentration in the delivered feed, samples were collected daily at the beginning, middle and end of each A.M. load and assayed. Feed assays showed Optaflexx was provided at target levels throughout the Optaflexx feeding period.

Table 1. Final live weights and carcass characteristics of early marketing reference cattle.

Reference group[a]	28	35	42	SEM
Final BW, lb	1168	1141	1118	8
Carcass weight, lb	751	725	709	4
Dressing %	64.3	63.5	63.4	0.7
Marbling[b]	515	530	513	17
Longissimus area, in^2	11.60	12.23	11.18	0.45
12^{th} rib fat depth, in	0.48	0.48	0.46	0.04

[a]Baseline cattle were marketed at initiation of each Optaflexx feeding duration treatment (28, 35, 42 days for the light block)
[b]Marbling score called by USDA grader where 500 = small[0] and 550 = small[50].

Seven steers were removed from the experiment due to health reasons during the Optaflexx feeding period. In addition, one animal died from interstitial atypical pneumonia diagnosed during necropsy. All causes of removal from experiment appear unrelated to Optaflexx treatments. Individual steer weights were taken on day 1 of Optaflexx treatment. Therefore, steers assigned to 42 days Optaflexx treatment were weighed 42 days prior to marketing, with the 35 days treatment steers weighed one week later, etc. Steers assigned to the heavy block were marketed one week prior to steers on the light block with cattle being fed for an average of 178 days.

At the end of the experiment, all cattle within block were weighed live for determination of live performance during the Optaflexx feeding phase. All cattle were marketed at a commercial abattoir (Tyson Foods, Inc., Dakota City, Neb.) where carcass data were collected. Hot carcass weights and liver abscess scores were collected on the day of slaughter, while fat depth, kidney, pelvic, and heart fat (KPH), longissimus muscle area (LM area), marbling score, and overall maturity (lean and skeletal maturity) measurements were collected after a 36-hour chill. Yield grades were based on measured carcass characteristics.

All data were analyzed as a randomized complete block design with block (i.e. two weight blocks) as a random effect. Treatments were analyzed as a 3 x 3 factorial design where the interaction between dose of Optaflexx and duration of feeding was tested initially. Within duration, dosage of 0, 100, and 200 mg/head/day were analyzed for orthogonal linear and quadratic responses.

Results

Final live weight and carcass characteristics of the baseline marketing groups are presented in Table 1. In order to determine carcass weight gain and changes in carcass characteristics over the duration of Optaflexx feeding, it is assumed that the baseline marketing steers accurately represent the remaining steers in the experiment.

Steer performance data are for the last 28, 35, or 42 days of the finishing period. All performance data presented are based on live weight (4% shrink). Live weight at the initiation of Optaflexx treatment averaged 1,164 lb. Based on DMI, average Optaflexx intakes were 109 mg/day and 215 mg/day for the 100 and 200 mg treatments, respectively.

Simple effects outlining feedlot performance for the Optaflexx feeding period are presented in Table 2. There were no dose x duration interactions ($P > 0.58$) for feedlot performance, and there were only two carcass characteristics (LM area and calculated

(Continued on next page)

Table 2. Live performance and carcass characteristics of steers fed 0, 100, or 200 mg/head/day of Optaflexx for 28, 35, or 42 days at the end of the finishing period.

Duration:	28 day			35 day			42 day					Linear main effect[b]	
Dosage:	0	100	200	0	100	200	0	100	200	SEM	Int.[a]	dose	duration
Replications, n	9	9	9	9	9	9	9	9	9				
Steers, n	94	95	95	94	94	93	94	93	95				
Initial BW, lb	1194	1189	1194	1165	1171	1161	1134	1134	1137	37	0.59	0.79	<0.01
Final BW, lb	1311	1310	1323	1311	1317	1313	1309	1316	1320	50	0.58	0.07	0.93
DMI, lb/day	24.1	23.9	23.8	24.2	24.0	23.6	24.2	24.1	23.3	0.9	0.69	0.01	0.65
ADG, lb	4.01	4.16	4.48	4.07	4.06	4.22	4.09	4.23	4.28	0.37	0.65	0.01	0.72
F:G	6.10	5.77	5.34	6.00	6.01	5.69	5.93	5.73	5.53	0.33	0.58	<0.01	0.87
Carcass weight, lb	848	853	857	850	853	852	846	855	859	30	0.49	<0.01	0.74
Dressing %	64.7	65.1	64.8	64.9	64.8	64.9	64.6	65.0	65.2	0.2	0.42	0.14	0.75
Marbling[c]	538	551	543	562	547	534	547	550	532	10	0.44	0.10	0.95
Longissimus area, in^2	13.28	13.35	13.66	13.32	13.41	13.33	13.03	13.43	14.07	0.15	<0.01	<0.01	0.44
12^{th} rib fat depth, in	0.54	0.56	0.56	0.58	0.54	0.58	0.57	0.53	0.52	0.02	0.11	0.39	0.39
Calc. USDA YG[d]	3.24	3.28	3.18	3.33	3.21	3.33	3.38	3.20	2.97	0.07	<0.01	<0.01	0.08

[a]P-value for the interaction between dose and duration.
[b]P-value for linear effect of either main dose or main duration. No variables had a significant quadratic response.
[c]Marbling score called by USDA grader where 500 = small[0] and 550 = small[50].
[d]Calculated USDA yield grade on scale of 1 to 5.

USDA yield grade) exhibiting a dose x duration interaction ($P < 0.01$). Initial BW was similar across dosages and within feeding durations, however, cattle that began Optaflexx treatment 42 d prior to marketing were lighter and initial weights increased linearly as the shorter duration treatments were initiated. Beyond initial BW, duration of Optaflexx feeding had no effect ($P > 0.65$) on feedlot performance, and little effect on carcass characteristics ($P > 0.08$). Therefore, the focus will be on the main effects of Optaflexx dosage (Table 3). Overall, cattle gained more than 4.0 lb/day over the Optaflexx feeding period regardless of Optaflexx dosage. Feeding Optaflexx increased ADG linearly ($P < 0.01$) and decreased DMI linearly ($P < 0.01$). The actual decrease in DMI was slight (0.5 lb). The slight decrease in DMI and increase in ADG combined for a marked improvement in F:G ($P < 0.01$) due to feeding Optaflexx. Feed conversions were improved 2.9 and 8.1% when Optaflexx was fed at 100 and 200 mg/day, respectively.

Carcass weight increased linearly ($P < 0.01$) with Optaflexx dosage. Marbling scores tended ($P = 0.10$) to be reduced linearly with Optaflexx feeding, and it appears that the decline occurred primarily at the 200 mg/head/day level (Table 3). Longissimus area increased linearly ($P < 0.01$) from 13.2 to 13.7 square inches with Optaflexx dosage. An increase in muscling is a common observation with Optaflexx. Fat depth at the 12th rib averaged 0.55 inches, and was not impacted ($P > 0.30$) by dosage. The increase in longissimus area without an increase in 12th rib fat suggests that the weight gain observed when feeding Optaflexx is primarily in muscle tissue.

Table 3. Main effects of Optaflexx dosage (mg/head/day) on live performance and carcass characteristics.

Dosage	0	100	200	SEM	linear[a]	quadratic[a]
Initial BW, lb	1164	1165	1164	37	0.79	0.97
Final BW, lb	1311	1314	1319	50	0.07	0.95
DMI, lb/day	24.1	24.0	23.6	0.8	0.01	0.38
ADG, lb	4.06	4.15	4.32	0.35	<0.01	0.86
F:G	6.01	5.84	5.52	0.29	<0.01	0.76
Carcass weight, lb	848	854	856	30	<0.01	0.43
Carcass ADG, lb[b]	3.00	3.08	3.18	0.04	<0.01	0.87
Dressing %	64.7	65.0	65.0	0.2	0.14	0.27
Marbling[c]	549	549	536	6	0.10	0.33
Longissimus area, in^2	13.21	13.40	13.69	0.11	<0.01	0.54
12th rib fat depth, in	0.56	0.55	0.55	0.02	0.39	0.23

[a]P-value for linear and quadratic main effect of Optaflexx dose.
[b]Calculated using baseline marketing cattle as a reference for carcass weight at initiation of treatment.
[c]Marbling score called by USDA grader where 500 = small^0 and 550 = small^{50}.

In this study, carcass weight increased 6 and 8 lb for steers fed 100 and 200 mg of Optaflexx/head/day, respectively, compared with steers fed no Optaflexx. When comparing the final live weights of the treatment groups, the difference is 3 and 8 lb for the 100 and 200 mg/head/day treatments, respectively, compared with the steers fed no Optaflexx. This suggests the increase in ADG due to Optaflexx feeding was carcass gain, which is further supported by a slight numerical increase in dressing percentage and an increase in longissimus area with increasing Optaflexx dosage. By using the baseline marketing groups to estimate carcass gain during the Optaflexx feeding period, efficiency of weight transfer (carcass weight gain/live weight gain) was calculated at 74.6% across all treatments. This represents the proportion of weight gain during the final 28 to 42 days prior to slaughter that was carcass gain, showing that a large proportion of the gain during this time was carcass gain. Carcass ADG, estimated using the baseline marketing groups as a reference, increased linearly ($P < 0.01$) with Optaflexx dosage.

In summary, feeding Optaflexx up to 200 mg/head/day for the last 28 to 42 days prior to marketing increases live weight gain, carcass weight, and improves feed conversion in feedlot steers. Larger longissimus area without an impact on fat depth suggests most, and possibly all, of the weight gain associated with Optaflexx feeding is due to lean carcass gain.

[1]Grant Crawford, graduate student; Galen Erickson, assistant professor; Kyle Vander Pol, research technician; Matt Greenquist, feedlot manager; Jeffrey Folmer, former research technician, Lincoln; and Mike Van Koevering, Elanco Animal Health, Omaha.

Effects of Optaflexx Fed in Combination with MGA on Feedlot Heifer Performance

William A. Griffin,
Galen E. Erickson
Bill D. Dicke
Terry J. Klopfenstein
Robert J. Cooper
D.J. Jordon
Jim S. Drouillard
William M. Moseley
Gary E. Sides[1]

Summary

A commercial feedlot experiment was conducted using 1,807 heifers to evaluate the effects of Optaflexx fed in combination with MGA on finishing heifer performance. In heifers recieving MGA throughout the entire 126-143 day feeding period, feeding Optaflexx for the last 31-38 days increased ADG and hot carcass weight compared to heifers fed MGA but not Optaflexx. Heifers fed MGA and Optaflexx had increased DMI, improved feed efficiency and increased final live weight. Carcass quality measurements were not influenced by treatment.

Introduction

Optaflexx, the trade name for ractopamine hydrochloride, is a βeta-1 adrenergic agonist that increases weight gain the last 28 to 42 days of the finishing period. Melengestrol acetate (MGA) is an orally active progestogen that inhibits estrus and ovulation and is a product commonly fed to finishing heifers. MGA has also been shown to increase weight gain and improve feed efficiency in heifers. Data on the response to feeding Optaflexx to finishing heifers are limited. Previous heifer trials that were conducted did not include heifers fed MGA in combination with Optaflexx; therefore, the objective of this study was to determine the effect of feeding Optaflexx in combination with MGA on finishing heifer performance.

Procedure

The experiment was conducted between August 2004 and March 2005 using 1,807 heifers (714 lb ± 45.5) in a randomized block design. Following arrival, heifers were individually weighed, processed, and blocked by date received and site of procurement. During initial processing, heifers were vaccinated for viral diseases (BoviShield Gold® 4, Pfizer, Animal Health, New York City, N.Y.), treated for internal and external parasites (Dectomax Injectable®, Pfizer, New York City, N.Y.), and implanted with Ralgro® (Shering-Plough Animal Health, Union, N,J,). Heifers were determined to be bred, open, or freemartins by rectal palpation. Freemartins and heifers over 100 days pregnant were removed from the trial. Heifers less than 100 days pregnant were given Lutalyse® (Pfizer, New York City, NY). Open heifers were not given Lutalyse, therefore, some nondiagnosed early pregnancies at initial processing may have allowed some pregnant heifers to complete the trial. Heifers from the separate locations were assigned randomly to one of two treatments, and then assigned to one of 20 home pens (10 replications/treatment). Treatments were: 1) heifers fed MGA (Pfizer Animal Health, New York City, N.Y.) for the entire finishing period, and 2) heifers fed MGA for the entire finishing period and Optaflexx® (Elanco Animal Health, Greenfield, Ind.) the last 31 to 38 days. MGA was not included in step up diets. The finishing diet was formulated to provide 0.4 mg of MGA/head, 330 mg of Rumensin® (Elanco)/head, and 90 mg of Tylan® (Elanco)/head/daily. During the last 31 to 38 days of finishing, Optaflexx was included in the diet to target 200 mg/hd/daily for cattle receiving Optaflexx treatment.

Heifers were reimplanted with Synovex Plus® (Fort Dodge Animal Health) an average of 80 day preslaughter (range 73 to 87 days), with animals implanted on the same day within arrival block. The final diet contained 38% dry-rolled corn, 29.5% steam-flaked corn, 18% distillers grains, 6% alfalfa hay, 2% sorghum hay, 1.5% fat, and 5% supplement in the control diet (DM basis). The Optaflexx supplement was delivered in a pellet form, fed at 4% of the diet DM and replaced dry-rolled corn. Optaflexx supplement consisted of fine ground corn and wheat midds. The diet was formulated to contain 14.9% CP, 0.72% Ca, 0.37% P, and 6.9% fat (DM basis). Heifers were fed an average of 133 days (range 126 to 143 days).

Pen weights were taken for each pen at initial processing, reimplant, start of Optaflexx feeding, and prior to shipment on the day of slaughter. Pen weights, excluding initial weight, were shrunk 4%. Initial weights were not shrunk because animals were processed immediately upon arrival or following an overnight receiving period. Pen weights were used for performance calculations on a live-basis. Additionally carcass weights were used and adjusted to a common dressing percentage of 63.5% to calculate a carcass adjusted live weight. Carcass adjusted live weight was used to determine daily gain and feed conversion on a carcass adjusted basis.

Both pens within a block (replication) were harvested under similar conditions on the same day, at the same plant. Hot carcass weights and liver abscesses were recorded on the day of harvest. Carcass fat thickness, marbling score, kidney, pelvic and heart fat (KPH), longissimus muscle area and USDA yield grade were recorded following a 24- to 36-hour chill.

(Continued on next page)

Economic Analysis

An economic analysis was conducted to determine the return for using Optaflexx with heifers fed MGA using two scenarios for cattle prices, 2-year and 10-year cattle prices. Finishing diet cost of $120.16/ton was calculated using 10-year average prices for ingredients (*agecon.unl.edu/mark/agprices/index.htm*). Intake and days on feed along with diet cost were used to determine total feed costs. In diets containing Optaflexx, a cost of $0.26/day was added to ration cost to account for the cost of Optaflexx delivered in the bunk. Other costs included $0.35/head/day yardage, $30.00 processing, health, shipping, etc., and 7% interest on animal and feed. Initial animal cost was determined using a 10-year average feeder heifer price of $77.65 /cwt and two-year average price of $95.32 /cwt (*www.feuzmarketanalysis.com*). Live sale price was calculated using a 10-year average fed heifer price of $ 70.24 /cwt. and a two-year average of $ 84.65 /cwt (*www.feuzmarketanalysis.com*). Along with selling cattle on a live basis, 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, yield-rewarding grid, and a commodity grid, as proposed by Feuz (2002 *Nebraska Beef Report,* pp.39-41). The dressed price used for the 10-year average was $111.91/cwt and $134.03/cwt (*www.feuzmarketanalysis.com*) for the two-year average. Premiums and discounts for each grid used are from Feuz (2002 *Nebraska Beef Report,* pp.39-41). Profitability was calculated from a 10-year and a two-year average dress base price with individual grid premiums and discounts applied. Grid profit or loss was calculated from a carcass breakeven calculated as with live break-even, with hot carcass weight instead of final BW as a multiplier.

Animal performance, carcass data and economics were analyzed using the Mixed procedure of SAS, with treatment as a fixed effect, and block as a random effect. Data are presented with deads and railers removed from the analysis. Fifteen animals (eight Optaflexx and MGA and seven MGA alone) were removed from the study at the feedlot. Four and three heifers were removed from the Optaflexx and MGA and MGA alone treatment, respectively, after inclusion of Optaflexx. Data were not collected from 72 rail-outs in the plant, 46 MGA only and 26 Optaflexx and MGA treated-heifers. Of the 1,720 heifers harvested, 852 were on the MGA alone and 868 were on the Optaflexx and MGA treatment, respectively. At slaughter, fetuses were observed in 82 heifers, 39 in the MGA alone group and 43 in the Optaflexx and MGA group. The pregnant heifers are included in the analysis. Feed intake was figured according to feedyard close-out information on each individual pen of cattle.

Table 1. Live and carcass adjusted performance.

Item	MGA Only	Optaflexx + MGA	Difference	SEM	*P*-value
Initial BW, lb	743.2	741.1	-2.1	13.86	0.52
Reimplant BW, lb	989.1	986.0	-3.1	18.90	0.70
Start of Optaflexx BW, lb	1153.4	1158.4	5.0	16.48	0.73
Final BW, lb	1257.4	1273.9	15.5	17.14	0.53
Overall[a]					
DMI, lb	23.39	23.77	0.38	0.46	< 0.01
ADG, lb	3.87	4.00	0.13	0.16	0.41
F :G	6.07	5.96	-0.11	0.10	0.03
Last 35 days [b]					
DMI, lb	22.86	23.53	0.67	0.28	0.01
ADG, lb	2.97	3.27	0.30	0.17	0.09
F :G	7.88	7.35	-0.53	0.26	0.07
Carcass Adjusted Performance [c]					
Final BW, lb	1263.1	1280.5	17.4	16.7	0.01
Overall[a]					
ADG, lb	4.14	4.28	0.14	0.11	< 0.01
F:G	5.66	5.57	-0.09	0.08	< 0.01
Last 35 days [b]					
ADG, lb	3.11	3.43	0.32	0.15	0.01
F:G	7.57	6.97	-0.60	0.52	< 0.01

[a]Heifer performance over the entire feeding period.
[b]Heifer performance during inclusion of Optaflexx in diet the last 35 days prior to slaughter.
[c]Carcass adjusted performance is hot carcass weight / 0.635.

Results

Performance

Heifer live and carcass adjusted performance results are presented in Table 1. Final BW ($P = 0.53$) was not different, but final BW was increased by 15.5 lb or 1.2% in Optaflexx fed heifers. However, at the start of Optaflexx feeding, heifers receiving Optaflexx and MGA were numerically heavier (1158 vs. 1153 lb). Given this 5-lb advantage in initial weight, the gain increase was reduced to 11 lb (0.8%) for heifers fed Optaflexx and MGA compared to heifers fed MGA alone. DMI was increased by 0.38 lb/d ($P < 0.01$) for heifers fed Optaflexx and MGA compared to heifers fed MGA alone over the entire feeding period. Feed conversion was improved by 1.8% ($P = 0.03$) for heifers fed MGA and Optaflexx compared with MGA alone, even though ADG was not impacted ($P = 0.41$) when comparing treatments over the entire 133 day finishing period.

The diet containing Optaflexx was formulated to provide 200 mg/head/day. However, based on DMI (range 22.3 to 25.9 lb) changes across block, actual Optaflexx intake averaged 205.0 mg/head/day (range 185.1 to 222.4 mg/hd/d). Animals consumed an average of .169 mg/lb Optaflexx (range .157 to .174 mg/lb) when calculated on a per BW basis.

When comparing treatments during the last 35 days (time heifers

Table 2. Carcass characteristics.

Item	MGA Only	Optaflexx + MGA	Difference	SEM	*P*-value
Hot carcass weight, lb	802	813	11.0	10.62	0.01
12th rib fat thickness, in	0.56	0.56	0.00	0.02	0.92
Yield Grade	2.73	2.77	0.04	0.11	0.47
Yield Grade 1, %	19.1	17.1	-2.0		
Yield Grade 2, %	44.7	45.7	1.0		
Yield Grade 3, %	29.9	31.1	1.2		
Yield Grade 4, %	5.5	5.5	0.0		
Yield Grade 5, %	0.7	0.6	-0.1		
Marbling [a]	552.9	552.2	0.70	8.57	0.89
Prime, %	1.2	1.2	0.0		
Choice+, %	4.9	6.5	1.6		
Choice0, %	20.0	17.4	-2.6		
Choice-, %	45.8	46.4	0.6		
Select, %	27.1	27.5	0.4		
Standard, %	0.9	1.0	0.1		
Longissimus area, in2	14.41	14.39	-0.02	0.21	0.91
KPH, %	1.96	1.95	-0.01	0.13	0.29
Dressing percentage, %	63.82	63.85	0.03	0.22	0.87
Empty body fat, %[b]	29.68	29.81	0.13	0.39	0.53

[a]Marbling score = 400 = Slight0, 500 = Small0 etc.
[b]Empty body fat = 17.76207 + (4.68142*12th rib fat thickness in cm) + (0.01945*carcass weight in kg) + (0.81855*marbling/100) - (0.06754*Longissmus in sq. cm.).

Table 3. Heifer economics.

Item	MGA Only	Optaflexx + MGA	Difference	SEM	*P*-value
10-year average pricing					
Total animal cost, $	898.69	909.13	10.44	8.78	0.01
Live heifer value, $	883.27	893.99	10.72	11.10	0.02
Commodity heifer value, $	875.80	885.03	9.23	11.55	0.04
Live profit or loss, $	-15.42	-15.14	0.28	7.04	0.93
Commodity profit or loss, $	-22.90	-24.10	-1.20	9.15	0.75
2-year average pricing					
Total animal cost, $	1038.61	1048.53	9.92	9.85	0.04
Live heifer value, $	1064.48	1077.40	12.92	13.38	0.02
Commodity heifer value, $	1053.34	1064.81	11.47	13.73	0.02
Live profit or loss, $	25.87	28.87	3.00	7.99	0.49
Commodity profit or loss, $	14.73	16.28	1.55	9.73	0.71

were fed Optaflexx), DMI increased ($P = 0.01$) by 0.67 lb/hd/d, which was unexpected. Feeding Optaflexx in combination with MGA increased ADG by 0.30 lb/day ($P = 0.09$) which led to a slight improvement ($P = 0.07$) in feed conversion of 6.7% for heifers fed Optaflexx and MGA compared to heifers receiving MGA alone when evaluating live performance.

When using carcass adjusted performance (HCW/.635), final live weight was increased ($P = 0.01$) 17.4 lb, or 1.4% for heifers receiving Optaflexx and MGA compared to heifers fed MGA alone. When ADG was calculated from carcass weight, heifer ADG was increased ($P < 0.01$) 0.14 lb/head/day with a significant improvement in feed conversion of 1.6% for heifers over the entire feeding period. Despite the relatively small improvement when expressed over the entire feeding period, ADG and F/G of heifers fed Optaflexx and MGA compared to heifers fed MGA alone on a carcass-adjusted basis were significantly different. When looking at only the last 35-day performance, heifers gained 0.32 lb/day more ($P = 0.01$) than the heifers fed MGA only, and feed conversion was improved 7.9% ($P < 0.01$) for heifers fed Optaflexx and MGA.

Carcass Characteristics

Carcasses of heifers in the Optaflexx and no Optaflexx treatments (Table 2) did not differ in USDA yield grade, marbling score, percentage of USDA choice and select based on Chi-Square analysis, 12th rib fat thickness, ribeye area, KPH, empty body fat, cutability, and dressing percentage. However Optaflexx-fed heifers had 11 lb heavier (1.4%) hot carcass weight ($P = 0.01$).

Optaflexx Economics

Total cost using a 10-year average (Table 3) was increased $10.44 for heifers fed Optaflexx and MGA ($P = 0.01$) due to cost of Optaflexx and increased DMI for heifers fed Optaflexx, although cost of gain was not different ($P = 0.19$). Only live and commodity grid pricing are shown in Table 3 due to similar price outputs between grids. Live pricing ($P = 0.02$) commodity ($P = 0.04$), yield rewarding ($P = 0.05$), and quality rewarding ($P = 0.03$) marketing grids showed an increase in total dollar value per animal based on the increased gain in the heifers fed Optaflexx in combination with MGA. There was no difference in profit, although when using a 10-year average price for live heifers, heifers receiving Optaflexx and MGA were numerically $0.28 ($P = 0.93$) more profitable when compared to heifers receiving MGA alone.

Total cost ($P = 0.04$) using a two-year average price (Table 3) was $9.92 higher for heifers fed Optaflexx and MGA, when compared to heifers fed MGA alone. Live pricing ($P = 0.02$) commodity ($P = 0.02$), yield rewarding ($P = 0.03$), and quality rewarding ($P = 0.02$) marketing grids showed an increase in total dollar value per animal based on the increase gain response in the heifers fed Optaflexx. However due to the incurred cost from feeding Optaflexx heifers marketed on a live basis ($P = 0.49$) were not different, but profit was numerically increased by $3.00/head. When selling heifers on commodity ($P = 0.71$),

(Continued on next page)

yield ($P = 0.76$), or quality ($P = 0.71$) rewarding marketing grids, heifers fed Optaflexx and MGA were not statistically different despite numerically higher profit ($1.43 - $1.56).

Regardless of average prices used for cattle, Optaflexx cost ($0.26/head/day) remained the same when comparing 10- and two-year averages. However, the value per pound of beef increased when using the two-year averages, causing the cattle that received Optaflexx and MGA to be numerically more profitable than heifers fed MGA alone. In both scenarios (two-year and 10-year), no significant difference was observed in profitability between heifers fed Optaflexx and MGA, or MGA alone.

Results from this experiment indicate heifers fed Optaflexx (200 mg/head/day) during the last 35 days of the finishing period responded with 11 lb heavier carcass weights and 15.5 lb (live weight) to 17.5 lb (carcass adjusted) final weight. Optaflexx can be fed to heifers receiving MGA without compromising carcass quality and yield. Due to increased costs incurred by feeding Optaflexx and increased intake of heifers fed Optaflexx and MGA in this study, an economic advantage was not observed in this study. However, when using a two-year average price for cattle compared to 10-year, when weight was worth more, Optaflexx feeding in combination with MGA was numerically more profitable.

---

[1] William A. Griffin, graduate student; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln; Bill Dicke, Robert J. Cooper, D.J. Jordon, Cattlemen's Nutrition Services, Lincoln, Neb.; William M. Moseley, Gary Sides, Pfizer Inc., Kalamazoo, Mich., Jim S. Drouillard, professor, Animal Science, Kansas State University, Manhattan, Kan.

Growth Promoting Agents and Season Effects on Blood Metabolite and Body Temperature Measures

Terry L. Mader
Wanda M. Kreikemeier[1]

Summary

To assess growth promoting agents efficacy among seasons, triiodothyronine, thyroxine, blood metabolites, and tympanic temperature were measured in summer and winter studies. Within each season, pens of heifers were assigned to one of six growth promotant treatments. Season by growth promotant treatment interactions ($P < 0.05$) indicated that the combination of estrogen and trenbolone acetate increased triiodothyronine in the winter, whereas trenbolone acetate alone decreased both triiodothyronine and thyroxine in the winter. Maximum tympanic temperature was greater ($P < 0.01$) in the summer than in the winter, while minimum tympanic temperature was lowered ($P < 0.01$) in the summer. Changes in blood metabolite levels resulting from the use of growth promotants do not appear to substantially influence seasonal changes in body temperature.

Introduction

Within a season, changes in temperature, wind speed, precipitation, and/or radiation can significantly influence physiological and metabolic processes. Physiological characteristics, particularly when cattle are under environmental stress, could be further influenced by anabolic agents. The objective of this experiment was to assess feedlot heifer responses to cold and heat exposure when administered growth promoting agents as determined by blood endocrine levels, plasma urea nitrogen (PUN), and tympanic temperature.

Procedure

During a summer and winter season, crossbred Angus, nonpregnant, yearling heifers (108/season; mean initial BW = 842 lb) were used for obtaining blood samples and tympanic temperatures (**TT**). Within a season, heifers had been stepped up to a 65.0 NEg (mcal/cwt; DM basis) high-energy finishing diet by the start of each study. Heifers were fed Rumensin and Tylan (Elanco Animal Health, Indianapolis, Ind.) throughout the experimental feeding period. Details of the vaccination, parasite control, and diet regimens used for the experiments have been reported previously *(2003 Nebraska Beef Report*, pp. 42-45). In early December (winter season), and early June (summer season), heifers were assigned randomly to 12 pens (nine heifers/pen) based on stratification of individual weights. Six growth promotant treatments (two pens of heifers/treatment/season) were imposed as follows: 1) control, 2) estrogenic implant (E; Compudose [24 mg of Estradiol-17β]; Vetlife, West Des Moines, Iowa), 3) androgenic implant (TBA; Finaplix-H [200 mg of trenbolone acetate]; Intervet, Inc., Millsboro, Del.), 4) E + TBA (ET), 5) no implant and fed MGA (MGA; Pharmacia and Upjohn, Kalamazoo, Mich.), and 6) ET implant and fed MGA (ETM). Heifers were bled via jugular puncture and weighed on days 0, 28, 56, and 84. Cattle were fed 104 and 105 days for the winter and summer feeding periods, respectively.

Blood Collection and Assays

In both seasons, heifers (four/pen) were bled via jugular puncture and weights were taken on days 0, 28, 56, and 84, beginning at 0800 and prior to being fed. Ten milliliters of blood for plasma were collected into tubes containing sodium heparin. Five milliliters of blood also were collected for serum. After blood collection, tubes were centrifuged (3,400 rpm) for 10 minutes. Plasma and serum fractions were isolated and frozen until analyzed. Serum samples were analyzed for insulin-like growth factor (IGF-1) concentration using RIA with acid–ethanol extraction. Concentrations of thyroxine ($\mathbf{T_4}$), triiodothyronine ($\mathbf{T_3}$) were quantified with solid phase RIA kits. Samples for T_3 and T_4 analysis were processed as separate assays.

Temperature measures

Individual heifers (two heifers/pen; four heifers/treatment/season) were used for obtaining TT, as a measure of body temperature, when ambient temperature was predicted to be < 32°F in the winter and > 77°F in the summer. Tympanic temperatures were recorded using data loggers and thermistor cables (Stowaway, XTI®, Onset Computer Corporation, Pocassatt, Mass.). Data loggers were secured in an ear of the heifer using self-adhesive bandages (Vet-Wrap®, 3M Corporation, St. Paul, Minn.) and 2.25 cm athletic tape (Andover Coded Products Inc, Salisbury, Mass.). Tympanic temperature was read every two minutes, with the average recorded every 15 minutes over a seven and five-day period for winter and summer, respectively. On day 28 of each study period, at the time of weighing, ear surface temperature was measured on four heifers from each pen using a Raynger 3i infrared gun (Raytek Corporation, Santa Cruz, Calif.).

Statistical Analysis

Blood metabolite concentrations were analyzed using Mixed Models procedures of SAS (SAS Inst. Inc., Cary, N.C.) for a split plot in time design. The model included season, growth promotant treatment, and day (used as repeated measures) plus two and three-way interaction. Unstructured covariance analysis was used for T_3, T_4, and PUN, while auto regressive

(Continued on next page)

procedures were used in the IGF-1 analysis. Tympanic temperature and ear surface temperature data were analyzed using Mixed Models procedures of SAS for a completely randomized design. Least squares means were compared using an F-protected LSD ($P < 0.05$).

Results

For the hot and cold periods, during which TT were obtained, ambient temperature averaged 80.1 and 26.8°F, respectively, and ranged from a daily average of 63.5 to 94.8°F for the hot period, and 2.5 to 51.8 for the cold period. Mean THI [temperature humidity index; THI = temperature – (0.55*(1-rh/100)*(temperature – 58))] was 76.6 for the hot period and 17.4 for the cold period. Based on the livestock safety index, heifers exposed to hot conditions were on the average in the alert (THI > 74) category, but also also exposed to emergency (THI > 83) category conditions, suggesting cattle were under heat stress during most of this period. During the cold TT collection period, THI ranged between 1.6 and 36.8. A THI < 35 has been suggested as being a cold stress threshold; clearly this threshold was reached.

In general, IGF-1 increased ($P < 0.05$) from day 0 to day 28 in the winter and in the summer (Table 1). However, IGF-1 levels declined ($P < 0.05$) after day 28 in the winter but tended to be maintained at day 28 levels throughout the summer. Thyroid hormone levels (T_3 and T_4) followed similar trends among seasons across bleed times. As expected, T_3 and T_4 levels were numerically elevated in the winter compared with the summer, but were very similar among season on day 84. In general, by day 84, ambient temperatures were declining in the summer, thus stimulating thyroid gland activity, and increasing in the winter which suppresses thyroid gland activity. On day 56, PUN was elevated in the winter and lowered in the summer when compared with day 28 ($P < 0.05$); thus PUN tended to peak around day 56 in the winter and day 28 in the summer.

Table 1. Mean blood PUN and endocrine concentration for feedlot heifers for season and time of bleed.

	Day of bleed[b]				
Item[a]	0	28	56	84	SE
IGF – 1, ng/mL					
Winter	98.42[cde]	129.03[f]	101.78[de]	90.64[c]	5.83
Summer	59.50[c]	104.64[ef]	95.43[de]	109.33[f]	5.83
T_3, ng/mL					
Winter	1.44[c]	1.48[c]	1.61[d]	1.46[c]	0.05
Summer	1.19[d]	0.94[c]	0.96[c]	1.34[e]	0.05
T_4, ng/mL					
Winter	66.12[c]	68.03[c]	77.65[d]	68.52[c]	1.95
Summer	66.65[de]	53.57[c]	63.29[d]	68.33e	1.95
PUN, mg/dL					
Winter	9.62[c]	13.50[e]	19.13[f]	12.19[d]	0.54
Summer	13.69[d]	17.66[e]	13.11[d]	11.60[c]	0.54

[a]T_3 = triiodothyronine; T_4= thyroxine; PUN = plasma urea nitrogen.
[b]Number of days into trial. Day by season interaction ($P < 0.05$) for all metabolites.
[cdef]Means without a common superscript differ ($P < 0.05$).

Table 2. Effects of growth promoting treatment and season on blood metabolite concentration.

	Growth promoting treatment[b]						
Item[a]	C	E	TBA	ET	MGA	ETM	SE
IGF – 1, ng/ml							
Winter	97.72	109.70	100.69	116.10	92.48	118.10	11.38
Summer	80.70	90.62	92.49	97.55	82.50	109.48	11.38
Mean	86.71[c]	100.16[cd]	96.59[cd]	106.82[d]	87.49[c]	113.79[d]	7.79
T_3, ng/ml[e]							
Winter	1.49[f]	1.44[f]	1.33[f]	1.72[g]	1.51[fg]	1.50[f]	0.07
Summer	1.17	1.20	1.14	1.02	1.06	1.05	0.07
Mean	1.33	1.32	1.23	1.37	1.29	1.28	0.05
T_4, ng/ml							
Winter	69.06	70.02	65.01	70.57	67.67	78.05	3.21
Summer	59.77	62.49	62.93	63.01	67.22	62.34	3.21
Mean	64.42	66.26	64.02	66.80	67.44	70.19	2.80
PUN, mg/dl							
Winter	13.70	14.87	12.91	12.05	15.12	13.00	0.73
Summer	14.91	15.11	15.12	12.84	14.04	12.08	0.73
Mean	14.30[g]	14.99[g]	14.01[g]	12.44[f]	14.58[g]	12.54[f]	0.49

[a]T_3 = triiodothyronine; T_4= thyroxine; PUN = plasma urea nitrogen.
[b]C = Control (no growth promotant), E = estrogenic implant, TBA = trenbolone acetate implant, ET = estrogenic + TBA, MGA = melengestrol acetate, ETM = E + TBA + MGA.
[cd]Means without a common superscript differ ($P < 0.10$).
[e]Growth promoting treatment by season interaction ($P < 0.05$).
[fg]Means without a common superscript differ ($P < 0.05$).

In these studies, season x growth promotant interactions were not found ($P > 0.05$) for ADG, although ADG was greater ($P < 0.01$; 3.18 vs 2.80 lb) in the winter than in the summer *(2003 Nebraska Beef Report*, pp. 42-45). In data reported herein, serum IGF-1 concentrations increased ($P < 0.05$) by ~ 43% from day 0 to 28 in the summer but by only 24% in the winter. Also in the winter, IGF-1 levels declined by ~ 21% from day 28 to 56, thus returning to near levels found on day 0. In the summer, IGF-1 levels only declined by ~ 9% ($P > 0.05$) from day 28 to 56 and remained above ($P < 0.05$) day 0 level through day 84. Since baseline IGF-1 (98.4 vs 59.5 mg/mL) were greater in the winter, differences in ADG are not likely due to the rise or change in IGF-1 over time or among seasons, but partially due to the baseline IGF-1 level associated with the cattle at the start of the study. Also, in the winter, during the period when ambient temperatures decline and approach winter lows, feed intake

Table 3. Effects of growth promoting treatment and time of bleed on IGF-1 and plasma urea nitrogen (PUN) concentrations in feedlot heifers.

	Growth promoting treatment[a]						
Item[a]	C	E	TBA	ET	MGA	ETM	SE
IGF – 1, ng/ml							
0 day	73.72	76.85	67.74	90.05	85.26	80.13	10.45
28 days	104.72^{bc}	121.01^{cd}	114.09^{bcd}	135.11^{d}	93.67^{b}	132.39^{d}	10.45
56 days	79.25^{b}	93.47^{bc}	113.14^{c}	100.71^{bc}	86.41^{b}	118.64^{c}	10.45
84 days	89.16^{b}	109.31^{bc}	91.39^{b}	101.43^{bc}	84.61^{b}	124.01^{c}	10.45
PUN, mg/dl							
0 day	11.09	12.34	11.35	11.37	12.56	11.21	0.97
28 days	16.99^{g}	17.35^{g}	15.75^{fg}	12.58^{e}	17.18^{g}	13.60^{ef}	0.97
56 days	17.18^{g}	18.06^{g}	16.39^{fg}	14.45^{ef}	16.44^{g}	14.20^{e}	0.97
84 days	11.95	12.20	12.57	11.37	12.12	11.15	0.97

[a]C = Control (no growth promotant), E = estrogenic implant, TBA = trenbolone acetate implant, ET = estrogenic + TBA, MGA = melengestrol acetate, ETM = E + TBA + MGA. Day by growth promoting treatment interaction ($P < 0.05$).
[bcd]Means without a common superscript differ ($P < 0.05$).
[efg]Means without a common superscript differ ($P < 0.10$).

Table 4. Effect of season on tympanic (TT) and ear surface (EST) temperature.

	Season		
Item	Summer	Winter	SE
EST, °F	92.26^{b}	56.48^{a}	0.22
TT, mean, °F	102.27	101.97	0.15
Maximum, °F	104.07^{b}	102.97^{a}	0.05
Minimum, °F	100.20^{a}	101.05^{b}	0.04

[ab]Means without a common superscript differ ($P < 0.01$).

is stimulated which resulted in greater PUN levels that were found on day 56. In the summer, ambient temperature would be peaking around day 56, thus suppressing feed intake resulting in blood PUN being lowered. This decline in summer PUN levels could be due to the decrease in DMI.

There was no ($P > 0.05$) growth promoting agent by season interaction for serum IGF-1, T_4, or PUN concentration (Table 2). Across both seasons, IGF-1 tended to be increased ($P < 0.10$) in ET and ETM treated heifers when compared with control heifers. No differences in T_4 were observed among growth promotant treatments within or among season. There was a growth promoting treatment by season interaction ($P < 0.05$) for T_3 concentration. The ET treated heifers had increased ($P < 0.05$) T_3 levels in the winter when compared with control and other implanted heifers. Across season, heifers receiving ET (ET and ETM treatments) had lower PUN levels.

A bleed time by growth promotant treatment interaction was not found for thyroid hormones but was found ($P < 0.05$) for IGF-1 and PUN (Table 3). In general, when compared with control heifer groups, ET and ETM treated heifers had greater ($P < 0.05$) IGF-1 concentrations on day 28, whereas the ETM and TBA treated cattle had greater IGF-1 concentrations on day 56; only the ETM treated heifers had greater IGF-1 concentrations on day 84. Thus, the ETM treated cattle had consistently greater IGF-1 concentration during the feeding period, which is supported by the tendency ($P < 0.10$) for those same heifers plus the ET treated group to have lower PUN concentrations (days 28 and 56) than the control heifer group.

Ear surface temperatures were 92.3°F and 56.5°F ($P < 0.01$), respectively for summer and winter (Table 4). The ear surface temperatures were recorded in the event growth-promoting agent by season interactions could be attributable to payout of the implant. Average tympanic temperature was not different ($P > 0.05$) between seasons. A greater range in TT was found in the summer than in the winter. Maximum TT was greater ($P < 0.01$) and minimum TT was lower ($P < 0.01$) in the summer than in the winter. Analysis of hourly data (Figure 1) indicate that peak summer TT occurs around 1700 while peaks in winter TT are not as evident. Also, minimum summer TT were found at 0700. Difference in TT between summer and winter were found at 0500, 0600, 0700, 0800, 1600, 1700, and 2100 with the diurnal TT pattern being flatter in the winter than in the summer.

There was a growth promoting treatment by season interaction ($P < 0.05$) for ear surface temperature

(Continued on next page)

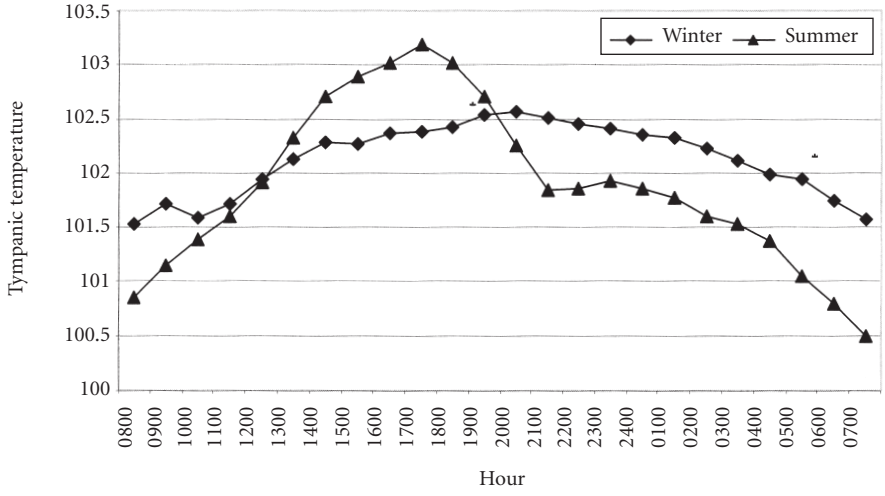


Figure 1. Effects of season on tympanic temperature over a 24-hour period. *Means differ ($P < 0.05$; SE = 0.18).

(Table 5). In the summer, there was no difference between ear surface temperatures across growth promoting treatments while in the winter, the MGA treated heifers had ear surface temperatures similar to control but lower ($P < 0.05$; 51.1 vs 58.5 ºF) than groups receiving implants. These data suggest that, at least in the winter, implanting can elevate ear surface temperatures as much as 10ºF, however, overall ear surface temperatures in the winter are over 36ºF lower than those found in the summer.

A growth promoting treatment by season interaction was evident for average maximum TT ($P < 0.05$) and for average minimum TT ($P < 0.10$), although the interaction was not evident for mean TT (Table 5 and Figure 1). Mean TT were similar among growth promotant treatment among seasons. Numerically, control heifer groups had greater maximum TT, particularly in the winter, with the MGA heifers having the lowest maximum TT in both seasons. The ET treated cattle had greater ($P < 0.05$) maximum TT in the summer when compared with MGA fed groups (MGA and ETM). However, in the winter, cattle receiving E and/or MGA (E, ET, MGA, and ETM) had lower maximum TT than control cattle. Differences in minimum TT tended to be found only in the summer, with E treated cattle having greater minimum TT than TBA and ETM treatment groups.

The data indicate that when cattle get hot in the summer, they tend to overcompensate at night by ridding the body of heat (resulting in a lower TT) in preparation for subsequent heat episodes. Thus, the range in TT will be greater in the summer than in the winter. The lower nighttime TT appears to enable cattle to prepare for the heat of the day, while greater overall TT in the winter buffers the animal against cold threats. The greater minimum TT found in the E treatment group in the summer would suggest E implanted cattle may be more susceptible to heat stress. If E increases TT, the mechanism by which MGA tends to lower TT is unclear, since the growth promoting response of both products are mediated through estrogen receptors. The estrus suppressing effect of MGA, which is not present in implants, is possibly responsible for any lowering of TT particularly in the ETM group. However, control heifers had greater overall maximum TT. Although limited growth promotant by season interactions existed, changes in blood metabolite levels resulting from the use of growth promotants do not appear to substantially influence seasonal changes in body temperature.

Table 5. Effect of growth promoting treatment and season on tympanic temperature (TT) and ear surface temperature (EST).

	Growth promoting treatment[a]						
Item	C	E	TBA	ET	MGA	ETM	SE
EST, ºF[b]							
Winter	54.50^{cd}	55.58^{d}	56.48^{d}	59.18^{d}	51.08^{c}	62.24^{d}	0.53
Summer	92.66	92.84	91.04	92.48	93.20	91.40	0.53
Mean	73.58	74.30	73.76	75.92	72.14	76.82	0.33
Mean TT, ºF							
Winter	102.63	101.79	100.53	101.64	101.59	101.97	0.37
Summer	102.15	102.25	102.09	103.46	102.85	101.75	0.37
Mean	102.40	102.02	102.18	102.56	102.22	101.86	0.24
Maximum TT, ºF[b]							
Winter	104.14^{d}	102.65^{c}	103.14^{cd}	102.45^{c}	102.43^{c}	102.99^{c}	0.17
Summer	104.41^{de}	103.95^{cde}	104.32^{de}	104.79^{e}	103.50^{c}	103.64^{cd}	0.17
Mean	104.29^{d}	103.30^{c}	103.64^{cd}	103.62^{cd}	102.97^{c}	103.32^{c}	0.08
Minimum TT, ºF[b]							
Winter	101.12	100.98	101.23	100.98	100.74	101.26	0.15
Summer	99.84^{f}	100.98^{g}	99.82^{f}	100.31^{fg}	100.44^{fg}	99.72^{f}	0.15
Mean	100.49	100.98	100.53	100.65	100.60	100.49	0.07

[a]C = Control (no growth promotant), E = estrogenic implant, TBA = trenbolone acetate implant, ET = E + TBA, MGA = melengestrol acetate, ETM = E + TBA + MGA.
[b]Growth promotant by climatic condition interaction ($P < 0.10$).
[cde]Means without a common superscript differ ($P < 0.05$).
[fgh]Means without a common superscript differ ($P < 0.10$).

[1]Terry Mader, professor; Wanda Kreikemeier, former graduate student, Department of Animal Science, Northeast Research and Extension Center, Concord.

Inhibition of Methanogenesis in Rumen Fluid Cultures

Eric J. Behlke
Razvan Dumitru
Stephen W. Ragsdale
James M. Takacs
Jess L. Miner[1]

Summary

We identified 32 compounds that inhibit 13 to 100% of the methane produced by in vitro cultures of rumen fluid and have the potential to inhibit enteric methanogenesis in ruminant animals. The compounds are analogous to a substrate in the methane biosynthesis pathway, and may inhibit methane production yet not affect other organisms in the rumen.

Introduction

Ruminal methanogens consume CO_2 and H_2, thereby depleting substrates used by bacteria to make volatile fatty acids. Methanogenesis accounts for a 3 to 12% loss of feed gross energy. Retention of lost feed gross energy would be a direct addition to the amount of energy available for gain, which is typically 30% of the feed gross energy. Methane is also a greenhouse gas and cattle account for approximately 15% of methane emissions to the atmosphere. Therefore, a strategy to inhibit ruminal methanogens could improve feed efficiency by up to a third and also be environmentally advantageous.

The enzyme 4-(β-D-ribofuranosyl) aminobenzene-5'-phosphate (RFAP) synthase, is a key to methane synthesis. Blocking this enzyme could inhibit methanogens. Because RFAP synthase is a methanogen specific enzyme, we expect that its inhibition would be selective for methanogens. The objective of this work was to determine if ruminal methane synthesis could be inhibited by analogs to a substrate of RFAP synthase.

Procedure

Analogs of para-amino benzoate were synthesized in the laboratory. Para-amino benzoate is one substrate of the enzyme targeted for inhibition. The analogs are identified by sequential numbers and collectively referred to as candidate inhibitors. The candidates were evaluated for ability to inhibit ruminal methane synthesis by use of an in vitro culture system.

McDougall's buffer (100 mL), distilled H_20 (100 mL), cellobiose (0.5 g), trypticase (0.5 g), Resazurin (0.25 mg), a micro mineral solution (25 μL), and ruminal fluid (53 mL) were gassed with CO_2 to create oxygen-free media. Candidates dissolved in dimethyl sulfoxide (DMSO) were added to individual 9.4 mL glass vials, in quadruplicate. Oxygen-free gas (H_2/CO_2, 80:20) was projected into the vials as the fermentation medium (4 mL) was added. The vials were pressurized to 100 kPa (1 atmosphere), and allowed to incubate in a water bath (37°C) for 22 hours.

Following incubation, pressure in the headspace of the vials was measured. Methane concentration was determined by gas chromatography using a silica packed column and thermal conductivity detector.

Table 1. Inhibition of methane production by selected compounds at multiple concentrations.

Compound and concentration[c]	% Inhibition	Compound and concentration	% Inhibition
A24		**C33**	
5.0 mM	65.5[a]	5.0 mM	99.2[a]
2.5 mM	61.1[a]	2.5 mM	98.8[a]
1.0 mM	39.1[a]	1.0 mM	98.5[a]
0.1 mM	0	0.1 mM	19.2[a]
A61		**C34**	
5.0 mM	36.9[a]	5.0 mM	100.0[a]
2.5 mM	21.2[a]	1.0 mM	88.8[a]
1.0 mM	16.9[b]	0.5 mM	65.0[a]
0.1 mM	0.9	0.1 mM	13.0[a]
B11		**C42**	
5.0 mM	37.7[a]	5.0 mM	100.0[a]
2.5 mM	11.8	2.5 mM	92.5[a]
1.0 mM	6.8	1.0 mM	85.4[a]
0.1 mM	6.6	0.1 mM	0

[a]Comparison to untreated vials ($P < 0.05$).
[b]Comparison to untreated vials ($P < 0.10$).
[c]1 mM = 6.02×10^{17} molecules/mL.

Results

Initially, 118 candidate RFA-P synthase inhibitors were tested at a concentration of 5 mM. The results of these tests are presented in Figure 1. Compounds such as A36, A83, C23, and C39 inhibited methane production from 14 to 20%, which was indicated by a tendency ($P < 0.10$) for treated vials to contain less methane than control vials following incubation. Methane production was decreased by 32 of the 118 compounds tested ($P < 0.05$). Inhibition ranged from 13 (A41) to 100% (C34 and C42).

Several compounds that inhibited methane production by greater than 30% were tested again at lower concentrations (Table 1). Some of these were effective at concentrations of 1 mM or less (A24, A61, C33, C34, and C42).

These observations indicate it is possible to block synthesis of methane by ruminal organisms by using chemicals that inhibit RFAP synthase. The development of this approach into a commercially feasible application we will require the identification of compounds capable of inhibiting the enzyme at lower dosages. It would not be practical to manufacture an amount of the current inhibitors that would be required to achieve a 1 mM concentration in the rumen.

[1]Eric Behlke, graduate student; Razvan Dumitru, graduate student; Stephen Ragsdale, professor of Biochemistry; James Takacs, professor of Chemistry; Jess Miner, associate professor of Animal Science.

(Continued on next page)

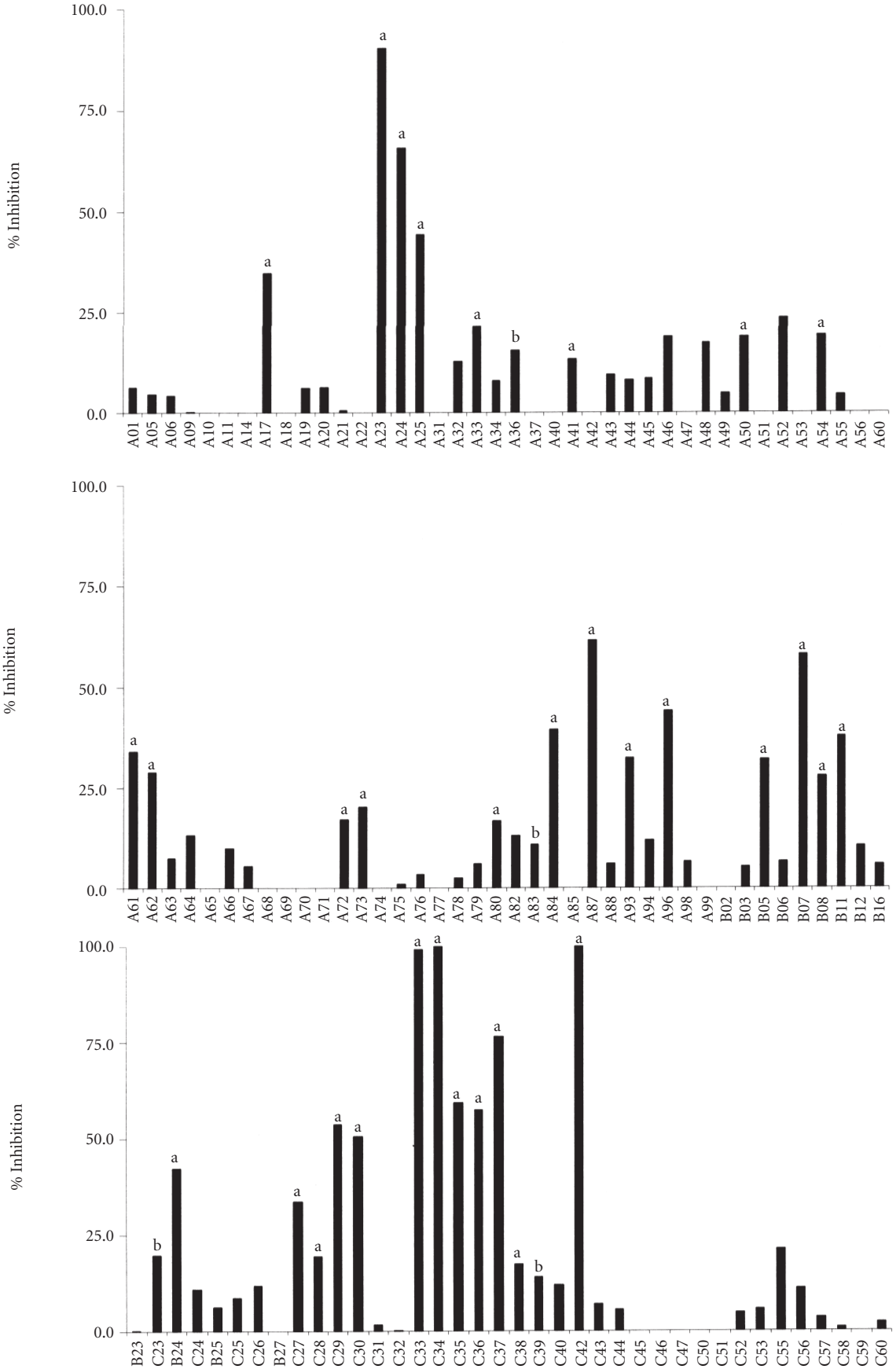


Figure 1. Percent inhibition of methane production (y-axis) exhibited by compounds (x-axis) tested at a concentration of 5 mM. [a] indicates a difference ($P < 0.05$) and [b] indicates a tendency ($P < 0.10$) for treated vials to produce less methane than untreated vials.

Livestock Risk Protection Insurance vs. Futures Hedging: Basis Risk Implications

Rik R. Smith
Darrell R. Mark
Allen L. Prosch[1]

Summary

This study analyzes the benefit of Livestock Risk Protection (LRP) insurance to cattle producers in reducing basis risk. Nebraska producers insuring fed cattle with LRP realize a basis risk reduction of one-third to one-half compared to futures or options hedging. Nebraska feeder cattle producers using LRP experience only a slight reduction in basis risk. Reduced basis risk results in smaller errors when forecasting basis levels for future time periods. With more accurate basis forecasts, producers can better estimate net hedged selling prices and, consequently, future cash flows.

Introduction

Livestock Risk Protection (LRP) is a relatively new insurance program offered by the USDA Risk Management Agency (RMA) that provides single-peril price risk insurance coverage to livestock producers. The insurance coverage provides minimum price protection for future livestock sales while allowing the user to benefit from price increases. For a complete review of how the LRP program works and how to hedge livestock sales with it, see Extension Circular 05-839 *Livestock Risk Protection Insurance: A Self-Study Guide* available at *http://www.lrp.unl.edu*.

Using LRP insurance to hedge future livestock sales involves basis risk just as traditional futures hedging does. However, when using LRP, futures basis is not relevant because price protection is not based on futures markets, but instead on cash market prices. Therefore the relevant basis to consider in an LRP hedge is the difference between a local cash price and the cash index on which LRP is based. Price levels are locked in by purchasing LRP. When the cattle are sold at the end of the insurance policy, the producer receives the local cash market price and an LRP indemnity, if applicable. The variation between the local cash price and the cash index (Actual Ending Value, or AEV) which coverage is based on represents basis risk, in this case *LRP basis* risk.

Forecasting basis for either futures or LRP hedges enables better estimation of future selling prices, which are related to future cash flows. By anticipating future cash flows, producers' budgeting and financial planning can be improved. Consequently, hedging tools with less basis risk have the potential to improve livestock producers' estimation of selling prices and cash flows. Given that LRP basis is the difference between a local cash price and AEV and the AEV may incorporate the local cash selling price to a small or large degree depending upon the geographic location and market volume, there exists the possibility for LRP basis to be smaller and less variable than traditional futures basis. Less variability in basis indicates a possibility for more accurate basis forecasts. The objective of this study is to compare traditional futures basis and LRP basis risk over time.

Procedure

To compare basis risk over time, traditional futures basis (Cash Price B Futures Price) and LRP basis (Cash Price B AEV) were calculated using weekly average prices from January 2000 to January 2005 for Nebraska fed steers and heifers and from January 2001 to January 2005 for feeder steers and heifers weighing between 600 and 800 lbs. in 100 lb. increments. Summary statistics were calculated to compare futures and LRP basis risk. The mean LRP and futures basis indicates how Nebraska cash prices compare to both the futures and average cash markets (AEV) over time. To measure variability of forecasting basis for a specific week of the year, standard deviations were calculated each week of the year across a multiyear period for both fed and feeder cattle. Standard deviations were calculated over four years for fed cattle (2001-2004) and three years for feeder cattle (2002-2004) because of data limitations. These standard deviations for each week of the year were then averaged across years to compare the mean futures and LRP basis variability.

Result

Summary statistics for futures basis and LRP basis for fed cattle are presented in Table 1. The mean LRP basis for Nebraska fed steers and heifers indicates that, on average, the Nebraska direct steer and heifer price was $0.07/cwt and $0.16/cwt higher than the AEV, respectively. The mean steer and heifer LRP basis was $0.36/cwt and $0.37/cwt higher than the traditional nearby futures basis. Thus, LRP fed cattle basis was closer to zero, as hypothesized. The range (difference between maximum and minimum) in LRP basis from January 2000 to January 2005 was about one-third to one-half of the range in futures basis. The standard deviation for Nebraska steer and heifer LRP basis was about a third of that for futures basis, confirming that LRP basis is less variable than futures basis. Thus, using an historical average for fed cattle LRP basis forecasts likely will be more precise than for futures basis.

Standard deviation of basis for each week within the year also showed reduced variability for LRP basis relative to futures basis for fed cattle. The average of these weekly standard deviations for fed steer and

(Continued on next page)

heifer LRP basis was $0.85/cwt and $0.76/cwt. The corresponding average standard deviations for futures basis were $1.99/cwt and $1.85/cwt. The substantial reduction in weekly basis variation for LRP further suggests that forecasting LRP basis using the historical average is less risky than for futures basis.

Summary statistics for futures basis and LRP basis for selected classes of feeder cattle are located in Table 2. Note that LRP basis for 600-700 lb. and 700-800 lb. heifers was substantially higher than futures basis. This is because the LRP program uses price adjustment factors to scale down heifer prices relative to steers, effectively raising LRP basis relative to futures basis. The range observed in LRP basis was slightly smaller than the range for futures basis for all classes of feeder cattle except 700-800 lb. heifers. However, the reduction was not as great as for fed cattle. Further, the variability as measured by standard deviation did not decline similarly for feeder cattle LRP basis. In most cases, the standard deviation was only slightly smaller for LRP basis. The benefit of the less variable LRP basis as observed for fed cattle did not appear to hold for feeder cattle.

Weekly standard deviations for feeder cattle showed a slight reduction in variability of LRP basis relative to futures basis. The average of these weekly standard deviations for 700-800 lb. steer LRP basis was $1.72/cwt compared to $2.20/cwt for futures basis. Similar reductions of less than 30% in the average weekly standard deviations for LRP basis compared to futures basis were observed for other types and weights of feeder cattle. This is smaller than the 40-50% reductions seen for fed cattle. So, while feeder cattle LRP basis was somewhat less variable than futures basis, the reduction in feeder cattle basis risk was not as large for Nebraska LRP users as for fed cattle.

Table 1. Nebraska Direct Fed Steer and Heifer LRP Basis and Futures Basis Summary Statistics, January 2000-January 2005.

	Mean	Minimum	Maximum	Standard Deviation
	($/cwt)	($/cwt)	($/cwt)	($/cwt)
Steers				
LRP Basis	0.07	-2.99	5.32	0.94
Futures Basis	-0.29	-7.52	13.24	2.46
Heifers				
LRP Basis	0.16	-2.34	4.17	0.82
Futures Basis	-0.21	-4.85	12.09	2.29

Table 2. Nebraska Feeder Steer and Heifer LRP Basis and Futures Basis Summary Statistics, 2002-2004.

	Mean	Minimum	Maximum	Standard Deviation
	($/cwt)	($/cwt)	($/cwt)	($/cwt)
600-700 lb. Steer				
LRP Basis	10.19	1.30	21.75	4.13
Futures Basis	11.07	1.74	26.60	4.34
700-800 lb. Steer				
LRP Basis	4.44	-3.13	13.58	2.62
Futures Basis	5.32	-1.02	18.43	2.77
600-700 lb. Heifer				
LRP Basis	11.63	3.10	18.55	3.21
Futures Basis	3.39	-5.14	11.73	3.36
700-800 lb. Heifer				
LRP Basis	7.31	-0.53	18.34	2.48
Futures Basis	-0.93	-9.15	8.10	2.59

The substantial reduction in basis variability when using LRP for fed cattle producers relative to futures or options is likely because Nebraska prices represent a greater proportion of the AEV on which the LRP insurance contract is indemnified for fed cattle when compared to feeder cattle. The fed cattle AEV, or 5-Area steer price, is weighted heavily with Nebraska prices. Therefore, the difference between Nebraska prices and the AEV (LRP basis) is relatively small and less variable. Basis variability did not decrease for Nebraska feeder cattle prices because the LRP AEV for feeder cattle (CME feeder cattle cash index) does not weight Nebraska prices as heavily as does the AEV for fed cattle. Further, the quality premiums and discounts observed geographically in the feeder cattle market increase the range of prices incorporated into the feeder cattle AEV.

Implications

Livestock Risk Protection (LRP) insurance provides a reduction in basis risk for hedging fed cattle in Nebraska. Reduced basis variability indicates fed cattle producers would have less difficulty in accurately forecasting LRP basis levels for future livestock sales. If producers can forecast future basis levels with greater accuracy, they can better estimate future selling prices and the cash flows that result from those sales which could allow for better financial planning and budgeting. For feeder cattle users, there is little basis risk reduction when using LRP insurance relative to futures hedging.

[1]Rik R. Smith, extension assistant; Darrell R. Mark, assistant professor; and Allen L. Prosch, extension educator, Agricultural Economics, Lincoln.

Summary of Manure Amounts, Characteristics, and Nitrogen Mass Balance for Open Feedlot Pens in Summer Compared to Winter

William F. Kissinger
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

Data from 18 experiments (244 pen means) over a 10-year period were summarized in order to make a long term comparison between seasons dealing with nutrient mass balance studies and characteristics and amount of manure from open feedlot pens. The amount of manure DM increased from 10.6 lb to 20.0 lb/head finished/day from summer (May to September) to winter (November to May). Quantities of OM, ash, and N (lb/head finished/day) increased from 2.5 lb OM, 8.1 lb ash, and 0.13 lb N to 4.8 lb OM, 15.2 lb ash, and 0.22 lb N/head finished/day from summer to winter, respectively. Summer pens averaged 2.7% of N excretion in pen runoff N, and 6.2% of OM excretion in pen runoff, while winter pens averaged 1.8% of N excretion in pen runoff N, and 1.9% of OM excretion in pen runoff. Average N volatilization was higher for summer feeding pens (69%) compared to winter (47%). The implications, which can be used in individualized NMPs, are more total manure and manure N must be handled, but less volatilization of N and less N runoff occur in the winter compared to the summer feeding period.

Introduction

It is important that correct nutrient mass balances and characteristics of manure from open feedlot pens are known, so producers are able to develop accurate and realistic nutrient management plans in compliance with environmental regulations. While individual experiments have been presented, no long-term comparisons have been made across season. Most experiments have not presented manure characteristics or amounts, which is vital information today. The objective of this study was to determine manure amounts, characteristics, and variation between winter and summer feeding periods.

Procedure

Data from 18 experiments over a 10-year period dealing with nutrient mass balance studies in open feedlot pens were summarized. These experiments have been previously reported (*1996 Nebraska Beef Report,* pp. 74-77; *1999 Nebraska Beef Report,* pp.60-63; *2000 Nebraska Beef Report,* pp. 68-71; *2002 Nebraska Beef Report,* pp. 54-57; 2003 Nebraska Beef Report, pp. 54-58; *2004 Nebraska Beef Report, pp.* 61-63; *2004 Nebraska Beef Report, pp* 69-71; *2005 Nebraska Beef Report,* pp. 54-56; *2005 Nebraska Beef Report,* pp. 76-77*).* While nutrient balance data have been presented, manure amounts and characteristics have not been summarized. These 18 experiments were conducted in a series of open pens with manure and runoff measurement capabilities. Soil was core sampled before each trial to estimate nutrient concentration on the pen surface. The animals were fed in those pens over the summer or winter feeding periods (summer feeding period defined as May to September; winter feeding period defined as November to May), after which pens were cleaned. Collected manure was piled on the cement apron and sampled during removal and pen soil samples were again collected to estimate mass nutrient balances after the feeding period. The soil cores from before and after each nutrient balance experiment were used to correct for either manure left in the pen or soil removed at cleaning. Wet manure was weighed at time of removal and samples used to account for nutrients removed in the manure. These pens also contain runoff collection basins to determine runoff from pens on different treatments. Nutrients in runoff were quantified by sampling each runoff event, during measurement of total volume. In all experiments, cattle were fed in pens with 350 ft^2 per steer and pens were sloped approximately 4%.

Nitrogen Mass Balance

Nitrogen intake was calculated using dietary N concentration from the nutrient profile of each diet fed multiplied by DMI. Feed refusals were quantified, composited, and analyzed to correct N intakes. Cattle nutrient retention was calculated according to the retained energy and protein equations established by the National Research Council for beef cattle. Nutrient excreted was calculated by subtracting nutrient retention from nutrient intake.

Mass balance for N was conducted for each pen in the combined studies. Manure N was quantified by multiplying manure N concentration by amount of manure removed (DM) from the pen surface. Net core N was quantified from soil core samples collected before and after each trial. Runoff N was determined from runoff collection basins. Total N volatilized was calculated by subtracting the sum of manure, soil core balance and runoff N from excreted N. Percentage of N volatilized was calculated as N volatilized divided by total N excretion. All N values were expressed on a pound per head finished basis.

Statistical Analyses

Statistical analyses were conducted using Mixed procedures of SAS (2004) to test for effect of season with experiment in the model. The 244 pens across all diet treatments were tested for differences across season, winter or summer.

(Continued on next page)

Results

The 18 experiments represented 2,038 head of cattle in 244 observations (seasonal = 132 summer and 112 winter pens). Data summarized in Table 1 for summer and winter pens averaged BW = 791 lb and 724 lb, and gained 477 lb and 602 lb over 128 days and 166 days, respectively. The summer trials averaged 24.7 lb DMI, 3.66 lb ADG, and 6.74 F:G, compared to 23.3 lb DMI, 3.65 lb ADG, and 6.34 F:G for the winter feeding period.

Table 2 is a summary of data of manure solids and related nutrient content for the two seasonal feeding periods. The average wet manure amounts increased from summer to winter, from 15.4 lb/head/day up to 32.9 lb/head/day, respectively. Although the average percentage DM decreased from nearly 70% in summer to just over 61% in winter, the DM amount of manure nearly doubled from summer to winter, increasing from 10.6 to 20.0 lb/head/day, respectively. This compares to the commercial study data that indicated an overall average 73% DM , 15.9 lb/head/day average wet manure, and 11.6 lb/head/day DM amount of manure (*2006 Nebraska Beef Report,* pp. 94-97*)*. There was variation in these values indicated by the minimum and maximum range in Table 2. This increase in DM amount of manure harvested seasonally from summer to winter in this study is explained partially by the substantial increase in quantity of soil hauled out of the pen in the manure during the winter feeding period, as reflected in the nearly doubling of quantity of ash from an average of 8.1 lb/head/day to 15.2 lb/head/day from summer to winter periods. This was the result of more moisture in the manure during the winter period and the mixing of soil into the manure as a result of hoof action of the cattle on the wet manure. Additionally, average percentage OM and OM amounts increased from 24.1% and 2.5 lb/head/day to 27.5% and 4.8 lb/head/day, respectively, from summer to winter. The amounts of manure N increased from 0.13 lb N/head/day to 0.22 lb N/head/day, respectively, from summer to winter, corresponding to the increased average amount of manure DM produced seasonally. But, as a percentage of manure, the average concentration of N in the manure decreased from 1.42 % N in the summer feeding period to 1.20% N in the winter period, presumably due to the increased amounts of soil removed in the manure from the winter feeding period. In comparison, the commercial study indicated (*2006 Nebraska Beef Report,* pp. 94-97) an average 27.8% manure OM , 3.2 lb OM/head/day, 1.21% manure N, and 0.14 lb N/head/day in harvested manure.

N mass balance is a critical evaluation in these studies (Table 3). Variation in values is indicated by the minimum and maximum range. Although average N retention was essentially the same during both

Table 1. Performance data collected from 132 pens during summer and from 112 pens during winter for cattle fed in open feedlot pens.

	Summer[a]				Winter[b]				
Variable	Mean	CV[c]	Min[d]	Max[d]	Mean	CV[c]	Min[d]	Max[d]	*P*-value[e]
Days on feed	128	15	87	166	166	17	105	194	
Initial BW, lb	791	9	650	930	724	13	535	902	<0.01
Final BW, lb	1268	4	1126	1361	1326	4	1181	1444	<0.01
DMI, lb	24.7	6	21.8	28.7	23.3	12	18.7	30.0	<0.01
ADG, lb	3.66	9	2.78	4.27	3.65	8	3.00	4.46	0.86
F:G (DMI/ADG)	6.79	8	5.68	8.22	6.39	8	5.24	8.38	<0.01

[a]Summer = feeding period from May to September.
[b]Winter = feeding period from November to May.
[c]CV= coefficient of variation, %.
[d]Min and Max are minimum and maximum observations for a pen within season.
[e]*P*-value comparing means between summer and winter seasons.

Table 2. Manure characteristics data collected from 132 pens during summer and from 112 pens during winter for cattle fed in open feedlot pens.

	Summer[a]				Winter[b]				
Variable	Mean	CV[c]	Min[d]	Max[d]	Mean	CV[c]	Min[d]	Max[d]	*P*-value[e]
Days on feed	128	15	87	166	166	17	105	194	
As-is, lb/head/day	15.0	47	3.5	35.7	31.9	47	6.3	78.1	<0.01
DM, %	69.6	11	47.0	87.1	61.4	17	31.5	76.9	<0.01
DM, lb/head/day	10.4	47	2.5	26.2	19.3	49	4.1	53.6	<0.01
OM, %	24.1	23	9.5	42.1	27.5	37	11.3	52.4	<0.01
OM, lb/head/day	2.46	47	0.6	5.8	4.84	33	0.9	8.4	<0.01
Ash, %	75.9	7	57.9	90.5	72.5	14	47.6	88.8	<0.01
Ash, lb/head/day	7.9	50	2.0	21.1	14.5	59	2.3	47.6	<0.01
N, %	1.42	39	0.53	2.59	1.20	26	0.62	2.02	<0.01
N, lb/head/day	0.13	48	0.03	0.27	0.22	33	0.04	0.36	<0.01

[a]Summer = feeding period from May to September.
[b]Winter = feeding period from November to May.
[c]CV= coefficient of variation, %.
[d]Min and Max are minimum and maximum observations for a pen within season.
[e]*P*-value comparing means between summer and winter seasons.

Table 3. Nitrogen mass balance data collected from 132 pens during summer and from 112 pens during winter for cattle fed in open feedlot pens. Values expressed as lb/head/day.

	Summer[a]				Winter[b]				
Variable	Mean	CV[c]	Min[d]	Max[d]	Mean	CV[c]	Min[d]	Max[d]	*P*-value[e]
N intake	0.52	16	0.31	0.67	0.48	12	0.38	0.61	<0.01
N retain	0.07	33	0.03	0.10	0.06	28	0.03	0.09	0.09
N excreted	0.47	17	0.28	0.58	0.42	11	0.34	0.52	<0.01
N manure[f]	0.13	51	0.01	0.30	0.22	37	0.04	0.41	<0.01
N runoff	0.012	71	0.00	0.038	0.005	104	0.00	0.031	<0.01
N lost	0.32	21	0.14	0.46	0.20	37	0.04	0.32	<0.01
N lost, %[g]	69.0	21	38.2	97.6	47.2	41	10.1	89.0	<0.01

[a]Summer = feeding period from May to September.
[b]Winter = feeding period from November to May.
[c]CV= coefficient of variation, %.
[d]Min and Max are minimum and maximum observations for a pen within season.
[e]*P*-value comparing means between summer and winter seasons.
[f] N manure = sum of N manure and N soil core balance.
[g]N lost = N volatilized to the atmosphere expressed as % of N excreted.

Table 4. Comparison of average amounts and percentages of runoff nutrients from open beef feedlot pens.

	Summary[a] 18 Expts	Summer[b] Pens	Winter[c] Pens
Pens, n	244	132	112
Cattle, n	2,038	1,142	896
Average days	145	128	166
Runoff gallons, gal/head	939	1202	643
Average precipitation/experiment, in.	10.8	13.8	7.7
Average rain event days, n	35	37	33
N excreted, lb/head finished	64.1	58.9	69.8
Runoff N, lb/head finished	1.33	1.62	1.04
% of N excreted in pen runoff N	2.1%	2.7%	1.5%
N concentration in runoff:			
ppm	169	161	193
lb/ac-in	38	37	44
OM excreted, lb/head finished	734	657	872
Runoff OM, lb/head finished	31.7	40.5	16.2
% of OM excreted in pen runoff OM	4.3%	6.2%	1.9%
OM concentration in runoff:			
ppm	4045	4042	3020
lb/ac-in	916	916	684

[a]Number of pens from which data were collected: Runoff gallons=244; Runoff N=192; Runoff OM=132.
[b]Number of pens from which data were collected: Runoff gallons=132; Runoff N=96; Runoff OM=84.
[c]Number of pens from which data were collected: Runoff gallons=112; Runoff N=96; Runoff OM=48.

seasons (0.07 lb and 0.06 lb N/head/day), average N intake decreased from summer to winter (0.52 lb N/head/day and 0.48 lb N/head/day, respectively), and N excretion decreased from summer to winter feeding periods (0.47 lb N/head/day and 0.42 lb N/head/day, respectively). Average manure N amount increased from summer to winter from 0.13 lb N/head/day to 0.22 lb N/head/day, with a CV of 51%, but average N runoff decreased from summer to winter feeding periods from 0.012 to 0.005 lb N/head/day, respectively, with a CV of 71%. The average amount of N volatilized decreased from summer to winter (0.32 to 0.20 lb N/head/day). Similarly, the percentage N volatilized decreased from 69% in the summer to 47% in the winter, presumably due to warmer temperature in the summer. The 69% N volatilized value is nearly identical to the average value of 70% N loss indicated from data from commercial studies summarized from collection periods across seasons (*2006 Nebraska Beef Report*, pp. 94-97). There was quite a range of values for percent N loss within season, with CV of 21% for summer, and 41% for winter.

Amounts and percentages of N and OM in runoff from pens in all eighteen experiments are shown in Table 4. In the 244 pens summarized for the 18 experiments, the 2038 steers averaged 145 days on feed, excreted 64.1 lb N/head finished, and 734 lb OM/head finished. The average runoff from each pen was 939 gallons/head. The 244 pens averaged 1.3 lb runoff N/head and 31.7 lb runoff OM/head finished. This was an average of 2.1% of N excretion in pen runoff N and 4.3% of OM excretion in pen runoff OM.

In seasonal comparison (Table 4), the steers in summer and winter pens averaged 128 and 166 days on feed, respectively. The summer steers averaged nearly 59 lb N excreted/head finished and the winter steers averaged 70 lb N excreted/head finished. The winter steers excreted more OM than the summer steers (872 lb OM excreted/head finished and 657 lb OM excreted/head finished, respectively). Although the length of the summer feeding periods were less than the winter periods, runoff from the summer pens was nearly double the amount from the winter pens (1202 gal/head compared to 643 gal/head, respectively) reflecting the higher rainfall amount for the summer feeding period. Although the average precipitation per experiment was 10.8 in. occurring in 35 rain event days, the summer pens received nearly twice the average rainfall amounts compared to the winter pens (13.8 in. in 37 rain event days compared to 7.7 in. in 33 rain event days, respectively). The runoff N amount of the summer pens was nearly 60% greater than the winter pens, and averaged 1.62 lb runoff N/head finished and 1.04 lb runoff N/head finished, respectively. This was 2.7% of N excretion and 1.5% of N excretion in pen runoff N amounts, respectively, for summer and winter pens. The summer pens runoff OM amounts averaged 40.5 lb runoff OM/ head finished, while the winter pens averaged 16.2 lb runoff OM/head finished. These amounts were 6.2% and 1.9% of OM excretion for average summer and winter pen runoff OM, respectively.

Although the average gallons of runoff from the winter pens were nearly half the summer amount, the N concentration in runoff from the winter pens was nearly 20% higher than the summer pens (193 ppm N and 161 ppm N, respectively). Overall, the pens in the 18 experiments averaged 169 ppm N concentration in runoff. But, the OM concentration in runoff decreased from winter to summer (75%). The OM concentration of runoff was 3020 ppm OM and 4042 ppm OM in runoff from winter and summer pens, respectively. The pens in the eighteen experiments averaged 4045 ppm OM concentration in runoff.

There are several implications from this study. Nearly twice the manure is produced on a daily basis/head finished in the winter period compared to summer. More total manure must be handled due to more soil (ash) in the manure during the winter period, in addition to a longer average feeding period in the winter compared to summer. There is more volatilization of N in the summer period compared to winter, resulting in higher manure N in the winter period. But, there is more than twice the N runoff in the summer period compared to winter due to increased rainfall amounts during the summer feeding period. These implications can be used in individualized NMPs.

[1]William F. Kissinger, graduate student, Mechanized Systems Management; Galen E. Erickson, assistant professor, Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Nitrogen Mass Balance and Cattle Performance of Steers Fed Clinoptilolite Zeolite Clay

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

Summary

A winter and a summer nitrogen mass balance experiment were conducted to analyze effects of feeding clinoptilolite zeolite clay to steers. No differences were found in steer ADG, F/G or carcass characteristics. Nitrogen mass balance and volatilization were not affected by a 1.2% addition of clinoptilolite in feedlot diets. These experiments indicate clinoptilolite zeolite clay does not have a large enough cation exchange potential to be effective in reducing N volatilization in open feedlot pens.

Introduction

Clinoptilolite zeolite clay is a proposed new method to reduce N volatilization. Zeolite clay is a naturally occurring hydrated aluminosilicate mined from volcanic ash deposits associated with alkaline lakes. The clay has a high cation exchange capability and permeability rate which may make it effective in adsorbing ammonia. The first hypothesis of this research is the addition of zeolite clay to feedlot cattle diets will bind the ammonia; therefore, reducing the amount of N lost. The second hypothesis is steer performance will not be negatively impacted by the addition of zeolite clay to the diet.

Procedure

Two feeding trials (96 steers/trial) were conducted using 96 crossbred steers. Calves (741 ± 26 lb) were fed for 168 days from November to April (Exp 1) and yearlings (842 ± 15 lb) were fed for 120 days from May to September (Exp 2). For each experiment, steers were stratified by weight and assigned randomly to 12 pens and one of two treatments (eight head/pen, six pens/treatment). Treatments were 1) control diet with 0% zeolite clay (CONTROL) or 2) treatment diet with 1.2% zeolite clay (CLAY). Diets were formulated to meet the steers' metabolizable protein requirements according to the 1996 Beef NRC. Steers were fed a three-week four-step-up program to the finishing diet shown in Table 1. The supplement in both diets used a ground corn carrier which was replaced with zeolite clay.

Steers were weighed initially on two consecutive days following a five-day limit-feeding period. Calves were again weighed on days 28, 84 and 168 (Exp 1). They were implanted with Synovex-Choice® (Fort Dodge Animal Health, Overland Park, Kan.) on day 1 and 84. Yearlings (Exp 2) were also weighed on day 25 and 120 and implanted on day 25 with Revelar-S® (Intervet, Millsboro, Del.). At slaughter, hot carcass weights and liver scores were recorded. Following a 24-hour chill, 12th rib fat thickness, rib-eye area, quality and yield grades were recorded. For data analysis, final weights were calculated as hot carcass weight divided by the common dressing percentage of 63.

Nitrogen mass balance experiments were conducted using 12 open feedlot pens with retention ponds to collect runoff. Total runoff from each pond was quantified using an ISCO 4230 flow meter (Lincoln, Neb.). Samples were collected during draining and analyzed for DM, OM and total N.

Prior to the steers entering the pens, November (Exp 1) and May (Exp 2), 16 core samples of the top 6 inches of lot surface material were taken at equally spaced intervals throughout each pen. Following removal of steers, April (Exp 1) and September (Exp 2), pens were cleaned and 16 core samples were taken at locations similar to the beginning cores. On the same day pen cores were taken, six, 6-inch cores of settled solids were removed from each retention pond. All cores were analyzed for DM, OM and N.

On the day steers were removed from the pens and sent to slaughter, the pens were thoroughly cleaned and total pounds of manure removed were recorded. As manure was loaded for transport to the compost yard, 30 random samples per pen were collected for analysis of DM and N.

For both experiments, N intake was calculated using analyzed dietary N content of each feedstuff and multiplied by total DMI. Individual steer N retention was calculated using the NRC (1996) net protein and net energy equations. N excretion was determined by the difference between N intake and N retention. Manure N was calculated using the total weight hauled and its N composition. Exp 1 manure N was corrected for inherent cleaning differences by adjusting for soil core N before and after the feeding period. Total N in Exp 1 lost was calculated by subtracting N levels of the soil corrected manure and runoff from excreted N. All Exp 1 values are reported on a per steer basis for 168 days. Total Exp 2 N lost was calculated by subtracting manure N from excreted N. All Exp 2 values

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

Ingredient	CONTROL	CLAY
High moisture/dry rolled corn[a]	62.5	62.5
Wet corn gluten feed	25	25
Alfalfa hay	7.5	7.5
Supplement[b]	5	5

[a]Exp 1 trial used high moisture corn, Exp 2 trial used dry rolled corn.
[b]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.

Table 2. Growth performance and carcass characteristics for Exp 1 steers.[a]

Item	CONTROL	CLAY	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
F/G [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 thickness, 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. Growth performance and carcass characteristics for the Exp 2 steers.[a]

Item	CONTROL	CLAY	SEM	*P*-value
Initial BW, lb	842	842	1	0.69
Final BW, lb	1323	1314	5	0.56
DMI, lb	27.1	27.1	0.1	0.65
ADG, lb	4.01	3.95	0.04	0.61
F/G[b]	6.90	7.30	0.01	0.33
Hot carcass weight	833	829	3	0.59
Marbling score[c]	535	530	12	0.79
Fat thick, in[d]	0.50	0.45	0.02	0.15

[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 4. Nitrogen mass balance in the feedlot for Exp 1 (values expressed as lb/steer over entire feeding period unless noted).

Item	CONTROL	CLAY	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	43.9	42.7	2.4	0.64
Runoff N	0.51	0.97	0.15	0.06
N lost [c]	29.2	30.6	4.0	0.82
% N lost[d]	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]Calculated as N excretion - manure N - core N - runoff N.
[d]N lost expressed as % of N excreted.

Table 5. Nitrogen mass balance in the feedlot for Exp 2 (values expressed as lb/steer over entire feeding period unless noted).

Item	CONTROL	CLAY	SEM	*P*-value
N intake	74.8	73.7	0.7	0.18
N retention [a]	9.0	8.9	0.3	0.69
N excretion [b]	65.8	64.8	0.5	0.11
Manure N	12.0	11.1	0.9	0.55
Runoff N	0.06	0.10	0.01	0.10
N lost[c]	53.8	53.6	0.9	0.90
% N lost[d]	81.7	82.7	1.4	0.64

[a]Calculated using NRC (1996) net protein and net energy equations.
[b]Calculated as N intake - N retention.
[c]Calculated as N excretion - manure N - runoff N.
[d]N lost expressed as % of N excreted.

are reported on a per steer basis for 120 days. All data were analyzed by analysis of variance using the Mixed Procedure of SAS.

Results

For both experiments there were no statistical differences in steer performance between the control and clay treatments. In Exp 1, CLAY steers had a 3.4% increase in ADG over CONTROL. The CLAY steers also had a 2.9% decrease in F/G (Table 2). Whereas, during Exp 2, CONTROL had a 1.5% increase in ADG over the CLAY steers and were more efficient with a 5.8% decrease in F/G over the CLAY steers (Table 3). However, these changes in performance were not statistically significant and we conclude the addition of 1.2% clinoptilolite zeolite has no impact on cattle ADG or F/G.

Nitrogen mass balance was not affected by the addition of zeolite clay for either experiment (Tables 4 and 5). No statistical treatment differences were present for manure N or N lost. The % N lost during Exp 2 was higher than other reported amounts by Erickson (*2002 Nebraska Beef Report*, pp. 54-57) and Adams (*2003 Nebraska Beef Report,* pp. 54-58). However, the N losses observed in this study were similar to observations by Wilson et al. (*2004 Nebraska Beef Report,* pp. 72-73). The higher levels of N lost during the summer, compared to previous research, could be due to environmental factors such as warm, humid conditions, rainfall, temperature, or diet differences.

Research with other species has shown zeolite clay to be effective in adsorbing N, thus having the ability to reduce N volatilization losses. The lack of a response to zeolite in the current study could be due to variations in clays used and methodology for assessing N losses. Also, zeolite clay may not have the cation exchange potential needed for the conditions in open pens versus confinement conditions.

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

Factors Affecting Nitrogen Losses as Measured Using Forced-Air Wind Tunnels and Nitrogen Mass Balance

Dawn M. Sherwood
Galen E. Erickson
Terry J. Klopfenstein
Dennis D. Schulte
Rick R. Stowell[1]

Summary

Two experiments using wind tunnels were conducted in conjunction with a N mass balance to evaluate the effect of clinoptilolite zeolite clay on ammonia (NH_3) losses. Ammonia losses were measured using the wind tunnels during the last six weeks of each feeding period and compared to losses calculated using a N mass balance. Nitrogen loss, pH, surface DM and N contents, and soil and surface temperatures were assessed as possible contributing factors. There were no differences in NH_3 volatilization due to dietary treatments. N loss was influenced by date, % DM, surface N and soil temperature. As measured by the wind tunnels, 26.4 to 29.2% of the total N loss (by mass balance) was lost as volatilized NH_3. The wind tunnel is a useful tool for measuring gaseous emissions; however, the short measurement period and small area of measurement may reduce the cumulative accuracy compared to mass balance techniques.

Introduction

Ammonia emissions are an environmental challenge facing livestock producers. There is a potential for feedlots to become regulated in regards to NH_3 emissions and nitrogen volatilization. One concern is how these emissions are measured and calculated, and whether the results are accurate.

Research at Nebraska has been conducted by measuring N loss using the mass balance method. This method takes into account the N consumed and excreted by the cattle. The N excreted is further measured as manure, soil, and runoff N. However, the mass balance method determines volatile N losses indirectly (by difference). N losses from the feedlot pen surface to the atmosphere are thought to be released predominantly as NH_3, and the wind tunnel can be used to measure NH_3 emissions directly.

The first hypothesis of this research is the wind tunnel will enable users to measure the N volatilized as NH_3, and that measured losses will be similar to N losses calculated using the mass balance technique. The second hypothesis is factors such as: DM, pH, soil temperature, and surface N, will affect the level of NH_3 volatilized.

Procedure

Two experiments were conducted on the effects of feeding clinoptilolite zeolite clay on N losses. These results are presented separately (*2006 Nebraska Beef Report,* pp. 90-91). Wind tunnels were used to sample NH_3 released from pens the last six weeks of each feeding period (March 25-April 29 and July 23-August 27). A wind tunnel was temporarily placed on the lot surface within each pen, and air was directed over the feedlot surface at 0.3 m/s for 30 minutes per pen. Collection was from 0900 to 1400 each day with pen order remaining constant throughout both experiments. A fraction of the airflow was diverted for analysis and NH_3 in this air was collected using a 0.2 *M* sulfuric acid trap. The tunnels were placed in similar locations within each pen (13 ft from the division fence and 24 ft from the concrete apron). The location was determined by a small preliminary study by Ryan Duysen in 2003. Pens were divided into six sections according to surface uniformity. Emission samples were collected and a weighted average was used to calculate the representative location for measuring NH_3. One-inch core samples were taken at four locations around the edge of the wind tunnel during each measurement period. The cores were composited and analyzed for pH, DM, and N. Surface and soil temperatures were taken at the start of each 30-minute run. Each vial of sulfuric acid solution was analyzed for NH_3 with a Seal AQ2 autoanalyzer. The NH_3 was then converted to g/head for each treatment (Table 1), accounting for the airflow rate of the wind tunnels, the tunnel and pen areas, and the stocking rate. These NH_3 levels were then incorporated into the N mass balance as lb/steer over the entire feeding period.

Results

Feeding clinoptilolite zeolite clay had no effect on cattle performance or N losses as no significant differences between the two treatments were present in either experiment (Table 1). Much more NH_3 was released during the summer experiment due to an increase in soil temperature and N level, which is in agreement with previous research. Using the mass balance technique, 28.7 and 29.5 lb of volatilized NH_3 - N per head were lost in the study conducted in the winter for cattle fed a control diet and zeolite treatment, respectively. In comparison, the NH_3-N losses, as measured using the wind tunnels were 7.7 lb and 13.4 lb of N per head. The estimated ammonia N loss using the wind tunnels was much lower than that calculated indirectly using mass balance measurements, averaging 35.1% of total excreted N compared to 40% based upon mass balance measurements.

Using the mass balance technique for summer fed cattle, 53.8 and 53.6 lb per head of NH_3-N were lost using the mass balance technique for control and zeolite treatments, respectively. Using the wind tunnels, 14.2 and 15.7 lb of NH_3-N were lost. As a percentage

Table 1. Nitrogen mass balance and ammonia emissions (measured using wind tunnels) during two separate feeding trials (expressed as lb/steer over entire feeding period).

Trial	Control	Clay	SEM	P-value
Exp 1				
Manure	43.9	42.8	2.4	0.64
Runoff	0.51	0.97	0.15	0.06
N lost[a]	20.9	16.1	4.0	0.88
N lost[b]	7.7	13.4	10.8	0.35
Exp 2				
Manure	12.0	11.1	0.9	0.55
Runoff	0.06	0.10	0.01	0.10
N lost[a]	39.6	37.9	0.9	0.90
N lost[b]	14.2	15.7	8.9	0.67

[a]N lost measured by nitrogen mass balance differences.
[b]N lost measured by wind tunnels as NH_3.

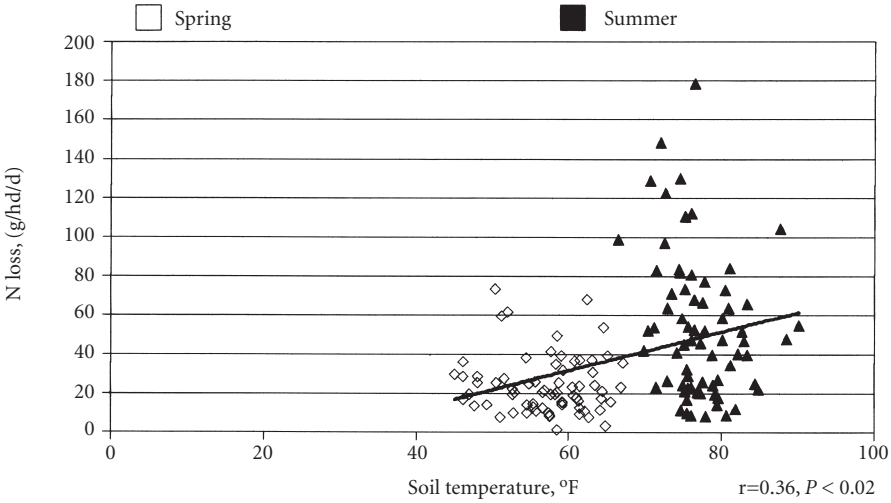


Figure 1. Correlation between N loss and soil temperature (all points of measure are combined).

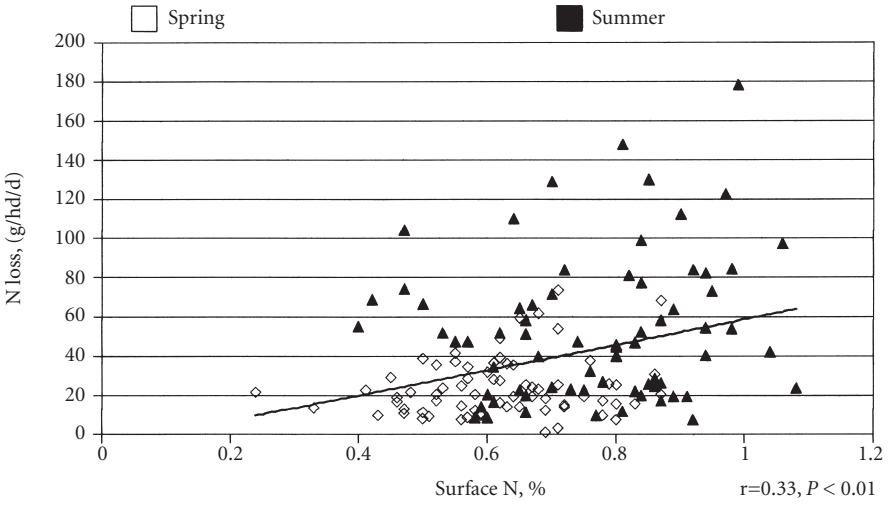


Figure 2. Correlation between N loss and percentage surface N (all points of measure are combined).

of total excreted N the wind tunnel measured N loss as NH_3-N as 26.4 to 29.2% for control and zeolite treatments, respectively, compared to 81.7 and 82.7 % based upon mass balance numbers. Therefore, either the NH_3-N losses are overestimated by the mass balance technique or the wind tunnel does not account well for total losses over 120 or 168 days.

The relationships of DM, pH, surface N and temperature to NH_3 loss, measured by the wind tunnels, were analyzed. In the spring period, N loss averaged 28.6 g/steer daily with pen surface samples averaging 3.85% N, 74.7% DM and 67.1ºF. In the summer sampling period, N loss averaged 56.5 g/steer daily with pen surface averaging 4.8% N, 78.6% DM and 77ºF. There were significant, but relatively weak correlations between N loss and soil temperature r = 0.36, $P < 0.02$) (Figure 1) and N concentration of the pen surface material r = 0.33, $P < 0.01$) (Figure 2). No correlation was observed between N loss and pH.

When the data were analyzed using a regression model, there was a significant effect of date on N loss, soil pH, soil N and DM contents, and surface and soil temperatures ($P < 0.01$). This is expected as time of year influences the temperature and moisture content of the feedlot surface.

With the use of the wind tunnels, researchers can measure NH_3 loss directly from open feedlot pens. However, a challenge with the use of the wind tunnel to quantify NH_3 losses is length of the measurement period and area measured. For example, during the winter trial in our study the wind tunnel measured 3 hours of emissions total per pen. The cattle were occupying the pens for a total of 4,032 hours; therefore, the wind tunnel only measured 0.07% of the time the cattle were in the pens. Additionally, the wind tunnel measures an area of 3.4 ft^2 in a pen with an area of 2,550 ft^2; therefore, the wind tunnel only measured 0.14% of the pen surface area. The wind tunnel is a useful tool for measuring relative differences between adjacent pens, presumably. More measurement periods may be needed to obtain a complete and accurate depiction of the NH_3 released from the pen surface over an entire feeding period.

[1] Dawn M. Sherwood, graduate student; Galen E. Erickson, assistant professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln. Dennis D. Schulte, professor; Rick R. Stowell, assistant professor, Biological Systems Engineering, Lincoln.

Managing Phosphorus in Beef Feedlot Operations[1]

William F. Kissinger
Galen E. Erickson
Terry J. Klopfenstein
Rick K. Koelsch[2]

Summary

A commercial feedlot study determined manure nutrient flow in six feedlots using a corn and by-product based diet with an average P content of 0.39% (DM basis), and a range of 0.34 to 0.48%. Mass balances for N and P were conducted on each pen. The average feed nutrient intake was 0.52 lb N/head/day (64.0 ± 7.6 lb/animal fed) and 0.09 lb P/head/day (10.9 ± 2.2 lb/animal fed). Based upon averages from the 6,366 head of cattle, 11.5% of the feed nitrogen and 16.9% of the feed phosphorus were retained by the animal with the remaining nutrients excreted. The harvested manure averaged 73% dry matter and 28% organic matter. A wide range of observed organic matter levels (9 to 63%), reflected soil being hauled out of pens along with the manure solids. Based upon these data, 31% of the excreted nitrogen or (17.2 lb/animal fed) and 90% of the excreted phosphorus (or 8.1 lb/animal fed) were removed in manure at cleaning.

Introduction

Revised standards for phosphorus (P) excretion by feedlot cattle have recently been accepted by ASAE, which are 50% lower than the previous standards. It is important that correct estimates of P removed as manure solids are available for producers to use in developing nutrient management plans that are based on utilization of manure P. If P content is over-predicted, acres required for appropriate distribution will be inflated. If under-predicted, P levels in the soil may be elevated and excess P may leave fields in runoff.

Few data exist for manure P harvested from feedlots. Previous work at the University of Nebraska suggested that less than 100% of P excreted is removed in manure. It is imperative to monitor P flow in the feedlot to determine how much is removed in manure in commercial feedlots compared to the amount excreted by cattle. The objectives of this study were to quantify the phosphorus and nitrogen in manure harvested from open lot beef cattle production systems, and to conduct a mass balance for P entering and exiting a feedlot. This information will help determine if nutrient management plans for feedlots can be developed by knowing the amount of P fed.

Procedure

Feedlot Study

Six central and eastern Nebraska feedlots ranging in size from less than 5,000 head to more than 20,000 head capacity were recruited during the fall of 2003 to participate in a study to quantify manure and nutrients harvested from pens during cleaning. Each of the feedlots was to assign three cattle feeding pens for this study, and to share information for approximately one year on the cattle fed in each pen. The completed study represents 15 feeding pens, 40 separate lots of cattle fed in those pens, and 6,366 head of cattle in those lots. For this study, both steers and heifers were fed. All calculations were made on a per animal basis and results were presented as amount per head. The period of time of data collection from the pens ranged from mid-October 2003 through December 2004.

Feed intake and the nutrient profile of each diet fed were furnished by the feedlot staff or consulting nutritionist. Bunk samples of delivered feed were collected for additional documentation of nutrient profiles. Animal performance on each lot of cattle fed in each pen was determined from data supplied by the feedlot staff for cattle weights in and out, number of animals, and days on feed for each lot of cattle.

Each pen in the study was initially cleaned prior to entry of cattle. Manure from feedlot pens is typically removed after a pen of cattle is marketed and prior to the next group of cattle arriving. In some instances in this study, more than one cycle of cattle were fed in a pen between manure harvestings. Subsequently, feedlot personnel scraped and harvested the manure during normal management procedures of the respective feeding operations. Manure was scraped and piled into central piles within each pen. In some instances, scraped manure was used to maintain the integrity of mounds within the pens. As the manure was harvested, gross and tare weights of truck loads were recorded and representative manure samples were collected for nutrient analysis at a commercial laboratory. Manure was either hauled directly to fields for land application, or transferred to a stockpile or compost yard.

Nutrient Balance

Nutrient intake was calculated using dietary nutrient concentration from the nutrient profile of each diet fed multiplied by DMI. Cattle nutrient retention was calculated according to the retained energy and protein equations established by the National Research Council (1996) for beef cattle. Nutrient excretion was calculated by subtracting nutrient retention from nutrient intake.

Mass balances for N and P were conducted as a group on those lots of cattle in residence during the period of time between manure harvesting for each pen in the study. Manure nutrients were quantified by multiplying the nutrient concentration of harvested manure by the amount of manure removed (DM) from the pen. Total nutrient loss was calculated by subtracting the mass of harvested manure nutrient from the amount of excreted nutrient. Percent nutrient loss was calculated as nutrient loss divided by total nutrient excretion. All nutrient values were expressed on a lb/head

Table 1. Nutrient intake of cattle fed in six Nebraska feedlots.

	Nutrient intake[a]				Feeding period[b]	
Variable	Mean	CV, %	Minimum	Maximum	Winter/spring	Summer/fall
DMI, lb/head/day	22.5	9	19.3	24.6	21.8	23.3
CP, %	14.4	8	13.4	16.6	14.2	14.5
N, lb/head/day	0.52	12	0.42	0.64	0.49	0.54
P, %	0.39	13	0.34	0.48	0.38	0.41
P, lb/head/day	0.09	20	0.07	0.12	0.08	0.10

[a]Values are for 22 cleaning periods.
[b]Values are average for 11 cleaning periods each within the winter/spring and summer/fall feeding periods.

Table 2. Analysis of harvested manure for cattle fed in six Nebraska feedlots.

	Manure characteristics[a]				Feeding period[b]	
Variable	Mean	CV, %	Minimum	Maximum	Winter/spring	Summer/fall
As-is, lb/head/day	15.9	79	1.9	61.0	17.5	14.3
DM, %	73.2	13	58.8	94.4	70.6	76.5
DM, lb/head/day	11.6	83	1.2	47.4	12.4	10.9
OM, %	27.8	45	8.8	63.0	33.5	34.6
OM, lb/head/day	3.2	45	0.3	6.1	2.9	3.6
N, %	1.21	45	0.44	2.51	1.40	1.53
N, lb/head/day	0.14	47	0.01	0.28	0.12	0.16
P, %	0.57	48	0.21	1.18	0.66	0.76
P, lb/head/day	0.07	49	0.01	0.13	0.06	0.08

[a]Values are for 22 cleaning periods.
[b]Values are average for 11 cleaning periods each within the winter/spring and summer/fall feeding periods.

Table 3. Nitrogen balance data for cattle fed in six Nebraska feedlots. Values expressed in lb/head/day unless noted.

	Nitrogen balance[a]				Feeding period[b]	
Variable	Mean	CV, %	Minimum	Maximum	Winter/spring	Summer/fall
N intake	0.52	12	0.42	0.64	0.49	0.5
N retain	0.06	—	0.03	0.08	0.06	0.06
N excrete	0.46	—	0.35	0.58	0.43	0.48
N manure	0.14	47	0.01	0.28	0.12	0.16
N lost	0.32	—	0.14	0.43	0.31	0.33
N lost, %	69.6	—	39.5	96.5	70.6	68.6

[a]Values are for 22 cleaning periods.
[b]Values are average for 11 cleaning periods each within the winter/spring and summer/fall feeding periods.

Table 4. Phosphorus balance data for cattle fed in six Nebraska feedlots. Values expressed in lb/head/day unless noted.

	Phosphorus balance[a]				Feeding period[b]	
Variable	Mean	CV, %	Minimum	Maximum	Winter/spring	Summer/fall
P intake	0.089	20	0.07	0.12	0.08	0.10
P retain	0.01	5	0.01	0.02	0.02	0.02
P excrete	0.074	--	0.05	0.11	0.07	0.08
P manure	0.066	49	0.01	0.13	0.06	0.08
P lost	0.007	--	-0.05	0.05	0.01	0.00
P lost, %	9.8	--	-94.3	89.9	13.1	6.4

[a]Values are for 22 cleaning periods.
[b]Values are average for 11 cleaning periods each within the winter/spring and summer/fall feeding periods.

basis. Nutrient mass balances were determined for N and P.

Statistical Analyses

Statistical analyses were conducted using procedures of SAS (2004). Only variables significant at the 0.15 level remained in the models considered in stepwise selection. In the correlation procedure, all variables were entered, resulting in the production of Pearson Correlation Coefficients.

Results

Data summarized are for cattle fed from October 2003 through December 2004. Cattle involved in this summary were typically yearlings (BW = 778 lb) and on average gained 403 lb over 123 days. The data were partitioned into two feeding periods: winter/spring and summer/fall feeding periods, in order to illustrate any differences between the average values for the two feeding periods.

Feed input is the critical nutrient input evaluated in this study. The average nutrient intake was 0.52 lb N/head/day (64.0 ± 7.6 lb/animal fed) and 0.09 lb P/head/day (10.9 ± 2.2 lb/animal fed) for the 123-day average feeding period (Table 1). For an industry average 153-day feeding period, this would amount to 79.1 lb N/animal fed and 13.6 lb P/animal fed. All feedlots were using corn and by-product based diets. The P content averaged 0.39% (DM basis), but ranged from 0.34 to 0.48%.

Based upon averages (Tables 3 and 4) from the 6,366 head of cattle, 11.6% of the feed N and 16.9% of the feed P was retained by the animal with the remaining nutrients excreted. On average, 56.3 lb of N and 9.1 lb of P (DM basis) were excreted per fed beef animal.

Based upon collected data, manure solids contents and nutrient contents of harvested manure were generated (Table 2). On average, 1.0 ton of manure (as-is) was removed per finished animal (15.9 lb/head/day). The harvested manure averaged 73% dry matter (71% during the winter and

(Continued on next page)

spring; 77% during the summer and fall) and 28% organic matter (OM). The wide range of observed organic matter levels (9 to 63%) reflected the amount of soil that was being hauled out of pens. Feedlot surface conditions during manure harvest and pre-harvest periods substantially impacted the amount of soil that was mixed with the manure. Percent ash (100 - % OM) is a potential marker for amount of soil contamination at the time of cleaning. Typically, without the addition of soils, 10-20% ash content of the manure would be expected.

The data from this study provide an indication of nutrients harvested from feedlots and available for land application. After 123 days in the pen on average, 31% of the excreted N or (17.2 lb/fed animal) and 90% of the excreted P (or 8.1 lb/fed animal) were recovered in harvested manure. The N unaccounted for by these measurements can likely be explained by N that volatilizes as ammonia and the dissolved or suspended N in feedlot runoff (5% or less of excreted N).

The only anticipated P loss would be from P contained in the runoff, which is 5% or less of excreted P. Thus, an estimate of P recovery of slightly less than 100% would be anticipated. These data (Table 4) indicate an average of 9.8% P loss. Although there is variation, one factor that might explain variation in P loss is feedlot conditions prior to and during manure harvesting. Wet feedlot surface conditions, more common during winter and spring, produce more mixing of manure and soil resulting from animal activity. Wet conditions at harvest create challenges for equipment operators to harvest manure only. Higher soil inclusion with the manure solids may cause manure P to exceed excreted P. With the continuous addition of soil to pens in many feedlots to offset the soil loss during manure harvest, it is possible for P in manure to exceed P excretion. P in manure would also be greater than P excretion if some P was removed at cleaning that was remaining in the pen from a previous group of cattle. If cleaning differences exist, it is challenging to match harvested P to P excreted.

Another factor that might explain the variability in P loss is that in some instances, scraped manure is used in maintenance of the mounds in the pens. Manure solids are not removed from the pen, resulting in a lower average quantity of harvested manure from the feedlot. Therefore, it may be difficult to always predict P in harvested manure from the amount excreted. However, these data in Table 4 suggest most (90.2%) of the excreted P is hauled away in manure, at least eventually, and may be a good indicator of the P needing distribution to crop land in nutrient management plans. But, pen-to-pen variation should be expected with a coefficient of variation as high as 49%.

These data suggest a positive correlation between P intakes and manure P. With an increase in P intake, manure P increased in these Nebraska feedlots, and was positively correlated ($r = 0.56$; $P < 0.01$) to P intake.

One additional source of information that will add to our ability to manage manure nutrients is the database of feedlot manure samples. Few summaries of typical feedlot manure characteristics exist especially for cattle fed by-products of corn processing. Based upon a database of 53 samples, Table 5 summarizes average values for N, P, total solids and volatile solids for feedlot manure from these Nebraska feedlots.

Another source of information is the comparative summary of average quantities of manure solids harvested from the feedlots in the study. Based upon the 40 lots of cattle fed in the six feedlots, Table 6 summarizes average quantitative values for each feedlot for DM, OM, N and P on a per head/day basis for harvested manure. Also shown are the average characteristics for percent OM, N, and P. On average, manure harvested values from the six feedlots for DM, OM, N, and P are 11.7, 3.2, 0.14, and 0.066 lb/head/day, respectively. The data in Table 6 further illustrate the variation which exists between individual feedlots and emphasize the need for determining individual values of P harvested from

Table 5. Characteristics of manure samples collected at six Nebraska feedlots.

	Summary manure samples (DM basis)							
Feedlot	# of samples	Total N %	P %[a]	pH	Ash %	OM %	DM %	N:P
I	3	1.72	1.06	7.3	62.6	37.4	71.1	1.6
II	8	2.42	1.13	7.3	46.1	54.0	76.2	2.1
III	9	1.50	0.89	7.6	66.9	33.1	74.0	1.7
IV	11	1.33	0.59	8.1	68.3	31.7	70.6	2.3
V	15	0.77	0.31	8.1	81.4	18.6	71.3	2.4
VI	7	0.84	0.39	7.8	82.0	18.0	84.9	2.2
Total/average	53	1.32	0.64	7.8	69.9	30.1	74.1	2.1

[a]P = Elemental Phosphorus. In order to convert to P_2O_5, multiply elemental P values by 2.29.

Table 6. Summary of average amounts and characteristics of manure harvested from six Nebraska feedlots.

	Manure harvested						
Feedlot Summary	DM lb/head/day	OM %	OM lb/head/day	Manure % N	Manure N lb/head/day	Manure % P	Manure P lb/head/day
I	2.5	37.8	0.9	1.72	0.04	1.06	0.026
II	7.6	54.9	4.2	2.34	0.18	1.06	0.080
III	10.2	32.7	3.3	1.47	0.15	0.88	0.089
IV	12.7	32.0	4.1	1.33	0.17	0.59	0.075
V	20.4	19.3	3.9	0.72	0.15	0.30	0.061
VI	3.4	19.1	0.7	0.89	0.03	0.38	0.013
Average[a]	11.6	27.8	3.2	1.21	0.14	0.57	0.066
CV	83	55	45	55	47	60	49

[a]Values are average for the 22 cleaning periods.

individual feedlots under individual management and pen conditions, if accurate and realistic NMPs are to be implemented.

An interesting comparison of quantity of manure nutrients from beef cattle can be made. The average values for harvested manure N and P from the 6,366 cattle fed in six Nebraska feedlots with dirt pens were compared to values calculated from the NRCS reference (USDA, 1992) for beef feedlot manure from an unsurfaced lot, and were well below NRCS projections. These data indicated an average 0.14 lb N/head/day and 0.066 lb P/head/day in harvested manure. This compared to values of 0.21 lb N/head/day and 0.137 lb P/head/day in manure nutrients calculated from the 1992 NRCS reference for the same average weight animal (980 lb) fed over the 123 days.

Although the average 0.39% P concentration (Table 1) of the diets fed in this study was higher than a conventional corn-based diet, the quantity of P removed (lb/head/day) in the manure harvested in these feedlots was 50% less than the amount obtained from calculation based on the 1992 NRCS reference for comparable weight animals.

These data suggest estimates based on the current NRCS reference (USDA, 1992) of P removed in manure are too high, and indicate acres required for distribution of manure P in NMPs should be 50% of the acres predicted by the NRCS reference. The characteristic and quantitative summary values of the feedlot manure harvested from these Nebraska feedlots are a significant improvement over existing standard values currently used in nutrient planning processes by producers, regulators, and planners.

---

[1]Author wishes to express appreciation to the six cooperating Nebraska beef feedlot operations which graciously agreed to assist with this study. Without the supreme efforts and cooperation of the talented and professional staff members of each of these feeding operations, these meaningful data could not have been gathered, and this research project would have been impossible to accomplish. The cooperating feedlots in this Phosphorus Management in Beef Feedlot Operations study deserving of recognition are:

Briggs Feed Yard, Seward, Neb.
Circle Five Beef, Inc., Henderson, Neb.
Drinnin Feedlots Inc., Columbus, Neb.
Feller & Co. Cattle Feeders, Wisner, Neb.
Midwest Feeding Co., Milford, Neb.
Wisner Feedlot, Inc., Wisner, Neb.

[2]William F. Kissinger, graduate student, Mechanized Systems Management; Galen E. Erickson, assistant professor, Terry J. Klopfenstein, professor, Animal Science; Richard K. Koelsch, associate professor, Biological Systems Engineering and Animal Science, Lincoln.

Economics of Manure Phosphorus Distribution from Beef Feeding Operations

William F. Kissinger
Ray E. Massey
Rick K. Koelsch
Galen E. Erickson[1]

Summary

An economic model was developed to evaluate cost and value of manure distribution. A 2,500 head feedlot was used as a case study to calculate excretion amounts from cattle fed diets with a range of phosphorus. Diet P and subsequent costs of distributing that manure were used to analyze the corresponding costs of manure P distribution, in addition to determining the required acres needed to be in compliance with a nutrient management plan (NMP) based on use of manure P by the crops grown. The model illustrated when animals are fed diets of increasing P concentration, total distribution cost increased, ranging from $2.80 - $5.10/head finished/year, but the agronomic and market value of manure produced increased at a rate faster than the rate of increasing costs of distribution for a small feedlot.

Introduction

Implementation of P management, as required by environmental regulation, will continue to present unique challenges to beef feedlots. Recent work (*2006 Nebraska Beef Cattle Report*, pp 94-97) suggests the amount of P harvested in manure from beef feedlots varies with 1) level of P in the diets 2) individual pen conditions prior to and at time of manure harvesting, and 3) requirements for use of manure solids for surface maintenance prior to harvesting. These data indicated a positive correlation between P intake and P in harvested manure in beef feeding operations. In addition, previous data (*2005 Nebraska Beef Cattle Report*, pp51-53.) suggested P excretion is positively correlated to P intake. It is important that correct estimates of P excretion are used by producers if NMPs are based on use of manure P.

Costs of manure P transport and distribution are critical information, but information is limited. The savings from least cost rations based on a corn processing by-product may be offset by the additional cost of handling manure P. An economic model that reflects P excretion from P intake and retention for individual operations can assist in development of NMPs for feedlots. Thus, the important objective of our project was to develop an economic analysis for proper distribution of manure P relative to dietary P and agronomic use in various crop rotations.

Procedure

Software Model Development

An economic model was developed to calculate nutrient excretion amounts from cattle fed diets with a variable range of P, and analyze the corresponding costs of manure P distribution. Software development incorporated appropriate features from existing models, previously developed by researchers at University of Nebraska and University of Missouri, for calculation of nutrient excretion amounts and analysis of manure distribution cost, respectively.

Equations used in the model were based upon the revised ASAE Standard D384.2, Manure Production and Characteristics. Nutrient intake was calculated using dietary nutrient concentration of each diet fed multiplied by DMI. Cattle nutrient retention was calculated according to the retained energy and protein equations established by the National Research Council (1996) for beef cattle. Equations used for beef excretion characteristics were based upon a calculation of dietary intake minus animal retention, the approach used by the ASAE nutrient excretion standard.

Model Data Input Variables

The software is designed to have flexibility of application of input variables. Table 1 shows values assumed in the model as constants, which can be changed if desired. The model allows the user to enter farm specific information such as average starting and finishing weights, average days on feed, feedlot capacity and turns of cattle/year; diet nutrient concentration; manure handling equipment values and capacities utilizing truck or tractor spreading equipment; fuel prices, fertilizer nutrient market values; loading time, travel speed, and spreading calibrations; various crop rotations; and, land available for distribution of manure nutrients, distance from the feeding operation, and crop removal rates of nutrients based upon crop and yield.

Case Study Feedlot Scenario

A case study was designed to help define the economic issues associated with feeding dietary P, and the costs of distributing manure on a P basis. In our case study, a theoretical 2,500 head one-time capacity feedlot, averaging 750 lb in weight and 1250 lb finish weight in 153 days, with two turns of cattle per year, was used to quantify the manure and nutrients harvested from cattle fed various combinations of diet P and CP. Multiple situational scenarios were identified for analysis of the economics of distribution of manure P harvested from cattle fed diets with a range from 0.29-0.49 % P (DM basis), illustrating a range from a corn and forage base diet, to diets with 10%, 20%, 30%, and 40% corn replacement with by-product from ethanol production. Analyses were performed increasing the diet % CP and % P concurrently as by-product % increased. In addition, scenarios were developed for 2- and 4-year application rates for P with various CP and diet P levels. All of these

Table 1. Case study comparison model data input assumed values (constants).

Initial BW, lb		750
Finish BW, lb		1250
Average days fed		153
Average DMI, lb		22.5
% of excreted N available after losses in pen		40%
% of excreted P available after losses in pen		95%
Wet manure, lb/head/d		15.9
NH_4-N:Total N		1:5
Nutrient availability		
NH_4-N	Continuous corn:	0%
Organic N	Continuous corn:	50%
Organic N	Corn-Soybeans	32%
Annual crop removal, lbs P_2O_5 (lbs P)		
185 bu. corn harvested for grain		83 lb (36 lb)
50 bu. soybeans		44 lb (19 lb)
Fertilizer market value, $/lb		
N		$0.19
P_2O_5		$0.26
Ownership and Operating Costs		
Tractor (160 hp) and spreader		$107,000
Years to replace		10 years
Salvage value		$34,000
Fuel		$1.50/gal
Labor		$10.00/hr
Interest (%/year)		8%
Insurance (%/year)		1%
Road speed		10 mph
Field speed		5 mph
Spreader capacity		16 ton
Swath width		12 feet

variables were compared for continuous corn (CC) and corn-soybean (C-SB) crop rotations to analyze the crop rotation effect.

Manure Nutrient Concentration

Based on the average values from previous studies (*2006 Nebraska Beef Cattle Report,* pp. 94-97*),* the model calculates annual manure production, and after accounting for open lot or feedlot scraped or stockpiled storage losses, manure nutrient concentration is determined.

Crop Removal Value of Manure Nutrients

With the total N, P_2O_5, and K_2O lb/ton of manure determined, the manure application rate is calculated based upon the nutrient use of the desired crop in the specified rotation. In this study, for total N, the NH_4-N to organic N ratio was set at 0.20:0.80, and it was assumed that no NH_4-N would be available to the crop. The reasoning was the assumption, in most cases the manure would not be incorporated soon after surface application and any remaining NH_4-N would be lost. Fifty percent of the organic N is credited for crop use for continuous corn and 32% for corn-soybeans. The model has the flexibility to determine manure application rates, on either P basis or N basis, as a function of nutrient concentration of the manure and nutrient removal rates (Table 1) for the specific crop yield of the specific crop grown. No nitrogen credit was given when applied to legumes; the only N value was credited for removal by growing corn.

Spreadable Acres Needed

The spreadable acres needed to use the annual manure produced were calculated from the annual manure produced divided by the average manure application rate for the rotation crops. This information is needed in a NMP. The model did not incorporate the cost of additional land ownership, or expenses related to control of added land for manure distribution.

Average Distance to Fields

For simplicity, the assumption in this case study was that all land nearby the feeding operation was available for manure application. Thus, the average distance to fields is relatively low in the scenarios investigated. In reality, this may not be the case, but the model has the capability to adapt to individual field locations available for manure application for each individual feedlot. Likely, at most, only half the land would be available. This is easy to adjust in the model by increasing the average distance to fields variable. Doing so will increase the costs of distribution, and the results will be more conservative.

Equipment Ownership and Operating Costs

The model tracts the equipment ownership and operating costs (Table 1) relative to value of the tractor(s), or truck chassis(s), and spreader(s), years to replace, salvage value, depreciation, interest, insurance, repair, and costs of fuel and labor. In addition, equipment capacities and swath width, road travel time, field travel time, total loaded miles, and total road miles are variables which affect costs of transporting and distributing manure.

Costs of Distribution: Costs of Transporting and Spreading Manure

When the farm specific amount of manure P has been established for the individual diet P concentration used in an individual beef feedlot, and the equipment ownership and operating costs have been determined, the model is intended to be used by feedlot operators to estimate the cost of distributing the resultant manure P on land. For individual feeding operations, the costs of scraping the pens, storage, and loading the manure remain constant, regardless the P concentration in the manure. Thus, those costs were not included in this study and this model. As the manure P concentration varies, the other variables in the model are distance required to transport the manure, and the necessary spreading of the manure to be in compliance with a NMP based on use of manure P by the crops grown. In this model, cost of transport plus

(Continued on next page)

Table 2. Case study comparison of manure P distribution economics (annual basis) with various scenarios of diet percentage P and percentage CP levels for continuous corn (harvested as grain) and corn-soybeans on two year P manure application basis.[a]

Manure applied on:	Two-year P basis									
Phosphorus % in diet (DM basis)	0.29	0.34	0.39	0.44	0.49	0.29	0.34	0.39	0.44	0.49
Crude protein % in diet (DM basis)	13.00	13.60	15.30	16.90	18.70	13.00	13.60	15.30	16.90	18.70
Cropping system / Results	Continuous corn					Corn-soybeans				
Spreadable acres in fields	500	620	730	840	950	660	810	950	1100	1250
Average distance to fields (mile)	0.18	0.24	0.28	0.31	0.33	0.26	0.30	0.33	0.42	0.49
Manure application rate (ton/A)	12.0	9.8	8.3	7.2	6.4	9.2	7.5	6.4	5.5	4.9
Total application time (hours)	230	260	300	330	360	280	320	360	410	450
Total cost of distribution	$16,800	$18,200	19,500	$20,700	$21,900	$18,700	$20,300	$21,900	$23,600	$25,300
Total fertilizer value of manure	$31,300	$36,600	42,900	49,100	$55,500	$27,900	$33,000	$38,800	$44,500	$50,400
Fertilizer value of manure ($/ton)	$5.20	$6.00	$7.10	$8.10	$9.20	$4.60	$5.50	$6.40	$7.40	$8.30
Cost per animal finished per year	$3.40	$3.60	$3.90	$4.10	$4.40	$3.70	$4.10	$4.40	$4.70	$5.10
Net manure value[b]	$14,400	$18,400	$23,500	$28,400	$33,600	$9,000	$12,700	$16,900	$20,900	$25,100
Net manure value/head finished[c]	$2.90	$3.70	$4.70	$5.70	$6.70	$1.80	$2.50	$3.40	$4.20	$5.00

[a]Comparisons are for annual manure production of 6,000 tons from case study 2,500 head one time capacity cattle feedlot with open dirt pens, 5,000 head annual production.
[b]Net manure value = fertilizer value of manure minus total cost of distribution on fields for various crops.
[c]Net manure value/head finished = fertilizer value of manure minus total cost of distribution divided by annually finished animals.

cost of spreading, together are defined as cost of distribution. The output is the variation in cost of distribution of manure P as a result of variation in diet P concentration. The value of the manure minus the cost of distribution equals the net manure value, as a function of diet P concentration. In addition, the cost of distribution per animal fed annually is determined.

Results

In all scenarios in this case study (Tables 2 - 4), as the spreadable P manure concentration increased as a result of increased diet P concentration, the manure application rate decreased and the spreadable acres required for all crop rotations increased. Correspondingly, the total application time and average distance to the fields increased as diet P concentration increased. The downside of these factors was the resultant increase in total cost to distribute the manure. This ranged from a low cost (Table 3) of $14,000 for the four-year continuous corn scenario with 0% by-product to a high cost (Table 2) of

Table 3. Case study comparison of manure P distribution economics (annual basis) with various scenarios of diet percentage P and percentage CP levels for continuous corn (harvested as grain) on four year P manure application basis.[a]

Manure applied on:	Four-year P basis				
Phosphorus % in diet (DM basis)	0.29	0.34	0.39	0.44	0.49
Crude protein % in diet (DM basis)	13.0	13.60	15.30	16.90	18.70
Cropping system / Results	Continuous corn				
Spreadable acres in fields	250	310	360	420	480
Average distance to fields (mile)	0.18	0.24	0.28	0.31	0.33
Manure application rate (ton/A)	24.1	19.7	16.7	14.4	12.7
Total application time (hours)	160	180	200	210	230
Total cost of distribution	$14,000	$14,800	$15,500	$16,300	$17,000
Total fertilizer value of manure	$29,800	$36,400	$42,900	$49,100	$55,500
Fertilizer value of manure ($/ton)	$4.90	$6.00	$7.10	$8.10	$9.20
Cost per animal finished per year	$2.80	$3.00	$3.10	$3.30	$3.40
Net manure value[b]	$15,800	$21,600	$27,400	$32,900	$38,500
Net manure value/head finished[c]	$3.20	$4.30	$5.50	$6.60	$7.70

[a]Comparisons are for annual manure production of 6,000 tons from case study 2,500 head one time capacity cattle feedlot with open dirt pens, 5,000 head annual production.
[b]Net manure value = fertilizer value of manure minus total cost of distribution on fields for various crops.
[c]Net manure value/head finished = (fertilizer value of manure minus total cost of distribution)/ annually finished animals.

Table 4. Case study comparison of manure P distribution economics (annual basis) with various scenarios of diet percentage P and percentage CP levels for corn-soybeans on four year P manure application basis.[a]

Manure applied on:	----------Four-year P basis----------				
Phosphorus % in diet (DM basis)	0.29	0.34	0.39	0.44	0.49
Crude protein % in diet (DM basis)	13.00	13.60	15.30	16.90	18.70
Cropping system / Results	Corn-soybeans				
Spreadable acres in fields	330	400	480	550	620
Average distance to fields (mile)	0.26	0.30	0.33	0.42	0.49
Manure application rate (ton/A)	18.4	15.0	12.7	11.0	9.7
Total application time (hours)	190	210	230	260	280
Total cost of distribution	$15,100	$16,000	$17,000	$18,000	$19,000
Total fertilizer value of manure	$27,800	$33,000	$38,800	$44,500	$50,400
Fertilizer value of manure ($/ton)	$4.60	$5.50	$6.40	$7.40	$8.30
Cost per animal finished per year	$3.00	$3.20	$3.40	$3.60	$3.80
Net manure value[b]	$12,700	$17,000	$21,800	$26,600	$31,400
Net manure value/head finished[c]	$2.60	$3.40	$4.40	$5.30	$6.30

[a]Comparisons are for annual manure production of 6,000 tons from case study 2,500 head one time capacity cattle feedlot with open dirt pens, 5,000 head annual production.
[b]Net manure value = fertilizer value of manure minus total cost of distribution on fields for various crops.
[c]Net manure value/head finished = fertilizer value of manure minus total cost of distribution divided by annually finished animals.

Table 5. Case study comparison of annual total fertilizer value[a] with selected diets (increasing CP and P concentrations), crops, and basis of P manure application.[b]

		Continuous corn		C-SB	
Base Scenarios:		P2[c]	P4[d]	P2[c]	P4[d]
0% By-product	13.0 % CP, 0.29% P	$31,300	$29,800	$27,900	$27,800
10% By-product	13.6 % CP, 0.34% P	$36,600	$36,400	$33,000	$33,000
20% By-product	15.3 % CP, 0.39% P	$42,900	$42,900	$38,800	$38,800
30% By-product	16.9 % CP, 0.44% P	$49,100	$49,100	$44,500	$44,500
40% By-product	18.7 % CP, 0.49% P	$55,500	$55,500	$50,400	$50,400

[a]Total fertilizer value = total fertilizer N and P_2O_5 market value of manure.
[b]Comparisons are for annual manure production of 6,000 tons from case study 2,500 head one time capacity cattle feedlot with open dirt pens, 5,000 head annual production.
[c]P2 = Phosphorus application rate for two years' crop use.
[d]P4 = Phosphorus application rate for four years' crop use.

Table 6. Case study comparison of annual P value[a] with selected diets (increasing CP and P concentrations), crops, and basis of P manure application.[b]

		Continuous Corn		C-SB	
Base Scenarios:		P2[c]	P4[d]	P2[c]	P4[d]
0% By-product	13.0 % CP, 0.29% P	$21,800	$21,800	$21,800	$21,800
10% By-product	13.6 % CP, 0.34% P	$26,700	$26,700	$26,700	$26,700
20% By-product	15.3 % CP, 0.39% P	$31,500	$31,500	$31,500	$31,500
30% By-product	16.9 % CP, 0.44% P	$36,400	$36,400	$36,400	$36,400
40% By-product	18.7 % CP, 0.49% P	$41,300	$41,300	$41,300	$41,300

[a]Annual P value = Total P value to the crop per year by application basis.
[b]Comparisons are for annual manure production of 6,000 tons from case study 2,500 head one time capacity cattle feedlot with open dirt pens, 5,000 head annual production.
[c]P2 = Phosphorus application rate for two years' crop use.
[d]P4 = Phosphorus application rate for four years' crop use.

$25,100 for the two-year corn-soybean rotation with 40% by-product in the diet. A feedlot will need to have access to increased land (up to 90%) and additional labor (increase by 45 to 65%) to meet the increased requirements for manure application to manage the additional P. On the positive side, high P diet increased the fertilizer value of manure faster than it increased the cost of distribution. In the case study scenarios in this report, the annual net market value of manure (Table 7) increased in all cases as the P concentration of the diet increased.

Tables 5 and 6 summarized the comparison of annual total fertilizer value and phosphorus value, respectively, by crop and variation in diet CP and P. There is little difference in fertilizer values when comparing 2-year to 4-year P application rates. Likewise, the cost comparison between 2-year and 4-year P application rates change a little, but not a lot, with slightly more expense in the 2-year than the 4-year. The surprise is the increase in net manure value as the diet P concentration increases.

An interesting bench mark is the cost per animal finished per year, calculated as total cost of distribution divided by total animals finished per year (Tables 2 - 4). These values ranged from $2.80/head finished/year in Table 3 for continuous corn with 0.29% P and 4-year P rate, to a high value of $5.10/head finished/year in Table 2 for C-SB at 0.49% P and 2-year P basis application rate.

Another interesting perspective is to compare these scenarios on the basis of net value of manure per animal finished per year. If a true fertilizer market value is placed on the manure and the cost of distribution of the manure is evaluated, then the net manure value per head can be determined by the model. For instance, from the case study data (Table 2 - 4), this value calculated from a low of $2.60/head (Table 4) to a high of $7.70/head (Table 3) for net manure value per annually finished animal.

(Continued on next page)

In conclusion, the model illustrated that when animals are fed diets of increasing P concentration, there are positive and negative aspects. On the downside, there was an increase in application time (Tables 2 - 4) and required spreadable acres (Table 8) receiving the increasing P manure concentrations, due to the decreasing rates of manure application. On the upside, the agronomic and market value of manure produced increased at a rate faster than the rate of increasing costs of distribution. This has a potential positive implication to the beef cattle industry, with the 2500 capacity feedlot in this study. Further scenarios need to be investigated with different sized feedlots, and available fields for manure distribution at much greater distances from the feedlot. This model has the ability to investigate such individual feedlot situations.

The observed benefits of feeding higher rates of distiller by-products can be applied only to the following situations until further investigation is completed:

1. Feedlots with 2,500 head capacity or less
2. Feedlots with access to 100% of the land closest to the animal housing
3. Feedlots where manure is applied at a P-based rate only.

In this case study, from the perspective of cost of distribution/head finished/year, lower diet P concentration is better than higher diet P values. However, due to the fertilizer value, increased diet P results in higher manure value. This higher manure value offsets the distribution cost by a range of $2.60/head to $7.70/head finished annually in the scenarios studied in this model. As higher diet P concentrations from feeding increasing amounts of by-products from ethanol production result in higher manure P concentrations, it is potentially beneficial to distribute the higher value manure in compliance with the nutrient management plan.

Table 7. Case study comparison of annual net manure value[a] with selected diets (increasing CP and P concentrations), crops, and basis of P manure application.[b]

		Continuous Corn		C-SB	
Base Scenarios:		P2[c]	P4[d]	P2[c]	P4[d]
0% By-product	13.0% CP, 0.29% P	$14,400	$15,800	$ 9,200	$12,700
10% By-product	13.6% CP, 0.34% P	$18,400	$21,600	$12,700	$17,000
20% By-product	15.3% CP, 0.39% P	$23,500	$27,400	$16,900	$21,800
30% By-product	16.9% CP, 0.44% P	$28,400	$32,900	$20,900	$26,600
40% By-product	18.7% CP, 0.49% P	$33,600	$38,500	$25,100	$31,400

[a]Net manure value = (total fertilizer N and P_2O_5 market value of manure) minus total cost of distribution on fields for various crops.
[b]Comparisons are for annual manure production of 6,000 tons from case study 2,500 head one time capacity cattle feedlot with open dirt pens, 5,000 head annual production.
[c]P2 = Phosphorus application rate for two years' crop use.
[d]P4 = Phosphorus application rate for four years' crop use.

Table 8. Case study comparison of total acres needed in a four-year planning horizon[a] with selected diets (increasing CP and P concentrations), crops, and basis of P manure application.[b]

		Continuous Corn		C-SB	
Base Scenarios:		P2[c]	P4[d]	P2[c]	P4[d]
0% By-product	13.0 % CP, 0.29% P	1000	1000	1320	1320
10% By-product	13.6 % CP, 0.34% P	1240	1240	1600	1600
20% By-product	15.3 % CP, 0.39% P	1460	1460	1900	1900
30% By-product	16.9 % CP, 0.44% P	1680	1680	2200	2200
40% By-product	18.7 % CP, 0.49% P	1900	1900	2500	2500

[a]Total acres needed = annual acres multiplied by the number of years in the application rate limit.
[b]Comparisons are for annual manure production of 6,000 tons from case study 2,500 head one time capacity cattle feedlot with open dirt pens, 5,000 head annual production.
[c]P2 = Phosphorus application rate for two years' crop use.
[d]P4 = Phosphorus application rate for four years' crop use.

[1]William F. Kissinger, graduate student, Mechanized Systems Management; Galen E. Erickson, assistant professor, Animal Science; Richard K. Koelsch, associate professor, Biological Systems Engineering and Animal Science, Lincoln; Raymond E. Massey, associate professor, Agricultural Economics, University of Missouri, Columbia.

Valuing Feedyard Management Education, Experience, and Expertise

Rik R. Smith
Darrell R. Mark[1]

Summary

This study uses a mail survey to determine the value Nebraska feedyard operators place on education, experience, and area of expertise in new assistant manager hires. Using conjoint analysis, calculations are made that estimate the marginal value of moving from one level of these attributes to another. Results show that operators preferred higher levels of education and experience. However, relevant experience was preferred over formal education. As an area of expertise, animal health was valued highest by operators of feedyards in all size categories for new assistant managers. Personnel management was valued lowest. Results suggest prospective assistant managers can maximize starting salary by gaining moderate levels of education and experience with an expertise in animal health.

Introduction

An individual feedyard must balance the need to attract quality labor through competitive wages with the need to keep labor costs low and the operation profitable. Average salary and compensation levels across Nebraska feedyards indicate that labor costs continue to increase substantially (University of Nebraska– Lincoln Extension Circular EC04-836, *Nebraska Feedyard Labor Cost Benchmarks and Historical Trends,* Smith, R. R., and D. R. Mark). A better understanding of the value placed on employee characteristics such as experience and education levels or an area of expertise will help employers set salary or wage levels appropriate to the skills they seek. Additionally, by understanding the value of skills possessed by potential new employees, employers could better recognize valuable attributes of job candidates and fit them to available positions in their operation. Further, knowing the value that agricultural employers place on job experience, educational training, and other employee characteristics can enable potential employees to seek positions for which they are best qualified and allow them to target their training and experience to gain employment in particular positions in agricultural operations. People seeking a position as an assistant manager in a feedyard will have a better understanding of the traits and characteristics operators are looking for in new hires so they can target their training and education for an assistant manager position. This study estimates the value that cattle feedyard managers place on education, experience, and expertise for new assistant managers.

Procedure

In March 2004, surveys were mailed to 198 feedyard operators across Nebraska followed by a second mailing two weeks later. Feedyards surveyed ranged in size from less than 1,000 head (one-time capacity) to over 50,000 head and were selected from Nebraska Cattlemen's commercial cattle feeders list. In addition to questions about feedyard demographics and other general questions, respondents were presented a hypothetical situation in which they were asked to consider 16 candidates for an assistant manager position in their feedyards. The hypothetical question was designed to determine feedyard operators' preference for assistant manager attributes. The hypothetical candidates in the experimental question were considered exactly alike except for four areasCEducation, Experience, Area of Expertise, and the Salary necessary to hire them. There were four possible levels or areas for each attribute, which are listed in Table 1. Because there are 256 possible combinations of candidates using the four levels of the four attributes, a reduced-form design was used to select 16 candidates with unique combinations of the attributes (no candidates had the same combination of any two given levels of attributes).

Table 1. Assistant manager candidate attributes and attribute levels.

Attribute	Level
Education	High school
	Some college, no degree
	Two-year degree
	Four-year degree
Experience	No experience
	< 2 years experience
	2-4 years experience
	>4 years experience
Expertise	Nutrition
	Animal health
	Ag Econ/Marketing
	Personnel Management
Salary	$18,000
	$24,000
	$30,000
	$36,000

The respondents were asked to rank each candidate from 1 to 7 to represent their likelihood of hiring each candidate. A response of 1 indicated the respondent was very unlikely and 7 very likely to hire each candidate. These rankings were then used as a measure of satisfaction that the survey respondent (feedyard operator) placed on each hypothetical candidate. The satisfaction measure for each candidate was then modeled as a function of the education, experience, expertise, and salary requirement attributes that candidate possesses. Ordinary least squares regression was then used to estimate parameters of the model for each attribute level. Additionally, using conjoint analysis and the parameters from this satisfaction model estimated with ordinary least squares regression, dollar values were calculated for

(Continued on next page)

Table 2. Valuation of assistant manager candidate attributes by feedyard operators.

Value of	Relative To	All Yards	Feedlot Capacity: Over 12,000	Feedlot Capacity: 4,000-12,000	Feedlot Capacity: Under 4,000
Some college, no degree	High school	$6,383	$10,500	-$837	$12,676
Two-year degree	Some college, no degree	$16,364	$5,250	$24,837	$16,056
Four-year degree	Two-year degree	$17,176	$22,500	$23,442	$1,690
< 2 years experience	No experience	$32,959	$31,500	$42,419	$20,282
2-4 years experience	< 2 years experience	$23,095	$16,500	$38,233	$7,606
>4 years experience	2-4 years experience	$14,971	$9,000	$27,628	$2,535
Animal health	Nutrition	$9,632	$6,000	$15,907	$4,225
Ag Econ/Marketing	Animal health	-$12,418	-$14,250	-$9,767	-$14,366
Personnel management	Ag Econ/Marketing	-$12,070	-$3,000	-$22,326	-$6,761

the various levels of each attribute. These represent the marginal value of switching between levels of a given attribute. In other words, it is possible to determine how much it is worth as a potential assistant manager to have a four-year college education relative to a two-year college education. Similarly, feedyard managers can determine how much more they will have to pay a new assistant manager with a four-year degree relative to a two-year degree. This is known as the compensating variation or willingness to pay (WTP) to switch between levels of a particular attribute.

Results

Fifty-nine usable surveys from the 198 distributed were returned for a response rate of 29.8%. The average feedyard responding had a maximum capacity of 9,473 head with a current on-feed inventory of 7,699 head and an annual inventory turnover of 2.26 times per year. This resulted in approximately 17,400 head marketed per year for the average feedyard (based on on-feed inventory). The average feedyard had a total annual labor expense of $354,822 including salaries, benefits, and bonuses. Based on this total labor expenditure, average labor cost per headday produced was about $0.10. Additional results are available in Smith and Mark.

The parameters estimated using ordinary least squares regression for the different attribute levels were statistically significant at the 0.10 level or better. These parameters were then used to calculate feedyard managers' WTP for the various attributes, which are listed in Table 2. The results are reported for all feedyards surveyed and are also grouped according to feedyard size. The values represent a salary tradeoff between the job candidate attributes and salary requirement (minimum salary necessary to hire that candidate) and can be interpreted in one of two equivalent ways (Smith, R. R. "An Evaluation of Feedyard Management Training and Experience." American Journal of Agricultural Economics 86(Number 5, 2004):1377-1383). First, the values represent how much more a feedyard operator would be willing to pay a candidate with attribute X_2 relative to X_1 (assuming attribute X_2 is more valuable than attribute X_1). Alternatively, a manager would only hire a candidate with attribute X_1 if the salary was lower than the salary of the candidate with attribute X_2 by the value in Table 2. For example, the first row of Table 2 indicates a feedyard operator would pay an assistant manager candidate with some college but no degree $6,383 more than a candidate with a high school diploma, everything else equal. The alternative interpretation is that the feedyard manager would hire the candidate with the high school education instead of the candidate with some college but no degree if the salary for the former candidate was $6,383 lower than for the latter. The values are also additive within the same attribute category. For example, managers would be willing to pay a candidate with a two-year degree $22,747 ($6,383 + $16,364) more than a candidate with a high school education.

Based on Table 2, feedyard managers appeared to place relatively more importance on experience than education in hiring assistant managers. They would pay a candidate with less than two years of experience $32,959 more than a candidate with no experience. This implies a strong tendency against hiring assistant managers with no experience. As an area of expertise, animal health had the highest value to feedyard managers relative to nutrition, marketing, or human resource management. This supports the idea that assistant managers are most involved in production phases of feedyard management rather than marketing or personnel decisions.

The WTP values met expectations and were fairly intuitive. Based on average salaries reported in Smith and Mark, the WTP values may appear somewhat overstated. Essentially, high WTP values can be viewed as penalties to candidates *not* having a certain attribute. In other words, there is a strong disincentive for hiring the candidate without the attribute having a high WTP. More interesting is the relative magnitudes both within a given attribute and between different attributes or different sizes of feedyards. For example, the largest WTP for experience was from no experience to less than two years. After that, the marginal value decreased for each increase in experience. This pattern held across all sizes of feedyards.

The education attribute showed some variation for feedyards of various sizes. Across all feedyard sizes, operators placed the highest value on a four-year degree. However, operators at feedyards under 4,000 head placed relatively low marginal value on a four-year degree relative to a two-year degree ($1,690) than did operators at feedyards with capacity of 4,000 to 12,000 and over 12,000 head ($23,442 and $22,500 respectively).

Within the expertise category, animal health was valued highest by feedyard operators in all size categories. While personnel management had the lowest value for operators in all size categories, operators of feedyards over 12,000 head placed relatively more value on personnel management than did operators at smaller size feedyards. This result was somewhat intuitive considering larger feedyards have more employees to manage.

One important point to consider in interpreting these size-based results is that in answering the hypothetical question, respondents were not given a job description as to what responsibilities the new assistant manager would have. This left the perceived role of an assistant manager up to the interpretation of the individual respondents. Therefore, it is quite likely that a respondent at a feedyard of 50,000 head would have different expectations for an assistant manager than a respondent at a feedyard of less than 4,000 head. The variation observed in WTP calculations for feedyards of different sizes, particularly for the expertise variable, can be attributed, at least partially, to the different job expectations respondents would have for an assistant manager at their feedyards.

Implications

The results of this study are important in quantifying the value feedyard operators place on education, experience, and expertise in potential assistant manager hires. The values can be used by feedyard operators when structuring salary differentials to offer competitive salaries to qualified candidates while discounting salaries for those candidates possessing attributes with lower value. Further, individuals interested in a career in feedyard management can use the results to determine how to best position themselves in order to maximize starting salaries. A good program for doing so may involve a college degree in animal science or animal health with time spent doing internships and working at feedyards to gain valuable experience. Results suggest programs that offer a mix of formal education and relevant experience in animal health may have an advantage in producing students who are well suited to the needs of Nebraska feedyard operators.

---

[1]Rik R. Smith, extension assistant, and Darrell R. Mark, assistant professor, Agricultural Economics, Lincoln.

Alternative Enhancement Strategies for Beef Muscles

Donald A. Moss
Chris R. Calkins[1]

Summary

USDA Select grade semitendinosus (eye of round) muscles from 12 cattle were used for controls (non-enhanced); salt and phosphate enhanced; water enhanced, or enhanced by addition of 10% of a solution containing 1, 3, or 5% sodium citrate to evaluate the effect of citrate on meat tenderness. Shear force and trained taste panel ratings were not different, ($P > 0.05$) between controls and citrate-treated muscles. Less than half of the enhancement solution was retained by the muscle. Perhaps the high connective tissue content of the semitendinosus or poor retention of the enhancement solution contributed to these results, which are in conflict with our previous research using other muscles.

Introduction

A wholesome, full-flavored, consistently tender piece of beef is of the utmost importance to consumers when a beef purchase is made. Consumers are willing to pay a premium for meat that is guaranteed tender. 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 prerigor with water were less tender than control samples while those injected prerigor with 200 and 400 mM sodium citrate, a glycolytic inhibitor, improved tenderness over the controls. This earlier research focused on prerigor beef muscles. Thus, the current study was conducted to determine the effect of a postrigor injection of sodium citrate on beef muscle tenderness.

Procedure

Meat

Select-grade semitendinosus muscles from 12 cattle were obtained and assigned randomly to one of four replications. Muscles in each replication were then split in half and assigned randomly to one of six treatments: 1) untreated, 2) enhanced by addition of 10% of muscle weight with water, 3) enhanced by addition of 10% of muscle weight with a solution containing water, 0.3% salt and 0.3% phosphate solution, 4) enhanced by addition of 10% of muscle weight with a solution containing water and 1.0% sodium citrate solution 5) enhanced by addition of 10% of muscle weight with a solution containing water and 3.0% sodium citrate solution, 6) enhanced by addition of 10% of muscle weight with solution containing water and 5.0% sodium citrate solution. Injection of water and solution was done by hand throughout the semitendinosus using a single-needle ham injection unit. Once injected, the muscles were vacuum packed and tumbled for 20 minutes. After allowing 24 hours for enhancement equilibration, muscles were removed from their package and weighed to determine the percentage pick-up of the enhancement. The semitendinosus muscles were cut in half and randomly assigned an aging period of 1 or 7 days. After aging at 38°F postinjection, three 1-inch thick steaks were removed in succession from each muscle and frozen. The first (counting from the cut surface) was designated for Warner-Bratzler shear force determination and the second and third were delegated for trained panel evaluation of tenderness, connective tissue, juiciness, and off-flavor intensity.

Warner-Bratzler Shear Force

A 1-inch thick steak from each muscle was broiled on a tabletop broiler to a final internal temperature of 160°F. Temperature was monitored at the geometric center of each steak using a thermocouple thermometer. Cooked steaks were chilled 24 hours at 38°F, 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 Universal Testing Machine with a Warner-Bratzler attachment and a 250 mm/min crosshead speed.

Objective Color

A 1-inch thick steak from each muscle was cut and allowed to oxygenate (bloom) for 1 hour. Objective color [L* (measure of lightness), a* (measure of red), and b* (measure of yellow)] was measured with Illuminant D65 using a Hunter Lab Mini Scan XE Plus colorimeter with a 1-inch port.

Trained Taste Panel

A 1-inch thick steak from each muscle was broiled on a tabletop broiler to a final internal temperature of 160°F. Temperature was monitored at the geometric center of each steak using a thermocouple thermometer. Steaks were then cut into 0.5 in x 0.5 in portions and placed in a double boiler to maintain temperature. The panel was specifically trained for evaluating tenderness, connective tissue, and juiciness. The panel was also asked to note any off-flavors, if present. The panelists received six randomly-assigned samples a day, plus an initial "warm-up" sample to begin each panel.

Statistical Analysis

Data were analyzed using the GLM procedures of SAS in a 6 x 2 factorial randomized complete block design.

Table 1. Effect of treatments on shear force values (lb), and sensory traits.[a]

Treatment	WBSF[b]	Juiciness	Tenderness	Connective Tissue	Saltiness	Off-Flavor Intensity
Control	8.66	4.97	6.02	5.25	5.69	5.53
Control with water	7.92	5.11	6.16	5.48	5.89	6.05
0.3% Salt/ 0.3% phosphate	8.17	5.22	6.17	5.49	5.66	5.89
1% Sodium citrate	8.97	5.09	6.03	5.00	6.04	5.92
3% Sodium citrate	8.95	5.05	5.97	5.02	5.85	5.83
5% Sodium citrate	8.02	5.19	6.25	5.39	6.07	5.94
SEM	0.43	0.19	0.17	0.22	0.19	0.18

[a]Evaluated on 8-point rating scale where 1= extremely dry, extremely tough, extreme amount of connective tissue, extremely salty, and extremely off-flavored and 8 = extremely juicy, extremely tender, no connective tissue, no salt, no off-flavor.
[b]Warner-Bratzler Shear Force.

Table 2. Pump percentage and 24 hour enhancement retention.

Treatment	Pump percentage	Solution retention percentage[a]
Control	0.00	0.00
Control with water	10.23	29.43
0.3% Salt/0.3% phosphate	10.10	27.54
1% Sodium citrate	10.10	41.15
3% Sodium citrate	10.03	37.95
5% Sodium citrate	10.00	38.11
Standard Error	0.04	6.58

[a] Means after 24 hours.

Table 3. Percentage of panelists detecting the presence of specific off-flavor notes.

Treatment	Liver	Sour	Metallic	Bitter	Oxidized	Rancid
Control	6.94	31.94	8.33	4.17	1.39	5.56
Control with water	0.00	31.94	11.11	0.00	4.17	0.00
0.3% Salt/ 0.3% phosphate	2.78	33.33	9.72	0.00	4.17	1.39
1% Sodium citrate	0.00	34.72	6.94	0.00	5.56	0.00
3% Sodium citrate	4.17	27.78	11.11	2.78	1.39	2.78
5% Sodium citrate	5.56	25.00	8.33	5.56	5.56	0.00
SEM	2.70	4.07	3.01	1.68	1.91	1.63

The model included the main effects of replication, treatment, aging, and treatment x aging.

Results

There were no differences due to aging time or aging by treatment for any of the traits measured ($P > 0.05$). Connective tissue shows little if any response to aging. It's likely the high connective tissue and elastin content of the semitendinosus account for this lack of aging effect.

Panelists were unable to detect any differences among the treatments in juiciness, tenderness, connective tissue amount, saltiness, or off-flavor intensity (Table 1). Similarly, no differences were found using the Warner-Bratzler shear, an objective measure of tenderness. One challenge in this study was the inability of the semitendinosus to retain the solutions which were added. Less than 42% of the solution was retained for any treatment (Table 2). This could account for the lack of effect. Traditional enhancement solutions contain salt and phosphate. Even this treatment in the present study failed to induce any changes in the muscle.

In previous research (Perversi et al., *2002 Beef Report,* pp. 85-87), prerigor injection of sodium citrate was shown to significantly enhance tenderness in other muscles. Results of the present study suggest the lack of response to sodium citrate may be attributed to the loss of the solution from the muscle, the high connective tissue content of the muscle studied, and/or the addition of sodium citrate postrigor rather than prerigor.

It was hypothesized that the sodium citrate solutions might impart a salty sensation, but that proved not to be the case (Table 1). Additionally, the addition of citrate did not contribute to specific problematic off-flavors (Table 3). Further, there were no effects of sodium citrate on pH or color measures, when compared to the untreated control (Table 4). Semitendinosus muscles injected with water or a solution containing salt and phosphate were lighter in color (higher L*) and less red (lower a*). There were no effects on the yellowness scale (b*). Previous speculation was that postrigor injection with sodium citrate may increase pH and ionic strength of muscles to a level where increased solubilization of myofibrillar proteins occurs, there by enhancing tenderness and the ability of the muscle to retain added water. This hypothesis did not hold true in this study.

Implications

Sodium citrate was not effective in changing the sensory properties of semitendinosus muscles. The lack

(Continued on next page)

of response may be attributed to the loss of the solution from the muscle, the high connective tissue content of the muscle studied, and/or the addition of sodium citrate postrigor rather than prerigor. Additional research is needed to clarify these issues.

[1]Donald A. Moss, graduate student; Chris R. Calkins, professor, Animal Science, Lincoln.

Table 4. Effect of treatments on pH and color.

Treatment	pH	L*[c]	a*[d]	b*[e]
Control	5.56	45.45[b]	22.82[a]	24.95
Control with water	5.54	49.02[a]	20.90[b]	24.26
0.3% Salt/ 0.3% phosphate	5.55	48.15[a]	20.26[b]	24.18
1% Sodium citrate	5.56	43.85[b]	22.36[a]	24.39
3% Sodium citrate	5.57	44.75[b]	22.50[a]	24.40
5% Sodium citrate	5.59	43.42[b]	23.46[a]	24.72
SEM	0.01	0.79	0.52	0.35

[a,b]Within a column, means without a common superscript letter differ ($P < 0.05$).
[c]L*= Lightness.
[d]a*= Redness.
[e]b*= Yellowness.

Flavor Relationships Among Muscles of the Beef Chuck and Round

Jessica L. Meisinger
Jennie J. James
Chris R. Calkins[1]

Summary

Flavor relationships among muscles and causes of liver-like off-flavor of six muscles from each of 30 beef carcasses were evaluated by a trained sensory panel. The infraspinatus (flat iron) was lowest in sour, metallic, and oxidized flavors and highest in fatty flavor. The vastus lateralis (knuckle side) had the most intense off-flavor and was among the highest for sour and oxidized. Heme iron concentration and pH were lowly related to off-flavor. Of 18 muscles from three carcasses, 16 were high in liver-like off-flavor. These data suggest liver-like off-flavor is related to something that impacts the entire animal.

Introduction

New cuts from the beef round and chuck have gained popularity. There have been anecdotal reports of off-flavors, especially a liver-like flavor, in some beef value cuts. The incidence and intensity of liver-like flavor in various muscles is unknown. Flavor is highly correlated with overall-like ratings in beef. With the importance of flavor to the consumer, it is likely that they will not try the same cut again if they have a bad flavor experience. The objective of this research was to compare different beef muscles for off-flavors and to determine the relationship of pH and heme-iron content to off-flavor.

Procedure

Knuckles and shoulder clods were removed from 16 Choice and 14 Select-grade beef carcasses. Hot carcass weight, fat thickness, marbling, rib-eye area, and percentage kidney, pelvic, and heart (KPH) fat were recorded and yield grade was calculated. The knuckles and shoulder clods were stored in a 33.8°F dark cooler until 7 days postmortem. The rectus femoris (REC; knuckle center), vastus lateralis (VAL; knuckle side), vastus medialis (VAM; knuckle bottom), infraspinatus (INF; top blade or flat iron), teres major (TER; petite tender), and triceps brachii-long head (TRI; clod heart) were fabricated from each carcass. The INF was filleted, and the connective tissue running laterally through the middle of the muscle was removed. Each half of the INF was then cut into three steaks. The TER and VAM were left as whole muscles due to size. A sample was cut from the end of each muscle, minced, and retained for chemical analysis. The VAL, REC, and TRI were cut into 1-inch steaks, wrapped, and frozen at -3°F.

Samples were prepared by cubing, freezing in liquid nitrogen, powdering the frozen sample with a blender, and storing at -112°F. Powdered sample was used to measure moisture content using a LECO Thermogravimetric Analyzer. A pH meter with a spear tip combination electrode was used to determine the pH of the muscle. Hemoglobin and myoglobin were extracted using acetone and hydrochloric acid and then quantified using a spectrophotometer.

Frozen steaks were tempered for 1 day in a 33°F cooler before cooking. The steaks were weighed and trimmed. Each steak was grilled to an internal temperature of 150°F. Thermocouples were inserted in the approximate center of each steak. A hand-held digital thermometer was also used to confirm the internal temperature. Steaks were first turned after two minutes and then flipped as needed to minimize charring.

After reaching the desired internal temperature, the steak was removed from the grill. The steaks were cut into 1 x 2 x 1 inch steak cubes and placed in double broilers until served (< 15 min). The trained panelists received between six and eight samples per session. All eight samples were either from the same muscle type or they were in groups of four from two different muscles. On days that samples from two muscles types were served, a five-minute break was given to separate the two muscles. All steaks were from a consistent location on the muscle. Because of the small size of the TER and VAM, they were cooked as whole muscles. The order of the day that each muscle was served was random and steaks for each muscle were served in random order. Panelists were not aware of which type of steak they were eating.

Panelists used 8-point hedonic rating scales with 8=extremely juicy, extremely tender, no connective tissue and no off-flavor, and 1=extremely dry, extremely tough, abundant amount of connective tissue, and extreme off-flavor. They also identified off-flavor notes including charred, liver-like, metallic, musty/oxidized, acidic, rancid, and sour flavors. Oxidized was described as a "warmed over" flavor and rancid was the flavor associated with lipid oxidation.

Muscle carcass traits and muscle off-flavor traits were analyzed by analysis of variance using the GLM procedure of SAS. Muscle off-flavor notes within flavor group were analyzed by analysis of variance using the MIXED procedure of SAS. The linear and quadratic functions of heme-iron and pH, as well as the interaction, were included in regression equations to obtain the coefficients of determination.

Results

Only percentage KPH fat and marbling differed between Choice and Select cattle, with Choice-grade cattle

(Continued on next page)

Table 1. The effect of muscle on sensory characteristics, heme-iron concentration, and pH[a,b]

Muscle[c]	Tender (S.E.)	C.T. (S.E.)	Juice (S.E.)	O.F. Intensity (S.E.)	Heme (S.E.)	pH (S.E)
INF	6.50^{de}(0.16)	5.77^{de}(0.17)	6.22^{d} (0.13)	6.03^{d} (0.16)	44.42 (1.97)	5.70^{d} (0.03)
REC	6.11^{e} (0.16)	5.44^{e} (0.17)	5.69^{e} (0.13)	5.68^{e} (0.16)	46.25 (1.97)	5.59^{e} (0.03)
TER	6.58^{d} (0.16)	5.85^{d} (0.17)	6.15^{d} (0.13)	5.41^{ef}(0.16)	42.99 (1.97)	5.71^{d} (0.03)
TRI	5.45^{f} (0.16)	4.32^{f} (0.17)	5.68^{e} (0.13)	5.54^{e} (0.16)	45.43 (1.97)	5.47^{f} (0.03)
VAL	4.66^{g} (0.16)	3.63^{g} (0.17)	5.07^{f} (0.13)	5.10^{f} (0.16)	45.60 (1.97)	5.54^{ef}(0.03)
VAM	5.45^{f} (0.16)	4.18^{f} (0.17)	6.04^{d} (0.14)	5.58^{e} (0.17)	47.47 (2.02)	5.66^{d} (0.03)

[a]Tender=Tenderness, C.T=Connective tissue, Juice=Juiciness, O.F. Intensity=Off-flavor intensity, and Heme=Heme-iron concentration, in ppm.
[b]Taste panel scale: 8=extremely juicy, extremely tender, no connective tissue and no off-flavor, and 1=extremely dry, extremely tough, abundant amount of connective tissue, and extreme off-flavor.
[c] INF=Infraspinatus, top blade or flat iron; REC=rectus femoris, knuckle center; TER=teres major, petite tender; TRI=triceps brachii-long head, clod heart; VAL=vastus lateralis, knuckle side; VAM=vastus medialis, knuckle bottom.
[defg] Means within a column (for sensory traits) with different superscripts are significantly ($P < 0.05$) different.

Table 2. The effect of muscle on percentage of panelists detecting each off-flavor note[a]

Muscle	Liver (S.E.)	Sour (S.E.)	Metallic (S.E.)	Char (S.E.)	Bloody (S.E.)	Oxid. (S.E)	Fatty (S.E)	Rancid (S.E)
INF	9.3 (2.9)	23.2^{c} (3.7)	8.7^{c} (2.2)	29.9^{d} (4.4)	1.6 (1.0)	9.5^{cd} (2.3)	14.0^{d} (1.3)	8.8 (1.6)
REC	9.7 (2.9)	44.2^{d} (3.7)	13.4^{c} (2.2)	20.4^{cd}(4.4)	3.4 (1.0)	7.4^{c} (2.3)	3.2^{c} (1.3)	4.9 (1.6)
TER	8.8 (2.9)	48.7^{d} (3.7)	15.5^{cd}(2.2)	21.6^{cd}(4.4)	1.8 (1.0)	8.5^{cd} (2.3)	3.3^{c} (1.3)	5.8 (1.6)
TRI	7.7 (2.9)	49.5^{d} (3.7)	19.5^{d} (2.2)	22.2^{cd}(4.4)	0.8 (1.0)	13.3^{cde}(2.3)	1.6^{c} (1.3)	5.6 (1.6)
VAL	9.1 (2.9)	48.4^{d} (3.7)	15.0^{cc}(2.2)	30.5^{d} (4.4)	1.3 (1.0)	17.5^{e} (2.3)	1.4^{c} (1.3)	6.8 (1.6)
VAM	10.8 (3.0)	49.0^{d} (3.8)	17.3^{cd}(2.2)	14.8^{c} (4.6)	2.9 (1.0)	14.6^{de} (2.3)	2.3^{c} (1.4)	7.2 (1.6)

[a]Liver=Liver-like, Char=Charred\bitter, Oxid=Oxidized.
[b] INF=Infraspinatus, top blade or flat iron; REC=rectus femoris, knuckle center; TER=teres major, petite tender; TRI=triceps brachii-long head, clod heart; VAL=vastus lateralis, knuckle side; VAM=vastus medialis, knuckle bottom.
[cde] Means within a column (for sensory traits) with different superscripts are significantly ($P < 0.05$) different.

having a greater amount of both. This result is expected because carcasses are sorted into quality grades based primarily on marbling.

Off-flavor intensity differed among muscles (Table 1). The INF had the lowest off-flavor intensity (a higher numerical score) and was among the most tender and juicy of the muscles tested. The VAL had the most intense off-flavor ratings (lower numerical scores) and was the least tender, had the most connective tissue, and had the lowest amount of juiciness ($P < 0.05$). This could be due to a "halo effect" where a sample that has a good flavor is rated more tender or juicy than one with bad flavor. The INF, TER, and VAM had the highest pH values of the muscles tested. There were no differences ($P < 0.05$) among muscles for heme-iron concentration.

Liver-like, bloody, and rancid flavors were not affected by muscle type (Table 2). The INF, which had the lowest amount of off-flavor, was among the lowest in percentage of panelists detecting sour, metallic, and oxidized flavors, although it received a higher rating of fatty flavor than the other muscles ($P < 0.05$). The VAL, which had the most intense off-flavor, was among the highest in percentage of panelists detecting sour, charred, and oxidized flavors ($P < 0.05$). Most of the other muscles were rated as being intermediate in the percentage of panelists detecting specific off-flavor notes. When the off-flavor intensity scores were assessed, it became obvious that when one muscle of a given carcass was off-flavored, all muscles were off-flavor (Table 3). Sixteen of the 18 muscles from animals six, seven, and nine had off-flavor intensity scores below five.

In an attempt to explore the off-flavor intensity ratings among these muscles, the muscles were grouped. All muscles where at least 30% of the panelists recognized the off-flavor as liver-like were classified as "off-flavor" while the other muscles were classified as "normal." There were no group by muscle interactions for sour, metallic, fatty, bloody, or oxidized off-flavor notes. The percentage of panelists detecting liver-like scores was very high which is to be expected, as this is how they were grouped (Table 4). Charred flavors were lower for the off-flavor group than for the normal group ($P < 0.05$). This could be because the intense liver-like flavor overwhelms the charred flavor. There was also an interaction among rancid samples that was only significant for the VAM, where off-flavor samples were less rancid than normal samples ($P < 0.05$). This suggests that liver-like flavor is not associated with other off-flavor notes.

Regression equations containing the linear and quadratic functions of heme-iron concentration, muscle pH, and their interaction were established for the frequency of off-flavor notes within each muscle for each quality grade (data not shown). Within Choice, only the VAL and INF showed a relationship between pH, heme, and

Table 3. Off-flavor intensity scores among muscles[a,b]

Animal	Grade	INF	TER	TRI	REC	VAL	VAM
1	Choice	6.36	4.20	6.06	6.44	5.58	5.25
2	Choice	6.25	6.17	6.00	5.75	5.14	5.65
3	Choice	6.75	6.45	6.31	6.78	5.44	6.05
4	Choice	7.19	5.44	6.11	6.75	5.86	6.33
5	Choice	6.61	5.00	5.56	6.75	5.72	5.65
6	Choice	4.17	2.55	3.56	3.83	3.36	3.10
7	Choice	4.38	3.39	4.39	3.31	4.14	4.90
8	Choice	6.07	6.05	4.89	6.38	4.86	5.50
9	Choice	4.56	5.35	5.06	4.94	4.60	4.00
10	Choice	6.55	5.33	4.88	6.31	4.56	6.22

[a]Taste panel scale: 8=no off-flavor and 1=extreme off-flavor.
[b] INF=Infraspinatus, top blade or flat iron; REC=rectus femoris, knuckle center; TER=teres major, petite tender; TRI=triceps brachii-long head, clod heart; VAL=vastus lateralis, knuckle side; VAM=vastus medialis, knuckle bottom.

Table 4. The effect of normal vs. off-flavor group[a] and muscle on percentage of panelists detecting each off-flavor note

Muscle[b]	Liver-like		Charred		Rancid	
	Normal (S.E.)	Off-flavor (S.E.)	Normal (S.E.)	Off-flavor (S.E.)	Normal (S.E.)	Off-flavor (S.E.)
INF	3.6[d] (1.5)	83.3[c] (5.4)	5.6 (15.7)	31.7 (4.3)	0 (6.0)	9.5 (1.6)
REC	5.1[d] (1.5)	48.2[c] (4.4)	23.2 (13.2)	20.6 (4.3)	7.9 (4.9)	4.6 (1.6)
TER	4.0[d] (1.5)	48.9[c] (4.4)	69.1[c](13.2)	16.9[d](4.3)	6.7 (4.9)	6.0 (1.6)
TRI	5.2[d] (1.5)	41.0[c] (5.4)	52.1[c](15.7)	19.7[d](4.3)	5.2 (6.0)	5.7 (1.6)
VAL	4.4[d] (1.5)	47.6[c] (4.4)	64.9[c](13.2)	26.9[d](4.3)	13.1 (4.9)	6.2 (1.6)
VAM	5.0[d] (1.5)	60.0[c] (4.4)	20.0 (13.2)	14.9 (4.5)	23.3[c](4.9)	5.3[d](1.7)

[a]Muscles where at least 30% of the panelists detected liver-like off-flavor were classified as off-flavor; all others were classified as normal.
[b] INF=Infraspinatus, top blade or flat iron; REC=rectus femoris, knuckle center; TER=teres major, petite tender; TRI=triceps brachii-long head, clod heart; VAL=vastus lateralis, knuckle side; VAM=vastus medialis, knuckle bottom.
[cd] Means within a row for a given off-flavor with different superscripts are significantly ($P < .05$) different.

bloody flavor ($P < 0.05$). There were no significant relationships between pH, heme-iron concentration, and metallic flavors or oxidized flavors for either Choice or Select-grade muscles. Muscles from Select-grade carcasses had stronger relationships between off-flavor notes and pH and heme-iron, possibly because the three carcasses with strong, liver-like off-flavor were Select. Heme-iron and pH explained some of the off-flavor intensity of the TER, VAL, and VAM ($P < 0.05$).

Bloody flavor notes in the TRI showed a relationship ($P = 0.003$) for heme-iron concentration and pH. Heme-iron concentration and pH influenced liver flavor ($P = 0.0003$) and sour flavor ($P = 0.042$) in the REC. Liver-like flavor in the VAM was also influenced ($P = 0.042$). Heme-iron concentration and pH influenced charred flavor ($P = 0.032$) and rancid flavor ($P = 0.042$) in the TER.

Conclusion

When one muscle from a carcass contained liver-like off-flavor, the other muscles tested from that same carcass also contained that flavor. This suggests liver-like flavor is related to something the entire animal experiences, like genetics, a feedstuff, or a pharmaceutical product. It is unknown if muscles other than those tested here would also have the off-flavor. Muscles from the chuck and round have different off-flavor amounts as well as different sensory characteristics. There appears to be only a slight relationship between heme-iron concentration, pH and off-flavor.

[1]Jessica Meisinger, graduate student; Jennie James, graduate student; Chris Calkins, professor, Animal Science, Lincoln.

The Influence of Cooking Rate and Holding Time on Beef Flavor

Jennie M. James
Chris R. Calkins[1]

Summary

Seven muscles from 10 beef carcasses were cooked quickly or slowly and held 0 or 1 hour to explore the influence of cooking rate and holding time on beef flavor. Off-flavor intensity was lowest when beef was cooked slowly (on a 300°F grill instead of a 480°F grill) and when it was held for 1 hour prior to sensory evaluation. The infraspinatus (flat iron) had the least intense off-flavor and the vastus intermedius (knuckle bottom) had the most intense off-flavor. Slow cooking or holding for 1 hour prior to consumption reduced the intensity of off-flavor in value cuts.

Introduction

The food-service industry has begun to use various steaks obtained from the chuck and the round. Managers in this industry report an increasing number of complaints about off-flavors in some of the value cuts. Some of the typical off-flavors are described as liver-like, fatty, sour, and metallic. Flavor is a combination of aroma and taste. As a result, some of the compounds that are part of the normal beef flavor may be concentrated or lost due to cooking. In the food-service industry, meat is cooked and then traditionally held for a time before being served.

The objectives of this research were to determine the effects of cooking rate and holding time on the flavor of steaks obtained from muscles in the chuck and the round.

Procedure

Seven muscles (*M. infraspinatus* -INF, flat iron; *M. teres major*- TER, shoulder tender; *M. triceps brachii*- TRI, clod heart; *M. rectus femoris*-REC, knuckle center; *M. vastus lateralis*-VAL, knuckle side; *M. vastus medialis*-VAM, knuckle bottom; and the *M. vastus intermedius*- VAI, knuckle bottom) located in the clod (IMPS #114) and knuckle (IMPS #167) from 10 animals (5=Choice and 5=Select) were separated and trimmed of external fat after aging 7 days postharvest. The thick band of connective tissue in the INF was removed. The TRI, REC, and VAL were cut into 1-inch steaks. The top and bottom portions of the INF were cut in half to make 4 steaks. The TER, VAM, and VAI were cut in half. Steaks were wrapped and frozen (3°F) until sensory evaluation was conducted.

Four steaks from one USDA Choice and four steaks from one USDA Select muscle type were randomly served during every taste panel session. Serving order of muscles was randomized. Steaks were thawed 24 hours prior to cooking for sensory evaluation. One steak from each muscle was cooked quickly (FAST) with a grill temperature of 480°-500°F to an internal temperature of 145°F and brought to 150°F during a 1 hour hold in a commercial food-service warming oven (Precision RS-201, Metal Products, Inc, Miami, Fla.) kept at approximately 165°F. A second steak from the muscle was slow cooked (SLOW) with a grill temperature of 300°F to an internal temperature of 145°F and held for 1 hour to a final internal temperature of 150°F. The remaining 2 steaks from each muscle were cooked SLOW and FAST, respectively, to an internal temperature of 150°F and served with no holding time (0 hour). Steaks to be served with no holding time were timed to finish cooking near the end of the 1 hour holding period of the other two steaks. Weight losses from cooking and holding were determined.

Panelists for this study were selected and trained according to the guidelines and procedures outlined by the American Meat Science Association. In order to prevent bias, panelists were seated in individual booths equipped with red fluorescent lights and partitioned to reduce possible collaboration between panelists and eliminate visual differences. Each panelist was served distilled water and unsalted, saltine crackers and given three minutes between samples to cleanse their palates. The panel evaluated the 0.5 inch x 0.5 inch x 1 inch pieces of the eight steaks each session for tenderness, connective tissue, juiciness, and off-flavor intensity on an 8-point hedonic scale with 1=extremely tough, extreme connective tissue, extremely dry, and extreme off-flavor and 8=extremely tender, no connective tissue, extremely juicy, and no off-flavor. Panelists were trained to identify the presence of specific off-flavors (liver-like, metallic, sour, charred, oxidized, rancid, or other) contributing to the off-flavor score for the steak.

Table 1. Least squares means for off-flavor intensity of four muscles from the chuck and round[1].

Muscle[x]	Fast[y] 0 h	Fast[y] 1 h	Slow[y] 0 h	Slow[y] 1 h
INF	5.83	5.94	5.62	5.93
TRI	4.86[a]	5.70[b]	5.82[b]	6.02[b]
REC	5.70	5.75	5.75	6.17
VAL	4.28[a]	5.57[b]	5.65[b]	5.57[b]
Pooled SEM		0.3632		

[1]8-point hedonic scale used to evaluate off-flavor with 1=extreme off-flavor; 8=no off-flavor
[a,b] Means in the same row without a common superscript are different ($P < 0.05$)
[x]INF=*infraspinatus* (flat iron), TRI=*triceps brachii* (clod heart), REC=*rectus femoris* (knuckle center), VAL=*vastus lateralis* (knuckle side).
[y]Grill Temperature: Fast= 480-500°F; Slow=300°F.

Table 2. Least squares means for off-flavor intensity scores for seven muscles.

Treatment[w]	Off-flavor Intensity[x]	*P*-value
HOLDING TIME		0.0237
0 h Hold	5.31[a]	
1 h Hold	5.78[b]	
SEM= 0.0881		
MUSCLES[y]		<0.0001
INF	6.27[d]	
TRI	5.67[b,c,d]	
TER	5.38[b,c]	
REC	6.11[c,d]	
VAL	5.31[b]	
VAI	4.41[a]	
VAM	5.65[b,c,d]	
SEM= 0.1649		

[a,b,c,d]Means within group without common superscript are different ($P<0.05$).
[w]Grill Temperature: Fast= 480-500°F.
[x]8-point hedonic scale used to evaluate off-flavor with 1=extreme off-flavor; 8=no off-flavor
[y]INF=*infraspinatus* (flat iron), TER= *teres major* (shoulder tender) TRI=*triceps brachii* (clod heart), REC=*rectus femoris* (knuckle center), VAL=*vastus lateralis* (knuckle side), VAI=*vastus intermedius* (knuckle bottom), and VAM=*vastus medialis* (knuckle bottom).

Table 3. Weight loss percentage after cooking, holding, and total loss

Muscle[w]	Cook Loss %[x]	Hold Loss %[y]	Total Loss %[z]
Fast Cook- 0 h Hold	26.71[a,b]	—	26.71[a]
Fast Cook- 1 h Hold	21.98[a]	11.75[b]	31.14[b]
Slow Cook- 0 h Hold	28.76[b]	—	28.76[a,b]
Slow Cook- 1 h Hold	25.89[a,b]	7.95[a]	31.79[b]
ER			
Fast Cook- 0 h Hold	25.95	—	25.95[a]
Fast Cook- 1 h Hold	22.54	9.46	29.92[b]
TRI			
Fast Cook- 0 h Hold	23.59[a]	—	23.59[a]
Fast Cook- 1 h Hold	19.23[a]	18.74	34.39[c]
Slow Cook- 0 h Hold	28.46[b]	—	28.46[b]
Slow Cook- 1 h Hold	21.82[a]	16.09	34.55[c]
REC			
Fast Cook- 0 h Hold	23.29	—	23.29[a]
Fast Cook- 1 h Hold	27.87	6.81	31.13[b]
Slow Cook- 0 h Hold	28.12	—	28.12[b]
Slow Cook- 1 h Hold	27.04	3.93	28.71[b]
VAL			
Fast Cook- 0 h Hold	25.12[a,b]	—	25.12[a]
Fast Cook- 1 h Hold	21.44[a]	18.20[b]	36.10[c]
Slow Cook- 0 h Hold	26.66[b]	—	26.66[b]
Slow Cook- 1 h Hold	26.57[b]	10.30[a]	34.28[c]
VAI			
Fast Cook- 0 h Hold	24.59[b]	—	24.59[a]
Fast Cook- 1 h Hold	19.61[a]	15.30	31.83[b]
VAM			
Fast Cook- 0 h Hold	24.29	—	24.59[a]
Fast Cook- 1 h Hold	21.97	15.36	33.93[b]

[a,b,c]Means within columns for each treatment with different letters are significantly different ($P < 0.05$).
[w]INF=*infraspinatus* (flat iron), TER= *teres major* (shoulder tender) TRI=*triceps brachii* (clod heart), REC=*rectus femoris* (knuckle center), VAL=*vastus lateralis* (knuckle side), VAI=*vastus intermedius* (knuckle bottom), and VAM=*vastus medialis* (knuckle bottom).
[x]Cook loss %= (Raw weight-Cooked weight)/Raw weight *100.
[y]Hold loss %= (Cooked weight-Hold weight)/Cooked weight*100; Hold loss % only includes steaks that had a 1 h hold time.
[z]Total loss %= (Raw weight-Cooked weight-Hold weight)/Raw weight *100.

Data were analyzed as a randomized complete block design by analysis of variance (ANOVA) using the MIXED procedure of SAS with a predetermined significance level of $P \leq 0.05$. Animal served as the experimental unit and was considered a random effect. The Kenward-Roger option was used to determine denominator degrees of freedom. Main effects of muscle, cooking rate, and holding time and their two-way and three-way interactions were included in the model. When significance was indicated by ANOVA, means separations were performed using the LSMEANS and PDIFF function of SAS.

Results

The TER, VAI, and VAM were too small to obtain four steaks from the muscle so only the fast cooking rate was used for these muscles. Off-flavor intensity scores for the remaining four muscles were different between cooking rate (P=0.0007), holding time (P=0.0002), the muscle*cooking rate interaction (P=0.0237), and the three way interaction of muscle*cooking rate*holding time (P=0.0121). The FAST cook rate and held for 0 h had the poorest scores for off-flavor intensity for the TRI and VAL muscles. The INF and the REC were not significantly different ($P > 0.05$) among the treatments (Table 1). When cooking rate was not included in the model and all seven muscles were analyzed, the same trend was observed with both muscle and holding time being significant, but the interaction was not (Table 2). Slow cooking and holding for 1 hour resulted in the least intense off-flavor ratings.

Total weight losses during the cooking and holding were always less for the steaks that were fast cooked with a 0 hour hold for all muscles (Table 3). Perhaps the increased weight loss is improving the off-flavor intensity ratings as shown in Table 1. This suggests off-flavor compounds are volatile and likely water-soluble. The off-flavors slightly dissipate when

(Continued on next page)

Table 4. Average percentage of panelists that observed an off-flavor.

Muscle[z]	Liver-like	Metallic	Sour	Charred	Oxidized	Rancid	Fatty	Other	None
INF	16.88	7.25[a]	17.12[a]	23.48[b]	0.59[a]	3.13[a]	9.55[c]	0.92[a]	17.35[b]
TRI	19.06	12.05[b,c]	39.37[b]	23.65[b]	15.66[b]	3.96[a]	1.94[a]	4.51[b]	11.67[a]
REC	18.96	8.33[a,b]	20.42[a]	12.85[a]	1.53[a]	3.51[a]	5.56[b]	5.31[b]	11.67[a]
VAL	15.86	12.75[c]	36.99[b]	31.47[b]	20.67[c]	7.63[b]	1.85[a]	2.79[a]	7.49[a]

[a,b,c]Means in same column without common superscripts are different ($P<0.05$).
[z]INF=*infraspinatus* (flat iron), TRI=*triceps brachii* (clod heart), REC=*rectus femoris* (knuckle center); VAL=*vastus lateralis* (knuckle side).

there is greater cooking and holding loss. It is known that water soluble compounds contribute to meat flavor.

Table 4 illustrates that all muscles had the same incidence of liver-like flavors. Panelists found sourness at a higher frequency in the TRI and the VAL. The INF was found to have the highest response of no off-flavors in the samples tested. The INF has been found to have desirable flavor in several other studies.

Neither cooking rate nor holding time affected the percentage of panelists perceiving liver-like, metallic, oxidized, and rancid flavors. The percentage of panelists perceiving sourness was significantly different ($P=0.0363$) for FAST (25.61%) and SLOW (31.35%) cooking rate as well as charred ($P < 0.0001$) and fatty ($P=0.0003$) flavor. The charred flavor was probably affected by the high cooking temperatures (36.90% for FAST versus 8.82% for SLOW) where more external browning would have formed. The fatty flavor was probably perceived more often due to increased cook loss in the SLOW cooked steaks which concentrated the fat flavor components (SLOW 7.05% versus FAST 2.38%).

Implications

Cooking rate and holding time play a role in the intensity of off-flavor perceived in muscles from the chuck and round, especially when the steaks are cooked quickly and served immediately. The slower cooking or the longer hold time create more total loss in weight and reduce intensity of off-flavor.

[1] Jennie M. James, graduate student; Chris R. Calkins, professor Animal Science, Lincoln.

Wet Distillers Grains Plus Solubles Do Not Increase Liver-like Off-Flavors in Cooked Beef.

Blaine E. Jenschke
Jennie M. James
Kyle J. Vander Pol
Chris R. Calkins
Terry J. Klopfenstein[1]

Summary

Crossbred steers fed with varying levels of wet distillers grains to test the incidence of liver-like off-flavors. USDA Choice steaks, when compared to USDA Select, had significantly higher trained sensory muscle fiber tenderness scores, less detectable connective tissue, higher juiciness scores, and more intense off-flavor ratings. USDA Choice steaks had a higher percentage of panelists denote liver-like and metallic off-flavors. Wet distillers grains did not significantly influence off-flavor indicating these by-products can be used to finish cattle without causing detrimental effects on the sensory profile.

Introduction

Recently, purveyors, retailers, and consumers have reported a liver-like off-flavor in beef cuts. Previous research indicates cuts cooked to higher degree of doneness, cuts with higher levels of myoglobin, and cuts with greater degrees of lipid oxidation typically express a liver-like off-flavor. More specifically, recent research has identified thirteen compounds that were higher in samples with liver-like off-flavor when compared to samples without liver-like flavors. Of these by-products, six were aldehydes formed from the oxidation of oleic and linoleic acid.

Distillers grains supplementation increases unsaturated fat content of the diet which may subsequently escape rumen biohydrogenation and become incorporated into the phospholipid fraction of muscle tissue, thus increasing the possibilities of lipid oxidation and subsequent off-flavors. Our objectives were to determine if feeding wet distillers grains plus solubles (WDGS) increases liver-like off-flavors in beef, and to determine the sensory attributes of cattle finished with WDGS.

Procedure

Two hundred eighty-eight crossbred yearling steers were randomly assigned to a dietary treatment containing 0, 10, 20, 30, 40, and 50% (DM basis) WDGS, where WDGS replaced a high-moisture/dry-rolled corn mixture (1:1 DM basis). Steers were implanted on day 28 with Revalor-S7, fed for 125 days and harvested at a commercial processing facility. At harvest, university personnel randomly selected 15 Choice and 15 Select carcasses from each treatment group (n=180). Carcass data (hot carcass weight, fat thickness, and ribeye area) were collected by university personnel while USDA marbling score and yield grade were determined by a USDA grader. Following grading, the knuckles (IMPS #167) (n=180) were removed from the carcasses, vacuum-packaged, and shipped to the Loeffel Meat Laboratory at the University of Nebraska.

Following a total aging period of 7 days at 34°F , the *M. rectus femoris* (knuckle centers) were isolated and cut into 1-inch steaks, freezer wrapped, and frozen (3°F) until sensory analysis was conducted. Steaks were allowed to thaw in a cooler at 34°F for 1 day prior to cooking for sensory evaluation.

Sensory Evaluation

Steaks were cooked to an internal temperature of 158°F on an electric broiler. Internal temperature was monitored with a digital thermometer with a type T thermocouple. When the internal temperature reached 95°F, the steak was turned once until the final temperature was reached. The steak was cut into 0.5 x 0.5 x 1- inch cubes and served warm to the panelists, approximately five minutes post cooking.

In order to prevent bias, panelists were seated in individual booths equipped with red fluorescent lights and partitioned to reduce collaboration between panelists and eliminate visual differences. Each panelist was served distilled water and unsalted, saltine crackers and given three minutes between samples to cleanse their palates. Six samples, identified using three-digit codes, were served on each day. Eight-point descriptive attribute scales (Muscle fiber tenderness: 1=extremely tough, 8=extremely tender; Connective tissue: 1=abundant, 8=none; Juiciness: 1=extremely dry, 8=extremely juicy; Off-flavor intensity: 1=extreme off-flavor, 8=no off-flavor) were used. Panelists were trained to identify the specific off-flavors (liver-like, metallic, sour, charred, oxidized, rancid, or other) contributing to the off-flavor score for the steak.

Statistical Analysis

Data were analyzed as a randomized complete block design by analysis of variance (ANOVA) using the MIXED procedure of SAS with a predetermined significance level of $P \leq 0.05$. Carcass served as the experimental unit and was considered a random effect. Main effects of treatment, grade, and their two-way interaction were included in the model. Since the treatment x grade interaction was not significant for any attribute, least square means were not reported. The Kenward-Roger option was used to determine denominator degrees of freedom. When significance was indicated by ANOVA, means separations were performed using the LSMEANS and PDIFF function of SAS.

(Continued on next page)

Results

Carcass Data

For this experiment, a subset of 180 animals was used. Treatment had an effect on hot carcass weight and USDA yield grade ($P = 0.0001$ and 0.036, respectively). Cattle finished on the 0%, 10%, and 50% diets had similar hot carcass weights, which were lighter than those from cattle fed 20%, 30%, and 40% diets (Table 1). Adjusted fat thickness, ribeye area, and USDA marbling score were not ($P = 0.37$, 0.08, and 0.31, respectively) different in the present study. Distillers grains have higher fat content than corn, which may contribute to higher yield grades.

Grade effects for hot carcass weight ($P = 0.72$), adjusted fat thickness ($P = 0.24$), ribeye area ($P = 0.95$) and USDA yield grade ($P = 0.10$) were not significant, but USDA marbling score, as expected, was highly significant ($P = 0.0001$).

Treatment had no effect on the sensory attributes muscle fiber tenderness, connective tissue amount, juiciness, and off-flavor intensity (Table 1). USDA Choice steaks were more tender, had lower amounts of detectable connective tissue, were juicer, and had a greater off-flavor intensity when compared to Select steaks.

Treatment did not significantly influence off-flavor intensity (Table 2), although the frequency of liver-like off-flavor notes was approaching significance ($P = 0.07$). The liver-like off-flavor occurred most frequently in the 0% and 10% WDGS diets (14.44 and 19.63, respectively) while steaks from animals fed the 30% and 50% WDGS diet had the lowest incidence of liver-like off-flavor (7.41 and 8.52, respectively). Liver-like and metallic off-flavors were more frequent in Select carcasses ($P = 0.02$ and $P = 0.0002$, respectively). Although oxidative rancidity was not measured in our study, we hypothesize that the

Table 1. Least squares means for main effects for hot carcass weight, adjusted fat thickness, yield grade, and marbling score for sub sampled carcasses.

Effect	Hot Carcass Weight,lb	Adjusted Fat Thickness,in	Ribeye Area,in^2	USDA Yield Grade	USDA Marbling Score[a]
Treatment[b]					
0	784[c]	0.44	12.8	2.4[c]	503
10	806[cd]	0.52	12.7	2.7[d]	521
20	817[de]	0.50	12.7	2.7[d]	494
30	832[e]	0.48	12.7	2.7[d]	508
40	839[e]	0.47	12.1	2.9[d]	504
50	794[cd]	0.49	12.2	2.7[d]	503
SEM[f]	8.65	0.02	0.2	0.11	8.10
P-value	0.0001	0.37	0.08	0.036	0.31
Quality Grade					
Choice	813	0.50	12.5	2.76	564[d]
Select	811	0.47	12.5	2.61	465[c]
SEM[f]	5.00	0.01	0.1	0.06	4.68
P-value	0.72	0.24	0.95	0.10	0.0001

[a]400= Slight^{00} and 500= Small^{00}.
[b]Treatments: Percentage of wet distillers grains plus solubles included in diet.
[cde]Mean values within a column and followed by the same letter are not significantly different ($P>0.05$).
[f] Standard error of the mean.

Table 2. Least squares means for main effects for muscle fiber tenderness, connective tissue amount, juiciness, and off-flavor intensity.

Effect	Muscle Fiber Tenderness[a]	Connective Tissue Amount[b]	Juiciness[c]	Off-Flavor Intensity[d]
Treatment[e]				
0	5.80	4.86	5.18	5.72
10	5.62	4.73	5.04	5.49
20	5.82	4.91	5.24	5.69
30	5.51	4.65	4.90	5.74
40	5.53	4.67	4.96	5.54
50	5.60	4.73	5.05	5.73
SEM[f]	0.13	0.14	0.13	0.11
P-value	0.37	0.72	0.46	0.47
Quality Grade				
Choice	5.90[h]	5.01[h]	5.24[h]	5.51[g]
Select	5.39[g]	4.51[g]	4.87[g]	5.80[h]
SEM[f]	0.07	0.08	0.08	0.07
P-value	0.0001	0.0001	0.0009	0.0020

[a]Muscle fiber tenderness: 1= Extremely Tough; 8= Extremely Tender.
[b]Connective tissue amount: 1= Abundant Amount; 8=No Connective Tissue.
[C]Juiciness: 1= Extremely Dry; 8= Extremely Juicy.
[d]Off-flavor intensity: 1=Extreme Off-Flavor; 8= No Off-Flavor.
[e]Treatments: Percentage of wet distillers grains plus solubles included in diet.
[f]Standard error of the mean.
[gh]Mean values within a column and followed by the same letter are not significantly different ($P>0.05$).

Table 3. Least squares means for main effects for livery-like, metallic, sour, oxidized, rancid, and other off-flavors.

Effect	Liver-like[a]	Metallic[a]	Sour[a]	Charred[a]	Oxidized[a]	Rancid[a]	Other[a]
Treatment[b]							
0	14.44	34.07	48.89	7.41	10.37	12.22	2.96
10	19.63	27.41	50.37	8.52	11.85	8.52	0.74
20	11.85	31.85	50.74	5.56	18.52	11.11	3.33
30	7.41	31.85	55.19	4.44	11.48	10.74	3.33
40	12.22	34.81	49.63	8.89	16.67	11.11	2.59
50	8.52	36.30	50.37	5.56	10.37	11.36	4.82
SEM[c]	0.03	0.04	0.03	0.02	0.03	0.02	0.01
P-value	0.07	0.73	0.82	0.37	0.21	0.75	0.10
QG[d]							
Choice	15.19[f]	39.26[f]	51.48	7.78	11.98	11.36	3.58
Select	9.51[e]	26.17[e]	50.25	5.68	14.44	9.38	2.35
SEM[c]	0.02	0.02	0.02	0.01	0.02	0.01	0.01
P-value	0.02	0.0002	0.65	0.14	0.30	0.24	0.12

[a]Off-flavors are expressed as a percentage of panelists that identified the off-flavor.
[b]Treatments: Percentage of wet distillers grains plus solubles included in diet.
[c]Standard error of the mean.
[d]Quality grade.
[ef]Mean values within a column and followed by the same letter are not significantly different ($P>0.05$).

increase in off-flavor intensity, liver-like, and metallic off-flavors may be due to lipid oxidation. A greater percentage of panelists detected the liver-like off-flavor (15.19 vs. 9.51) and the metallic off-flavor (39.26 vs. 26.17) in USDA Choice steaks when compared to USDA Select steaks. All other off-flavor notes were not significant in terms of quality grade.

[1]Blaine Jenschke, graduate student; Jennie James, graduate student; Kyle Vander Pol, graduate student; Chris Calkins, professor, Animal Science, Lincoln; Terry Klopfenstein, professor, Animal Science, Lincoln.

Statistics Used in the Nebraska Beef Report and Their Purpose

The purpose of beef cattle and beef product research at UNL is to provide reference information that represents the various populations (cows, calves, heifers, feeders, carcasses, retail products, etc.) of beef production. Obviously, the researcher cannot apply treatments to every member of a population; therefore, he/she must sample the population. The use of statistics allows the researcher and readers of the Nebraska Beef Report the opportunity to evaluate separation of random (chance) occurrences and real biological effects of a treatment. Following is a brief description of the major statistics used in the beef report. For a more detailed description of the expectations of authors and parameters used in animal science see Journal of Animal Science Style and Form (beginning pp 339) at: *http://jas.fass.org/misc/ifora.shtml.*

- **Mean** — Data for individual experimental units (cows, steers, steaks) exposed to the same treatment are generally averaged and reported in the text, tables and figures. The statistical term representing the average of a group of data points is mean.

- **Variability** — The inconsistency among the individual experimental units used to calculate a mean for the item measured is the variance. For example, if the ADG for *all* the steers used to calculate the mean for a treatment is 3.5 lb then the variance is zero. But, this situation never happens! However, if ADG for individual steers used to calculate the mean for a treatment range from 1.0 lb to 5.0 lb, then the variance is large. The variance may be reported as standard deviation (square root of the variance) or as standard error of the mean. The standard error is the standard deviation of the mean as if we had done repeated samplings of data to calculate multiple means for a given treatment. In most cases treatment means and their measure of variability will be expressed as follows: 3.5 ± 0.15. This would be a mean of 3.5 followed by the standard error of the mean of 0.15. A helpful step combining both the mean and the variability from an experiment to conclude whether the treatment results in a real biological effect is to calculate a 95% confidence interval. This interval would be twice the standard error added to and subtracted from the mean. In the example above, this interval is 3.2-3.8 lb. If in an experiment, these intervals calculated for treatments of interest overlap, the experiment does not provide satisfactory evidence to conclude that treatments effects are different.

- **P Value** — Probability (P Value) refers to the likelihood the observed differences among treatment means are due to chance. For example, if the author reports $P \leq 0.05$ as the significance level for a test of the differences between treatments as they affect ADG, the reader may conclude there is less than a 5% chance the differences observed between the means are a random occurrence and the treatments do not affect ADG. Hence we conclude that, because this probability of chance occurrence is small, there must be difference between the treatments in their effect on ADG. It is generally accepted among researchers when P values are less than or equal to 0.05, observed differences are deemed due to important treatment effects. Authors occasionally conclude that an effect is significant, hence real, if P values are between 0.05 and 0.10. Further, some authors may include a statement indicating there was a "tendency" or "trend" in the data. Authors often use these statements when P values are between 0.10 and 0.15, because they are not confident the differences among treatment means are real treatment effects. With P values of 0.10 and 0.15 the chance random sampling caused the observed differences is 1 in 10 and 1 in 6.7, respectively.

- **Linear and Quadratic Contrasts** — Some articles contain linear (L) and quadratic (Q) responses to treatments. These parameters are used when the research involves increasing amounts of a factor as treatments. Examples are increasing amounts of a ration ingredient (corn, by-product, or feed additive) or increasing amounts of a nutrient (protein, calcium, or vitamin E). The L and Q contrasts provide information regarding the shape of the response. Linear indicates a straight line response and quadratic indicates a curved response. P-values for these contrasts have the same interpretation as described above.

- **Correlation (r)** — Correlation indicates amount of linear relationship of two measurements. The correlation coefficient can range from –1 to 1. Values near zero indicate a weak relationship, values near 1 indicate a strong positive relationship, and a value of –1 indicates a strong negative relationship.

Animal Science

http://animalscience.unl.edu

Curriculum **—** The curriculum of the Animal Science Department at the University of Nebraska–Lincoln is designed so that each student can select from a variety of options oriented to specific career goals in professions ranging from animal production to veterinary medicine. Students have unique opportunities to double major in Grazing Livestock Systems (*http://gls.unl.edu*) or complete the Feedlot Management Internship Program (*http://feedlot.unl.edu/intern*).

Careers:

- Animal Health
- Banking and Finance
- Animal Management
- Consultant
- Education
- Marketing
- Technical Service
- Meat Processing
- Meat Safety
- Quality Assurance
- Research and Development
- Veterinary Medicine

Scholarships **—** Each year the Animal Science Department offers over 20 scholarships to incoming freshmen and 24 scholarships to sophomore, junior and senior Animal Science students.

ABS Global Scholarship
Baltzell-Agri-Products, Inc. Scholarship
Maurice E. Boeckenhauer Memorial Scholarship
Mike Cull Judging and Activities Scholarship
Don Geweke Memorial Award
Parr Young Senior Merit Award
Nebraska Pork Producers Association Scholarship
Waldo Family Farms Scholarship
Frank and Mary Bruning Scholarship
Art and Ruth Raun Scholarship
Animal Science Department Freshman Scholarship
Feedlot Management Scholarship
Robert Boeckenhauer Memorial Scholarship
Burnell Scholarship Fund
Doane Scholarship
Lincoln Coca-Cola Bottling Company Scholarship
William J. and Hazel J. Loeffel Scholarship
Nutrition Service Associates Scholarship
Parr Family Student Support Fund
Chris and Sarah Raun Memorial Scholarship
Walter A. and Alice V. Rockwell Scholarship
Standard Manufacturing Co. Scholarship
Max and Ora Mae Stark Scholarship
D.V. and Ernestine Stephens Memorial Scholarship
Dwight F. Stephens Scholarship
Arthur W. and Viola Thompson Scholarship
Thomas H. Wake, III Scholarship
Franke E. Card Scholarship
Derrick Family Scholarship
G. H. Francke Livestock Judging Scholarship
Eric Peterson Memorial Award
Winkler Memorial Livestock Judging Scholarship