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Nebraska Beef Cattle Report 2008

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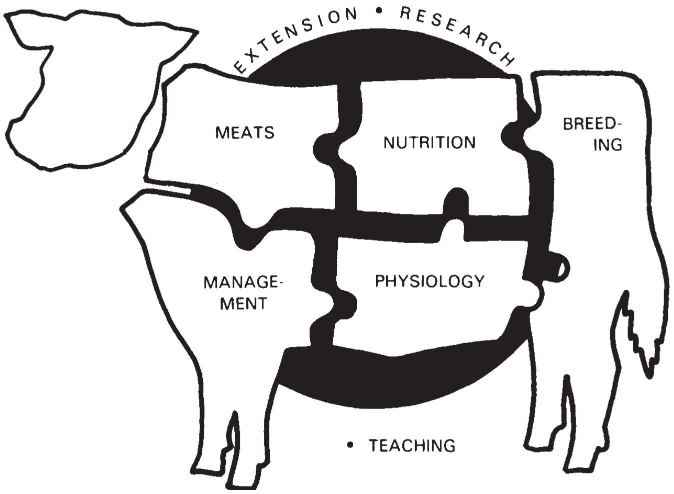

Agricultural Research Division
University of Nebraska Extension
Institute of Agriculture and Natural Resources
University of Nebraska–Lincoln

NEBRASKA

2008
Beef Cattle Report

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Summary

Developing heifers to reach a target weight of 50% of mature body weight at the beginning of the breeding season is an effective method for reducing heifer development cost. Net costs to produce a bred yearling heifer and 2-year-old cow were lower when heifers were developed to 50% rather than 55% of mature body weight, regardless of breeding season length. Administration of oral progestin to heifers developed to 50% mature body weight prior to breeding did not affect reproductive performance during the first breeding season when heifers were exposed to bulls 13 days after the end of progestin treatment.

Introduction

It is commonly recommended heifers be developed to between 60% and 65% of mature body weight (MBW) prior to breeding. However, Funston and Deutscher (*Journal of Animal Science*, 2004, 82:3094-3099) reported similar pregnancy rates from the initial through fourth breeding season for heifers developed to reach either 53% or 58% of MBW prior to breeding as yearlings. Initial results and economic analyses from developing replacement heifers to 50% or 55% of MBW were reported previously (*2005 Nebraska Beef Report,* pp. 3-6). The majority of heifers that failed to become pregnant were acyclic at the beginning of the breeding season. Because the oral progestin, MGA, is known to induce cyclicity in prepubertal heifers, the objectives of this study were to: 1) determine the effects of developing heifers to a pre-breeding target weight of 50% or 55% of MBW, and 2) determine effects of supplementing heifers developed to 50% of MBW with progestin prior to breeding.

Procedure

Two experiments were conducted using crossbred MARC II (¼ each Angus, Hereford, Simmental, and Gelbvieh) x Husker Red (¾ Red Angus, ¼ Simmental or Gelbvieh) heifers at Gudmundsen Sandhills Laboratory (GSL), Whitman, Neb.

Experiment One

Two hundred sixty-one heifers (505 lb; n = 88, 90, and 83 in 2001, 2002, and 2003, respectively) were assigned randomly to development in intensive (INT; n = 119) or relaxed (RLX; n = 142) systems. Heifers in the INT system were developed to 55% of MBW before a 45-day breeding season. In the RLX system, heifers were developed to 50% MBW before a 60-day breeding season. An estimated MBW of 1,200 lb was used since the weight of mature cows (4 years old and up) in this herd the previous five years was 1,171 lb. In order to assure an adequate number of heifers would remain in the herd as 2 year olds, more heifers were developed and the breeding season extended for the RLX system because reduced heifer pregnancy rate was expected.

At the initiation of the trial each year, heifers were weighed two consecutive days, stratified by first day weight and birth date, and assigned randomly to treatment. Treatments were initiated Jan. 1, 2001, and Dec. 1 in 2002 and 2003. Heifers were placed in hay-feeding grounds, by treatment, for the winter feeding period and fed a diet consisting of meadow hay and protein supplement (*2005 Nebraska Beef Report,* pp. 3-6). Heifers were weighed monthly and feed amounts adjusted to obtain desired gains. At the end of the winter feeding period (May 15), heifers were weighed and body condition score (BCS) was determined. Blood samples were collected 10 days apart prior to initiation of the breeding season and progesterone concentration was analyzed to determine the number of heifers pubertal before the breeding season.

Heifers were maintained on native Sandhills upland range for breeding, beginning May 20 of each year. After 45 days of breeding season, INT heifers were removed from the breeding pasture while RLX heifers remained with bulls an additional 15 days. Sixty days after the end of the breeding season for RLX heifers (approximately Sept. 10), pregnancy diagnosis was performed via rectal palpation.

After pregnancy diagnosis, heifers were maintained as a single group on sub-irrigated meadow regrowth during fall (September through October). During the subsequent winter, bred heifers received 1.5 lb/head/day supplement and *ad libitum* access to meadow hay. Pre-calving BW and BCS were recorded approximately Feb. 15 each year and calving began approximately March 1. Calf birth BW was recorded within 24 hours of parturition.

After calving, primiparous cows were maintained on meadow hay and supplement until May 10, at which point they were placed on sub-irrigated meadow until June 5. Native upland Sandhills range was grazed for the remainder of the trial. Two-year-old cows were exposed to bulls for 60 days beginning June 5. In early September, cow rebreeding pregnancy diagnosis was performed and calves were weaned. Calf weaning BW and cow BW and BCS were recorded at this time.

Experiment Two

One hundred eighty-four heifers (474 lb; n = 104 and 80 in 2004 and 2005, respectively) were developed to achieve 50% MBW before a 45-day breeding season and were assigned randomly to control (CON; n = 103) or progestin treatment (MGA; n = 81). Heifers were managed in a common

(Continued on next page)

group except during progestin treatment. After weaning in late September until approximately Jan. 1 each year, heifers grazed subirrigated meadow regrowth and were supplemented with 1 lb/day of a 28% CP cube containing 62% dried distillers grains. Beginning approximately Jan. 1 each year, heifers were maintained in drylot and fed meadow hay *ad libitum* and 1 lb/day supplement. Heifers fed MGA received 0.5 mg/head/day MGA in supplement for 14 days, beginning 27 days prior to initiation of a 45-day breeding season. The CON heifers received similar supplement without MGA during this time. Heifers were moved to upland range at the beginning of the breeding season and remained on upland range pasture through October.

After the summer grazing period, heifers grazed corn crop residue and received 1 lb/day supplement from Nov. 1 to Feb. 22 each year. During the pre-calving period, heifers were allowed *ad libitum* access to meadow hay. After calving until early May, 1 lb/day supplement was fed in addition to free-choice meadow hay. Primiparous cows and calves grazed subirrigated meadows from early May until beginning of the second (60 day) breeding season on June 12 each year. Cow/calf pairs remained on native range throughout the remainder of the study.

Results

Experiment One

Performance results from heifers from treatment initiation through second-calf conception are reported in Table 1. There was no difference (P = 0.99) in beginning weight (505 lb) between the two systems. There was a 68 lb difference in pre-breeding weight (P < 0.001) and 0.5 unit difference in pre-breeding BCS (*P* < 0.001) between systems, due to the difference (0.44 lb/day; P < 0.001) in winter ADG. Targeted pre-breeding weight for both systems was based on expected MBW of 1,200 lb. Heifers in both systems exceeded their targeted pre-breeding weight, which resulted in RLX heifers averaging 51% and INT averaging 57% MBW prior to the initial breeding season.

Table 1. Growth, reproductive, and calf performance of heifers developed in intensive (INT) or relaxed (RLX) systems from treatment initiation through rebreeding as 2 year old cows.[a]

	RLX	INT	SEM	*P*-value
Data through first breeding season				
n	142	119		
Beginning BW, lb	505	505	7	0.99
Winter ADG, lb/day	0.75	1.19	0.04	<0.001
Pre-breeding wt., lb	611	679	15	<0.001
Pre-breeding BCS	5.2	5.7	0.1	<0.001
Pre-breeding proportion MBW, %	50.9	56.5	—	<0.001
Cycling at beginning of breeding season, %[b]	34.9	52.1	—	0.39
Pregnancy check BW, lb	827	847	33	0.006
Pregnancy check BCS	5.6	5.9	0.1	<0.001
Pregnancy rate, %	87.2	89.8	—	0.51
Proportion of nonpregnant heifers pre-pubertal prior to breeding season, %	78.9	46.8	—	0.07
Data from initial calving season through second breeding season				
Pre-calving BW, lb	955	990	31	<0.001
Pre-calving BCS	5.3	5.4	0.1	0.06
Calf birth date, Julian d	77	70	1	<0.001
Calf birth BW, lb	73	73	2	0.95
Calving difficulty, %[c]	31.3	24.7	—	0.18
Calf weaning BW, lb	428	439	9	0.07
Pregnancy diagnosis BW, lb	919	950	22	0.005
Pregnancy check BCS	5.07	5.16	0.09	0.10
Pregnancy rate, %	92.4	93.8	—	0.61
2-year old retention, %[d]	75.6	79.1	—	0.72

[a] ADG = average daily gain; BCS = body condition score; MBW = mature body weight.

[b] Proportion of heifers determined to have reached puberty as indicated by serum progesterone concentration > 1ng/ml prior to the initial breeding season.

[c] Proportion of heifers requiring assistance during calving.

[d] Proportion of heifers exposed to bulls during the initial breeding season that became pregnant as 2-year-old cows.

The proportion of heifers pubertal prior to breeding did not differ (Table 1; *P* = 0.39) between the two systems. However, of heifers that failed to become pregnant, a greater proportion of (*P* = 0.07) RLX than INT heifers were pre-pubertal when the breeding season began. Interestingly, further characterization of nonpregnant heifers within each system revealed 79% (14 of 17) of nonpregnant RLX heifers (after a 60-day breeding season) but only 45% (5 of 11) of nonpregnant INT heifers (after a 45-day breeding season) were pre-pubertal at the start of the breeding season.

Weight at pregnancy diagnosis was still greater (*P* = 0.006) for INT heifers compared to RLX heifers; however, the difference was less than one-third seen at initiation of breeding (68 vs. 20 lb difference at beginning of breeding and pregnancy diagnosis, respectively). This indicates RLX heifers were able to compensate during summer grazing for some of the weight difference created by winter development system. A similar pattern was observed for BCS, with RLX heifers having lower (*P* < 0.001) pre-breeding and pregnancy diagnosis BCS but gaining more condition throughout the summer than INT heifers. Pregnancy rate following the initial breeding season was not different (*P* = 0.51) between INT and RLX heifers and averaged 89% across systems.

Weight differences created by winter development system were maintained over the second wintering period; therefore, pre-calving weight was greater (*P* < 0.001) for INT than RLX heifers. Pre-calving weight difference was 35 lb, compared to 20 lb weight difference at pregnancy diagnosis. Pre-calving BCS was also greater (*P* = 0.06) for INT than RLX heifers. Average calving date was 7 days later (*P* < 0.001) for RLX than INT heifers, primarily due to the 15-day longer breeding season for RLX heifers. Neither calf birth weight (*P* = 0.61) nor the proportion of heifers requiring assistance at calving (*P* = 0.31) were different between systems. Calving rate during the initial calving season, based on the number of heifers exposed to bulls, was not affected (*P* = 0.68; data not shown) by development system.

In this study, RLX heifers calved 7

Table 2. Growth, reproductive, and calf performance of heifers developed to 50% MBW with or without prebreeding progestin exposure.[a]

	CON	MGA	SEM	*P*-value
Data through first breeding season				
n	103	81		
Pre-breeding wt., lb	617	619	42	0.55
Cycling at beginning of breeding season, %[b]	71.8	77.8	—	0.69
Pregnancy check BW, lb	833	840	49	0.47
Pregnancy check BCS	5.8	5.9	0.2	0.13
Pregnancy rate, %	91.3	88.9	—	0.69
Data from initial calving season through second breeding season				
Pre-calving BW, lb	926	939	15	0.22
Pre-calving BCS	5.3	5.3	0.1	0.34
Calf birth date, Julian d	66	66	1	0.69
Calf birth BW, lb	71	73	2	0.52
Calving difficulty, %[c]	38.4	32.0	—	0.56
Calf weaning BW, lb	425	434	15	0.28
Pregnancy diagnosis BW, lb	939	944	9	0.78
Pregnancy check BCS	5.2	5.2	0.1	0.44
Pregnancy rate, %	93.3	88.0	—	0.03

[a] ADG = average daily gain; BCS = body condition score; MBW = mature body weight.
[b] Proportion of heifers determined to have reached puberty as indicated by serum progesterone concentration > 1ng/ml prior to the initial breeding season.
[c] Proportion of heifers requiring assistance during calving.

days later than INT heifers. Funston and Deutscher (*Journal of Animal Science*, 2004 82:3094-3099) reported no difference in calving date following a 45-day breeding season between heifers developed to 53% or 58% MBW prior to breeding. Retrospective analysis considering only RLX heifers bred within the first 45 days of the breeding season, based on days pregnant at pregnancy diagnosis, revealed similar ($P = 0.20$; data not shown) 45-day pregnancy rates for INT (90%) and RLX (78%) systems. During the extended 15 day breeding period (from 45 to 60 days) for the RLX heifers, an additional 9% of heifers became pregnant.

Calf weaning weights were greater (Table 1; $P = 0.07$) for INT than RLX heifers; however, pre-weaning calf weight per day of age (WDA) was not affected ($P = 0.38$; data not shown) by heifer development system. Weaning rate, as a proportion of heifers exposed for breeding, was similar ($P = 0.67$; data not shown) between treatments. Cow body weights and BCS at weaning (Table 1; $P = 0.005$) and second pregnancy diagnosis ($P = 0.10$) were greater for INT than RLX cows. However, second-calf pregnancy rates were similar ($P = 0.61$) between treatments (91% vs. 92% for RLX and INT, respectively). Additionally, the proportion of heifers exposed for breeding as yearlings remaining in the herd as pregnant 2 year olds was similar ($P = 0.72$) between systems averaging 76% and 79% for the RLX and INT systems, respectively.

Experiment Two

Target pre-breeding weight for heifers in Experiment 2 was 600 lb, or 50% predicted MBW. Pre-breeding weights were similar (Table 2; $P = 0.55$) for CON and MGA heifers, and averaged 617 lb, slightly greater than target breeding weight. As a result, heifers in Experiment 2 were developed to 52% MBW at the time of breeding, based on an expected MBW of 1,200 lb. Weight and BCS at pregnancy diagnosis were similar ($P = 0.47$ and $P = 0.13$, respectively) for CON and MGA heifers.

Pregnancy rates were 91% for CON and 89% for MGA ($P = 0.69$). Pre-breeding treatment with the oral progestin MGA did not affect the proportion of heifers achieving puberty prior to breeding or becoming pregnant within a 45 day breeding season in Experiment 2. These results were surprising because a greater proportion of nonpregnant RLX heifers than INT heifers were pre-pubertal in Experiment 1. In Experiment 2, heifers were exposed to bulls beginning 13 days after completion of MGA feeding. Due to estrous synchronization, heifers fed MGA should not have displayed estrus until approximately 5 to 10 days after beginning of breeding. Therefore, no differences were observed in pregnancy rate, calving date, or calf weaning weight in heifers developed to 52% MBW and administered MGA because a high percentage of CON heifers were pubertal before the breeding season and due to timing of MGA withdrawal relative to beginning of the breeding season.

Pre-calving weight (Table 2; $P = 0.22$) and BCS ($P = 0.34$) were similar between treatments. Heifer development treatment did not affect ($P > 0.50$) calf birth date, birth weight, or the proportion of heifers requiring assistance during calving. At weaning, similar calf weights ($P = 0.28$) were achieved by calves from CON and MGA cows. Furthermore, cow weight ($P = 0.28$) and BCS ($P = 0.78$) at second pregnancy diagnosis were similar for CON and MGA cows. However, second breeding season pregnancy rates were greater ($P = 0.03$; 93% vs. 88 %) for CON than MGA cows.

Conclusions

Developing heifers to reach a target weight of 50% MBW is an effective method for reducing heifer development cost (*2005 Nebraska Beef Report,* pp. 3-6), and extending the breeding season beyond 45 days for lighter weight heifers allows first-calf pregnancy rates to equal those of heifers heavier at the initiation of breeding. Cost per pregnant 2-year-old cow is also reduced, despite later average calving date and lighter weaning weights. The later calving date does not affect the ability of heifers to re-breed during the second breeding season. Administration of oral progestin to heifers developed to 52% MBW prior to breeding did not affect reproductive performance during the first breeding season when a high percentage of heifers were pubertal and when MGA-fed heifers were exposed to bulls 13 days after the end of progestin treatment.

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[1] Jeremy L. Martin, graduate student; Kelly W. Creighton, former graduate student; and Jacquelin A. Musgrave, research technician, Gudmundsen Sandhills Laboratory, Whitman. Terry J. Klopfenstein, professor Animal Science; and Richard T. Clark, retired professor agricultural economics, Lincoln. Don C. Adams, director, West Central Research and Extension Center, North Platte; Rick N. Funston, associate professor, animal science, West Central Research and Extension Center, North Platte.

Effect of Wintering System and Nutrition around Breeding on Gain and Reproduction in Heifers

Daniel M. Larson
Jeremy L. Martin
Rick N. Funston[1]

Summary

Replacement heifers were developed using corn stalks (Experiments 1 and 2), winter range (Experiment 1), or a dry lot (Experiment 2) with or without a high energy supplement around breeding. Corn stalk development reduced ADG and the percentage pubertal prior to breeding; however, neither first service conception nor pregnancy rates were affected. High energy supplemental nutrition around breeding tends to improve first service conception. Corn stalk development does not appear to negatively impact reproduction, although it resulted in lighter calf birth weight compared to winter range.

Introduction

The paradigm of developing replacement heifers to target 65% of mature body weight by breeding is costly and unrealistic for some producers. There is increasing interest in lower cost, lower gain development. Funston and Deutscher (*Journal of Animal Science, 2004,* 82:3094) indicated heifers reaching only 53% of mature body weight by breeding did not differ in pregnancy rate when compared to heifers developed to 58% of mature body weight. However, the effect of developing replacement heifers using corn stalks or dormant winter pasture on first service conception rate is unknown. Furthermore, supplementation offered to nutritionally restricted multiparous females prior to breeding improved embryo survival (Khireddine et al., *1998 Theriogenelogy,* 49:1409). Therefore, the current study evaluated the effect of low cost development with additional nutrition around the time of breeding on first service conception rate, pregnancy rate, and first calf production characteristics.

Procedure

All procedures were approved by the University of Nebraska Institutional Animal Care and Use Committee. Two studies were conducted: Experiment 1 was conducted at Gudmundsen Sandhills Laboratory, Whitman, Neb.; Experiment 2 was conducted at the West Central Research and Extension Center, North Platte, Neb.

Experiment 1

Weaned heifer calves (n = 96) were blocked by initial BW (489 ± 7 lb) and assigned randomly to graze either corn stalks (Stalk) or dormant native Sandhills Range from November through March. The heifers were weaned at an average age of 209 days and began treatment at an average age of 240 days. A daily supplement was offered (1 lb/head; Table 1). Both the Stalk and Range groups grazed for a period of 138 days. Subsequently, all heifers were recombined and grazed a common pasture for 48 days with a daily supplement (1 lb/head; Table 1). After the 48-day grazing period, heifers were reassigned to breeding treatments within winter development treatment randomly by BW. The breeding treatments included offering heifers a supplement (S; 3 lbs/day, Table 1) 7 days prior to and for 14 days following prostaglandin injection or not offering a supplement (NS). Body weight was measured after 138, 160, and 170 days on trial for both the Stalk and Range groups. Two blood samples were collected 26 and 14 days prior to PGF injection. Progesterone concentrations were quantified using radioimmunoassay and concentrations > 1 ng/ml were interpreted to indicate luteal activity and hence, attainment of puberty.

Table 1. Formulation of supplement offered while grazing for Experiments 1 and 2.

Item	DM%
Dried distillers grain	62
Wheat midds	11
Cottonseed meal	9
Corn gluten feed	5
Cane molasses	5
Other[a]	8

[a]Provided 80 mg/day of monensin.

Estrus was synchronized using a single injection of PGF (day 0). A progestin was not used to avoid confounding the effect of winter development on age at puberty. Five days prior to PGF, fertile bulls were turned in with both groups of heifers for a period of 45 days. The heifers were recombined after the supplementation period. Pregnancy rate was determined via transrectal ultrasonography 40 days after bull removal. At approximately 23 months of age, heifers were weighed and BCS was assessed. At parturition, calf birth date, birth weight, calving ease score, and sex were recorded.

The heifer weight, ADG, calf birth date, birth weight, and calving ease score data were analyzed using Proc Mixed of SAS. The interactions between winter development and supplemental nutrition were found to be insignificant and will not be presented. In addition, percentage of heifers pubertal, pregnancy rate, and calf sex were analyzed using a Chi-square analysis with Proc Freq of SAS.

Experiment 2

Weaned heifer calves (n = 99) were blocked by initial BW (571 ± 8 lb) and assigned randomly to graze either corn stalks (Stalk) or developed in a dry lot (Lot) from November through March. The lot heifers were fed the winter diet for 143 days (14 lb/head) and the spring diet for 45 days (15 lb/head; Table 2). A daily supplement

Table 2. Diets offered in dry lot, Experiment 2.

Item	Winter Lot	Spring Lot	Spring Stalk	HE	LE
	DM%				
Grass hay	62	57	61	57	74
Dry rolled corn	—	—	—	16	—
Corn silage	20	26	20	17	16
Dried distillers grain + solubles	13	12	13	—	—
Wet corn gluten feed	—	—	—	67	
Supplement[a]	5	5	5	3	4

[a]Provided 200 mg/day of monensin.

Table 3. Effect of wintering system and supplemental nutrition, Experiment 1.

	Range	Stalk	NS	S
n	48	48	48	48
Weight, lb				
Initial	489	492	—	—
Day 138	582^{a}	536^{b}	—	—
Day 170	655^{a}	595^{b}	—	—
Pregnancy diagnosis	802^{a}	763^{b}	—	—
Parturition	989	963	971	981
Daily gain, lb/day				
Prior to breeding	0.71^{a}	0.44^{b}	—	—
After breeding	1.57^{a}	1.79^{b}	1.70^{x}	1.65^{y}
BCS				
Pregnancy diagnosis	5.8	5.7	5.8	5.8
Parturition	5.1^{x}	5.2^{y}	5.2	5.1
Percent pubertal, %	72.9^{a}	33.3^{b}	—	—
Pregnancy rate, %	87.5	85.4	85.4	87.5
Calf birth weight, lb	73	72	73	72
Calving ease score	1.53	1.45	1.56	1.42
Bull calves/total calving	21/37	23/38	26/39	18/39
Heifer calves/total calving	16/37	15/38	13/39	18/39

[ab]Means differ, Range vs. Stalk ($P \leq 0.10$)
[xy]Means differ, NS vs. S ($P \leq 0.10$)

Table 4. Effect of wintering system and supplemental nutrition, Experiment 2.

	Lot	Stalk	HE	LE
n	49	50	50	49
Weight, lb				
Initial	571	569	—	—
Day 134	767^{a}	635^{b}	—	—
Day 193	912^{a}	808^{b}	—	—
Pregnancy diagnosis	1069^{a}	1015^{b}	1046	1038
Daily gain, lb/day				
Prior to breeding	1.70^{a}	1.19^{b}	—	—
After breeding	1.26^{a}	1.63^{b}	1.54^{x}	1.37^{y}
Percent pubertal, %	94.0^{a}	46.9^{b}	—	—
TAI conception rate, %	50.0	49.0	58.0^{a}	40.8^{b}
Pregnancy rate, %	88.0	81.6	86.0	83.7
Gestation length of TAI, day	281^{x}	284^{y}	282	282
Calf birth weight, lb	80	77	79	77
Calving ease score	1.46	1.40	1.47	1.39
Bull calves/total calving	26/39	21/44	24/42	23/41
Heifer calves/total calving	18/39	18/44	18/42	18/41

[ab]Means differ, Lot vs. Stalk ($P \leq 0.10$)
[xy]Means differ, HE vs. LE ($P \leq 0.10$)

was offered to the Stalk group while grazing (1 lb/head; Table 1). The Stalk heifers grazed for 134 days and were subsequently moved to the Lot for 59 days. The Lot diet for the Stalk group is described in Table 2 (14 lb/head) and was designed to target an ADG of 1 lb/day. Heifers were assigned within winter treatment by BW to receive either a high (HE) or low (LE) energy diet seven days prior to and for 12 days after timed artificial insemination (TAI). The HE diet and the LE diet compositions are described in Table 2. Body weight was assessed and blood samples were collected 62, 48, and 38 days prior to TAI. Progesterone concentrations were analyzed as described in Experiment 1.

Estrus was synchronized using an MGA/ PGF system. Beginning 36 days prior to TAI and continuing for 14 days, MGA was added to the diet. Eighteen and one-half days after MGA withdrawal, a single injection of PGF was administered and TAI was performed for both groups 60 hours after PGF. Thirteen days after TAI, fertile bulls were turned in with both groups for a period of 60 days. Transrectal ultrasonography was performed 44 days after TAI to determine first service conception rate and again approximately 50 days after bull removal to determine pregnancy rate. At parturition, calf birth date, birth weight, calving ease score, and sex were recorded.

The heifer weight, ADG, calf birth date, birth weight, and calving ease score data were analyzed using Proc Mixed of SAS. The interactions between winter development and supplemental nutrition were found to be insignificant and will not be presented. In addition, percentage of heifers pubertal, pregnancy rate, and calf sex were analyzed using a Chi-square analysis with Proc Freq of SAS.

Results

Experiment 1

Heifer performance data, puberty, and pregnancy rate are presented in Table 3. The Stalk heifers were lighter after grazing ($P < 0.001$), at PGF injection ($P < 0.001$), and at pregnancy diagnosis ($P = 0.004$) when compared to the Range heifers, although BCS at pregnancy diagnosis was not different ($P > 0.\ 10$). The Stalk heifers also had a lower ($P < 0.001$) ADG prior to breeding compared to Range heifers. However, Stalk heifers had a greater ($P < 0.001$) ADG after breeding, which indicates compensatory gain. Supplemental nutrition did

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not affect ($P > 0.10$) weight nor BCS at pregnancy diagnosis or ADG after breeding. There were a greater ($P < 0.001$) percentage of Range heifers pubertal prior to breeding than Stalk heifers (73% vs. 33%). However, neither winter development nor supplemental nutrition affected ($P > 0.10$) overall pregnancy rate (86%).

First calf production data are presented in Table 3. Neither winter development nor supplemental nutrition affected ($P > 0.10$) BW prior to parturition. However, Stalk heifers tended to have a greater ($P = 0.06$) BCS than Range heifers. Winter development and supplement treatments did not affect ($P > 0.10$) calf birth weight, calving ease score, or sex distribution.

Experiment 2

Heifer performance, puberty, and pregnancy rate data are presented in Table 4. The Stalk heifers were lighter after grazing ($P < 0.001$), at PGF injection ($P < 0.001$), and at pregnancy diagnosis ($P = 0.003$) when compared to the Lot heifers. The Stalk heifers also had a lower ($P < 0.001$) ADG prior to breeding compared to Lot heifers. However, Stalk heifers had a greater ($P < 0.001$) ADG after breeding, indicating compensatory gain similar to Experiment 1. The HE diet also improved ($P = 0.02$) ADG after breeding. There was a lower ($P < 0.001$) percentage of Stalk heifers pubertal prior to breeding than Lot (47% vs. 94%) similar to Experiment 1 where Stalk group had a reduced percentage of pubertal heifers compared to WR. Winter development did not affect ($P > 0.10$) first service conception rate (50%) or overall pregnancy rate (85%). The HE heifers tended ($P = 0.09$) to have greater first service conception rates compared to LE heifers, although, there was no effect ($P > 0.10$) of supplemental nutrition on overall pregnancy rate.

First calf production data are presented in Table 4. For heifers conceived to TAI, the Stalk heifers had a longer ($P = 0.05$) gestation than the Lot heifers. However, neither winter development nor supplemental nutrition affected ($P > 0.10$) calf birth weight, calving ease score, or sex distribution. There were no interactions of winter development and breeding supplementation on calf parameters.

Conclusion

Winter development using corn stalks reduced ADG and the percentage of heifers attaining puberty prior to breeding compared with winter range or dry lot development. However, there was no effect of treatment on first service conception or pregnancy rates. Offering nutritionally challenged heifers a higher energy diet around the time of breeding may improve first service conception. While the factors that mediate these effects are unclear, developing heifers using corn stalks does not appear to negatively affect reproductive efficiency.

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[1] Daniel M. Larson, graduate student; Jeremy L. Martin, graduate student; and Rick N. Funston, associate professor, Animal Science, West Central Research and Extension Center, North Platte.

Pre and Peri-pubertal Feeding of Melengesterol Acetate (MGA) Alters Testis Characteristics in Bulls

Racheal G. Slattery
Shantille G. Kruse
Michelle M. Baltes-Breitwisch
Jeremy L. Martin
Daniel M. Larson
Debra T. Clopton
Karl V. Moline
Jeff W. Bergman
Andrea S. Cupp[1]

Summary

Bulls were fed 1 mg/head/day of MGA from 5.5 to 6.5 months ; 6.5 to 9; or fed a control diet. Body weight, scrotal circumference, combined testis weight, testis composition, and testosterone concentration were measured. Feeding MGA prior to puberty increased scrotal circumference and decreased testosterone concentration at 12 months compared to controls. Thus, feeding MGA prior to puberty can alter testis characteristics in bulls.

Introduction

Implants containing 17Beta-estradiol administered prior to puberty impaired testis size. In addition, GnRH immunization has been used to immunocastrate bulls at several stages of testis development and resulted in reduced testis size through arrest of spermatogenesis. More recently, a study involving bulls treated with different doses of MGA at or after 9 months of age attempted to reduce aggressive male behavior but showed no effects on behavior or testis characteristics. Previous data (*Tepfer et al., 2006 Nebraska Beef Report,* pp. 16-17) demonstrated that body weight and testosterone were altered by feeding MGA prior to 9 months. In the current study, we used greater numbers of bulls with similar treatment groups to determine if there were effects of feeding MGA during the pre- and peri-pubertal period. The current trial investigated a treatment that would be easy for producers to administer, would have dramatic effects on testis function, and allow for manipulation of testis size in bulls to meet the individual goals of the producer. In the case of seed-stock producers, administration of MGA during the pre-pubertal period may optimize or increase spermatogenic capacity of the bulls allowing for increased sperm cells per ejaculate.

Procedure

Eighty cross-bred bull calves (420 ± 11 lb; 5 months) were fed MGA either pre- (PRE) or peri-pubertally (PERI) and a control (CON) group. Calves were allowed to graze a bromegrass pasture and supplemented with soybean hulls (60%, DM basis) and corn (40%, DM basis). The PRE treatment group was fed MGA (1mg/head/day) for 70 days, while the PERI treatment group was fed MGA (1mg/head/day) for 88 days. Treatment protocols are described in Figure 1. At each time point until bulls were castrated, right testis weight was collected as well as combined testis weight (from both testis), scrotal circumference was measured, and blood samples were collected to be later analyzed for testosterone concentration.

Results

Scrotal Circumference

Bulls in the PRE group had increased scrotal circumference at 12 months (36.2 ± 0.8 cm; Figure 2; $P = 0.03$) when compared to CON (34.1 ± 1.0 cm) and their scrotal circumference tended ($P = 0.06$) to be greater than PERI (34.1 ± 0.8 cm). No other effects of either treatment on scrotal circumference at any other collection period were observed.

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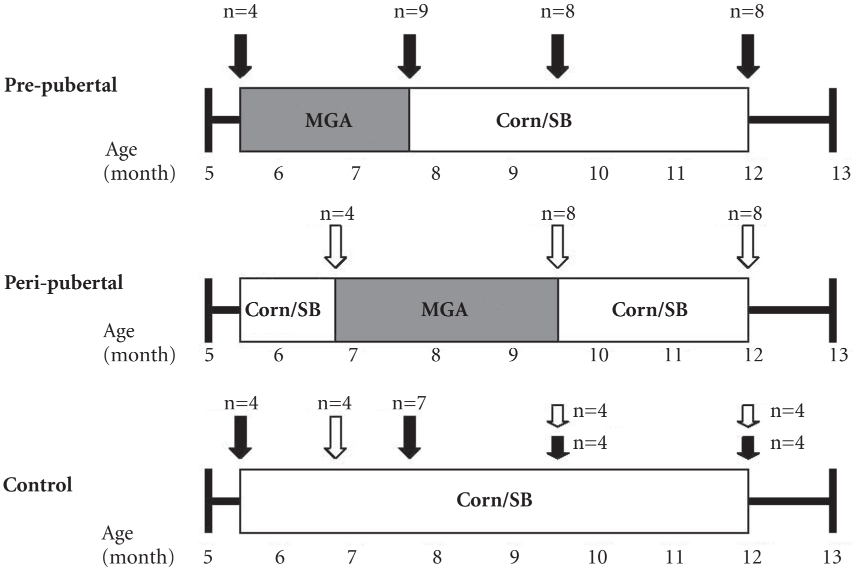

Figure 1. **Schematic of treatment groups and when MGA was administered to bulls, blood samples were collected, and bulls were castrated. Black arrows represent when PRE and CON bull blood samples, SC, and BW were taken. Numbers above the arrows represent the number of bulls from PRE and CON that were castrated. Open arrows represent when PERI and CON bull blood samples, SC, and BW were collected. Numbers above open arrows represent the number of bulls that were castrated at that collection.**

Testis Weight

Bulls in the PRE group had greater right testis weight (RTW; 484.9 ± 19.5 g; Figure 3; $P = <0.001$) at 12 months of age when compared to PERI (365.8 ± 19.8 g) and were not different from CON ($P = 0.17$; 457.1 ± 23.0 g). Similarly at 12 months, bulls in the PRE group tended to have heavier combined testis weight (CTW; 821.7 ± 33.9 g; Figure 4) when compared to the CON ($P = 0.08$; 751.5 ± 39.9 g) and PERI ($P = 0.06$; 683.8 ± 34.3 g). Bulls in the PERI group had lighter RTW ($P = 0.01$; 365.8 ± 19.8 g) compared to CON (457.1 ± 23.0 g) at 12 months of age.

Testosterone

Feeding MGA pre- and peri-pubertally, affected all testosterone concentration measurements and treatment groups except for the 5.5 month measurement, which showed no difference between groups. The bulls in the PERI group (2.48 ± 0.47ng/ml; Figure 5) resulted in an increased ($P = 0.003$) concentration of testosterone at 6.75 months compared to the CON (0.06 ± 0.40 ng/ml) and increased ($P = 0.02$) testosterone concentration compared the PRE (1.06 ± 0.40 ng/ml). The bulls in the PRE group (1.56 ± 0.41 ng/ml) tended to have an increased ($P = 0.08$) testosterone concentration at 7.5 months when compared to PERI (0.40 ± 0.51 ng/ml). The PERI bulls (2.61 ± 0.51 ng/ml) also showed a decrease ($P = <0.001$) in testosterone compared to the CON (6.50 ± 0.84 ng/ml) and the PRE (6.19 ± 0.51 ng/ml) groups at 9 months. At 12 months of age, bulls in the PRE group (7.14 ± 0.73 ng/ml) tended to have lower testosterone concentrations ($P = 0.07$) compared to the CON (8.98 ± 0.84 ng/ml) and had lower concentrations of testosterone ($P = 0.04$) than the PERI group (9.22 ± 0.73 ng/ml).

Body Weight

Feeding MGA increased BW in the PRE group (1115 ± 26.08 lb; Figure 6; $P = 0.05$) compared to the CON (1,040 ± 27.23 lb) and tended to be heavier ($P = 0.08$) then the PERI group (1,043

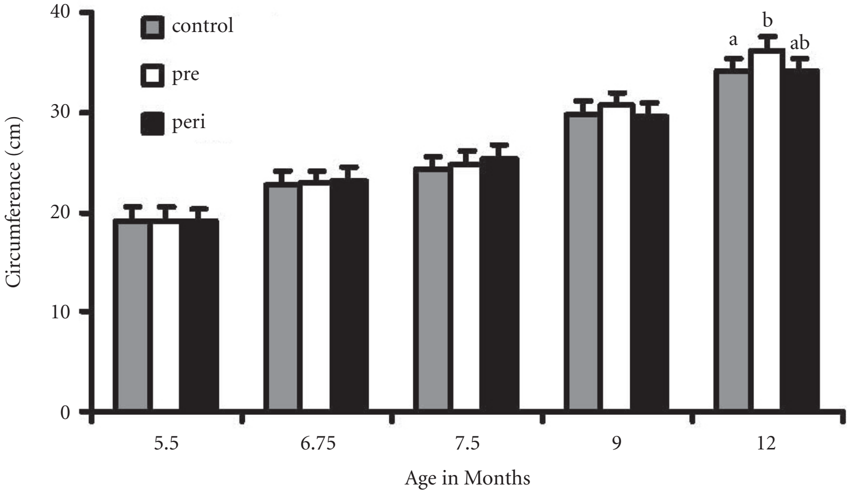

Figure 2. **Effect of feeding MGA on scrotal circumference (SC) during the pre- and peri-pubertal period in bulls.**
^{ab}Means within time point without a common superscript differ ($P \leq 0.05$).

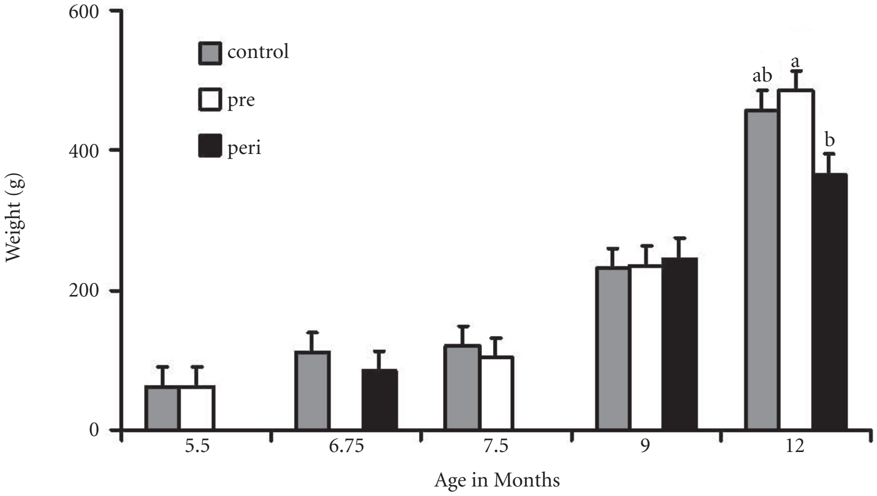

Figure 3. **Effect of feeding MGA on right testis weight (RTW) during the pre- and peri-pubertal period in bulls.**
^{ab}Means within time point without a common superscript differ ($P \leq 0.05$).

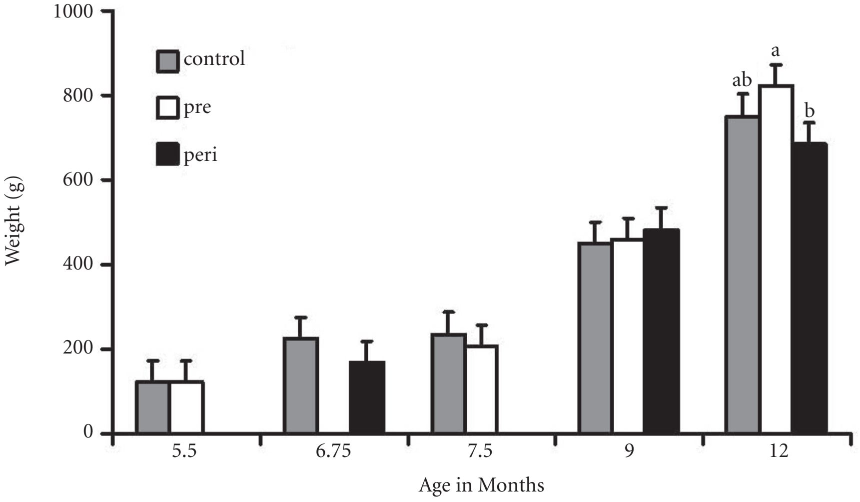

Figure 4. **Effect of feeding MGA on combined testis weight (CTW) during the pre- and peri-pubertal period in bulls.**
^{ab}Means within time point without a common superscript differ ($P \leq 0.05$).

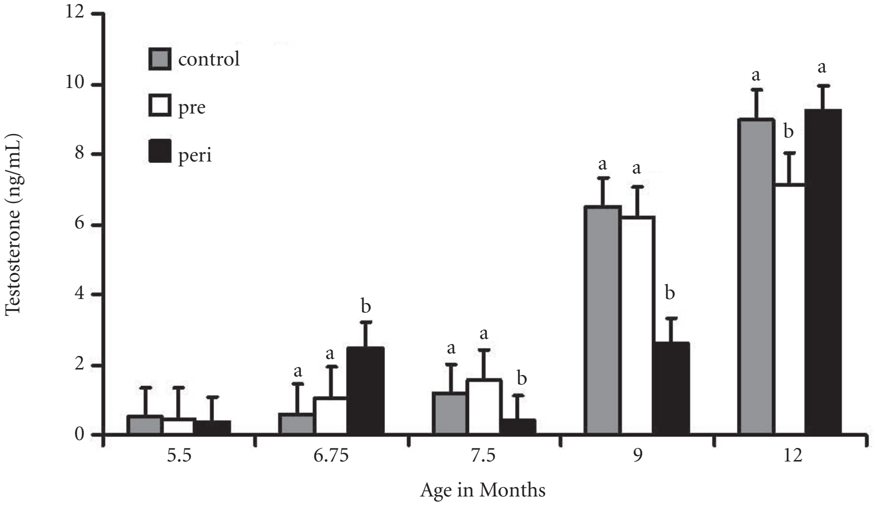

Figure 5. Effect of feeding MGA on testostesrone (T) concentration during the pre- and peri-pubertal period in bulls.
^{ab}**means within time point without a common superscript differ (*P*≤0.05).**

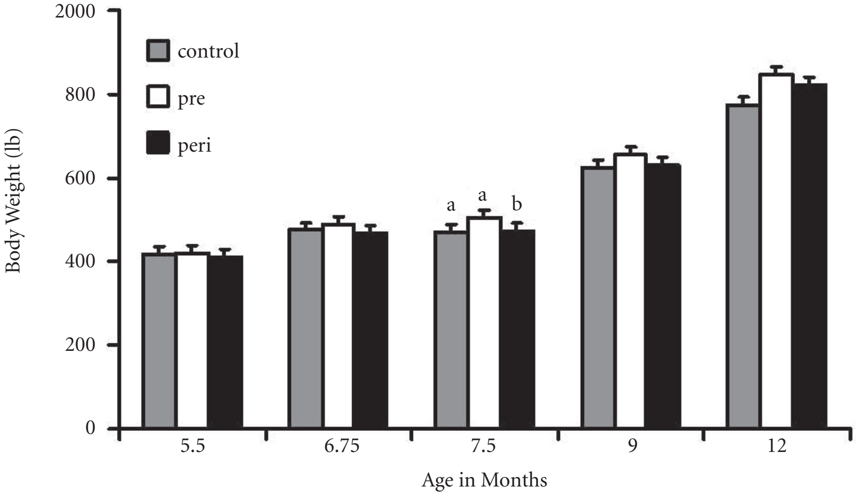

Figure 6. Effect of feeding MGA on body weight (BW) during the pre- and peri-pubertal period in bulls.
^{ab}**means within time point without a common superscript differ (*P*≤0.05).**

± 32.61 lb) at 7 months of age. At 12 months of age, the bulls of the PRE group (1,872 ± 46.14 lb) tended to have an increased (*P* = 0.06) bodyweight in comparison to the CON (1,750 ± 53.46 lb).

Testis Composition: Interstitium vs. Seminiferous Tubule Area

Differences between treatment groups at any of the measurements for either interstitium or seminiferous tubule area were not apparent. Seminiferous tubules contain developing sperm and if this area was larger we might speculate an increase in number or capacity of spermatogenesis. Cells within the interstitium produce androgens such as testosterone. Thus, an increase in the area of these cells might suggest a greater capacity in the testis to produce testosterone. Since we did see a difference in scrotal circumference and testis weight, this suggests that overall size of the testis was larger in PRE vs. CON treatments with no changes in composition of the internal testis compartments.

In this experiment, pre-pubertal MGA feeding increased scrotal circumference, testis weight and decreased testosterone at 12 months compared to the control and the peri-pubertal treatments. Thus feeding MGA during different stages of pre- and peri-pubertal development can alter testosterone development and may increase spermatogenic capacity of the testis. Since no seminal characteristics were evaluated further research needs to be conducted to determine if sperm characteristics (volume, motility, etc) were also enhanced.

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[1] Racheal G. Slattery, graduate student; Shantille G. Kruse, undergraduate student; Daniel M. Larson, graduate student; Jeremy L. Martin, graduate student; Michelle M. Baltes-Breitwisch, former graduate student and laboratory manager; Debra T. Clopton, research analyst; Karl V. Moline, cow/calf manager; Jeff W. Bergman, agriculture technician; and Andrea S. Cupp, associate professor, Animal Science, Lincoln.

Effects of Summer Climatic Conditions on Body Temperature in Beef Cows

Darci A. McGee
Rick J. Rasby
Merlyn K. Nielsen
Terry L. Mader[1]

Summary

Tympanic and vaginal temperature logging devices were used to collect internal body temperature in three trials using mature nonpregnant beef cows. A model was developed to predict daily patterns for internal body temperature of a cow as a function of ambient temperature. Panting scores were recorded and differed across days as cows experienced changes in ambient temperature and humidity. Vaginal and tympanic temperatures were positively correlated, thus tympanic temperature may be used to predict internal body temperature of cows.

Introduction

In cow-calf production systems, reproductive performance is essential to the success and profitability of the enterprise. Heat stress can delay puberty in heifers, cause anestrous in cows, depress estrus activity, induce abortions, and increase perinatal mortality. Effects of heat stress on fertility are prominent when occurring at or near the time of estrus. The mean body temperature of cows is 101.4° to 101.5°F. Indicators of heat stress in cattle include elevated rectal body temperature and an increase in respiration rate.

Most beef cows and heifers are bred in late spring through midsummer when environmental conditions may cause heat stress and affect reproductive performance. The objective of this study was to determine the effect of heat-stress indicators on internal body temperature and panting scores of beef cows in a dry-lot setting and to determine the relationship between vaginal and tympanic temperatures.

Procedure

Three trials using mature, nonpregnant crossbred cows were conducted to determine effects on internal body temperature during the spring/summer. To monitor internal body temperature, a modified CIDR containing a logging device with a resolution of 0.5°C was inserted into the vaginal cavity of each animal. The loggers were deployed to record internal body temperature every 60 minutes for each trial period.

Trial 1 occurred in late June and early July 2006. Body temperatures were measured in mature, nonpregnant beef cows (n = 20; BW = 1,270 lb; BCS = 5.9) for a 14-day period in a dry-lot at the ARDC feedlot facility near Mead, Neb. Besides body temperature, panting scores were recorded during the final 6 days of the trial period. Panting scores were assigned to individual animals between 1400 and 1500 in the afternoon (CDT) by visual observation using the scoring system presented in Table 1. Trial 2 was conducted in late July to August 2006, using nonpregnant beef cows (n = 20; BW = 1,270 lb; BCS = 5.9) for a 14-day period in a dry-lot at the ARDC feedlot facility near Mead, Neb. Body temperature and panting scores were recorded throughout the entire trial period. Panting scores were assigned to each animal between 1400 and 1500 CDT by visual observation.

Environmental conditions were also monitored and obtained from weather stations located near all sites for each of the trials. The weather history was downloaded in a daily format and included minimum and maximum temperature as well as average relative humidity. The average temperature and average relative humidity were used to calculate the Temperature-Humidity Index (THI) for each day using the following equation: $THI = Temperature-(.55-(.55x(RH/100))) \; x \; (Temperature-58)$.

Trial 3 was completed in April 2007, with nonpregnant beef cows (n = 20; BW = 1270 lb; BCS = 5.6) used for a period of 7 days to determine the correlation between vaginal and tympanic temperatures. Temperatures were measured in both the tympanic and vaginal areas using a logging device with 0.125°C resolution.

Body temperature and panting score data were analyzed using the mixed procedures of SAS with cow effects assumed random. Hourly body temperature was fit to a Fourier series (sine plus cosine) model. After examining multiple models, the best fitting model retained periodicities of 12, 10, 9, 8, and 7 hours. This model, accounting also for the interaction with ambient temperature, was used to predict internal body temperature patterns in cows when subjected to different daily maximum temperatures. The correlation between vaginal and tympanic temperatures was estimated using SAS.

Results

Figures 1, 2, and 3 depict the average body temperature of a cow on

Table 1. Panting scores assigned to cows.

Score	Description
0	Normal respiration
1	Elevated respiration
2	Moderate panting and/or presence of drool or small amount of saliva
3	Heavy open-mouthed panting; saliva usually present
4	Severe open-mouthed panting accompanied by protruding tongue and excessive salivation; usually with neck extended forward

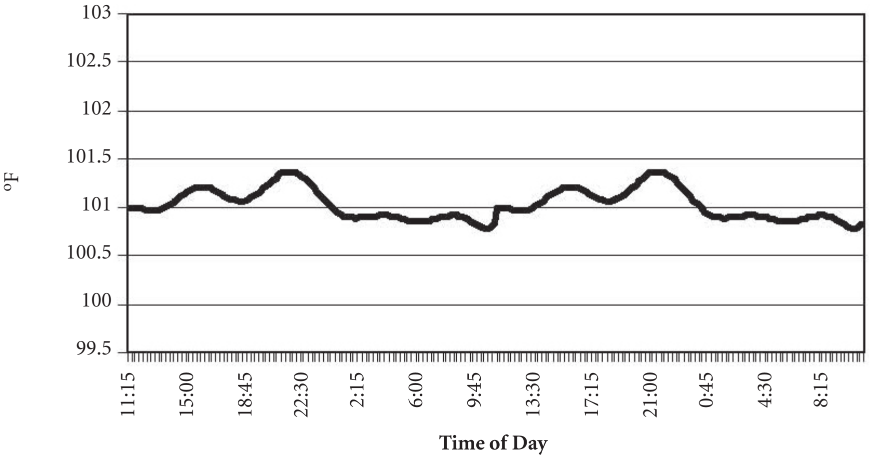

Figure 1. **Cow body temperature (°F) within time of day over a 48-hour period when 70°F is the maximum daily temperature.**

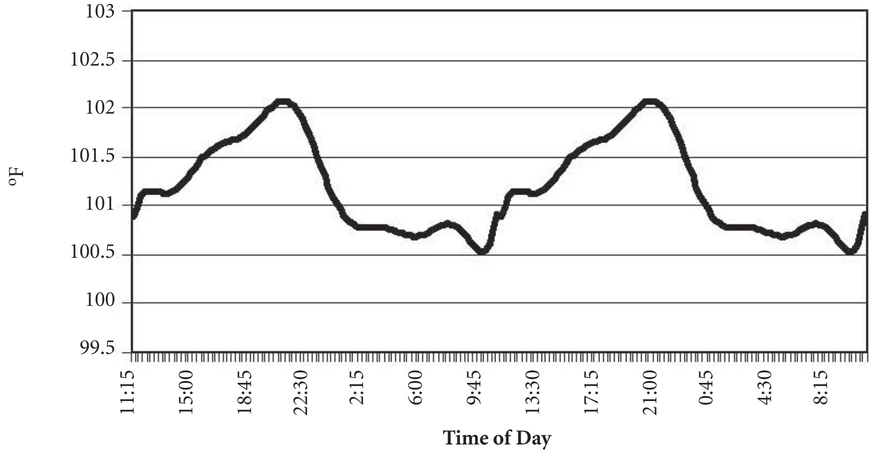

Figure 2. **Cow body temperature (°F) within time of day over 48-hour period when 80°F is the maximum daily temperature.**

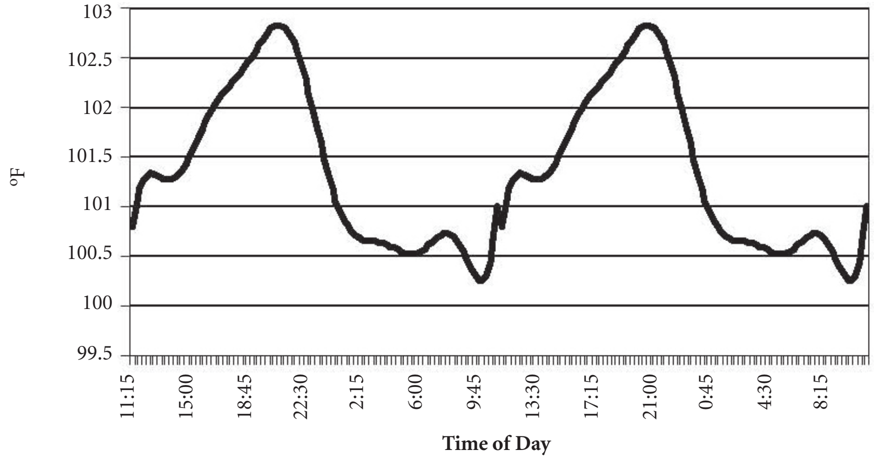

Figure 3. **Cow body temperature (°F) within time of day over 48-hour period when 90°F is the maximum daily temperature.**

days when the maximum temperature reached either 70°, 80°, or 90°F, based on data from Trial 2. The body temperatures are displayed starting at 1115 CDT and continue for a 48-hour time period to get a clear picture of the pattern. When cows experienced a 70°F day, there appeared to be little variation in body temperature and it deflects minimally from normal body temperature of 101.4°F (Figure 1). When beef cows are subjected to environmental temperature of 80°F to 90°F, there was a greater deflection from normal body temperature (Figures 2 and 3). Cows took on a heat load during the day, and if environmental conditions were conducive, the heat load was dissipated during the evening hours. Body temperatures approached 103°F on a day when environmental temperatures were 90°F.

Table 2 illustrates the low, high, and average ambient temperatures, humidity, and THI index for the last 6 days of Trial 1 during June and July. Table 3 depicts the percentage of cows that exhibited 0, 1, 2, 3, or 4 on the panting score scale during this period. A regression was performed on panting score using ambient temperature ($p = 0.335$), humidity ($p < .0001$) and THI ($p < .0001$) as the variables. As temperature, humidity, and THI increase, a larger percentage of cows exhibited a panting score of 1 or 2. On days 5 and 6, the cows were subjected to heat loads due to high temperature and humidity, and there were more cows with a panting score of 2. Prior to days 5 and 6, cows had panting scores of 0 and 1 when environmental conditions were less adverse and the cattle were able to accumulate and dissipate a heat load more effectively.

The correlation between vaginal and tympanic temperatures was significant ($p < .0001$) at 0.83. At this level of correlation, tympanic temperature can be used to predict internal body temperature. Tympanic temperatures would be useful for research protocols that preclude using vaginal temperature measurement.

These preliminary data will enable us to better understand the impact

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of the environmental conditions that impact reproductive performance of beef females. Future research will be aimed at modeling body temperature when environmental conditions are not conducive to dissipation of a heat load, such as high temperature and high humidity that extend into the night when heat load accumulated during the day is typically lost.

Table 2. Temperature (ºF), humidity (%), and Temperature-Humidity Index (THI) by day—trial 1.

Day	Temperature			Humidity			THI		
	L[a]	H	A	L	H	A	L	H	A
1	63.4	81.2	72.5	49.2	95.2	71.6	63.1	75.6	69.9
2	62.7	89.4	76.3	44.7	100	75.0	62.7	79.8	72.8
3	68.3	74.4	71.0	92.1	100	96.5	68.2	73.4	70.7
4	68.3	80.8	74.3	61.5	100	84.4	68.0	76.7	72.5
5	62.8	86.3	75.3	52.5	100	80.0	62.8	79.0	72.7
6	69.0	93.6	77.3	55.7	100	85.2	66.3	93.0	85.8

[a]L = low, H = high, A = average (over 24-hour period).

Table 3. Percentage of cows displaying specific panting scores by day—trial 1.

Day	0	1	2	3	4
1	75	25	0	0	0
2	80	20	0	0	0
3	20	80	0	0	0
4	30	70	0	0	0
5	0	75	25	0	0
6	0	65	35	0	0

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[1] Darci A. McGee, graduate student; Rick J. Rasby, professor; and Merlyn K. Nielsen, professor, Animal Science, Lincoln. Terry L. Mader, professor, Animal Science, Haskell Agricultural Laboratory, Northeast Research and Extension Center, Concord.

Supplementing Beef Cows Grazing Cornstalk Residue with a Distillers Based Cube

Zachary C. Hall
Rick J. Rasby
Mark Dragastin[1]

Summary

A 4-year study is being conducted to determine the effect of excess undegradable intake protein supplementation using a cube that is 2/3 dried distillers grains (DDG) to beef cows in late gestation on cow and calf performance and the performance of heifer calves whose dams were supplemented with protein. Feeding a supplement containing DDG did not influence calf birth and weaning weights, cow body weight prior to calving, and calving interval. Cow body condition score and percentage of cows cyclic prior to breeding increased for supplemented cows.

Introduction

Profitability for cow/calf producers is driven by reproduction. Beef cow reproductive performance is directly related to body condition. The greatest cost to cow/calf enterprises is the feeding of stored feeds through winter months. Wintering cows on cornstalk residue is a common practice for cow/calf producers in Nebraska and across the corn-belt region. As the ethanol industry expands, the availability of dried distillers grains (DDG) will become more accessible for cow/calf producers. Dried distillers grains are an excellent protein and energy source; therefore, they can be used as a supplement when grazing medium to low-quality forages.

Supplementing protein during the last trimester may impact the cow's female offspring by altering development of the reproductive axis, growth and development of the fetus, and subsequent performance of the female offspring. The objectives of our study are to assess the effects of supplementing undegradable intake protein (UIP) to beef cows while grazing cornstalk residue on cow and calf performance and fetal programming.

Procedure

Multiparous, crossbred, spring-calving beef cows are being used in a 4-year experiment conducted at the University of Nebraska–Lincoln, Dalbey-Halleck Research Unit near Virginia, Neb. In each year, cows are blocked by age, BCS, weight and calving interval and assigned randomly to one of two treatments: supplemented (SUPP; n = 247) with protein (25% CP, 7.10% fat) in the form of a range cube that was approximately 2/3 DDG while grazing cornstalk residue during the last trimester of pregnancy, or not supplemented (CON; n = 247) during the last trimester while grazing cornstalk residue.

Changes in body weight and body condition score (BCS) are used as predictors of nutritional status and are recorded three times annually: October, February, and May (weaning/stalks initial weight; off stalks weight/pre-calving; and pre-breeding, respectfully). Body condition scores are assigned independently by two technicians each time the cows are weighed. Cows are weighed once, without restriction of feed or water, in October, and 2-day weights and BCS are collected in February when cows are removed from the residue fields. Weights and BCS are recorded 10 days apart in May prior to the initiation of the breeding season. Calving season begins approximately the first of March and weaning occurs in mid-October of each year. Calf birth weights are recorded within 24 hours of parturition. Calf weaning weights are evaluated on an adjusted weight basis using to BIF guidelines. Cows are exposed to fertile bulls for a 62-day breeding season beginning approximately May 23 of each year. Pregnancy is diagnosed via rectal palpation approximately 60-days after the end of the breeding season.

Corn ear-drop is estimated prior to grazing in two 178 acre, irrigated cornstalk residue fields located on the same section of land near Pickerell, Neb. An equation developed by Wilson, et al., (*2004 Nebraska Beef Report*, pp. 13-15) is used to determine residue grazing days. SUPP cows receive on average 2.2 lb/cow supplement daily on a DM basis three times per week throughout the supplementation period until the start of the calving season. After calving begins, the two treatment groups are combined and managed as a single group on dormant pasture and fed a base diet consisting of smooth bromegrass and alfalfa hay.

Heifers are developed in a pasture then in a dry-lot from October to the end of May each year. An initial and final BCS are recorded and BW are collected 14 days apart until the beginning of the breeding season. Heifers are fed smooth bromegrass hay ad libitum and fed DDG at a rate of 0.6% BW on a DM basis. Diets are adjusted monthly to target an ADG of 1.3 lb/heifer.

Blood samples are drawn from cows 10 days apart immediately before the start of the breeding season to determine serum progesterone concentrations to assess ovarian luteal activity. Blood samples are drawn 14 days apart beginning in December (year 1) and January (year 2) to determine when heifers became pubertal. Serum progesterone concentrations were determined by radioimmunoassay. Serum progesterone concentrations $\geq$ 1 ng/mL are used to determine if a cow has resumed ovarian luteal activity or a heifer has become pubertal.

Estrus in heifers is synchronized using two injections of prostaglandin $F_{2\alpha}$ (PGF) administered 14-days apart with an 18 gauge, 1.5 inch needle. Estrus detection is performed for 5

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days following the second PGF injection, and heifers observed in estrus are bred by artificial insemination (AI) approximately 12 hours later. Heifers are then exposed to fertile bulls for approximately 45 days while grazing pastures beginning 10 days after the final AI on May 27 (year 1) and May 23 (year 2). Conception rates to AI are determined via transrectal ultrasonography approximately 45 days after the final AI on July 18 (year 1) and July 6 (year 2). A second ultrasound 45 days following removal of bulls is performed to determine final pregnancy rates.

Performance data and age at puberty were analyzed using PROC MIXED of SAS. Percentage of heifers reaching puberty, estrous synchronization response, conception rate to AI, pregnancy rates, and percentage of cows cyclic prior to the initiation of the breeding season were analyzed using Chi-square procedures in PROC GENMOD of SAS. Carryover effects from the previous year's treatment were analyzed as a covariate in multi-year analyses.

Results

Cornstalk residue grazing periods averaged 89 days while supplementation periods averaged 108 days and ear drop averaged 1.1 bu/ac. Cow performance and body condition data are presented in Table 1. No carryover effects from year 1 to year 2 were noted. There was no difference between groups in BW in October, February, and May and no significant change in BW from pre-calving to pre-breeding. However, SUPP cows gained more weight during the cornstalk grazing period than CON cows (63 lb vs. 51 lb, respectively). From the end of cornstalk grazing until prior to the start of the breeding season, both groups lost a similar amount of BW.

Initial BCS in October was similar between groups. Body condition scores were different in February (end of cornstalk grazing) and in May (prior to the breeding season) and were greater (*P* = 0.001) for SUPP

Table 1. Performance of cows that were either supplemented or not supplemented with a distillers grains based cube in late gestation while grazing corn stalk residue.

	SUPP[a]	CON[b]	*P*-value
Oct. Wt, lb	1279	1282	0.81
Feb. Wt, lb	1342	1333	0.41
May Wt, lb	1258	1236	0.16
Change in Wt, Oct. - Feb., lb	63	51	0.008
Change in Wt, Feb. - May, lb	-96	-97	0.95
BCS, Oct.	5.5	5.5	0.59
BCS, Feb.	5.8	5.5	0.001
BCS, May	5.6	5.4	0.001
Change in BCS, Oct. - Feb.	0.3	0.0	0.001
Change in BCS, Feb. - May	-0.1	-0.2	0.30
Cows cyclic prior to breeding[c], %	84.5	76.0	0.06
Cow pregnancy rate	92.0	95.0	0.28
Calving interval	365	365	0.70
Calf birth wt, lb	87	87	0.83
Calf weaning wt, lb[d]	547	548	0.86

[a] Cows receiving protein supplement during the final trimester.
[b] Cows not receiving protein supplement during the final trimester.
[c] Percentage of cows that had resumed ovarian activity prior to the breeding season.
[d] Calf weaning weight adjusted for age of dam, age of calf, and calf sex.

Table 2. Performance of heifers whose dams were either supplemented or not supplemented in late gestation[a].

	Year 1		Year 2		Year
	SUPP[b]	CON[c]	SUPP[b]	CON[c]	*P*-value
Initial wt, lb	573	577	569	579	0.83
Final wt, lb	816	817	771	773	0.001
Initial BCS	5.4	5.4	5.6	5.6	0.001
Final BCS	5.7	5.7	5.4	5.4	0.001
ADG[d], lb	1.27	1.28	0.89	0.86	0.01

[a] Treatment means are presented by year due to a year effect for final weight, initial BCS, final BCS and ADG.
[b] Heifers from dams receiving protein supplement during the final trimester.
[c] Heifers from dams not receiving protein supplement during the final trimester.
[d] Calculated ADG from weaning to breeding.

Table 3. Reproductive performance of heifers whose dams were either supplemented or not supplemented in late gestation.

	SUPP[a]	CON[b]	P-value
Age at puberty, day	315	326	0.08
Estrus response[c], %	85.0	84.2	0.88
Time of estrus, hours[d]	67.7	69.2	0.66
AI conception rate[f], %			
Year 1	65.4	50.0	0.29
Year 2	72.0	85.7	0.22
AI pregnancy rate[g], %			
Year 1	56.7	37.0	0.14
Year 2	60.0	80.0	0.09
Overall pregnancy rate[eh], %	86.7	85.2	0.87

[a] Heifers from dams receiving protein supplement during final trimester.
[b] Heifers from dams not receiving protein supplement during final trimester.
[c] Percentage of heifers detected in estrus within 5 days following second PGF injection.
[d] Time elapsed between second PGF injection and observed standing estrus.
[e] Data presented for year 1 only.
[f] Proportion of heifers detected in estrus that conceived to AI service.
[g] Percentage of total group of heifers that conceived to AI service.
[h] Percentage of total group of heifers that became pregnant.

compared to CON cows. The magnitude of these changes in BCS likely have limited biological significance, especially when BCS is greater than 5.0 at all dates it was recorded. Calf birth and adjusted weaning weights were not influenced by dam supplementation strategy. Percentage of cows pregnant was not different for SUPP or CON cows. Calving interval was similar between groups; however, percentage of cows cyclic prior to breeding tended ($P = 0.06$) to be greater for SUPP cows compared to CON cows. Calving interval between the treatment groups is similar because the breeding season begins at a fixed date each year. The restricted breeding season does not allow cows that become cyclic early the opportunity to rebreed.

Heifer performance is reported in Table 2. Analyses indicate a significant year effect. Heifers from SUPP and CON dams did not differ in initial weight. Final weight, initial BCS, final BCS, and ADG did not differ between SUPP and CON heifers within year. Final weight, initial BCS, final BCS, and ADG were greater in year 1 than year 2. The lighter final weights and lower ADG in year 2 were likely due to the lower ambient temperature and greater precipitation during the winter feeding period in 2007 compared to 2006.

Heifer reproductive performance is presented in Table 3. Age at puberty tended to be lower ($P = 0.08$) for heifers from SUPP vs. CON dams. There was no difference in percentage responding to synchronization or the hours from the last PGF injection to estrus. In year 1, there was a tendency ($P = 0.14$) for heifers from SUPP dams to have a higher AI pregnancy rate. In year 2, heifers from CON dams tended ($P = 0.09$) to have a higher AI pregnancy rate. AI conception rate and overall pregnancy rate did not differ between treatments in either year.

Conclusions

Based on the first two years of this study, incorporating DDG in supplement for cows grazing cornstalk residue in their final trimester tends to increase the percentage of cows cycling prior to the start of the breeding season. More research is needed to determine the effect of supplementation during late gestation on the reproductive performance of the resulting heifer calves.

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[1] Zachary Hall, graduate student; and Rick J. Rasby, professor, Animal Science, Lincoln. Mark Dragastin, Dalbey-Halleck Research Unit, unit manager, Virginia.

Comparison of Crude Protein and Digestibility of Diets of Grazing Cattle at Different Sandhills Range Sites

Bobbi Gene Geisert
Terry J. Klopfenstein
Don C. Adams
Jackie A. Musgrave[1]
John Maddux[2]

Summary

Diet samples were collected May through September (2003) and May through November (2004) using esophageally fistulated cows at ranches in the Sandhills and southwest Nebraska. Differences in CP between the two locations were significant. Diets collected in May and June had higher CP ($P = 0.04$) than those collected in August through November. No interactions were detected between year and location in diet digestibility and diet digestibility was similar for southwest Nebraska and Sandhills diets.

Introduction

Grazing native range pastures year-round is one way producers can decrease feed costs. Protein content and DM digestibility of diets consumed by grazing cattle varied among seasons (*1997 Nebraska Beef Report*, pp. 3-5). Diets consumed during the plant's growing season changed rapidly as the plants grow and mature. However, during the dormant season, diet digestibility and protein content were not as variable.

Differences in plant species and the proportion of each species among range sites can alter diet composition of grazing cattle making it difficult to compare diet quality among different range locations across Nebraska. The objective of this study was to compare diet CP and *in-vitro* IVOMD of two ranches in Nebraska.

Procedure

Diet samples were collected using three esophageally fistulated cows from May 2003 to September 2003; and May 2004 to November 2004. Pastures were sampled at the Gudmundsen Sandhills Laboratory (GSL) near Whitman, Neb. and the Maddux Ranch near Wauneta, Neb. Two pastures were sampled at the Maddux Ranch and one pasture was sampled at the Gudmundsen Sandhills Laboratory. Pastures in both locations were grazed during the collection periods only by the fistulated cows during the time of collection. Samples were collected every three weeks during the growing season and monthly during the dormant season (September through November). Eighteen samples were collected in 2003 and 24 in 2004 at each location.

Samples were immediately frozen after collection. They were then freeze-dried and ground through a Wiley Mill (1 mm screen), and analyzed for CP and IVOMD. The IVOMD procedure included 5 forage standards developed by Geisert et al., (*2007 Nebraska Beef Report*, pp. 109) with known *in vivo* digestibilities. Statistical analysis was conducted using the mixed procedures of SAS.

Results and Discussion

Diet samples have not been collected previously in southwest Nebraska; therefore, the analyses for these samples are presented separate from the GSL samples (Table 1). Digestibility of diets collected at Maddux differed ($P < 0.01$) by month. Diets collected in May and June had higher IVOMD than those collected in August through November. During May and June, the leaf to stem ratio is high and so is digestibility. Warm-season plants begin to mature and reproduce in July and early August. By September these plants are dormant and the mature plant material is lower in digestibility. Crude protein (Table 1) of diets collected at Maddux differed by month ($P < 0.01$). Protein was highest in May and June then decreased throughout the remaining summer and fall. Advancing season decreased CP of diets collected from grazing cattle. Similar trends for diet digestibility and CP in diets collected at GSL were reported by Lardy et al. (*1997 Nebraska Beef Report*, pp. 3-5). Digestibilities in that trial were not adjusted to *in vivo* values and were higher during the growing (63.8 %) and dormant (53.3 %) seasons than reported here.

No interactions ($P > 0.09$) between year, month and location were detected for CP, IVDMD, or IVOMD; therefore, the data from both locations are combined in Tables 2 and 3. There was a significant difference ($P = 0.04$) in CP between the two locations with average CP values of 10.8% and 12.9% for GSL and Maddux respectively (Table 3). Diets collected in May and June were higher in CP ($P = 0.04$) than those collected in the late summer and early fall (Table 2). This agrees with other pasture data from western Nebraska (*1997 Nebraska Beef Report*, pp. 3-5; *2007 Nebraska Beef Report*, pp. 109).

There was no effect of location on IVOMD (61.9% and 61.5 % for Maddux and GSL, respectively; Table 3).

Table 1. Composition (% of DM) of diet samples collected at Maddux ranch.

	Month							Statistics		
Variable	May	June	July	Aug	Sept	Oct	Nov	SEM	Month[a]	LSD[b]
IVDMD	60.6	63.0	60.7	56.7	54.2	46.1	42.3	2.5	<0.01	8.4
IVOMD	61.9	66.2	62.4	60.6	56.7	52.0	47.1	2.7	<0.01	7.8
CP	16.1	15.1	12.3	12.0	10.1	7.4	6.2	1.1	<0.001	4.6
NDF	62.8	56.4	64.1	66.6	63.6	72.6	75.9	3.6	0.09	11.6

[a] Probability value for effect of month.
[b] Least significant difference.

Table 2. **Monthly CP, IVDMD, IVOMD and NDF (% DM) for diet samples collected at Gudmundsen Sandhills Laboratory and Maddux Ranch (significant month effect P < 0.05 for CP, IVDMD, and IVOMD).**

	Month					Statistics		
Variable	May	June	July	Aug	Sept	SEM	Month[a]	LSD[b]
IVDMD	62.2	64.2	57.7	55.7	51.6	1.8	<0.01	5.9
IVOMD	65.3	66.8	60.5	59.5	56.5	1.7	<0.01	2.0
CP	14.1	13.7	11.5	10.3	9.6	0.7	0.04	2.2
NDF	62.8	56.4	64.1	66.6	63.6	2.4	0.62	6.0

[a]Probability value for effect of month.
[b]Least significant difference.

Table 3. **Year and location effects for diet samples collected at the Gudmundsen Sandhills Laboratory and Maddux Ranch from May through September.**

Variable	Year		Location		Statistics		
(% DM)	2003	2004	GSL	Maddux	SEM	Year[a]	Location[b]
CP	12.0	11.7	10.8[a]	12.9[a]	0.7	0.85	0.04
IVDMD	57.9	58.6	57.6	59.0	1.1	0.63	0.38
IVOMD	60.8	62.6	61.9	61.5	1.1	0.27	0.83
NDF	65.5	64.8	66.4	63.9	1.5	0.75	0.28

[a]*P*-value for year effect.
[b]*P*-value for location effect.

No differences (P = 0.27) were indicated between years on diet IVOMD.

Conclusion

Location affected diet CP, but not IVOMD. The below average annual precipitation at GSL in 2003 and 2004 and potential differences in the plant communities available for grazing may have influenced results. Diets were higher in digestibility and CP content in May and June as compared to those collected in August and September. These data suggest that diet quality of range in southeast Nebraska is similar to that in the Sandhills.

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[1] Bobbi Gene Geisert; graduate student; Terry J. Klopfenstein, professor, Animal Science, Lincoln. Don C. Adams, director, West Central Research and Extension Center, North Platte. Jackie A. Musgrave, research technician, Whitman.

[2] John Maddux, owner/manager, Maddux Ranch, Wauneta.

Determination of Diet Protein and Digestibility of Native Sandhills Upland Range

Bobbi Gene Geisert
Terry J. Klopfenstein
Don C. Adams
Jackie A. Musgrave
Walter H. Schacht[1]

Summary

A significant year by grazing level effect was detected on CP content of diet samples collected from 2003 to 2005 at the Gudmundsen Sandhills Laboratory. During drought years (2003 and 2004) cows selected plants which were higher in CP and lower in digestibility. High levels of grazing pressure decreased diet IVOMD compared to diets from ungrazed and moderately grazed pastures. Prediction models generated from these data predict dietary CP and organic matter disappearance (OMD) of cattle grazing native Sandhills range pastures.

Introduction

When grazing native range year-round, diet quality varies throughout the year and with level of grazing pressure (*1997 Nebraska Beef Report*, pp. 3-5; *2001 Nebraska Beef Report*, pp. 23-25). Lower diet quality during dormant months may increase the need for protein or energy supplements during these periods to meet cow requirements (*1997 Nebraska Beef Report*, pp. 3-5). Reports of diet digestibilities collected by grazing cattle are limited. Lardy et al. (*1997 Nebraska Beef Report*, pp. 3-5) demonstrated that diet DM digestibility of Sandhills upland range is the highest in June and July and decreased through the dormant season. However, these digestibility estimates are relative differences and *in vivo* digestibility was not estimated.

Accurate *in vivo* estimates are necessary to formulate supplements and also needed to predict animal performance. Geisert et al. (*2006 Nebraska Beef Report*, pp. 109) reported a 5 percentage unit difference in OMD between *in vitro* and *in vivo* digestibility of forages. *In vivo* digestibility can be estimated by including a calibration set of samples (with known *in vivo* digestibility) within *in vitro* procedures. Therefore, this study was initiated to determine *in vivo* OMD and CP values of Sandhills Range as influenced by month, year(moisture) and grazing pressure.

Procedure

Diet samples were collected at the Gudmundsen Sandhills Laboratory, Whitman, Neb., using six esophageally fistulated cows. Collections began May 2003 and continued through November 2005. Pastures were chosen for sampling based on the stocking rate prior to sampling. Pastures were separated into three grazing groups: non-grazed (None), medium SR (Med, 0.1 to 0.45 AUM) high stocking rate (High, < 0.5 AUM). One pasture was not grazed and was sampled at every collection time while the remaining three pastures varied based on the ranch's grazing rotation. Diet samples were collected every 3 weeks during the growing season and monthly during the dormant season. Diet samples were frozen immediately following collection, freeze-dried, and ground through a Wiley Mill using a 1 mm screen. Samples were composited by pasture and analyzed for CP and IVOMD.

Precipitation data were collected throughout the trial. Moisture at each collection time was cumulative beginning October 1 of the previous year to two days prior to sampling date. Grazing data were recorded to calculate grazing pressure.

In vitro organic matter disappearance (OMD) was based on five forages with known *in vivo* OMD used as standards. Three separate *in vitro* runs were conducted and all diet sample IVOMD values were adjusted to *in vivo* OMD using regression equations generated from the standards. Regression equations were generated from each *in vitro* run and adjusted for run differences using procedures outlined by Geisert et al., (*2006 Nebraska Beef Report*, pp. 109).

Multiple regression analysis was conducted to generate prediction equations to estimate dietary CP and OMD of diets consumed by grazing cattle in the Sandhills. Variables included in this analysis included moisture, day, and grazing pressure (AUM/ton of forage). The day started on April 1 of each year and continued through March 31 of the following year to follow the forage growth patterns. Grazing pressure (GP) was calculated as AUM/ton of forage produced. Clipped sample data from GSL (1998 through 2006) and Barta Brothers Ranch (1999 through 2006) were used to determine annual forage production. Total forage production was estimated using the regression equation; $y = 71.056x + 412.47$ ($R^2 = 0.3575$) where y = forage yield and x = moisture. The total forage yield was adjusted based on forage growth curves for the Sandhills region from the NRCS using the equation $y = 1.953E07x^4 - 1.692\ E05x^3 + 0.0498x^2 - 5.244x + 178.284$ ($R^2 = 0.9948$) where y = forage yield and x = moisture.

Statistical analysis to separate variable differences was conducted using the mixed model in SAS. The regression procedures of SAS were used to analyze prediction equations.

Table 1. Year by grazing effect on CP% values of diets collected from cows grazing upland range pastures.

	Grazing Pressure			
Year	None[2]	Med[3]	High[4]	SEM
2003	8.5^{a}	8.0^{a}	9.1^{a}	0.6
2004	9.4^{a}	8.6^{a}	8.5^{ac}	0.5
2005	9.5^{ac}	9.0^{ac}	7.1^{ab}	0.4

[1] Year x grazing pressure interaction ($P = 0.04$).
[2] Means un-grazed pastures.
[2] Means moderately grazed pastures.
[4] Means heavily grazed pastures.

Table 2. Monthly average IVOMD and CP (% DM) values of diet samples from native Sandhills upland range pastures.

	IVOMD				
Sample Date	Ave[1]	High[2]	Med[3]	None[4]	CP[5]
January	54.2	52.2	56.5	53.0	6.9
February	54.6	53.0	55.9	55.0	6.2
March	52.6	53.5	52.7	52.0	7.4
April	59.5	60.5	60.9	62.8	8.0
May	65.8	62.5	67.5	67.2	12.4
June	62.6	62.6	61.8	63.4	10.8
July	55.9	50.7	57.0	60.0	11.5
August	55.5	50.9	57.9	57.6	8.9
September	51.4	51.6	47.3	55.2	8.8
October	53.0	50.1	51.7	56.4	7.9
November	51.4	49.4	50.5	54.3	7.6
December	53.9	51.6	51.3	58.7	7.0
Average	55.8	49.3	55.9	58.0	8.6

[1] IVOMD average for all pastures.
[2] IVOMD values for high grazing level.
[3] IVOMD values for moderate grazing levels.
[4] IVOMD values for un-grazed pastures.
[5] CP (% DM) average for all pastures.

Results

Annual precipitation was 13, 15, and 19 inches for 2003, 2004, and 2005, respectively. The average precipitation for this area is between 18 and 20 inches annually. A year by grazing pressure interaction ($P = 0.04$) occurred for CP of diet samples (Table 1). There was no difference in CP among GP in 2003 and 2004 and among Med and un-grazed pastures in 2005. In 2005 High GP decreased CP compared to Med and non-grazing. This could be explained by drought conditions in 2003 and recovering drought conditions in 2004. Cows may have selected plants such as forbs which were generally higher in CP, but lower in digestibility than grasses.

There was a year effect ($P < 0.001$) on IVOMD where 2003 was higher than 2005 with 2004 as intermediate; however year did not interact with GP. The average IVOMD was 59.1%, 55.4% and 53.0% for 2003, 2004, and 2005, respectively. This could be explained by decreased precipitation in 2003 and 2004 delaying plant maturity thus increasing digestibility.

Grazing pressure significantly affected ($P < 0.01$) IVOMD of diet samples where High GP decreased digestibility compared to None with Med intermediate (54.1%, 55.9%, and 58% for High, Med, and None, respectively). Grazing cattle naturally select plants and plant components which are higher in digestibility than what is generally available. As more grazing pressure is applied to a pasture, the availability of highly digestible plants and plant parts decreases, forcing cattle to consume diets with lower digestibility.

Diet IVOMD was ($P < 0.001$) effected by month (Table 2), with diets collected May through July being more digestible than diets collected during the dormant season. Diets collected during the dormant season remained relatively constant in IVOMD and values gradually increased to peak growing season. Lardy et al. (*1997 Nebraska Beef Report*, pp. 3-5) showed similar results where digestibility was the greatest in the growing season and lowest throughout the dormant season.

Regression equations formulated from each *in vitro* run were used to adjust the IVOMD values. These adjustments allow for comparison of samples analyzed in different runs. The average adjustment for all IVOMD runs for the current trial was 3 percentage units. There was a 2 percentage unit difference in digestibility comparing the data set from Lardy et al. *(1997 Nebraska Beef Report*, pp. 3-5), who did not adjust to *in vivo* values, to the data generated from this trial. When comparing IVOMD data from Patterson et al., (*2000 Nebraska Beef Report*, pp 5-6) to IVOMD data from this trial, the average difference is 5.4 percentage units. This is similar to the difference seen by Geisert et al. (*2006 Nebraska Beef Report*, pp. 109).

(Continued on next page)

Table 3. Organic matter digestibility and CP prediction equations for diets consumed by cattle grazing native Sandhills range pastures

Variable	Equation	R²	Model *P*-value
CP	$0.273*D$[a] $-4.56E^{-3}*D2$[b] $+2.86E^{-5}*D3$[c] $-8.01E^{-8}*D4$[d] $+8.345E^{-11}*D5$[e] $+7.88$	0.630	<0.001
OMD			
Early Growing[f]	$3.2825*M$[i] $- 5.7359E^{-4}*D2 - 2.0086E^{-1}*M2$[j] $- 1.67E^{-3}*GP2$[k] $+5\ 4.47846$	0.4590	0.0120
Late Growing[g]	$-0.4268*GP$[l] $-0.76643*M -0.06015*D +0.01070*GP2 +73.98686$	0.3371	0.0025
Dormant[h]	$-0.14294*GP -7.77112*M + 0.1923*M2 + 0.00271*GP2 + 126.15238$	0.5490	<0.001

[a] Means day.
[b] Means day*day.
[c] Means day*day*day.
[d] Means day*day*day*day.
[e] Means day*day*day*day*day.
[f] Means growing season beginning April 1 (day 1) through June 15 (day 76).
[g] Means growing season beginning June 16 (day 77) through Sept. 30 (day 183).
[h] Means dormant season beginning Oct. 1 (day 184) through March 31 (day 365).
[i] Means cumulative moisture.
[j] Means cumulative moisture*cumulative moisture.
[k] Means grazing pressure*grazing pressure.
[l] Means grazing pressure.

However, due to variability among *in vitro* runs, one cannot simply assume a constant adjustment percentage. The regression equation from samples with known digestibility must be generated for each *in vitro* run to appropriately adjust the data, one equation for all runs will not accurately adjust each individual run.

Monthly CP values (Table 2) followed a similar pattern to IVOMD values ($P < 0.001$). These patterns agree with previous data from Lardy et al. (*1997 Nebraska Beef Report*, pp. 3-5) where CP is highest in the growing season and lowest during the dormant months.

Organic matter disappearance prediction equations (Table 3) were separated into three segments; early growing (days 1-76), late growing season (days 77-183) and dormant season (days 184-365). Day 1 was April 1 and day 365 was March 31 of the following year in order to follow the plant growing cycle. Significant variables in the prediction models varied among the three different seasons. Predicted OMD values were not different ($P = 0.9999$) from the observed values in all seasons. When evaluating the prediction of the control pasture (no grazing pressure) the model predicted similar results as seen in the observed OMD results (Figure 1). In 2003, lower moisture increased diet OMD, and increasing moisture in 2004 and 2005 decreased predicted OMD. In order to evaluate the model's ability to predict OMD based on grazing pressure we used 2005 moisture data. When grazing pressure was assumed to be high (32 Animal Unit Days/ton of forage in a deferred grazing system), compared (Figure 2) to no grazing pressure, diet OMD was lower at any time point throughout the year when grazing pressure was considered high.

Conclusions and Implications

For producers, nutritionists or others to accurately predict cattle performance of cattle on pasture using the 1996 NRC Model, it is essential to have appropriate protein and energy values for the grazed forage. By adjusting *in vitro* data to *in vivo*, as was done in this experiment, we believe accurate energy (OMD) values were obtained. By collecting diet samples with fistulated cattle, the samples reflect what cattle in a production setting would eat. Collecting samples over three years differing in rainfall allowed us to estimate the effect of moisture on diet quality. Finally, by collecting samples after known amounts of grazing pressure, the effect of grazing pressure on diet quality was determined.

When all of the data were used in the computer model, three complex equations were developed for the three phases of the growing season. The equations account for advancing plant maturity (day), moisture and grazing pressure. This allows the user to predict forage OMD in a variety of individulized situtions. Model output is illustrated in Figures 1 and 2 where one or more of the variables was held constant. This model has potential for widespread use in Nebraska native pastures.

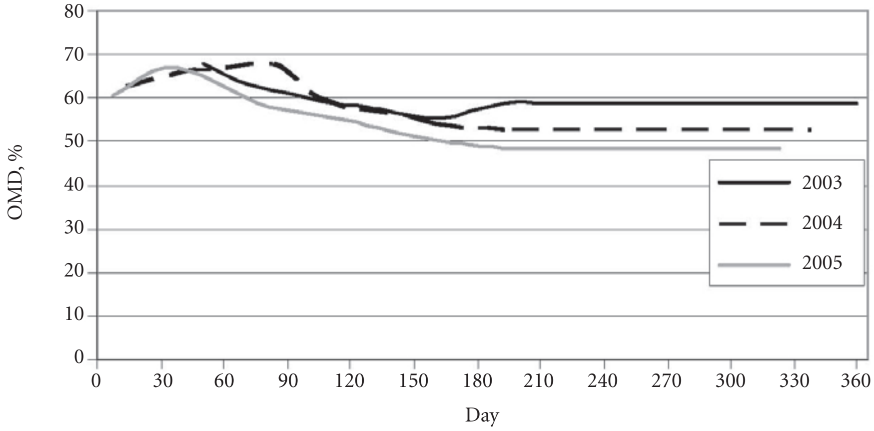

Figure 1. **Seasonal predicted dietary OMD for the control pasture (none-grazed) during three consecutive years.**

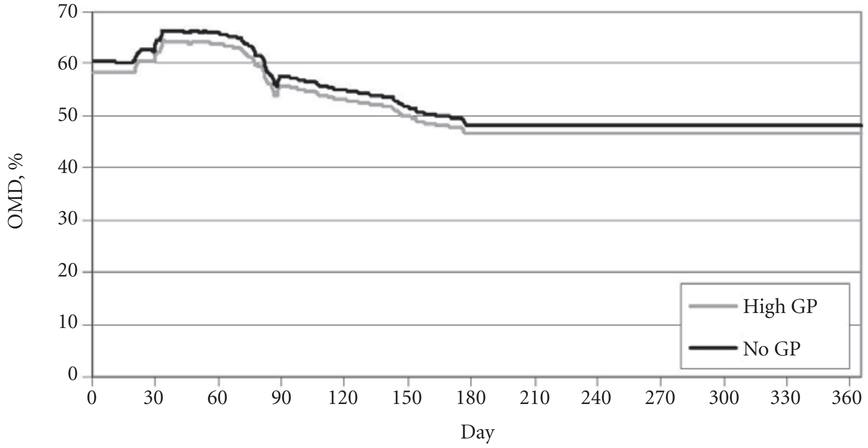

Figure 2. **Grazing pressure effect on predicted dietary OMD values. High grazing pressure assumed at 32 AUD/ton of forage produced.**

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[1] Bobbi Gene Geisert, graduate student; Terry J. Klopfenstein, professor, Animal Science, Lincoln. Don C. Adams, director, West Central Research and Extension Center, North Platte. Jackie A. Musgrave, research technician, Whitman. Walter H. Schacht, professor, Agronomy and Horticulture, Lincoln. The authors would like to express their appreciation to the rest of the crew at the Gudmundsen Sandhills Laboratory for all of their help and hard work.

Evaluation of Storage Methods for Wet Distillers Grains Plus Solubles with Added Forages

Daniel R. Adams
Mallorie F. Wilken
Brandon L. Nuttleman
Luke M. Kovarik
Josh R. Benton
Matt A. Greenquist
Galen E. Erickson
Terry J. Klopfenstein
Rick J. Rasby[1]

Summary

Six experiments indicated minimum amounts of dry feedstuffs needed for storage of wet distillers grains plus solubles (WDGS) in a silo bag, with a constant pressure of 300 psi, were 15% grass hay, 12.5% wheat straw, 22.5% alfalfa hay, 50% dry distillers grains and 60% wet corn gluten feed (WCGF) with the remaining percentage as WDGS (DM basis). For storage in bunker silos, the recommended levels are 40% grass hay, 30% wheat straw and 30% cornstalks.

Introduction

Because WDGS are delivered in semi-load quantities and are perishable in 7 to 10 days, smaller operations may not be able to use WDGS. Similarly, most cow-calf operators do not purchase WDGS because of low feeding rates which can lead to spoilage. Cow-calf operations demand for WDGS is often in the winter. The demand for WDGS in the winter is much higher compared to summer due to a greater number of cattle-on-feed in Nebraska feedlots.

WDGS will keep when oxygen is excluded; however the DM of the traditional WDGS is relatively low (30%-35%). As a result, WDGS by itself is challenging to store in a bunker silo or a silo bag under pressure.

Two other types of byproducts are modified WDGS (DM 45%-50%) and WCGF (DM 45%-60%). These byproducts can be packed into silo bags under pressure but cannot be packed into a bunker silo without additions.

The objective for the first three experiments was to maximize the amount of WDGS stored with adding minimal forages. In the next three experiments, the objective was to mix in larger amounts of low quality forage with the byproducts to obtain greater use of the low quality forages, while storing the wet byproducts.

Procedure

Traditional WDGS were mixed using a truck mounted feed mixer with weighing capability. During all of the bagging experiments, the bagger was held at a constant pressure of 300 psi. All of the grass hay, wheat straw, and cornstalks were ground through a tub grinder with a 5-in screen; alfalfa hay was ground with a 7-in screen. Feed products used in the experiments contained different DM (Table 1), therefore all percentages are presented on a DM basis.

Experiment 1

WDGS were mixed with one of five different feedstuffs including grass hay, alfalfa hay, wheat straw, dry distillers grains (DDGS) and wet corn gluten feed. During the experiment, adjustments were made based on how the different products bagged.

Grass hay was tested at 17.5%, 15%, 12.5%, 10%, and 7.5% with the remaining percentage being WDGS on a DM basis. Alfalfa hay was tested at 25%, 22.5%, 20%, 17.5% and 15% on a DM basis. Wheat straw was mixed with WDGS at 15% and 12.5% DM basis. Ratios of DDGS:WDGS evaluated were 50:50 and 60:40 (DM basis). Wet corn gluten feed was mixed with WDGS at ratios of 40:60 and 50:50, respectively (DM basis).

Experiment 2

Two semi-loads of WDGS were mixed with 30% grass hay and two loads were mixed with 40% grass hay

(Continued on next page)

Table 1. DM of forage and feedstuffs used in six experiments to evaluated storage of WDGS when mixed together.

	%DM
Experiment 1	
Wet distillers grains plus solubles	34%
Grass hay	90%
Alfalfa	90%
Wheat straw	90%
Dry distillers grains plus solubles	90%
Wet corn gluten feed	44%
Experiment 2	
Wet distillers grains plus solubles	34%
Grass hay	90%
Experiment 3	
Wet distillers grains plus solubles	37%
Cornstalks	77%
Experiment 4	
Wet distillers grains plus solubles	34%
Wheat straw	90%
Experiment 5	
Wet distillers grains plus solubles	36%
Corn stalks	83%
Experiment 6	
Wet distillers grain plus solubles	34%
Grass hay	90%

for storage in silo bunkers. A skid loader with rubber tracks was used for packing mixtures in the bunker silos. To test how well the mixture of grass hay and WDGS packed, a pay loader was driven onto the pile to determine if the mixture would maintain the weight of the pay loader.

Experiment 3

Cornstalks (29% of DM) were mixed with WDGS to be packed into a bunker silo. This mixture was packed into the bunker silo using a skid loader with tracks.

Experiment 4

WDGS were mixed with wheat straw at two different levels and stored in silo bags to be used in a feeding study (*2008 Nebraska Beef Cattle Report,* pp 33-34). One mixture was 67% wheat straw and 33% WDGS (DM basis). The other mixture was 33% wheat straw and 67% WDGS (DM basis).

Experiment 5

WDGS were mixed with cornstalks and stored in a silo bag. Cornstalks: WDGS were mixed at a ratio of 50:50 (DM basis).

Experiment 6

In the last experiment, WDGS was mixed with grass hay. Grass hay was mixed with WDGS at a ratio of 56:44 grass hay to WDGS (DM basis). The mixture was stored to be fed over the course of the summer to grazing cattle.

Table 2. Calculations from DM % to as-is % of the minimal levels of WDGS and feedstuffs from Experiment 1.

Product	Ingredient DM, %	% of Mix (DM Basis)	% of Mix/Product DM *100 Parts as-is	% of Mix (As-is basis)	Mixture DM
Grass hay	90.0%	15.0%	16.7	6.2%	37.5%
WDGS	34.0%	85.0%	250.0	93.8%	
% Totals		100.0%	266.7	100.0%	
Alfalfa Hay	90.0%	22.5%	25.0	9.9%	39.5%
WDGS	34.0%	77.5%	227.9	90.1%	
% Totals		100.0%	252.9	100.0%	
Straw Hay	90.0%	12.5%	13.9	5.1%	36.9%
WDGS	34.0%	87.5%	257.3	94.9%	
% Totals		100.0%	271.2	100.0%	
Dry Distillers Grains	90.0%	50.0%	55.5	27.4%	49.4%
WDGS	34.0%	50.0%	147.1	72.6%	
% Totals		100.0%	202.6	100.0%	
Wet Gluten Feed	44.0%	60.0%	136.4	53.7%	39.4%
WDGS	34.0%	40.0%	117.6	46.3%	
% Totals		100.0%	254.0	100.0%	

Figure 1. Picture illustrates the different height and width of silo bags depending on forage or dry feed added. We evaluated the lower limits required and did break the bag when too little forage was added.

Results

Calculations of minimal levels of WDGS and feedstuffs needed to prevent splitting of the bag from Experiment 1 are shown in Table 2. During Experiment 1, the silo bag split open during the bagging process at the 7.5% and 10% grass hay levels. It also split open at the 40% and 50% levels of WCGF. Based on Experiment 2, the minimal level of grass hay with WDGS in a bunker silo was 30% grass hay; however, we recommend the 40% level of grass hay because a skid loader with tracts was used to pack the product into the bunker silo. The skid loader with tracts has a lower lb/in^2 for compaction compared to a pay loader. The 30% grass hay pile was not able to support the weight of the pay loader when compacting the pile.

In all of the experiments, quality of the stored material was good because spoilage did not occur. Exclusion of oxygen is necessary for good storage. Mixtures of 12.5% to 67% (DM basis) wheat straw with WDGS in silo bags were successfully stored. Based on Experiment 1 and Experiment 5, it appears that wheat straw and cornstalks have similar characteristics for storage in a silo bag.

The range of roughage levels that can be used for storing in bunker silos

Figure 2. **A side-by-side comparison of 40% grass hay and WDGS (left) and 30% grass hay and WDGS (right). Bunker sizes are not identical, but more bulk is produced with the 40% grass hay mixture as expected.**

is likely narrower than for bagging, although fewer levels were evaluated. Likely, 30% to 40% roughage with WDGS is appropriate for bunker storage with grass hay or equivalent, and lower levels when using wheat straw or cornstalks.

Producers may need to make adjustments as they store WDGS to make it work within their operations.

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[1] Daniel R. Adams, graduate student; Mallorie F. Wilken, graduate student; Brandon L. Nuttleman, graduate student; Luke M. Kavorik, graduate student; Josh R. Benton, research technician; Matt A. Greenquist, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor; and Rick J. Rasby, professor, Animal Science, Lincoln.

Use of Dried Distiller's Grains to Extend Range Capacity

Kristin H. Gustad
L. Aaron Stalker
Terry J. Klopfenstein
Walter H. Schacht
Don C. Adams
Jackie A. Musgrave
Jerry D. Volesky[1]

Summary

At the University of Nebraska Gudmundsen Sandhills Lab for 60 days from mid-June to mid-August for 2 years (2005 and 2006), 24 paddocks were randomly assigned to one of three treatments. Treatments were control (CON) at the recommended stocking rate and no supplementation, double stocked (2X) or double stocked with 5 lb of DDGS daily (SUP). There was no difference in ADG between the CON and 2X calves; however, SUP calves gained more than the unsupplemented groups. Forage use was not different between SUP (58%) and 2X (62%); however, use was lower for CON group (36%). Distillers dried grains supplementation increased ADG of calves; however, DDGS did not replace or conserve grazed forage such that stocking rate could be increased twofold.

Introduction

The improvement in performance of grazing yearlings when supplemented with DDG has been documented (*2007 Nebraska Beef Cattle Report*, pp 10-11) and studies using harvested feeds to directly measure intake have reported forage replacement rates from 27% to 62%. Findings of these studies suggest that DDGS supplementation may allow for maintained or improved animal performance at increased stocking rates. The objectives of this study were 1) to evaluate the effect of DDGS supplementation on yearlings in heavily stocked situations, and 2) the subsequent effects of heavy stocking rates on range condition.

Procedure

This experiment was conducted at the University of Nebraska Gudmundsen Sandhills Laboratory (GSL) near Whitman, Neb. Twenty-four 2.4 acre paddocks were assigned randomly within two blocks to one of three treatments: 1) control (CON) at the recommended stocking rate (0.6 AUM/acre in 2005 and 0.4 AUM/acre in 2006, adjusted for drought) with no supplementation, 2) double stocked (1.2 AUM/ac in 2005 and 0.8 AUM/acre in 2006; 2X), or 3) double stocked with 5 lb dry matter/head daily of DDGS (SUP). The DDGS pellet was 88% DM, 28% CP, and 11.2% fat.

Paddocks were rotationally grazed once each year for 60 days from mid-June to mid-August, with days of grazing per paddock adjusted for stage of plant growth. The order which pastures were grazed was rotated between years to maximize recovery. Due to drought in 2006, stocking rate was reduced and put-and-take of calves were used to maintain forage removal similar to 2005.

In 2005, 42 summer-born spayed yearling heifers (534 ± 33 lb BW) and in 2006, 24 summer-born yearlings (14 spayed heifers and 10 steers) (505 ± 37 lb BW) were stratified by BW and assigned randomly to treatment paddocks. In addition, six similar yearlings were maintained in 2006 for put-and-take. Calves were limit-fed meadow hay at 2% of BW for five days at the beginning and end of the trial and weighed for three consecutive days.

Paddock species composition was determined prior to grazing each year using step-point analysis (Table 1). Forage use and standing crop were determined by clipping twenty, 1-m^2 quadrats pre- and post- grazing in late June, mid-July and early August (the 2nd, 4th, and 6th paddocks, respectively in a six pasture rotation).

All data were analyzed using the MIXED procedure of SAS (SAS Inst., Inc., Cary, N.C.). Yearling performance was analyzed as a randomized complete block design with treatment, year, and block analyzed as fixed effects. Standing crop data were analyzed with treatment, order grazed, block, year, and clip type (pre or post) as fixed variables, and pasture as a random effect. Orthogonal contrasts were constructed between the control and both double stocked treatments, and between supplemented and un-supplemented double stocked treatments. Least square means were separated using the Least Significant Difference Method when a significant ($P < 0.05$) f-test was detected. Significance of interactions was determined at the $P < 0.1$ level.

Table 1. Species composition of paddocks at the initiation of the trial.

	Block	
Species	West (%)	East (%)
Sedge (*Carex* spp.)	25	23
Prairie sandreed (*Calamovilfa longifolia*)	19	19
Needleandthread (*Stipa comata*)	10	15
Little bluestem (*Schizachrium scoparium*)	8	6
Switchgrass (*Panicum virgatum*)	7	6
Prairie junegrass (*Koeleria macrantha*)	3	4
Sand dropseed (*Sporobolus cryptandrus*)	3	3
Blue grama (*Bouteloua gracilis*)	5	4
Hairy grama (*Bouteloua hirsuta*)	4	3
Sand bluestem (*Andropogon hallii*)	2	3
Western ragweed (*Ambrosia psilostachys*)	6	6
Stiff sunflower (*Helianthus pauciflorus*)	3	3
Other	5	5
Total	100	100

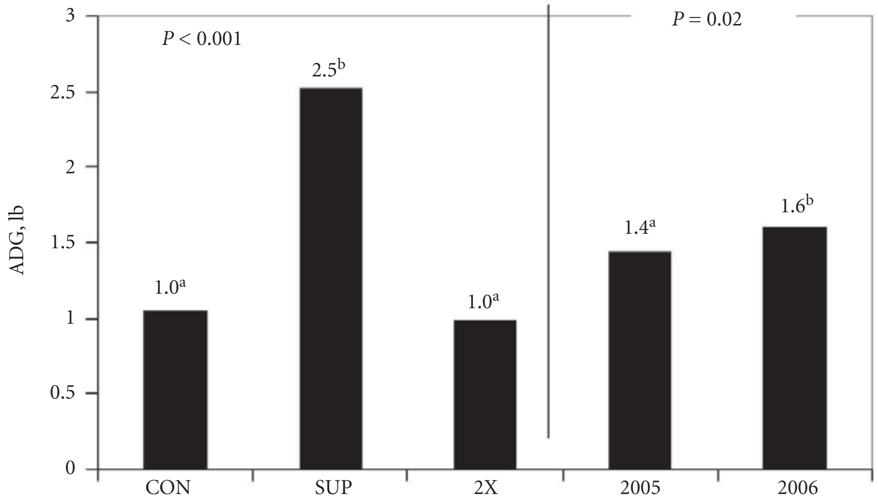

Figure 1. Calf average daily gain at recommended stocking rate, 2X recommended stocking rate and 2X plus distillers dried grains supplement and average daily gain for both years. [a,b]Means with unlike superscripts differ.

Table 2. Live standing crop (lb/ac).

Order:	Late June			Mid-July			Mid-August		
Treatment:	CON[a]	SUP[b]	2X[c]	CON	SUP	2X	CON	SUP	2X
2005									
Pre-graze	1107	1085	977	1228	1125	859	1349	1251	1199
Post-graze	754	486	421	753	428	236	692	414	408
% Utilization[d]	31.9	55.2	95.8	38.7	62.0	72.5	48.7	66.9	66.0
2006									
Pre-graze	874	840	941	1128	1082	1137	1074	1046	1042
Post-graze	738	589	592	702	336	340	598	329	312
% Utilization[d]	15.6	30.0	37.1	37.8	68.9	70.1	44.3	68.5	70.1

[a] Control, .6AUM/ac.
[b] 1.2 AUM/ac plus 5 lb DDGS daily.
[c] 1.2 AUM/ac.
[d] Control different from SUP and 2X (P <0.001).

Results

No ($P > 0.1$) year by treatment interaction occurred for calf performance (Figure 1). There was no difference between the CON and 2X calves ($P = 0.44$); however, the SUP calves gained (2.5 lb/day) more ($P < 0.001$) than the un-supplemented groups (1 lb/day). There was also a difference in ADG between the two years (Figure 1). This may be a direct result of a lower stocking rate in 2006. While the goal was to maintain similar forage remaining after grazing between the groups, at times there may have been less grazing pressure in 2006 because visual appraisal was used to determine when calves were added or removed.

Because stocking rate differed between the CON and 2X groups, forage intake, and therefore energy intake, should have been different. The lack of difference in ADG between CON and 2X treatments implies energy was not the first limiting nutrient in unsupplemented calves. The lower than anticipated ADG for the CON calves likely was a result of a metabolizable protein (MP) deficiency resulting from the use of young growing calves with a high MP requirement. The NRC (1996) model, using 120% NE adjusters and the average IVOMD and CP for the grazing period, suggests CON and 2X calves were deficient in MP by 147 g/day and had an energy allowable ADG of 1.7 lbs. In contrast, the supplemented calves had a 145 g/day MP excess, and energy allowable ADG of 2.6 lb, which was very near their actual gain. This further supports our hypothesis that digestible undegradable protein was the first limiting nutrient in these calves, and some of the response to DDGS supplementation was likely a response to undegradable protein.

Use of live standing crop is presented in Table 2. Due to significant interactions between years, the standing crop data are presented by year. We did not expect differences in the standing crop components of the 2005 pre-graze standing crop as paddocks had been rested for 8 years; however, even though paddocks were assigned randomly to treatments, some differences existed at the onset of the trial. There were significant interactions between order grazed, treatment, and block ($P < 0.001$) in the amount of live grass. These interactions are caused by variation among pastures, lack of precision in measurement, and low number of replications.

These paddocks consisted of primarily warm-season grasses; therefore, peak yield of grasses did not occur until late in the summer. Live grass standing crop was lower across treatments after grazing. Across all paddocks, CON paddocks had more standing live grass and forbs following grazing ($P < 0.001$) than either of the double-stocked treatments.

Across all treatments, standing crop was lower in 2006 (Table 4), but this is likely due to decreased precipitation and not prior treatment. There was no effect of treatment in live grass ($P = 0.49$); however, order grazed did impact standing crop ($P < 0.001$). Across both years, use averaged 36.4%, 58% and 62% for CON, SUP and 2X treatments, respectively.

Contrary to our hypothesis, no significant reduction in forage removal was induced by the supplementation of DDGS in comparison to the CON or 2X treatments. Klopfenstein et al. (*2007 Nebraska Beef Cattle Report*, pp 10-11) found a forage replacement rate of nearly 50% when DDGS was supplemented to calves fed harvested

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feeds. The DDGS forage substitution in our study is likely quite similar to that seen when DDGS is supplemented to harvested feeds. Extrapolation of the harvested forage data to ours suggests that at our rate of supplementation (5 lb daily), only 2.5 lb daily of forage would have been replaced. If this is accurate, forage replacement may have indeed occurred, but not at a level that could be detected in the design and sampling procedure of this study.

Supplementation of DDGS to calves grazing native Sandhills range increased ADG even when stocking rate was doubled. No apparent reduction in voluntary forage intake was detected in this study due to DDGS supplementation. Some of the laboratory data and visual observations suggest some level of replacement may occur early in the grazing period, but is not sustained throughout a grazing period at these stocking rates. Increasing stocking rate can have detrimental impacts on range condition over time. While the duration of the study was not sufficient to measure this decline, visual appraisals of the double stocked paddocks, along with previous research, warn that the double stocked treatments could decrease range condition. The findings of our study show that DDGS supplementation is an effective tool in increasing ADG of calves grazing native Sandhills range; however, forage replacement is not such that stocking rate can be increased twofold.

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[1] Kristin H. Gustad, graduate student; L. Aaron Stalker, assistant professor; Terry J. Klopfenstein and Walter H. Schacht, professors, Animal Science. Don C. Adams, director, West Research and Extension Center, North Platte. Jackie A. Musgrave, technician, Gudmundsen Sandhills Laboratory. Jerry D. Volesky, Associate Professor.

Dried Distillers Grains Supplementation to Yearling Cattle Grazing Smooth Bromegrass: Response and Performance Profile Summary

Matthew A. Greenquist
Terry J. Klopfenstein
Galen E. Erickson
Matt K. Luebbe[1]

Summary

Four years of data were summarized to evaluate yearling performance on smooth bromegrass when supplemented with dried distillers grains (DDG). On average cattle were supplemented 0.525% of BW daily with DDG for the entire grazing period (84 to 156 days). Daily gains were increased 0.55 lb/day for the entire grazing season. Performance from the last two years of data show a quadratic decrease in ADG as grazing days increase and forage quality decreases for both the supplemented and nonsupplemented cattle. The response to DDG supplementation increases with increasing grazing days.

Introduction

Increases in feedlot ration costs have made pasture and grass programs for yearling beef cattle more attractive. Dried distillers grains are a good source of both undegradable protein and energy and have been shown to increase ADG in animals consuming low and high quality forages (*2005 Nebraska Beef Cattle Report,* pp. 18-20) with both the concentrated energy and undegradable protein contributing to the improvements in gain (*2006 Nebraska Beef Cattle Report,* pp. 27-29). The response of yearling cattle to DDG supplementation over time is unclear. The objective of our research was to summarize the overall response and performance profile of yearling cattle on smooth bromegrass supplemented with DDG.

Procedure

Data were summarized from four grazing experiments (*Nebraska Beef Cattle Reports, 2004,* pp. 25-27*; 2006,* pp. 27-29*; 2007,* pp. 12-14; and 2006 unpublished Nebraska data) where distillers grains were supplemented at 0.525% of BW to yearling cattle grazing smooth bromegrass. All four experiments were conducted on the same pastures at the Agricultural Research Development Center near Mead, Neb., from 2002 to 2006. Two of the experiments were with heifers and two were with steers. The length of trials ranged from 84 days to 156 days. Initial BW ranged from 650 lb to 811 lb. In each experiment cattle were rotationally grazed in six pastures per replication. Cattle were stocked at similar stocking rates (3.5 and 4.0 AUM/acre) and pastures were fertilized at similar rates across years (73 to 80 lb N/acre).

Cattle were limit fed a common diet for 5 days at the beginning and end of all the trials and weights were measured for three consecutive days to minimize variation in gut fill. Diet collections were taken at representative time points throughout the grazing period via ruminally fistulated steers. Diet DM, CP and IVDMD were subsequently determined. Dried distillers grains ranged between 25% to 30% CP, and 10% to 12% EE for the four experiments.

Two of the four experiments were used to look at the response of yearling cattle to DDG supplementation over time. Interim weights were taken at the end of each of five grazing cycles (24 days in cycles 1 and 5, and 36 days in cycles 2, 3, and 4) within the grazing season. Six pastures were rotationally grazed within each cycle. All interim weights were analyzed on a shrunk (4%) basis.

Results

Diet samples collected from 2002 to 2006 are shown in Table 1. There was substantial year to year variation

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Table 1. Forage quality of diet samples collected from 2002 to 2006.[a]

	Year					
Item	2002	2003[bc]	2004[b]	2005[bc]	2006[bc]	Mean
CP, % DM						
April	—	—	—	18.5	18.1	18.3
May	19.9	25.3	20.7	19.2	14.7	20.0
June	15.1	13.3	20.8	14.9	12.1	15.2
July	—	20.4	21.4	14.9	11.0	16.9
Aug	—	—	—	17.6	16.8	17.2
Sept	—	—	—	17.6	16.6	17.1
Mean	17.5	19.7	21.0	17.1	14.9	18.0
IVDMD, %						
April	—	—	—	68.2	74.6	71.4
May	61.5	69.5	66.7	65.6	71.9	67.0
June	51.9	51.3	65.1	58.8	63.2	58.1
July	—	53.9	63.5	53.4	52.4	55.8
Aug	—	—	—	50.7	62.3	56.5
Sept	—	—	—	51.6	65.2	58.4
Mean	56.7	58.2	65.1	58.0	64.9	60.6

[a] Steers were supplemented on average 0.525% of BW daily with DDG for the entire grazing period. DDG contained 25% to 30% CP, and 10% to 12% EE.
[b] Quadratic effect of time for CP ($P < 0.05$).
[c] Quadratic effect of time for IVDMD ($P < 0.05$).

which is expected because of inherent environmental fluctuations within and between years. In all years except 2002, which was limited by the number of samples taken, there was a quadratic effect ($P < 0.05$) of time for CP, ranging from an average high in May (20% CP) during the early growing period, to a low in the summer months of June and July (15% to 16%), and back up to intermediate levels (17% CP) in the late summer due to late season regrowth. Similar quadratic ($P < 0.05$) trends were seen in IVDMD from 71% early in the season to 56% in the middle of the summer and then to 59% at the end of the summer.

Table 2. Response of yearling steers grazing smooth bromegrass to dried distillers grains supplementation.

Experiment	BW	CONT ADG	SUPP ADG	%BW Supp	Response/ 1% BW supp
NEBR '04[a]	650	1.50[b]	1.75[c]	0.50	0.50
NEBR '06[a]	811	1.48[d]	2.32[e]	0.50	1.68
NEBR '07[a]	767	1.37[d]	1.95[e]	0.55	1.05
Unpub[f]	766	1.77[d]	2.30[e]	0.55	0.96
Mean	749	1.53	2.08	0.53	1.05

[a] *Nebraska Beef Reports 2004, 2006*, and *2007* data collected in years 2002, 2004, and 2005, respectively.
[bc] Means without a common superscript differ (P<0.05).
[de] Means without a common superscript differ (P<0.01).
[f] Unpublished. University of Nebraska–Lincoln, 2006 data.

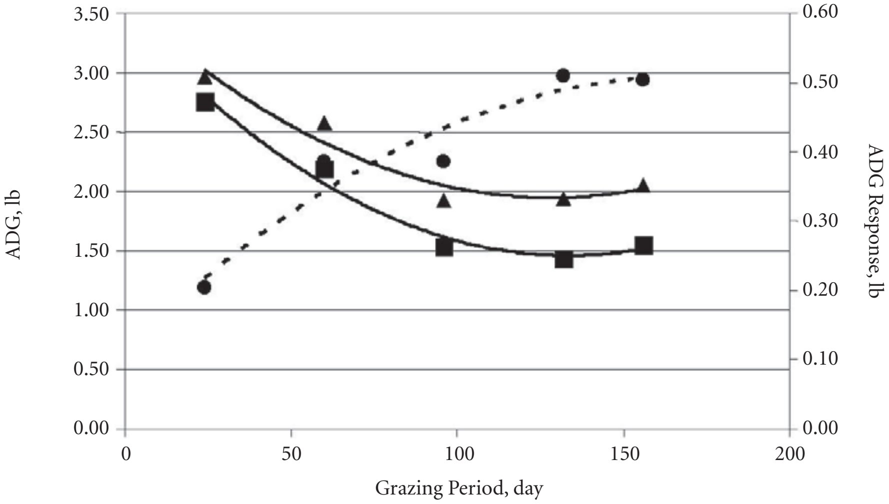

Figure 1. Growth profile for steers grazing smooth bromegrass and supplemented with dried distillers grains. The quadratic decrease in cumulative ADG (P < 0.01) for both the supplemented (——▲; $y = 0.0001x^2 - 0.0254x + 3.5743$; $R^2 = 0.94$) and nonsupplemented (——■; $y = 0.0001x^2 - 0.03x + 3.4617$; $R^2 = 0.98$) cattle is expressed over the entire grazing period. The ADG response (-----●) of the supplemented cattle over the controls increases as grazing days increase. The quadratic ($y = -0.00005x^2 + 0.0046x + 0.1138$; $R^2 = 0.9235$) response is inversely related to diet quality.

Mean BW of the yearlings at the start of the grazing season was 749 lb and ranged from 650 to 811 lb (Table 2). Daily gains of nonsupplemented cattle averaged 1.53 lb/day and ranged from 1.37 to 1.77 lb/day. The average supplementation level was 0.525% BW, which increased ADG by 0.55 lb/day to 2.08 lb/day (ranged 1.75 to 2.32 lb/day). The response in ADG for each 1% BW supplementation was 1.05 lb. This is slightly higher (1.05 lb vs. 0.99 and 0.95 lb) than the response reported in a larger summary (*2007 Nebraska Beef Cattle Report,* pp. 10-11) that included experiments from both cool and warm season grasses. Both of these summaries clearly show an added response greater than what is typically observed (0.3 lb/day) from supplementing with undegradable intake protein. This added response can be attributed to both the concentrated energy and undegradable protein found in the DG (*2006 Nebraska Beef Cattle Report,* pp. 27-29).

Interim performance from the last two years of data show a quadratic decrease in cumulative ADG ($P < 0.01$) for both the supplemented and nonsupplemented cattle over the entire grazing period (Figure 1). The overall decrease in ADG through the grazing period is indicative of the diet quality. Digestibility of cool season grasses generally declines on the order of 0.25% to 0.50% per d until it reaches a low of 50% to 55%. However, because of the characteristic regrowth that is often observed in the later portion of the grazing season, a quadratic response is often observed in digestibility and ADG tends to respond accordingly. The ADG response of the supplemented cattle over the controls increased as grazing days were increased. This quadratic response appears to be inversely related to the decrease in diet quality. This is possibly due to a protein response to DDG supplementation early in the grazing period when forage quality is relatively high and an energy response as forage quality diminishes.

Supplementing yearling cattle on smooth bromegrass with DDG is an effective way to increase weight gain. It appears that even though daily gain is decreasing through most of the grazing period, as forage quality also decreases, the response to supplementation increases compared to nonsupplemented cattle and this weight is maintained for the remainder of the grazing period.

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[1] Matthew A. Greenquist, graduate student; Terry J. Klopfenstein, professor; Galen E. Erickson, assistant professor; and Matt K. Luebbe, research technician, Animal Science, Lincoln.

The Effects of Supplementing Wet Distillers Grains Mixed With Wheat Straw to Growing Steers

Brandon L. Nuttelman
Terry J. Klopfenstein
Galen E. Erickson
William A. Griffin
Matt K. Luebbe[1]

Summary:

A growing study compared feeding wet distillers grains, dried distillers grains, and a mix of 66% wet distillers grains and 33% wheat straw as supplements to a forage-based diet. Steers were supplemented 0, 2, 4, or 6 lb distillers grains/ head daily. Wet distillers grains and dried distillers grains produced higher final body weight and dry matter intake compared to the mix. Increasing levels of distillers grains increased performance in forage based diets and wet grains mixed with straw reduced forage intake.

Introduction

Supplementing DDGS in forage based diets decreases forage DMI and increases ADG (*2006 Nebraska Beef Report*, pp. 30-32). Increasing ADG and decreasing DMI allows producers the opportunity to increase carrying capacity of pastures without needing to acquire additional land. When we attempted to decrease Sandhills Range intake by supplementing with DDGS, the reduction in intake was small and the yearlings gained more rapidly (*2008 Nebraska Beef Cattle Report,* pp. 28-30). Yearlings and cows are limited in intake by "fill" which is characterized by fiber (NDF). WDGS can be mixed at various levels with different types of forages, packed, and stored with minimal to no spoilage. Therefore, the objective of this study was to determine if forage DMI can be reduced by feeding WDGS mixed with low quality forage, and to determine the differences in performance between WDGS and DDGS.

Procedure

Ninety-three crossbred steer calves (590 ± 31 lb) were stratified by weight and assigned randomly to one of three supplemental treatments to evaluate performance between different types of distillers grains. Treatments included DDGS, WDGS, and a mix that was 67% WDGS and 33% ground wheat straw (MIX) stored in silo bags for 30 days prior to initiation of the trial. Within each treatment steers were fed one of four levels of supplement: 0, 2, 4, or 6 lb of distillers grains/ head daily adjusted to changes in BW using percentage of BW fed (0%, .33%, .67%, and 1.0 % respectively) and one-day interim weights every 28 days. For cattle on the MIX, supplement was fed to allow cattle to consume the assigned level of distillers grains. For example, the 2 lb level of MIX received 2 lb of WDGS and 1 lb of wheat straw equaling 3 lb of supplement (DM-basis). Distillers grains were fed on top of the base diet to encourage total consumption of the supplement. The base diet consisted of 60% sorghum silage and 40% alfalfa hay and was used to simulate a similar response in performance that one would typically expect from steers in a grazing phase of production.

Steers were individually fed for 84 days using Calan electronic gates. Steers were limit fed a mix of 47.5% alfalfa hay, 47.5% wet corn gluten feed, and 5.0% supplement for 5 days prior to and for 5 days following the conclusion of the feeding period to reduce variation due to gut fills. After limit feeding cattle were weighed three consecutive days prior to trial initiation and following the end of the feeding period. The average of the three-day weights were used as the initial and final BW. Individual weigh backs were collected weekly and a sample of refused feed was taken and DM was determined using a 60°C forced air oven. Bunks were evaluated daily, and necessary adjustments made to the base diet accordingly. NDF analysis was performed on the supplement ingredients fed using the Ankom procedure. Percentage NDF was 77.9% for wheat straw and 43.8% for WDGS. The MIX had an NDF content of 55%. DDGS was 34.5% NDF and the WDGS that was supplemented alone was 48% NDF.

Results

Type of Supplementation

There were no type*level interactions. No difference between supplementation type for initial BW ($P = 0.14$), ADG ($P = 0.20$), or F:G ($P = 0.32$) existed. Final BW for cattle supplemented with DDGS and WDGS were similar ($P = 0.81$). However, cattle supplemented with WDGS and DDGS had heavier final BW compared to MIX ($P = 0.05$), suggesting the MIX fed cattle gained at a slower rate. Dry matter intake was similar for cattle supplemented with DDGS and WDGS ($P = 0.15$). Cattle supplemented with MIX had lower DMI when compared to DDGS and WDGS ($P = 0.05$).

Level of Supplementation

There were no significant differences for initial BW ($P = 0.78$) when comparing levels of supplementation. Final BW ($P < 0.01$) exhibited a linear increase of 90 lb from the 0 lb level of supplementation to the 6 lb level of supplementation. Additionally, ADG ($P < 0.01$) increased linearly with the 0 lb level of supplementation gaining 1.53 lb/day and the 6 lb level of supplementation gaining 2.62 lb/day. Gain efficiency improved linearly ($P < 0.01$) with increasing levels of distillers grains supplementation. There was a quadratic effect for DMI

(Continued on next page)

Table 1. Level of distillers dry and wet grains on calf performance.

		DDG			WDGS			MIX			
Item	0	2	4	6	2	4	6	2	4	6	SEM
Initial BW, lb	588	599	605	590	578	604	592	586	579	586	10
Final BW, lb	722	795	805	829	772	810	800	743	773	807	16
ADG, lb/day	1.58	2.31	2.36	2.81	2.29	2.42	2.45	1.84	2.28	2.6	.15
DMI, lb/day	13.6	16.36	17.33	17.04	15.49	15.89	14.71	15.07	15.18	14.24	.61
Supplement	—	2.08	4.24	6.29	1.98	4.27	6.21	2.00	4.10	6.18	.11
Forage	13.6	14.28	13.09	10.75	13.51	11.62	8.50	12.07	9.03	4.98	.54
Straw	—	—	—	—	—	—	—	1.00	2.05	3.08	—
F:G	7.23	7.05	7.28	6.03	6.70	6.55	5.94	8.06	6.57	5.40	.27

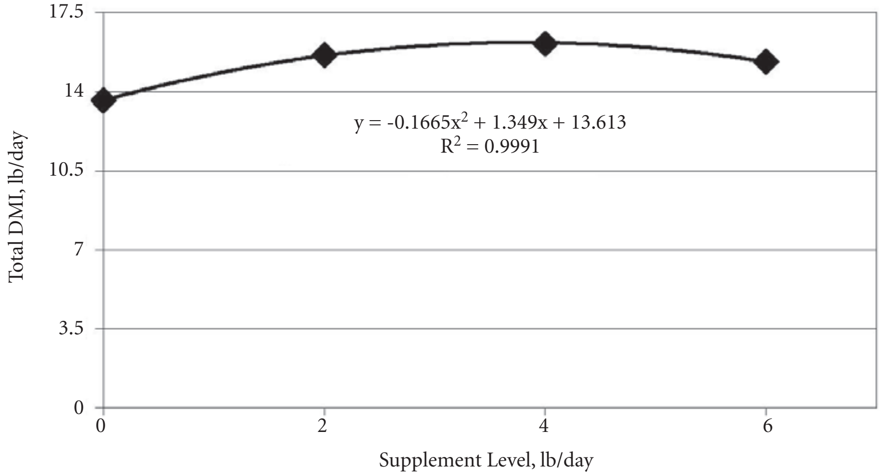

Figure 1. Depiction of DMI relative to pounds of distillers grains supplemented.

($P < 0.01$) between levels of supplementation with cattle supplemented 4 lb/head daily consuming the most feed (16.1 lb DMI) and cattle supplemented 0 lb/head daily consuming the least amount of feed (13.6 lb DMI) (Figure 1).

There were no differences in performance between DDGS and WDGS. Mixing WDGS with wheat straw did decrease DMI without affecting F:G. Additionally, increasing the level of distillers grain supplemented increased final BW and improved animal performance relative to ADG and F:G.

Using the MIX could be a way to decrease grass consumption in grazing cattle production, because of the lower intakes experienced in this trial and because grazing animals consume to a physical fill. At the highest feeding level each lb of DDGS replaced 0.5 lb of forage and each lb of WDGS replaced 0.8 lb of forage. When the MIX was fed, each lb of the MIX replaced 0.9 lb of forage. If we assume the WDGS in the MIX replaced 0.8 lb of forage, then each lb of straw replaced 1.6 lb of forage. The 1.6 lb of forage would contain about 0.9 lb fiber (NDF) and the 1 lb of straw about .8 lb of NDF. This suggests that NDF in the straw supplied the fill to limit forage intake.

These data suggest that mixes of WDGS and straw from 33% to 50% straw will store, be palatable, and will reduce intake of forage of quality equivalent to grazed forage.

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[1] Brandon L. Nuttelman, graduate student; Terry J. Klopfenstein, professor; Galen E. Erickson, associate professor; William A. Griffin, graduate student; and Mathew K. Luebbe, research technician, Animal Science, Lincoln.

Forage Quality and Grazing Performance of Beef Cattle Grazing Brown Mid-rib Grain Sorghum Residue

Andrea K. Schwarz
Corineah M. Godsey
Matt K. Luebbe
Galen E. Erickson
Terry J. Klopfenstein
Robert B. Mitchell
Jeffrey F. Pedersen[1]

Summary

The control (CON) grain sorghum hybrid AWheatland x RTx430 and its near-isogenic brown midrib counterpart (BRM) containing the gene bmr-12, were used in a 72-day residue grazing experiment. Grain yield averaged 119 bu/ac and was not affected by treatment. ADG was increased from 0.75 lb in CON to 1.23 lb in BMR treatments over the grazing period. NDF digestibility increased 6%-12% units in leaf fractions in BMR over CON. NDF digestibility decreased 2%-12% units over the 72-day grazing period for both hybrids. Similarly, NDF digestibility of stem fraction increased 14%-19% units in BMR over CON. NDF digestibility of the stem fractions remained constant, regardless of treatment, over time.

Introduction

Many crop species have been successfully developed with the brown midrib trait which is associated with reduced lignin including corn, pearl millet, grain sorghum, and sudangrass. However, to date, there has been little research on the effects of the brown midrib trait in grain sorghum. Previous research at the University of Nebraska (Oliver, et al., 2005 Crop Science) using the common grain sorghum hybrid AWheatland x RTx430, and its counterpart near-isogenic for the brown midrib gene *brm-12* showed no difference in grain yield and residue NDF content, but an improvement of *in vitro* NDF digestibility *(IVNDFD)* associated with the brown midrib trait. The objectives of our experiment was to determine if cattle performance was positively affected by the brown midrib trait when grazing post-harvest grain sorghum residue, and to verify the previous small-plot results indicating no reduction in grain yield, but increased digestibility of similar NDF content, in a commercial-scale field experiment.

Procedure

Forty-eight steers (550 ± 50 lb) were stratified by BW and assigned randomly to 5.75 acre paddocks containing the conventional grain sorghum hybrid AWheatland x RTx430 (CON) or its near-isogenic brown midrib counterpart (BMR) containing the gene *bmr-12*. Two treatments and four replications, for a total of eight paddocks were used. Steers were limit fed a 25% alfalfa, 25% grass hay, and 50% wet corn gluten feed diet for 5 days at the beginning and end of the trial and weighed consecutively for 2 days to minimize variation due to gut fill. Steers grazed from Nov. 27, 2006 to Feb. 7, 2007, stocked at approximately 1 AU/acre (5.75 acre/paddock with 6 steers/paddock). Over the course of the grazing period, steers were supplemented at 2.5 lb/steer daily. The supplement consisted of 93.8% dry distillers grain, 4.7% limestone, 0.8% tallow, 0.1% Rumensin-80, 0.3% beef trace mineral, 0.2% selenium, and 0.1% vitamin A-D-E. Each steer received approximately 10 lb grass hay during 3 days of substantial snow cover.

Grain was harvested with a commercial combine on Oct. 13, 2006, weighed in a commercial grain cart, and yields were adjusted to 14.5% moisture. Samples of the residue were collected on day 4 (Dec. 1, 2006), 30 (Dec. 26, 2006), and 60 (Jan. 26, 2007) of the grazing period. Small metal exclosures were placed in each paddock and sampled to allow a comparison to any change in residue quality over time when residue is not grazed. Residue sample was collected from 3 ft in each row in each paddock in the grazed and non-grazed areas. All samples were dried in a 60°C forced air oven and separated into leaf, stem, and head fractions. After separating plant fractions, samples were ground and analyzed for NDF, IVNDFD (*in vitro* NDF digestibility), and CP.

NDF content was determined by agitating 0.50 g samples in heat sealed Ankom filter bags in 1,900 mL NDF solution (15 g/24 samples sodium sulfite was added to aid in protein degradation) for 75 minutes, rinsed in three, five-minute boiling distilled water rinses, dried and finally re-weighed.

In vitro NDF digestibility was determined by a 48-hour incubation of 0.3 g substrate in a 1:1 mixture of McDougal's buffer (1 g/L urea) and rumen fluid collected from steers fed a forage-based diet. Tubes were stoppered, flushed with CO_2, incubated at 39°C and swirled every 12 hours. After 48 hours, the residue was refluxed for 1 h in 100 ml NDF solution (0.3 g sodium sulfite was added to aid in protein degradation), filtered, and dried for 24 hours. *In-vitro* NDF digestibility was calculated as: *1 -{ [(Residue + Filter paper) - Filter paper] - blank} / [(Sample Wt) x (DM)] = IVNDFD (%). In-vitro* NDF digestibility was conducted to simulate a grazing occurrence by date.

All data were analyzed using the MIXED procedure of SAS. Lab data were analyzed as repeated measures with an auto-regressive (AR-1) covariance structure. Samples were analyzed for the effects of treatment, sample type (i.e., leaves and stems), day, and grazed versus non-grazed. Significance was determined by comparing the least square means for repeated measures ($P < 0.05$).

Results

Grain Yield

Grain yields averaged 119 bu/ac across the entire experiment, and CON yields (122 bu/ac) were not significantly different from BMR yields (116 bu/ac; $P > 0.05$).

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Table 1. Effect of grain sorghum hybrid on steer performance when grazing residue for 72 days.

	CON	BMR	SEM	*P*-Value
Initial BW, lb	564	564	3	0.85
Final BW, lb	618	652	7	0.01
ADG, lb	0.75	1.23	0.08	0.01

Table 2. Mean *In-vitro* NDF digestibility % for grazed and non-grazed portions of CON and BMR grain sorghum residue for the 72-day grazing period.

GRAZED	Leaves			Stems		
Day	CON	BMR	*P*-Value	CON	BMR	*P*-Value
4	68.6^{a}	77.1^{a}	<0.01	59.1^{a}	77.3^{a}	<0.01
30	65.7^{a}	76.2^{a}	<0.01	60.3^{a}	$75.9^{a,b}$	<0.01
60	57.2^{b}	69.1^{b}	<0.01	59.5^{a}	73.3^{b}	<0.01
NON-GRAZED EX-CLOSURES						
	Leaves			Stems		
Day	CON	BMR	*P*-Value	CON	BMR	*P*-Value
4	69.9^{a}	$76.0^{a,b}$	<0.05	59.0^{a}	77.6^{a}	<0.01
30	$68.8^{a,b}$	78.8^{a}	<0.01	62.1^{a}	76.7^{a}	<0.01
60	66.5^{b}	74.0^{b}	<0.01	60.6^{a}	78.6^{a}	<0.01

^{a,b}Means with a column for either grazed or non-grazed with unlike superscripts differ ($P < 0.05$).

Cattle Performance

At the end of grazing, BW ($P < 0.01$) and ADG ($P < 0.01$) were significantly different across treatments. Steers grazing the BMR residue gained more (1.23 lb/day) than CON (0.75 lb/day). This amounts to an increase of 0.48 lb/day for steers grazing grain sorghum residue with the BMR trait compared to CON.

Neutral Detergent Fiber

Treatment caused no significant difference in NDF content of the leaf fraction in the nongrazed metal exclosures across date ($P > 0.41$), averaging 67.6% for BMR and 66.9% for CON. Similarly, NDF of the stem fraction inside the metal exclosures was not different across treatment or date ($P > 0.45$). The NDF content in stem fractions for BMR and CON averaged 75.6% and 75.3% respectively. The NDF content in the stem fractions across both treatments at day 60 was significantly higher compared to day 4 or day 30 ($P<0.05$), with NDF contents of 73.7%, 74.0%, and 76.4% for day 4, 30, and 60, respectively.

A similar interaction was observed across treatments and dates for NDF content of the leaf fraction in residue from grazed areas. NDF content averaged 69.8% for BMR and 69.1% for CON which is not significantly different between the two hybrid treatments ($P > 0.20$). Additionally, leaf NDF was significantly higher in both treatments at day 60 ($P < 0.01$) compared to day 4 and day 30 for grazed areas. Stem fractions, from grazed areas, were not significantly different ($P > 0.20$) at any date or across treatments ($P > 0.10$), averaging 75.6% for BMR and 75.3% for CON.

In-Vitro *NDF Digestibility*

Interactions were observed between residue sample type, day in grazing period, grazed or non-grazed portions, and hybrid treatment. Therefore, simple effects of hybrid by residue sample type are presented by day in grazing period as well as collection from grazed or non-grazed areas (Table 2).

Regardless of whether samples were collected from grazed or non-grazed areas of the residue, throughout the grazing period leaf fractions had greater IVNDFD in BMR compared to CON ($P < 0.01$). On average, there was an increase of 6%-12% units for IVNDFD for BMR compared to CON. However, the increase in IVNDFD was dependent upon whether the sample was from grazed or non-grazed areas and the length of grazing. Interestingly, IVNDFD was observed to decrease over time in the leaf fraction, regardless of treatment. The most notable decrease (8%-12% units) occurred in the grazed areas of the paddock over the entire grazing period, with most of decline occurring from day 30 to day 60 ($P < 0.01$) in both BMR and CON. While there was an observed decrease in IVNDFD over the course of the grazing period for the non-grazed exclosures, the reduction was only observed to be 2%-4% units over time.

A large increase in IVNDFD in BMR compared to CON was observed for the stem fraction. Regardless of sample location, a 13%-19% unit increase for IVNDFD was observed for BMR compared to CON ($P < 0.01$). Additionally, no difference was observed between IVNDFD for stems from grazed or non-grazed areas at day 4 or day 30 ($P > 0.3$). While there was a difference in IVNDFD of stem fractions at day 60 for the BMR treatment between grazed and non-grazed areas ($P < 0.01$), the difference is only 5% units. This observation suggests that grazing pressure does not markedly impact the digestibility of the stem fraction compared to the leaf fractions. However, because cattle tend to consume primarily the leaf fraction of the grain sorghum residue, the overall change in IVNDFD for stem fractions may be less important compared to the change in IVNDFD for the leaf fraction.

Perhaps the most interesting observation was that although there appeared to be a significant difference ($P < 0.01$) in IVNDFD between the leaf and stem fractions of the CON treatment, IVNDFD was comparable between the leaf and stem fractions in the BMR hybrid ($P > 0.05$). This suggests cattle could consume the stem residue of the *bmr-* grain sorghum hybrid and perform similar to grazing the leaf fractions, if stems are palatable.

Grazing grain sorghum residue containing the *bmr*-trait can provide an alternative method of backgrounding. Incorporating the *bmr*-trait does markedly improve NDF digestibility, which carried over to a positive gain response for grazing calves.

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[1] Andrea K. Schwarz, undergraduate student; Corineah M. Godsey, graduate student; Matt K. Luebbe, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor; Animal Science, Lincoln. Robert B. Mitchell and Jeffrey F. Pedersen, USDA-Agricultural Research Service, Lincoln.

Meta-Analysis of UNL Feedlot Trials Replacing Corn with WCGF

Virgil R. Bremer
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

A meta-analysis of UNL feedlot trials was conducted to evaluate the effect of replacing dry-rolled or high-moisture corn with wet corn gluten feed (WCGF) on feedlot cattle performance and carcass characteristics. The feeding value of WCGF was dependent on ratio of steep to corn bran of the WCGF. The performance of cattle fed WCGF composed of wet bran and steep was similar to corn fed cattle. Feeding and carcass performance of cattle fed WCGF composed of dry bran, steep, and germ improved linearly as dietary inclusion increased.

Introduction

The availability of wet corn gluten feed (WCGF) generated from the wet milling industry is expected to increase as ethanol production increases. The actual composition of WCGF varies depending on the plant's capabilities. Steep, a combination of steep liquor and distillers solubles, contains more energy (136% the feeding value of corn) and CP than corn bran or germ meal (*1997 Nebraska Beef Report*, pp. 72-74). Plants applying more steep to corn bran or germ meal will produce WCGF higher in CP and energy.

In general, two types of WCGF are commonly used in the feedlot industry. The first (WCGF-A) is composed of wet bran and steep and contains 40% to 42% DM and 15% to 18% CP (DM basis). The second WCGF (WCGF-B) is composed of dry bran, steep, and germ meal and contains 60% DM and 22% to 25% CP (DM basis).

The feeding value of WCGF is dependent on its composition. In addition, the impact of WCGF inclusion level on quality grade has not been summarized. Therefore, the objective of our meta-analysis was to evaluate the effect of WCGF dietary inclusion on feedlot cattle performance and carcass characteristics.

Procedure

Treatment means (n = 35) from University of Nebraska feedlot experiments evaluating use of WCGF in finishing diets were compiled (WCGF-A, *1986 Nebraska Beef Report,* pp. 17-19; *1993 Nebraska Beef Report*, pp. 46-47; *1994 Nebraska Beef Report,* pp. 37-38; *1995 Nebraska Beef Report,* pp. 34-36; *2004 Nebraska Beef Report,* pp. 61-63; WCGF-B, *1995 Nebraska Beef Report*, pp. 26-28; *1997 Nebraska Beef Report,* pp. 70-72; *1998 Nebraska Beef Report,* pp. 50-53; *2001 Nebraska Beef Report*, pp. 59-63; *2007 Nebraska Beef Report*, pp. 25-26; *2007 Nebraska Beef Report*, pp. 27-28). Steers (n = 1,389; 509 WCGF-A; 880 WCGF-B) in these studies were predominantly black, crossbred steer calves or yearlings. Within experiment, cattle were blocked by initial BW, allocated randomly to pens, then pens assigned randomly to dietary treatments. Only studies that replaced dry-rolled corn, high-moisture corn, or a combination of the two types of corn with WCGF (0% to 40% of diet DM) were included in the analysis.

Steers across these experiments were fed for 111 to 169 days. In each individual experiment, cattle were fed the same number of days and marketed at a commercial abattoir. Hot carcass weight was recorded on day of slaughter. Fat thickness was measured after a 24- to 48-hour chill. USDA Marbling score was called by a professional USDA grader. Final BW, ADG, and F:G were calculated based on hot carcass weights adjusted to a common trial dressing percentage. The feeding value of each WCGF at different inclusion levels was calculated using feed efficiency. The F:G difference between each WCGF treatment and the individual experiment control (0% WCGF) was calculated, divided by the F:G of the control treatment, and divided by the percentage of WCGF in the individual diet to give a feeding value of WCGF relative to corn.

The two WCGF products were analyzed and summarized separately. An iterative meta analysis methodology was used to integrate quantitative findings from multiple studies using the PROC MIXED procedure of SAS.

Results

Dry matter intake of cattle fed increasing levels of WCGF-A was similar ($P > 0.38$) to cattle fed corn (Table 1). However, ADG increased linearly ($P = 0.10$) as more WCGF-A replaced corn in finishing diets. The improvement in ADG with similar DMI did not result in significant differences in feed conversion ($P > 0.59$) across WCGF-A inclusion levels. The feeding value of WCGF-A was 99% of corn. Because the feeding performance was similar to control fed cattle, the carcass characteristics of cattle fed WCGF-A were similar to cattle fed corn alone. There was no relationship between dietary inclusion level of WCGF-A and 12th rib fat thickness ($P > 0.46$). Marbling score decreased linearly ($P = 0.09$) as the level of WCGF-A increased in finishing diets, but the change was subtle with a decrease of 11 marbling score units between 0% and 40% inclusion.

The feeding value of WCGF-B was 112% of corn. The feeding value improvement is due to a linear increase ($P < 0.01$) in ADG as WCGF-B inclusion increased; however, DMI also increased linearly ($P < 0.01$). The replacement of corn with WCGF-B improved F:G linearly ($P = 0.03$) as dietary inclusion increased. The increased DMI and improved F:G sug-

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Table 1. Finishing steer performance when fed different dietary inclusions of wet corn gluten feed (WCGF).

WCGF Inclusion [a]:	0WCGF	10WCGF	20WCGF	30WCGF	40WCGF	Linear [b]	Quadratic [b]
WCGF-A[c]							
DMI, lb/day[d]	22.2	22.3	22.5	22.8	23.0	0.38	0.48
ADG, lb	3.44	3.47	3.50	3.54	3.57	0.10	0.90
F:G[d]	6.44	6.44	6.44	6.44	6.44	0.59	0.60
12th rib fat, in[d]	0.45	0.45	0.45	0.45	0.45	0.46	0.46
Marbling score[e]	504	501	498	495	493	0.09	0.60
WCGF-B[c]							
DMI, lb/day	21.8	22.3	22.9	23.4	24.0	< 0.01	0.35
ADG, lb	3.67	3.80	3.92	4.05	4.17	< 0.01	0.67
F:G	5.96	5.90	5.85	5.80	5.74	0.03	0.48
12th rib fat, in	0.46	0.47	0.49	0.50	0.52	< 0.01	0.87
Marbling score[e]	492	497	501	506	511	< 0.01	0.78

[a] Dietary treatment levels (DM basis) of wet corn gluten feed (WCGF), 0WCGF = 0% WCGF, 10WCGF = 10% WCGF, 20WCGF = 20% WCGF, 30WCGF = 30% WCGF, 40 WCGF = 40% WCGF.

[b] Estimation equation linear and quadratic term t-statistic for variable of interest response to WCGF level.

[c] WCGF-A composed of wet bran and steep, WCGF-B (Sweet Bran) composed of dry bran, steep, and germ meal.

[d] Reported values are variable of interest means due to no WCGF level differences (t > 0.10).

[e] 400 = Slight 0, 500 = Small 0.

gest WCGF-B also reduced acidosis. Because ADG was greater for cattle fed WCGF-B, carcasses from cattle fed WCGF-B were fatter compared to cattle fed corn alone and marbling scores increased linearly ($P < 0.01$) as inclusion increased. Since WCGF-B diets had improved feeding values relative to corn, the cattle gained weight quicker than corn-fed controls and required fewer days to reach the same backfat and marbling endpoints.

The feeding value of WCGF is dependent on the ratio of bran to steep in the production process. Feeding as much as 40% WCGF will provide cattle performance similar to, or better than, corn-fed cattle. Our conclusion is that the increase in fat depth and marbling from feeding WCGF-B is related to improved animal performance. Feeding diets that increase ADG cause cattle to fatten more rapidly, which can improve the quality grade of feedlot cattle when cattle are fed the same number of days.

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[1] Virgil R. Bremer, research technician; Galen E. Erickson, associate professor; and Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Meta-Analysis of UNL Feedlot Trials Replacing Corn with WDGS

Virgil R. Bremer
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

A meta-analysis of UNL feedlot trials replacing dry-rolled or high-moisture corn with wet distillers grains plus solubles (WDGS) indicated WDGS fed between 15% to 40% of diet DM was 130% the feeding value of corn. Feed: Gain, ADG, marbling score, and fat thickness responded quadratically as WDGS inclusion increased. In most cases, performance and carcass characteristics improved up to 30% to 40%, then gradually decreased. Feeding WDGS up to 40% of diet DM improved performance and quality grade.

Introduction

Previous UNL feedlot research indicated an increased feeding value of WDGS relative to dry-rolled corn. However, the increased feeding value of WDGS was dependent on inclusion level and method of corn processing used in the diet. In addition, the impact of WDGS inclusion level on quality grade was not summarized.

A Meta-analysis is used to account for individual trial variation on the combined results of multiple studies. Therefore the objective of this Meta-analysis was to evaluate the effect of WDGS dietary inclusion level of diets containing dry-rolled or high-moisture corn on feedlot cattle performance and carcass characteristics.

Procedure

Treatment means (n = 34) from University of Nebraska ARDC research feedlot experiments evaluating the use of WDGS in finishing diets were compiled (*1993 Nebraska Beef Report,* pp. 43-46; *1994 Nebraska Beef Report*, pp. 38-40; *1999 Nebraska Beef Report,* pp. 32-33; *2004 Nebraska Beef Report,* pp. 45-48; *2006 Nebraska Beef Report,* pp. 51-53; *2007 Nebraska Beef Report,* pp. 25-26; *2007 Nebraska Beef Report,* pp. 33-35; *2008 Nebraska Beef Report,* pp. 60-62). Steers (n = 1,257) in these studies were predominantly black, crossbred steer calves or yearlings. Within experiment, cattle were blocked by initial BW, allocated randomly to pens, then pens assigned randomly to dietary treatments. Only studies that replaced dry-rolled corn, high-moisture corn, or a combination of the two types of corn with corn WDGS (0% to 50% of diet DM) were included in the analysis. Wet DGS also replaced CP in the diet if CP needs were met by byproduct inclusion level. All finishing diets contained 5% to 7.5% roughage (DM basis).

Steers in these experiments were fed for 99 to 168 days. In each individual experiment, cattle were fed the same number of days and marketed at a commercial abattoir. Hot carcass weight was recorded on day of slaughter. Fat thickness was measured after a 24 to 48-hour chill. USDA Marbling score was called by a professional USDA grader, where 500 = Small^0. Final BW, ADG, and F:G were calculated based on hot carcass weights adjusted to a common trial dressing percentage of 62% or 63%. The feeding value of WDGS at different inclusion levels was calculated using feed efficiency. The difference between each WDGS treatment and the individual experiment control diet (0% WDGS) was calculated, divided by the feed efficiency value of the control treatment, as well as the percentage of WDGS in the individual diet to give a feeding value of WDGS relative to feeding corn.

An iterative meta analysis methodology was used to integrate quantitative findings from multiple studies using the PROC MIXED procedure of SAS.

Results

Replacement of grain with WDGS consistently improved F:G (Table 1). The feeding value of WDGS was consistently higher than corn and suggests a 30% improvement in feeding value when WDGS replaced 15%

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Table 1. Finishing steer performance when fed different dietary inclusions of wet distillers grains plus solubles (WDGS).

WDGS Inclusion[a]:	0WDGS	10WDGS	20WDGS	30WDGS	40WDGS	50WDGS	Lin[b]	Quad[b]	Cubic[b]
DMI, lb/day	22.3	22.7	22.8	22.5	21.8	20.8	0.01	0.01	0.75
ADG, lb	3.47	3.70	3.83	3.87	3.81	3.66	< 0.01	< 0.01	0.30
F:G	6.44	6.16	5.95	5.81	5.74	5.73	< 0.01	0.09	0.39
12th rib fat, in	0.49	0.54	0.55	0.53	0.52	0.55	< 0.01	0.04	0.06
Marbling score [c]	518	528	533	532	526	514	0.05	0.05	0.36
Feeding value, % [d]	100	155	131	130	131	113	0.01	0.03	0.05

[a] Dietary treatment levels (DM basis) of wet distillers grains plus solubles (WDGS), 0WDGS = 0% WDGS, 10WDGS = 10% WDGS, 20WDGS = 20% WDGS, 30WDGS = 30% WDGS, 40WDGS = 40% WDGS, 50WDGS = 50% WDGS.

[b] Estimation equation linear, quadratic, and cubic term t-statistic for variable of interest response to WDGS level.

[c] 500 = Small^0.

[d] Percent of corn feeding value, calculated from individual trial treatment mean feed conversion relative to individual trial 0WDGS feed conversion, divided by WDGS inclusion.

to 40% of the diet. The feeding value at low levels (less than 15%) was approximately 160% the feeding value of corn. When higher levels of WDGS were used (greater than 40%), the feeding value was still greater than corn, but less than when intermediate levels of WDGS were fed. The increase in feeding value was due to improvements in ADG when WDGS replaced corn (Figure 3). Because ADG was greater for cattle fed WDGS, carcasses from cattle fed WDGS were fatter, and marbling score increased. The response in ADG and marbling score were significantly quadratic and increased as WDGS inclusion increased to 30% (DM basis) and then decreased. All cattle were sold at one time and carcass characteristics measured. Therefore, if one dietary treatment had a negative impact on performance, then those cattle were less finished (i.e., fat) at the conclusion of the experiment. Likewise, treatments that improved performance resulted in greater carcass fatness due to the same number of days-on-feed within experiments. In conclusion, feeding as much as 40% WDGS increased gain, improved F:G, increased marbling score, as well as increased fat thickness. The increase in fat depth and marbling from feeding byproducts was related to improved F:G and ADG.

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[1] Virgil R. Bremer, research technician; Galen E. Erickson, associate professor; and Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Effect of Inclusion Level of Modified Distillers Grains plus Solubles in Finishing Steers

Taia J. Huls
Matt K. Luebbe
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

Modified distillers grains plus solubles (MDGS) was fed at 0%, 10%, 20%, 30%, 40%, and 50% of the diet (DM basis) replacing dry rolled corn and high moisture corn. The feeding value of MDGS is 123% to 109% the value of corn as MDGS inclusion increases from 10% to 50% (DM basis). Except for hot carcass weight and calculated yield grade no differences in carcass characteristics were observed between treatments. Finishing diets including MDGS may be fed up to 50% of diet DM; however, optimal performance is likely between 20% to 40% of the diet DM.

Introduction

Modified distillers grains plus solubles (MDGS) is produced by combining the distillers grains and distillers solubles fractions. The ethanol plant will partially dry the wet distillers grains and then apply all the distillers solubles to the wet grains. MDGS varies from the other dry milling byproducts with a DM around 42% to 48%. Previous research has shown wet distillers grains plus solubles (WDGS) and dry distillers grains plus solubles (DDGS) to have a higher feeding value when compared to corn (Vander Pol et al., *2006 Nebraska Beef Report,* pp. 51-53, Buckner et al., *2007 Nebraska Beef Report,* pp. 36-38). The total inclusion of distillers solubles in MDGS provides a higher fat content which may provide a higher feeding value or the drying process may reduce the feeding value relative to corn. Therefore, the objective of this trial was to determine feeding performance and carcass characteristics of feedlot steers fed 0% to 50% MDGS (DM basis).

Procedure

A finishing trial was conducted at UNL research feedlot near Mead, Neb. using yearling crossbred steers (n=288; BW = 732 ± 38 lb) Prior to trial initiation, steers were limit-fed 5 days to minimize gut fill differences (a 1:1 ratio of alfalfa hay and wet corn gluten feed at 2% of BW). On day 0 and day 1, individual BW data were collected, animals were blocked by BW, stratified within block, and assigned randomly to pens. Pen (8 steers/pen) was assigned randomly to treatment. Thirty six pens were used to provide six replications of the six treatments.

Six treatments included a control (CON) with 0% MDGS, 10% MDGS (10MDG), 20% MDGS (20MDG), 30% MDGS (30MDG), 40% MDGS (40MDG), and 50% MDGS (50MDG) on a DM basis. As MDGS level increased across treatments the 1:1 ratio of dry-rolled corn (DRC) and high moisture corn (HMC) decreased. All diets included alfalfa hay and supplement at 7.5% and 5% (DM basis) respectively. The supplement used for CON and 10MDG treatments were formulated to provide 13.5% CP using 1.28% and 0.64% urea, respectively. Corn gluten meal (CGM) was added for the first 100 days for CON and 50 days for 10MDG to meet metabolizable protein (MP) requirements. Supplements were formulated to provide Rumensin (*Elanco Animal Health*) at 320 mg, Tylan (*Elanco Animal Health*) at 90 mg, and thiamine at 150 mg per steer daily.

Weekly feed ingredient samples were collected for DM analysis in a 60°C forced air oven for 48 hours. Steers were adapted to finishing diets using four diets fed for 3, 4, 7, and 7 days with alfalfa hay replacing corn. Steers were implanted on days 1 and 67 with Synovex® Choice (*Fort Dodge Animal Health*). Steers were slaughtered on day 176 at a commercial abattoir (*Greater Omaha Pack, Omaha, Neb.*). Hot carcass weights (HCW) and liver scores were collected on the day of slaughter. Following a 48-hour chill, USDA marbling score, 12th rib fat depth, and longissimus dorsi (LM) area were recorded. A calculated USDA yield grade (YG) was derived from HCW, fat depth, LM area, and a common 2.5% kidney-pelvic-heart-fat (KPH). Carcass adjusted performance was calculated using a common dressing percent of 63% to determine final BW, ADG, and feed conversion (F:G).

The feed efficiency difference between each MDGS treatment and the CON was calculated, divided by the feed efficiency of the CON treatment, as well as the percentage of MDGS in the diet to give a feeding value of MDGS relative to feeding corn.

The MDGS used for this experiment was procured from U.S. BioEnergy Platte Valley (Central City, Neb.). The DM of MDGS was 48.8% and CP averaged 31.0%.

Data were analyzed using the Proc MIXED procedure of SAS. Pen was the experimental unit and treatments were analyzed as a randomized complete block design. Orthogonal polynomial contrasts were constructed to evaluate a response curve (linear and quadratic) for MDGS level.

Results

Performance and carcass characteristics are presented in Table 1. Seven steers died on experiment, five for respiratory and two bloat/digestive upsets. These steers were fairly evenly distributed across treatments (1 CON, 1 10MDG, 2 20MDG, 2 30MDG, and 1 50MDG), and were probably related to harsh winter feeding conditions. Carcass adjusted final BW responded

(Continued on next page)

Table 1. Yearling steer finishing feedlot performance when fed varying levels of MDGS.[a]

	CON	10MDG	20MDG	30MDG	40MDG	50MDG	SEM	Lin[b]	Quad[c]
Performance									
Initial BW, lb	748	749	748	745	747	748	27	0.32	0.32
Final BW[d] lb	1395	1411	1448	1439	1418	1398	38	0.82	<0.01
DMI, lb/day	23.0	23.1	23.5	23.2	22.8	21.6	0.7	0.03	0.01
ADG, lb	3.67	3.75	3.97	3.94	3.81	3.69	0.10	0.73	<0.01
F:G[e]	6.23	6.11	5.90	5.87	5.94	5.82		<0.01	0.28
Carcass Characteristics									
HCW, lb	879	889	912	906	893	881	24	0.82	<0.01
Dressing percent[f]	63.7	63.4	64.1	64.5	63.5	64.0	0.3	0.32	0.32
Marbling score[g]	520	513	538	498	505	490	17	0.10	0.42
12th Rib fat, in	0.57	0.57	0.61	0.62	0.57	0.54	0.04	0.54	0.12
LM Area, in^2	12.8	12.5	12.8	12.8	12.7	12.7	0.2	0.98	0.97
Calculated yield grade [h]	3.68	3.91	3.92	3.91	3.84	3.64	0.17	0.69	0.04

[a] Dietary treatment levels (DM basis) of MDGS, CON= 0% MDGS, 10MDG= 10% MDGS, 20MDG= 20% MDGS, 30MDG= 30% MDGS, 40MDG= 40% MDGS, 50MDG=50% MDGS.

[b] Contrast for the linear effect of treatment P-Value.

[c] Contrast for the quadratic effect of treatment P-Value.

[d] Calculated from hot carcass weight, adjusted to a 63% yield.

[e] Calculated from total gain over total DMI, which is reciprocal of F:G.

[f] Calculated from hot carcass weight divided by final live BW with a 4% shrink.

[g] 450 = Slight 50, 500 = Small 0.

[h] Where yield grade = 2.5 + 2.5(Fat thickness, in) – 0.32(LM area, in^2) + 0.2(KPH fat, %) + 0.0038(hot carcass weight, lb).

quadratically ($P < 0.01$) as MDGS inclusion increased. DMI showed a quadratic response ($P = 0.01$), with 20MDG having the greatest intakes. Similarly, a quadratic response ($P < 0.01$) was observed with ADG as MDGS inclusion increased from 0% to 50% of the diet (Figure 1). Cattle fed 20MDG produced the greatest ADG. Feed conversion (Figure 1) showed a linear improvement ($P < 0.01$) with optimum conversion observed when cattle were fed 50MDG. Calculated feeding value of MDGS relative to HMC/DRC was greatest for 10MDG and decreased as MDGS increased to 50% of diet DM (123% to 109% the feeding value of corn, respectively). HCW responded quadradically ($P < 0.01$) as MDGS inclusion increased in the diet with 20MDG cattle having the heaviest carcasses. The calculated YG responded quadratically ($P < 0.05$) with the 20MDG cattle having the highest YG. Fat depth and marbling score were not affected by diet suggesting that all cattle were finished to similar endpoints.

In summary, MDGS has 109% to 123% the feeding value of corn in feedlot finishing diets. When cattle were fed increasing levels of MDGS, ADG was greatest at 20% to 30% MDGS inclusion, and F:G was lowest at 40% to 50% MDGS dietary inclusion. Finishing diets including MDGS may be fed up to 50% of diet DM, with optimal performance at 20% to 40% of diet DM.

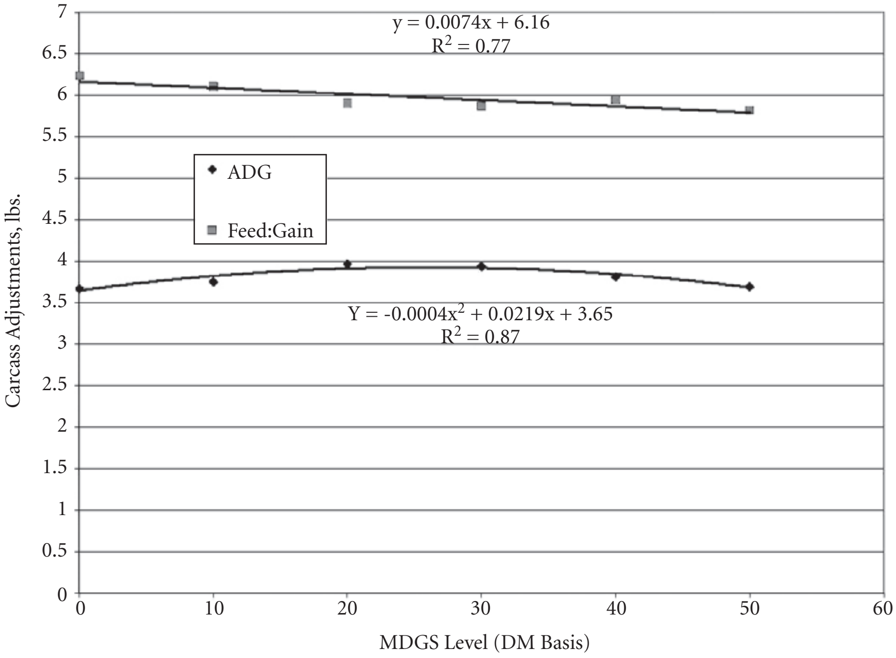

Figure 1. Carcass adjusted ADG and F:G relative to MDGS inclusion.

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[1] Taia J. Huls, graduate student; Matt K. Luebbe, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Effects of Corn Processing and Wet Distillers Grains on Nutrient Metabolism

Mark E. Corrigan
Galen E. Erickson
Terry J. Klopfenstein
Nathan F. Meyer[1]

Summary

Seven ruminally cannulated steers were used in a metabolism experiment to determine the effects of distillers grains level (0% or 40% of diet DM) on diet digestibility and rumen metabolism in diets consisting of dry-rolled, high-moisture, or steam-flaked corn. Intakes were greater while digestibility was reduced for DM and organic matter in steers fed 40% compared to 0% distillers grains. Average and maximum pH were less for steers fed 40% distillers grains, but pH change and variance were also less for 40% compared to 0% WDGS. Feeding WDGS does not increase rumen pH, but does decrease variance. Starch intakes were equal whether 0 or 40% WDGS were fed because cattle fed 40% WDGS had greater DMI, which may influence rumen pH.

Introduction

In a previously reported study (*2007 Nebraska Beef Report*, pp. 33-35), diets based on dry-rolled corn (DRC), high-moisture corn (HMC), or steam-flaked corn (SFC) were fed. Corn was replaced with increasing amounts of wet distillers grains with soluble (WDGS; 0%, 15%, 27.5%, or 40% of diet DM). No effect of WDGS level on feed efficiency was observed in SFC based diets, and ADG was reduced when 27.5% or 40% WDGS were fed. In DRC and HMC based diets however, feed efficiency improved linearly with increasing WDGS level, and ADG increased. The current study was conducted to determine the effects of corn processing method and WDGS level on nutrient digestion and ruminal fermentation characteristics in an attempt to elucidate the reasons for the interaction observed in the finishing trial.

Procedure

Seven ruminally cannulated steers were used in a six-period cross-over study. A 3 × 2 factorial treatment structure was used. The first factor was corn processing method (DRC, HMC, or SFC), and the second factor was WDGS inclusion level (0% or 40% of diet DM; Table 1). Steers were assigned randomly to one of two groups. Group 1 steers were assigned to diets containing 0% WDGS during the first three periods and diets containing 40% WDGS during the final three periods, while group 2 steers were assigned to diets containing 40% WDGS during the first three periods and diets containing 0% WDGS during the final three periods A two-week transition period was included between periods three and four during which group 2 steers were fed decreasing levels of WGDS as follows: day 1 to 4: 30%, day 5 to 10: 20%, and day 11 to 14: 10% WDGS, DM. During that transition, group 1 steers were switched immediately to diets containing 40% WDGS and all diets were based on an equal mixture of DRC, HMC, and SFC.

Period duration was 20 days and consisted of a 15-day adaptation period followed by a 5 day fecal sample and pH data collection period. Chromic oxide (7.5g/dose) was dosed intraruminally at 0800 and 2000 daily beginning on day 11 in each period. Fecal samples were collected daily at 0800, 1400, and 2000, composited by period, and analyzed for chromium content to determine nutrient digestibility. Steers were fed once daily at 0730 and, if present, feed refusals were also collected at this time. Continuous ruminal pH measurements were taken using pH probes that were suspended in the rumen fluid via the rumen cannula. Data were collected using a computer and software (Labtech, Wilmington, Mass.) that collected readings every 6 seconds and averaged those for each minute for the 5 days collection within each period.

Table 1. Diets fed to steers in the digestibility experiment evaluating wet distillers grains plus solubles (WDGS) when fed with different corn processing methods[a] (% of diet DM).

Ingredient	0% WDGS	40% WDGS
DRC, HMC, or SFC	82.5	47.5
WDGS	0.0	40.0
Alfalfa hay	7.5	7.5
Molasses	5.0	0.0
Supplement	5.0	5.0

[a]DRC = dry-rolled corn, HMC = high-moisture corn, and SFC = steam-flaked corn.

Data were analyzed as a six- period crossover design using the MIXED procedure of SAS (SAS Inst. Inc.). Period was included in the model as a fixed effect and the random effect was steer. No corn processing method × WDGS inclusion level interactions were observed ($P > 0.20$) for any variables, so only the main effects of corn processing method and WDGS inclusion level are presented. As a result, main effects were analyzed and statistics presented with the interaction term removed from the model.

Results

Data for nutrient intake and digestibility are presented in Table 2. No corn processing method × WDGS inclusion level interactions for nutrient intake or digestibility were observed ($P > 0.43$), so main effects will be discussed. Corn processing method did not affect intake or digestibility of DM or organic matter (OM). Digestibility of neutral detergent fiber (NDF) was similar between corn processing methods; however, cattle fed HMC consumed slightly less NDF ($P < 0.05$). Starch intake was not impacted by corn processing method, but starch digestibility was greater

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($P < 0.06$) for SFC compared to both DRC and HMC. Feeding WDGS increased intake of DM and OM but decreased the digestibility percentage of both. While NDF digestibility was not impacted by feeding WDGS, cattle fed 40% WDGS consumed more NDF ($P < 0.01$) because WDGS contain more NDF than corn. Starch is removed during the production of WDGS. Despite lower dietary starch percentage in the 40% WDGS diets, feeding WDGS did not reduce total starch intake ($P = 0.90$) and did not impact starch digestibility.

Table 2. Effect of corn processing method and wet distillers grains plus solubles (WDGS) level on nutrient intake and digestibility.

	Corn processing method^{a}			WDGS level		P-value^{b}		
Item	DRC	HMC	SFC	0%	40%	Process	WDGS	Inter
DM								
Intake, lb/day	20.8	19.5	20.7	18.4	22.3	0.25	0.01	0.93
Digestibility, %	78.7	78.8	81.4	81.8	77.5	0.31	0.08	0.96
OM								
Intake, lb/day	20.1	19.0	19.9	18.0	21.4	0.34	0.02	0.94
Digestibility, %	80.7	80.9	83.3	84.0	79.3	0.32	0.05	0.94
NDF								
Intake, lb/day	3.94^{c}	3.35^{d}	3.74^{c}	2.39	4.97	0.02	0.01	0.64
Digestibility, %	49.4	47.2	50.9	47.8	50.5	0.80	0.72	0.73
Starch								
Intake, lb/day	12.0	11.2	11.7	11.6	11.7	0.65	0.90	0.77
Digestibility, %	95.5^{c}	96.5^{c}	99.1^{d}	96.6	97.5	0.04	0.57	0.43

^{a}DRC = dry-rolled corn, HMC = high-moisture corn, and SFC = steam-flaked corn.
^{b}P-value where Process = corn processing method; WDGS = wet distillers grains plus solubles level; Inter = interaction between corn processing method and WDGS level.
^{c,d}Means with different superscripts differ ($P < 0.06$).

Table 3. Effect of corn processing method and wet distillers grains plus solubles (WDGS) level on rumen pH.

	Corn processing method^{a}			WDGS level		P-value^{b}		
Item	DRC	HMC	SFC	0%	40%	Process	WDGS	Inter
Average pH	5.53	5.56	5.44	5.61	5.41	0.27	0.12	0.51
Maximum pH	6.22^{c}	6.41^{d}	6.50^{d}	6.50	6.26	0.04	0.07	0.49
Minimum pH	5.00	5.06	4.93	5.01	4.98	0.63	0.80	0.82
pH change	1.21^{c}	1.34^{c}	1.56^{d}	1.50	1.25	0.05	0.08	0.27
pH variance	0.070^{c}	0.109^{c}	0.161^{d}	0.140	0.087	0.02	0.09	0.56
Area under curve (magnitude of pH < 5.6 or 5.3 by minute)								
< 5.6	260^{c}	307^{cd}	398^{d}	245	399	0.10	0.07	0.62
< 5.3	67^{c}	113^{cd}	149^{d}	76	144	0.06	0.08	0.97

^{a}DRC = dry-rolled corn, HMC = high-moisture corn, and SFC = steam-flaked corn.
^{b}P-value where Process = corn processing method; WDGS = wet distillers grains plus solubles level; Inter = interaction between corn processing method and WDGS level.
^{c,d}Means with different superscripts differ ($P < 0.10$).

Rumen pH data are presented in Table 3. No corn processing method × WDGS inclusion level interactions for rumen pH data were observed ($P > 0.27$), so only the main effects are discussed. An effect of corn processing method on maximum pH ($P = 0.04$), the magnitude of pH change ($P = 0.05$), and the variance of the ruminal pH ($P < 0.02$) was observed. Steers fed DRC had lower maximum rumen pH values compared to steers fed HMC and SFC ($P < 0.10$). Interestingly, average and minimum rumen pH values were not different between the three corn processing methods. This led to both magnitude of pH change and variance of pH being numerically lowest in steers fed DRC. Although not significant, steers fed HMC had a numerically greater pH change and variance than steers fed DRC. Steers fed SFC experienced a pH change and variance that was greater ($P < 0.10$) than steers fed DRC or HMC. Inclusion level of WDGS also affected rumen pH. Interestingly, steers fed 0% WDGS tended to have greater average pH ($P < 0.12$), maximum pH ($P = 0.07$), pH change ($P = 0.08$), and pH variance ($P = 0.09$) compared to steers fed 40% WDGS. As was the case with corn processing method, minimum pH was not different between 0% and 40% WDGS. Area under the curve for pH of 5.6 and 5.3 followed similar trends as maximum pH. Steers fed SFC had a rumen pH below 5.6 and 5.3 for more minutes compared to steers fed DRC, with HMC fed steers being intermediate. Interestingly, feeding 40% WDGS resulted in greater time spent below a rumen pH of 5.6 or 5.3 compared to cattle fed 0% WDGS. These data agree with previous research evaluating rumen metabolism with and without WDGS (*2007 Nebraska Beef Report*, pp. 39-42).

The lack of an interaction between corn processing method and WDGS inclusion level in this trial does not explain the interaction observed in previous finishing trials. However, DMI was markedly reduced when WDGS were fed at 40% of the diet in SFC-based diets in the previous finishing study. A similar intake response was not observed in this metabolism experiment as DMI was 18.9 lb/day for 0% WDGS and 22.4 lb/day for 40% WDGS in SFC diets. Despite no interaction between corn processing method and WDGS inclusion, starch digestibility was consistent between WDGS levels in HMC and SFC diets, with less than 0.3 percentage unit change between 0 and 40% WDGS within each corn processing method. However, steers fed 0% WDGS with DRC had a starch digestibility of 93.9% which was numerically lower than the 40% WDGS with DRC treatment (97.0%).

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[1]Mark E. Corrigan, graduate student; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor; Nathan F. Meyer, research technician; Department of Animal Science, Lincoln.

Effect of Distillers Grains Fat Level on Digestibility

Mark E. Corrigan
Galen E. Erickson
Terry J. Klopfenstein
Nathan F. Meyer[1]

Summary

Four steers were used in a three-period switchback design to determine effects of dry distillers grains fat level on digestibility. Forage based diets were supplemented with distillers grains with differing fat levels (6.9% or 13.3 % dry matter). Intake and digestibility of DM and organic matter did not differ between treatments. Neutral detergent fiber intake was less and digestibility tended to be less in steers supplemented with high fat distillers grains. Differences in fiber type and intake as well as fat intake may be responsible for the small difference in neutral detergent fiber digestibility.

Introduction

Variability in composition of wet distillers grains has been demonstrated (*2008 Nebraska Beef Report*, pp. 126-127), and it is likely that these differences in nutrient composition impact overall feed value. Previously we have reported an interaction between dry distillers grains (DDG) composition and supplementation level (*2007 Nebraska Beef Report*, pp. 17-18.). In that study, ADG and F:G improved with increasing DDG supplementation level in steers fed DDG containing intermediate levels of solubles (5.4% to 19.1%, DM basis). When steers were supplemented with DDG containing 21.1% solubles however, ADG and F:G were optimized with the 0.50% supplementation level and decreased with increasing supplementation levels thereafter. Distillers solubles have a higher fat content (approximately 20% of DM) than do distillers grains without solubles (7% of DM). Therefore, as DDG solubles level increased, so did DDG fat content. We hypothesize the high fat intake of steers fed high levels of the high solubles DDG may have caused a reduction in nutrient digestibility. The current study was conducted to determine if DDG composition affects DM, OM, and NDF digestibility.

Procedure

Four steers were used to determine effects of DDG composition on digestibility of DM, OM, and NDF in growing steers fed a forage-based diet. A three-period switchback design was used. Treatments included supplementation of one of two types of DDG fed in a previous experiment (*2007 Nebraska Beef Report*, pp 17-18). The DDG differed in nutrient composition (Table 1) and were supplemented at 1% of BW. Nutrient composition was different due to different amounts of distillers solubles added to distillers grains (0% and 22.1%, DM basis). Steers were assigned randomly to one of two groups. Group 1 steers were supplemented with the low fat DDG (LOW FAT) during periods 1 and 3 and the high fat DDG (HIGH FAT) during period 2. Group 2 steers were supplemented with HIGH FAT DDG during periods 1 and 3 and LOW FAT DDG during period 2. For 5 days prior to initiation of the experiment, steers were supplemented with DDG containing 14.5% solubles at 1% of BW and allowed ad libitum intake of a mixed forage diet (58.8% alfalfa hay, 39.2% brome hay, and 2.0% supplement). Throughout the experiment steers were fed the mixed forage diet at 95% of their previously recorded ad libitum intake. Steers were individually fed once daily at 0800.

Period duration was 14 days and consisted of a 10-day adaptation period followed by a 4 day total fecal collection period. Fecal collection bags were placed on the steers at 0800 on day 11. Bags were replaced and fecal contents were weighed and sampled at 0800 and 1700 daily. Fecal samples were immediately frozen and later analyzed for DM, OM, and NDF content.

Table 1. Composition of dry distillers grains (DDG) with different amounts of distillers solubles fed to steers at 1% of BW.

Item	Low Fat DDG	High Fat DDG
DM, %	95.5	89.6
CP, %	32.1	30.9
Fat, %	6.9	13.3
NDF, %	36.8	29.3

Data were analyzed as a three-period switchback design using the MIXED procedure of SAS (SAS Inst. Inc., Cary, N.C.). Carryover effect and treatment sequence were included as fixed effects in the model.

Results

Intake of DM and OM were not different between treatments (Table 2). This is not surprising as forage intake was limited throughout the experiment to 95% of ad libitum. However, intake of NDF was greater (*P* = 0.02) in steers fed LOW FAT DDG compared to steers fed HIGH FAT DDG. This is a reflection of the different NDF percentages of LOW FAT (36.8%, DM basis) and HIGH FAT DDG (29.3%, DM basis). No treatment differences were observed for digestibility of DM or OM. There was however a 3% improvement in NDF digestibility in steers fed LOW FAT DDG compared to steers fed HIGH FAT DDG, which was approaching significance (*P* = 0.14).

There was a large difference in the fat content of LOW FAT (6.9% fat, DM basis) and HIGH FAT DDG (13.3% fat, DM basis). Supplemental fat has been shown to reduce the digestibility of DM, OM, and NDF in forage diets (Paven et al., *Journal of Animal Science*). The observation of 3% greater NDF digestibility for steers supplemented with LOW FAT DDG compared to HIGH FAT DDG may be a result of the amount of daily fat intake (0.8 and 1.1 lb/day for LOW FAT and HIGH FAT DDG, respectively). The NDF from the DDG would be expected to be more digestible than

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that of the forage. Therefore, the higher proportion of NDF intake from DDG in steers supplemented with LOW FAT DDG compared to HIGH FAT DDG supplemented steers may explain some of the difference. Intake of NDF from DDG was 36.6% and 29.9% of total NDF intake for LOW FAT and HIGH FAT DDG, respectively. In contrast, lower fiber intakes observed in steers supplemented with HIGH FAT DDG would have been expected to increase digestibility of DM, OM, and possibly NDF. Therefore, the reasons for the observed small difference in NDF digestibility between treatments remain unclear.

Table 2. Intake and digestibility of dry matter, organic matter, and NDF from DDG varying in fat content when fed at 1% of BW.

Item	Low Fat DDG	High Fat DDG	*P*-value
DM			
Intake, lb	14.7	14.7	0.90
DDG, lb	6.6	6.6	0.90
Digestibility, %	67.5	66.2	0.58
OM			
Intake, lb	14.2	14.2	0.91
DDG, lb	6.5	6.4	0.46
Digestibility, %	69.8	68.5	0.55
NDF			
Intake, lb	8.2	7.7	0.02
DDG, lb	2.9	2.4	<0.01
Digestibility, %	62.6	59.6	0.14

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[1] Mark E. Corrigan, graduate student; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor; Nathan F. Meyer, research technician; Department of Animal Science, Lincoln.

Cattle CODE: An Economic Model for Determining Byproduct Returns for Feedlot Cattle

Crystal D. Buckner
Virgil R. Bremer
Terry J. Klopfenstein
Galen E. Erickson
Darrell R. Mark[1]

Summary

Cattle CODE — Coproduct Optimizer Decision Evaluator — is a model developed to predict performance and economic returns when byproducts are fed to finishing cattle. Four scenarios were evaluated to illustrate how the model works and to show sensitivity to corn price and distance from the ethanol plant, which resulted in positive returns for feeding WDGS, Sweet Bran, or DDGS up to 50% of diet DM and under 100 miles distance from the ethanol plant to the feedlot. The model can be found at http://beef.unl.edu under the byproduct feeds tab.

Introduction

Type of byproduct, dietary inclusion level, moisture content, trucking costs, feeding costs, and price relationship between byproducts and corn price affect cattle feeding profit or loss when using byproducts. Our objective was to use Coproduct Optimizer Decision Evaluator (Cattle CODE, at *http://beef.unl.edu*), a model designed to estimate profit or loss from feeding byproducts in feedlot diets, to evaluate these factors.

Procedure

Cattle CODE required cattle inputs of feeder and finished BW and their respective prices. Dry matter intake and F:G for cattle fed a corn-based diet with no byproducts were required inputs. Cattle processing and medical costs, death loss, yardage costs, and loan interest were also required. Feed ingredient prices, ingredient DM (%), and dietary inclusion level on a DM basis were needed for corn, byproducts, roughages, and a supplement. Inputs of semi-truck load size, cost/loaded mile, and miles hauled to the feedlot were needed for trucking costs (Table 1).

With these inputs, the model predicts DMI and F:G for each byproduct type and inclusion levels based on equations from research trials. The trials used include: wet distillers grains plus solubles (WDGS; Vander Pol et al., *2006 Nebraska Beef Report*, pp. 51-53), dry distillers grains plus solubles (DDGS; Buckner et al., *2007 Nebraska Beef Report*, pp. 36-38), modified distillers grains plus solubles (MDGS; Huls et al., *2008 Nebraska Beef Report*, pp. 50-51), Sweet Bran® and traditional wet corn gluten feed (Bremer et al., *2008 Nebraska Beef Report*, pp. 37-38), and wet Dakota Bran cake (Dbran; Bremer et al., *2006 Nebraska Beef Report*, pp. 57-58). With predicted DMI and F:G, the model calculated ADG. Feeder and fat cattle BW do not change in the model with inclusion of byproducts. Therefore, days on feed (DOF) were calculated based on ADG.

Yardage costs were divided into two parts. The model assumed 1/3 of yardage cost was for feeding costs, while the other 2/3 was for nonfeeding yardage costs. The feeding yardage cost component would account for any added costs associated with feeding wetter diets due to wet byproduct inclusions. Processing and medical expenses, death loss, and cattle loan interest remained the same in the model regardless of byproduct inclusion.

The model added urea (and associated cost) to diets when supplemental protein was needed to obtain at least 13.5% dietary CP. The model calculated dietary DM content with the inputs of feed ingredient DM and % inclusion, which was important for calculating feeding yardage costs. Byproduct hauling costs were calculated with load size, cost/loaded mile, and miles delivered to the feedlot.

A few byproduct feeding scenarios were evaluated to illustrate how this model can calculate profit/loss with any given inputs. Assumptions for inputs included: 740 lb feeder steer at breakeven price to cause the corn diet to have $0 profit, 1,300 lb finished steer at $90/cwt, 24 lb DMI and 6.5 F:G for cattle consuming a corn-based

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Table 1. Inputs required and outputs derived for Cattle CODE.

Inputs Required	Outputs Generated
Cattle	*Predicted/ Calculated Parameters*
Feeder weight	DMI for byproduct scenario
Feeder price/cwt	F:G for byproduct scenario
Finished weight	ADG
Finished price/cwt	DOF
DMI on corn diet	*Costs/ head*
F:G on corn diet	Nonfeeding yardage
Yardage cost/head/day	Feeding yardage
Processing and medical costs/ head	Byproduct transportation to the feedlot
Death loss %	*Diets*
Cattle loan interest %	DM%
Feed	CP%
Byproduct costs/ ton and %DM	Diet cost/ ton DM
Corn costs/ bushel, %DM, % of diet	Total feeding cost/ head
Roughage cost/ ton, %DM, % of diet	*Overall*
Supplement and urea costs/ ton, %DM, % of diet	Cost of gain/ lb
Transportation	Profit or Loss/ head
Truck load size (lbs as-is)	Byproduct returns/ head
Hauling cost/ loaded mile	
Miles from ethanol plant	

diet, $12.00/ head for processing and medical costs, 1.5% death loss, 8.1% cattle loan interest, and $0.35/ hd*day for yardage costs. Feed inputs included blending dry-rolled corn ($3.70/bu) with high-moisture corn ($3.35/bu) on an equal DM basis, 7% alfalfa hay ($130/ton), 4% dry supplement ($190/ton), and urea priced at $320/ton. Only three byproducts were evaluated for this report, including: WDGS (33% DM) and Sweet Bran (60% DM) priced at 95% and DDGS priced at 100% the price of corn (DM basis). Transportation inputs included $3.00/ loaded mile and 50,000 lb (as-is) byproduct capacity per load. A sensitivity analysis was conducted for mileage at 0, 30, 60, and 100 miles with hauling WDGS or Sweet Bran to a feedlot from the supplier. As the ethanol industry continues to expand with changing byproduct prices, we wanted to examine the price relationship of WDGS to corn at 95%, 85%, and 75% (DM basis). We also evaluated the sensitivity of changing corn prices at $2.70, $3.70, and $4.70/ bu with a changing corn market on DDGS returns.

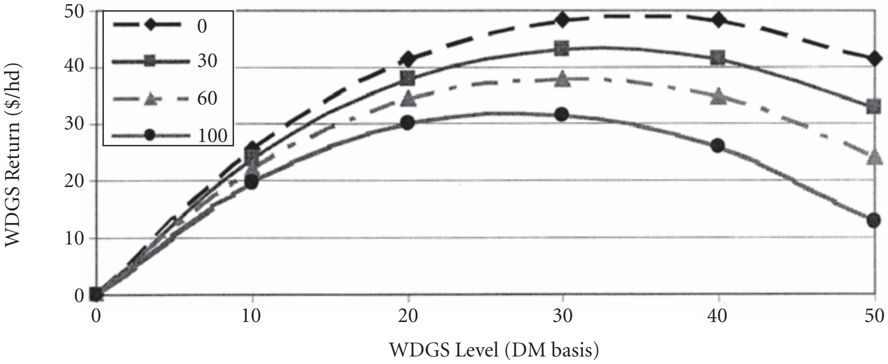

Figure 1. Economic return for feeding WDGS at 95% the price of corn ($3.70/bu corn) at 0, 30, 60, and 100 miles.

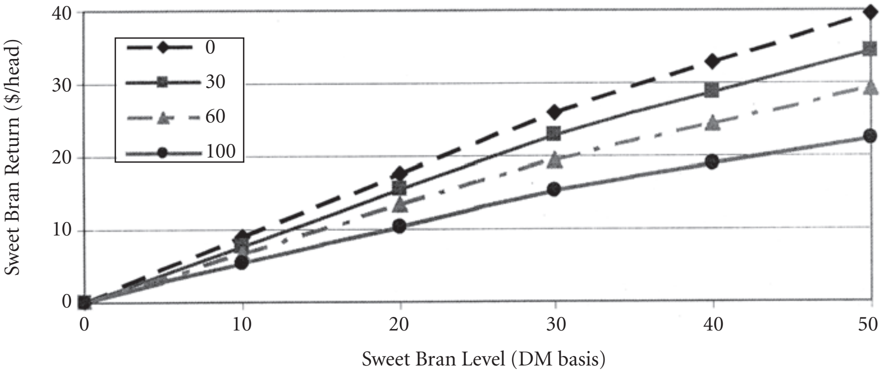

Figure 2. Economic return for feeding Sweet Bran at 95% the price of corn ($3.70/bu corn) at 0, 30, 60, and 100 miles.

Results

Distance between the ethanol plant and the feedlot impacted cattle returns when WDGS was fed. Feeding WDGS (priced at 95% of corn price) increased returns quadratically as WDGS inclusion levels increased up to 50% diet DM compared to feeding corn alone (Figure 1). If the feedlot was at the ethanol plant, the optimum inclusion level was 35% to 40% of diet DM and returns were $40-50 more/head compared to feeding corn. As the distance from the ethanol plant to the feedlot increased from 0 to 100 miles, the returns decreased for feeding WDGS when compared to corn alone. The optimum inclusion of WDGS also decreased as distance increased from the ethanol plant to the feedlot. These examples suggest that the optimum DM inclusion of WDGS was 35% to 40% if the feedlot was at the ethanol plant compared to an optimum inclusion of 20% to 25% if the feedlot was 100 miles away from the plant. Distance from the ethanol plant to the feedlot has a larger impact on economic returns as dietary inclusion level increased.

The analysis for transporting Sweet Bran (priced at 95% of corn price, DM basis) from 0 to 100 miles to a feedlot resulted in positive returns by feeding Sweet Bran up to 50% of diet DM (Figure 2). When the feedlot was located at the ethanol plant, the optimum inclusion level of Sweet Bran was 50% diet DM, with returns

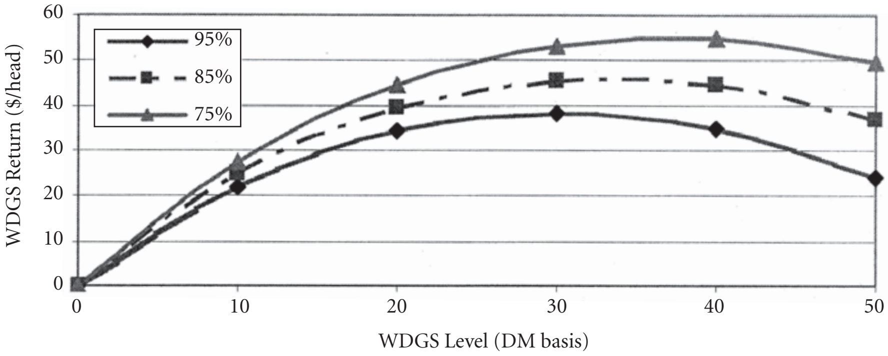

Figure 3. Economic return for feeding WDGS with $3.70/bu corn at 60 miles to the feedlot with 95%, 85%, and 75% WDGS price relative to corn (DM basis).

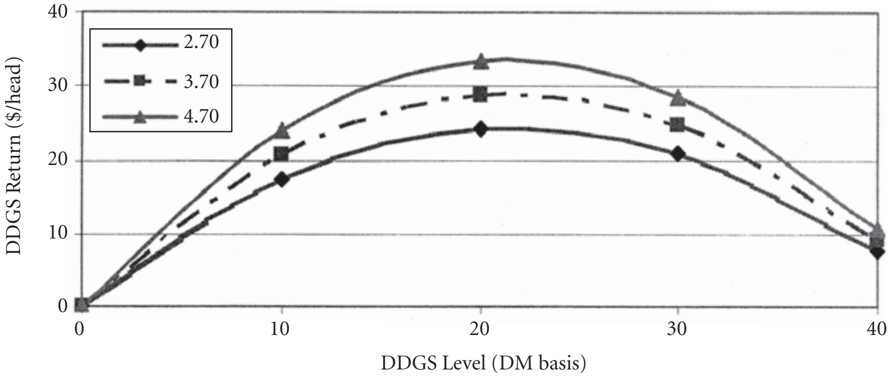

Figure 4. Economic return for feeding DDGS at 60 miles to the feedlot with 100% DDGS price relative to corn when corn is priced at $2.70, $3.70, or $4.70/bu.

up to $40/head compared to feeding corn. As distance from the ethanol plant to the feedlot increased from 0 to 100 miles, the optimum economic inclusion level for Sweet Bran remained the same at 50% diet DM, but the overall returns at 50% inclusion decreased to about $20/head at 100 miles. These results suggested that feeding Sweet Bran increased returns as dietary inclusion levels increased up to 50% of diet DM compared to corn, regardless of mileage. Inclusion level had a larger impact than distance from the ethanol plant for Sweet Bran based on economic returns.

With a constant corn price ($3.70/bu) and distance (60 miles), economic returns were sensitive to price of WDGS relative to corn. If WDGS was priced at 95% of corn price, then optimum inclusion of WDGS was 30% which returned $38/head (Figure 3). The optimum inclusion of WDGS was 35% diet DM when WDGS was priced at 85% of corn price and returns were $45/head. When pricing WDGS at 75% of corn price, the optimum inclusion level increased to 40% diet DM and returned $55/head. Pricing WDGS at a lower cost relative to corn had a larger impact on economic returns as inclusion levels of WDGS increased.

We determined the sensitivity of corn prices at $2.70, $3.70, and $4.70/bu with DDGS (priced at 100% of corn price), as 60 miles hauling distance for DDGS remained constant. This resulted in positive quadratic returns up to 40% diet DM (Figure 4) as optimum DDGS inclusion level remained the same at 20% to 25% diet DM for each of these corn prices with returns of $25 to $33/head. Increasing corn prices improved returns for feeding DDGS, but the most economic changes were observed at intermediate dietary inclusion levels of DDGS. Similar relationships were observed with feeding WDGS and increasing corn prices, as more profit resulted from increased corn prices with greater WDGS inclusion levels.

Based on these limited examples, feeding byproducts increased cattle economic returns compared to feeding corn. However, returns were impacted by type of byproduct used, inclusion level in the diet, distance from the ethanol plant, corn price, and byproduct price relative to corn. This model should allow for producers to use their own inputs and improve their decision making ability on using byproducts. The model can be downloaded at *http://beef.unl.edu*.

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[1] Crystal D. Buckner, research technician; Virgil R. Bremer, research technician; Terry J. Klopfenstein, professor; and Galen E. Erickson, associate professor, Animal Science, Lincoln. Darrell R. Mark, assistant professor, Agricultural Economics, Lincoln.

Economics of Modified Wet Distillers Grains Plus Solubles Use in Feedlots

Taia J. Huls
Virgil R. Bremer
Crystal D. Buckner
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

An economic analysis was conducted of steers fed five dietary levels of modified distillers grains plus solubles (MDGS) using the economic model, Cattle CODE. Marginal returns to feeding were greatest when feeding MDGS at 30% to 40% of diet DM when MDGS was 95% the price of corn (DM basis), and trucking was 60 miles from the feedlot. When distance from the plant increased to 100 miles, optimum inclusion rate of MDGS decreased to 20% to 30% diet (DM basis). When MDGS was priced at 75%, 85%, or 95% of corn price, optimum dietary inclusion was 30% to 40% (DM basis) with marginal returns of $38.57, $26.20, or $13.83, respectively. Optimum inclusion levels also appeared to be at 30 to 40% of diet (DM basis) when corn is priced at $4.70, $3.70, or $2.70/bu.

Introduction

A trial was conducted feeding modified wet distillers grains plus solubles (MDGS; 42% to 48% DM) to finishing steers (Huls et al., *2008 Nebraska Beef Report*, pp 41-42). These data were entered into Cattle CODE, which is available at *http://beef.unl.edu/*, to evaluate the marginal return to feeding varying levels of MDGS compared to a corn control diet. Cattle CODE is an economic budget model developed at UNL to determine dollars returned on feedlot cattle when fed different types and amounts of byproduct.

Previous trials suggest feeding value of MDGS relative to corn was 123% to 109% as inclusion level increased from 10% to 50% MDGS (Huls et al., *2008 Nebraska Beef Report*, pp. 41-42). MDGS may result in a reduction in hauling costs for feedlots that are further from ethanol plants due to a greater DM (42% to 48%) than traditional WDGS (30% to 35% DM). The objective of this experiment was to incorporate feeding MDGS into Cattle CODE and determine the economic benefit of feeding MDGS when compared to a corn-based finishing feedlot diet.

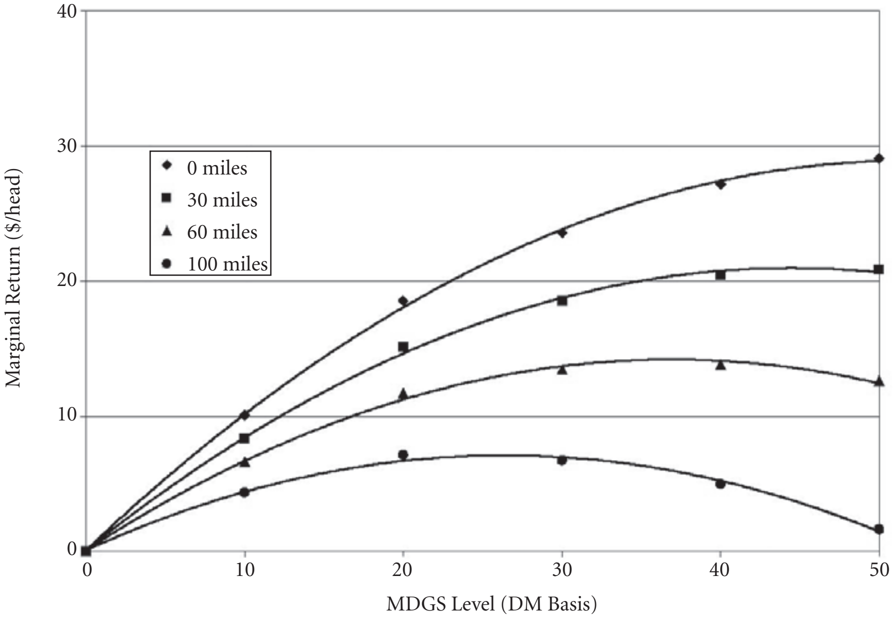

Figure 1. Marginal return to feeding MDGS at 95% the price of corn ($3.70/bu corn) at 0, 30, 60, and 100 miles from plant.

Procedure

Performance Inputs

Treatment means from a 288-head finishing trial evaluating MDGS were used for Cattle CODE inputs (Huls et al., *2008 Nebraska Beef Report*, pp. 41-42). The DMI equation used was $y= -0.00177x^2 + 0.06548x + 24$ where x was the byproduct inclusion level expressed as a percentage and y was the predicted DMI. The G:F equation used was $y= 0.000204x + 0.1538$ where x was the byproduct inclusion level expressed as a percentage and y was the predicted G:F. Feeder prices varied in the model, based on corn price, to adjust the profit/loss to zero for the diet with no byproducts. Feeder price paid in $/cwt were $118.99, $108.97, and $98.94 for $2.70, $3.70, and $4.70/bu corn, respectively. All other inputs in the model remained constant, with a feeder BW of 732 lb, finished BW of 1398 lb, fed cattle selling price of $90/cwt, 23.0 lb DMI, and a F:G of 6.23. A processing and medical cost of $12.00/head, 1.5% death loss, 8.1% cattle loan interest, and $0.35/head/day yardage charge were used in the model.

Feed Ingredient Prices

In this analysis, feed prices were varied along with different prices of MDGS relative to corn. MDGS was valued FOB the ethanol plant at 95%, 85%, and 75% the value of corn. MDGS prices were expressed relative to corn as the dry ton price of MDGS divided by the dry ton price of corn. Corn and MDGS prices were based on corn prices at $2.70, $3.70, or $4.70/bu (84.5% DM). In each analysis, alfalfa hay, supplement and urea cost were priced at $147.73, $200.00, and $320.00 per ton of DM, respectively.

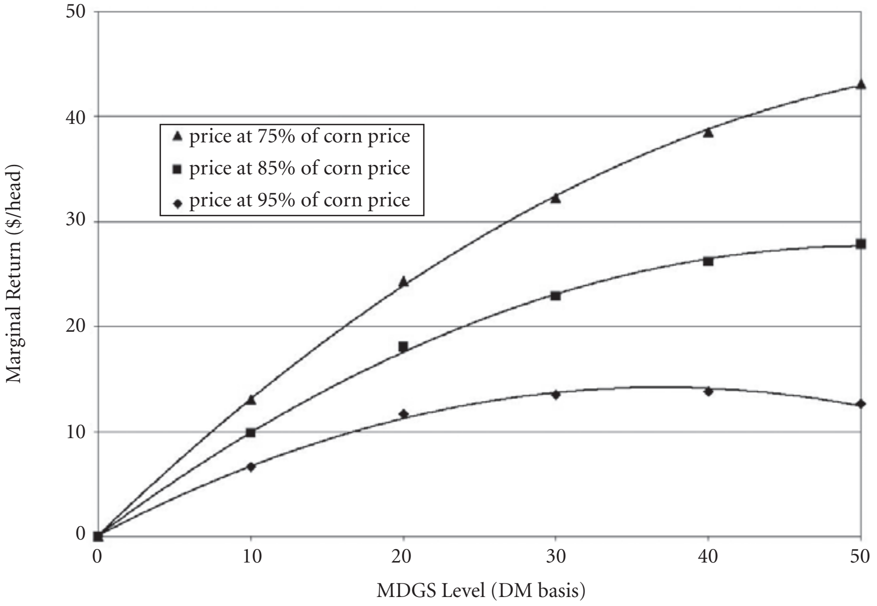

Figure 2. Marginal return to feeding MDGS with $3.70/ bu corn at 60 miles to the feedlot with 95%, 85%, and 75% MDGS price relative to corn (DM basis).

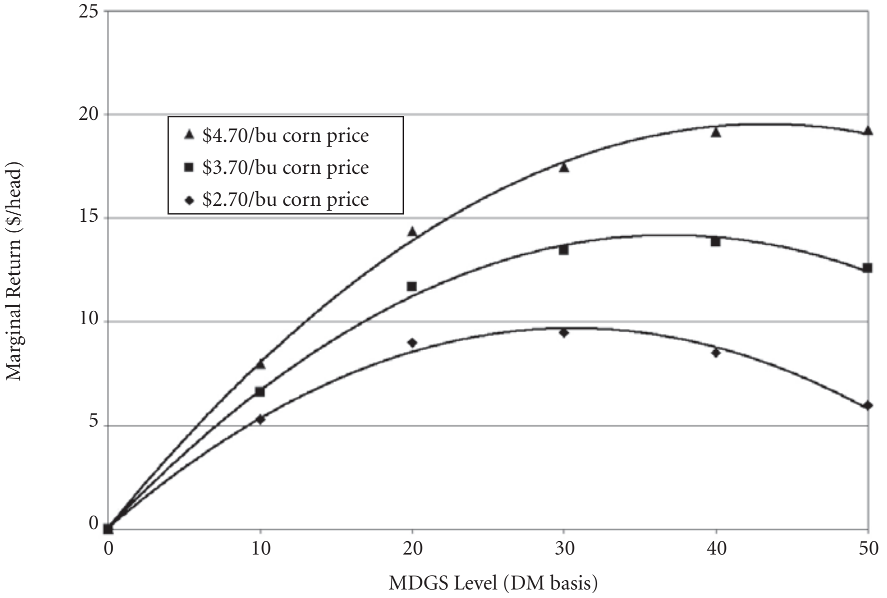

Figure 3. Marginal return to feeding MDGS at 60 miles to the feedlot with 95% MDGS price relative to corn when corn is priced at $2.70, $3.70, or $4.70/bu.

Transportation

Semi-truck load capacity used in each scenario was 50,000 lb (as-is). Hauling cost per loaded mile of $3.00 was used. Distance from the ethanol plant to the feedlot was evaluated at 0, 30, 60, and 100 miles.

Results

When MDGS was priced at 95% the value of corn ($3.70/bu), increased distance from the feedlot to ethanol plant reduced dollars returned to the owner. In Figure 1, a quadratic relationship was observed between marginal returns and dietary inclusion levels. When trucking is 30 and 60 miles, it was more economical to feed MDGS at 35% to 45% of the diet (DM basis). When trucking distance reaches 100 miles, optimum feeding level decreased to 20% to 25% dietary inclusion.

Pricing of byproducts varies seasonally when cattle-on-feed fluctuate. A quadratic relationship was observed between dietary inclusion level and marginal return (Figure 2). As price of MDGS increased (75%, 85%, or 95%) relative to corn price, overall marginal returns decreased (Figure 2). Optimum dietary inclusion of MDGS appeared to be greater than 50% of the diet DM when MDGS was priced at 75, or 85% the price of corn. This intake range, however, was out of our sampling range and is not recommended due to concerns with dietary fat and sulfur. If MDGS was priced at 95% the cost of corn, optimum inclusion levels decreased to 35% to 40% (DM basis).

Feedlots also see corn price fluctuate throughout the year and across years. If MDGS was priced at 95% the value of corn and trucking distance is 60 miles, varying corn price had a dramatic impact on marginal returns to profit for feeding MDGS. A quadratic response (Figure 3) was observed with MDGS inclusion at corn prices of $4.70, $3.70, and $2.70/bu. Optimal MDGS inclusion level decreased from 43%, 37%, to 31% of the diet DM as the price of corn decreased from $4.70, $3.70, to $2.70/bu, respectively.

In summary, feeding MDGS increased returns compared to feeding corn; however, the marginal returns were dependent on many factors. The Cattle CODE byproduct model may be a useful tool for feedlot operations to optimize the level for many different types of byproducts. This model demonstrates the importance of considering factors beyond just the price of MDGS. While cattle ADG was greatest at 20% to 30% dietary inclusion of MDGS, economic data suggested MDGS inclusion was most profitable when fed at 35% to 45% of diet DM. It is important that producers use their own distances and feed prices to appropriately estimate their potential returns to byproduct feeding.

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[1] Taia J. Huls, graduate student; Virgil R. Bremer, research technician; Galen E. Erickson, associate professor; and Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Influence of Corn Hybrid, Kernel Traits, and Growing Location on Digestibility

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

Summary

One hundred thirty-two commercially available corn hybrids, grown in 2 field replications within three locations, were evaluated for effects of corn hybrid, kernel traits and growing location on digestibility. A significant hybrid by location interaction was observed for most kernel traits. There is potential to select hybrids for DM digestibility, but digestibility shows no consistent relationship with other kernel traits.

Introduction

Studies (*2004 Nebraska Beef Report*, pp. 54-57 and *2006 Nebraska Beef Report*, pp. 45-47) have shown that corn hybrids with a larger proportion of softer endosperm can improve feedlot performance and digestibility. Effects of location or growing environments, on kernel characteristics, feedlot performance, and digestibility have not been reported. Therefore, the objective of our experiment was to evaluate kernel traits and *in situ* digestibility of corn hybrids grown at three locations.

Procedure

Grain Production and Sampling

One hundred thirty-two commercially available corn hybrids were grown at three separate commercial research locations throughout the Corn Belt. Within the three locations (Pekin, Ill., Ames, Iowa, and Waterloo, Neb.), hybrids were grown in two similar, independent field plots. At harvest, a 5 lb corn sample was collected for analysis. A small subsample was collected and sent to a commercial (Precision Grain Analytics) laboratory for near infrared (NIR) analyses of starch, protein, and oil. The remaining sample was analyzed at the University of Nebraska Animal Science Complex.

1,000 Kernel Weights and Stenvert Hardness Test

Samples were analyzed in duplicate for both 1,000 kernel weight and Stenvert hardness test as described in previous research (*2006 Nebraska Beef Report*, pp. 43-44).

In Situ *Dry Matter Digestibility*

Thirty hybrids were chosen for *in situ* digestibility analysis in order to identify physical characteristics which could predict digestibility. Hybrids were chosen based on a range of kernel weights and hardness as well as from prior research conducted with many of the hybrids from this trial. Samples were ground through a Wiley Mill with a 6.35 mm screen to simulate a masticated dry-rolled corn sample. Once ground, a 5 g sample was placed in a 5×H10 cm Dacron bag, which was then heat sealed. Two replications of each sample were incubated in two ruminally and duodenally fistulated Holstein steers. In total, 24 individual replications, two per plot per location, were observed for each selected hybrid. Bags were incubated for 22 hours, which was based on the 75% mean retention time for a 3.44%/hour passage rate. After incubation, bags were removed, rinsed, and machine washed using five three-minute cycles and dried in a 60°C forced air oven for 48 hours.

Data analysis

Kernel traits were analyzed using the MIXED procedure of SAS (SAS Institute, Cary, N.C.), with hybrid, location, and hybrid*location interaction as fixed effects. Relationships were analyzed using the CORR procedure of SAS to obtain simple correlation coefficients.

Hybrids used in this study represent a large range in growing seasons or relative maturity (RM). The RM is a crop research tool that evaluates the length of time necessary for the corn plant to reach full maturity, in order to be grown in different geographical locations. Seven RM groups were represented within the entire group of hybrids, with three groups most consistent with Nebraska corn production. The categories were an RM of 97-103 (Group 1), which would be grown in northern and western Nebraska, an RM group of 104-107 (Group 2), which would represent northeastern Nebraska as well as northern Iowa and an RM group of 108-112 (Group 3), which would represent production in central and southeastern Nebraska.

Results

RM group 97 - 103 (Group 1)

Physical and chemical characteristics for hybrids within Group 1 are presented in Table 1. Twenty-five hybrids fell into this group, with 5 of those hybrids being evaluated for *in situ* DM digestibility (ISDMD). A significant hybrid*location interaction was observed for all kernel traits within this group. No significant relationships were observed between ISDMD and any other kernel characteristic, but we only had five hybrids evaluated for ISDMD within this group. The strongest relationships observed for Group 1 were between NIR measurements. Starch content was negatively related to both oil and protein (r = -0.54, and r = -0.58 respectively).

Table 1. Physical and chemical characteristics across hybrids within maturity group 97-103 (Group 1).

				Standard	# of	
Variable	Mean	Maximum	Minimum	Deviation	hybrids[a]	*P* - value[b]
Kernel wt., g	273.7	345.8	223.1	22.8	25	<0.01
Stenvert Hardness						
Time to grind, s	6.4	8.0	5.0	0.69	25	<0.01
RPM	2428	2610	2210	75	25	<0.01
Soft ht, %	72.73	79.61	66.04	1.88	25	<0.01
Hard %	72.25	75.94	64.92	1.84	25	<0.01
Oil, %	4.32	4.94	3.65	0.30	25	<0.01
Protein, %	10.07	11.06	8.86	0.51	25	<0.01
Starch, %	71.41	72.71	68.97	0.74	25	<0.01
ISDMD[c]	32.11	41.10	23.90	4.57	5	<0.01

[a] Number of hybrids evaluated for each trait
[b] *P* - value of hybrid*location effect
[c] ISDMD = *in situ* DM digestibility

Table 2. Physical and chemical characteristics across hybrids within maturity group 104-107 (Group 2).

			Standard	# of		
Variable	Mean	Maximum	Minimum	Deviation	hybrids[a]	*P* - value[b]
Kernel wt., g	271.6	371.7	203.9	38.3	21	<0.01
Stenvert Hardness						
Time to grind, s	6.7	10.0	5.0	0.97	21	<0.01
RPM	2418	2700	2280	74	21	<0.01
Soft ht, %	72.93	78.64	68.37	1.91	21	<0.01
Hard %	72.24	78.41	64.38	2.30	21	<0.01
Oil, %	4.18	5.06	3.40	0.35	21	0.34
Protein, %	9.83	11.31	8.62	0.61	21	<0.01
Starch, %	71.67	73.51	68.93	0.83	21	0.05
ISDMD[c]	33.14	39.65	20.67	4.69	5	0.22

[a] Number of hybrids evaluated for each trait
[b] *P* - value of hybrid*location effect
[c] ISDMD = *in situ* DM digestibility

Table 3. Physical and chemical characteristics across hybrids within maturity group 108-112 (Group 3).

			Standard	# of		
Variable	Mean	Maximum	Minimum	Deviation	hybrids[a]	*P* - value[b]
Kernel wt., g	287.3	381.1	202.2	31.2	36	<0.01
Stenvert Hardness						
Time to grind, s	6.7	9.0	5.0	0.91	36	<0.01
RPM	2417	2640	2250	75	36	<0.01
Soft ht, %	72.59	79.13	67.62	1.78	36	<0.01
Hard %	72.44	76.93	66.19	1.86	36	<0.01
Oil, %	4.39	5.28	3.41	0.32	36	0.02
Protein, %	9.55	11.04	7.84	0.62	36	<0.01
Starch, %	71.47	72.90	69.46	0.75	36	0.66
ISDMD[c]	33.38	41.12	22.47	4.52	7	0.08

[a] Number of hybrids evaluated for each trait
[b] *P* - value of hybrid*location effect
[c] ISDMD = *in situ* DM digestibility

RM group 104 - 107 (Group 2)

Table 2 contains the physical and chemical kernel characteristics for Group 2. Within this group, 21 hybrids were represented for kernel analysis. A significant interaction between hybrid and location was observed for all kernel traits except oil, starch, and ISDMD. Starch content was only affected by hybrid ($P < 0.01$), while both oil and ISDMD were affected by hybrid ($P < 0.03$) and location ($P < 0.03$). Similar to Group 1, no significant relationships between ISDMD and other kernel traits were observed, though soft height percentage was approaching significance ($P = 0.08$, r = 0.32). Also similar to Group 1, the NIR measurements showed the strongest relationships, with starch content being negatively correlated with both oil and protein (r = -0.48, and r = -0.47 respectively).

RM group 108 - 112 (Group 3)

Physical and chemical kernel characteristics for Group 3 are presented in Table 3. In this group, 36 hybrids were evaluated, with seven of these evaluated for ISDMD. Similar to Group 2, significant interactions were observed for all kernel traits except starch and ISDMD. Location was not significant for either trait ($P < 0.20$), though both were affected by hybrid ($P < 0.02$). Similar to both previous RM groups, no significant relationships were observed between ISDMD and other kernel characteristics. Again, the NIR measurements were observed to have the strongest relationships between each other. Starch content was negatively correlated to both oil and protein (r = -0.57, and r = -0.41 respectively). Oil content was also positively correlated to 1,000 kernel weight (r = 0.41) indicating that heavier kernels contain more oil.

The results of this trial suggest that a hybrid*location interaction exists for most kernel traits no matter what RM group they are in. The results also show that a wide range in kernel traits exist and that these ranges are observed throughout all RM groups. We were unable to detect significant relationships between ISDMD and other chemical or physical kernel traits, though within most RM groups no interaction between hybrid and location was observed. Grind time had a negative correlation, though not significant, with ISDMD within almost all RM groups, which would suggest that harder kernels are less digestible.

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[1] Flint W. Harrelson, graduate student; Galen E. Erickson, associate professor; and Terry J. Klopfenstein, professor, Animal Science, Lincoln. David S. Jackson, professor, Food Science and Technology, Lincoln. Wayne A. Fithian, Golden Harvest Seeds, Waterloo,.

Influence of Corn Hybrid and Processing Method on Finishing Performance and Carcass Characteristics

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

Summary

Five commercially available corn hybrids were evaluated for finishing cattle performance and carcass characteristics when fed as high-moisture (HMC) or dry-rolled corn (DRC). No significant interactions were observed between hybrid and processing method. Corn hybrid had no significant impact on ADG or DMI, but did have a minor influence on F:G. However, these data suggested that processing as HMC-method had a greater effect on cattle performance than hybrid.

Introduction

Limited research has evaluated corn hybrid differences across different processing methods. In a study conducted by Macken et al., (*2003 Nebraska Beef Report*, pp. 32-34) two corn endosperm types, floury and flinty, were fed as high-moisture or dry-rolled corn. Their results indicated hybrids fed as high-moisture corn were more efficiently used than those fed as dry-rolled corn, and that the flintier hybrids were improved more by processing than the floury type. Our objectives were to evaluate the influence of corn hybrid, processing method, and any interaction between hybrid and processing method on finishing cattle performance and carcass characteristics.

Procedure

Grain Production

Five commercially available corn hybrids were selected based on prior research (*2005 Nebraska Beef Report*, pp. 45-47) to be grown for a finishing trial. The trial was designed as a 2×5 factorial, with five corn hybrids fed as either high-moisture (HMC) or dry-rolled corn (DRC). Hybrids were selected to represent a wide variety of kernel characteristics, including kernel weight and hardness. The selected hybrids were H-8562, H-8803Bt, H-9230Bt, H-9485Bt (Golden Harvest Seeds Co., Waterloo, Neb.), and 33P67 (Pioneer Hybrids, Johnston, Iowa). Grain was grown at the University of Nebraska's Agricultural Research and Development Center in two similar irrigated fields with identity preservation maintained throughout the growing season, storage, and feeding. Corn being used for DRC was harvested in early October and was targeted to be 85% DM. HMC was harvested in early September and was targeted to be 73% to 74% DM. After the high-moisture corn was harvested, DM was analyzed. H-9230Bt contained the most moisture at harvest (69.5% DM), 33P67 contained the least moisture (74.6% DM), with H-9485Bt, H-8562, and H-8803Bt being intermediate (73.9%, 72.4%, and 72.4% DM respectively). Whole grain for the dry-rolled treatments was stored in individual bins throughout the trial, and corn was trucked to the feed mill to be rolled as necessary. High-moisture corn was rolled at harvest and ensiled in separate ensiling bags and removed as necessary for feeding.

Kernel Characteristics

Upon dry corn harvest, grain samples were collected for kernel characteristic analysis. Grain was cleaned to remove cracked kernels and other debris, so a whole kernel sample could be analyzed. One thousand kernels were counted using an automated seed counter and weighed to obtain an air dry kernel weight measurement. This measurement was then adjusted based on DM to determine a dry 1,000 kernel weight. Also a Stenvert Hardness Test was conducted on each sample (procedure detailed in *2006 Nebraska Beef Report*, pp. 43-44). All hybrids were replicated twice for each kernel measurement.

Feedlot Procedure

Crossbred yearling steers (n = 475, 837 lb BW) were used in a 2×5 factorial design, with factors of processing method and corn hybrid. Cattle were limit fed 2% of BW for 5 days, prior to being weighed two consecutive days, at trial initiation, in order to obtain initial BW. Cattle were stratified by BW into two blocks, and then randomly assigned to 1 of 60 pens (eight steers/pen). Treatments (n = 10) were assigned randomly to pens, with a total of 6 pens/treatment. Diets consisted of 67.5% corn, 20% wet corn gluten feed (Sweet Bran®, Cargill Inc. Blair, Neb.), 7.5% alfalfa hay, and 5% supplement (all DM basis). Corn gluten feed was added to the diet in order to limit digestive upsets, considering the HMC treatments contained high levels of rapidly fermentable starch. Diets were formulated using the lowest protein value of any corn, 8.88% CP, in order to eliminate any differences in performance being attributed to protein differences. The supplement, which was identical across treatments, included 0.44% urea and was formulated to provide 90 mg/head/day Tylan® and 320 mg/head/day Rumensin®. Cattle were fed once daily and were allowed ad libitum access to feed and water throughout the trial. On day 22, cattle were implanted with Revalor S® and fed either 127 days (heavy block) or 134 days (light block). Cattle were weighed off trial on the morning of shipping, and loaded out in the early evening. All cattle were harvested at a commercial abattoir (Greater Omaha, Omaha, Neb.) with the sequence, liver scores and HCW collected on the day of harvest. Following a 48 h chill, 12th rib fat thickness, ribeye area, kidney pelvic and heart fat, and USDA marbling

Table 1. Kernel characteristics for all corn hybrids.

Variable	H-9485Bt	H-8562	33P67	H-9230Bt	H-8803Bt	*P*-value[d]
Kernel wt., g	369.32^{a}	364.46^{a}	327.13^{b}	320.68^{bc}	299.07^{c}	<0.01
Yield, bu/ac	210.9	197.4	218.6	190.32	207.1	
Stenvert Hardness						
Grind Time, s	6.5	6.0	7.5	7.2	6.7	0.68
RPM	2698	2703	2640	2621	2662	0.99
Soft height, cm	7.7	8.6	6.9	7.8	7.7	0.21
Total height, cm	10.8	11.6	10.4	11.2	10.5	0.25
Soft height, %	70.77	74.43	66.17	69.81	73.08	0.21
Hard, %	75.83	74.09	77.88	77.42	75.83	0.65

[a,b,c] Means within a row with unlike superscripts differ ($P < 0.05$).
[d] *P* - value for the effect of hybrid.

Table 2. Effect of processing method on finishing performance and carcass characteristics.

Variable	HMC	DRC	*P*-value	hybrid * processing
Performance				
Initial BW, lb	837	837	0.88	0.79
Final BW, lb	1362	1351	0.17	0.90
DMI, lb/d	24.9	25.7	<0.01	0.51
ADG, lb	4.02	3.95	0.18	0.74
F:G	6.17	6.49	<0.01	0.49
Carcass Characteristics				
HCW, lb	858	851	0.17	0.68
Marbling score[a]	517	507	0.21	0.71
12th rib fat, in	0.54	0.51	<0.01	0.71
KPH %[b]	2.02	2.01	0.54	0.26
Ribeye area, in^2	13.41	13.19	0.05	0.74
Yield grade[c]	3.23	3.17	0.27	0.85

[a] Marbling score: 450 = Slight50, 500 = Small00 etc.
[b] KPH % = kidney, pelvic, and heart fat %
[c] Calculated yield grade = Calculated as: yield grade = 2.5 + (2.5*12th rib fat) + (0.2*KPH%) + (0.0038*HCW) - (0.32*ribeye area).

Table 3. Effect of corn hybrid on finishing performance and carcass characteristics.

Variable	H-9485Bt	H-8562	33P67	H-9230Bt	H-8803Bt	*P*-value
Performance						
Initial BW, lb	836	838	836	839	834	0.45
Final BW, lb	1364	1362	1353	1354	1349	0.66
DMI, lb/d	25.2	25.2	25.3	25.2	25.5	0.92
ADG, lb	4.05	4.01	3.97	3.95	3.95	0.70
F:G	6.20	6.27	6.39	6.39	6.44	0.12
Carcass Characteristics						
HCW, lb	860	858	852	853	850	0.66
Marbling score[a]	506	514	512	512	514	0.95
12th rib fat, in	0.52	0.54	0.53	0.53	0.52	0.82
KPH %[b]	2.01	2.00	2.03	2.01	2.02	0.89
Ribeye area, in^2	13.45	13.21	13.42	13.29	13.15	0.36
Yield grade[c]	3.17	3.24	3.18	3.20	3.22	0.88

[a] Marbling score: 450 = $Slight^{50}$, 500 = $Small^{00}$ etc.
[b] KPH % = kidney, pelvic, and heart fat %.
[c] Calculated yield grade = Calculated as: yield grade = 2.5 + (2.5*12th rib fat) + (0.2*KPH%) + (0.0038*HCW) - (0.32*ribeye area).

scores were collected. Using HCW, ribeye area, 12th rib fat thickness, and kidney, pelvic and heart fat, the yield grade was calculated.

Statistical Analysis

All data were analyzed using the MIXED procedure of SAS (SAS 9.1, SAS Inst., Cary, N.C.). Kernel traits were evaluated as dependent variables upon hybrid. Correlations between kernel traits and feed efficiency were also analyzed. Pen was used as the experimental unit, with block, hybrid, processing, and hybrid*processing interactions run as fixed effects. If a significant interaction between hybrid and processing method was observed, then only the simple effects were reported. However, if the interaction was not significant, the main effects of hybrid and processing method were presented separately.

Results

Kernel Characteristics

Kernel characteristics among hybrids are summarized in Table 1. Kernel weight was the only trait significantly affected by hybrid, with hybrids H-9485Bt and H-8562 being the heaviest (369 and 364 g, respectively). H-8803Bt was the lightest (299 g) and H-9230Bt and 33P67 were intermediate (320 and 327 g, respectively). Hybrids showed numeric differences in grain yield; however, these differences could not be analyzed because this trial was not designed to evaluate yield differences. Hybrid 33P67 had the highest yield (218.6 bu/ac), hybrid H-9230Bt had the lowest yield (190.3 bu/ac), and hybrids H-9485Bt, H-8803Bt, and H-8562 being intermediate (210.9 bu/ac, 207.1 bu/ac, and 197.4 bu/ac, respectively).

Finishing Performance

No significant hybrid*processing interactions were observed for any finishing performance or carcass characteristics; therefore, the main effects of hybrid and processing method will be presented. Processing method affected finishing performance and carcass characteristics (Table 2). Cattle fed DRC had greater ($P < 0.01$) DMI compared to HMC fed cattle. Also, F:G was improved ($P < 0.01$) by 5.2% for cattle fed HMC compared to those fed DRC. The HMC fed cattle had greater 12th rib fat thickness ($P = 0.02$) compared to cattle fed DRC. Cattle fed HMC also had a larger ribeye area ($P = 0.05$); however, this increase in ribeye area did not affect calculated yield grade.

Table 3 summarizes the hybrid effects on finishing performance and carcass characteristics. No significant hybrid effects were observed for DMI or ADG. There was a trend

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(P = 0.12) for a hybrid effect on F:G, with H-9485Bt being the most efficiently used, and H-8803Bt being the least efficiently used hybrid, with H-8562, H-9230Bt, 33P67 being intermediate.

Based on previous research (*2006 Nebraska Beef Report,* pp. 38-39) we expected an interaction between hybrid and processing method, however this did not occur, and we are not sure why no interaction was observed. We did however observe better feeding values for all hybrids when processed as HMC compared to DRC. The greatest improvement in conversion was found for H-8803Bt (8.53%), with the least improvement for 33P67 (2.26%), with H-9230Bt, H-8562, and H-9485Bt intermediate (5.65%, 4.82%, 4.25%, respectively) when processed as HMC compared to DRC.

Kernel weight was the only significant ($P < 0.02$) kernel characteristic, with a strong relationship to efficiency ($r = 0.94$). This relationship indicates that as kernel weight increases, efficiency improves as well. This finding was similar to the results found by Jaeger (*2004 Nebraska Beef Report,* pp. 54-57).

The results of this study suggest hybrid and processing method do not interact in finishing diets. This observation suggests that if one hybrid is better than another when fed as DRC, it should also be better when fed as HMC. There were also few significant effects of corn hybrid on finishing performance. These results agree with numerous studies that HMC is an effective way to improve feed conversion compared to DRC. The results also suggest that kernel characteristics, especially kernel weight, may predict feeding value for feedlot cattle.

1Flint W. Harrelson, graduate student; Matt K. Luebbe, research technician; Galen E. Erickson, associate professor; and Terry J. Klopfenstein, professor, Animal Science, Lincoln. Wayne A. Fithian, Golden Harvest Seeds, Waterloo.

Influence of Corn Hybrid and Processing Method on Ruminal and Intestinal Digestion

Flint W. Harrelson
Nathan F. Meyer
Galen E. Erickson
Terry J. Klopfenstein
Wayne A. Fithian[1]

Summary

Using the mobile bag technique, five commercially available corn hybrids harvested as either dry-rolled or high-moisture corn were evaluated for site and extent of DM and starch digestion. Total-tract DM digestibility was improved 7 to 16 percentage units, and total-tract starch digestibility was improved 9 to 18 percentage units among hybrids when processed as high-moisture corn compared to dry-rolled corn. The results of this trial suggest that hybrid and processing method interact and can influence DM and starch digestibility.

Introduction

Macken et al. (*2003 Nebraska Beef Report*, pp. 32-34), found corn hybrids which contain more floury endosperm were more efficiently used by finishing cattle when dry-rolled, although harder endosperm hybrids were improved more than floury hybrids when processed as high-moisture corn. A more recent study (*2006 Nebraska Beef Report*, pp. 38-39) using three hybrids processed as either dry-rolled (DRC) or high-moisture corn (HMC) found that hybrid differences as well as processing method impact nutrient digestion. Our objective for this study was to evaluate corn hybrid, processing method, and interactions between these factors on-site and extent of DM and starch digestion, using five hybrids as DRC or HMC.

Procedure

Corn Production and Sampling

Five commercially available corn hybrids were selected based on a range of kernel characteristics, including hardness and kernel weight, from previous research conducted in 2004-2005 (*2006 Nebraska Beef Report*, pp. 45-47). Corn hybrids were grown and stored for a concurrent finishing trial (procedure detailed in *Nebraska Beef Report 2008*, pp. 54-56). Each sample for this trial was a composite of the first six weekly samples from the finishing trial.

Sample Preparation

Each sample was ground through a Wiley Mill with a 6.35 mm screen to simulate mastication. Dry-rolled corn samples were directly ground and high-moisture samples were freeze ground using dry ice. A 2 g sample (DM) of each ground sample was placed in a Dacron bag for incubation. For ruminal digestibility, each sample was replicated four times in two ruminally and duodenally fistulated Holstein steers. Each sample was replicated six times in each steer to determine post-ruminal and total-tract digestibility. Bags were heat sealed prior to incubation.

All bags were ruminally incubated for 22 hours, based on a 75% mean retention time for a 3.44%/hour passage rate. Following ruminal incubation, post-ruminal bags were exposed to a simulated abomasal digestion utilizing pepsin and hydrochloric acid. Post-ruminal bags were rolled and placed in the duodenal fistula one at a time beginning at approximately 1700 hour. Bags were inserted every 5 minutes allowing for the movement of the previous bags into the intestines to avoid compaction. Eight bags were incubated per day, within a 4-day sampling week, and were collected in the feces, usually within 24 hour post-insertion. Bags not collected within 48 hours post-insertion were treated as missing data.

Lab Analysis

At the conclusion of the trial, bags were machine washed with five 3-minute cycles and placed in a 60°C forced air oven for 48 hours. Bags were then composited within animal and sample across days in order to run starch analysis. Using the Megazyme® procedure, starch concentration was determined in the original samples and composites, and used to determine starch digestibility.

Statistical Analysis

Data were analyzed using the MIXED procedure of SAS (SAS 9.1, SAS Inst., Cary, N.C.) with the model including the effects of hybrid, processing method, and hybrid*processing method interaction with day and steer as random variables. At the conclusion of this trial and the finishing trial, correlations were determined between digestibilities and G:F as well as kernel characteristics.

We designed an index utilizing the Stenvert measurements of grind time and rpm to simplify the analysis of hard vs soft endosperm types. This index was derived by taking the drop in RPM from 3,600 (beginning RPM) and multiplying this by the grind time. By doing this calculation we were able to have a measurement similar to an "area under the curve" measurement. This measurement would be useful to identify the magnitude of kernel hardness based on drop in RPM and grind time.

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Table 1. Effect of hybrid and processing method on DM and starch digestibility.

	H-9485Bt		H-8562		33P67		H-9230Bt		H-8803Bt		
Treatment	DRC	HMC	DRC	HMC	DRC	HMC	DRC	HMC	DRC	HMC	P-value[a]
Ruminal DMD[b]	40.98^{d}	49.79^{e}	40.18^{d}	63.37^{g}	38.33^{d}	57.48^{d}	37.88^{d}	68.02^{g}	38.40^{d}	65.08^{g}	<0.01
Ruminal SD[c]	37.21^{g}	52.65^{f}	35.63^{g}	71.11^{d}	36.65^{g}	60.80^{ef}	38.43^{g}	76.08^{d}	35.39^{g}	68.79^{de}	<0.01
Post-ruminal DMD	62.10	68.51	62.89	67.55	52.17	62.35	56.60	61.31	54.21	66.42	0.28
Post-ruminal SD	66.69^{g}	82.64^{e}	65.36^{gh}	91.11^{d}	53.59^{i}	76.88^{f}	56.62^{ij}	86.51^{de}	60.23^{hi}	88.45^{d}	<0.01
Total-tract DMD	77.27^{fg}	84.13^{h}	77.89^{g}	88.40^{i}	69.83^{d}	83.65^{h}	72.75^{de}	88.21^{i}	70.76^{d}	83.31^{i}	<0.01
Total-tract SD	79.82^{f}	92.91^{e}	79.79^{f}	98.08^{d}	70.75^{h}	91.40^{e}	74.41^{g}	97.84^{d}	73.89^{gh}	97.15^{d}	<0.01

[a] Protected F-statistic for the hybrid*processing interaction effect.

[b] DMD = Dry matter digestibility.

[c] SD = Starch digestibility.

[d,e,f,g,h,i,j] Means with unlike superscripts within a column differ $P < 0.05$.

Table 2. Correlations between G:F and DM and starch digestion.

	Across Processing		Within HMC		Within DRC	
Variable	r	P-value	r	P-value	r	P-value
Rum. DMD[a]	0.78	<0.01	-0.12	0.85	0.33	0.58
Rum. SD[b]	0.80	<0.01	-0.10	0.99	0.35	0.57
PR DMD[c]	0.78	<0.01	0.75	0.14	0.25	0.68
PR SD[c]	0.86	<0.01	0.70	0.19	-0.05	0.95
TT DMD[d]	0.86	<0.01	0.39	0.53	0.31	0.61
TT SD[d]	0.86	<0.01	0.49	0.41	0.12	0.85

[a] DMD = DM digestibility

[b] SD = Starch digestibility

[c] PR = Post-ruminal

[d] TT = Total-tract

Results

Digestibility

A significant interaction was observed between hybrid and processing for ruminal, post-ruminal, and total-tract starch, as well as ruminal and total-tract DMD, therefore only simple effects will be presented for all variables (Table 1). No interaction between hybrid and processing method for post-ruminal DMD was observed. One interesting observation was, with the exception of post-ruminal DMD, the observed improvement in digestibility for high-moisture corn compared to dry-rolled corn decreased as the feedstuff traveled through the digestive tract. Ruminal DMD was greatest for hybrid H-9230Bt fed as HMC and was lowest for the same hybrid fed as dry-rolled corn (DRC). A range of 9 (40.98 vs. 49.79) to 30 (37.88% vs. 68.02%) percentage unit improvement in ruminal DMD was seen within hybrids when processed as HMC vs. DRC.

For ruminal starch digestibility H-9230Bt HMC (76.1%) was the most digestible with H-8803Bt DRC (35.4%) being the least digestible. The greatest change in digestibility among hybrids when processed as HMC compared to DRC was 37.7 percentage units (38.4% vs. 76.1%). The smallest change for ruminal starch digestibility between HMC and DRC among hybrids was 15.5 percentage units (37.2% vs. 52.7%).

Post-ruminal DMD was significantly increased ($P < 0.01$) when hybrids were processed as high-moisture corn compared to dry-rolled corn (65.30% vs. 57.74%). Hybrids were significantly (P < 0.01) different in post-ruminal DMD with hybrids H-8562 (65.22%) and 33P67 (65.30%) being the most digestible, H-9485Bt (57.26%) the least digestible, and H-8803Bt (60.32%) and H-9230Bt (58.96%) being intermediate.

Hybrid H-8562 HMC (91.1%) had the greatest extent of digestion for starch entering the small intestine, while 33P67 DRC (53.6%) exhibited the least extensive post-ruminal starch digestion. HMC improved digestion of starch entering the small intestine by 15.9 (66.7% vs. 82.6%) to 29.9 (56.6% vs. 86.5%) percentage units compared to DRC among hybrids.

The greatest extent of DM digestion, throughout the digestive tract, was observed for H-8562 HMC (88.4%), with 33P67 DRC (69.8%) exhibiting the least amount of DM digestion. DRC samples, among hybrids, were less digestible for DM compared to those hybrids processed as HMC as shown in Table 1.

Total-tract starch digestibility was lowest for 33P67 DRC (70.8%) and highest for H-8562 HMC (98.1%). When hybrids were processed as HMC, starch was more digested throughout the entire digestive tract compared to being processed as DRC as shown in Table 1. Comparing these results with previous mobile bag research using some of these same hybrids (*2006 Nebraska Beef Report*, pp. 38-39), our findings are similar though the numbers are slightly lower than those previously reported. Both studies included hybrids H-8562, H-9230Bt, and 33P67, and in both studies similar patterns of digestibility were seen, with H-8562 being generally the most digestible, 33P67 the least digestible, and H-9230Bt intermediate. However, in the previous study processing and hybrid interactions were only found for post-ruminal and total-tract DM digestibility, where we found an interaction for all digestibilities except post-ruminal DM digestibility.

Correlation with G:F

Correlations between this study and the concurrent finishing study (*2008 Nebraska Beef Report*, pp. 54-56) were determined in order to evaluate the relationship of digestibility to G:F. Table 2 outlines the correlation coefficients, and corresponding *P* - values, of DM and starch digestibility with G:F. The table contains the correlations for all treatments, as well as hybrids within processing methods. Significant ($P < 0.01$) correlations were found between feed efficiency and DM and starch digestibilities. The strongest relationships to G:F were observed for post-ruminal starch, total-tract starch and total-tract DM (r = 0.86 for all) digestibility. The lowest, though still high, were observed for ruminal starch (r = 0.80), ruminal and post-ruminal dry matter digestibility (r = 0.78 for both). If the treatments were separated by processing method, we no longer detected any significant relationships between G:F and DM or starch digestibility. Within HMC only, the highest correlation was observed with post-ruminal dry matter digestibility (r = 0.75). No high correlations were observed between G:F and DM or starch digestibility within DRC only.

Correlations with kernel characteristics

Correlations with kernel characteristics were analyzed for DRC and HMC independently. Within DRC, ruminal (r = 0.90) and total-tract (r = 0.89) DM digestibility (DMD) were correlated with kernel weight ($P = 0.04$ for each). Post-ruminal DMD was strongly related (r = 0.86, $P = 0.06$) to kernel weight as well. Our hardness index correlated negatively with ruminal (r = -0.83, $P = 0.09$), post-ruminal (r = -0.81, $P = 0.10$) and total-tract (r = -0.80, $P = 0.11$) DMD . These negative relationships indicated that harder kernels decreased DMD.

Within HMC, the relationships between kernel characteristics and DMD changed dramatically. Kernel weight was not a significant indicator of digestibility, though the relationships between ruminal (r = -0.61, $P = 0.27$) and post-ruminal (r = 0.56, $P = 0.32$) DMD were relatively high. Post-ruminal DMD was highly correlated ($P = 0.03$) with the hardness index, and the relationship was very high (r = -0.92). Interestingly, neither ruminal or total-tract DMD were correlated to the hardness index ($P = 0.74$ and $P = 0.72$ respectively).

In conclusion corn hybrid interacted with processing method for DM and starch digestion. Also, high correlations between G:F and DMD exist, and are affected by processing method more than corn hybrid. We can also conclude kernel weight and kernel hardness can be used to predict DMD for DRC, however those relationships are lower for HMC. Our results also suggest some hybrids are more digestible as HMC, while some hybrids show much less response in digestibility as HMC.

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[1] Flint W. Harrelson, graduate student; Nathan F. Meyer, research technician; Galen E. Erickson, associate professor; and Terry J. Klopfenstein, professor, Animal Science, Lincoln. Wayne A. Fithian, Golden Harvest Seeds Co., Waterloo.

Nutrient Mass Balance and Performance of Feedlot Cattle Fed Wet Distillers Grains

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

Summary

Two experiments were conducted to evaluate effects of three dietary inclusions (0%, 15%, and 30%, DM basis) of wet distillers grain plus solubles (WDGS) on feedlot performance and nutrient mass balance in open feedlots. Replacing corn with WDGS increased ADG response and HCW in both experiments. Feeding WDGS balanced for MP (15%) or in excess of requirements (30%) resulted in more OM in the manure but only more manure N in the winter experiment. Percentage N loss was not different among WDGS level but the amount of N lost was increased when WDGS were fed due to greater N excretion compared with cattle fed the control diet. Increasing dietary P with WDGS resulted in more phosphorus in the manure.

Introduction

Improving the C:N ratio of feedlot manure by increasing roughage levels or using a less digestible NDF source reduces the amount of nitrogen lost to volatilization. Corn bran with steep inclusion (wet corn gluten feed) was effective in reducing N losses in the winter as well as maintaining cattle performance (*2005 Nebraska Beef Report*, pp. 54-56). Wet distillers grains with solubles (WDGS) improves cattle performance and is moderate in neutral detergent fiber content (35% to 30% NDF). The NDF may trap more N in the manure but WDGS have levels of CP (30% to 35%) which may not be trapped by the additional OM in the manure. The objectives of this study were to evaluate effects of WDGS level on steer performance and nutrient mass balance.

Procedure

Cattle Performance

Two experiments were conducted using 96 steers each, calves (649 ± 73 lb BW) were fed 167 days from November to May (WINTER) and yearlings (820 ± 54 lb BW) fed 133 days from May to October (SUMMER) to evaluate wet distillers grains with solubles (WDGS) level on N and P balance in open feedlots. Steers were blocked by BW, stratified within block and assigned randomly to pen (8 steers/pen). Dietary treatments consisted of 0%, 15%, and 30% dietary inclusion of WDGS (DM basis) replacing corn (CON, 15WDGS, and 30WDGS, respectively). Traditional WDGS (32% DM) was fed in the WINTER and modified WDGS (48% DM) was fed in the SUMMER experiment. Basal diets for both experiments consisted of high-moisture and dry-rolled corn fed at a 1:1 ratio, 7.5% alfalfa hay, 5% molasses, and 5% supplement (DM basis). Corn gluten meal (65% CP) was included in the CON diet at 3.5% for 90 days for WINTER steers and 2.0% for 60 days for SUMMER steers to meet the metabolizable requirement of those calves. Cattle were adapted to finishing diets over a 21-day period with the corn blend replacing alfalfa hay. The CON and 15WDGS diets were balanced for MP using the 1996 NRC while the 30WDGS was in excess of requirements. Crude protein concentrations were 13.1%, 13.9%, and 17.0% for CON, 15WDGS, and 30WDGS, respectively in the WINTER and 13.0%, 13.8%, and 16.9%, in the SUMMER. Dietary P concentrations were 0.33%, 0.43%, and 0.48%, for CON, 15WDGS, and 30WDGS (respectively) in the WINTER and 0.34%, 0.39%, and 0.46% in the SUMMER. Rumensin, Tylan and Thiamine were fed at 320, 90, and 130 mg/head/day (respectively) in both experiments.

Steers in the WINTER experiment were implanted on d1 with Synovex Calf (Fort Dodge Animal Health, Overland Park, Kan.) followed by Revelor-S (Intervet Inc., Somerville, N.J.) on day 67. Steers in the SUMMER experiment were implanted once on day 1 with Revelor-S. Steers were slaughtered on day 167 (WINTER) and day 133 (SUMMER) at a commercial abattoir (Greater Omaha, Omaha, Neb.). Hot carcass weight and liver scores were recorded on day of slaughter. Fat thickness and LM area were measured after a 48-hour chill and USDA called marbling score was recorded. Final BW, ADG, and feed efficiency were calculated based on hot carcass weights adjusted to a common dressing percentage of 63.

Nutrient Balance

Nutrient mass balance experiments were conducted using 12 open feedlot pens with retention ponds to collect runoff. When rainfall occurred, runoff collected in the retention ponds was drained and quantified using an air bubble flow meter (ISCO, Lincoln, Neb.). Before placing cattle in pens, 16 soil core samples (6 inch depth) were taken from each pen in both experiments. After cattle were removed from the pens, manure was piled on a cement apron and sampled (n = 30) for nutrient analysis while being loaded. Manure was weighed before it was hauled to the University of Nebraska compost yard. Manure was freeze-dried for nutrient analysis and oven dried for DM removal calculation. After manure was removed, additional soil core samples were taken from each pen.

Ingredients were sampled monthly and feed refusals were analyzed to determine nutrient intake using a weighted composite on a pen basis. Retained steer N and P were calculated using the energy, protein, and P equations (NRC, 1996). Nutrient excretion was

Table 1. Growth performance and carcass characteristics for steers fed during WINTER.

Dietary Treatment^{a}:	CON	15	30	SEM	P-value^{b}
Performance					
Initial BW, lb	648	654	650	6	0.61
Final BW, lb^{c}	1251	1279	1295	17	0.10
DMI, lb/day^{c}	20.7	21.2	21.5	0.4	0.19
ADG, lb^{c}	3.55	3.68	3.80	0.10	0.14
Feed: Gain	5.83	5.77	5.66	0.06	0.27
Carcass Characteristics					
Hot Carcass Weight, lb^{c}	789	806	816	11	0.10
Marbling Score^{d,e}	545^{f}	533^{f}	577^{g}	7	< 0.01
Ribeye Area in.	13.9	14.0	13.7	0.2	0.44
12th Rib Fat, in	0.49	0.47	0.43	0.04	0.29

[a]Dietary treatments: CON = Control corn-based diet with no WDGS, 15% = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).

[b]F-test statistic for dietary treatment.

[c]Linear effect of WDGS level.

[d]400 = Slight 0, 500 = Small 0.

[e]Quadratic effect of WDGS level.

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

Table 2. Growth performance and carcass characteristics for steers fed during SUMMER.

Dietary Treatment^{a}:	CON	15	30	SEM	P-value^{b}
Performance					
Initial BW, lb	824	825	822	10	0.96
Final BW, lb	1350	1392	1381	18	0.10
DMI, lb/day	25.0	26.0	25.9	0.4	0.13
ADG, lb^{c}	3.96^{e}	4.27^{f}	4.21^{f}	0.10	0.05
Feed: Gain	6.53	6.17	6.23	0.16	0.38
Carcass Characteristics					
Hot Carcass Weight, lb^{c}	850	877	870	8	0.10
Marbling Score^{d}	478	514	498	13	0.09
Ribeye Area in.	13.1	13.0	13.2	0.3	0.85
12th Rib Fat, in	0.47	0.57	0.53	0.14	0.12

[a]Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).

[b]F-test statistic for dietary treatment.

[c]Linear effect of WDGS level.

[d]400 = Slight 0, 500 = Small 0.

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

Table 3. Effect of dietary treatment on nitrogen mass balance during WINTER.^{a}

Dietary Treatment^{b}:	CON	15	30	SEM	P-value^{c}
N intake^{d}	69.4^{i}	79.8^{j}	98.4^{k}	1.6	< 0.01
N retention^{d,e}	12.2	12.7	13.0	0.3	0.08
N excretion^{d,f}	57.1^{i}	67.1^{j}	85.3^{k}	1.6	< 0.01
Manure N^{d,g}	25.2^{i}	24.0^{i}	38.1^{j}	5.2	0.04
N Run-off	1.03	1.18	1.72	0.36	0.18
N lost^{d}	30.9^{i}	42.0^{j}	45.5^{j}	4.6	0.03
N loss, %^{h}	55.1	63.8	55.0	6.8	0.37
DM removed	1691	1877	2033	231	0.37
OM removed^{d}	350	447	480	58	0.12

[a]Values are expressed as lb/steer over entire feeding period (167 DOF) unless noted.

[b]Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).

[c]F-test statistic for dietary treatment.

[d]Linear ($P < 0.05$) effect of WDGS level.

[e]Calculated using the NRC net protein and net energy equations.

[f]Calculated as N intake - N retention.

[g]Manure N with correction for soil N.

[h]Calculated as N lost divided by N excretion.

[i,j,k]Within a row, means without a common superscript letter differ ($P < 0.05$).

determined by subtracting nutrient retention from intake (ASABE, 2005). Total N lost (lb/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion. Dietary treatments were fed in the same pens for both experiments. Animal performance data were analyzed as a randomized complete block design with pen as the experimental unit. Nutrient balance data were analyzed as a completely randomized design. Orthogonal contrasts were used to test significance for linear and quadratic response to WDGS level for both animal performance and mass balance data.

Results

Feedlot Performance

Dry matter intake, ADG, final BW, and HCW increased linearly ($P < 0.05$) with WDGS level in the WINTER experiment (Table 1). Marbling score was greater ($P < 0.01$) for 30WDGS compared with both CON and 15WDGS in the WINTER experiment. Average daily gain and HCW increased linearly ($P < 0.05$) with WDGS level in the SUMMER (Table 2). However, feed efficiencies were not different ($P > 0.10$) among treatments in either experiment. Ribeye area, liver scores, and 12th rib fat depth were not influenced ($P > 0.10$) by WDGS level in either experiment.

Nutrient Balance

Nitrogen intakes were greatest ($P < 0.01$) for 30WDGS, intermediate for 15WDGS, and least for CON in both experiments (Tables 3 and 4). Nitrogen retention increased linearly ($P < 0.05$) with WDGS level in the WINTER due to ADG response, but was not different ($P = 0.16$) in the SUMMER. Excretion of N was greatest ($P < 0.01$) for 30WDGS, intermediate for 15WDGS, and least for CON in both experiments. Manure N was greater ($P = 0.04$) for 30WDGS compared with 15WDGS and CON in the WINTER. Manure N was not different ($P = 0.89$) among WDGS level in the SUMMER. Amount of N lost (lb/steer) was greater ($P = 0.03$) for 30WDGS and 15WDGS compared with CON in the WINTER. In the SUMMER, amount of N lost was greatest ($P < 0.01$) for 30WDGS, intermediate for 15WDGS, and least for CON. When expressed as a per-

(Continued on next page)

centage of N excretion, loss of N was not different *($P > 0.20$)* among dietary treatments in both experiments. The amount of OM removed from the pen surface linearly increased *($P < 0.05$)* with WDGS level in the WINTER. Dry matter and OM removed in the SUMMER were greater *($P < 0.05$)* for 30WDGS compared with either 15WDGS or CON. These results suggested that WDGS increased OM removed and manure N removed in the WINTER but did not compensate for all of excreted N fed with WDGS. Runoff did not constitute much of what was excreted in either experiment, resulting in 1.8% to 2.0% of N in the WINTER and 2.8% to 4.9% in the SUMMER.

When WDGS was fed, P intake linearly increased *($P < 0.05$)* for both experiments (Tables 5 and 6). Retention of P linearly increased *($P < 0.05$)* with WDGS level in the WINTER due to ADG response but was not different *($P = 0.16$)* among WDGS levels for the SUMMER experiment. Excretion of P linearly increased with WDGS level *($P < 0.01$)* in both experiments. Similarly, manure P linearly increased in both experiments with WDGS level *($P < 0.01$)*. Correcting manure for soil P accounted for 98%, 79%, and 102% of excreted P in the WINTER and 87%, 62%, and 57% of excreted P in the SUMMER for CON, 15WDGS, and 30WDGS, respectively. Lower P recoveries in the SUMMER may be due to the dryer conditions when the pens are cleaned in the fall. In dry conditions P may not be removed because the soil is not as thoroughly mixed with the manure compared with wet conditions found in the spring cleaning. These results for P mass balance are similar to previous studies (*2000 Nebraska Beef Report*, pp. 65-67). Runoff P was not different *($P > 0.10$)* among WDGS level and averaged 3.8%, and 9.5% of excreted P for WINTER and SUMMER, respectively.

Table 4. Effect of dietary treatment on nitrogen mass balance during SUMMER.[a]

Dietary Treatment[b]:	CON	15	30	SEM	*P*-value[c]
N intake[d]	63.8[i]	78.2[j]	94.6[k]	1.2	< 0.01
N retention[e]	10.1	10.9	10.8	0.3	0.16
N excretion[d,f]	53.6[i]	67.3[j]	83.9[k]	1.1	< 0.01
Manure N[g]	19.8	21.3	22.1	5.0	0.89
N Run-off	2.6	1.9	3.4	1.2	0.53
N lost[d]	31.2[i]	44.1[j]	58.4[k]	5.1	< 0.01
N loss, %[h]	58.1	65.6	69.6	7.2	0.15
DM removed	1140[i]	1167[i]	2208[j]	354	0.02
OM removed[d]	216[i]	237[i]	343[j]	45	0.04

[a] Values are expressed as lb/steer over entire feeding period (133 DOF) unless noted.
[b] Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[c] *F*-test statistic for dietary treatment.
[d] Linear *($P < 0.05$)* effect of WDGS level.
[e] Calculated using the NRC net protein and net energy equations.
[f] Calculated as N intake - N retention.
[g] Manure N with correction for soil N.
[h] Calculated as N lost divided by N excretion.
[i,j,k] Within a row, means without a common superscript letter differ *($P < 0.05$)*.

Table 5. Effect of dietary treatment on P mass balance during WINTER.[a]

Dietary Treatment[b]:	CON	15	30	SEM	*P*-value[c]
P intake[d]	11.5[i]	14.4[j]	17.2[k]	0.3	< 0.01
P retention[d,e]	3.0	3.1	3.2	0.1	0.12
P excretion[d,f]	8.6[i]	11.3[j]	14.0[k]	0.3	< 0.01
Manure P[d]	6.1[i]	8.4[i,j]	9.9[j]	1.1	0.02
Run-off P	0.5	0.3	0.4	0.1	0.66
P manure+soil[d,g]	8.4[i]	9.0[i]	14.4[j]	1.9	0.02
N:P ratio[h]	3.06	2.81	2.65	0.36	0.53

[a] Values are expressed as lb/steer over entire feeding period (167 DOF) unless noted.
[b] Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[c] *F*-test statistic for dietary treatment.
[d] Linear *($P < 0.05$)* effect of WDGS level.
[e] Calculated using the NRC net protein and net energy equations.
[f] Calculated as P intake - P retention.
[g] Correction for soil P.
[h] Nitrogen to Phosphorus ratio, DM basis.
[i,j,k] Within a row, means without a common superscript letter differ *($P < 0.05$)*.

Table 6. Effect of dietary treatment on P mass balance during SUMMER.[a]

Dietary Treatment[b]:	CON	15	30	SEM	*P*-value[c]
P intake[d]	11.4[i]	13.5[j]	16.0[k]	0.2	< 0.01
P retention[d,e]	3.1	3.3	3.3	0.1	0.16
P excretion[d,f]	8.3[i]	10.2[j]	12.7[k]	0.2	< 0.01
Manure P[d]	4.5[i]	5.7[i]	9.5[j]	1.2	< 0.01
Run-off P	1.0	0.7	0.7	0.4	0.79
P manure+soil[d,g]	7.2	6.3	7.2	2.8	0.93
N:P ratio[d,h]	3.06	4.03	3.95	1.26	0.70

[a] Values are expressed as lb/steer over entire feeding period (133 DOF) unless noted.
[b] Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[c] *F*-test statistic for dietary treatment.
[d] Linear *($P < 0.05$)* effect of WDGS level.
[e] Calculated using the NRC net protein and net energy equations.
[f] Calculated as P intake - P retention.
[g] Correction for soil P.
[h] Nitrogen to Phosphorus ratio, DM basis.
[i,j,k] Within a row, means without a common superscript letter differ *($P < 0.05$)*.

These data suggest increasing dietary P will increase manure P and the amount of land needed for manure application. The results from this study suggest feeding WDGS improves cattle performance; however, N losses are greater when WDGS are used by feedlot cattle compared with corn in feedlot rations.

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[1] Matt K. Luebbe, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor, Matt A. Greenquist, research technician, Animal Science, Lincoln.

Aerobic Composting or Anaerobic Stockpiling of Feedlot Manure

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

Summary

Two manure management and storage methods, manure stockpiled anaerobically or composted aerobically for 104 days were evaluated. Nitrogen recovery was 85.7% and 56.4% for stockpiled and composted manure, respectively. Organic nitrogen concentrations were greater for composted manure while ammonium nitrogen concentrations were greater for stockpiled manure. Simulation of hot, dry conditions during field application indicated the amount of ammonia nitrogen lost from stockpiled manure was not great enough to offset the total nitrogen recovery advantage of this method. When evaluated on a nutrient basis, stockpiled manure has greater value as a fertilizer compared with composted manure in this study.

Introduction

Scraped manure from pens, aerobic composting, and anaerobic (passive) stockpiling are the most common methods to store and distribute manure from feedlots. Stockpiled manure often has more total N compared with composted manure but also has more ammonium N. If N is lost prior to incorporating, there may not be a net benefit to stockpiling. Aerobic composting of manure decreases the amount of material that needs to be hauled to the field and also reduces odor. However, composting manure increases cost due to a larger area of land needed for control of runoff and the equipment and extra management of windrows. These management and storage options have a large impact on gas emissions as well as amount and type of nutrients available to crops. The objective of this research was to compare anaerobic stockpiling and aerobic composting manure storage methods on nutrient recovery.

Procedure

Manure from 30 open feedlot pens was used to determine the impact of storage method on changes in amount and type of N over time for manure anaerobically stockpiled or aerobically composted. In July, manure was piled on the cement apron, sampled, weighed, and hauled to the compost yard. Manure from three pens was used to construct compost windrows for a total of 6 windrows. Manure from six pens was used to construct two anaerobic stockpiles. Initial windrows contained approximately 10 ton of manure (DM) with a volume of 3’ x 3’ x 30’. The stockpiles contained approximately 20 ton of manure (DM) and were conical in shape with a base diameter of 22’.

Windrows were turned on days 14, 42, 59, 69, and 83. The composted windrows were considered “finished” when the temperature did not rise following turning of the manure. The stockpiles were left undisturbed throughout the 104 days with the exception of core and temperature samples. Manure core samples and temperature were collected on days 42, 69, 83, and 104 from compost and stockpiles. Core samples (n = 4/pile) were taken at a depth of 36” and temperature (n = 4/pile) were collected at 48”. Nutrient recoveries were calculated using total ash as an internal marker with the following equation: Nutrient recovery = 100 x [(% ash initial / % ash after) x (% Nutrient after / % Nutrient before)]. The total amount of nutrient content was also evaluated in a similar manner using total ash as a marker for DM. Samples were analyzed by a commercial laboratory (Ward Laboratories Inc., Kearney, Neb.). Ammonium N was measured on samples as-is and after drying for 24 hours in a 100°C oven to determine how much N is lost when manure is spread and exposed to high temperatures. Data were analyzed using the mixed procedure of SAS with six replications/sampling date for compost and two replications/sampling date for stockpile with sampling date as a repeated measure.

Results

For comparison of fresh manure with stockpiled or composted manure, day 0 samples were collected during pen cleaning. The recommended level of moisture for composting is generally between 30% and 60%. The compost in this study was typically 30% moisture (Table 1). The temperature of the compost taken 2 to 3 days after turning was considered an indicator of active composting. The suggested temperature of active composting is between 100° and 150°F. Temperature for the compost was within this range except for the final measurement when the compost was considered “finished” (Table 1).

Dry matter recovery was not different ($P = 0.14$) among storage methods over time (Table 1). The % DM of manure was not different among the two storage methods because of rainfall that occurred during the 104 days. The larger surface area and incorporation of water from rain when the compost was turned did not allow the compost to dry as observed in most cases. Because the DM recoveries were similar and the weight as water was slightly greater for compost, hauling these to the field would have similar costs. Organic matter recoveries were 37% greater ($P < 0.01$) for the stockpile compared with the compost after 104 days. The largest loss of OM occurred during the first 42 days for both storage methods. Comparing storage methods among the last four sampling periods, stockpiling had

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Table 1. Effect of manure storage method on nutrient concentrations and recoveries.[a]

	Stockpile					Compost						
Day[b]:	0	42	69	83	104	0	42	69	83	104	SEM[c]	*P*-Value[d]
Temperature,°F	146.0	139.5	132.5	126.0	127.5	148.3	117.8	120.2	101.8	78.3		
DM recovery, %	100.0	89.1	87.2	85.7	85.7	100.0	86.3	82.3	81.8	81.4	1.5	0.14
DM %	72.5	75.6	74.3	74.2	73.8	71.2	73.2	70.0	70.0	72.6	2.8	0.78
OM recovery, %	100.0^{g}	63.4^{h}	57.1^{hi}	51.8^{i}	51.0^{i}	100.0^{g}	53.9^{i}	40.1^{j}	38.6^{j}	37.2^{j}	4.0	< 0.01
Organic C, g/kg	174.4^{g}	122.9^{h}	113.1^{h}	104.7^{i}	104.1^{i}	171.5^{g}	106.3^{hi}	83.3^{j}	80.5^{jk}	77.9^{k}	8.2	< 0.01
P_2O_5 recovery, %	100.0	106.5	100.7	100.1	101.6	100.0	99.4	97.5	94.6	95.0	5.5	0.83
P_2O_5 g/kg DM	14.4	15.4	15.4	15.3	15.6	14.8	14.7	14.4	13.9	14.0	0.75	0.41
C :N[e]	13.2^{g}	11.4^{h}	10.6^{i}	10.2^{ij}	9.9^{jk}	12.6^{g}	11.2^{h}	10.0^{j}	9.6^{k}	9.7^{jk}	0.4	0.05
N :P[f]	2.26^{g}	1.85^{h}	1.76^{h}	1.77^{h}	1.80^{h}	2.26^{g}	1.79^{h}	1.49^{i}	1.43^{i}	1.34^{j}	0.65	< 0.01

[a] Values are expressed on a 100% DM basis.
[b] Day = sampling date from pen cleaning.
[c] Pooled standard error of the mean.
[d] *F*-test statistic for storage method by time interaction.
[e] Carbon to nitrogen ratio.
[f] Nitrogen to phosphorus ratio
[g,h,i,j,k] Within a row, means without a common superscript letter differ (*P* < 0.05).

Table 2. Effect of manure storage method on amount and type of nitrogen concentration and recoveries.[a]

	Stockpile					Compost						
Day[b]:	0	42	69	83	104	0	42	69	83	104	SEM[c]	*P*-Value[d]
Total N recovery, %	100.0^{e}	87.5^{f}	83.0^{fg}	82.9^{fg}	85.7^{fg}	100.0^{e}	78.5^{g}	64.0^{h}	59.4^{h}	56.4^{i}	4.1	< 0.01
Total N, g/kg DM	14.2^{e}	12.4^{efg}	11.8^{g}	11.8^{g}	12.2^{fg}	14.6^{e}	11.5^{g}	9.3^{h}	8.7^{i}	8.2^{i}	1.0	< 0.01
NH_4, g/kg DM	1.10^{gh}	2.30^{e}	1.85^{e}	2.00^{e}	2.40^{e}	1.07^{h}	2.37^{f}	0.35^{fg}	0.62^{fg}	0.35^{fgh}	0.24	< 0.01
NH_4, % total N	7.9^{g}	18.2^{ef}	15.8^{f}	17.1^{ef}	19.0^{e}	7.3^{g}	20.5^{e}	3.7^{h}	7.2^{g}	4.2^{h}	0.9	< 0.01
Organic N, g/kg DM	13.1	10.1	9.9	9.6	9.6	13.6	9.1	7.8	7.8	7.4	1.0	0.17
Organic N, % total N	91.9^{ef}	81.6^{h}	83.4^{g}	81.7^{g}	78.5^{h}	92.7^{e}	79.5^{h}	94.6^{e}	89.9^{f}	90.2^{f}	3.1	< 0.01

[a] Values are expressed on a 100% DM basis.
[b] Day = sampling date from pen cleaning.
[c] Pooled standard error of the mean.
[d] *F*-test statistic for storage method by time interaction.
[e,f,g,h,i] Within a row, means without a common superscript letter differ (*P* < 0.05).

Table 3. Effect of manure storage method and laboratory analysis on nitrogen concentration and recoveries.[a]

	Stockpile					Compost						
Day[b]:	0	42	69	83	104	0	42	69	83	104	SEM[c]	*P*-Value[d]
Wet laboratory analysis[e]												
Total N recovery, %	100.0^{g}	87.5^{h}	83.0^{hi}	82.9^{hi}	85.7^{hi}	100.0^{g}	78.5^{i}	64.0^{j}	59.4^{jk}	56.4^{k}	4.1	< 0.01
Total N, g/kg DM	14.2^{g}	12.4^{ghi}	11.8^{i}	11.8^{i}	12.2^{hi}	14.6^{g}	11.5^{i}	9.3^{j}	8.7^{k}	8.2^{k}	1.0	< 0.01
NH_4, g/kg DM	1.10^{ij}	2.30^{g}	1.85^{g}	2.00^{g}	2.40^{g}	1.07^{j}	2.37^{h}	0.35^{hi}	0.62^{hi}	0.35^{hij}	0.24	< 0.01
NH_4, % total N	7.9^{i}	18.2^{gh}	15.8^{h}	17.1^{gh}	19.0^{g}	7.3^{i}	20.5^{g}	3.7^{j}	7.2^{i}	4.2^{j}	0.9	< 0.01
Dry laboratory analysis[f]												
Total N recovery, %	100.0^{g}	75.3^{hi}	77.6^{h}	71.9^{hi}	73.3^{hi}	100.0^{g}	69.4^{hi}	68.4^{i}	61.4^{j}	60.0^{j}	4.7	< 0.01
Total N g/Kg DM	13.4^{g}	10.9^{h}	10.8^{hi}	10.4^{hij}	10.7^{hij}	13.8^{g}	9.6^{ij}	9.3^{j}	8.4^{k}	8.2^{k}	0.7	0.01
NH_4, g/kg DM	0.32^{j}	0.82^{i}	0.87^{i}	0.67^{i}	0.90^{g}	0.29^{j}	0.47^{h}	0.44^{j}	0.42^{j}	0.38^{j}	0.07	< 0.01
NH_4, % total N	2.27	6.5	7.3	5.6	7.4	1.9	4.2	3.7	4.9	4.2	1.2	0.12

[a] Values are expressed on a 100% DM basis.
[b] Day = sampling date from pen cleaning.
[c] Pooled standard error of the mean.
[d] *F*-test statistic for storage method by time interaction.
[e] Samples analyzed wet, values expressed on a 100% DM basis.
[f] Samples analyzed after drying in a 100^{0}C oven for 24 hours to estimate ammonia losses.
[g,h,i,j,k] Within a row, means without a common superscript letter differ (*P* < 0.05).

greater recoveries ($P < 0.01$) of OM compared with composting. Organic C concentrations followed a similar trend to OM with more ($P < 0.01$) organic C being recovered for stockpiles after day 69. Carbon and OM losses are associated with microbial decomposition and the primary release of carbon dioxide.

The largest loss of N occurred from the time of removal to the first sampling date for either storage method (Table 2). After only 42 days (one turn of the windrows), N recoveries for the stockpile were greater ($P < 0.01$) in comparison to the compost and remained that way through the last sampling date. Organic N (% of total N) was greater ($P < 0.01$) for the compost on sampling days 69, 83, and 104. The incorporation of N into organic N is attributed to addition of oxygen during windrow turning and the lower temperatures found in the compost compared with the stockpiles. At temperatures above 140°F the rate of OM and N decomposition from bacteria is often reduced.

Across sampling days, ammonium N was greater ($P < 0.01$) for stockpiles compared with compost (1.9, and 1.0 g/kg, respectively). Ammonium N (% of total N) was greater for stockpiles on days 69, 83, and 104 compared with compost. It is generally assumed that ammonium N is rapidly converted to ammonia N and volatilized, indicating a greater amount of N loss would occur after stockpiled manure is spread on fields. However, the difference between total N recoveries for the analysis of wet and dry (oven dried) samples for ammonium N indicated that total N recoveries remained greater ($P < 0.01$) for stockpiled manure compared with compost (Table 3). The conditions in the 100°C oven completely dry the sample which gives an estimate for ammonia losses if manure was spread on a field and not incorporated in hot, dry conditions.

Nitrate N was detected in only 50% of the samples submitted for analysis. Most of the nitrate N that was measured was found after sampling day 69 at concentrations of 0.07% of total N or less (mean = 0.03%). Recovery of P_2O_5 was not different ($P = 0.83$) among storage methods because the P is not volatilized (Table 1). However, there appears to be a numerical decrease in P_2O_5 across time in the compost. This may be due to a greater surface area exposed to runoff losses of P.

When manure samples were dried down completely to simulate hot, dry conditions during field application, the amount of ammonia nitrogen lost from stockpiled manure was not great enough to offset the total nitrogen recovery advantage of stockpiling compared with composting. The limited amount of total DM reduction from composted manure was not large enough to improve transportation efficiency for field application in this study.

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[1] Matt K. Luebbe, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor; and Matt A. Greenquist, research technician, Animal Science, Lincoln.

Effects of Distillers Grains and Manure Management on Nutrient Management Plans and Economics

Virgil R. Bremer
Richard K. Koelsch
Raymond E. Massey
Galen E. Erickson[1]

Summary

Feed Nutrient Management Plan Economics software (FNMP$; Koelsch et al., 2007; available at http://cnmp.unl.edu *under software resources) was used to evaluate the effect of distillers grains inclusion and manure application rate on feedlot nutrient management plans. Inclusion of distillers grains in diets resulted in greater nutrient excretion, land requirements, and manure hauling distances. However, the increased cost of manure management from feeding byproducts has the potential to be offset by increased manure fertilizer value. Changing from N-based to a P-based application rate increased the amount of land required and costs to apply manure. However, when manure was applied at a 4-year P-based rate instead of a 1-year P-based rate, single year land requirement remained similar and application time was reduced by 41% from the 1-year P-based rate.*

Introduction

Both dietary N and P levels in feedlot diets impact the fertilizer value of feedlot manure. A specific feedlot may adjust ration ingredient inclusions to minimize feed costs which may change the N and P in the diet and the nutrient profile of the feedlot manure.

Traditional manure management programs have been based on crop N needs. Due to an imbalanced ratio of N to P in feedlot manure compared to crop needs, applying manure on a N basis results in applying P in excess of crop requirements. Long-term net addition of P to agricultural soils has the potential for degrading surface water quality. Therefore, environmentally preferred manure management programs should be based on practices that apply manure to meet crop P needs.

Ration changes and transitioning from a N-based to a P-based manure application system affect manure management cost and manure fertilizer value. However, accurately calculating these costs/values has been difficult due to the many steps and intricate details involved. The objective of this analysis was to use the feed nutrient management plan economics (FNMP$) software tool to evaluate the effect of distillers grains inclusion and manure application rate on feedlot nutrient management plans.

Procedure

The FNMP$ software tool (Koelsch et al., 2007; available at *http://cnmp.unl.edu* under software resources) is designed to estimate 1) nutrient excretion, 2) manure amounts and nutrient content, 3) land requirements for agronomic utilization of the manure, 4) time requirements (labor and equipment) for land application, 5) costs associated with land application, and 6) potential nutrient value (N and P only) of manure (Table 1).

Research has shown that feedlots may increase profitability by including distillers grains plus solubles (DGS) in feedlot finishing diets (*2006 Nebraska Beef Report*, pp. 54-56; *2008 Nebraska Beef Report*, pp. 50-51). The inclusion of DGS in feedlot diets changes subsequent manure nutrient composition. Three distillers grains plus solubles (DGS) scenarios were evaluated for a 10,000-head feedlot. The feedlot was assumed to have access to 40% of the land around it for manure application and crop land was in a corn (175 bu/ac) and soybean rotation (60 bu/ac). Dietary inclusion rates of 0%, 20%, and 40% (DM basis) DGS replacing corn in feedlot rations were compared.

In addition, federal and state regulations require feedlots to apply manure at rates that do not exceed crop nutrient needs. This has required feedlots to apply manure on P-based rates instead of N-based rates. P-based

Table 1. Summary of key user inputs and outputs of individual modules within FNMP$ software.

Module	Inputs	Outputs
Excretion	Ration nutrient concentration Feed intake Animal performance (e.g. weight gain, days on feed) Facility housing animals	Excreted nitrogen mass Excreted phosphorus mass Excreted solids mass and concentration
Nutrient Availability	Manure housing/storage type Nutrient retention in storage (optional) Crop availability (optional) Land application characteristics Manure moisture and ash concentrations	Crop available nitrogen Crop available phosphorus Harvested manure mass and volume (liquid systems only)
Land and Distance	Crop rotation, yield, and crops receiving manure Crop nutrient requirements (optional) and credits from non-manure sources Basis for application rate Average field size Land Availability Value of nutrients	Manure nutrient concentration Application rate Land requirements for agronomic use Average and maximum travel distance
Economics	Application and nurse tank/truck equipment Application equipment operating characteristics Operating costs (optional)	Application time for spreading equipment and nurse tank/ truck Total annual costs for manure application Nutrient value of manure Net costs of manure application

rates are typically lower than N-based rates, requiring additional land access and time for manure applications. The FNMP$ tool was used to compare manure application at a N-based rate versus a 1-year P-based rate. The results from the 1-year P-based rate were compared to a 4-year P-based rate. A 1-year P-based rate applies sufficient manure P to meet crop removal for 1 cropping year. A 4-year P-based rate applies sufficient manure P to meet P removal for 4 cropping years with no additional manure application during the 4-year period.

Table 2. Impact of inclusion of distillers grains with soluble (DGS) in cattle ration for 10,000-head capacity feedlot. Assumes 40% of land is accessible for manure application and cropland is in a corn (175 bu/ac) and soybean rotation (60 bu/ac).

Options:		0% inclusion of DGS in diet [a]	20% inclusion of DGS in diet[a]	40% inclusion of DGS in diet[a]
Manure Nutrients Available				
Nitrogen				
Excreted (lb/year)		1,096,000	1,320,000	1,653,000
Crop Available (lb/year)		218,000	265,000	331,000
Phosphorus (P_2O_5)				
Excreted (lb/year)		134,000	192,000	256,000
Crop Available (lb/year)		128,000	185,000	245,000
Manure Application				
Land Required (acres)		5,780	8,430	11,070
Land Required (acres/year)		1,580	2,100	2,770
Average Haul Distance (miles)		2.0	2.5	2.9
Maximum Haul Distance (miles)		3.0	3.7	4.3
Application Rate (as-is ton/acre)		8.0 [b]	5.8	4.5
Land Available for Manure		40%	40%	40%
Manure Application Equipment				
Application Equipment Selected		Truck mounted 20-ton spreader	Truck mounted 20-ton spreader	Truck mounted 20-ton spreader
Total Time (hours/year)		820	990	1,200
Field Time (hours/year)		460	570	720
Road Travel Time (hours/year)		210	260	300
Loading/Unloading (hours/year)		160	160	160
Manure Management Economics				
Nutrient Value	Total ($/year)	$ 109,000	$ 148,000	$ 192,000
	Total ($/ton)	$ 3.50	$ 4.70	$ 6.20
Application Cost	Total ($/year)	$ 48,000	$ 59,000	$ 72,000
	Total ($/ton)	$ 1.50	$ 1.90	$ 2.30
Net Value	Total($/year)	$ 61,000	$ 89,000	$ 120,000
	Total ($/ton)	$ 2.00	$ 2.80	$ 3.90

[a] Ration crude protein and P concentrations are 13% and 0.29% (0% inclusion), 15.3% and 0.39% (20% inclusion), and 18.7% and 0.49% (40% inclusion), respectively.
[b] Limited to N-based rate. P-based rate exceeded crop N requirement.

Table 3. Impact on costs of manure application when manure application rate was determined on an N or P based rate. Assumes 40% of land is accessible for manure application and cropland is in a corn (175 bu/ac) and soybean rotation (60 bu/ac).

Manure Application Rate Options:		N-Based Rate[a]	1-year P-Based Rate[a,b]	4-year P-Based Rate[a]
Manure Nutrients Available				
Nitrogen - Crop Available (lb/year)		331,000	331,000	331,000
Phosphorus - Crop Available (lb/year)		243,000	243,000	243,000
Manure Application				
Land Required (acres)		2,400	11,900	11,100
Land Required (acres/year)		2,400	11,100	2,800
Average Haul Distance (miles)		1.2	3.0	2.9
Maximum Haul Distance (miles)		1.9	4.4	4.3
Application Rate (as-is ton/acre)		5.4	1.1	4.5
Portion of Land Available for Manure		40%	40%	40%
Manure Application Equipment				
Application Equipment Selected		Truck mounted 20-ton spreader	Truck mounted 20-ton spreader	Truck mounted 20-ton spreader
Truck mounted 20-ton spreader				
Total Time (hours/year)		920	2,100	1,200
Field Time (hours/year)		640	1,600	720
Road Travel Time (hours/year)		130	320	300
Loading/Unloading (hours/year)		160	160	160
Manure Management Economics				
Nutrient Value	Total ($/year)	$ 197,000	$ 195,000	$ 192,000
	Total ($/ton as-is)	$ 6.40	$ 6.40	$ 6.20
Application Cost	Total ($/year)	$ 52,000	$ 144,000	$ 72,000
	Total ($/ton as-is)	$ 1.70	$ 4.70	$ 2.30
Net Value	Total($/year)	$ 145,000	$ 51,000	$ 51,000
	Total ($/ton as-is)	$ 4.70	$ 1.70	$ 3.90

[a] Ration crude protein and P concentrations are 18.7% and 0.49% (40% inclusion of DGS), respectively for a 10,000 head feedlot.
[b] Field speed of manure applicator was assumed to be 5.0 miles/hour for the N-based rate and 4-year P-based rates. It was assumed to increase to 8.0 miles/ h for a 1-year P-based rate.

Results

Impact of Feeding DGS

The impact of the dietary change was quantified in terms of manure nutrient excretion, land area, labor and equipment operating time, and land application costs. Increased inclusion of DGS from 0% to 40% (DM basis) increased diet CP from 13% to 18.7% and P in the diets from 0.29% to 0.49%. Greater diet N and P resulted in greater N and P excretion for 40% DGS compared to 0% DGS (51% and 90% N and P increase, respectively; Table 2). Land area increased from 5,780 to 11,070 acres and average haul distance increased from 2.0 to 2.9 miles at 40% DGS to manage the extra P. Equipment operating time and labor increased with greater land requirements. Most of the increase in time requirement was a result of greater field time for manure application. Finally, the total costs associated with land application of manure increased from $48,000 to $72,000, or by about $24,000.

For this situation, the negative impacts on land, time, and costs were offset by the increased nutrient value of the manure being land applied assuming the end-user of manure pays fertilizer prices for manure nutrients. The $24,000 increase in land application costs were more than offset by an $83,000 increase in manure value. The actual increase in manure value may be less than this value

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based on neighboring land owners willingness to pay fertilizer value for manure nutrients. If manure was valued for N, P, and K fertilizer nutrient values, OM content for improvement of soil structure and water holding capacity, Ca liming effect, and micronutrient composition, dietary changes that increase nutrient excretion increase manure value. To achieve this value, manure would need to be applied to fields where excess nutrients have not accumulated and crop producers need to recognize this value and substitute manure for commercial fertilizer.

Another consideration is the impact of a feed management change on animal production and profitability. For example, the average profitability of the animal is increased by $15 to $30 per finished animal using 20% to 40% DGS in the diet depending on inclusion level, distance from the plant, and price relative to corn grain (*2006 Nebraska Beef Report,* pp. 54-56). Therefore, the annual economic return for 20,000 finished steers (two turns in a 10,000 head feedlot) from least cost formulation in this example would be $300,000 to $600,000 due to including DGS in the diet. The income from feeding DGS is quite large compared to the increased cost ($24,000) to spread manure further.

Impact of N vs. P-Based Application Rate

Nitrogen and P-based rates were evaluated for the feedlot introduced previously with 40% DGS inclusion in the diet and those results were summarized in Table 3. For this example, moving from a N-based rate to a P-based rate (applied to meet a single crop year P needs) increased total land requirements from 2,400 to 11,900 acres. In addition, labor and equipment operation time increased from 920 to 2,100 hour/year, which is a 230% increase. Most of these hours were for field application of the manure. The maximum haul distance of available fields increased from 1.9 to 4.3 miles. A $94,000 increase in land application costs was also identified. Therefore, the net value of the manure was decreased.

Impact of 1-year vs. 4-year P-Based Application Rates

The total land requirement for 4-year P-based manure application remained similar to a 1- year P-based rate. However, for a 1-year P-based rate, all land must receive manure each year as opposed to every fourth year, and application rates must be reduced (1.1 vs. 4.5 tons/acre). If the model feedlot applied manure on a 4-year P-based rate instead of a 1-year P-based rate, it would decrease annual labor and equipment operating time by approximately 900 hours. In addition, the feedlot would reduce application cost by more than $70,000 annually. The nutrient value of manure exceeded the costs of manure application for all situations evaluated, assuming that neighboring farmers are willing to pay fertilizer value for manure nutrients. Transitioning to a 4-year P-based rate had significantly less costs than a 1-year P-based rate. A 1-year P-based rate has no environmental benefit over a 4-year rate (Agricultural Phosphorus Management and Water Quality Protection in the Midwest, 2005).

A history of manure application to fields close to the feedlot with N-based application rates may have provided a more than adequate supply of P for future crop production. Therefore, farmers further from the feedlot may be willing to pay more for the full nutrient value of the manure to replace commercial P fertilizer. The access to new land may offer feedlots new opportunities to market manure, especially higher P manure produced by cattle fed DGS.

The transition from a N-based rate to a single year P-based application will have substantial impact on all costs evaluated. Feedlot managers will experience far less financial and time burdens if a 4-year P-based application system is used instead of a 1-year P-based rate while achieving the same environmental benefits.

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[1] Virgil R. Bremer, research technician, Animal Science; Richard K. Koelsch, associate professor, Biological Systems Engineering and Animal Science; Galen E. Erickson, assistant professor, Animal Science, Lincoln. Raymond E. Massey, associate professor, Agricultural Economics, University of Missouri, Columbia.

Total and Water Soluble Phosphorus Content of Feedlot Cattle Feces and Manure

Virgil R. Bremer
Crystal D. Buckner
Galen E. Erickson
Terry J. Klopfenstein[1]

Summary

The percentage of feedlot feces and manure P that is water soluble was 41% (not accounting for additional soluble P from urine) and 24% respectively. The interaction of feces and urine with minerals and metals reduced the water solubility of P in feedlot manure relative to feces. Increasing dietary P level increased manure P concentration and water solubility of manure. Manure P from cattle fed feedlot diets containing 0.30% to 0.50% P was 28% water soluble P. The water solubility of P in feedlot feces and manure is an indicator of the potential for P runoff from feedlots and fields receiving manure.

Introduction

Of the P fed 80% to 88% is excreted in feces and urine by feedlot cattle. As dietary P intake increases, the form of P in runoff from fields receiving manure is impacted and may contribute to eutrophication.

Water solubility of P may affect the runoff potential of P in compost applied to crop fields (*2003 Nebraska Beef Report*, pp. 52-54). However, no research has been conducted on the water solubility of P in feedlot feces and manure. Furthermore, the differences in rate changes of soluble P to total P in feedlot manure and feces are unknown. The objective of our study was to evaluate the effect of dietary P on fecal and manure total P as well as water solubility of P in feces and manure of feedlot cattle.

Procedure

Two hundred fifty-four fecal samples and 158 manure samples from 15 University of Nebraska–Lincoln feedlot cattle trials (*1998 Nebraska Beef Report,* pp. 77-80; *1998 Nebraska Beef Report*, pp. 84-85; *1999 Nebraska Beef Report,* pp. 60-62; *2000 Nebraska Beef Report,* pp. 65-67; *2002 Nebraska Beef Report,* pp. 45-48; *2002 Nebraska Beef Report*, pp. 52-53; *2002 Nebraska Beef Report,* pp. 54-57; *2003 Nebraska Beef Report,* pp. 54-58; *2004 Nebraska Beef Report,* pp. 49-51; *2004 Nebraska Beef Report,* pp. 61-63; *2005 Nebraska Beef Report,* pp. 51-53; *2005 Nebraska Beef Report,* pp. 54-56) representing 1,608 cattle were analyzed for total P (TP) and water extractable P (WEP). Samples were from cattle fed diets containing 0.10% to 0.49% P. The cattle were consuming 20 to 57 g P and excreting 15 to 47 g P daily.

Fecal samples (feces collected directly from steers) were collected from mass-balance pen studies, individually fed animals, and from metabolism experiments. Multiple samples were taken for each experimental unit over time and frozen. The fecal samples from the mass-balance studies were freeze dried, and the other fecal samples were oven dried at 60°C for 48 hours. All fecal samples were composited by experimental unit within each experiment for laboratory analysis.

All manure samples (feces and urine mixed with soil over a feeding period) were collected from cattle fed in pens containing 8 to 11 steers at the University of Nebraska Mead Research Feedlot. In each study, manure was collected at the completion of the feeding period. As the manure was removed from each pen, approximately 20 samples were collected, frozen, freeze-dried, ground, and composited by pen within trial.

Total P (TP) of each sample was analyzed in duplicate by ashing 1 g of sample at 600°C for 6 hours, refluxing with 10 mL of 3 N HCl for 5 minutes, standardizing to 100 mL volume with double distilled water and filtering through filter paper (Whatman 42; 2.5 um). Water extractable P (WEP), the amount of P in a sample that is readily soluble in water, was analyzed in duplicate by shaking 0.5 g DM of each sample with 100 mL double distilled water at 150 rpm for 1 hour, a 50 mL aliquot was then centrifuged at 1,500 g for 10 minutes, 125 uL of concentrated HCl was added to a subsequent 14 mL aliquot of supernatant. All samples were stored at 4°C prior to colorimetric analysis with the molybdovanadate method on a spectrophotometer calibrated with standards developed in a matrix similar to each analytical procedure. Internal standards and blanks were included with each set of six samples for quality control.

Table 1. Average, minimum, and maximum P and ash values for feces and manure samples analyzed in this study[a,b].

	Average	Minimum	Maximum
Feces			
Diet TP, %	0.29	0.10	0.49
TP, %	0.49	0.18	1.43
WEP:TP	0.41	0.20	0.80
Ash, %	12	4	30
Manure			
Diet TP, %	0.33	0.18	0.49
Diet TP, g/day	36	21	57
TP, %	0.37	0.21	0.64
WEP:TP	0.24	0.12	0.47
Ash, %	73	48	89

[a] TP = total phosphorus, WEP = water extractable phosphorus
[b] All values are on a DM basis.

The ratio of WEP:TP will be used as an index of the potential of P in a sample to be lost in runoff. An increase in WEP:TP means that the P in a sample is more likely to be lost in runoff than P from a sample that has a lower WEP:TP.

The fecal and the manure samples were analyzed independently. An iterative meta analysis methodology was utilized to integrate quantitative findings from multiple studies using the PROC MIXED procedure of SAS.

Results

The average, minimum, and maximum TP, WEP:TP, and % ash values for fecal and manure samples are presented in Table 1.

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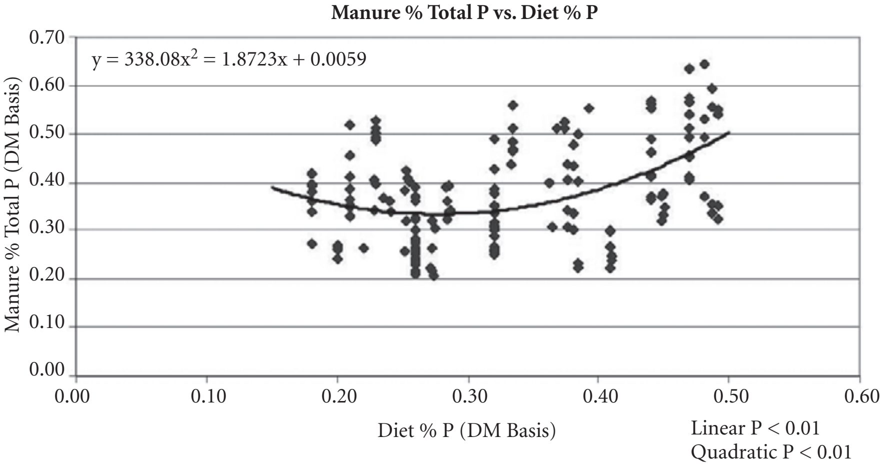

Figure 1. Quadratic relationship between the concentration of P in the diet and the concentration of manure P collected from the pen surface.

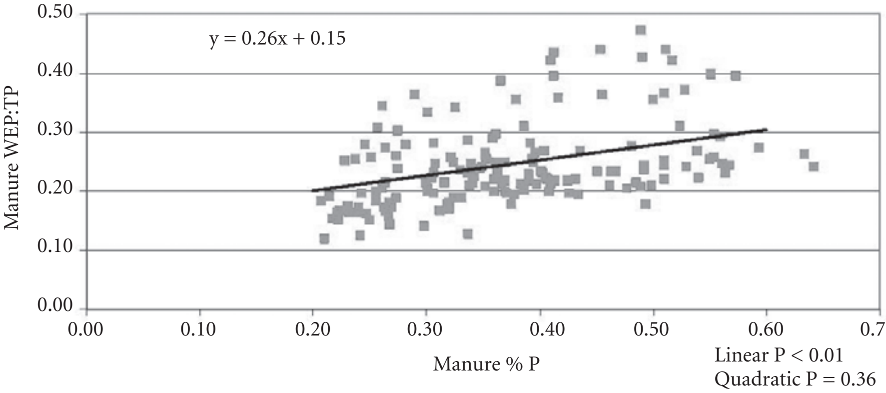

Figure 2. Linear increase in manure WEP:TP as manure TP concentration increased.

As proportionally more P was fed in feedlot diets, there was a quadratic response in the concentration of manure TP (Figure 1). Fecal WEP:TP increased linearly as diet P increased. Fecal P averaged 0.41 WEP:TP; however, this average does not account for additional urinary soluble P contribution.

Cattle fed diets containing the highest concentration of P also produced manure with the highest concentration of TP. Increasing manure TP concentration resulted in a linear increase in manure WEP:TP (Figure 2). However, the increase was small. Increasing manure TP from 0.20% to 0.60% TP (diets containing 0.18% to 0.49% P) resulted in an 11 unit increase in WEP:TP.

In one trial, 0.35% and 0.70% Ca diets were individually fed to cattle. Feeding 0.70% dietary Ca reduced fecal WEP:TP from 0.60 to 0.48 (18% reduction). All other samples in this study were from cattle consuming diets containing 0.65% to 0.70% Ca.

Fecal samples contained a higher concentration of TP than manure samples, even though the fecal samples were collected from cattle fed diets containing less P than diets fed to cattle that manure samples were collected from. Diet TP, soil contamination, P loss in runoff and degree of OM loss (bacterial breakdown to CO_2) may affect TP concentration of manure. Increased soil contamination and manure P loss in runoff would be expected to decrease the concentration of TP in manure relative to feces. The net effect of decreased manure TP relative to feces was presumably caused primarily by soil contamination to feces and urine on the pen surface.

The WEP:TP of manure was less than the WEP:TP of feces, regardless of dietary P level (Table 1). This may be due to interaction of excreted P with minerals and soil metals. The interaction of Ca with P has been shown to decrease the WEP:TP of feces. Previous research has shown excreted P can interact with Ca, Al, and Fe from soil contamination to cause a reduction in WEP:TP of manure by as much as 48%. The combined effects of the many positively charged ions in soil, when mixed with manure P from hoof action on the pen surface, may form immobilized phosphate compounds that are not water soluble.

Runoff events may remove proportionally more WEP than TP. However the loss of P in runoff from feedlot pens was less than 5% of excreted P. Back calculating manure P solubility to account for a 5% loss (all in WEP form) of manure TP increased manure WEP:TP 3.9 units. The calculated manure WEP:TP becomes 0.28 instead of the analyzed value of 0.24. However, this value is still less than the fecal WEP:TP value of 0.41. In addition, when urinary P is added to fecal WEP, the resulting mix of urine and feces is expected to be 0.52 WEP:TP. This expected value is 24 units of solubility higher than the actual value. These results showed the mixing of fecal and urinary P with soil contamination on feedlot pen surfaces reduced the WEP:TP of the resulting manure.

When interpreting the results from this study for commercial feedlots, the reader is cautioned that the minimum and average TP values for feces and manure are influenced by data collected from cattle fed experiment diets containing lower P (as little as 0.10% diet DM from diets containing corn bran and grits) than industry.

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[1] Virgil R. Bremer, graduate student; Crystal D. Buckner, research technician; Galen E. Erickson, associate professor; and Terry J. Klopfenstein, professor, Animal Science, Lincoln.

Climate Conditions in Bedded Confinement Buildings

Terry L. Mader
Leslie J. Johnson
Sheryl L. Colgan[1,2]

Summary

Climate conditions in bedded feedlot facilities during summer, fall, and winter seasons were measured. Summer season temperatures and THI levels were greatest at the front of the building. In winter, the building (with a curtain) maintained greater temperature, when compared to outside conditions, by decreasing wind speed through the building. Wind speeds through the building were reduced regardless of curtain usage.

Introduction

Confinement buildings are used for finishing cattle to allow more efficient collection of animal waste and to buffer animals against adverse climatic conditions. Buildings are typically naturally ventilated and positioned to take advantage of seasonal climatic conditions. In bedded units, bedding absorbs moisture and provides insulation as well as a softer surface for cattle. The objective of our study was to determine climate conditions in bedded feedlot facilities during summer, fall, and winter seasons.

Procedure

Data were obtained from a 1,044 ft long bedded confinement building with the long axis oriented east to west. The south side (front) is 28 ft high and the north (back) side is 16 ft high with 12 ft being open (at the top). The opening was closed to within 3 ft of the top in the winter using a curtain. The building is 96 ft wide with a 15 ft alley on the north side. Within the building, there are 8 pens that hold approximately 250 cattle each. Feedbunks are located on both north and south sides of the pen.

HOBO datalogger Procedure

Summer Trial — HOBO dataloggers (Onset, Pocasset, Mass.) were placed at the front and back sides of two bedded confinement pens. In addition, dataloggers were also placed on support columns in the middle of the pen and at the waterers, which are located midway between support columns and the front of the pen. Two dataloggers were also placed outside the building approximately 60 ft from the building.

Dataloggers were set to record temperature and relative humidity (RH) data starting at noon on June 20, 2006. They were removed on the morning of Aug. 10.

Winter Trial — HOBO Pro Series dataloggers were placed in two bedded confinement pens (same pens as summer trial). Dataloggers were set to record temperature and RH starting at 1500 on Jan. 9, 2007. They were removed on Jan. 17.

Kestrel Procedure

Fall and Winter Trials — Four Kestrel 4000 weather monitors (Nielsen-Kellerman Co., Boothwyn, Penn.) were placed in bedded confinement pens. Two monitors were placed on the front (high side) of the pen and two on the back (low) side of the pen. Monitors measured temperature, RH, and wind speed in the fall starting on Oct. 2, 2006, at 1500 and were removed the morning of Oct. 5 and in the winter from Jan. 9, 2007, at 1500 to the afternoon of Jan. 17.

General Procedures

For all seasons, dataloggers and monitors were approximately 7 ft from the ground. Weather data were also obtained from an automated weather station near Concord, Neb. approximately 7 miles from the confinement buildings.

The temperature humidity index (THI) was calculated for the summer and fall trials using the following equation:

$$THI = T-[0.55-\{0.55*(RH/100)\}]*(T-58)$$

where T = air temperature (°F) and
RH = relative humidity (%).

A THI value of less than 74 is considered normal. Threshold levels above 74 are defined as follows: 75-78 Alert; 79-83 Danger; 84+ Emergency.

In addition to weather data, pen surface temperatures were measured using an infrared gun at approximately 1500 during the fall trial in two confinement building pens and five outside feedlot pens in which no building was present.

Results

Air temperatures, RH, wind speeds, and indices from all trials are shown in Table 1.

Summer Trial — A period of high wind speed (primarily from the south and averaging 11.0 mph), and a period of low wind speed (primarily from the east-south-east and averaging 5.2 mph) were identified.

During the period of high wind speed, the average air temperature (Table 1) was similar in all locations except at the front of the building. The air temperature at the front of the building was greater than the temperature at the back of the building. This is probably due to the height of the front of the building, which allows for more direct exposure to sunlight as compared to the back of the building. Temperatures at the front of the building were greater during the day, but lower at night, and were actually cooler than the back of the building at 0600 (Figure 1). The average RH at the front of the building was greater than RH at the middle of the pen. Accumulation of moisture from cattle defecating and urinating while eating may create this difference. Hourly differences in RH between the front and back of the barn indicate RH was greater in the back of the building during daylight hours but then an opposite trend occurs at night. The

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average THI was similar across all locations during this period. In contrast to average data, hourly data shows that the THI was greater at the front of the building, when compared to the back of the building, during daylight hours only (Figure 2).

During the period of lower wind speed, similar temperatures (Table 1) were found outside the pen, at the waterer, the back of the pen, and the middle of the pen, but temperatures were greater at the front of the pen. Hourly differences between the front and back of the pen followed the same pattern as was found during periods of high wind with temperatures at the front of the pen being greater during most of the daylight hours due to the direct exposure to sunlight. Average RH during the low wind period were similar at the waterer, the middle of the pen and outside the confinement building. The RH at the back and the front of the building were greater than RH at the waterer and middle. Hourly RH data during this period indicated similar trends as found under the higher wind speed period. As discussed previously, the greater RH at the front and back may be due to the wetter manure/bedding accumulated behind the bunks versus the dryer bedding found in the middle of the pen. The THI during the lower wind period was the same in all locations excluding the front of the building. The THI at the front was greater due to elevated temperature and RH (Table 1). The THI at the front of the building was greater during 17 hours during the day, but was similar to THI at the back of the building during the nighttime hours from 0200 to 0800.

Fall Trial — Average air temperatures were different at each location. Temperatures were lowest outside and greatest at the front of the building (Table 1). Hourly air temperatures were found to be greater at the front of the building than at the back during the daylight hours, but no differences between front and back were observed during evening and night hours (Figure 3). Average RH were also different at all locations, with the front of the building having the lowest RH and outside being the greatest (Table 1). However,

Table 1. Results of summer, fall, and winter trials.

	Location					
	Outside	Front	Waterer	Middle	Back	SE
Summer 2006						
High Wind Speed (11.0 mph)						
Air Temperature, °F	88.4^{ab}	89.9^{b}	88.2^{ab}	88.1^{ab}	87.5^{a}	1.0
Relative Humidity, %	50.1^{ab}	54.4^{b}	50.2^{ab}	48.8^{a}	53.4^{ab}	2.4
THI[d]	79.1	80.6	79.3	79.0	79.5	0.9
Low Wind Speed (5.2 mph)						
Air Temperature, °F	81.7^{a}	84.4^{b}	82.3^{a}	81.6^{a}	81.5^{a}	1.0
Relative Humidity, %	71.0^{ab}	79.6^{c}	69.6^{a}	68.9^{a}	74.6^{b}	2.4
THI[d]	77.0^{a}	80.0^{b}	77.7^{a}	77.0^{a}	77.5^{a}	0.9
Fall 2006[e]						
Air Temperature, °F	59.0^{a}	61.2^{c}	—	—	60.1^{b}	0.4
Relative Humidity, %	74.0^{c}	68.9^{a}	—	—	71.4^{b}	0.9
THI[d]	58.8^{a}	60.6^{b}	—	—	59.8^{b}	0.4
Wind Speed, mph	8.9^{c}	3.6^{a}	—	—	5.8^{b}	0.4
Wind Chill Index, °F[f]	57.4	62.0	—	—	59.8	5.3
Winter 2006-2007[e]						
Air Temperature, °F	6.1^{a}	11.1^{c}	12.2^{c}	9.9^{bc}	9.6^{b}	0.7
Relative Humidity, %	79.8^{ab}	82.5^{c}	81.8^{c}	79.1^{a}	80.3^{b}	0.6
Wind Speed, mph	14.9^{b}	0.9^{a}	—	—	1.1^{a}	1.0
Wind Chill Index, °F[f]	-11.6^{a}	12.4^{c}	—	—	9.5^{b}	0.7

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

[d]THI (Temperature Humidity Index) = T_a - [0.55 - {0.55 * (RH /100)}] * (T_a-58), where T_a = ambient temperature, °F and RH = relative humidity, %.

[e]Outside data were obtained from automated weather station located approximately 7 miles from feedlot site.

[f]Wind Chill Index = 35.74 + 0.6215 * T_a - 35.75 * WS^0.16 + 0.4275 * T_a * WS^0.16, where T_a = ambient temperature, °F and WS = wind speed, mph.

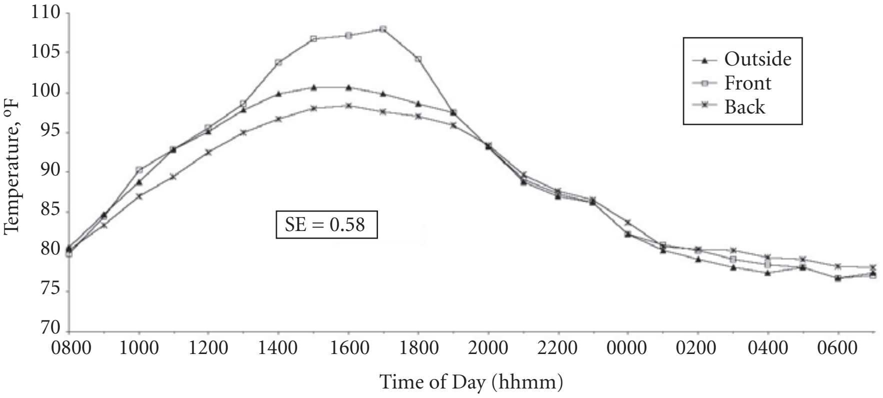

Figure 1. **Summer 2006 air temperatures by hour during high wind conditions. Front vs. back were different from 1000 to 1900, at 0000, and at 0600. Outside vs. front and back were different at 1100, from 1500 to 1800, at 0300 and at 0400.**

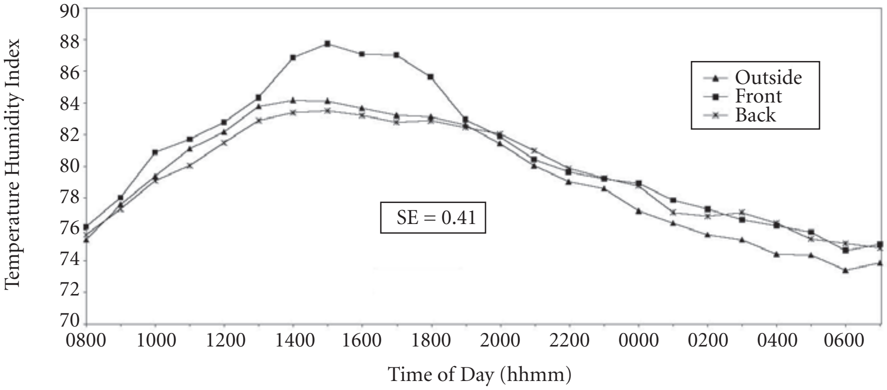

Figure 2. **Summer 2006 temperature humidity index (THI) by hour during high wind conditions. Front vs. back were different from 1000 to 1800. Outside vs. front and back were different from 1400 to 1800 and from 0000 to 0700.**

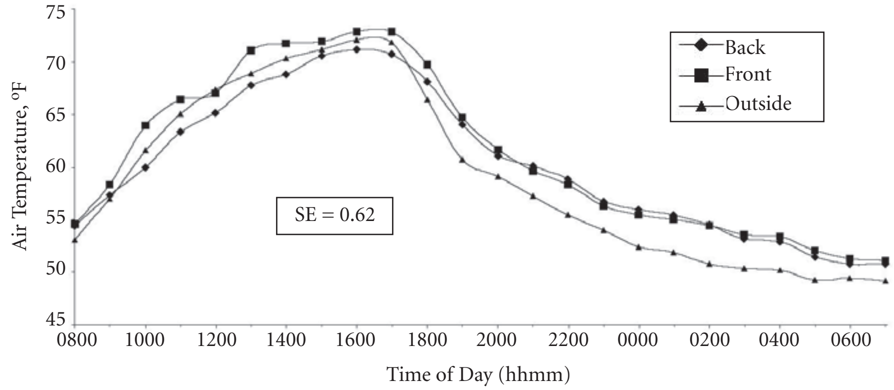

Figure 3. Fall 2006 air temperature by hour. Front vs. back were different from 1000 to 1400 and from 1600 to 1800. Outside vs. front and back were different at 0800 and from 1800 to 0700.

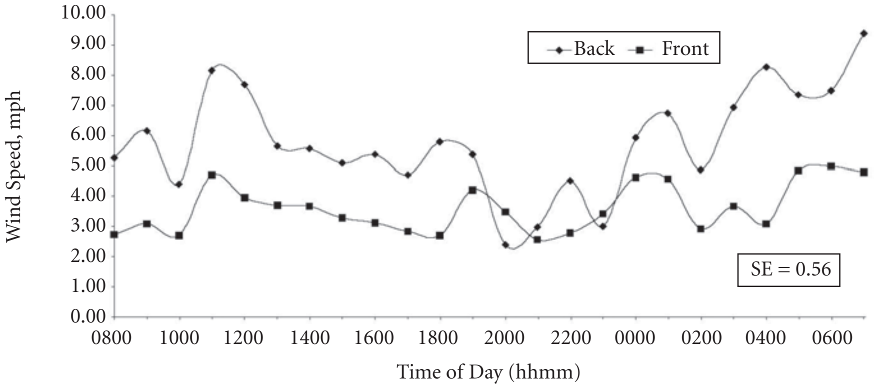

Figure 4. Fall 2006 wind speed by hour. Front vs. back were different from 0800 to 1800, at 2200, and from 0000 to 0700.

similar trends in hourly RH were found in the fall as those found in the summer with RH being lower at the front of the building during the daylight hours. No differences in RH were observed between the front and back of the building during the night hours. Average THI was similar within the building, but greater than those found outside (Table 1). Average wind speed differed at each location; it was greatest outside and lowest at the front of the building (Table 1). Hourly wind speeds were greater at the back of the building during most of the day (Figure 4).

Winds were most likely greater at the back of the building because of the funneling effect achieved by the design of the building resulting in the compression of air at the back of the building due to less open space when compared to the front. The average wind chill indices (WCI) during the fall trial were similar across all locations.

Infrared temperatures obtained during this time period indicated that pen surface temperatures at the front of the building were warmer than the back of the building, but were not as warm as the surface temperatures in outside pens (Table 2).

Table 2. Infrared temperatures of feedlot surfaces in two confinement building (CB) pens and five outside pens which contain cattle.

	Temperature, F	SE
Front of Pen (in sun)	98.3^{b}	1.2
Back of Pen (shaded)	72.0^{a}	2.7
Outside Pen	109.0^{c}	3.7

^{abc}Surface temperatures differ ($P < 0.05$).

Winter Trial — Average air temperatures during the winter trial were lowest outside the confinement pens (Table 1). The average temperatures at the middle of the pen were similar to both the back and the front of the pen, but the back temperature was lower than the waterer and the front of the building temperature. No significant differences were observed between the front and the back of the building at any hour. Average RH were greater at the front of the pen and at the waterer when compared to RH at other locations (Table 1). Relative humidity at the front of the pen was approximately 8 units greater at the front of the pen than at the back of the pen at 0900. Average wind speeds were similar within the building, but the outside wind speed was much greater (Table 1). No differences were found between the front of the building and the back, because the use of a curtain on the back side of the building diminished airflow through the pen when it was closed. The average WCI during the winter trial was different at each location (Table 1). The WCI was much lower outside than in the building but remained lower at the back of the building than the front. This is probably because of sun exposure elevating air temperatures at the front of the building, thus increasing the WCI.

In conclusion, low wind speed and/or decreased air movement associated with the building produced greater RH at the front of the building (south facing) in the summer and winter. The use of the buildings did not lessen heat stress in the summer, as measured by the THI, but acted as a solar shield (shade) and decreased solar heat load on the animal. In winter, when the north end of the building is nearly closed, via the use of a curtain, RH levels are elevated at the front of the building and at the waterer. However, temperatures in the building are elevated between 3.5 to over 6°F across the building.

Bedded barn facilities are useful for buffering cattle against the adverse effects of the environment under hot and cold conditions. In addition, if properly bedded, bedded barn facilities should virtually eliminate adverse effects that mud can have on cattle welfare and performance.

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[1] Terry L. Mader, professor; Leslie J. Johnson, research technician; and Sheryl L. Colgan, research technician, Animal Science, Haskell Agricultural Laboratory, Northeast Research and Extension Center, Concord.

[2] The authors would like to express their appreciation to the Dixon County Feedyard, Allen, Neb., for the use of their facilities to conduct this study.

Modeling Daily Water Intake in Cattle Finished in Feedlots

Rodrigo A. Arias
Terry L. Mader[1]

Summary

Simple regression and multiple regression analyses were conducted to estimate factors affecting daily water intake (DWI) of finishing cattle. Seasonal simple linear regression equations were very poor predicting DWI ($r^2 < 0.15$*). Best results were obtained with the overall simple regression. The multiple regression analysis showed that daily minimum temperature (or THI), solar radiation, and dry matter intake were the most important factors affecting DWI in cattle finished in feedyards. The following prediction equation was developed:* $\text{daily water intake, gal*d}^{-1} = -0.52677 + (0.1229 \text{ *DMI, lb*d}^{-1}) + (0.01137\text{*solar radiation, kcal*d}^{-1}) + (0.06529\text{*daily minimum temperature, }^{o}\text{F})$.

Introduction

Water is a very limited resource in many places, and its demand is expected to increase in next years as result of the development of the ethanol industry and by the greater demand for irrigation purposes. The relationship among ambient temperature and water intake in beef cattle has been a topic of interest but there are still some questions that need to be answered. Previous research conducted in Nebraska suggests that one steer consume around 9.0 gal/day of water during the summer and 4.5 gal/day during the winter (*2007 Nebraska Beef Report,* pp. 47-49). The current DWI recommendations of NRC are based in the work developed by Winchester and Morris in middle '50s. Their work was developed under technical conditions, type of diet, and cattle genetics among other factors that are different than those used at the present. The interaction among climatic factors, type of diet, breed, and the animal weight, as well as the different physiological strategies adopted by each animal make it difficult to predict DWI and the performance of cattle. Besides, there is limited information concerning how other environmental factors along with temperature can simultaneously affect the physiology and performance of cattle under commercial feedlot conditions. Thus, the objectives of this study were to establish which environmental variables affect daily water intake and to find the best model to predict daily water intake in cattle finished in feedyards.

Procedure

The dataset used for this analysis was derived from eight experiments that were conducted at the University of Nebraska Northeast Research and Extension Center and used predominantly Angus or Angus crossbreds. Five of these experiments utilized steers and they were previously reported (*2007 Nebraska Beef Report, pp. 47-49*). Three new experiments were added to this dataset. The first experiment used 270 heifers to compare the effect of different growth promotant strategies in the winter. The experiment was conducted over a 104-day feeding period during the winter season of 1999-2000. The second experiment was conducted as a replication of the previous one for summer season of 2001 with 270 heifers fed 105 days. The last experiment used included 90 heifers and 48 steers which were fed over a period of 92 days to compare the effects of NaCl and fat supplementation on DMI, behavior, DWI and tympanic temperature during the summer of 2002 (*2006 Nebraska Beef Report,* pp. 62-65).

The database included daily measures of temperatures (mean, maximum, and minimum), precipitation, relative humidity, wind speed, solar radiation, and temperature-humidity index (THI); as well as DMI and DWI. The THI was calculated as: $THI = Ta - (0.55-(0.55*(RH/100)) * (Ta-58)$; where Ta = ambient temperature and RH = % relative humidity. The climatic variables were compiled using a weather station located at the feedlot facility. Solar radiation was obtained from the High Plains Climate Center automated weather station located 0.37 miles west and 0.93 miles north of the feedlot facilities. The total number of observations resulted in 4,463 data points. However, due to water meter malfunction or possible recording error, approximately 2.3% of the total data points were removed from the final dataset. For each season, simple regression analyses for linear, quadratic, cubic and quartic polynomial degrees were determined between daily water intake and each environmental variable using JMP 5.0.1.2 © (SAS Institute Inc). Inflection points were determined from the second derivative from the best polynomial equations. The inflection points represent a threshold or shift in the rate of change in DWI. Subsequent multiple regression analyses used forward stepwise regression procedures of SAS© with DWI (gal/day) as the response variable. Multiple regression analyses were conducted using both genders for each season (summer and winter) and both seasons and genders for the complete overall model. The number of final parameters included in each model was determined based on change in the magnitude of R^2 value. A parameter was included in the model if its addition produced an increase greater than 0.01 units in total R^2.

Results

Table 1 displays the means and standard deviations for the climatic variables and recorded animal performance variables. Cattle finished during the summer consumed 86% more water than those finished during the winter (8.6 ±2.3 vs. 4.6 ±1.1 gal/day). The summer average was very similar to that one reported in a study conducted in feedyards located in the Texas high plains using 50,000

Table 1. Means for daily water intake and other climatic factors across seasons for feedlot cattle (±SD)‡.

Season	Water Intake (gal/day)	DMI (lb/day)	Temperature (°F)			RH (%)	Wind speed (mph)	Solar radiation (kcal/day)	Precipitation (in/day)	THI (%)
			Max	Min	Mean					
Summer	8.55^a ±2.3	21.1^b ±3.26	81.5 ± 9.2	59.9 ± 8.7	70.5 ± 8.1	77.7^a ±10.7	8.9^a ±4.89	4567^a ±1493	0.068^a ±0.24	69.0^a ± 7.08
Winter	4.56^b ±1.0	24.7^a ±2.58	39.6 ±15.3	16.2 ±12.8	28.4 ±12.8	74.9^b ±12.6	7.7^b ±4.76	2058^b ±1081	0.017^b ±0.08	32.4^b ±11.4
Overall	6.49 ±2.7	23.0 ±3.44	59.9 ±24.4	37.4 ±24.5	48.7 ±23.7	76.2 ±11.8	8.3 ±4.8	63274 ±1804	0.042 ±0.18	50.1 ±20.6

‡Means with unlike superscript within column differ ($P < 0.001$). The comparison was made only between the winter season and the summer season and did not consider temperatures.

Table 2. Coefficients of determination (r^2) of simple linear regression for environmental variables on evaluation to predict DWI.

Variables	r^2 values Summer Model	Winter Model	Overall Model
Minimum Temperature	0.0985	0.0199	0.5586
Maximum Temperature	0.0608	0.0650	0.5350
Solar Radiation	0.1408	0.0322	0.4674
Wind Speed	0.0002	0.0440	0.0018
Dry Matter Intake	0.0031	0.0176	0.1236
Relative Humidity	0.0000	0.0699	0.0004
Precipitation	0.0011	0.0231	0.0057
Mean Temperature	0.1126	0.0439	0.5707
THI^a	0.1176	0.0549	0.5730

^{a}THI = Ta – (0.55*(RH/100)*(Ta-58); where Ta = ambient temperature and RH = % relative humidity.

head of cattle. There was also greater variability in DWI during the summer than during the winter. These results are in agreement with our previous results, when variation was observed in the amount of water consumed by cattle maintained under the same diet and same environmental conditions. Average DMI was 17% greater in the winter than in the summer (24.7±2.58 vs. 21.1±3.26 lb /day, respectively). These differences are typical as it has been demonstrated that feed intake increases as the temperature falls below the thermoneutral conditions. Previous studies conducted at UNL have showed that large variations in DMI can exist in feedlot cattle, and that seasonal patterns are likely dependent on normal vs. abnormal environmental conditions.

Simple regression analysis

Table 2 displays the coefficients of determination of simple linear regression analyses for both genders for the summer, the winter, and overall. The combination of data from each gender did not improve the r^2 value of seasonal models. These were lower than 0.2 for all the models. For the summer model, solar radiation (r^2=0.14), THI (r^2=0.12) and mean temperature (r^2=0.11) had the best r^2 values. Daily maximum temperature (r^2=0.07), relative humidity (r^2=0.07), and THI (r^2=0.05) were the best predictors for the winter season. In the complete overall model, the highest r^2 values were obtained with THI and mean temperature (r^2= 0.57), daily minimum temperature (r^2=0.56), and daily maximum temperature (r^2= 0.53). These results confirm the importance of environmental temperature on DWI. Subsequently, the environmental variables with the highest r^2 values for each season were fitted to quadratic, cubic and quartic polynomial regressions equations. The objective was to identify the best predictor for DWI. As result of these procedures for the summer and the winter model little improvement in r^2 were observed. However, the complete overall model using daily minimum temperature as predictor was improved, reaching r^2=0.59 with a simple cubic regression.

Multiple regression analysis

The parameters included in each model after multiple regression analysis, as well as their respective coefficients are displayed on Table 3. Seasonal models were very poor in predicting DWI. The summer model explained only 23.6% of the variability and included three factors; solar radiation (R^2= 0.14), daily minimum temperature (R^2= 0.05), and dry matter intake (R^2= 0.04). Moreover, the winter model included six of the seven variables evaluated, excluding only daily minimum temperature. Relative humidity, daily

(Continued on next page)

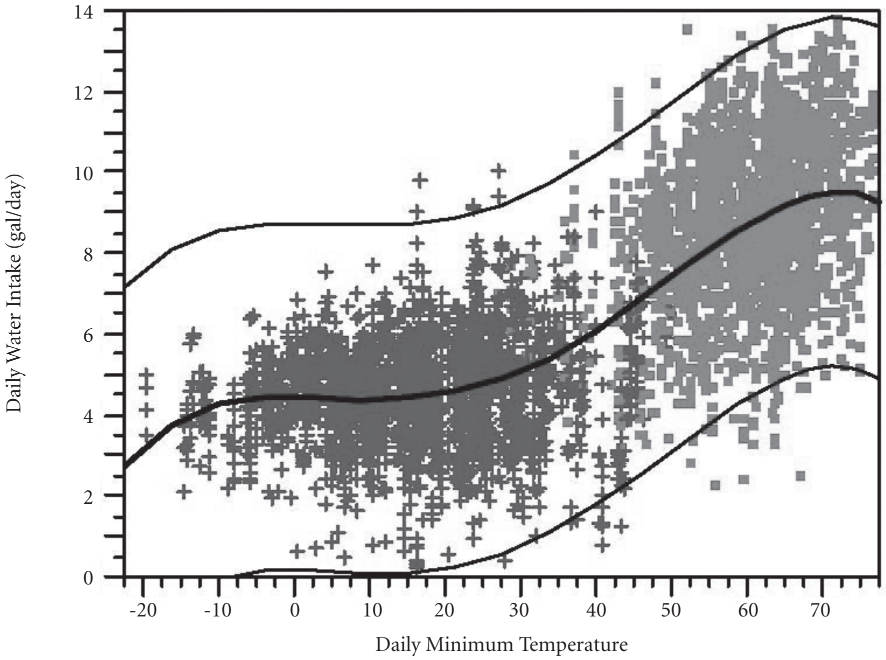
Table 3. Partial regression coefficients ±SE for models assessing environmental and performance factors affecting water intake in feedlot cattle^a.

Parameter	Summer			Winter			Overall		
	Estimate	SE	Partial R^2	Estimate	SE	Partial R^2	Estimate	SE	Partial R^2
Intercept	-1.06096	0.478	—	2.71761	0.259	—	-0.52677	0.231	—
Dry Matter Intake	0.14422	0.013	0.0430	0.05097	0.007	0.0139	0.12293	0.009	0.0168
Solar Radiation	0.01030	0.000	0.1420	0.00224	0.000	0.0134	0.01137	0.000	0.0734
Max Temperature	—	—	—	0.01891	0.001	0.0462	—	—	—
Min Temperature	0.07285	0.005	0.0514	—	—	—	0.06529	0.001	0.5586
Wind Speed	—	—	—	- 0.04610	0.004	0.0448	—	—	—
Relatively Humidity	—	—	—	- 0.01315	0.002	0.0700	—	—	—
Precipitation	—	—	—	- 2.36970	0.245	0.0468	—	—	—
Total R^2			0.2364			0.2350			0.6487

^{a}P values for all statistics < 0.01

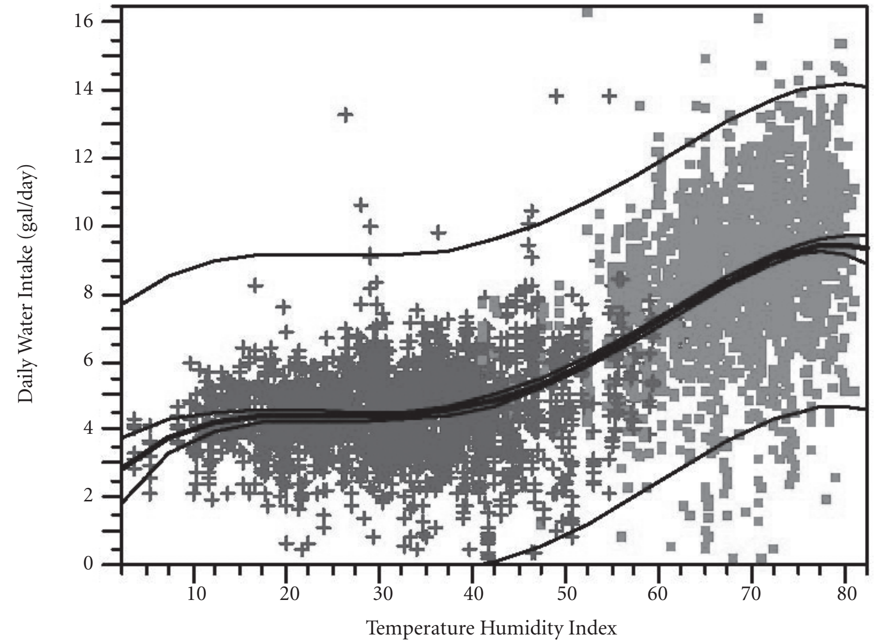
maximum temperature, precipitation, and wind speed were the four most important factors accounting for 20.8% of the variability, (of a total of 23.5%) accounted for the winter model. Wind speed, precipitation and relative humidity displayed a negative effect on DWI. On the other hand, the complete overall model explained 64.9% of the total variability of DWI for cattle finished in feedlots. The same three factors included in the summer model were included in the final overall model. However, daily minimum temperature accounted for 55.9% of variability, whereas solar radiation only accounted for 7.3% of DWI. When the analyses used THI instead of daily maximum and minimum temperature in the model, the R^2 values did not change ($R^2 = 0.65$, data not shown).

Figure 1 illustrates that DWI was relatively constant for daily minimum temperatures between -10°F and 40°F. This means that in that range of temperatures the amount of water that cattle consume does not change so much. Nevertheless, a great variability was found among animals. Therefore, there is an individual response of each animal, which is peculiar and hard to predict. A greater variability in DWI was observed for the summer season with daily minimum temperatures between 40° and 75°F. When daily minimum temperature was used as predictor, using a quartic polynomial equation, it explained 60% of the variability. This value was slightly inferior to the same quartic polynomial equation using THI as predictor (r^2=0.63). The inflection points for daily minimum temperature were 4.8° and 49.8°F. The upper threshold would represent a trigger in the amount of DWI per unit of DMI. This means that cattle begin to increase the amount of DWI per unit of DMI after this daily minimum temperature. Figure 2 shows a similar pattern for DWI, but using THI instead of daily minimum temperature. The best model was reached using THI as predictor accounting for 63% of the



Water intake = 4.4433 - (0.0019 Tmin) - (1.1544 e-3 $Tmin^2$) + (8.7853 e-5 $Tmin^3$) - (8.0418 e-7 $Tmin^4$)
r^2 = 0.60, inflection points = 4.80 and 49.82.
Inflection points would represent a thresholds or shift in the rate of change of daily water intake.

Figure 1. Daily water intake in function of daily minimum temperature (°F, Tmin) for overall season in feedlot cattle. The "+" signs represent the winter season and the "■" represent the summer season.



Water intake = 1.6973 + (0.3861 THI) – (0.0187 THI^2) + (3.568 e-4 THI^3) – (2.1034 e-6 THI^4)
r^2 = 0.625, inflection points = 24.64 and 60.17.
Inflection points would represent a thresholds or shift in the rate of change of daily water intake.

Figure 2. Daily water intake in function of temperature humidity index (THI) for overall season in feedlot cattle. The "+" signs represent the winter season and the "■" represent the summer season.

variability. It was slightly superior to daily minimum temperature (r^2= 0.60). The upper threshold for THI found in this study (60.2) was slightly under the value reported as normal in the Livestock Weather Safety Index (LWSI = 72-74). The importance of daily minimum temperature has been previously established as a strategy used by cattle to dissipate the overload of heat during the nighttime. Similarly, a high THI during nighttime could have the same effects of high minimum temperatures. Both factors would represent the limitation of cattle to lose heat by convection and conduction processes during summer nights. Therefore, THI as well as daily minimum temperature would represent indirect modulators of DWI, and they can be used to predict DWI.

All variables used to determine DWI with simple regression procedures showed lower r^2 values than the final R^2 values from multiple regression analyses. Multiple regression analyses improved the explanation of the variability across the seasons and were better models to predict water intake than with simple regression models. These results also confirm that DWI increases significantly during the summer season. Daily minimum temperature and THI play an important role on DWI of cattle as was demonstrated by the summer and the complete overall models, whereas maximum temperature seems to be the most important factor during the winter season.

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[1] Rodrigo A. Arias, graduate student; and Terry L. Mader, professor, Animal Science, Northeast Research and Extension Center, Concord.

Sorting Steers by Weight into Calf-Fed, Summer Yearlings and Fall Yearling Feeding Systems

Daniel R. Adams
Matt K. Luebbe
Terry. J. Klopfenstein
Galen E. Erickson[1]

Summary

Sorting steers into one of three different feeding periods — calf-feds, summer yearlings, and fall yearlings — resulted in no differences in performance or average carcass characteristics. Sorting decreased the amount of variation in hot carcass weight and carcasses over 950 lbs.

Introduction

Cattle are ideally sorted by placing the heaviest calves at weaning into the calf-fed feeding system. The lightest calves at weaning would enter the fall yearling feeding system and the middle weight calves would enter the summer yearling feeding system. Our study was designed to determine if sorting into feeding systems by weight would decrease variation in feedlot performance and carcass characteristics.

Procedure

Two-day weights were collected on a group (n = 288) of ranch direct calves that were received in November with average BW of 591 lb (374 to 870lbs). Cattle were limit fed at 2% of body weight for five consecutive days before the 2-day BW. From the 2-day BW, cattle were assigned randomly into one of two different groups, sorted and unsorted cattle. At this time, the cattle in the unsorted group were assigned randomly to calf-feds, summer yearlings or fall yearlings. For the sorted group, the heaviest 1/3 were placed into the calf-fed feeding system. The remaining 2/3 were placed on cornstalks with the summer and fall yearlings from the unsorted group. The sorted and unsorted cattle grazed cornstalks and grass as one group. In April, when the summer and fall yearlings were removed from cornstalks, 2-day BW were collected and the cattle in the sorted group were assigned into either the summer yearling or fall yearling feeding system based on BW. The heaviest ½ of the remaining 2/3 of the sorted group entered the feedlot as summer yearlings. The lightest ½ of the remaining 2/3 of the sorted group were then placed into the fall yearling feeding group. The summer yearling cattle entered the feedlot in late May and were fed until mid October when marketed. The fall yearlings were taken to the Sandhills to graze native range. The fall yearlings grazed native range until late September when the cattle entered the feedlot. Fall yearlings were marketed in January.

The calf-fed feeding system consisted of placing the calves at arrival into the feedlot and feeding a high concentrate diet. Two-day weights were collected in November at the beginning of the finishing phase. The calves were fed until May when harvesting occurred. Cattle placed in the summer yearlings and fall yearling groups were weighed at arrival like the calf-feds. The cattle in these groups were then placed on cornstalks for the winter months. During the time of stalk grazing, cattle were supplemented with 5 lb/head daily of wet corn gluten feed (DM basis) to achieve a 1.5 lb ADG. At the end of winter, the cattle were removed from stalks and 2-day BW were collected (April 20). The cattle grazed smooth brome grass pastures until the end of May. At the end of May, cattle in the summer yearling groups were placed into the feedlot after 2-day BW were collected and were fed until October. The cattle in the fall yearling feeding system were taken to a Sandhills ranch to graze Sandhills range for the remainder of the summer. In the early fall, about Sept. 15, cattle were removed from pasture, weighed on two consecutive days and fed in the feedlot until January.

At the time of slaughter; hot carcass weight (HCW), rib eye area, 12th rib back fat, and quality grade were collected at the plant and USDA Yield Grade was calculated (YG= (2.5+(2.5* fat)+(0.2*KPH%)-(0.332*REA)+(0.0038*HCW)). Final BW was determined from HCW by dividing the HCW by an average dressing percentage of 63% and the final weight used to determine performance in the feedlot.

Results

There were no difference in DMI, ADG, and F: G between the sorted and unsorted groups of cattle (Table 1). There was no effect of sorting on HCW, ADG, and F: G, fat thickness, marbling, or number of cattle with YG $\geq$ 4 ($P > 0.21$). Sorting increased average initial weights of calf-feds by 91 lb and reduced the average initial feedlot weights of fall yearlings by 64 lb. Sorting also decreased the amount of variation in initial feedlot BW and HCW. Essentially all of the values fall within $\pm$ 3 standard deviations (SD) of the mean. In the summer yearlings, sorting decreased the SD by 38 lb, and in the fall yearlings, sorting decreased the SD by 51 lb. The HCW SD was decreased by 33 lb in the summer yearlings and 32 lb in the fall yearlings.

The calf-fed system had the lowest DMI while the fall yearlings had the highest DMI. The calf-fed cattle had the lowest ADG but were the most efficient. The fall yearling cattle were the least efficient of the three feeding systems. These data are consistent with previous research (*2007 Nebraska Beef Report,* pp. 58-60).

Sorting cattle into feeding systems decreased the number of carcasses over 950 lb and 1,000 lb (Table 2). The unsorted group for the fall yearlings

Table 1. Performance data.

Feeding System	Calf Feds		Summer Yearling		Fall Yearlings				P-value	
Sort/unsort	unsort	sort	unsorted	sort	unsort	sort	SEM	System	Sorting	Systmem*Sorting
Initial BW[a]	605	696	824	823	1008	944	4	<0.01	0.02	<.01
IW[b] SD	66	57	71	33	121	70				
HCW	777	820	867	865	933	878	8	<.01	0.83	<.01
HCW[c] SD	68	68	77	44	10	5 73				
DMI	20.92	21.49	25.75	25.75	28.91	27.25	0.28	<.01	0.20	<.01
ADG	3.76	3.72	4.15	4.14	4.08	3.87	0.08	<.01	0.22	0.50
F:G	5.56	5.78	6.17	6.21	7.09	7.04	0.10	<.01	0.23	0.27

[a]Feedlot entry weight
[b]Initial weight standard deviation
[c]Hot carcass weight standard deviation

Table 2. Overweight carcass data by feeding system.

Feeding System	Sort/Control	Carcasses over 950 lb	Carcasses over 1000 lb
Calf-fed	Unsorted	2%	0%
Calf-fed	Sorted	6%	2%
Summer Yearling	Unsorted	19%	2%
Summer Yearling	Sorted	4%	0%
Fall Yearling	Unsorted	42%	23%
Fall Yearling	Sorted	11%	2%

had 42% of the carcasses over 950 lbs compared to only 11% in the sorted group. In the summer yearlings, the unsorted group had 19% over 950 lb while the sorted summer yearlings only had 4% over 950 lb. In the fall yearling unsorted group, 23% of the carcasses were over 1,000 lb while only 2% in the sorted group of fall yearlings.

When combining all of the unsorted groups together and all of the sorted groups together, the carcass weights were 858 lb (SD=66 lb) for sorted cattle compared to 859 lb (SD=105 lb) for the unsorted cattle. The combined unsorted group had 21% of the carcasses heavier than 950 lbs while only 7% of the carcasses were over 950 lbs in the combined sorted group.

Sorting cattle decreased the variation of HCW and the number of overweight carcasses without affecting fat thickness. Sorting worked well because cattle were able to be marketed in more uniform groups. The number of carcasses over 950 lb was lower and the amount of variation was also lower within the feeding periods without affecting the performance or carcass characteristics.

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[1]Daniel R. Adams, graduate student; Matt K. Luebbe, research technician; Terry J. Klopfenstein, professor; and Galen E. Erickson, associate professor, Animal Science, Lincoln.

Performance and Economics of Two Calf Wintering Systems

William A. Griffin
Terry J. Klopfenstein
Galen E. Erickson[1]

Summary

Two wintering systems, cornstalk grazing plus 5 lb/head/day of wet corn gluten feed and cornstalk grazing followed by dry lot where steers were fed hay and supplemented 5lb/head/day of wet corn gluten feed were evaluated. There were no differences in daily gain, or final body weight for either system. While there were no statistical differences in cost of gain, breakeven, or profitability, economics numerically favored steers grazing cornstalks alone.

Introduction

With the increase in corn price, there is potential for more corn acres leading to more cornstalk residue available for grazing cattle. Traditional wintering programs have included some cornstalk grazing and a period of dry lotting with hay and other feed resources. However, harvested forage prices have increased, increasing the cost of dry-lotting programs for feeder cattle. These increases in corn price and hay prices have caused producers to look for alternative ways to winter feeder cattle.

Therefore, the objective of this study was to determine the differences in steer performance and economics of season long cornstalk grazing and partial season cornstalk grazing with a dry lotting period.

Procedure

Experiments

The wintering system comparison used data from the University of Nebraska from 2000 to 2007. The data used for this comparison are from the long-yearling system projects that were conducted each year. Calves were received in the fall of each year and placed on cornstalks after processing and a 30 to 45 day receiving period in which cattle were allowed to graze brome grass pasture.

Partial season cornstalk grazing

Four years of data from 2000 to 2003 from 515 steers (541 ± 51 lb) were used to determine animal performance and economics of a wintering growing system using cornstalks and dry lotting with grass hay. Steers grazed cornstalk residue from the first of December until the end of February (average = 80 days). In February, steers were placed in a dry lot and fed grass hay ad-libitum until the middle of April (average = 61 days). During each phase of the wintering period, steers were supplemented 5 lb/head/day of wet corn gluten feed (WCGF).

Full Season cornstalk grazing

Four years of data from 2004 to 2007 from 845 steers (535 ± 59 lb) were used to determine animal performance and economics of a wintering growing system using cornstalk grazing from the first of December until the middle of April (average = 152 days). Steers were supplemented 5 lb/head/day WCGF during cornstalk grazing.

Effect of Grazing on Yield in a Corn-Soybean Rotation

There is a concern in production agriculture with the effect cattle grazing cornstalks can have on subsequent year crop production. A 9-year study was conducted to determine the impact of grazing cornstalks on subsequent year crop yield in a corn-soybean rotation. Steers were allowed to graze cornstalk residue in the fall and spring of each year with the grazing treatment in the spring being a 2.5 times greater than the recommended stocking rate of 0.8 acres/head for 60 days. Grazed and ungrazed areas were maintained on the respective treatments for the 9-year. Crop yields were collected using a grain cart with load cells.

Economics

Initial animal cost was determined using the USDA December 2006 feeder steer price of $117.35/cwt for a 550 lb steer. Health and processing were charged at $8.33/head for the winter period. The interest rate used was determined using the 7-year average prime interest rate. The interest rate used is equal to prime plus 1% for the months that cattle were owned (7.6%). Simple interest was charged on initial animal cost and health for the entire period of ownership.

The cost of corn residue was charged at a rate of $0.32/head/day. This cost includes $0.12/head for the rent of cornstalk residue and $0.20/head/day charged as yardage while steers grazed cornstalk residue. This yardage cost includes the cost of fencing stalk fields and cost of labor to deliver WCGF and water to the cattle. Steers were supplemented with 5 lb/head/day of WCGF for the winter period at a cost of $123.09/ton (DM basis) which is 95% the average price of corn from December 2006 to April 2007. Interest was charged on the WCGF for half of the winter period and the remainder of ownership.

For steers in dry lot, hay price was calculated using the monthly average price of grass hay for 2007 during the months that cattle were dry lotted. Additionally, steers were assessed $0.30/head/day yardage for the dry lot period. Hay cost per steer was determined using the animal unit equivalent of the steers used in this study. Animal unit equivalents were determined by averaging the initial weight and weight of cattle when they were removed from dry lot and dividing by 1,000 lb.

Final animal value was determined using the 2007 USDA April feeder steer price of $99.64/cwt. Profitability of each system was determined by adding initial animal cost and all cost of the wintering period and subtracting from the final value of each animal.

Table 1. Effect of cornstalk grazing on subsequent year crop yield in a corn-soybean rotation.

Item	Grazed	Ungrazed	SEM
Soybean Yield, bu/ac[a]	60.6	59.2	0.9
Corn Yield, bu/ac[b]	210.7	211.1	2.3

[a] Soybean yield during subsequent growing season.
[b] Corn yield during second growing season following grazing.

Table 2. Effect of wintering system on animal performance.

Item	Cornstalks + dry lot	Cornstalks	SEM
Initial BW, lb	535	541	13
Final BW, lb	757	748	16
ADG, lb/day	1.55	1.41	0.19
Days	140^{b}	152^{a}	5

^{a,b}Means within a row with different superscripts differ ($P < 0.05$).

Table 3. Economic analysis of wintering system.

Item	Cornstalks + dry lot	Cornstalks	SEM
Initial Steer Cost, $/head	634.32	627.52	15.19
Final Steer Value, $/head	754.27	745.08	15.78
Yardage[c], $/head	43.71^{b}	30.40^{a}	0.69
Feed Cost[c], $/head	95.05^{b}	65.01^{a}	3.83
Breakeven, $/cwt	102.91	98.64	0.04
Cost of Gain, $/cwt	68.40	52.71	0.10
P/L[d], $/head	-23.76	7.90	30.36

^{a,b}Means within a row with different superscripts differ ($P < 0.01$).
[c] For cornstalk, grazing yardage was charged at a rate of $0.20/head/day and rent (feed cost) was $0.12/head/day; dry lot yardage was charged at a rate of $0.30/ head/day.
[d] p/l is profit or loss.

Statistical Analysis

Effect of Grazing on Yield in a Corn-Soybean Rotation

Data were analyzed using the Mixed procedure of SAS with grazing treatment as a fixed effect. Year was used as a random effect. The experimental unit was plot within year with a total of 385 replications per crop treatment.

Wintering Program

Data were analyzed using the Mixed procedure of SAS with wintering program as a fixed effect. Year and year*treatment interaction were used as random effects. The experimental unit was replication within year (two replications/year). There were a total of eight replications per treatment.

Results

Effect of Grazing on Yield in a Corn-Soybean Rotation

Corn ($P = 0.72$) yields were not different for grazed and ungrazed treatments (Table 1). However, soybean ($P = 0.12$) yields were numerically higher for grazed plots compared with ungrazed plots. Therefore, grazing cornstalks with cattle has no affect on subsequent year crop yields in a corn-soybean rotation.

Animal Performance

Initial BW ($P = 0.69$) and BW at the end of the wintering period ($P = 0.61$) were not different (Table 2.) However, steers that grazed cornstalks for the entire season were in their wintering program 12 days longer compared to cattle that grazed cornstalks for a partial season (140 vs. 152 days). Daily gain for steers was not different across treatment ($P = 0.19$) but was numerically lower for steers grazing the entire season.

Economics

Initial steer cost ($P = 0.67$) and final steer value ($P = 0.58$) were not different across treatments (Table 3). Breakevens for steers in the wintering program including cornstalk grazing and dry lotting were $4.27/cwt numerically higher compared to steers that grazed cornstalks for the entire wintering period. Additionally, cost of gain tended to be lower for steers that grazed cornstalks only ($P = 0.15$), because of the added cost of the grass hay used in dry lot and extra yardage cost. Profitability was not statistically different across treatment ($P = 0.33$) even though cattle grazing season long cornstalks had $31.66/head higher returns than cattle that grazed partial season cornstalks.

The lack of statistical difference in profitability is due to rather large year to year variation caused by weather and residue quality and availability. The year to year variation is perhaps most evident in the range of ADG on corn stalks with a minimum and maximum ADG of 1.10 and 1.82 lbs/head, respectively. Calves performed similarly in the two systems. Additionally, feed and yardage costs were less for grazing cattle. Therefore, we concluded that savings can be made by season-long grazing of corn residue compared to partial season. We have also demonstrated that season long grazing was not detrimental to subsequent crop production.

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[1] William A. Griffin, graduate student; Terry J. Klopfenstein, professor; Galen E. Erickson, associate professor, Animal Science, Lincoln.

Evaluation of Calf-fed and Long Yearling Production with Increasing Corn Price

William A. Griffin
Terry J. Klopfenstein
Galen E. Erickson
Darrell. R. Mark1

Summary

An economic comparison of calf-fed and long-yearling production was conducted to determine the impact of increasing corn price on steer profitability. Corn prices of $2.50, $3.50, and $4.50/bu were used. With increasing corn price, feeder prices were assumed to decrease which decreased initial cost more for yearlings than calf-feds. Profitability of yearlings versus calf-feds increased $4-6 for each $1/bu increase in corn price.

Introduction

Calf-feds consume more corn than cattle placed in an extensive production system (long-yearlings); therefore, increasing corn prices can have a substantial impact on profitability of calf-feds compared to long-yearlings.

Efficiency of gain has historically favored calf-feds in terms of animal performance; however, this gain is achieved with corn-based diets. Yearling production has focused on gaining weight using feedstuffs other than corn grain, primarily forage resources.

Therefore, the objective of our study was to determine economic differences between calf-feds and long-yearlings with increasing corn prices.

Procedure

Experiments

Data from the University of Nebraska from calf-feeding or yearling grow/finish experiments conducted each year (1996 to 2004) except for 1997, where a different yearling production system was used, were utilized. Calf-finishing trials beginning in the fall each year were selected for comparisons. Calves were sorted from a large pool of animals received during the fall of each year and sorted by weight. Heavier, larger framed steers from this sort were placed into a calf-feeding system. Lighter, smaller framed steers were purchased each year and placed into a yearling finishing system. The calf system represents 804 head of steers fed in 80 pens and the yearling system represents 302 head of steers fed in 18 pens. Feedlot performance is presented in Table 1. For more details on the calf-fed vs. yearling performance comparison refer to *2007 Nebraska Beef Report,* pp. 58-60.

Economics

Historical information does not exist for feeder prices based on corn prices that are predicted to occur. Therefore, to determine initial price paid for each steer, a calf-fed breakeven analysis using data from the *2007 Nebraska Beef Report,* pp. 58-60, was used to determine the amount a producer could pay for cattle in a $2.50, $3.50, or a $4.50/bu corn market and a $90.00/cwt fed cattle price. Average price a producer could pay for a 642 lb steer was determined by averaging the prices determined from the breakeven analysis. Results indicate that base price for a 650 lb steer would be $131.07, $121.24, and $112.31, when corn prices are $2.50, $3.50, and $4.50/bu, respectively. Price slides were not available for varying weight of cattle fed in these corn markets; therefore, price slides, from *Dhuyvetter et al,* 2001 Kansas State University Research Publication MF-2504, were determined to be $9.18, $7.01, and $4.84/cwt for $2.50, $3.50, and $4.50/bu, respectively.

Final live value of steers was calculated using an average fed cattle price of $90.00/cwt and using the USDA 10-year average monthly fed cattle index to determine differences in fed cattle price for the month steers were sold. Calf-feds were sold in May and the average index was 100. Long-yearlings were sold in December and the average index was 100.

The interest rate used was determined using the 7-year average prime interest rate. The interest rate used was equal to prime plus 1% for the months that cattle were owned (7.6%). The interest rate was the same for both calf-feeding and yearling cost. Therefore, all costs are assessed as interest rate of 7.6%.

Calf-fed Economics

Interest was applied to initial cost of the animal over the entire ownership. Health, processing, and implanting were assessed a flat rate of $ 16.66/head. Feed costs for calf-feds were based on the current prices for supplement and alfalfa hay for the months that ingredients were used. Corn was priced into the diet using $2.50, $3.50, or $4.50/bu corn prices, and wet corn gluten feed (WCGF) was priced using 95% the price of the corn used in the diets. Diet costs were $105.77, $141.94, and $178.11/ton (DM-basis) for $2.50, $3.50, and $4.50, respectively. Yardage was charged at a rate of $0.35/head/day. Interest was charged on finishing diet and yardage for half of the feeding period. A 2% death loss was applied to the calf-feds. To calculate breakevens, total cost was divided by final live BW.

Long-yearling economics

The cost of corn residue was charged at a rate of $0.32/head/day. This cost includes $0.12/head/day for the rent of cornstalk residue and $0.20/head/day charged as yardage while steers grazed cornstalk residue. This yardage cost includes the cost of fencing stalk fields and cost of labor

Table 1. Animal performance as a main effect of production system.

Item	Calf-fed	Yearling	SEM
Initial BW, lb	642[a]	526[b]	5
FINT[c], lb	642[a]	957[b]	7
Final BW, lb	1282[a]	1365[b]	8
Feedlot ADG	3.81[a]	4.53[b]	0.04
DOF[d]	168[a]	90[b]	1
DMI, lb/day	21.36[a]	30.56[b]	0.15
F/G	5.63[a]	6.76[b]	0.02
Total Feed[e], lb	3591[a]	2754[b]	32.1

[a,b] Means within a row with different superscripts differ ($P < 0.01$).
[c] FINT = initial BW at the beginning of the finishing period.
[d] DOF = days on feed.
[e] Total Feed = amount of feed consumed during the finishing period.

Table 2. Cost analysis of production systems as an effect of corn price.

Item	Calf-fed	Yearling	SEM
$2.50/bu			
Steer Cost, $	846.13[a]	751.73[b]	4.71
Interest[c], $	30.02[a]	62.14[b]	1.26
Feed Cost, $	189.93[a]	144.20[b]	6.60
Yardage, $	58.94[a]	31.58[b]	1.57
Total Cost, $	1154.31[a]	1193.58[b]	8.32
COG[d], $/cwt	52.56[a]	49.07[b]	1.45
$3.50/bu			
Steer Cost, $	782.59[a]	688.66[b]	4.73
Interest[c], $	28.68[a]	57.40[b]	1.20
Feed Cost, $	254.82[a]	193.51[b]	8.54
Yardage, $	58.94[a]	31.58[b]	1.57
Total Cost, $	1154.28[a]	1189.73[b]	9.80
COG[d], $/cwt	62.19[a]	56.08[b]	1.59
$4.50/bu			
Steer Cost, $	719.07[a]	625.86[b]	4.93
Interest[c], $	27.31[a]	52.58[b]	1.15
Feed Cost, $	319.71[a]	242.83[b]	10.48
Yardage, $	58.94[a]	31.58[b]	1.57
Total Cost, $	1154.26[a]	1185.87[b]	11.35
COG[d], $/cwt	71.85[a]	63.14[b]	1.83

[a,b] Means within a row with different superscripts differ ($P < 0.05$).
[c] Interest is the total amount of interest accrued from the animal and all cost of production.
[d] COG is the cost of gain for the entire production system.

Table 3. Profitability analysis of production systems as an effect of corn price.

Item	Calf-fed	Yearling	SEM
Live Value[c], $	1154.45[a]	1228.09[b]	23.68
$2.50/bu			
Breakeven, $/cwt	90.15	87.54	1.43
Live p/l[d], $/head	0.00	34.56	19.72
$3.50/bu			
Breakeven, $/cwt	90.04	87.16	1.38
Live p/l[d], $/head	0.00	38.41	19.11
$4.50/bu			
Breakeven, $/cwt	90.04	86.88	1.30
Live p/l[d], $/head	0.00	42.28	18.69

[a,b] Means within a row with different superscripts differ ($P < 0.05$).
[c] Live value is based on a live price of $90/cwt for all corn prices.
[d] p/l is profit or loss.

to deliver WCGF and water to the cattle. Steers were supplemented with 5 lb/head/day of WCGF (DM-basis). Steers were assessed a 1.5% death loss during the wintering period. Interest was charged on the WCGF for half of the winter period and the remainder of ownership.

Summer grazing cost was charged using the 7-year average animal unit month (AUM) value of $23.29 for native range. To determine the animal unit equivalent of the steers used in this study the initial weight and weight of cattle when they were removed from grass was averaged and divided by 1,000 lb. Cattle were charged $8.33 for summer health cost and a death loss of 0.3% was assessed during the summer grazing period. Interest was charged for the cost of the AUM and health cost.

Finishing costs for yearlings were similar to calf-feds using the same yardage rate of $0.35/head/day. Feed costs for yearlings were based on the current prices for supplement and alfalfa hay for the months that ingredients were used. Corn was priced into the diet using $2.50, $3.50, or $4.50/bu corn prices, and wet corn gluten feed was priced using 95% the price of corn used in the diets. Diet costs were $104.75, $140.57, and $176.39/ton (DM-basis) for $2.50, $3.50, and $4.50/bu, respectively. A death loss of 0.2% was assessed during the finishing period. Average DMI for each pen was used to determine total feed consumption during the finishing period. Interest was charged on finishing diet and yardage for half of the feeding period. To calculate breakevens, total cost was divided by final live BW.

Profitability for both systems was determined using the final BW multiplied by the calculated fed cattle price for the month cattle were sold, and subtracting all costs from the final value of the animal.

Results

For all economic analyses the same yardage values for each production

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system and the same final values for steers in each production system were used. However, feedlot yardage was \$27.36 greater for calf-feds ($P < 0.01$) compared with yearlings because of more days fed and final live value for yearlings was \$73.64 greater than calf-feds ($P = 0.02$) because of larger final weights. Cost of gain is represented as the cost of gain for the entire production system.

Cost of production for all corn prices are presented in Table 2. Profitability for each production system with varying corn prices is presented in Table 3.

\$2.50/bu corn price

Average initial steer price was calculated to be \$142.71/cwt for yearlings and \$131.80/cwt for calf-feds, causing steer cost to be \$94.40 per steer higher for calf-feds compared with yearlings ($P < 0.01$) because of greater BW. Interest costs were greater for yearlings compared with calf-feds ($P < 0.01$) because of increased length of ownership. Feed cost was \$45.75/head higher for calf-feds compared to yearlings ($P < 0.01$). Cost of gain was \$3.49/cwt less for yearlings compared with calf-feds ($P = 0.03$). However, total cost of production was \$39.27 greater for yearlings compared with calf-feds ($P < 0.01$). Breakevens were \$2.61/cwt less for yearlings (P = 0.12) and profit was \$34.56 more for yearlings (P = 0.12).

\$3.50/bu corn price

Average initial steer price was calculated to be \$130.72/cwt for yearlings and \$121.80/cwt for calf-feds, causing steer cost to be \$93.93 higher for calf-feds compared with yearlings ($P < 0.01$). Interest cost was \$28.72 greater for yearlings compared with calf-feds ($P < 0.01$) because of increased length of ownership. Feed cost was \$61.31/head higher for calf-fed compared to yearlings ($P < 0.01$). Cost of gain was \$6.11/cwt less for yearlings compared with calf-feds ($P < 0.01$). However, total cost of production was \$35.45 greater for yearlings compared with calf-feds ($P < 0.01$). Breakevens were \$2.88/cwt less for yearlings ($P = 0.08$) and profit was \$38.41 more for yearlings ($P = 0.08$).

\$4.50/bu corn price

Average initial steer price was calculated to be \$118.78/cwt for yearlings and \$112.70/cwt for calf-feds, causing steer cost to be \$93.21 higher for calf-feds compared with yearlings ($P < 0.01$). Interest cost was \$25.27 greater for yearlings compared with calf-feds ($P < 0.01$) because of increased length of ownership. Feed cost was \$76.88/head higher for calf-fed compared to yearlings ($P < 0.01$). Cost of gain was \$8.71/cwt less for yearlings compared with calf-feds ($P < 0.01$). However, total cost of production was \$31.61 greater for yearlings compared with calf-feds ($P = 0.03$). Breakevens were \$3.16/cwt less for yearlings ($P = 0.06$) and profit was \$42.28 more for yearlings ($P = 0.06$).

As corn price increases the difference in initial animal cost between calf-feds and yearlings increases. For every \$/bu increase in corn price the profit for feeding yearlings increased \$4 to \$6. Because of the increase in the difference between initial animal cost and the difference in the amount of grain consumed by yearlings in the feedlot compared with calf-feds, profitability is shifting from no difference in lower corn markets to yearlings being more profitable in higher corn markets. From this analysis, if corn prices continue to increase, yearlings would be the most profitable type of cattle to produce, however, yearling ownership must be retained through the entire production system for the profit to be realized.

Two factors that affect this relationship are yardage cost and pasture cost. We used yardage cost of \$0.35/d but cost may be as high as \$0.45/d. This \$0.10 difference would increase the yearling advantage by \$7.80/head. Alternativley, grass was priced at the 7-year average of \$23.39/AUM. The total grazing cost was approximately \$90/head. Grass lease rates have incrased over time and may continue to increase. A 10% increase in grass cost would reduce the yearling advantage by \$9/head.

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[1] William A. Griffin, graduate student; Terry J. Klopfenstein, professor; and Galen E. Erickson, associate professor, Animal Science, Lincoln. Darrell R. Mark, associate professor, Agricultural Economics, Lincoln.

The Effect of Delaying Initial Feedlot Implant on Performance and Carcass Characteristics of Calf-fed Steers

William A. Griffin
Don C. Adams
Rick N. Funston[1]

Summary

Steers in two, 2-year experiments (n = 409) were either given an implant at feedlot arrival or implanted 30 days after feedlot entry. In Experiment 1, steer calves were not implanted at branding and in Experiment 2 calves were implanted at branding. There was no difference in feedlot performance for either experiment. However, in Experiment 1 there was a year by treatment interaction for marbling score suggesting that delaying implant in calves may affect quality grade.

Introduction

Common perception is that cattle have to be fed a certain number of days before they will grade choice, suggesting that marbling develops later in the life of cattle. However, hypertrophy of adipocytes begins at 100 to 200 days of age (Vernon, R.G., 1980 *Progress in Lipid Research* 19:23), suggesting management practices such as implanting schedule can alter marbling in the life of calves.

Implanting with low dose initial implants or delaying implanting has been shown to improve quality grade (Scaglia et al., *2004 Prof. Anim. Sci.* 20:170). Cattle in the majority of these studies receive only one implant in the feedlot phase of production. Most implants only pay out for 100 to 120 days, leaving calf-feds that are often fed more than 200 days with a substantial portion of the feeding period with no implant in a single implant system.

The objective of our study was to determine if delaying initial feedlot implant affects feedlot performance and carcass characteristics of steer calves that were implanted or not implanted at branding.

Procedure

Experiment 1

One hundred steer calves (474 ± 44 lb) were received each year for two consecutive years from the Gudmundsen Sandhills Laboratory in the fall. Upon arrival, cattle were dewormed and vaccinated using standard feedlot procedures. Steers were not given an implant at branding. Therefore, the initial feedlot implant would have been the first implant in the life of the calf. Upon arrival, calves were weighed and allotted to one of two treatments: delay initial feedlot implant until 30 days on feed or receive initial feedlot implant at the beginning of the finishing period. Weights were taken on day 0, 30 (delay implant), 115 (reimplant), and 212. Calves in both treatments were reimplanted on the same day.

Experiment 2

One hundred twenty-seven and eighty-four steer calves (525 ± 52 lb) were received in year one and year two, respectively. Calves were received from the Gudmundsen Sandhills Laboratory in the fall. Upon arrival, cattle were dewormed and vaccinated using standard feedlot procedures. Steers received for this experiment were given a Synovex C implant at branding. Upon arrival calves were weighed and allotted to one of two treatments: delay initial feedlot implant until 30 days on feed or receive initial feedlot implant at the beginning of the finishing period. Weights were taken on day 0, 30 (delay implant), 104 (reimplant), and 218. Calves in both treatments were reimplanted on the same day.

In both experiments, weights were the average of two consecutive day weights taken in the morning prior to feeding. Final BW was calculated by adjusting hot carcass weight to a common 63% dressing percentage. Cattle were slaughtered at a commercial packing plant and hot carcass weight was collected on day of slaughter. Following a 24-hour chill USDA Marbling Score, KPH fat, fat thickness, and ribeye area data were collected. Yield grade was calculated for analysis. Additionally, cattle in both experiments were given Synovex S® as their initial feedlot implant and reimplanted with Synovex Choice®. All calves were fed a diet containing 48% dry-rolled corn, 40% wet corn gluten feed, 7% alfalfa hay, and 5% supplement. Statistical analysis was performed using the Mixed procedure of SAS, with pen as the experimental unit, and treatment, year, and year by treatment interaction in the model statement.

Results

Experiment 1

The simple effects of treatment by year from Experiment 1 are presented in Table 1. For feedlot performance there was no treatment by year interaction ($P > 0.20$). When looking at implant treatment, initial BW ($P = 0.60$), BW at reimplant ($P = 0.16$), and final BW ($P = 0.52$) were not different. However, BW on day 30 was 24 lb greater for steers in the normal implant treatment ($P < 0.01$). Daily gain from day 0 to 115 ($P = 0.35$), day 30 to 115 ($P = 0.15$), day 30 to 212 ($P = 0.22$), and overall ADG ($P = 0.68$) were not different across treatments. However, ADG from day 0 to 30 was 0.66 lb/day greater ($P = 0.02$) for cattle implanted on day 0. Feed to gain and DMI can not be reported because cattle from both treatments were fed in the same pens.

Hot carcass weight ($P = 0.51$), fat thickness ($P = 0.59$), ribeye area ($P = 0.81$), KPH fat ($P = 0.93$), and yield grade ($P = 0.88$) were not different when comparing cattle that

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Table 1. Simple effects of delaying initial feedlot implant on feedlot performance and carcass characteristics from Experiment 1.

	Year 1		Year 2			*P*-value		
Item	Normal	Delay	Normal	Delay	SEM	Treatment	Year	Treatment*Year
Feedlot Performance								
Initial BW, lb	478	475	473	471	6	0.60	0.36	0.92
Day 30 BW[a], lb	618	591	594	574	4	< 0.01	< 0.01	0.41
Day 115 BW[a], lb	931	914	927	917	8	0.16	1.00	0.20
Final BW, lb	1273	1266	1276	1268	12	0.52	0.84	0.97
Day 0-30 ADG, lb/day	4.27	3.52	3.79	3.23	0.19	0.02	0.11	0.63
Day 0-115 ADG, lb/day	4.01	3.88	3.85	3.78	0.09	0.35	0.24	0.78
Day 30-115 ADG, lb/day	3.85	3.97	3.83	3.94	0.06	0.15	0.72	0.94
Day 30-212 ADG, lb/day	3.83	3.94	3.57	3.63	0.06	0.22	< 0.01	0.69
Day 0-212 ADG, lb/day	3.92	3.89	3.64	3.61	0.07	0.68	< 0.01	1.00
Carcass Characteristics								
Hot carcass weight, lb	802	798	804	799	7	0.51	0.84	0.95
Marbling score[b]	527	570	558	536	12	0.44	0.92	0.05
Fat thickness, in	0.49	0.48	0.56	0.59	0.02	0.59	< 0.01	0.30
Ribeye area, in^2	12.73	12.85	12.86	12.80	0.14	0.81	0.79	0.55
KPH fat, %	2.84	2.85	2.03	2.02	0.05	0.93	< 0.01	0.85
Yield grade	3.3	3.2	3.2	3.3	0.1	0.88	0.33	0.12
Choice, %	68	90	86	71	6	0.59	0.91	0.05

[a] Day 0 = Feedlot entry, Day 30 = delay cattle receive initial feedlot implant, Day 115 = Reimplant, Day 212 = Day of Harvest.

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

were implanted at feedlot entry and cattle delayed initial implant 30 days. However, there was a year by treatment interaction for marbling score (*P* = 0.05) and percentage of carcasses grading choice or higher (*P* = 0.05). With delayed cattle in year one grading 22 percentage units higher choice and in year two cattle that were implanted on day 0 grading 14.5 percentage units higher choice.

Experiment 2

The simple effects of treatment by year from Experiment 2 are presented in Table 2. For feedlot performance and carcass characteristics there were no treatment by year interactions (*P* > 0.22). When comparing across implant treatment, initial BW (*P* = 0.89), BW at delayed implant (*P* = 0.92), BW at reimplant (*P* = 0.84), and final BW were not different (*P* = 0.80). Daily gain from day 0 to 30 (*P* = 0.40), day 0 to 104 (*P* = 0.40), day 30 to 104 (*P* = 0.79), day 30 to 218 (*P* = 0.70), and overall ADG (*P* = 0.58) were not different across treatments. Feed to gain and DMI can not be reported because cattle from both treatments were fed in the same pens.

When comparing carcass characteristics for Experiment 2, hot carcass weight (*P* = 0.80), fat thickness (*P* = 0.28), ribeye area (*P* = 0.43), KPH fat (*P* = 0.86), yield grade (*P* = 0.64) marbling score (*P* = 0.28), and percentage choice (*P* = 0.46) were not different when comparing cattle that were implanted at feedlot entry and cattle delayed initial implant 30 days.

From this study, it is evident that calves that are implanted at branding and delayed initial feedlot implant 30 days after feedlot entry do not exhibit any performance response or improvement in carcass characteristics when compared to cattle that are implanted at feedlot entry. However, naive cattle that receive their first implant at feedlot entry have greater ADG the first 30 days of the feeding period compared to cattle that are delayed initial implant 30 days after arrival, however, carcass weights were not affected by implant regimen. Additionally, because of the year by treatment interaction exhibited in experiment one; it is unclear as to whether delaying implanting in cattle that were not implanted at branding creates any difference in quality.

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[1] William A. Griffin, graduate student, Animal Science, Lincoln. Rick N. Funston, associate professor; Don C. Adams, professor, West Central Research and Extension Center, North Platte.

Table 2. Simple effects of delaying initial feedlot implant on feedlot performance and carcass characteristics from Experiment 2.

	Year 1		Year 2			*P*-value		
Item	Normal	Delay	Normal	Delay	SEM	Treatment	Year	Treatment*Year
Feedlot Performance								
Initial BW, lb	509	513	538	538	18	0.89	0.16	0.92
Day 30 BW[a], lb	619	619	642	639	15	0.92	0.17	0.92
Day 104 BW[a], lb	976	975	982	975	8	0.84	0.89	0.89
Final BW, lb	1286	1280	1301	1290	34	0.80	0.70	0.94
Day 0-30 ADG, lb/day	3.41	3.29	3.48	3.37	0.14	0.40	0.59	0.95
Day 0-104 ADG, lb/day	3.73	3.68	3.93	3.86	0.07	0.40	0.02	0.86
Day 30-104 ADG, lb/day	3.79	3.78	4.04	3.99	0.13	0.79	0.10	0.89
Day 30-218 ADG, lb/day	3.54	3.50	3.58	3.54	0.11	0.70	0.71	0.97
Day 0-218 ADG, lb/day	3.51	3.47	3.58	3.53	0.09	0.58	0.46	0.98
Carcass Characteristics								
Hot carcass weight, lb	810	806	820	813	21	0.80	0.69	0.95
Marbling score[b]	579	582	560	517	18	0.28	0.05	0.22
Fat thickness, in	0.51	0.53	0.52	0.52	0.02	0.56	0.74	0.56
Ribeye area, in^2	13.54	13.31	14.34	14.23	0.22	0.43	< 0.01	0.78
KPH fat, %	1.83	1.93	1.88	1.80	0.08	0.86	0.57	0.26
Yield grade	2.9	3.0	2.7	2.7	0.1	0.64	0.07	0.56
Choice, %	88	92	84	63	12	0.46	0.18	0.29

[a] Day 0 = Feedlot entry, Day 30 = delay cattle receive initial feedlot implant, Day 104 = Reimplant, Day 218 = Day of Harvest.

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

Effect of Backgrounding Gain, Grazing Length and Dry Distillers Grain Consumption on Performance and Carcass Traits of June Born Cattle

J. Alan Taylor
L. Aaron Stalker
Terry J. Klopfenstein
Don C. Adams
William A. Griffin[1]

Summary

June-born cattle backgrounded at a lower rate during the winter were unable to fully compensate during summer grazing for restricted gain during backgrounding. Increased gain during backgrounding resulted in cattle being heavier for all market periods. The higher cost associated with increased gain was offset by heavier sale weights. Cattle grazing meadow regrowth had improved feedlot performance and heavier finished weight. Backgrounding cattle grazing winter range supplemented with DDG costs less than backgrounding cattle in a drylot. Supplementing with DDG during summer grazing decreased forage intake and increased gain, with 1.8 lb/head/day being more cost effective than 5 lb/head/day.

Introduction

Previous research from the University of Nebraska showed calves produced in a June calving system had lower production costs and higher net returns at weaning and harvest compared to cattle from traditional March calving (*2001 Nebraska Beef Cattle Report*, pp. 10-12). This same study also determined June born calves, marketed as finished cattle, generated greater returns when sold as finished yearlings compared to finished calf-feds but the growing period was not profitable as a stand alone enterprise. The objective of this study was to examine the performance from different winter backgrounding gains and summer grazing lengths. Our further objective was to examine how cattle in this study would be affected by the feeding of DDG during grazing. We hypothesized cattle backgrounded at a higher rate of gain would be heavier at sale time compared to lower backgrounding gains. Further, we hypothesized grazing meadow regrowth after a period of summer grazing would provide excellent ADG and economically increase BW.

Procedure

Crossbred steers (n = 39) and heifers (n = 46) were used in a 2 x 2 x 3 factorial arrangement of treatments in an unstructured experimental design, replicated over two years. The calves were born to heifers from a June calving herd at Gudmundsen Sandhills Laboratory (GSL). Forty-one calves were born in 2002, (year 1) and 44 were born in 2003, (year 2). Calves were weaned in November at GSL and the study began approximately 50 days later. Cattle were assigned randomly to one of four treatment combinations: winter backgrounding; LOW or HIGH and time spent grazing; SHORT or LONG.

Table 1. Least square means of animal performance and carcass data during backgrounding, range and meadow grazing and feedlot phases.

	Treatments						
	Low		High			*P*-values	
Item	Short	Long	Short	Long	SEM[a]	Background	Graze
Number of head	22	21	21	21			
Background							
Initial BW, lb	426	426	427	435	14	0.70	0.77
ADG, lb/day	1.39	1.51	2.36	2.44	0.06	< 0.001	0.08
DMI, lb	10.3	10.5	14.4	14.8	0.4	< 0.001	0.47
Feed/Gain	7.4	7.0	6.1	6.1	0.2	< 0.001	0.83
Days Fed	108	108	108	108			
Range							
Initial BW, lb	576	590	681	700	17	< 0.001	0.34
ADG, lb/day	1.44	1.46	0.98	1.06	0.05	< 0.001	0.27
Days Fed	100	100	100	100			
Meadow							
Initial BW, lb	—	734	—	805	17	< 0.001	—
ADG, lb/day	—	0.83	—	0.76	0.05	0.34	—
Days Fed	—	59	—	59			
Finishing							
Initial BW, lb	712	785	781	851	18	< 0.001	< 0.001
ADG, lb/day	3.42	3.98	3.44	4.19	0.12	0.33	< 0.001
Final BW lb[b]	1185	1258	1253	1348	27	0.004	0.002
DMI, lb	23.2	26.7	24.3	27.0	0.06	0.23	< 0.001
Feed/Gain	6.8	6.7	7.1	6.4	0.2	0.80	0.008
Days Fed	140	119	140	118			
Carcass data							
HCW, lb	746	792	790	849	17	0.004	0.002
Dress, %	62.5	62.6	63.8	63.6	0.3	< 0.001	0.81
Yield Grade	2.7	2.8	2.9	2.8	0.1	0.53	0.85
Fat Thickness, in	0.47	0.50	0.54	0.53	0.03	0.08	0.87
Internal Fat, %	2.0	2.1	2.1	2.2	0.1	0.19	0.10
Ribeye Area, in^2	13.2	13.6	13.8	14.6	0.3	0.007	0.03
Marbling Score[c]	598	620	613	624	18	0.61	0.36

[a] Greatest standard error of treatment means (SEM) reported.
[b] Hot carcass weight divided by 0.63 dressing percent.
[c] Marbling Score = Slight^0 = 400, Small^0 = 500, etc.

Table 2. Least square means of steer and heifer calves backgrounded at different rates and different lengths of range and meadow grazing.

	Sex			*P*-value
Item	Steers	Heifers	SEM[a]	Sex
Number of Head	39	46		
Background				
Initial BW, lb	441	416	10	0.08
ADG, lb/day	2.09	1.75	0.04	<0.001
DMI, lb	13.0	12.0	0.3	0.009
Feed/Gain	6.2	6.9	0.20	0.006
Range				
Initial BW, lb	667	606	13	< 0.001
ADG, lb/day	1.28	1.20	0.03	0.10
Meadow				
Initial BW, lb	794	725	12	< 0.001
ADG, lb/day	0.85	0.74	0.05	0.17
Finishing				
Initial BW, lb	821	743	13	< 0.001
ADG, lb/day	4.06	3.46	0.09	< 0.001
Final BW, lb	1337	1185	20	< 0.001
DMI, lb	26.7	23.9	0.4	< 0.001
Feed/Gain	6.6	6.9	0.14	0.10
Carcass data				
HCW, lb	842	746	12	< 0.001
Dress, %	63.4	62.9	0.2	0.12
Yield Grade	2.7	3.0	0.1	0.17
Fat Thickness, in	0.50	0.52	0.02	0.43
Internal Fat, %	2.2	3.1	0.05	0.42
Ribeye Area, in^2	14.6	13.0	0.2	< 0.001
Marbling Score[b]	586	642	13	0.003

[a] Greatest standard error of treatment means (SEM) reported.

[b] Marbling Score: 500 = choice minus, 600 = choice ave.

Average daily gain for backgrounding was designed to be 1 lb/head/day (LOW) and 2 lb/head/day (HIGH). Backgrounding was done in drylot at the West Central Research and Extension Center (WCREC) in North Platte, Neb. After backgrounding, cattle grazed Nebraska Sandhills range from May until September. At the end of summer grazing one-half of the cattle from each backgrounding treatment were either placed into the feedlot at WCREC for finishing (SHORT) or were returned to GSL for approximately 60 days to graze meadow regrowth (LONG). After grazing meadow regrowth, cattle returned to the WCREC feedlot for finishing. Beginning and ending weight for all production phases was determined from two consecutive day weighings after dry matter intake (DMI) had been restricted to 2.0% of BW for two days.

Distillers dried grains treatments were a simulated supplementation of: 0, 1.8 or 5 lb/head/day DDG to cattle grazing summer range and fall meadow. Effects from supplementing DDG were calculated using data from past University of Nebraska research (*2006 Nebraska Beef Cattle Report*, pp. 30-32 and pp. 33-35; *2007 Nebraska Beef Cattle Report*, pp. 17-19). Also, using this past research we analyzed LOW and HIGH cattle as if the cattle had been backgrounded on winter range and supplemented with sufficient DDG to produce the same ADG as the original LOW and HIGH treatments. The increased BW from DDG supplementation was added to the original ending BW. Data will be presented as if cattle had consumed DDG.

Animal performance and carcass traits were analyzed using the MIXED procedure of SAS (SAS Inst., Inc. Cary, N.C.). Animal starting weight was used as a covariate for analyzing performance and carcass data. The model included sex, backgrounding treatment, length of grazing and DDG intake. Experimental unit was animal for all data analyses.

Results

There were no statistical interactions among phases of the systems or with calf gender.

Background phase, (January-May)

LOW cattle had an ADG 0.95 lb less than HIGH ($P < 0.001$) making the LOW cattle 108 lb/head lighter (Table 1) at the end of the background treatment ($P < 0.001$). Daily gains of steers and ending weights were 0.34 ($P < 0.001$) and 61 ($P < 0.001$) lb greater than heifers, respectively (Table 2). Daily DMI was not different between steers and heifers and steers were more efficient than heifers ($P < 0.001$).

Summer phase, (June-September)

During the summer phase (Table 1) LOW cattle had an ADG 0.44 lb greater than HIGH cattle ($P < 0.001$). Increased gain for growth restricted cattle compared with nonrestricted during summer grazing was consistent with previous research. LOW cattle compensated for 39% of the backgrounding weight difference while on range. Compensatory gain decreased the weight difference between LOW and HIGH from 108 lb/head at the beginning of summer grazing to 65.5 lb/head by the end of summer grazing ($P < 0.001$).

Meadow phase, (September-November)

There were no significant differences in ADG on the meadow between treatments (Table 1). Ending weights were different, with HIGH being 69 lb/head heavier than LOW ($P < 0.001$). A lack of gain difference between treatments would indicate compensatory gain did not occur after September. Steers were heavier than heifers by 45 lb/head ($P < 0.001$; Table 2); however, the ADG difference between steers and heifers (0.1 lbs) was not significant ($P = 0.16$). Meadow gains from both years were less than expected. Possible reasons for the lower than expected gain and difference between years could be forage quantity. The analysis of meadow

(Continued on next page)

samples from this trial showed CP and TDN were less than reported previously. Though forage quality in year-1 of this study was higher than year-2; in year-1 the meadow was cut for hay later in the summer shortening the time available for regrowth. Based on data collected at GSL; precipitation in year-1 for July-October was 41.4% of the 1994-2004 average for those months. Precipitation in year-2 was 106% of the 1994-2004 average for July-October. With less precipitation and less regrowth time, forage quantity was likely decreased in year-1 compared to year-2, which decreased ADG below expectations.

Finish phase, (September-January), (November-February)

Daily gains for LONG cattle were 0.66 lb greater than SHORT cattle (*P* < 0.001; Table 1). There was no difference in ADG between LOW and HIGH treatments. Live finish weight was 79 lb/head greater for HIGH compared with LOW (*P* < 0.001). Because compensatory gain did not continue after summer grazing, HIGH cattle maintained all of their weight advantage over LOW from September through finishing. LONG cattle were 84 lb/head heavier than SHORT cattle (*P* < 0.001). Daily DMI were not different between LOW and HIGH treatment cattle (*P* = 0.15). LONG cattle had daily DMI 3.1 lb greater than SHORT (*P* < 0.001). LONG cattle had better feed efficiencies than SHORT (*P* = 0.03). With meadow gain restricted by a possible decrease in quantity of forage, greater BW, ADG, DMI and efficiency of LONG over SHORT may be explained by compensatory effect. Finish weight and ADG for steers were greater than heifers by 152 lb/head and 0.50 lb/head.day (*P* < 0.001; Table 2). Steers had 2.8 lb greater daily DMI (*P* < 0.001) and were more efficient (*P* = 0.03) than heifers.

Carcass data from USDA grading at the Tyson processing plant in Lexington, Neb. was used for analysis (Table 1). Of the 85 animals, 95% graded Choice or better and 95% were Yield grade 2 or 3.

Table 3. Effect of system on profitability.

	System				SEM
Item	Low	High	Short	Long	
Sept. P/L[a] $/head	67.86	74.66	70.33	72.13	8.28
Oct. P/L, $/head	43.60	47.68	—	45.64	20.40
Finish P/L, $/head	(0.72)	20.09	(8.08)	27.62	8.01
Finish[b] P/L, $/head	18.81	41.32	7.81	52.57	5.36
Finish[c] P/L, $/head	8.67	30.99	0.40	39.45	5.36

[a] P/L is profit (loss).
[b] With 1.8 lb DDG on grass.
[c] With 5 lb DDG on grass.

Table 4. Costs associated with backgrounding cattle at a HIGH vs LOW rate of gain compared to simulated costs associated with backgrounding at equivalent rates of gain using distillers dried grains and range.

	Treatment							
	LOW				HIGH			
	Short		Long		Short		Long	
	Drylot	DDG[b]	Drylot	DDG[c]	Drylot	DDG	Drylot	DDG
Background Costs, $								
Feed	51.15	42.53	51.48	42.99	69.30	62.41	71.79	64.41
Yardage	32.34	7.59	32.34	7.55	32.46	7.57	32.46	7.56
Health	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Interest	10.96	10.60	10.96	10.62	11.11	10.78	11.34	11.00
Total	102.45	68.72	102.78	69.16	120.87	88.76	123.59	90.97

[a] Greatest standard error treatment means (SEM) reported.
[b] DDG intake (2.9 lbs/head/day, DM).
[c] DDG intake (6.5 lbs/head/day, DM).

Carcass weights from LOW cattle were 51 lb/head less than HIGH cattle and carcass weights from SHORT treatment cattle were 53 lb/head less than LONG cattle (*P* < 0.001). Cattle on LOW had an average ribeye that was (*P* = 0.05) smaller than HIGH treatment cattle. There were no differences between LOW and HIGH for backfat, yield grade or internal fat. For graze treatments; SHORT had a smaller ribeye than LONG (*P* = 0.03). The larger ribeye for HIGH and LONG was due to heavier carcasses. Cattle on treatments SHORT and LONG had no differences for dressing percentage, yield grade, backfat thickness, or KPH (*P* > 0.05). Steers had 96 lb/head heavier carcass weights than heifers (*P* < 0.001). Yield grade for heifers was 0.33 higher than steers (*P* = 0.02) and ribeye area was greater for steers than heifers (*P* < 0.001). There were no significant differences between steers and heifers for the carcass traits; yield grade, dressing percentage, backfat thickness and internal fat (Table 2).

Dry distillers grains treatments simulation

Supplementation of DDGS during summer range and meadow grazing increased animal weight compared to no DDG supplementation for all production phases (P < 0.05). Supplementation of 1.8 lb/head/day DDG while cattle grazed summer range increased animal BW by 35 and 37 lb/head for LOW and HIGH, respectively. Supplementation of 5 lb/head/day DDG while grazing summer range increased animal BW by 42 and 44 lb/head for LOW and HIGH, respectively. DDG supplementation during meadow grazing at 1.8 lb/head. day increased BW by 22 and 24 lb for LOW and HIGH. Supplementation of 5 lb/head/day DDG during meadow grazing increased BW by 26 and 29 for LOW and HIGH. As stated, this increased weight was added to the original finished weight of each animal to provide the finished weights for DDG treatments. Final finish weights by treatment were increased by 44, 53, 37 and 60 lb/head for LOW, HIGH, SHORT and LONG, respectively, at 1.8 lb/head/day DDG. Finished weights for DDG treatment 5 lb/head/day were increased by 49, 57, 44, and 71 lb/head for LOW, HIGH, SHORT and LONG, respectively.

Economics

Cattle were most profitable if sold off grass in September (Table 3). Higher rates of winter gain increased profit by $4.80 to $20.81 per head. Grazing meadow increased profit by $35.70 per head.

Feeding DDG on grass was profitable at all market times. Feeding 1.8 lb daily increased profit by an average of $16.15/head at finish. Feeding 5 lb daily increased profit by $10.15/head.

Compared to dry lot, feeding DDG on winter range decreased costs of backgrounding across all production systems (Table 4). Savings were about $33 per head. Use of DDG in both backgrounding and grazing situations increased profit by nearly $50 per head. Range in profit among the systems presented was large. Calves backgrounded at the low level and grazed for a short period were unprofitable while those backgrounded at a high rate on DDG supplement with DDG on grass, and with extended grazing on meadow had a profit of $52.57/head at finish. Steers were about $20/head more profitable than heifers.

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[1] Alan Taylor, graduate student; L. Aaron Stalker, assistant professor; Don C. Adams, director, West Central Research and Extension Center, North Platte. Terry J. Klopfenstein, professor; and William A. Griffin, graduate student, Animal Science, Lincoln.

Price Discovery in North and West Central Nebraska Livestock Auction Markets

Matthew C. Stockton
Roger K. Wilson
L. Aaron Stalker[1]

Summary

Price data from west central Nebraska livestock auction markets were used to determine the price discovery and information flow patterns between weight-gender cattle classes using time series analysis and directed acyclical graphs (DAG). Results indicated steers weighing 400-600 lb were the point of price discovery; the price change of each weight of steers impacted the price of the next heavier class of steers. Price movements for 600-700 lb heifers impacted prices of many other weight/gender classes including the price of heavier heifers and steers.

Introduction

The mechanics of how supply and demand work to set the price for a specific sale transaction is known as "Price Discovery." It involves several inter-related concepts including the relative power of buyers and sellers, how buyers decide their maximum bids, and how market information is transmitted.

Pricing decisions by buyers and sellers along the beef supply chain are made using available information about the current situation coupled with future expectations. Price information from these transactions are used by other buyers and sellers in their decision making process. It is this recursive process where market information impacts stakeholder's decisions that this study explores.

The purpose of this study was to determine which weight/gender classes of feeder cattle (calves between 300 and 999 lb) were the price leaders and which were market followers. The methodologies used in this study to determine causality and the direction of information flow were developed by researchers in the field of artificial intelligence.

Procedure

The Agricultural Marketing Service (AMS), an agency in the USDA, publishes price data by sex and BW for individual livestock auction markets in Nebraska. Price data from the auction markets located in the Nebraska Sandhills and adjacent counties were collected beginning Aug. 1 and ending May 31 for the years 2003-4, 2004-5, and 2005-6. Livestock auction price data during June and July was sparse because sales were infrequent with few feeder cattle being sold during these months.

More than half the cattle marketed through these auctions were sold in the three months of October, January, and February. The largest numbers of cattle sold were in October (18.79%) followed by January (17.89%) and February (13.76%). This pattern was consistent over the three year period.

The weighted average BW of calves sold declined from 804 lb in August to 569 lb in October. Yearlings are generally sold directly off of grass in the fall and calves are sold later, after weaning. The decrease in average BW reflects fewer yearlings being sold as the fall season progresses. The weighted average BW of calves then increases to 693 lb in March, probably reflecting BW gains for calves over the winter. The weighted average BW drops to 664 lb in April and increases to 691 lb in May. Apparently producers begin holding their heavier calves in April.

The cattle were grouped by weight/gender using 100 lb increments. Calves weighing less than 300 lb or over 999 lb were not included in this study making a total of 14 groups. A weighted average price was calculated for each weight/gender class for each week.

The analysis was completed in two steps. First, a time series method was employed to account for the dynamic relationships among the price series. Vector Auto Regression (VAR) analyses and an Error Correction Model (ECM) were run to determine which, if any, of the weight/gender classes were independent of the others. Second, a directed acyclical graph (DAG) as determined by TETRAD IV, software developed by researchers at in the area of artificial intelligence at Carnegie-Mellon University and located on the internet at *www.phil.cmu.edu/projects/tetrad/*, was constructed showing the causal relationships among the 14 price series. A DAG is a picture that uses arrows and lines that represent causal links between variables. Acyclical relationships are causal flows that do not feed back into themselves. The TETRAD IV program, mentioned above, uses a logical, step-by-step procedure and a strict set of assumptions for identifying these causal relationships. The data used in the TETRAD IV procedure was the residuals, or innovations, from the VAR/ECM models.

Results

Figures 1 and 2 show the historical plot of cattle prices in $/cwt for the 14 weight/gender classes included in this study. The patterns of price movement among the different weight/gender classes were similar in appearance. Price level differences were not easily recognized because the scale used to chart these prices varied from one graph to another. The pattern of price movements was somewhat similar for calves weighing 600 lb or more. The pattern of price movements for calves less than 500 lb varied from the heavier animals price series. These observed differences in price patterns suggested there may be more than one price system.

Table 1 provides a list of the means and standard deviations of the prices for the different weight/gender

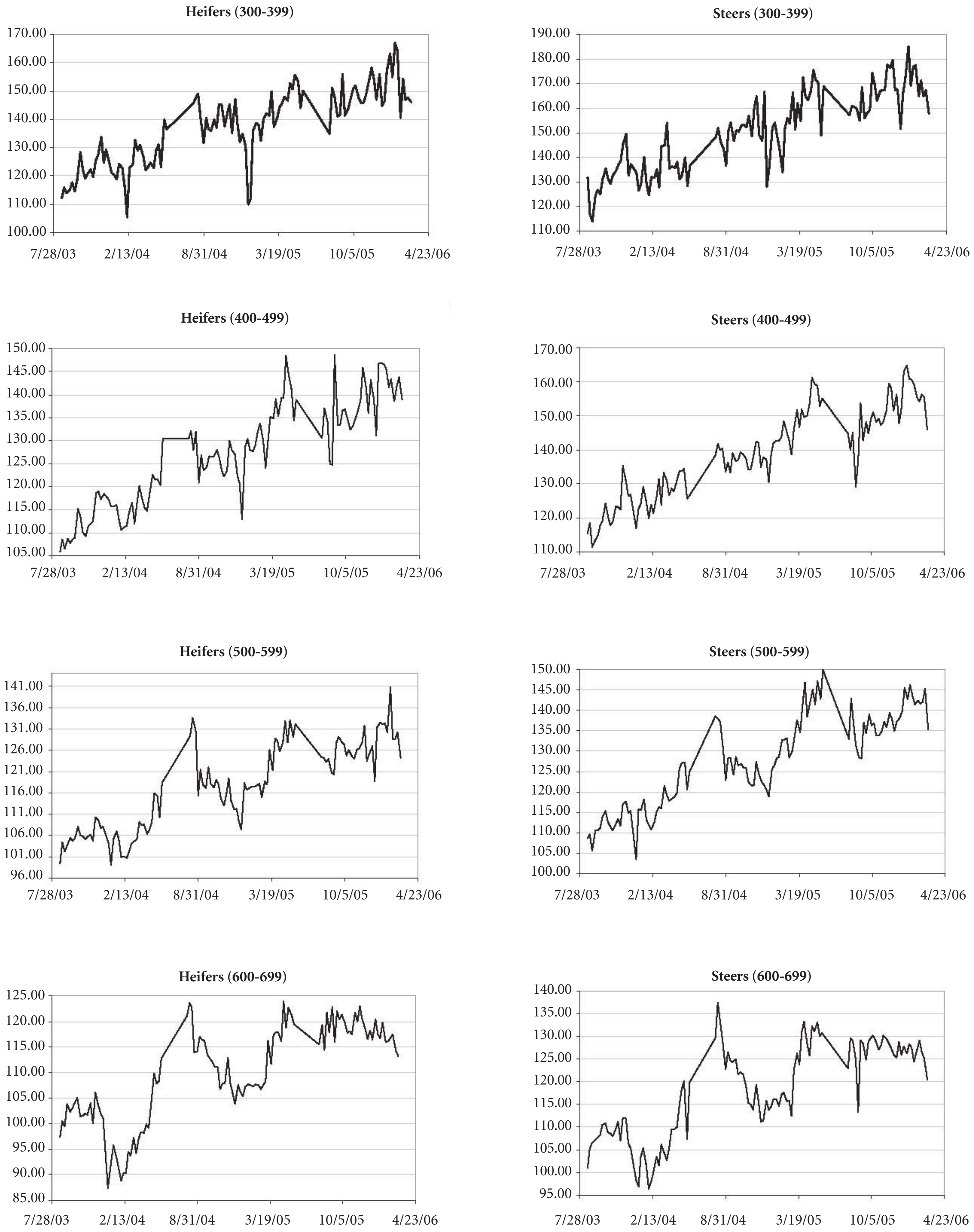

Figure 1. Plots of auction market prices by weight class, intact heifers and steers, weekly data August 2003 through April 2006.

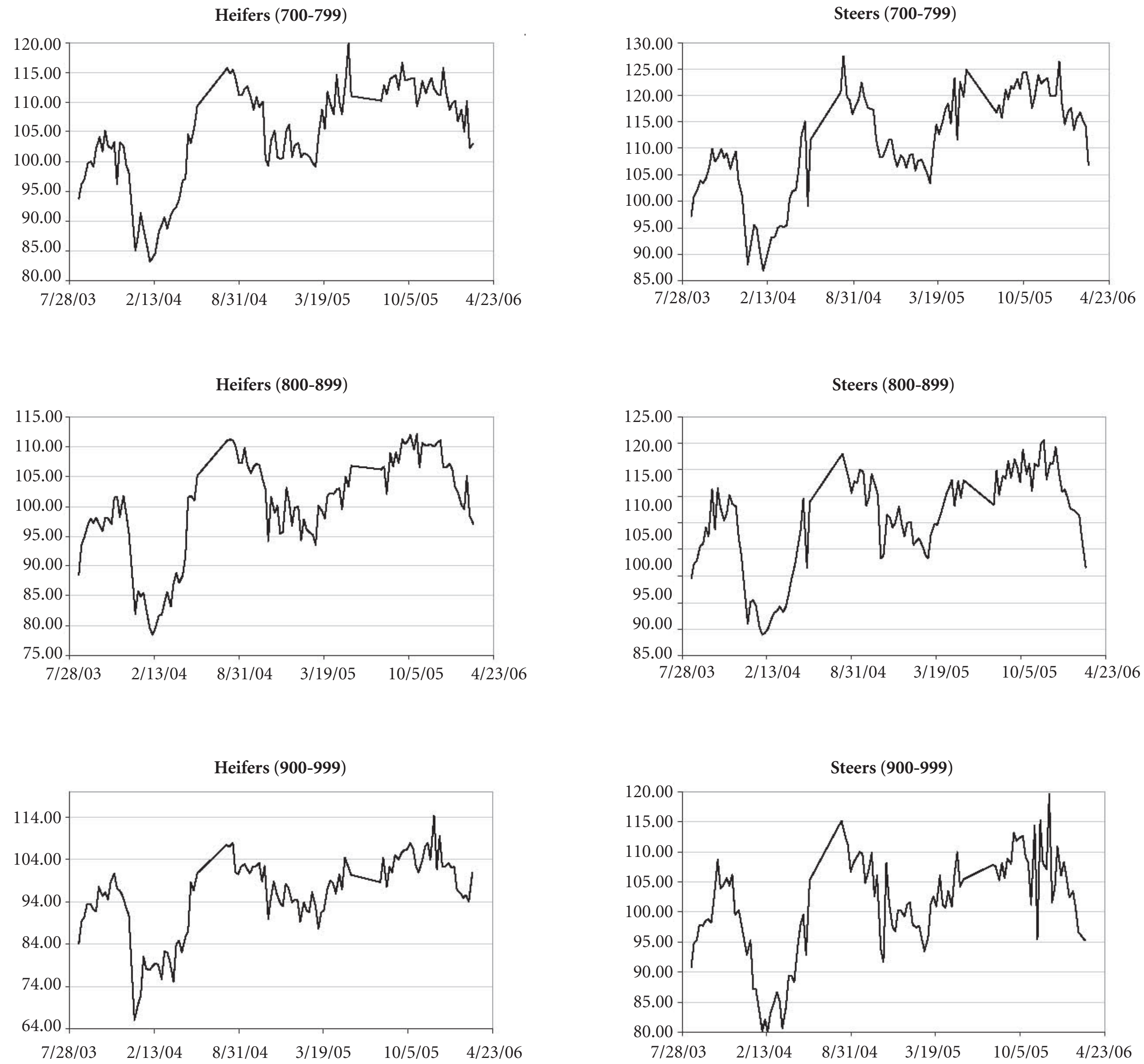

Figure 2. Plots of auction market prices by weight class, intact heifers and steers, weekly data August 2003 through April 2006.

groups. As expected, the average price per pound decreased as individual animal BW increased. Also, as expected, the average price for steers was higher than that of heifers for each weight category. Price variability, measured by standard deviation, generally followed the same pattern, lighter weight animals had higher standard deviation then their heavier contemporaries, with the exception that heifers weighing more than 900 lb had a larger standard deviation than heifers weighing 700-899 lb even though the average price received was less.

The time-series analysis indicates that the prices for 400-500 and 500-600 lb steers did not follow the price changes of the other weight/gender classes. This indicates that they may have been the price leaders while the prices of the other weight/gender classes followed. These results were only marginally significant.

However, when these results were combined with the DAG, an interesting picture of causation between these weight/gender classes emerged. Figure 3 shows the DAG created by the TETRAD IV program. Here a line drawn between two weight/gender classes represents existence of some type of relationship. If a line has an arrow, the price of the weight/gender class being pointed to is considered "caused" by the price of the weight/gender class from which the arrow is pointing. Information and causation flow in the direction of the arrow. When neither end of a line has an arrow, we can not say which weight/gender price was caused and which

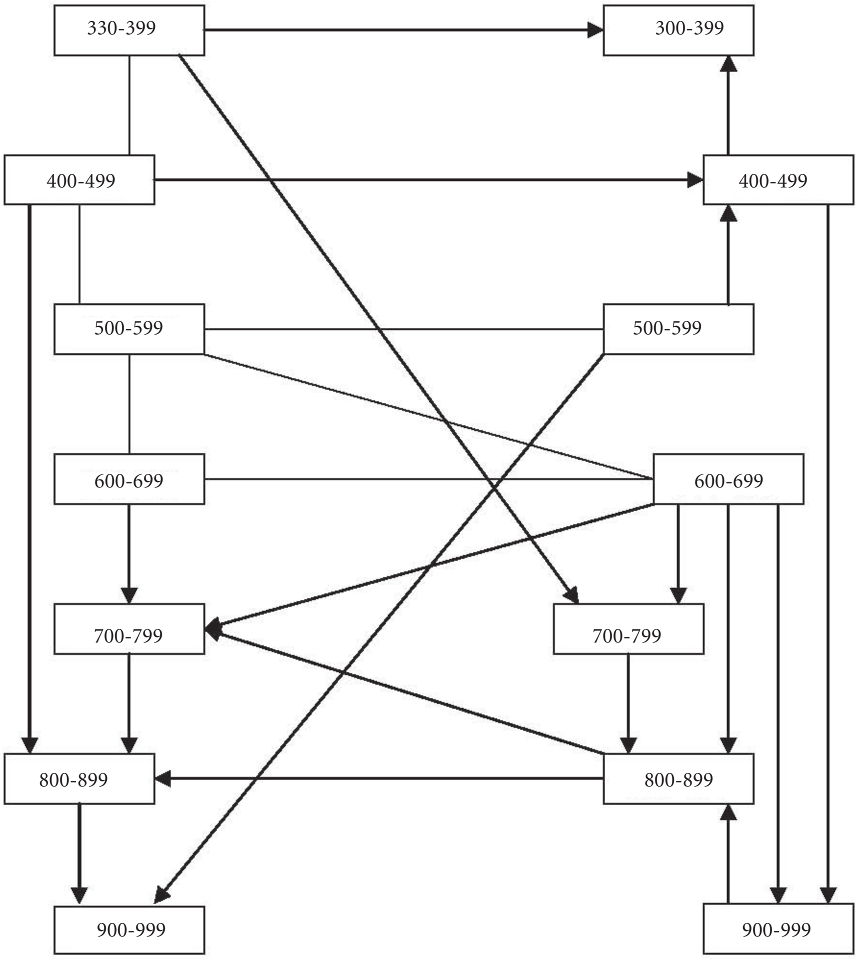

Figure 3. **Pattern Found with GES Algorithm on Innovations from an Error Correction Model on Prices from Fourteen Feeder Cattle Market Classes, Weekly Data Aug. 6, 2003 - April 26, 2006.**

Table 1. Means and standard deviations of heifer and steer prices by weight classes.

Market Class	Mean $/CWT	Standard Deviation $/CWT
Heifers		
300-399 lb	136.89	13.69
400-499 lb	126.75	11.41
500-599 lb	117.34	10.20
600-699 lb	109.61	9.39
700-799 lb	104.33	8.62
800-899 lb	99.80	8.65
900-999 lb	95.43	9.28
Steers		
300-399 lb	150.32	16.21
400-499 lb	138.41	13.27
500-599 lb	127.35	11.50
600-699 lb	118.05	10.32
700-799 lb	110.75	9.73
800-899 lb	105.48	9.24
900-999 lb	100.86	8.62

Note: Observed data are monthly average prices received in each market measured as *Dollars* per hundred pounds. Entries in the column labeled "Mean" refer to the simple mean price for the class listed in the far left-hand-most column of each row over the observation period August, 2003 through March, 2006. The columns headed by "Standard Deviation" give the standard deviation associated with observed prices from the class listed in the far left-hand-most column over the period listed in the row heading.

was causal. In Figure 4, the results from the VAR/ECM time-series analysis were used to direct some of the relationships in the DAG that the TETRAD IV program left undirected. These relationships are shown as heavy, dashed lines. Several generalizations from Figure 4 are noteworthy. First, no prices from weight/gender classes greater than or equal to 600 lb caused prices in classes less than 600 lb, while prices in classes less than 600 lb did cause prices in classes greater than 600 lb. Information of each weight/gender class price 600 lb or greater flowed to the next heavier weight class except information from 900-999 lb heifers which flowed to 800-899 lb heifers, which implied that information from the lighter classes of animals was being used in the discovery of price in the larger animals.

Another interesting note was prices for the cluster of steers weighing 700 lb or more did not cause any prices outside of this steer weight cluster. However the cluster of price classes of heifers weighing at least 500 lb or more were causal to heavy steers which made these heifers part of the price discovery of steers this size. This did not however hold for the light heifers. The prices of the two lightest weight steer classes caused the prices of the two lightest weight heifer classes. The prices of the two lightest weight heifer classes were also caused by the prices of heifers in the third lightest weight class 500-599 lb heifers. This could be interpreted that the two main factors that determined light heifer prices were heifers approaching breeding size and contemporary steers.

There were four unusual causal relationships that deserve note, two same sex causations and two cross sex relationships. The prices for both 400-499 steers and heifers caused prices of their respective sex in much heavier weight classes, 800-899 lb steer prices and 900-999 lb heifer prices respectively. The two extended cross sex effects were for the 300-399 steers which caused the price of 700-799 lb heifers and the 500-599 heifer prices

(Continued on next page)

which were causal to the price of 900-999 lb steers. Unfortunately three cross sex edges were left undirected, 600-699 lb heifers and steers, 600-699 lb heifers and 500-599 lb steers, and 500-599 lb heifers and steers making it impossible to determine conclusively whether heifer prices caused the prices in the other weight/gender classes. However, what is apparent from the graph was the 600-699 lb heifer price class has more edges and transfers more information than any other single weight/gender class. Ranked next was 800-899 lb heifers, with five edges, which made the these heifers key in the determination of beef cattle prices.

Discussion

From casual observation and speaking with others involved in the feeder cattle market, one might assume that prices flow upstream with heavier BW steers and heifers leading the market and subsequent lighter BW animals following. However, this study suggests the opposite was true; prices for lighter BW steers were the market leaders and "caused" the prices of heavier BW cattle. It also suggests prices of middle and heavier BW heifers influenced the price of the heavier BW steers. The importance of heavier BW heifer prices was consistent with similar research conducted in Texas by David Bessler and Ernest Davis.

One possible explanation of why the light weight steer and middle weight heifer markets were so important in price discovery is because these are the points where new information enters the system. The question, "How many calves are available to be processed into beef," is partially answered when calves are first marketed. The prices paid for these calves affects the other markets as this information is dispersed through the system. The next critical point in the flow of information is how many heifer calves will be extracted from the system to be used in the breeding herd. This information becomes available when the middle weight heifers are sold and the information is transferred to the other heavier weight/gender classes.

These findings indicate that individuals interested in determining the direction of the market and the strength of the market would be best served to pay particular attention to the price of light weight steers and middle weight heifers.

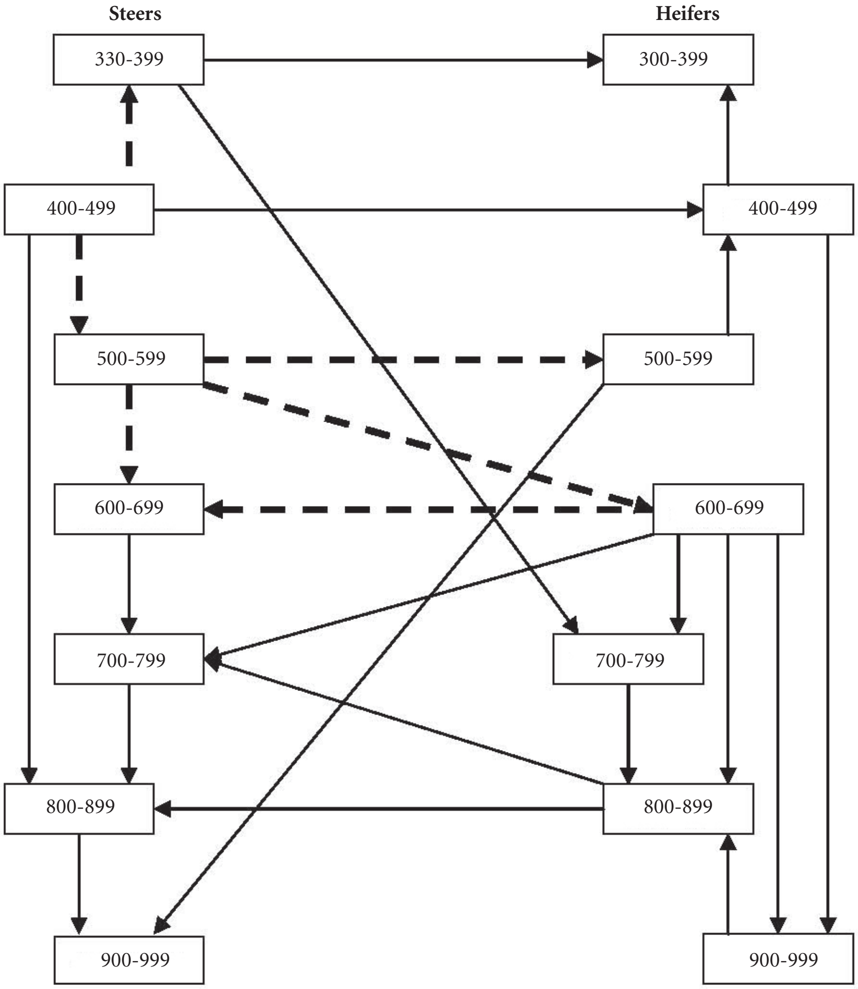

Figure 4. Added arrow direction to undirected edges by rank of the chi-squared test statistic critical values for exogeneity, to the Pattern Found with GES Algorithm on Innovations from an Error Correction Model on Prices from Fourteen Feeder Cattle Market Classes, Weekly Data Aug. 6, 2003 - April 26, 2006.

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[1] Matthew C. Stockton, assistant professor; Roger K. Wilson, technician, Agricultural Economics, West Central Research and Extension Center, North Platte. L. Aaron Stalker, assistant professor, Animal Science, Lincoln.

The Cattle Price Cycle: Revisited Again

Matthew C. Stockton
Roger K. Wilson
L. Aaron Stalker[1]

Summary

New analyses and statistical techniques were applied to historical data to determine if time, changes in production technology, and business structure changes in the sector had altered the length of the cattle price cycle. Most recent work has been done the cattle inventory cycle. The price cycle was shown to be remarkably constant, despite many changes in the industry. Feeder cattle prices have continued to follow an approximate 10-year cycle. The model demonstrates the consistency of the cycle but shows that unexplained price variations occur suggesting caution be employed when it is used as a marketing guide.

Introduction

Most recent research on cattle cycles have been done on inventories. An advantage of studying the price cycle is it is reflective of the interaction of supply and demand while research on inventory cycles impact only supply. A clearer understanding of defined price patterns can lead to better and more informed production and marketing decisions by stakeholders.

It has long been accepted that beef cattle prices are cyclical in nature. Identifying the exact point where an individual cycle reaches its low or high is complicated by random variation (noise) in the price series. The purpose of this study was to determine if the cattle price cycle's length has persisted over time.

Procedure

Several techniques were used to capture the nature of the cattle price cycle. This work used USDA's price data for calves less than 500 lb for two primary reasons. First only a few price series of an appropriate length were readily available, the 500 lb feeder calf series was one of those. Secondly, our recent work supports the use of this feeder cattle weight/gender group, because we determined lighter weight feeder cattle prices were key in the price discovery process.

The price series for calves less than 500 lb was obtained from USDA's National Agricultural Statistics Service's web-hosted data base called "Quick Stats." This price series was from "U.S. & All States Data – Prices – Monthly Prices Received – Calves Less Than 500 Lbs." The data series began August 1909 and continued through December 1990. It resumed January 1998 and continued through December 2006. Data for 1991 through 1997 were obtained from the Publication titled "Agricultural Prices Summary," and was consistent with Quick Stats data. This report can be accessed at the Web site *usda.mannlib.cornell.edu/MannUsda/homepage.do* under the subject "Economics and Management."

The Consumer Price Index values used to convert these nominal prices to 1982 prices were obtained from the U.S. Department of Labor's Bureau of Labor Statistics Web site located at *www.bls.gov/cpi/*. This site provided a number of indices. The index titled "All Urban Consumers (Current Series) U.S. All items, 1982-84=100 - CUUR0000SA0" was the one chosen to convert the price series.

Because of the cyclical nature of the price cycle, a harmonic function was used in the estimation process. Harmonic functions, those that use the trigonometric identities such as sines and cosines, are commonly used to model cycles in many different areas of science where waves, or repetitive motion model are required.

First, the real prices were plotted (Figure 1). If these data were truncated, leaving off the first and last partial cycles, they exhibited a distinctive bow shape with the high point being January 1972, indicating a period of an increasing price trend and a later period of downward trending prices. This overall trend was consistent with demand of the two periods. The per capita consumption of meat reached a high in the 1970s and has since declined.

This bow shape trend was verified by the application of the Akaike Information Criterion (AIC), which

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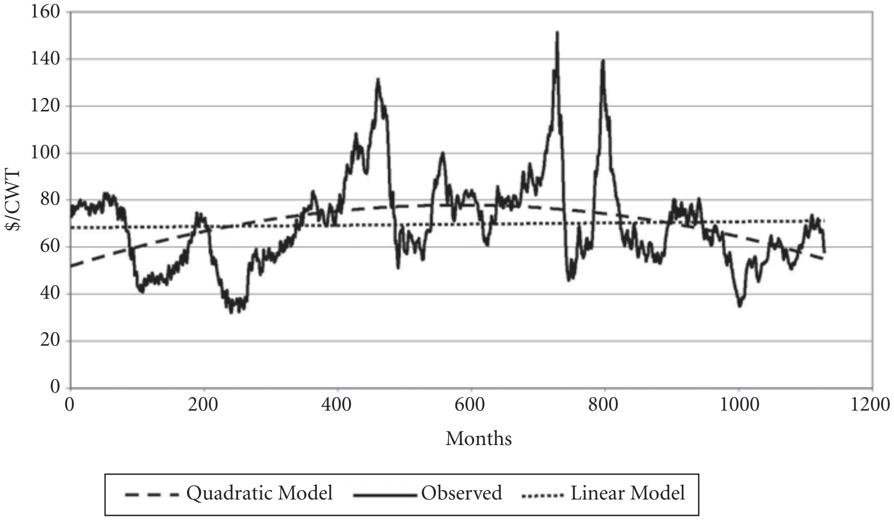

Figure 1. Comparison between the quadratic and linear models.

indicated that the quadratic model was superior to a linear model. The AIC was also used to determine the length of the two cycles, the long term cycle (LTC) over many years, and the short term cycle (STC), seasonal variation. Other studies have shown the price cycle completed one cycle in approximately 120 months, LTC, and that the cattle prices exhibit seasonal variation making the STC cycle of 12 months appropriate. Rather than search across all possible combinations of the two cycles, the number of possible cycle lengths was limited. The only possible LTC's considered ranged between 110 and 130 months and the possible STC's were limited to range between 6 and 18 months. However, before estimating each possible combination of the two cycles, the data set was truncated at both ends to remove the effect any incomplete cycles might have on the explanatory parameter estimates. The first 107 and last 38 observations were dropped.

Results

The combination LTC and STC with the lowest AIC score was an LTC of 123 months, and an STC of 12 months (Figure 2). This outcome was supportive of the notion that the price cycle maintained its regularity since 1972 when it was last studied. This result was not surprising and was indicative of the robustness of the price cycle over an extended period of time. The most recent low in the cycle prior to 2003 was in 1993, and if the cycle holds true the next high will occur early in 2009 and the next low in 2014.

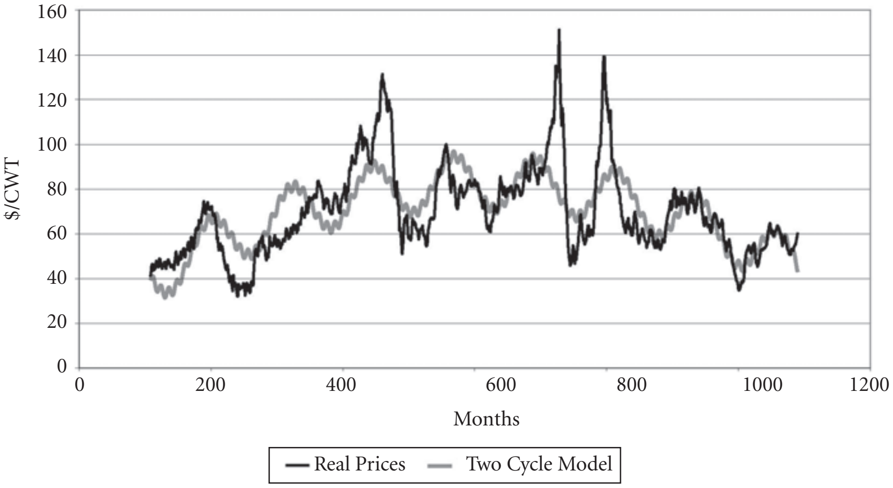

Figure 2. Real prices versus the two cycle model.

It was clear from Figure 2 that while the general pattern was consistent, there was a great deal of variation. This variation seems to provide lows and highs that occur off cycle and out of scale from the predicted prices.

This limited work only addresses the length of the cycle. No effort to analyze the pattern or magnitude of the highs and lows was conducted. Our analysis does not prove without a doubt the cattle price cycle will be about 10 years long, but it does suggest a cycle about that long has persisted historically and the persistence has been maintained despite many economic, institutional, and physical changes in the industry. It would be unwise to ignore the past persistence of the cycle and equally unwise to assume it will always persist unchanged. The results of this research should be considered carefully and used cautiously.

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[1] Matthew C. Stockton, assistant professor; Roger K. Wilson, technician, Agricultural Economics, West Central Research and Extension Center, North Platte. L. Aaron Stalker, assistant professor, Animal Science, Lincoln.

Effect of Excede® Administered to Calves at Arrival in the Feedlot on Performance and Respiratory Disease

Josh R. Benton
Galen E. Erickson
Terry J. Klopfenstein
David R. Smith
Matt K. Luebbe
Gary E. Sides
Lonty Bryant[1]

Summary

In a clinical trial where cattle were either given Excede® or not on arrival, ADG increased and F:G was numerically improved for cattle that received Excede compared to control cattle. There were no differences between initial or final BW, or DMI observed during the receiving period due to the administration of Excede. The incidence of bovine respiratory disease (BRD) for the 32 days of the study was 4.4% for cattle that received Excede at arrival and was different compared to the control cattle which was 12.2%. The correlation (-0.157) between DMI and morbidity observed in this study was not significant. Metaphylactic treatment with Excede improved ADG and effectively reduced the cumulative incidence of BRD during the study.

Introduction

Controlling BRD among incoming calves using metaphylaxis (mass medication of cattle with antibiotics at feedyard arrival) may be an important management option for veterinarians and cattle producers. A previous study evaluated the effect of administration of a long-acting formulation of ceftiofur crystalline free acid (Excede® Sterile Suspension, Pfizer Animal Health, New York, N.Y.) at arrival, or at revaccination (16 to 27 days after arrival) on morbidity, mortality, and BW gain of calves (*2007 Nebraska Beef Report*, pp. 68-70). In this study, calf morbidity from BRD was predominantly within the first 10 to 14 days. Excede administered at arrival significantly reduced ($P<0.01$) the incidence of BRD compared to treatment at revaccination. A -0.22 correlation ($P < 0.01$) was observed between the proportions of steers pulled for BRD treatment and daily DM offered. However, DMI was restricted initially with ad libitum intakes after day 10.

The objective of the current study was to determine the effect of administering Excede at feedlot arrival on morbidity, mortality, BW gain, and the correlation of DMI to pen morbidity rates during the first 30 to 35 days of the feedlot receiving period.

Procedure

Two treatments were evaluated within the feedlot receiving system: 1) control (no arrival treatment) with no post treatment interval (PTI) observed (CONTROL), or 2) Excede® Sterile Suspension on arrival using the base of the ear as the injection site with a PTI of 7 days observed (EXCEDE). A total of 842 steer calves received at the University of Nebraska Agricultural Research and Development Center between Oct. 17 and Oct. 29, 2006, were used in this experiment. Steers were a mixture of "ranch-direct" and "auction market" sources. Steers were housed by treatment group and pens sharing a water tank were assigned to the same treatment in order to minimize environmental cross-exposure, or cross-protection. Fifty-two feedlot pens housed between 12 and 20 head/pen to supply 26 replications per treatment. Pens were blocked by arrival day (6 blocks). Steers received ad libitum intake of a typical feedlot receiving diet containing (DM basis) 27% dry rolled corn, 35% alfalfa hay, 35% wet corn gluten feed, and 3% supplement containing 135 mg/steer daily Deccox® (Alpharma Inc., Fort Lee, N.J.) and 200 mg/steer daily Rumensin (Elanco Animal Health, Greenfield, Ind.). Steers also received long-stem grass hay (3.4 lb/head/day, DM basis), which was removed after day 2.

Steers were assigned to treatment based on processing order on arrival, with every other animal assigned to each treatment. Only calves that were large framed and weighed more than 550 lb were assigned on this experiment as all of these calves were designated as "calf-feds." Steers' ID tags were notched to identify treatment assignment. Calves were processed on arrival by receiving three separate tags for individual identification including an electronic ID, panel tag, and metal clip tag. Calves were weighed and vaccinated with the following at feedlot arrival: BoviShield™ Gold 5, Somubac®, and Dectomax® Injectable (Pfizer Animal Health). All calves with horns were dehorned or tipped as needed. Intact bull calves were excluded from this study. Calves were weighed and revaccinated at 10-14 days after arrival which included vaccination with Somubac/Ultrabac® 7 and a second dose of BoviShield Gold 5. Calves were individually weighed off trial after 32 days (range 30-35 days) following a 5-day limit-fed period to minimize variation due to gut fill.

All pens were evaluated by the same animal health personnel within the same day to provide equivalent evaluation across treatments. Calves categorized as sick by the cattle crew were pulled, symptoms assessed, rectal temperature recorded, and BRD cases treated with Draxxin® Injectable Solution (Pfizer Animal Health, New York, N.Y.). When sick calves were treated, their panel ID tag was marked to prevent retreating. Animals were returned to home pens as soon as possible after treatment. A PTI of 7 days was honored after treatment with Draxxin before another treatment could occur. Any animals that were pulled for reasons other than respiratory disease were treated according to UNL feedlot SOPs.

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Initial BW, revaccination BW, final BW, ADG, DMI, feed:gain ratio, morbidity and mortality were measured. Initial BW was based on BW recorded at arrival and was assumed to be a shrunk weight. Final BW was based on the average of 2-day consecutive weights recorded at the end of the trial after a 5-day limit-feeding period to minimize variation due to gut fill. Body weight, ADG, DMI, F:G, and pull rate data using pen as the experimental unit were analyzed using the Proc MIXED procedure of SAS (Version 9.1, SAS Inc., Cary, N.C.) with arrival (and source) as a blocking criteria and antibiotic treatment as a fixed effect. The Proc CORR procedure of SAS (Version 9.1, SAS Inc.) was used to correlate DMI and morbidity. The Proc GENMOD procedure of SAS (Version 9.1, SAS Inc.) was used to analyze binary respiratory disease morbidity outcomes in a generalized estimating equations model using the logit link and accounting for correlation of animals within pen. An animal was classified as a respiratory disease observation for the trial if the animal was treated for respiratory disease by the animal health personnel.

Results

There were no significant differences ($P > 0.05$) between initial BW (612 ± 4 lb), revaccination BW (661 ± 5 lb), final BW (687 ± 5 lb), or DMI (13.9 lb/day) observed in this study due to administration of Excede (Table 1). ADG over the study period was 8% higher for cattle that received Excede on arrival than for those that did not. Cattle that received Excede on arrival had a greater ($P = 0.02$) ADG and a numerically improved ($P = 0.07$) F:G ratio compared with CONTROL cattle. A total of 71 animals were treated for BRD in this study, 19 from EXCEDE and 52 in CONTROL. Also, there were not any animals in this study that had to be retreated or that died. With treated animals removed from the dataset, EXCEDE cattle continued to have significantly greater ($P < 0.01$) ADG and significantly improved ($P = 0.02$) F:G

Table 1. Effects of administration of Excede at arrival on performance during the 32-day receiving period.

	CONTROL	EXCEDE	SEM	P-Value
Results for All Animals Using Pen as the Experimental Unit				
Initial BW, lb	614	610	4	0.32
Revac BW, lb[a]	659	663	5	0.51
Final BW, lb	686	687	5	0.75
DMI, lb/day	13.7	14.0	0.2	0.13
ADG, lb	2.20	2.37	0.07	0.02
F:G[b]	6.21	5.88		0.07
Results Excluding 71 Animals Treated for BRD				
Initial BW, lb	615	610	4	0.22
Revac BW, lb[a]	660	663	5	0.58
Final BW, lb	686	688	5	0.77
DMI, lb/day	13.7	14.0	0.2	0.13
ADG, lb	2.19	2.40	0.08	<0.01
F:G[b]	6.25	5.81		0.02

[a] Revac BW = Revaccination BW.

[b] Analyzed as gain:feed, reciprocal of feed conversion.

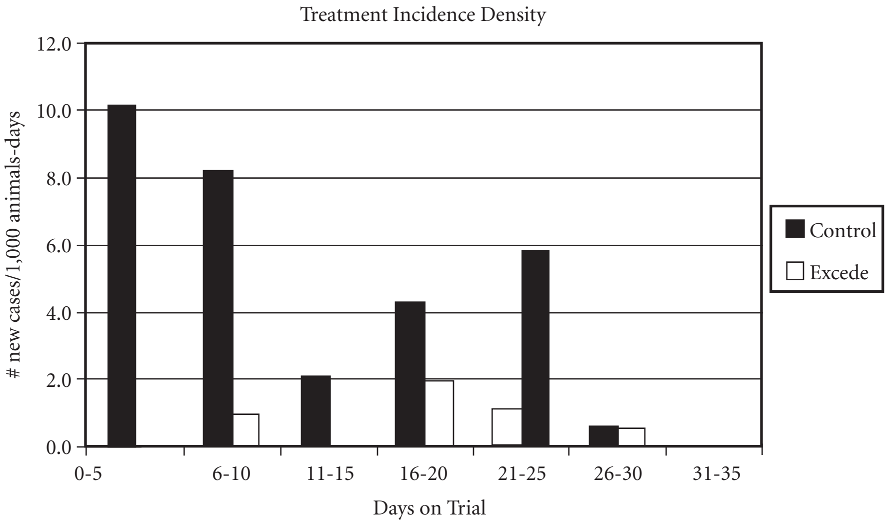

Figure 1. Incidence density of first pulls for BRD by treatment and days on trial.

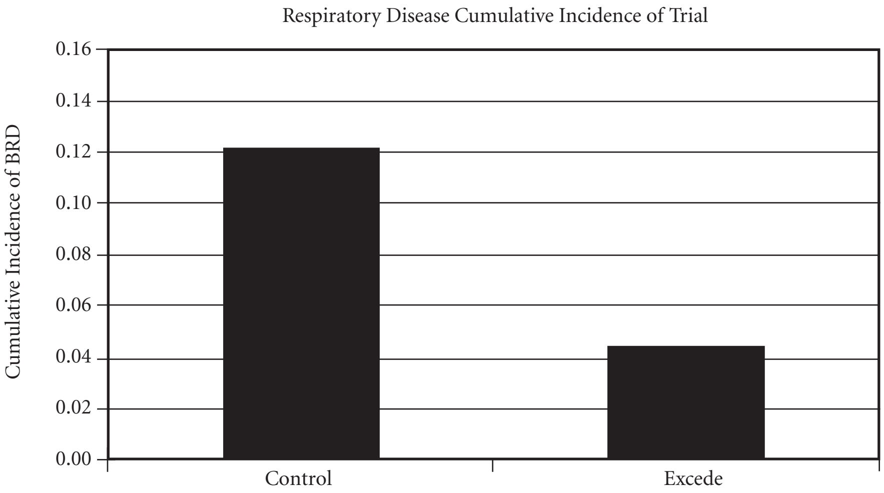

Figure 2. Cumulative incidence of BRD for the study period by treatment.

ratio compared to CONTROL cattle. There were no differences observed for BW or DMI. The correlation (-0.157) between DMI and pen-level incidence of BRD morbidity for the study period was not significant ($P = 0.27$).

CONTROL and EXCEDE cattle were first pulled for BRD at different periods of time after receiving (Figure 1). CONTROL cattle had a higher incidence of BRD at the beginning of the study, mainly between day 0 and day 10; however, EXCEDE cattle were not eligible for BRD treatment until 8 days after enrollment into the study. The incidence of BRD for cattle treated with Excede peaked between days 21-25. The only variable that significantly explained the incidence of BRD was metaphylactic treatment with Excede (odds ratio = 0.33, $P < 0.01$). Cumulative incidence of BRD for the study period was 4.4% for cattle that received Excede at arrival and 12.5% for CONTROL cattle. Cattle that received metaphylactic treatment were 64% less likely to be treated for BRD than CONTROL cattle.

In conclusion, metaphylatic treatment with Excede at arrival in the feedlot effectively reduced the incidence of BRD by 64%, and also improved ADG 8% during the receiving period compared to no metaphylaxis.

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[1] Joshua R. Benton, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor; and Matt K. Luebbe, research technician, Animal Science, Lincoln. David R. Smith, professor, Veterinary and Biomedical Sciences, Lincoln. Gary E. Sides and Lonty Bryant, Pfizer Animal Health, New York, N.Y.

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

Rodney A. Moxley
David R. Smith
Karen Hansen
Matt K. Luebbe
Galen E. Erickson
Terry J. Klopfenstein
Dragan Rogan[1]

Summary

A clinical trial conducted during the summer of 2006 evaluated the effects of two- and three-dose regimens of an Escherichia coli *O157 vaccine product on the probability of detecting* E. coli *O157:H7 in feces and on colonization of the terminal rectum. The three-dose regimen significantly reduced the probability for cattle to shed* E. coli *O157:H7 in feces by 63% compared to placebo treated cattle. A dose-effect was demonstrated because a two-dose regimen of the vaccine product was intermediate in effect. These results are consistent with previous estimates of vaccine efficacy against fecal shedding and agree with our previous finding that efficacy is related to the number of doses.*

Introduction

Vaccination of feedlot cattle against type III secreted proteins of *Escherichia coli* O157:H7 as a strategy to reduce the probability for cattle to shed the organism and effects of dose regimen has been reported in several beef reports (*2006 Nebraska Beef Report*, pp. 68-69; *2006 Nebraska Beef Report*, pp. 70-71; *2005 Nebraska Beef Report*, pp. 61-63).

The issue of how many vaccine doses to administer for effectiveness is an important one for efficiency of cattle handling. Our 2003 study tested the number of doses of vaccine administered to cattle within pens (*2005 Nebraska Beef Report*, pp. 61-63). In that study, vaccination of a majority of cattle within the pen conferred protection to nonvaccinated animals within pens indicating a pen-level effect of vaccination. In order to clarify the effect of the number of vaccine doses, a clinical trial was conducted that compared the effects of two and three doses of vaccine against nonvaccinated animals, with vaccination treatment being applied to the pen rather than the individual animal as in the previous study.

Procedure

The clinical trial was conducted from June to October of 2006 at the beef research feedlot of the University of Nebraska Agricultural Research and Development Center at Ithaca, Neb. Four hundred eighty medium weight steers were stratified by BW and randomly assigned to 60 pens (8 steers/pen). Twenty pens were assigned to each of three treatments: 1) three doses of placebo given at days 0, 21, and 42; 2) two doses of vaccine given at days 0 and 42; and 3) three doses of vaccine given at days 0, 21, and 42. Pens were managed in 4 blocks to account for differences in date of first vaccination, vaccination-to-slaughter intervals (15 or 16 weeks) and location within the feedlot facility. All animals were fed similar high-moisture corn (HMC) diets with 20% wet corn gluten feed, 7.5% roughage, and 5.0% supplement. Blocks 1 and 2 were comprised of 18 pens each, with each block treated and sampled at different times (block 2 was vaccinated one week later and slaughtered 1 week later than block 1). Block 3 was composed of 9 pens with 3 pens per vaccine treatment. Block 4 was composed of 15 pens with 5 pens per treatment. Blocks 3 and 4 were treated and sampled on the same days but were in different locations within the feedlot. Vaccine and placebo treatments were coded by the manufacturer (Bioniche Life Sciences Inc.) so that researchers and feedlot personnel were blinded to treatment.

Fecal samples were obtained from the rectum on days 0, 63, 77, 91 and the day prior to harvest (i.e., 1 pre-treatment period and 4 test period samplings), and a sample of the terminal rectum mucosa (TRM) was collected at harvest. Fecal cultures from all steers were collected by block as stated above within the same test period. Fecal samples were labeled with a bar-code and TRM samples were numbered in order of harvest, which blinded laboratory personnel to animal identification. All samples were transported to the laboratory within a few hours of collection. Standard broth enrichment and plate culture methods *(2006 Nebraska Beef Report,* pp. 68-69) with modifications were used to yield a positive or negative result and determination of the probability (prevalence) of *E. coli* O157:H7 fecal shedding or TRM colonization. Serial dilution of weighed samples followed by direct plating (i.e., without broth enrichment) and standard culture methods (*2006 Beef Report,* pp. 68-69) with modifications were used to quantify *E. coli* O157:H7 CFU per gram of feces or TRM.

The effect of vaccine treatment on the probability of detecting *E. coli* O157:H7 from feces was modelled using multi-level logistic regression (GENMOD, SAS Institute, Cary, N.C.). Least squared means of the parameter estimates from the multivariate analysis were used to estimate adjusted probabilities for vaccine treatment. Relative risk (RR) values for each vaccine treatment were calculated from the adjusted probabilities and vaccine efficacy was calculated as 1-RR.

Results

Prevalence of E. coli *O157:H7 fecal shedding*

In this study *E. coli* O157:H7 was detected in 236 of 2,387 fecal samples (10%); 117 of 478 pre-treatment (24%) and 119 of 1,909 post-treatment fecal samples (6%) were culture positive. The prevalence of fecal shedding among all treatment groups declined during the feeding period, with a very slight increase at harvest (Figure 1).

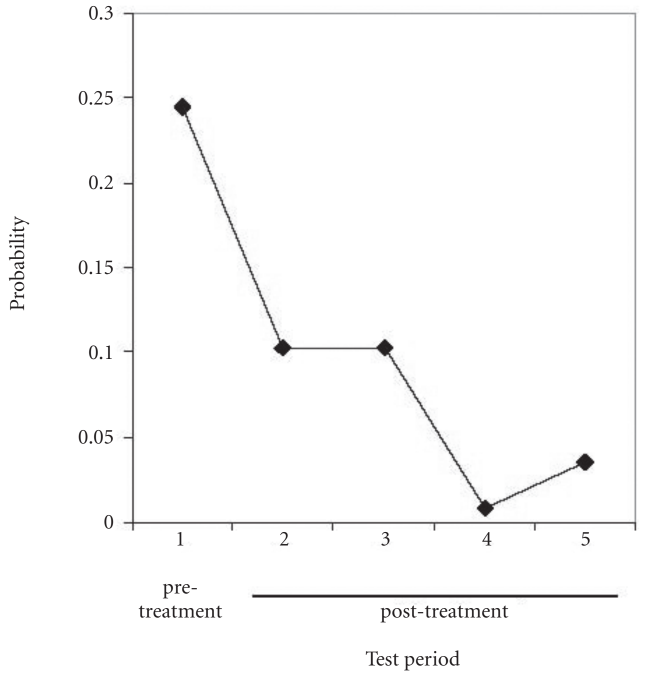

Figure 1. Unadjusted prevalence of *E. coli* O157:H7 fecal shedding as determined by enrichment culture, plotted by test period.

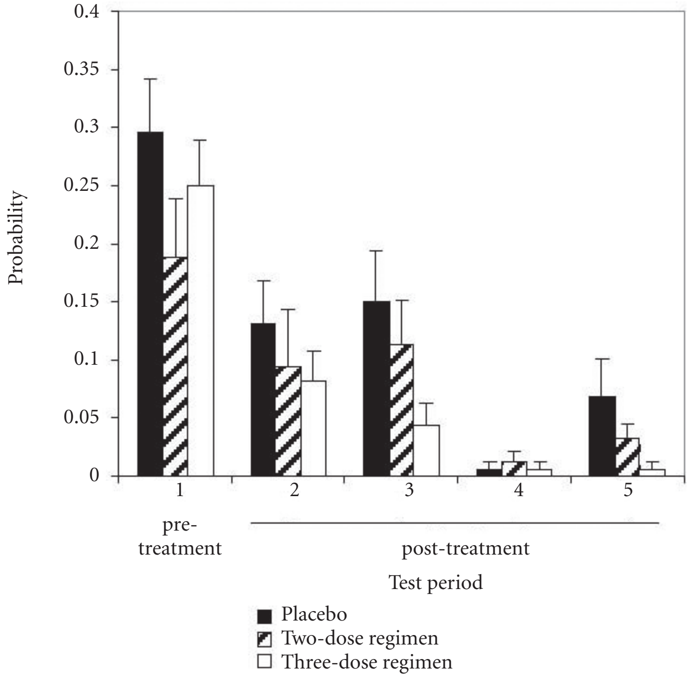

Figure 2. Unadjusted mean pen-level prevalence of *E. coli* O157:H7 fecal shedding as determined by enrichment culture, plotted by treatment and test period. Error bars represent one SEM.

The unadjusted mean prevalence of shedding by treatment and test period is summarized in Figure 2. The pen-level prevalence of *E. coli* O157:H7 fecal shedding during the post treatment period was 9%, 6% and 3% for placebo-treated, 2-, and 3-dose vaccine regimens, respectively.

Quantification of E. coli *O157:H7 shed in feces*

Direct plating for quantification of *E. coli* O157:H7 was completed on a total of 1,961 pre- and post-treatment fecal samples. The organism was detected in 29 of 1,961 samples (1.5%). *E. coli* O157:H7 was detected in 16 of 415 pre-treatment samples (3.9%); 7 were from placebo-treated, 2 were from 2-dose-treated, and 7 were from 3-dose-treated pens of cattle. Mean (SEM) $\log_{10}$ bacterial counts (CFU/g) were 3.0 (0.38), 3.5 (0.50) and 3.2 (0.41) for placebo-treated, 2-dose, and 3-dose treatment groups, respectively, suggesting that in cattle that were shedding, relatively similar amounts of the organism were shed. *E. coli* O157:H7 was detected in 13 of 1,546 post-treatment samples (0.8%); 5 from placebo-treated, 4 from 2-dose, and 4 from 3-dose treated pens of cattle. Mean (SE) $\log_{10}$ bacterial counts (CFU/g) were 2.6 (0.29), 4.1 (0.55), and 3.7, (0.64) for placebo-treated, 2-dose, and 3-dose treatment groups, respectively.

Prevalence of E. coli *O157:H7 Colonization*

At harvest, a total of 5 of 380 (1.3%) steers were colonized; 3 were placebo-treated and 2 had been vaccinated 3 times. Only 2 steers were culture positive from direct plating, both were from the placebo-treated group.

Statistical tests of efficacy

Statistical tests of colonization and fecal quantification from direct plating were not done because there were too few positive observations among placebo-treated cattle to make valid inferences regarding vaccine efficacy. Pre-treatment pen-level prevalence of fecal shedding did not differ between pens of cattle in the three treatment groups, based on either a generalized linear mixed model with block as random effect, or a generalized estimation equation model defining correlation of pens within block. Post-treatment vaccine efficacy was tested using three multilevel modeling approaches. Estimates of vaccine efficacy from each of the three models were nearly identical, based on least square means of the three model estimates. The significance of within-treatment differences was nearly identical for each of the three models. The

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outcome of the first model is shown graphically in Figure 3.

The three-dose regimen significantly reduced the probability for cattle to shed *E. coli* O157:H7 in the feces 63% compared to placebo treated cattle. A dose-effect was demonstrated in that a 2-dose regimen of the vaccine product was intermediate in effect between placebo and a 3-dose regimen. These results are consistent with previous estimates of efficacy for fecal shedding and agree with our previous finding that efficacy of 2 or 3 doses of vaccine exhibit a dose-response.

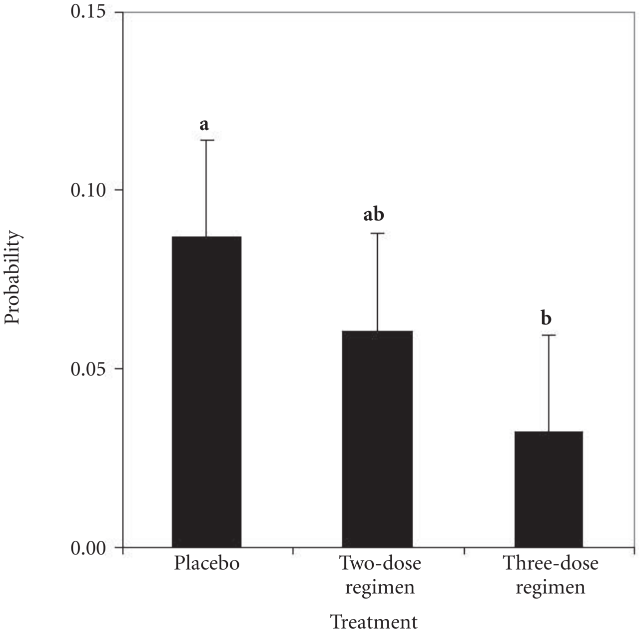

Figure 3. Model-adjusted post-treatment probabilities for cattle to shed *E. coli* O157:H7 in feces, determined by enrichment culture, by treatment. Error bars represent one SEM. Treatments with different superscripts differ, $P < 0.05$.

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[1] Rodney A. Moxley, professor; David R. Smith, professor; and Karen Hansen, graduate student; Department of Veterinary and Biomedical Sciences, Lincoln. Matt K. Luebbe, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor, Animal Science, Lincoln. Dragan Rogan, vice-president, Research and Development, Bioniche Animal Health, Bioniche Life Sciences, Belleville, Ontario, Canada.

Mapping Tenderness of the *Serratus Ventralis*

Lauren M. Grimes
Chris R. Calkins[1,2]

Summary

*Serratus ventralis muscles from eight USDA Choice and eight Select carcasses were obtained. Samples were enhanced with a marination or left as controls, then blade tenderized once as whole muscles and cut into steaks. Enhanced steaks were then blade tenderized individually. Odd-numbered steaks were cooked, cored, and sheared for Warner-Bratzler (***WBS***) shear force determination. Tenderness was found to vary sporadically throughout the muscle with the posterior end being the most tender, regardless of grade. Enhanced samples produced lower WBS values than controls. The serratus ventralis does respond to enhancement techniques, and steaks could especially be fabricated from the posterior end.*

Introduction

Muscle profiling projects have revealed that many unconventional muscles of the chuck and round have the potential to be marketed as steaks at the retail and restaurant level. One such muscle is the *serratus ventralis* (**SV**), a "fan-shaped" muscle found in the chuck of beef carcasses. The SV has been reported to vary significantly in tenderness randomly throughout the muscle. Also, previous studies have concluded that the SV is not ideal for use as single-muscle steaks, and aging the muscle did not improve tenderness. Marination and mechanical tenderization effects have not been studied in the SV. Therefore, the objectives of this study were to map the tenderness of the SV, examine the effects of marination and mechanical tenderization on the tenderness of this muscle, and evaluate USDA grade effects that might possibly exist.

Procedure

Sample Processing and Data Collection

The left and right side *serratus ventralis* muscles from eight USDA Choice and eight USDA Select carcass were obtained (32 total) from modified arm chucks, with the brisket and shoulder clod removed, that were shipped to the University of Nebraska meat laboratory. *Serratus ventralis* muscles were removed from the chucks. USDA Select carcass muscles were labeled 1 through 8 and left or right side (of the carcass), with the right side of odd-numbered *SV* being pumped and vacuum tumbled with a 12.5% solution containing beef broth, salt, phosphate, and rosemary extract; the left side of odd-numbered muscles were the control. In contrast, the left sides of even-numbered muscles were enhanced with the 12.5% solution, and the right sides were labeled as controls. USDA Choice carcass muscles were labeled 9-16, and followed the same enhancement procedures as the USDA Select muscles.

Both control and enhanced muscles were then blade tenderized once as a whole muscle. All muscles were then cut into halves by a medial cut from dorsal to ventral, splitting the muscles into anterior and posterior halves. The halves were then cut into steaks by lines from anterior to posterior creating 4 to 8 steaks per anterior and posterior halves. All steaks of the enhanced muscles were then blade tenderized individually. After blade tenderizing, all steaks were vacuum packaged and frozen. Odd-numbered steaks from each half were packaged together for the purpose of WBS determination.

Odd-numbered steaks were then cooked to an internal temperature of 158°F on Hamilton Beach grills, covered and allowed to cool to room temperature. After cooling, 0.50 inch diameter cores were removed parallel to the muscle fibers and finally sheared on an Instron Universal Testing Machine with a WBS attachment to obtain shear force values. Cores were taken approximately every inch from anterior to posterior throughout the steak and data was recorded. Cook time, beginning and end temperature, and cook loss were also recorded. Figure 1 shows how the muscles were cut

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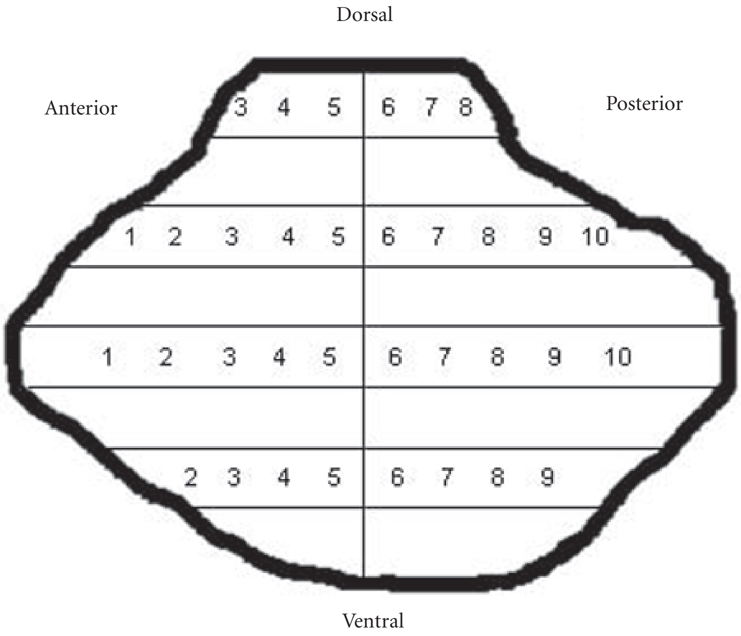

Figure 1. Fabrication of the *Serratus ventralis.*

in half, the steaks were fabricated, and approximately where the cores were obtained.

Statistical Analysis

An analysis of variance (**ANOVA**) using the GLIMMIX procedure of SAS (Version 9.1, Cary, N.C., 2002) was used to analyze the data. Data were blocked by treatment, grade, and steak position. Core location shear force data were analyzed as a split-split-split plot. When indicated significant by ANOVA ($P \leq 0.050$) main effects (grade, treatment, position, and location) were separated using the LSMEANS, DIFF, and LINES functions, while simple effects of interactions were generated using the LSMEANS, SLICE, and SLICEDIFF functions, respectively. Due to minimal observations from core position 1 and 10, those present were dropped from the analysis. Very few muscles produced more than six steaks per half; therefore, those observations were dropped from the analysis. Adjacent core positions were averaged together as follows: 2 and 3; 4 and 5; 6 and 7; 8 and 9.

Results

The WBS values varied sporadically throughout the muscles, partially due to heavy sheets of connective tissues and changing fiber direction. Enhanced samples produced significantly lower WBS values ($P < 0.0001$) than controls, decreasing WBS on average from 8.49 to 6.59 lb. USDA Choice samples showed significant differences between cores regardless of steak position ($P < 0.0001$), with the posterior portions requiring less force to shear. USDA Select muscles showed significant differences between cores only in steak 5 (most ventral) with the most anterior core position resulting in greater shear force values ($P < 0.0001$).

Table 1. Mean shear force values from USDA Choice *Serratus ventralis* muscles.

	Core Location			
Steak Position	2-3	4-5	6-7	8-9
1 (Dorsal)	7.47^{ab}	8.29^{a}	6.33^{b}	6.13^{b}
3 (Medial)	9.50^{a}	7.67^{b}	6.02^{c}	6.31^{bc}
5 (Ventral)	8.91^{a}	8.44^{a}	6.50^{b}	7.39^{ab}

^{a,b,c}Means in the same row with different superscripts differ.

Table 2. Mean shear force values from USDA Select *Serratus ventralis* muscles.

	Core Location			
Steak Position	2-3	4-5	6-7	8-9
1 (Dorsal)	7.83^{xy}	7.36	7.23	7.74
3 (Medial)	7.05^{y}	7.21	8.44	7.25
5 (Ventral)	9.59^{ax}	7.91^{b}	7.03^{b}	7.25^{b}

^{a,b}Means in the same row with different superscripts differ.
^{x,y}Means in the same column with different superscripts differ.

Implications

The *serratus ventralis* responds favorably to enhancement and multiple blade tenderization applications. It appears that steaks could be cut from the posterior portion of the *serratus ventralis*, as this end required less force to shear and WBS values were in the acceptable range. Consumer studies are needed to determine acceptability.

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[1] Lauren M. Grimes, graduate student; and Chris R. Calkins, professor, Animal Science, Lincoln

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

Factors that Influence Consumers' Overall Sensory Acceptance of Strip Steaks

Jennie M. Hodgen
Bethany M. Johnston
Blaine E. Jenschke
Kent M. Eskridge
Chris R. Calkins[1,2]

Summary

Multivariate analysis was used to determine demographic, knowledge, habits, and sensory preferences that influence a consumer's opinion about the acceptability of strip steaks from corn-fed, barley-fed, and grass-fed beef. Even with all the additional information, most consumers' final opinions about specific types of steaks are based on how they perceive the flavor, tenderness, and juiciness of the beef.

Introduction

Numerous studies have asked consumers to pick which type of meat they prefer through taste panels, pictures, and descriptions of production systems. One of our studies looked at how individual demographic and beef knowledge impacted sensory and purchasing habits of consumers when comparing strip steaks from corn-fed beef, barley-fed beef, and grass-fed beef (*2004 Nebraska Beef Report*, pp. 83-85). However, unlike the individual trait approach used in most studies including the one mentioned above, multiple factors going into the decision-making process to purchase beef and return to buy the same type of meat again. To gain a better understanding of the traits that makes a person prefer a specific type of beef, an approach using multiple variables together must be used. Therefore, this study was conducted to determine specific characteristics of consumers and consumer habits that can help predict overall satisfaction of U.S. beef consumers with beef steaks produced on corn-based, barley-based, and grass-based finishing diets.

Procedure

Data were obtained as described by *2004 Nebraska Beef Report*, pp. 83-85. Briefly, marbling scores, Warner-Bratzler Shear Force (WBSF), and chemical characteristics (moisture, ash, and fat percentages) were determined for strip steaks from domestic (corn-finished; n = 76), Canadian (barley-finished; n = 39), and Australian (grass-finished; n = 30) strip loins. Domestic steaks were paired with either Canadian or Australian steaks according to WBSF for consumer evaluations. Sensory evaluations on the paired steaks for tenderness, juiciness, flavor, and overall acceptability, Vickory auctions, a 10-question beef knowledge quiz, and a survey of demographic information, eating preferences, and purchasing behavior were collected from consumers in Denver, Colo. (n = 132) and Chicago, Ill. (n = 141).

After taste panels were performed, scores for overall acceptability were classified as like, neither like nor dislike, or dislike. A stepwise selection procedure was performed using the STEPDISC function in SAS (SAS Inst. Inc., Cary, N.C.) to select variables that would contribute to a discrimination function of consumers for overall acceptability of domestic, Australian, and Canadian beef steaks. This procedure reduces the variables to the ones that may play a role in consumers preference to the specific steak type. These selected variables were used in the DISCRIM procedure of SAS with the canonical function. Canonical correlations with a P-value lower than 0.05 were said to be significant. As illustrated in Figures 1-3, domestic and Canadian-produced steaks had two significant canonical correlations (an x and y axis) for overall acceptability while Australian-produced steaks only had one. This means preference for Australian, grass-fed steaks can be explained by one set of variables while the domestic, corn-fed and Canadian, barley-fed had two combinations of variables that explained why U.S. consumers liked or disliked those types of steaks. Variables that

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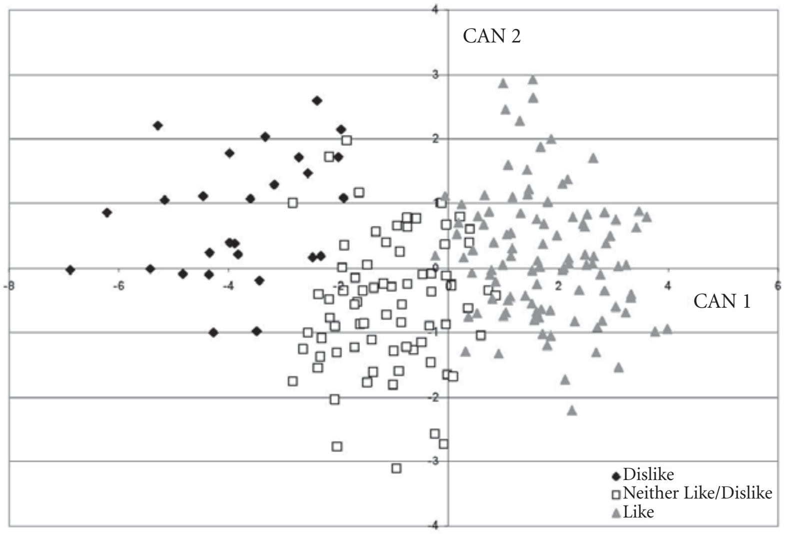

Figure 1. **Classification of USA consumers for overall sensory acceptability of domestic, corn-fed beef. CAN 1 is the first canonical correlation of tenderness and flavor. CAN 2 is the second canonical correlation of marital status, whether or not they used magazines to get information about beef, and preference for frozen meat. These two canonical correlations were used to group the consumers into three groups: like, neither like nor dislike, and dislike.**

contributed to each set of canonical correlations were chosen when the pre-set absolute value of 0.50 was reached.

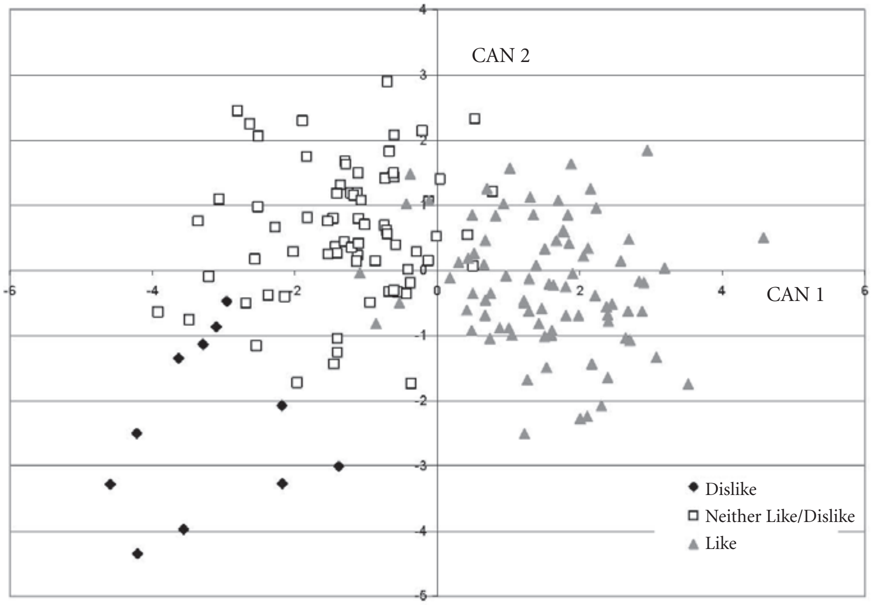

Figure 2. **Classification of USA consumers for overall sensory acceptability of Canadian, barley-fed beef. CAN 1 is the first canonical correlation of tenderness and flavor. CAN 2 is the second canonical correlation of Warner-Bratzler Shear Force and household size. These two canonical correlations were used to group the consumers into three groups: like, neither like nor dislike, and dislike.**

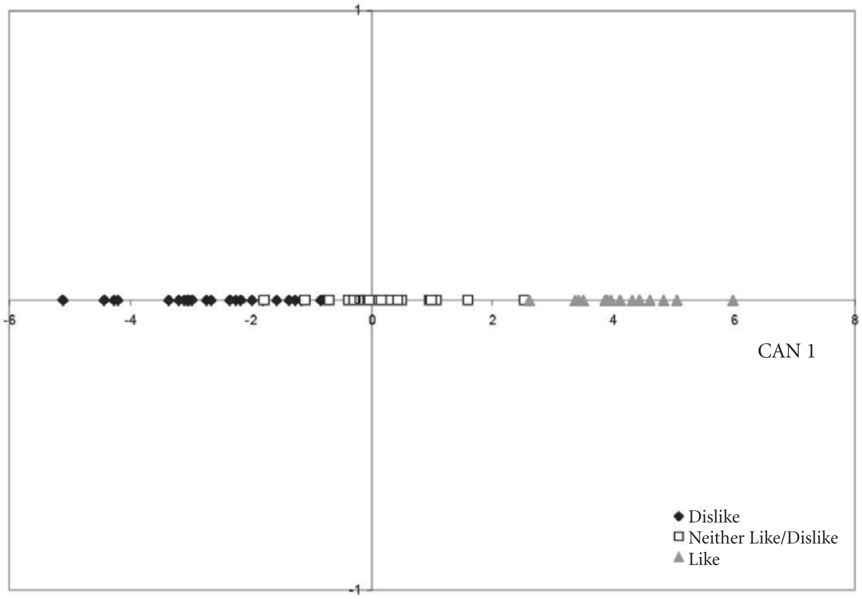

Figure 3. **Classification of USA consumers for overall sensory acceptability of Australian, grass-fed beef. CAN 1 is the canonical correlation of tenderness, flavor, and juiciness used to group the consumers into three groups: like, neither like nor dislike, and dislike.**

Results

Out of all of the questions asked and results from taste panels and lab assays, 17, 38, and 19 variables were used for classification for the domestic, Canadian, and Australian canonical discriminant analysis, respectively (Table 1). These variables for each specific type of steak (corn-finished, barley-finished, and grass-finished) were then used to try to group the consumers into one of three groups: they "like" that type of steak, they "dislike" that type of steak or they are "neutral" toward that type of steak. It should be noted there were almost double the amount of variables that go into the discrimination procedure to help predict how consumer's will prefer Canadian, barley-fed steaks compared to Australian, grass-fed and domestic, corn-fed steaks.

Acceptability of domestic, corn-fed beef had two canonical correlations. Consumers' ratings of tenderness and flavor (canonical correlation 1- CAN1 on the x-axis) as well as marital status, whether or not they used magazines to get information about beef, and preference for frozen meat were the main factors that influenced overall acceptability of domestic steaks (canonical correlation 2- CAN2 on the y-axis) (Figure 1). The figure shows the distinct groupings of consumers that liked, disliked, or were neutral toward the domestic, corn-fed beef. The right side of the x-axis illustrates a higher rating of tenderness and flavor for the corn-fed beef as scored by the panelists during the taste panel portion of the study. The higher value on the y-axis demonstrated, the more likely the individual had been married, did not use magazines to gain information about beef, and had a lower preference for frozen beef. When the first canonical correlation and the second one were plotted, the statistical program determined which category into which the consumer likely fell — like, dislike, or neither like nor dislike. Canadian steak acceptability classification was also based on two canonical correlations of tenderness and flavor (canonical correlation 1- CAN1 on the x-axis) along with a slight decrease in WBSF and larger household sizes improving the acceptability (canonical correlation 2- CAN2 on the y-axis) (Figure 2). Unlike the domestic, corn-fed beef that was separated mainly based on the first canonical correlation of tenderness and flavor on the x-axis, the consumers that "liked" and were "neutral" toward Canadian, barley-fed steaks were separated by tenderness and flavor, but the consumer's that "neither liked nor disliked" or "disliked" were discriminated into

Table 1. Selection variables for discriminant analysis for corn-finished, barley-finished, and grass-finished steaks.

Corn-Finished Domestic	Barley-Finished Canadian	Grass-Finished Australian
Sensory tenderness	Sensory tenderness	Sensory tenderness
Sensory flavor	Sensory flavor	Sensory flavor
Marital status	Marbling score	Sensory juiciness
Education	WBSF	Gender
Employment status	Fat content	Income
Type of meat most often consumed at home	Ash content	Household size
Type of meat most often consumed at restaurant	Moisture content	Raised in Colo., Ill., or another state
Degree of doneness preference	Gender	Marinate/Season steaks
Beef information learned from family	Household size	Frequency meat prepared at home
Beef information learned from magazines	Marital status	Beef cut preference
Purchasing importance of knowing who produced the beef	Employment status	Importance of COOL on hamburger/ground beef
Purchasing importance of good visual presentation of beef	Age	Location beef is purchased
Purchasing importance of beef being frozen	Type of meat preferred	Average value of meat purchases
Preference of COOL labeled beef	Frequency meat prepared at home	Purchased beef product after unsatisfactory experience
Amount willing to pay for COOL hamburger	Cooking method for steaks	Beef information learned from family
Importance of COOL on steaks	Degree of doneness preference	Beef information learned from cookbooks
Importance of COOL on hamburger/ground beef	Main factor for buying meat	Importance of COOL on steaks
	Average pounds of meat purchases	Purchasing importance of production methods
	Average value of meat purchases	Purchasing importance of beef being frozen
	Beef palatability satisfaction	
	Grade of beef purchased	
	Beef information learned from magazines	
	Beef information learned from meat counter personnel	
	Beef information learned from grocers' pamphlets	
	Type of beef purchased to prepare at home	
	Purchasing importance of knowing who produced the beef	
	Purchasing importance of beef freshness and tenderness	
	Purchasing importance of beef quality grade and marbling	
	Purchasing importance of food safety inspection	
	Purchasing importance of beef production systems	
	Influence of beef packaging information	
	Raised in Colo., Ill., or another state	
	Importance of COOL on roasts, pre-prepared, and processed meats	
	Change selection criteria after unsatisfactory beef eating experience	

their proper groups because of the WBSF and how many people were in their households. Results from Australian steak acceptability revealed classification was based on one canonical correlation of flavor, tenderness, and juiciness (canonical correlation 1- CAN1 on the x-axis) (Figure 3). U.S. consumers can be grouped on how they will respond to Australian, grass-fed beef by the palatability traits without significant contribution from their demographics, beef knowledge, or beef buying habits.

Using cross-validation, this analysis correctly placed consumers' overall acceptability responses into the three groups (like, neither like nor dislike, or dislike) approximately 92.2%, 83.5%, and 91.7% for domestic, Canadian, and Australian steaks, respectively. Consumers' ratings of overall acceptability were based mainly on palatability issues, but other demographic and social factors may also play a role in satisfaction of strip steaks.

Continued efforts are being made to investigate factors that play a role in purchasing habits which have larger impact on marketing plans for specific niche markets in the beef industry. However, based on this analysis despite differences in education, knowledge, feelings about the environment, and other demographics, most people base their overall eating satisfaction on how they rate the palatability of the steak.

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[1] Jennie M. Hodgen, former graduate student; Bethany M. Johnston, former graduate student; Blaine E. Jenschke, research technician; Kent M. Eskridge, professor, Statistics, Lincoln. Chris R. Calkins, professor, Animal Science, Lincoln.

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

Analysis of Veal Shoulder Muscles for Chemical Attributes

Gary A. Sullivan
Chris R. Calkins
D. Dwain Johnson
Brian G. Sapp[1,2]

Summary

The value of wholesale veal cuts varies; the rack, loin, and leg demand a premium price, while the shoulder brings little more per pound than the live animal. This study characterized the chemical properties of muscles from the veal shoulder for the potential to upgrade their value. The m. infraspinatus *and* m. rhomboideus *fell in the intermediate or desirable groups for all traits. All nine muscles show promise in the ability to increase value.*

Introduction

Veal muscles from the loin, rack and leg are being fully utilized using conventional culinary applications and therefore sell for a premium; conversely, few applications are commonly applied to shoulder muscles thus causing a lower-value primal. The objective of this study was to characterize the shoulder muscles, using their chemical properties, for the potential to upgrade their value.

Procedure

Eighteen veal shoulders from separate animals were purchased from two veal packers and shipped to the University of Florida Meat Processing facility for muscle fabrication and isolation of the *m. complexus*, *m. pectoralis profundus*, *m. infraspinatus*, *m. rhomboideus*, *m. serratus ventralis*, *m. splenius* , *m. supraspinatus*, *m. teres major,* and *m. triceps brachii*. Muscles were denuded and a 4 g sample was taken from each muscle to evaluate expressible moisture. Vacuum packaged samples were shipped to the University of Nebraska–Lincoln Loeffel Meats Laboratory and aged 13 days from slaughter. The muscles were evaluated for color and ground to obtain a representative sample. This ground sample was then frozen and powdered using liquid nitrogen and a Waring Blender.

Expressible moisture/water holding capacity (WHC) was measured 4 days postmortem by placing a 2 g lean sample in a paper thimble, centrifuging, and weighing to determine moisture loss.

Color values were measured using a Hunter Lab® Mini Scan XE with a 1 in port using a series of three measurements to measure L*, a*, and b* using illuminant A and a 10^{o} standard observer on samples that were allowed to bloom for 30 minutes.

Proximate composition for moisture and ash was determined using a LECO Thermogravimetric Analyzer-601. Fat content was determined using the Soxhlet ether extraction AOAC procedures.

Muscle pH was measured by preparing slurry of 10 g of sample and 90 mL of water using a combination bulb pH probe and temperature probe.

Means and separations were completed using PROC MEANS, LSMEANS and DIFF processes of PROC GLIMMIX functions of SAS.

Results

All chemical traits measured showed a significant muscle effect ($P < 0.008$). The *m. teres major* was numerically highest in expressible moisture (lowest WHC) at 39.53% and was significantly different than all but two muscles ($P < 0.044$). Most of the veal muscles were quite lean. The *m. serratus ventralis* had the highest fat content at 5.04% ($P = 0.043$) followed by the *m. complexus* at 4.41% ($P = 0.003$) with the remaining muscles ranging from 2.28-3.26%. Higher fat samples tended to have lower moisture values. The *m. serratus ventralis* had the lowest moisture content (75.58%) and was significantly lower than all but *m. complexus* ($P > 0.05$).

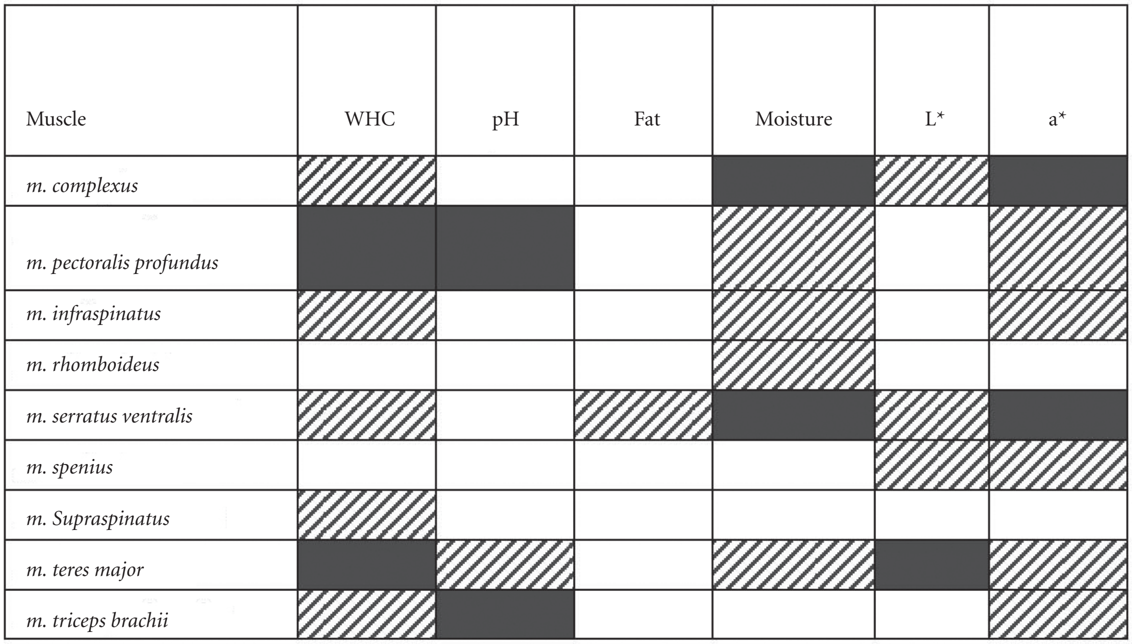
When measured for color, the *m. supraspinatus* was the lightest (highest L*) muscle ($P = 0.023$). The *m. serratus ventralis* was considered the least desirable for redness and was significantly redder than all but one muscle ($P > 0.05$). Of the nine muscles, only two, the *m. pectoralis profundus* and *m. triceps brachii*, were least desirable for pH at 5.67 and 5.69 respectively while *m. infraspinatus* was most desirable with a pH of 5.99 ($P > 0.05$). Muscles with higher pH have better WHC.

The *m. infraspinatus* and *m. rhomboideus* were statistically superior ($P < 0.05$) in chemical traits compared to muscles with the least desirable values. Conversely, the *m. pectoralis profundus* was statistically similar to the least desirable value ($P > 0.05$) for three of the traits. Figure 1 graphically displays the data and is broken into desirable, intermediate and undesirable, white, striped

Table 1. Mean values for chemical traits of veal muscles.

Muscle	WHC %	Moisture %	Fat %	Ash %	pH	L*	a*	b*
m. complexus	37.47^{bcd}	75.82^{de}	4.41^{d}	1.04^{ab}	5.86^{bc}	48.81^{cd}	27.88^{cd}	22.79^{ab}
m. pectoralis profundus	38.56^{cd}	76.34^{cd}	2.73^{abc}	1.16^{de}	5.67^{e}	49.22^{bc}	26.16^{ab}	19.50^{e}
m. infraspinatus	36.25^{ab}	76.86^{bc}	3.26^{c}	1.00^{a}	5.99^{a}	50.00^{b}	26.20^{ab}	21.17^{cd}
m. rhomboideus	35.20^{a}	76.88^{b}	2.54^{ab}	1.12^{cd}	5.80^{cd}	49.76^{bc}	25.82^{ab}	20.10^{de}
m. serratus ventralis	36.65^{abc}	75.58^{e}	5.04^{e}	1.03^{ab}	5.89^{b}	48.69^{cd}	28.05^{d}	23.46^{a}
m. splenius	35.89^{ab}	77.47^{a}	2.39^{a}	1.07^{bc}	5.86^{bc}	48.80^{bcd}	26.65^{b}	20.70^{cde}
m. supraspinatus	37.23^{abc}	77.33^{ab}	2.76^{abc}	1.16^{de}	5.85^{bc}	51.37^{a}	25.32^{a}	20.11^{de}
m. teres major	39.53^{d}	76.21^{d}	3.06^{bc}	1.16^{de}	5.75^{d}	47.83^{d}	26.49^{b}	20.31^{de}
m. triceps brachii	37.19^{abc}	77.16^{ab}	2.28^{a}	1.21^{e}	5.69^{e}	49.61^{bc}	26.77^{bc}	21.77^{bc}

$^{a\text{-}e}$Means within a given column with common superscripts do not differ significantly ($P > 0.05$).



Muscle	WHC	pH	Fat	Moisture	L*	a*
m. complexus	▨	□	□	■	▨	■
m. pectoralis profundus	■	■	□	▨	□	▨
m. infraspinatus	▨	□	□	▨	□	▨
m. rhomboideus	□	□	□	▨	□	□
m. serratus ventralis	▨	□	▨	■	▨	■
m. spenius	□	□	□	□	▨	▨
m. Supraspinatus	▨	□	□	□	□	□
m. teres major	■	▨	□	▨	■	▨
m. triceps brachii	▨	■	□	□	□	▨

WHC	pH	Fat %	Moisture %	l*	a*
W = < 36%	W = > 5.8	W = < 5%	W = > 77%	W = > 49	W = < 26
S = 36-38%	W = 5.7-5.8	S = 5-7%	S = 76-77%	S = 48-49	S = 26-27
G = > 38%	G = < 5.7	G = > 7%	G = < 76%	G = < 48	G = > 27

Figure 1. Graphic representation of the traits of veal muscles where white (W) is desirable, striped (S) is intermediate, and dark gray (G) is undesirable.

and gray, respectively, for each trait. Muscles that are desirable or intermediate for all traits are *m. infraspinatus*, *m. rhomboideus*, *m. splenius* , and *m. supraspinatus* and consequently show much promise to be upgraded. The *m. triceps brachii* had an undesirable grouping for only pH while *m. complexus*, *m. pectoralis profundus*, *m. serratus ventralis*, *m. teres major* had two traits each that were classified as undesirable. Yet from a chemical profile perspective, all of the muscles possessed some favorable characteristics and in the proper culinary application still could be utilized as a value-added muscle.

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[1] Gary A. Sullivan, graduate student; and Chris R. Calkins, professor, Animal Science, Lincoln. D. Dwain Johnson, professor, Animal Science; and Brian G. Sap, graduate student, University of Florida, Gainseville.

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

Effects of Aging on Veal Shoulder Muscles

Gary A. Sullivan
Chris R. Calkins
D. Dwain Johnson
Brian G. Sapp[1,2]

Summary

Six muscles were attained from 36 paired veal shoulders and each pair was assigned to one of six aging comparisons. After aging, muscles were cooked and evaluated using Warmer Bratzler shear force. The largest decline in shear force occurred during comparison of 3 and 10 days aging with additional improvements found up to 24 days. The m. infraspinatus was the most tender muscle; the m. supraspinatus *was the toughest. The* m. serratus ventralis *had the greatest response to aging and the* m. pectoralis profundus *(brisket) had the least.*

Introduction

The veal industry strives to meet customer demands for “fresh, never frozen product”’ and consequently much veal is sold without a significant postmortem aging period. Much research has been and continues to study the effects of aging in beef, but little has looked at the effects on veal. A recent study was completed to determine physical and sensory characteristics of the veal shoulder to determine possibilities to add value to the veal shoulder (Sullivan *et al.*, *2008 Nebraska Beef Report* pp. 112-113). This purpose of this study was to determine the effects of aging time on tenderness of veal shoulder muscles.

Procedure

Thirty-six paired veal shoulders from two plants were fabricated and six muscles were attained from each, *m. complexus* (**COM**), *m. pectoralis profundus* (**DEP**), *m. infraspinatus* (**INF**), *m. serratus ventralis* (**SEV**), *m. supraspinatus* (**SUP**) *and m. triceps brachii* (**TRB**). Each pair of muscles was assigned to one of six comparison treatments from four aging periods: 3, 10, 17, and 24 days. Due to weather delaying a shipment, muscles from one plant that were assigned to 3-day treatment were shifted to 5-day. Upon arriving at Loeffel Meat Laboratory at the University of Nebraska–Lincoln, muscles were stored at 38°F for the defined aging period and then frozen at -8°F. Muscles were thawed 24 hours and paired muscles were cooked side-by-side on Hamilton Beach HealthSmart Electric Indoor grills. Samples were allowed to cool for 4 hours at 38°F. Six-1/2 in cores were taken from each sample and Warner-Bratzler shear force (WBS) was determined using an Instron Universal Testing Machine (Instron Corp. Canton, Mass.). Treatment allocation was completed in a balanced incomplete block design and analyzed using the LSMEANS function of PROC GLIMMIX in SAS (SAS Inst. Inc, Cary, N.C.). Carcass within plant and side within carcass and plant were treated as random effects.

Results

Muscle and aging main effects ($P < 0.001$) for both traits were significant. The INF was the most tender muscle and the SUP was the toughest. The mean WBS declined with aging. Muscles aged 3 days was statistically tougher than 10 days ($P < 0.05$) and muscles aged 24 days had statistically lower WBS than all period but 17 days aging ($P < 0.05$). The 3- to 10-day showed the greatest decline in shear force. There were no statistical differences found between the aging periods of the COM, DEP, and TRB ($P > 0.05$) but it should be noted there was a general numerical decline with aging for these muscles. At 3 days, the INF was tougher than 5, 17, and 24 days aging ($P < 0.05$). The SEV had a higher WBS at 3 days than all other aging periods ($P < 0.05$). The SUP at 3 days was only statistically different than 24 days aging ($P = 0.004$). Due to the lower sample numbers when looking at the muscle specific effects, there were little to no differences in aging periods but when evaluating the overall aging effects, improvements could be made in increasing aging from 3 days to 10 days or longer. The veal industry could improve the overall tenderness of veal shoulder muscles and consequently improve eating characteristics by introducing a postmortem aging period.

Table 1. Mean WBS (lbs) values by muscle and by aging period.

Muscle	WBS	Aging	WBS
INF	6.03^{a}	3	8.12^{d}
TRB	6.91^{b}	5	7.70^{cd}
SEV	7.59^{c}	10	7.48^{bc}
COM	7.81^{cd}	17	7.26^{ab}
DEP	8.05^{d}	24	7.02^{a}
SUP	8.78^{e}		

$^{a-e}$Means within a given column with common superscripts do not differ significantly ($P > 0.05$).

Table 2. Mean WBS (lbs) values for each muscle by aging period.

Aging	COM	DEP	INF	SEV	SUP	TRB
3	8.05^{a}	8.32^{a}	7.00^{b}	8.91^{b}	9.42^{b}	7.11^{a}
5	8.36^{a}	7.85^{a}	5.59^{a}	7.70^{a}	9.33^{b}	7.33^{a}
10	7.48^{a}	8.03^{a}	6.16^{ab}	7.57^{a}	8.80^{ab}	6.89^{a}
17	7.50^{a}	8.12^{a}	5.85^{a}	7.02^{a}	8.38^{ab}	6.75^{a}
24	7.66^{a}	7.94^{a}	5.57^{a}	6.75^{a}	7.96^{a}	6.49^{a}

$^{a-b}$Means within a given column with common superscripts do not differ significantly ($P > 0.05$).

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[1] Gary A. Sullivan, graduate student; and Chris R. Calkins, professor, Animal Science, Lincoln. D. Dwain Johnson, professor, Animal Science, University of Florida, Gainesville. Brian G. Sapp, graduate student, University of Florida, Gainesville.

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

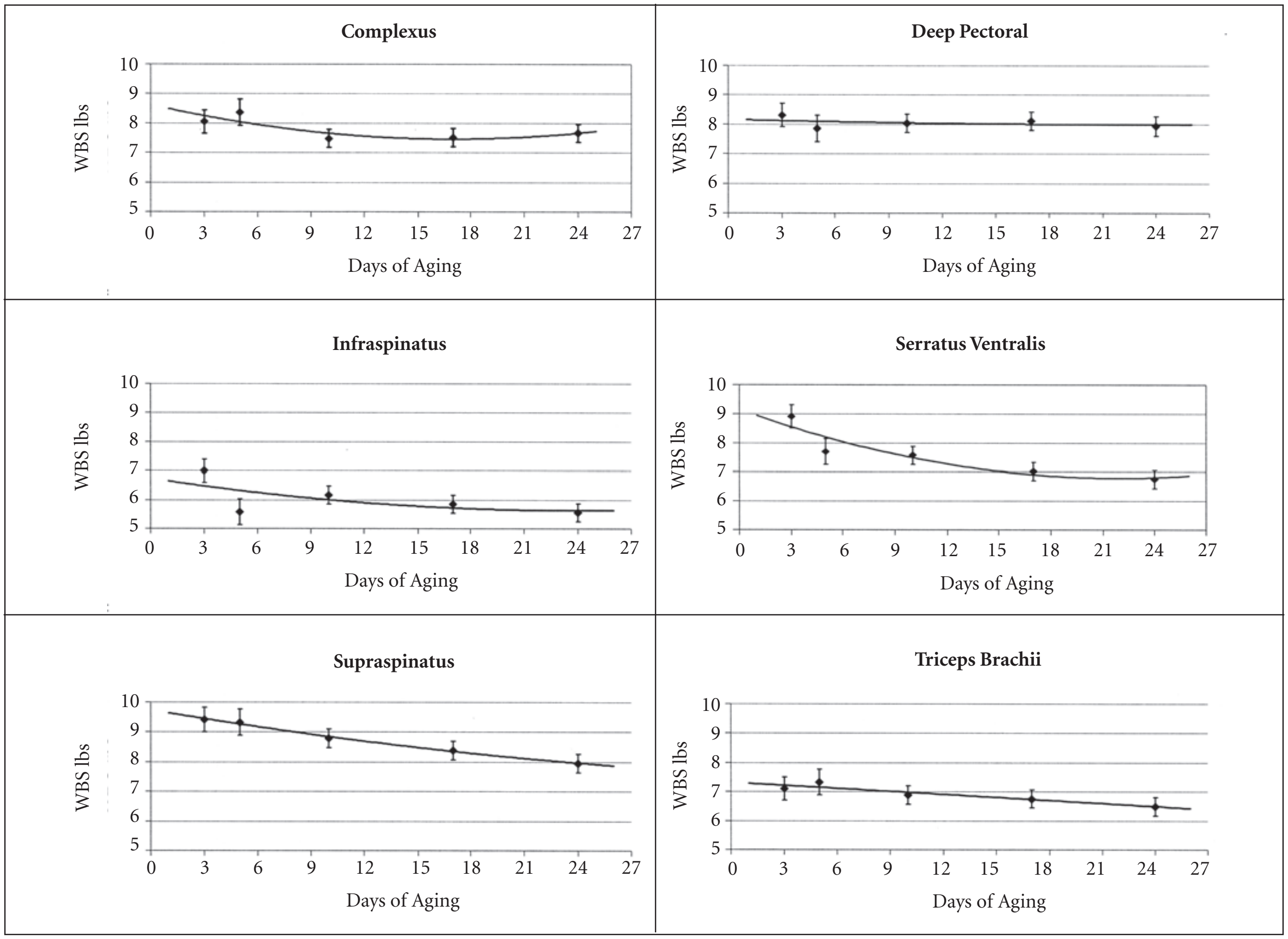

Figure 1. Aging effects on individual muscles.

Tenderness, Sensory, and Color Attributes of Two Muscles from the Beef Knuckle

Blaine E. Jenschke
Brittni J. Swedberg
Chris R. Calkins[1,2]

Summary

Twelve USDA Choice and twelve USDA Select quadriceps muscles were fabricated traditionally or the seams it shares with the top and bottom round were separated pre-rigor to test the effect of pre-fabrication on tenderness, sensory, and color. Results from this study indicated treatment had minimal effects on quality attributes. The proximal portions of the knuckle were more tender, lighter in color, and more red when compared to the distal portions, although all were reasonably tender. Pre-fabrication can be conducted without detriment to product quality.

Introduction

The Uniform Retail Meat Identity Standards were developed to standardize meat labeling at the retail sector. Included in the labels are species, primal, and the retail cut name. According to these standards, the knuckle would be labeled as a Beef Round Sirloin Tip Center Roast. The Institutional Meat Purchasing Specifications of the USDA classify the knuckle as originating from the round under current fabrication practices used in the United States. However, if the quadriceps (**QUAD**), which consists of the knuckle and ball tip under current fabrication procedures, is removed prior to the round/loin separation, then the knuckle is classified as being from the sirloin and would be higher in value. If no quality is acceptable for both (tenderness, sensory, and color) knuckles and ball tips, the value of the knuckle could be increased. Additionally, discrepancies in labeling could be resolved.

Pre-fabrication of the knuckle might ease removal of this cut after chilling. If so, removal of the intact knuckle prior to cutting the round would preserve the sirloin designation under current labeling guidelines. Therefore, the objectives of our study were to document intramuscular differences in tenderness and objective color within the two major muscles of the knuckle and determine if separating pre-rigor the natural seams shared by the quadriceps and the top and bottom round pre-rigor altered tenderness and color.

Procedure

Twenty-four animals were selected for this study (12 USDA Choice and 12 USDA Select) from a commercial abbattoir. Right sides were alternatively assigned to the innovative fabrication procedure (**HOT**) while the other side was traditionally fabricated (**COLD**). The HOT treatment was a prerigor separation of the natural seams between the QUAD and the top and bottom round while attachments to the femur were maintained. Following a 2-day chilling period, intact QUAD muscles from both treatments were removed prior to the sirloin/round break, vacuum-packaged, and shipped to the Loeffel Meat Laboratory at the University of Nebraska. After a 7-day aging period, the *M. Rectus femoris* (**REC**) and *M. Vastus lateralis* (**VAL**) were isolated and cut into 1 in steaks from the proximal end of the muscle (Figure 1). Steaks were then allowed to bloom for 1 hour before objective color was measured. Following color measurement, steaks were vacuum-packaged and frozen until sensory and shear force measurements were conducted.

A Hunter Lab® Mini Scan XE Plus colorimeter containing a 1 inch port with a 10° standard observer and illuminant A was used. Three random measurements were taken on each steak, and the mean of the three measurements was reported.

Starting from the proximal end of the QUAD, the 2nd, 4th, and 6th steak were used for sensory analysis. 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. Once the internal temperature reached 95°F, the steak was turned once. The steak was then cut into 0.5 in x 0.5 in x 1.0 in cubes and served warm to 6 to 8 panelists, approximately 5 minutes post cooking. Six samples, identified using three-digit codes, were served on each day. Eight-point descriptive attribute scales (Muscle Fiber Tenderness: 1 = extremely tough,

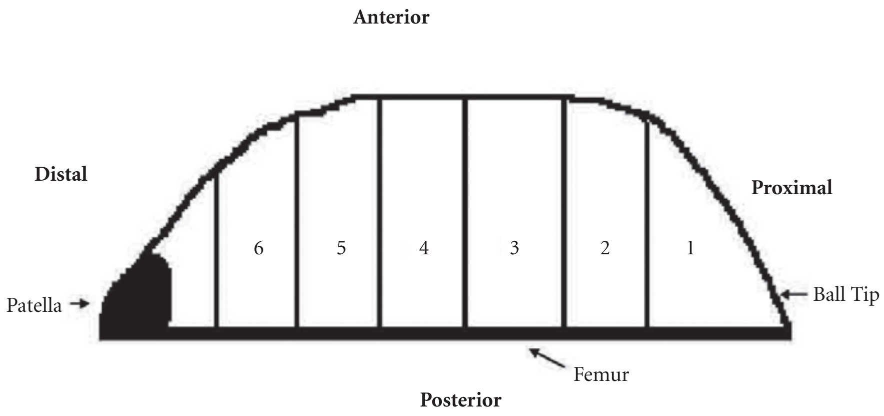

Figure 1. Anatomical directions of the quadriceps muscle.

Table 1. Treatment by position by location interaction for Warner-Bratzler shear force values of the *M. Rectus femoris*.[ab]

	Treatment, Location					
Position	Cold, Anterior	Cold, Middle	Cold, Posterior	Hot, Anterior	Hot, Middle	Hot, Posterior
1	3.12	3.45	3.57^{d}	2.85^{d}	2.94^{d}	3.22^{e}
3	3.14^{z}	3.44^{z}	3.99^{dy}	3.21^{dz}	3.21^{dz}	4.36^{cy}
5	3.34^{z}	3.98^{y}	4.25^{cy}	4.02^{cy}	4.17^{cy}	3.79^{dy}
SEM	0.29	0.32	0.30	0.29	0.37	0.31

[a]Treatment by position by location interaction P-value = 0.026

[b]Cold = conventional processing; Hot = pre-fabrication

[cde]Values containing the same superscript within a column do not differ statistically ($P > 0.050$).

[yz]Values containing the same superscript within a row do not differ statistically ($P > 0.050$).

Table 2. Grade by treatment interaction of the *M. Rectus femoris* for the sensory attribute tender.[abc]

Treatment	USDA Choice	USDA Select
Hot	5.63^{e}	5.84
Cold	5.91^{d}	5.69
SEM	0.14	0.13

[a]Grade by treatment interaction P-value = 0.016.

[b]1 = Extremely Tough; 8 = Extremely Tender.

[c]Cold = conventional processing; Hot = pre-fabrication.

[de]Values containing the same superscript within a column do not differ statistically ($P > 0.050$).

Table 3. Grade by position interaction of the *M. Rectus femoris* for the sensory attribute tender.[ab]

Position	USDA Choice	USDA Select
2	6.04^{c}	6.26^{c}
4	5.72^{c}	5.84^{d}
6	5.54^{d}	5.19^{e}
SEM	0.14	0.13

[a]Grade by position interaction P-value = 0.050.

[b]1 = Extremely Tough; 8 = Extremely Tender.

[cde]Values containing the same superscript within a column do not differ statistically ($P > 0.050$).

Table 4. Position by location interaction for Warner-Bratzler shear force values of the *M. Vastus lateralis*.[a]

Position	Anterior	Posterior
1	4.33^{by}	4.87^{bz}
3	5.18^{c}	5.10^{b}
5	5.58^{d}	5.69^{c}
SEM	0.25	0.25

[a]Position by location interaction P-value = 0.043.

[bcd]Values containing the same superscript within a column do not differ statistically ($P > 0.050$).

[yz]Values containing the same superscript within a row do not differ statistically ($P > 0.050$).

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.

Beginning with the proximal end of each muscle, the 1st, 3rd, and 5th steaks were used for shear force measurement. After cooking, steaks were covered and allowed to cool at room temperature for 4 hours. Following the cooling period, 6 to 9 (0.5 in diameter) cores were removed parallel to the muscle fibers and core location was recorded. Cores were sheared on an Instron Universal Testing Machine with a Warner-Bratzler shear attachment set at a crosshead speed of 9.84 in/minute and equipped with an 1102 lb load cell.

An analysis of variance (**ANOVA**) using the GLIMMIX procedure of SAS (Version 9.1, Cary, N.C., 2002) was used to analyze the data. When indicated significant by ANOVA ($P \leq 0.050$) main effects (grade, treatment, location, and position) were separated using the LSMEANS, DIFF, and LINES functions, while simple effects of interactions were generated using the LSMEANS, SLICE, and SLICEDIFF functions, respectively.

Results

Warner-Bratzler shear force and sensory analysis

A significant ($P = 0.026$) treatment by position by location interaction for shear force of the REC was noted (Table 1). Regardless of location (anterior to posterior), there were significant ($P < 0.050$) positional (proximal to distal) differences in muscles receiving the HOT treatment. For all HOT-treated muscles, tenderness decreased moving from the proximal to distal position. A similar trend was noted for traditionally fabricated muscles and the posterior location which was closest to the bone. Regardless of treatment or location, there were no tenderness differences between the most proximal positions. However, within position 3 (regardless of treatment), the posterior location of the muscle was the toughest. Within position 5 (most distal) the cold and anterior treatment combination was the most tender. Grade had no effect on shear force values ($P = 0.340$). Generally, all of the shear force values were in the acceptable range.

Sensory analysis revealed a significant ($P = 0.016$) grade by treatment interaction and grade by position ($P = 0.050$) interaction for sensory tenderness (Tables 2 and 3). Within each treatment, there were no differences among USDA grades ($P \geq 0.286$). Moreover, there were no differences ($P = 0.161$) between treatments among USDA Select muscles. However, within USDA Choice muscles, the COLD treatment required slightly more force to shear

(Continued on next page)

(0.62 lb), but was significantly more tender when compared to the HOT treatment ($P = 0.021$). Regardless of position, there were no significant grade effects ($P \geq 0.136$). Within each USDA grade, tenderness significantly decreased proximally to distally ($P \leq 0.027$) which likely corresponds to the significant ($P < 0.001$) increase in connective tissue amount moving from the proximal to distal aspect. Off-flavor intensity was lower in the distal aspect ($P = 0.001$), while juiciness was not affected by grade, treatment, position, or location.

Neither grade ($P = 0.227$) nor treatment ($P = 0.289$) had an effect on the shear force values of the VAL. However, a significant ($P = 0.043$) position by location interaction was observed (Table 4). Within position 1 (most proximal), the anterior portion of the VAL was significantly ($P = 0.003$) more tender when compared to the posterior aspect. No location differences were observed within position 3 and 5 ($P \geq 0.508$). Within both the anterior and posterior location, tenderness decreased moving from the proximal to the distal aspect of the VAL.

Sensory analysis revealed similar findings in which tenderness significantly ($P < 0.001$) decreased moving from the proximal to distal portion of the muscle. A significant ($P = 0.040$) grade by treatment by position interaction for connective tissue amount was observed. Within all treatment and grade combinations (except Choice and COLD), connective tissue amount increased moving from the proximal to the distal aspect of the VAL. Within position 4, more connective tissue was detected in the COLD treatment (regardless of grade) when compared to the HOT treatment. Juiciness was not affected by grade ($P = 0.219$), but a significant ($P = 0.045$) treatment by position interaction was observed. No positional differences were noted among the COLD treatment, but within the HOT treatment, juiciness decreased when moving from the proximal towards the distal aspect of the VAL. Additionally, off-flavor intensity was highest in the distal position of the SIDE. The tenderness and sensory properties of the VAL were generally less desirable than the REC.

CIE colorspace values

M. Rectus femoris. Grade, treatment, and position significantly ($P < 0.001$) affected L* (lightness) values of the REC. For all grade and treatment combinations, muscles were darker when moving towards the distal portion. Within positions 2, 3, and 4, USDA Select muscles that received the HOT treatment were significantly darker when compared to USDA Select muscle receiving the COLD treatment. Among USDA Choice steaks and all positions, no significant treatment differences were observed. A significant ($P = 0.021$) grade by treatment effect for a* (redness) values was observed. Within both the HOT and COLD treatments, USDA Choice steaks were numerically ($P = 0.161$) redder when compared to USDA Select steaks. However, within the USDA Choice grade, the HOT-treated steaks were numerically redder; while the COLD treated steaks were numerically redder among select steaks. No grade or treatment effects were observed for b* (yellowness) values.

M. Vastus lateralis. The proximal aspect of the SIDE was significantly darker, redder and more yellow in color ($P < 0.001$). The distal portion of the SIDE was the lightest and least red and yellow. Grade and treatment also affected L* values as indicated by a significant ($P < 0.001$) interaction. There were no treatment differences among USDA Choice steaks, but USDA Select steaks that received the HOT treatment were significantly darker ($P < 0.001$). Additionally, the HOT treatment tended ($P = 0.068$) to be less red and significantly ($P = 0.001$) less yellow.

Implications

Results from this study indicate that while the distal portions of the REC and VAL statistically have greater WBSF and sensory tenderness values when compared to the proximal positions, the distal portion of the REC and VAL are still relatively tender. Therefore, these portions of the knuckle could be fabricated as sirloin which would increase the value of the beef carcass. Pre-fabrication has few negative effects on tenderness and color.

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[1] Blaine E. Jenschke, research technician; Brittni J. Swedberg, former student worker; and Chris R. Calkins, professor, Animal Science, Lincoln.

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

Characteristics of Beef Finished on Wet Distillers Grains with Varying Types and Levels of Roughage

Blaine E. Jenschke
Josh R. Benton
Chris R. Calkins
Timothy P. Carr
Kent M. Eskridge
Terry J. Klopfenstein
Galen E. Erickson[1,2]

Summary

Beef knuckles (n = 160) were obtained from source-verified cattle finished on 30% wet distillers grains plus solubles enriched with varying levels of alfalfa hay, corn silage, or corn stalks based on NDF. Our objectives were to determine if roughage inclusion, in conjunction with wet distillers grains plus solubles and cattle location affects beef flavor. Data from this study indicate type and level of roughage inclusion and cattle location have minimal effects on fatty acid profiles and sensory properties of the M. Rectus femoris. However, individual fatty acids of subcutaneous and intramuscular fat were significantly correlated with liver-like off flavor.

Introduction

Even with numerous feedlots in the Midwest finishing cattle on distillers grains, little research has been published on the effects of distillers grains on carcass quality. Recent research in our laboratory has concentrated on the effects of wet distillers grains plus solubles (**WDGS**) on meat quality. Specifically, we have shown that finishing cattle with 30% WDGS increases polyunsaturated fatty acids (**PUFA**) which in turn can comprise the color of some muscles under retail display. The objectives of this research were to investigate effects of varying roughage sources and types, in addition to cattle source, on meat quality characteristics of the *M. Rectus femoris* (**REC**) with particular interest in liver-like off flavor.

Procedure

Three hundred eighty-five crossbred steer calves of known birth ranch, approximately 7 months of age, were purchased from sale barns in South Dakota (**SD**) or Nebraska (**Neb.**), implanted with Syonvex-C, and grazed on corn stalks for 45 days prior to being placed in their respective feeding treatments. The steers were then weighed, implanted with Revalor-S, stratified to treatment by weight, and randomly assigned a pen. Cattle were on the finishing diets for 139 days. Dietary treatments included of a control, which contained a mixture of dry-rolled and high-moisture corn fed at a 1:1 ratio and 30% WDGS on a DM basis. Additionally, alfalfa hay was included in the diet at either 4% or 8% in addition to 30% WDGS. Diets containing low and high levels of both corn silage and corn stalks were balanced to provide equal levels of NDF based on the diets containing low and high amounts of alfalfa, respectively. This resulted in 6% or 12% corn silage and 3% or 6% corn stalks. For the final 28 days, all steers were supplemented (200 mg/steer) with Optaflexx. On day 140, cattle were harvested at a local commercial facility. Following grading, knuckles were removed, vacuum-packaged and shipped to the Loeffel Meat Laboratory at the University of Nebraska–Lincoln. After a 7-day aging period, the REC was isolated, cut into 1 in thick steaks, vacuum packaged, and frozen at -112°F until appropriate analyses could be conducted. The most proximal steak was minced, frozen in liquid nitrogen, pulverized, and used for chemical analysis while the most distal steak was used for trained sensory analysis.

Steaks were cooked to an internal temperature of 158°F on an electric broiler. Internal temperature was monitored with a digital thermometer and a type T thermocouple. When the internal temperature reached 95°F, the steak was turned once. The steak was then cut into 0.5 in x 0.5 in x 1.0 in cubes and served warm to 6-8 trained panelists, approximately 5 minutes post cooking. 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. Off-flavors were rated using a 15-point intensity scale (0 = extremely bland; 15 = extremely intense).

Moisture and ash (expressed as percentages) were quantified using a LECO Thermogravimetric Analyzer while percent fat was determined using an ether extraction method. Fatty acids were extracted using a 2:1 chloroform:methanol solution and methylated using boron fluoride-methanol. Oxidation-reduction potential (**ORP**) was determined using an epoxy body, gel filled ORP triode and thermocouple, while pH was determined using a Ross ultra glass combination pH electrode and a thermocouple.

An analysis of variance (**ANOVA**) using the MIXED procedure of SAS (Version 9.1, Cary, N.C., 2002) was used to analyze the data. When indicated significant by ANOVA ($P \leq 0.050$) main effects (treatment and source) were separated using the LSMEANS and DIFF, while simple effects of interactions were generated using the LSMEANS, and SLICE functions, respectively.

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Results

Chemical Data

Main effects (diet and location) were not statistically significant ($P \geq 0.129$) for proximate analysis and ORP, nor was the location effect for pH. A significant ($P = 0.012$) diet effect for pH was observed (Table 1). The pH values were in the range of what would be expected of 7-day aged beef (5.59 - 5.68). The control treatment was similar to the silage treatment (regardless of level) and to the low corn stalk treatment ($P \geq 0.253$). Finishing cattle on alfalfa (regardless of amount) resulted in significantly ($P \leq 0.033$) higher pH when compared to the control diet.

Subcutaneous Fatty Acids. Saturated fatty acid content of subcutaneous adipose tissue did not differ ($P \geq 0.084$) among diets or locations for 10:0, 12:0, 13:0, 14:0, 16:0, 18:0, 19:0, 20:0, and saturated fatty acids (**SFA**). Cattle from SD (45.74%) tended ($P = 0.065$) to contain more SFA when compared to cattle from Neb. (44.77%).

Minimal differences were noted for unsaturated fatty acids (**UFA**) profiles. No significant ($P \geq 0.128$) diet or location effects were noted for 14:1 (n-5), 16:1(n-7), 17:1(n-7), 18:1(n-9), *cis* 18:1(n-7), 20:1(n-9), 20:2(n-6), 20:3 (n-6), or 20:4(n-6). Diet tended ($P = 0.100$) to affect 18:2(n-6), in which cattle finished on corn silage (regardless of amount) had numerically greater levels when compared to cattle finished on the control, alfalfa, or corn stalks diets. No significant location effect was observed for 18:2(n-6) ($P = 0.439$). Trans fatty acids, conjugated linoleic acid (**CLA**), PUFA, and omega 6 fatty acid contents were not affected ($P \geq 0.112$) by diet or location. Additionally, dietary effects for monounsaturated fatty acids (MUFA) and PUFA were not different ($P \geq 0.304$). However, cattle from Neb. contained more MUFA ($P = 0.048$) and tended to contain more UFA ($P = 0.068$).

Table 1. Least squares means for main effects for moisture, ash, pH, percent fat, and ORP.

Effect	Moisture	Ash	pH	Percent Fat	ORP[a]
Treatment[b]					
CONT	73.41	1.18	5.58^{f}	5.02	538.79
LALF	73.41	1.20	5.65^{cde}	5.47	534.84
HALF	73.27	1.16	5.66^{cd}	5.19	523.63
LSTALK	73.80	1.17	5.62^{def}	5.52	528.82
HSTALK	74.09	1.18	5.68^{c}	4.76	533.82
LSIL	73.65	1.22	5.61^{bcd}	4.52	532.55
HSIL	73.66	1.21	5.59^{ef}	5.22	531.55
SEM	0.29	0.02	0.02	0.31	3.42
$P > F$	0.516	0.320	0.012	0.198	0.157
Location					
NE	73.57	1.20	5.63	5.12	533.26
SD	73.74	1.18	5.62	5.08	530.74
SEM	0.15	0.01	0.01	0.16	2.08
$P > F$	0.382	0.129	0.729	0.852	0.435

[a] Oxidation-reduction potential.
[b] Treatments: CONT = Control; LALF = Low Alfalfa; HALF = High Alfalfa; LSTALK = Low Corn Stalks; HSTALK = High Corn Stalks; LSIL = Low Corn Silage; HSIL = High Corn Silage.
[bcde] Mean values within a column and followed by the same letter are not significantly different ($P > 0.050$).

Table 2. Least square means for main effects of selected saturated fatty acids for intramuscular fat.[a]

Effect	16:0	18:1 (n-9)	18:2 (n-6)	20:4 (n-6)	22:5 (n-3)	MUFA[b]	PUFA[c]
Treatment[d]							
CONT	25.12^{e}	29.85^{fg}	6.19^{ef}	1.18^{e}	0.28^{ef}	43.30^{g}	9.17^{ef}
LALF	24.59^{e}	31.52^{e}	5.50^{f}	0.86^{f}	0.21^{g}	45.20^{f}	7.98^{f}
HALF	24.41^{efg}	31.07^{ef}	6.14^{ef}	1.12^{ef}	0.28^{ef}	44.45^{efg}	9.00^{f}
LSTALK	24.59^{e}	31.67^{e}	5.66^{f}	0.95^{ef}	0.24^{fg}	45.04^{ef}	8.33^{f}
HSTALK	23.83^{g}	30.65^{efg}	6.26^{ef}	1.23^{e}	0.28^{ef}	43.85^{fg}	9.16^{ef}
LSIL	24.08^{fg}	30.33^{efg}	7.00^{e}	1.23^{e}	0.31^{e}	43.89^{efg}	9.98^{e}
HSIL	24.10^{fg}	29.46^{g}	6.95^{ef}	1.23^{e}	0.28^{ef}	43.61^{g}	10.04^{e}
SEM	0.28	0.58	0.39	0.10	0.02	0.51	0.51
$P > F$	0.011	0.044	0.046	0.050	0.018	0.040	0.039
Location							
NE	24.24	30.83	6.16	1.06	0.26	44.30	8.95
SD	24.54	30.47	6.32	1.16	0.27	44.08	9.23
SEM	0.15	0.29	0.02	0.06	0.01	0.26	0.25
$P > F$	0.837	0.374	0.571	0.215	0.301	0.536	0.415

[a] Fatty acids are expressed as percentage of total fatty acid methyl esters.
[b] Monounsaturated fatty acids.
[c] Polyunsaturated fatty acids.
[d] Treatments: CONT = Control; LALF = Low Alfalfa; HALF = High Alfalfa; LSTALK = Low Corn Stalks; HSTALK = High Corn Stalks; LSIL = Low Corn Silage; HSIL = High Corn Silage.
[efg] Values containing the same superscript within a column do not differ statistically ($P > 0.050$).

Intramuscular Fatty Acids. No significant ($P \geq 0.153$) diet or location effects (Table 2) were observed for 10:0, 12:0, 14:0, 15:0, iso 16:0, iso 18:0, 18:0, 19:0, 20:0 or SFA. Cattle from Neb. had more ($P = 0.049$) 13:0, but the dietary effect for 13:0 was not significant ($P = 0.477$). Location had no effect on 16:0 concentration ($P = 0.160$), but diet significantly ($P = 0.011$) affected 16:0 levels. Cattle finished on corn silage (regardless of level) and high amount of corn stalks had significantly lower levels of 16:0 when compared to the control. However, cattle finished on low amounts of corn stalks and alfalfa hay (regardless of level) were similar to the control. Significant ($P \leq 0.046$) dietary effects were observed for 18:1(n-9) and 18:2(n-6). Cattle finished on the low amounts of alfalfa and corn stalks had greater amounts of 18:1(n-9) when compared to the control, but had less 18:2(n-6) (Table 2). Additionally, cattle finished on low amounts of alfalfa had significantly ($P \leq 0.050$) lower levels of 20:4(n-6) and 22:5(n-3) when compared to the other treatments. Cattle from Neb. had significantly ($P = 0.020$) greater amounts of CLA when compared to S.D. cattle. Cattle finished on low amounts of alfalfa and corn stalks

Table 3. **Correlation coefficients between chemical attributes and the liver-like off flavor.**

Attribute	r	$P > F$
18:2 9*t*,12*t*[a]	-0.17	0.037
20:1(n-9)[a]	0.21	0.001
CLA 9*c*,11*t*[a]	0.16	0.046
20:4(n-6)[a]	-0.14	0.088
22:4(n-6)[b]	-0.15	0.066
pH	0.14	0.076

[a]Subcutaneous adipose tissue.
[b]Intramsucular adipose tissue.

had the greatest amounts ($P < 0.050$) of MUFA, while cattle finished on corn silage (regardless of level) had the greatest amount ($P < 0.050$) of PUFA and omega 6 fatty acids (Table 2).

The mechanism for source effects is not quite understood. Since all the cattle were on the finishing trial for 139 days, these results suggest that the source differences in fatty acid profiles existed prior to entering the trial. Further research should be conducted to investigate the possible mechanisms.

Sensory Analysis. Significant diet effects were observed for muscle fiber tenderness ($P = 0.014$) and juiciness ($P = 0.002$) while connective tissue amount was approaching significance ($P = 0.068$). Cattle finished on low amounts of alfalfa and corn stalks were the most tender and most juicy when compared to the other diets. Additionally, these diets tended to have the least amount of detectable connective tissue which probably contributed to the increased tenderness of these treatments. No diet effect was noted for off-flavor intensity ($P = 0.819$). Location effects for muscle fiber tenderness, connective tissue amount, and off flavor intensity were not significant ($P \geq 0.241$). However, cattle from South Dakota were significantly juicer than cattle from Nebraska.

($P = 0.019$). No significant diet or location effects were observed for liver-like, metallic, sour, charred, or oxidized off-flavors ($P \geq 0.169$). However, cattle finished on low amounts of corn stalks had 3 times as many panelists indicate liver-like off flavor when compared to the other treatments. Significant diet ($P = 0.006$) and location ($P = 0.023$) effects were reported for bloody notes. Cattle finished on the low amounts of alfalfa most frequently had bloody off-flavor while cattle finished on the control, high amounts of alfalfa and corn stalks, and silage treatments had the lowest bloody notes. Additionally, cattle from South Dakota had higher bloody notes than cattle from Nebraska. Correlation coefficients between chemical attributes and the liver-like off flavor were calculated (Table 3). Subcutaneous levels of 18:2 9*t*,12*t* were inversely related with liver-like off flavor while subcutaneous levels of 20:1(n-9) and CLA 9*c*,11*t* were directly related. Although not quite statistically significant ($P = 0.076$) , pH tended to be directly related, while subcutaneous level of 20:4(n-6) and intramuscular levels 22:4(n-6) were indirectly related to the liver-like off flavor.

Implications

Data from this study indicated including roughage with WDGS had minimal effects on the sensory attributes of beef. However, including silage in the diet could increase the probability of oxidation due to increases in PUFA. Furthermore, PUFA, but not cattle source, played a significant role in the development of liver-like off flavor. Dietary manipulation of these fatty acids may prove beneficial in reducing the incidence of the liver-like off flavor.

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[1]Blaine E. Jenschke, research technician; Josh R. Benton, research technician; and Chris R. Calkins, professor, Animal Science, Lincoln. Timothy P. Carr, associate professor, Nutrition and Health Sciences; and Kent M. Eskridge, professor, Statistics, Lincoln. Terry J. Klopfenstein, professor, Animal Science; Galen E. Erickson, associate professor, Animal Science, Lincoln.

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

Influence of Feeding Wet Distillers Grains on Fatty Acid Composition of Beef

Amilton S. de Mello Jr.
Blaine E. Jenschke
Chris R. Calkins[1,2]

Summary

Ribeye slices (M. Longissimus thoracis) *were obtained from 94 calf-fed, crossbred steers. Animals were randomly allocated into three groups and finished for 133 days with corn-based diets and varying levels of wet distillers grains plus solubles (0%, 15% or 30%, DM Basis). No treatment differences were found for total lipid, unsaturated, and saturated fatty acids. However, values of 18:2 9t,12t, total polyunsaturated fatty acids, total amount of trans fatty acids, conjugated linoleic acid and the omega 6: omega 3 ratio were elevated. It appears that wet distillers grains plus solubles finishing diets alters the fatty acid profile of beef.*

Introduction

Fatty acid composition of beef is important due to potential effects on quality. High levels of polyunsaturated fatty acids (**PUFA**) are associated with higher values of oxidation and compromised beef color. Also, oxidation of fatty acids results in ketones and aldehydes which affect beef flavor. Thus, alterations of the fatty acid profile may affect quality attributes such as flavor, color, and lipid oxidation capacity.

Negative correlations between beef flavor and PUFA lead to lower consumer acceptance as PUFA content increases. Little research has been conducted on the effects of distillers grains on beef fatty acid profile of beef. Therefore, the aim of this work was to determine the effects of feeding WDGS on fatty acid profile in beef.

Procedure

Ninety-four calf-fed, crossbred steers were allocated to three different treatments (0%, 15% or 30% WDGS, DM basis) and fed for 133 days. After grading, a one-quarter inch thick ribeye slice (*M. Longissimus thoracis*) was excised from each carcass at the 12th/13th rib and transferred to the Meat Laboratory at the University of Nebraska under refrigeration. The ribeye slices were trimmed, submerged in liquid N, pulverized and stored at -112°F. Total lipid was extracted with chloroform: methanol (2:1, v/v) mixture. An extract containing 25 mg of lipid was converted to fatty acid methyl esters and separated by Gas Chromatography (GC) using a capillary column. Column oven temperature was programmed at 284° to 428°F at 3.6°F/minute and held at 428°F for 20 minutes. Injector and detector temperature was maintained at 518° and 572°F, respectively, and helium was the carrier. Individual fatty acids were identified by comparison of retention times with known standards.

Results

Results of this study are presented in Table 1 and Table 2. Diets did not significantly influence total lipid content ($P = 0.19$), total unsaturated fatty acids (**UFA**) ($P = 0.76$) or total

Table 1. Weight percentage of fatty acids[1] and fat content of ribeye slices (*M. Longissimus thoracis*) from steers fed with WDGS finishing diets.

	Dietary treatments[2]			
Fatty acids	0%	15%	30%	*P*-value
Fat%	5.44	5.91	5.94	0.19
14:0	2.94	2.96	2.84	0.50
14:1(n-5)	0.64^{a}	0.63^{a}	0.54^{b}	0.03
15:0	0.54^{b}	0.57^{a}	0.49^{b}	0.02
iso16:0	0.93	0.90	0.81	0.22
16:0	26.35^{a}	25.83^{ab}	25.12^{b}	<0.01
16:1(n-7)	3.50^{a}	3.23^{b}	2.90^{c}	<0.01
17:0	1.43^{b}	1.66^{a}	1.43^{b}	0.01
iso18:0	0.66	0.73	0.64	0.24
17:1(n-7)	1.08^{ab}	1.17^{a}	0.98^{b}	0.03
18:0	13.76^{b}	14.13^{b}	15.03^{a}	0.02
18:1Δ6-11*t*	2.28^{b}	2.61^{b}	3.76^{a}	<0.01
18:1(n-9)	36.14^{a}	34.66^{b}	34.02^{b}	<0.01
cis-vaccenic [C18:1, n7]	3.20^{a}	2.77^{b}	2.41^{c}	<0.01
18:1Δ13*t*	0.10^{c}	0.51^{b}	0.64^{a}	<0.01
18:1Δ14*t*	0.49	0.48	0.43	0.06
19:0	0.02	0.01	0.04	0.26
18:2 9*t*, 12*t*	0.003^{b}	0.01^{b}	0.03^{a}	0.01
18:2(n-6)	3.27^{b}	4.22^{a}	4.50^{a}	<0.01
20:0	0.005^{b}	0.007^{b}	0.03^{a}	0.02
18:3(n-3)	0.07	0.09	0.06	0.51
20:1(n-9)	0.15	0.16	0.20	0.06
CLA *cis-9,trans-11*	0.21^{b}	0.22^{ab}	0.27^{a}	0.04
20:3(n-6)	0.29^{b}	0.33^{ab}	0.35^{a}	0.05
20:4(n-6)	1.06	1.02	1.03	0.92
Others	0.93	1.07	1.49	0.06

[1] Weight percentage values are relative proportions of all peaks observed by GC.
[2] Wet distillers grains plus solubles.
[a,b,c] Means in the same row having different superscripts are significant at $P \leq 0.05$ level.

Table 2. Weight percentage of total fatty acids[1] of ribeye slices (*M. Longissimus thoracis*) from steers fed with WDGS finishing diets.

	Dietary treatments[2]			
Fatty acids	0%	15%	30%	*P*-value
Trans	2.87^{c}	3.61^{b}	4.86^{a}	<0.01
UFA	52.47	52.15	52.10	0.76
PUFA	4.90^{b}	5.91^{a}	6.23^{a}	<0.01
SFA	46.60	46.79	46.42	0.79
UFA:SFA	1.13	1.12	1.13	0.84
Omega 3	0.07	0.09	0.06	0.51
Omega 6	4.62^{b}	5.60^{a}	5.86^{a}	<0.01
Omega 6: Omega 3	26.72^{c}	33.64^{b}	41.75^{a}	<0.01

[1] Weight percentage values are relative proportions of all peaks observed by GC.

[2] Wet distillers grains plus solubles.

[a,b,c] Means in the same row having different superscripts are significant at $P \leq 0.05$ level.

saturated fatty acids (**SFA**) ($P = 0.79$). As WDGS in finishing diets increased, higher concentrations of 18:0 ($P = 0.02$), 18:1Δ6-11*t* ($P < 0.01$), 18:1Δ13*t* ($P < 0.01$), 20:3 (n-6) ($P = 0.05$), 18:2 9*t*,12*t* ($P = 0.01$), and total trans ($P < 0.01$) were observed. Values of 18:2 (n-6), polyunsaturated (**PUFA**) and omega 6 fatty acids were significantly higher ($P < 0.01$, $P < 0.01$ and $P < 0.01$ respectively) in ribeyes from cattle fed 15% and 30%. As WDGS increased in finishing diets the values of 14:1 (n-5), 15:0, 16:0, 16:1 and *cis*-vaccenic [18:1, n-7] fatty acids decreased ($P = 0.03$, $P = 0.02$, $P < 0.01$, $P <0 .01$ and $P < 0.01$, respectively). Research suggests that consumption of conjugated linoleic acid (**CLA**) *cis-9 trans-11* may have human health benefits. This study shows that WDGS in the diet increased CLA *cis-9 trans-11* content and omega 6:omega 3 ratio, ($P = 0.04$ and $P < 0.01$, respectively).

These data suggest feeding distillers grains alters the fatty acid profile of beef. Higher values of PUFA could support greater oxidation, reduction in color stability and possibly impact flavor. Further work is needed to clarify these relationships.

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[1] Amilton S. de Mello Jr., graduate student; Blaine E. Jenschke, research technician; and Chris R. Calkins, professor, Animal Science, Lincoln.

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

Wet Distillers Grains Plus Solubles Affect Lipid Oxidation and Objective Color of Beef Steaks

Amilton S. de Mello Jr.
Blaine E. Jenschke
Chris R. Calkins[1,2]

Summary

Strip loins (M. Longissimus lumborum), *tenderloins* (M. Psoas major) *and top blades* (M. Infraspinatus) *from 48 calf-fed, crossbred steer carcasses, were used to test the effects of wet distillers grains plus solubles finishing diets on beef shelf life. After 7-day display, inclusion of wet distillers grains plus solubles in the diet caused higher levels of oxidation on top blades and strip loins and negative effects on color of top blade and tenderloin steaks after 3 days of retail display.*

Introduction

Deviation in muscle color can determine economic losses due product rejection by the consumer. A bright-red color is considered an indicator of freshness as compared to brown color which is not. Feeding regimen, fatty acid profile, fat content and packaging systems can affect not only meat color, but also flavor and lipid oxidation.

Diet formulation may affect beef quality, composition and ultimately shelf life due to increases in polyunsaturated fat acids (**PUFA**). Finishing diets with wet distillers grains plus solubles (**WDGS**) may negatively impact color stability during retail display through an increase in PUFA. Therefore, the focus of this research was to study the effects of WDGS finishing diets on color and oxidation of strip loins, tenderloins and top blades.

Procedure

Ninety-four calf-fed, crossbred steers were allocated to three different finishing diets (0%, 15% or 30% - WDGS – DM basis) (Luebbe et al., *2008 Nebraska Beef Report*, pp. 60-62) and fed for 133 days. Forty-eight carcasses, 16 from each treatment, were randomly selected from the 94 and their respective short loins (IMPS #174) and shoulder clods (IMPS #114) were removed, vacuum packaged and shipped to the Loeffel Meat Laboratory at the University of Nebraska–Lincoln. After 7 days aging at 39°F, the strip loins (M. *Longissimus lumborum*) and tenderloins (M. *Psoas major*) were excised from the short loins and the top blades (M. *Infraspinatus*) from the shoulder clods. After fabrication, two 1-inch thick steaks were cut from each strip loin, tenderloin and top blade. One steak was vacuum packaged and frozen (3.2°F) immediately until the lipid oxidation analysis could be made (thiobarbituric acid assay - TBA). The other steak was divided in two and the halves were placed on a Styrofoam tray and wrapped in oxygen-permeable film. Two display retail cases maintained at 35.6 ± 2°F were used to simulate retail display conditions. Samples were randomly placed in the cases and exposed to continuous 2850 Lm fluorescent lightning with intensity of 1614 lux.

Objective color measurement was recorded for L* (psychometric lightness; black = 0, white = 100), a* (red = positive values; green = negative values) and b* (yellow = positive values; blue = negative values) using a HunterLab chromameter with a 1-inch diameter measurement area using a D65 illuminant. The chromameter was calibrated using the ceramic disk provided by the manufacturer everyday before measuring. Color measures were obtained at 1, 3, 4, 5, 6 and 7 days of display and the values were recorded from three different locations of each steak. Lipid stability was evaluated in the same steaks that were kept under retail conditions. The steaks were submerged in liquid N, pulverized and stored at -112°F. Lipid oxidation was measured by the thiobarbituric acid assay at 0, 3 and 7 days of retail display.

Results

Objective color

Significant color values are shown on Tables 1 and 2 (top blades and tenderloins respectively). Increasing levels of WDGS resulted in lower L* values (darker) for top blade steaks when compared to controls ($P = 0.03$). The a* (redness) values were significantly lower ($P = 0.01$) for top blades from cattle fed 30% WDGS after 7 day display when compared to 0% and 15%.

Tenderloins from cattle fed 15% and 30% WDGS had lower a* values after 3 days of retail display ($P = 0.05$) when compared to 0% (Table 2). Conversely, dietary treatment did not significantly influence any objective color parameter (L*, a* or b*) of strip loin steaks.

Roeber and others (*Journal of Animal Science, 2005*, 83: 2455-2460) reported that finishing diets including distillers grains at high rates (40% to 50% - DM basis) may negatively affect color stability of strip loin steaks although low to moderate levels (10% to 25%) could be included with no negative effects. Conversely, data from this study indicate that levels up to 30% did not affect shelf life of strip loin steaks. However, top blade and tenderloin steaks had compromised shelf life as WDGS increased and when moderate levels were used (30%), respectively.

Lipid Oxidation Analysis

Top blade steaks from cattle fed 30% had higher levels of oxidation

Table 1. Least square means of L* and a* for top blade steaks from WDGS treatments.

		Dietary treatments[1]			
Parameter	Display time	0%	15%	30%	*P*-value
L*		37.81^{A}	36.07^{B}	36.56^{AB}	0.03
a*					0.02
	Day 1	22.50^{a}	22.78^{a}	22.13^{a}	
	Day 3	21.91^{Aa}	21.62^{Ab}	19.24^{Bb}	
	Day 4	22.28^{Aa}	22.52^{Aab}	19.29^{Bb}	
	Day 5	21.23^{Aab}	21.80^{Aab}	18.89^{Bb}	
	Day 6	19.80^{Abc}	21.67^{Aab}	15.77^{Bc}	
	Day 7	18.66^{Ac}	19.52^{Ac}	14.61^{Bc}	

[1] Wet distillers grains plus solubles (%, DM basis).

^{A,B}Means in the same row having different superscripts are significant at $P \leq 0.05$ level.

^{a,b,c}Means in the same column having different superscripts are significant at $P \leq 0.05$ level.

Table 2. Least square means of a* for tenderloin steaks from WDGS treatments.

		Dietary treatments[1]			
Parameter	Display time	0%	15%	30%	*P*-value
a*					0.05
	Day 1	25.36^{a}	24.27^{a}	25.49^{a}	
	Day 3	22.86^{Ab}	20.68^{Bb}	20.71^{Bb}	
	Day 4	21.67^{c}	21.05^{b}	20.00^{b}	
	Day 5	19.70^{d}	17.14^{c}	17.77^{c}	
	Day 6	15.57^{Ae}	$14.19A^{Bd}$	13.32^{Bd}	
	Day 7	15.76^{e}	15.67^{c}	13.77^{d}	

[1] Wet distillers grains plus solubles (%, DM basis).

^{A,B}Means in the same row having different superscripts are significant at $P \leq 0.05$ level.

^{a,b,c,d,e}Means in the same column having different superscripts are significant at $P \leq 0.05$ level.

Table 3. Least square means of TBA values (mg malonaldehyde/kg) for top blade and strip loin steaks from WDGS treatments.

		Dietary treatments[1]			
Muscle	Display time	0%	15%	30%	*P*-value
Top blade					<0.01
	Day 1	0.68^{a}	0.53^{a}	0.59^{a}	
	Day 3	1.43^{Aa}	2.37^{ABb}	3.42^{Bb}	
	Day 7	3.84^{Ab}	5.04^{Ac}	8.42^{Bc}	
Striploin					<0.01
	Day 1	0.58^{a}	0.52^{a}	0.45^{a}	
	Day 3	0.65^{a}	1.74^{a}	1.45^{a}	
	Day 7	2.02^{Ab}	3.77^{Bb}	4.80^{Bb}	

[1] Wet distillers grains plus solubles (%, DM basis).

^{A,B}Means in the same row having different superscripts are significant at $P \leq 0.05$ level.

^{a,b,c}Means in the same column having different superscripts are significant at $P \leq 0.05$ level.

(higher TBA values) ($P < 0.01$) after 7 days of display when compared to 0% and 15% WDGS (Table 4). This demonstrates the relationship between oxidation and color due the negative effect found also on top blade color. Conversely, no WDGS effects were identified on TBA values of tenderloin steaks ($P = 0.19$). However, 15% and 30% did significantly increase TBA values of strip loin steaks ($P < 0.01$). These observations suggest that individual cuts respond differently to WDGS finishing diets.

Mello Jr. et al. (*2008 Nebraska Beef Report,* pp. 120-121) reported increased PUFA in beef from steers fed WDGS. Based in this information we hypothesize that high levels of PUFA leaded more oxidation and detrimental effects on color. However, future studies are needed to clarify these effects.

Conclusion

The data of this study indicate that including WDGS in finishing diets can compromise the color and oxidation capacity of beef steaks resulting in lower shelf life.

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[1] Amilton S. de Mello Jr., graduate student; Blaine E. Jenschke, research technician; and Chris R. Calkins, professor, Animal Science, Lincoln.

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

Effects of Wet Distillers Grains Finishing Diets on Fat Content and Marbling Score in Steers

Amilton S. de Mello Jr.
Blaine E. Jenschke
Chris R. Calkins[1,2]

Summary

Ninety-four, calf-fed, crossbred steers were randomly allocated to three finishing diets consisting of different amounts of wet distillers grains plus solubles (0%, 15% or 30%, DM basis). Steers were fed for 133 days to test the relationship between marbling score and fat content, as well as effects on marbling texture and marbling distribution. Results of this research suggest that feeding up to 30% of wet distillers grains plus solubles has no detrimental effects on marbling in beef.

Introduction

Marbling is an important factor in determining the USDA quality grade of beef. It is also considered a visual indicator of palatability. It has been proposed that feeding wet distillers grains plus solubles (**WDGS**) alters the relationship between intramuscular fat and marbling score such that cattle fed WDGS receive lower marbling score (and USDA quality grade) at similar intramuscular fat content to cattle finished on corn. Feeding grains leads to more production of propionate leading to glucose conversion and marbling deposition. On the other hand, a high level of fiber from forage diets leads acetate production and external fat deposition (subcutaneous fat). During ethanol production starch in corn is converted to ethanol. Ethanol co-products such as distillers grains have lower levels of starch which could lead to lower glucose and thereby lower marbling. Most of the research on WDGS conducted by the University of Nebraska shows a neutral or positive on increase marbling score. Vander Pol et al. (*2007 Nebraska Beef Report*, pp. 39-42) demonstrated that feeding WDGS lowered acetate and elevated propionate. Therefore, we hypothesize that WDGS do not alter marbling in beef.

Procedure

Ninety-four calf-fed, crossbred steers were assigned to three different finishing diets (0%, 15% or 30% WDGS, DM basis). At 48 hours postmortem, marbling score, marbling texture and marbling distribution were assessed by a USDA grading supervisor. After grading, a quarter-inch thick ribeye slice (*M. Longissimus thoracis*) was excised from each carcass at the 12th/13th rib interface and transferred under refrigeration to the Loeffel Meat Laboratory at the University of Nebraska–Lincoln. The ribeye slices were trimmed, submerged in liquid N, pulverized and stored at -112°F. Total lipid was determined by ether extraction

Results

There were linear relationships between marbling score and fat percentage in the ribeye (Figure 1). The coefficients of determination were 21%, 33% and 40% for 0%,

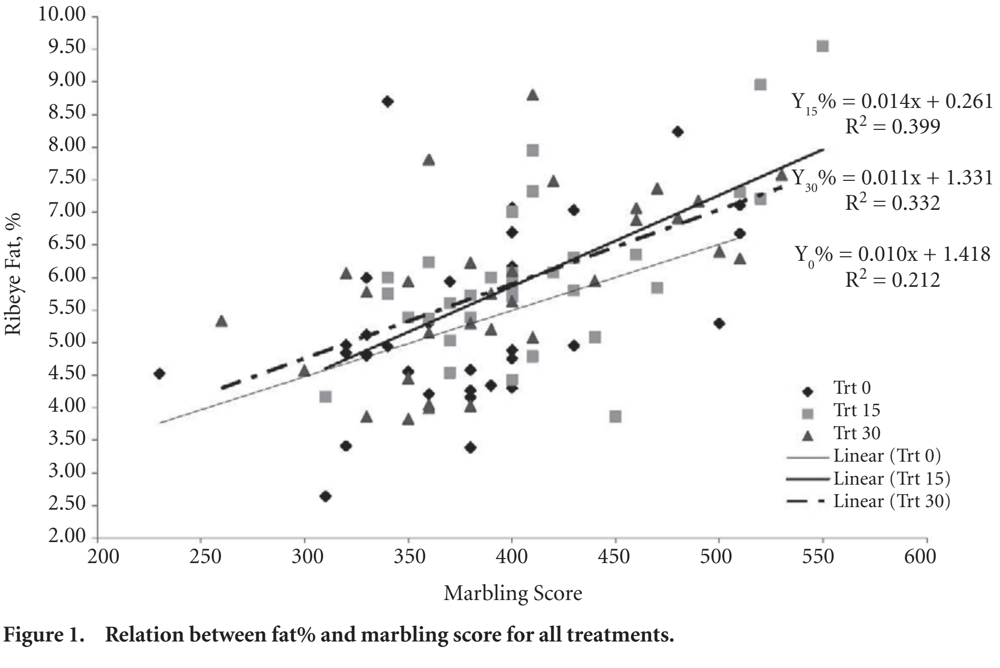

Figure 1. Relation between fat% and marbling score for all treatments.

Table 1. WDGS diets effects on quality attributes.

	Dietary treatments[a]			
Attributes	0	15%	30%	*P*-value
Marbling score[b]	393	403	404	0.46
Marbling texture[c]	1.60	1.58	1.52	0.84
Marbling distribution[d]	1.29	1.15	1.22	0.40
Fat, %	5.44	5.91	5.94	0.19

[a] Wet distillers grains plus solubles.
[b] Slight = 300 - 399, Small = 400 - 499.
[c] Fine = 1, Medium = 2, Course = 3.
[d] Even = 1, Uneven = 2.

15%, and 30%, respectively. Slopes were statistically similar ($P = 0.72$) indicating an equal rate of change between marbling score and fat content among all treatments. Feeding 15% or 30% WDGS did not significantly influence marbling score, marbling distribution, marbling texture or fat content when compared to 0% WDGS (Table 1). Thus, there appears to be no detrimental effects on fat and marbling from feeding WDGS to cattle.

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[1] Amilton S. de Mello Jr., graduate student; Blaine E. Jenschke, research technician; and Chris R. Calkins, professor, Animal Science, Lincoln.

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

Sampling Wet Distillers Grains Plus Solubles to Determine Nutrient Variability

Crystal D. Buckner
Sarah J. Vanness
Galen E. Erickson
Terry J. Klopfenstein
Joshua R. Benton[1]

Summary

Dry matter, protein, fat, phosphorus, and sulfur were measured on 100 wet distillers grains plus solubles (WDGS) samples per ethanol plant (6 plants total) with 10 samples/day, 5 consecutive days, and 2 separate months (periods). Coefficients of variation were 1.5% to 4.5% for DM within plant. Fat in WDGS averaged 11.8% and ranged from 10.7% to 13.1% across plants, with ranges of 2 to 5 percentage units within plant. Coefficients of variation were 5% to 8% and as great as 36% within plant for sulfur. The variation in protein and phosphorus were minimal.

Introduction

Wet distillers grains plus solubles (WDGS) is becoming more common as a cattle feed, yet nutrient composition is not well developed. Three nutrients that are important to measure in WDGS are DM, fat, and S. If DM content varies, then the price paid on a DM basis will vary in addition to dietary inclusion on DM basis. Knowing the fat content and variability in WDGS is important with high inclusion levels as too much fat could decrease ADG instead of improving performance. Sulfur from WDGS is important (average and variability) as high dietary S may cause problems associated with polioencephalomalacia (PEM, polio, or "brainers") and decrease performance. Limited data exist on average as well as variation in DM, fat, and S of WDGS.

Procedure

Six ethanol plants in Nebraska agreed to sample WDGS for conducting nutrient analysis. The samples represented a semi-truck load of WDGS that a cattle producer would receive. Samples were taken from 4 to 5 locations in the WDGS pile to be loaded on the truck or directly from the loader that filled the truck. These samples were combined, mixed thoroughly, then a smaller quantity of 0.5-1.0 lb was placed into a plastic, air-tight bag. Ten samples were taken per day for five consecutive days, with 50 samples total during the week. Samples were frozen and shipped overnight to the UNL ruminant nutrition laboratory for analysis. This report represents the first two sampling periods, late summer 2006 and winter 2007, of four total periods being conducted.

Analysis was conducted in duplicate and included DM, CP, P, S, fat, and ash content. Dry matter was determined by drying in a 60°C forced air oven for 48 hours, which is the simplest and most accurate means for determining DM (Wilken, *2008 Nebraska Beef Report*, pp 128-129). The samples were ground through a 1mm Wiley Mill after drying for nutrient analysis. Crude protein was calculated from % nitrogen using a LECO nitrogen analyzer. Phosphorus and sulfur were determined by wet ashing with nitric and perchloric acids and analyzing colorimetrically. Fat was determined by extraction with petroleum ether under pressure.

Results

Samples were collected from ethanol plants producing traditional WDGS (30%-35% DM) and modified WDGS (42%-48% DM); therefore, DM values for each plant were calculated relative to their actual average and converted to a percentage based on 100 (Table 1). Dry matter content varied from plant to plant. Coefficients of variation for DM within plants ranged from 0.9%-7.1%, indicating more variation in some plants than others. However, variation was not necessarily the same across the 2 periods for a plant. Loads varied within a day, within a plant, as well as across days. Overall, cattle feeders should be aware of some variation potential in DM from load to load from a plant.

Fat (% of DM) averages did not result in numeric differences across sampling periods within plants (Table 2), suggesting there are processing differences from plant to plant that influence fat levels. The overall fat average among plants was 11.8%, but averages between plants ranged from 10.7% to 13.1%. Because solubles contain more fat than wet grains, higher fat content in WDGS may be related to the amount of solubles added to wet distillers grains. Coefficients of variation within plants ranged from 1.9%-8.8%. Fat is an excellent energy source; therefore, higher fat levels in WDGS is desirable unless dietary inclusion is greater than 40%-50% of diet DM. High inclusion of fat in diets may depress cattle intake and eventually feed conversion. Therefore, the fat content of WDGS interacts with its inclusion level in feedlot and forage diets.

Sulfur (% of DM) varied across ethanol plants (Table 3) and tended to be greater in period 1 (0.84%) than period 2 (0.75%). The overall sulfur average of WDGS from these plants was 0.79%. Coefficients of variation were higher for sulfur than any of the other nutrient tested and ranged from 3.5%-36.3%, with most plant

Table 1. DM means, coefficients of variation, and minimum and maximum values for WDGS from each ethanol plant.

	Ethanol Plant					
	A	B	C	D	E	F
Period 1						
Mean	100	100	100	100	100	100
CV%	1.5	3.6	2.7	2.2	1.2	3.5
Minimum	96.5	89.3	91.1	93.7	96.8	90.8
Maximum	105.7	107.9	105.0	103.9	102.0	104.8
Period 2						
Mean	100	100	100	100	100	100
CV%	1.4	0.9	4.0	4.7	1.2	7.1
Minimum	97.0	97.7	89.6	91.6	97.8	86.0
Maximum	102.2	102.2	108.1	114.2	102.5	111.2

Table 2. Average fat (% DM), coefficients of variation, and minimum and maximum values for WDGS from each ethanol plant.

	Ethanol Plant					
	A	B	C	D	E	F
Period 1						
Mean	12.5	10.8	12.7	12.4	11.5	11.5
CV%	2.8	7.6	3.3	4.4	3.5	6.7
Minimum	11.6	7.2	11.6	11.2	10.7	9.6
Maximum	13.0	12.6	13.5	13.6	12.5	13.1
Period 2						
Mean	11.7	10.7	13.1	11.7	11.8	11.7
CV%	1.9	2.3	5.6	3.9	8.7	8.8
Minimum	11.2	10.1	11.8	10.4	10.3	9.8
Maximum	12.4	11.1	15.3	12.9	13.5	13.3

Table 3. Average S (% DM), coefficients of variation, and minimum and maximum values for WDGS from each ethanol plant.

	Ethanol Plant					
	A	B	C	D	E	F
Period 1						
Mean	0.71	0.72	0.83	1.06	0.81	0.90
CV%	36.3	8.4	6.1	7.8	5.5	6.3
Minimum	0.44	0.58	0.73	0.90	0.69	0.79
Maximum	1.72	0.84	0.93	1.26	0.93	1.04
Period 2						
Mean	0.76	0.74	0.72	0.69	0.76	0.82
CV%	12.8	4.8	5.9	8.6	3.6	4.2
Minimum	0.61	0.64	0.60	0.61	0.69	0.73
Maximum	0.95	0.82	0.80	0.83	0.82	0.89

CVs at 5% to 7%. The range in sulfur content among plants was 0.65% to 0.90%; however, the greatest range within an individual plant was 0.44% to 1.72% sulfur. Clearly, sulfur content and variation among plants and between loads within the same plant are different and should be carefully monitored.

Protein averaged 31% of DM for all samples with CVs of 1.3% to 3.9% within plants. Phosphorus averaged 0.82% of DM with CVs of 1.3% to 6.0% within plants.

Statistical correlations were conducted among nutrients to determine if any relationships exist. Fat was significantly correlated ($P < 0.01$) to P ($r = 0.71$) and fat was correlated to S ($r = 0.17$). Fat and P are concentrated more in distillers solubles than wet grains; therefore, one potential cause of the observed variation is the amount of solubles added back to wet grains to produce WDGS. As the correlation between fat and S was poorer, the reason is likely due to more than just the proportion of distillers solubles to wet grains.

This sampling project characterized nutrient variability, which was different for each nutrient tested, both across ethanol plants and within the same plant. The three most critical measures are DM, fat, and S. While DM is commonly measured, more sampling and analysis of DM, fat, and S would be useful to determine accurate averages and ranges that producers might observe in WDGS.

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[1] Crystal D. Buckner, research technician, Sarah J. Vanness, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor; and Joshua R. Benton, research technician, Animal Science, Lincoln.

Evaluation of Methods for Dry Matter Determination of Ethanol Byproducts

Mallorie F. Wilken
Galen E. Erickson
Joshua R. Benton
Crystal D. Buckner
Terry J. Klopfenstein
Kip Karges
Matt Gibson[1]

Summary

Traditional wet distillers grains plus solubles, modified distillers grains, Dakota Bran Cake, and distillers solubles were sampled and replicates tested using oven drying (n = 8) at 105°C and 60°C, vacuum oven drying (n = 3) and toluene distillation process (n = 8). Two replicates were evaluated using Karl Fischer titration. Oven drying was compared to toluene distillation as the standard. Oven drying at 60°C for 24 hours resulted in the same DM (P > 0.10) as toluene distillation for wet byproducts.

Introduction

With the growing availability of wet ethanol byproducts, accurate determination of the DM content of these wet byproducts is important.

Many different methods are available for determining DM, but the most common are oven drying procedures because of their cost effectiveness. Our objective was to compare different methods of DM determination to obtain the most consistent and accurate DM procedure for an ethanol plant or producer using wet byproducts.

Procedure

Samples

Samples of wet distillers grains plus solubles (WDGS), modified wet distillers grains (MWDGS), Dakota Bran Cake (Dbran), and distillers solubles (solubles) were obtained. For the least variability possible, large 5 lb byproduct samples were taken and used for each method. Traditional wet distillers grains plus solubles (WDGS) has a DM of 31%-35% and is used widely in feedlot diets. Modified wet distillers grains (MWDGS) is partially dried to about 42%-48% DM. Dakota Bran Cake (Dbran), marketed by Poet Nutrition, has a DM of 50%-54% and is a bran and distillers solubles mix. Distillers solubles (e.g. solubles), is generally 25%-35% DM and is added back to wet grains, fed as a separate ingredient, or used in liquid supplements.

Oven Drying Methods

The 105°C and 60°C oven drying methods were conducted by weighing out 8 replications of each of the four products (5g wet weight). Weights were recorded at three different drying times of 3, 8, and 24 hours for the 105°C oven. The samples in the 60°C oven were weighed back at 24 and 48 hours.

Vacuum Oven Analysis

Vacuum oven analysis was conducted using the AOAC Official Method 934.01. Each product was replicated three times using approximately 5 g of wet byproduct. The samples were dried using a temperature of $\leq$ 70°C and pressure of $\leq$ 50 mm Hg.

Toluene Distillation Process

The toluene distillation procedure was based on AOAC Official Method 925.04,. The 90-minute procedure required 12-15 mL of moisture, therefore approximately 25 g (as-is) sample was used. The sample was weighed into a 250 mL Pyrex flask and toluene added to cover the byproduct sample. Toluene was then rinsed down the sides of the condenser into the collection trap and the trap was filled until it was slightly running over into the flask. Heat was applied so the toluene boiled at approximately 7 to 10 minutes. Measurements were taken at 30, 45, 60, 75, and 90 minutes. The condenser was rinsed after measuring at 45, 60, 75, and 90 minutes. After allowing time to cool, the condenser tube was rinsed to take a final reading. An aliquot of the distilled moisture was collected via syringe and analyzed for any volatiles using gas chromatography (GC). Four of 8 distillation replications were analyzed with the GC by preparing 2.0 mL of moisture collected with 0.5 mL 2-Ethylbutyrate.

The toluene heated faster than the solubles forcing the solubles to stick to the glassware. Therefore, to solve this challenge, dried bran (105°C for 24 hours) was added to the distillers solubles in a 1:3 ratio of bran to solubles. This allowed the solubles to remain within the toluene for the duration of the procedure. Amounts were then back-calculated to account for the bran.

Karl Fischer Titration

Karl Fischer titration, AOAC method 2001.12, was conducted in duplicate on all products.

Results

For WDGS, the DM determined from toluene distillation was 33.2%, which was not different (P > 0.10) from DM measured using 60°C oven for either 24 hours or 48 hours (Table 1). Also, no difference (P > 0.10) was observed between the 60°C oven for 48 hours and 105°C oven for 3 hours. It was determined that samples in the 105°C oven decreased in DM over time. The vacuum oven results were higher in DM content than all other methods for WDGS.

The MWDGS toluene distillation DM was 43.3% and was not different (P > 0.10) from the 105°C oven for 3 hours. The 60°C oven for 24 hours and 48 hours were not different

Table 1. Average DM percentages and CV between replicates of four different ethanol byproducts evaluated by different methods.

Sample	60°C		105°C			Toluene	Vacuum
	24 h	48 h	3 h	8 h	24 h		
WDGS	33.2^{a}	33.0^{ab}	32.7^{b}	32.2^{c}	31.6^{d}	33.2^{a}	35.2^{e}
CV%	1.35	1.57	0.99	1.09	1.14	1.36	0.49
MWDGS	44.1^{a}	43.7^{a}	42.9^{b}	42.2^{c}	41.3^{d}	43.3^{b}	45.0^{e}
CV%	0.22	0.42	0.59	0.78	0.51	0.47	0.34
Dbran	54.0^{a}	53.7^{a}	52.8^{b}	52.1^{c}	51.3^{d}	53.7^{a}	55.4^{e}
CV%	0.56	0.42	0.54	0.57	0.63	0.46	0.34
Solubles	35.6a	34.9^{b}	33.5^{c}	32.2^{d}	31.1^{e}	35.9^{a}	35.8^{a}
CV%	1.53	1.96	3.13	3.87	3.28	2.00	0.26

^{a,b,c,d,e}Means with different superscripts differ ($P < 0.10$).

($P > 0.10$) from each other. A reduction in DM was observed with drying MWDGS in the 105°C oven over time. The vacuum oven DM was 45.0%, which was greater than other methods discussed.

Dry matter was not different ($P > 0.10$) between the toluene distillation and 60°C oven (24 hours or 48 hours) for Dbran. The DM for Dbran was 53.7% for toluene distillation. Drying at 105°C decreased DM ($P < 0.10$) compared to toluene distillation or 60°C oven drying for Dbran, which is similar to what was observed with WDGS and MWDGS. Dry matter determined from the vacuum oven was also greater than oven drying at 60°C or toluene distillation.

Distillers solubles DM was 35.9% for toluene distillation (Table 1). No differences ($P > 0.10$) between toluene distillation, 60°C oven, and vacuum oven were observed. The only byproduct with the vacuum oven method being similar ($P > 0.10$) to toluene distillation was distillers solubles. The same decreases in DM occurred with the 105°C oven over time. This sample, averaged across methods, had the highest calculated coefficient of variation (CV).

The vacuum oven offered the most consistent CV as a method across all samples followed by the 60°C oven for 24 hours and toluene distillation. The 105°C oven was the least consistent especially with distillers solubles.

Less than 0.03% volatiles were present for water distilled from the 4 replications of toluene distillation suggesting the distillation removed only moisture For this reason, only 4 of the 8 replications for toluene distillation were completed.

Results from the Karl Fischer analysis were a DM of 37.3% for WDGS, 45.6% for MWDGS, 54.8% for Dbran, and 35.7% for distillers solubles. Coefficients of variation were 2.85%, 0.31%, 0.77%, and 2.38%, respectively. Because only 2 replicates were evaluated using Karl Fisher, the reader is cautioned to not compare the variation from Karl Fisher to other methods. No statistical comparisons were made due to less runs using Karl Fisher. However, the values are consistently greater than all other methods and for all byproducts except for vacuum oven. Interestingly, the solubles DM were consistent across all methods except for the 105°C oven method suggesting that the solubles can be measured using multiple methods.

Conclusions and Implications

Toluene distillation DM values were similar to 60°C oven for 24 hours. The 60°C oven is more cost effective and more easily completed than toluene distillation. With the decrease in DM over time in the 105°C oven, it could be implied that volatiles are lost due to more intense heat. However, loss of volatiles with the forced-air 60°C oven method was not observed given the close agreement with toluene distillations. Karl Fischer titration provides similar DM values to the vacuum oven method, and result in higher DM calculations than oven drying and toluene distillation. It is recommended that the 60°C for 24 hours be used as the standard for DM determination of wet byproducts because it is less tedious and costly than toluene distillation.

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[1] Mallorie F. Wilken, graduate student; Galen E. Erickson, associate professor; Josh R. Benton, research technician; Crystal D. Buckner, research technician; Terry J. Klopfenstein, professor, Animal Science, Lincoln. Kip Karges and Matt Gibson, Poet Nutrition, Sioux Falls, S.D.

Ruminal Methane Production Following the Replacement of Dietary Corn with Dried Distillers Grains

Eric J. Behlke
Tim G. Sanderson
Terry J. Klopfenstein
Jess L. Miner[1]

Summary

Methane production was measured following the replacement of corn with DDGS in vitro and also after the simultaneous replacement of corn and corn oil with DDGS (for 30% of the diet) in vivo. In vitro substitution of corn with DDGS increased the amount of methane produced per milligram of DM digested. Likewise, in vivo methane production was increased by 44% when corn and corn oil were replaced with DDGS. The greater energy value of DDGS relative to corn in a concentrate-based diet is not due to decreased methanogenesis.

Introduction

The inclusion of DDGS in a corn-based diet results in the DDGS possessing a greater amount of net energy available for gain relative to the corn it replaces, and this increase may be attributed to a decrease in ruminal methane production. DDGS contains a greater amount of fat than does corn, and some fatty acids predominant in corn oil have been reported to specifically inhibit methanogenesis. Furthermore, DDGS contains a lesser amount of fermentable substrates than does corn. We hypothesized that the replacement of corn with DDGS would decrease ruminal methane production.

Procedure

In vitro methane production

Ruminal fluid collected from a fistulated heifer receiving a mixed forage and concentrate diet was used to inoculate cultures (n = 4/substrate combination) provided with one of five substrate combinations at a rate of 10 mg DM/mL. Substrate combinations were 100% corn (0%), 25% DDGS and 75% corn (25%), 50% DDGS and 50% corn (50%), 75% DDGS and 25% corn (75%), or 100% DDGS (100%). Nutrient content of the substrates is outlined in Table 1. Cultures also contained a modified McDougall's buffer, distilled H_2O, trypticase, resazurin, a micro mineral solution, and Na_2S. Following the addition of media to 40 mL glass vials, an oxygen-free environment was created by purging each of the cultures with CO_2. The vials were then sealed, pressurized to 100 kPa above atmospheric pressure, and placed in a shaking incubator (102°F) for 22 hours. Following incubation, headspace pressure was measured and methane concentration was determined using a gas chromatograph. Media were then centrifuged and the supernatant was removed for volatile fatty acid (VFA) concentration analysis. IVDMD was determined by filtration and subsequent drying of the filter (140°F) for 48 hours. Data were analyzed using direct regression in order to determine the significance of the linear and quadratic effects of DDGS inclusion level.

Table 1. Nutrient content of substrates (%DM; in vitro experiment).

Nutrient Content	Substrate DDGS	 Fine ground corn
Neutral detergent fiber	27.3	18.7
Starch	8.17	1.6
Crude protein	29.3	10.6
Ether extract	9.9	3.7

Table 2. Diet composition and nutrient content (%DM; sheep experiment).

Composition of Pellets	Diet CORN	 CORN/DDGS
Fine ground corn	71.4	43.7
DDGS	0.0	29.9
Alfalfa	10.0	10.0
Brome hay	10.0	10.0
Mineral	2.5	2.5
Ammonium chloride	2.5	2.5
Corn oil	2.2	0.0
Lignin sulfonate	1.4	1.4
Nutrient Content		
Starch	56.6	44.6
NDF	17.5	26.5
CP	14.3	18.5
EE	4.0	6.1

Lamb experiment

Nine crossbred lambs (38 ± 7 lb) were assigned randomly to receive a sequence of diets in a 2-period crossover design. Lambs were fed twice daily and at 3% of BW. Diets contained 71% corn, 2% corn oil, and 27% forage and supplement (CORN) or DDGS replaced both corn and corn oil for 27.7% and 2.2%, respectively, of the diet (CORN/DDGS). Diet compositions and nutrient contents are outlined in Table 2. Lambs were adapted to grain by feeding 50%, 40%, 35%, and 30% forage and supplement (DM basis) replaced by concentrate (corn or corn/DDGS) for 4, 4, 4, and 2 days, respectively, prior to the commencement of feces collection. Periods were 19 days with 14 days of adaptation and 5 days of collecting orts and feces for determination of DM digestibility. Methane production was determined on days 17 and 18 of each period using the sulfur hexafluoride tracer technique, which was described previously (2007 *Nebraska Beef Report*, pp. 19-21). Ruminal fluid was collected via the esophagus at 1200 hour on day 19. The pH of the samples was recorded and samples were immediately frozen for later VFA analysis. Data were analyzed utilizing the MIXED procedure of SAS. The model included the fixed effects of period, diet, and day of sampling and the random effect of animal. Because the same animal was sampled twice, each period a repeated measures covariance structure was used.

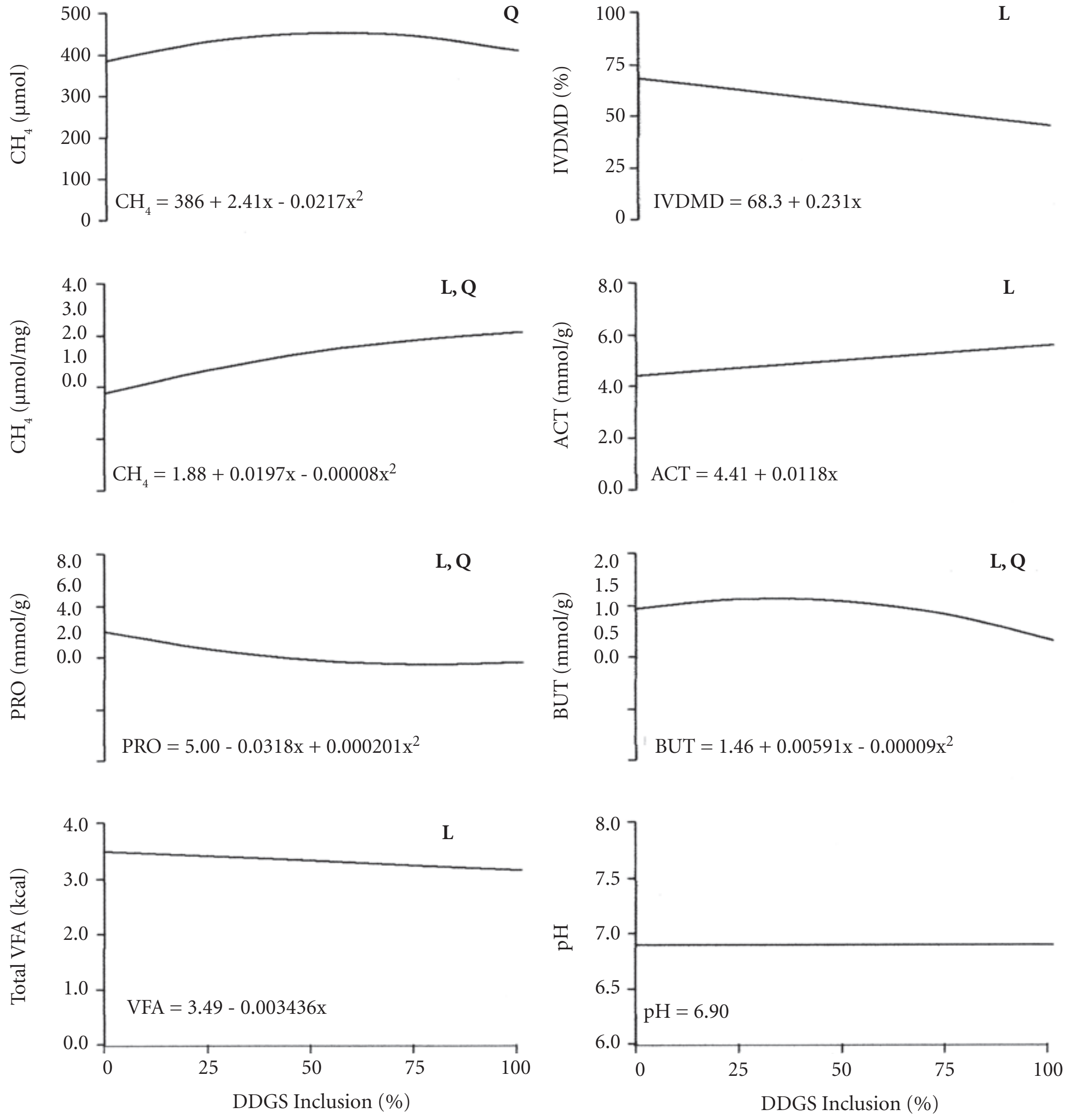

Figure 1. L = linear coefficient was significant ($P < 0.05$), Q = quadratic coefficient was significant ($P < 0.05$). Response curves for total methane (CH_4) production, IVDMD (in vitro dry matter digestibility), CH_4 production per mg of digestible DM, acetate (ACT) production, propionate (PRO) production, butyrate (BUT) production, total kcal produced in the form of VFA calculated as (0.209*ACT)+(0.367*PRO)+(0.524*BUT), and final culture pH when DDGS replaced corn as a substrate for in vitro fermentation.

Results

In vitro methane production

The complete replacement of corn with DDGS did not affect the total amount of methane produced by cultures (Figure 1). As DDGS was substituted for corn, IVDMD decreased ($P < 0.01$). The decrease in DM digested as DDGS replaced corn resulted in an increase ($P < 0.01$) in the amount of methane produced per milligram of digested substrate. Consistent with commonly observed fermentation patterns, replacement of the substrate composed predominantly of starch (corn) with a more fibrous substrate (DDGS) resulted in an increase ($P < 0.01$) in the amount of acetate produced per milligram of digested DM but a decrease ($P < 0.01$) in the amount of propionate and butyrate produced per milligram of digested DM. The kcal of energy available from the VFA produced per milligram of digested DM decreased ($P < 0.05$) as corn was replaced with DDGS. The latter observation is likely a function of the greater amount of non-fermentable substrate (ether extract, and protein) present in the DDGS compared to corn, which decreases the amount of fermentable substrate (fiber and starch) available for VFA production.

Lamb experiment

DMI was greater ($P = 0.03$) for the CORN diet but no difference in digestibility was detected (Table 3). The simultaneous replacement of corn and corn oil with DDGS resulted in a 29% increase ($P = 0.02$) in methane

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emissions. Likewise, methane emissions per lb of digested DM increased (P = 0.01) 44% when corn and corn oil were replaced with DDGS. The pH of collected ruminal fluid tended to be lesser (P = 0.06) for CORN/DDGS animals compared to CORN animals, but no differences were detected in the concentrations of acetate, propionate, or butyrate.

The increase in methane production observed in vitro and in vivo can be attributed to the accompanying increase and decrease in NDF and starch, respectively, because fiber possesses a greater methanogenic potential than starch. One caveat to our interpretation involves potential effects of oil. Both diets contained corn oil but the physical form of this oil in DDGS may affect methanogenesis differently than the physical form of added oil in the CORN diet. We conclude that a decrease in methane production is not responsible for the increased energy value of DDGS when it is used to replace corn in a feedlot diet.

Table 3. Effects of simultaneously replacing corn and corn oil with DDGS.

	Diet			
Variable	CORN	CORN/DDGS	SEM	*P*-value
DMI (lb)	1.34	1.28	0.08	0.03
DM Digestibility (%)	78.1	75.8	1.3	0.15
CH_4 (mL/min)	10.2	13.2	2.0	0.02
CH_4 (mL/min • lb)[a]	9.48	13.7	1.7	0.01
pH	5.85	5.49	0.14	0.06
Acetate (mM)	24.3	24.3	2.4	0.99
Propionate (mM)	17.0	14.3	2.1	0.37
Butyrate (mM)	6.79	6.12	1.33	0.69

[a] CH_4 production rate per lb of digested DM.

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[1] Eric J. Behlke, graduate student; Tim G. Sanderson, undergraduate student; Terry J. Klopfenstein, professor; and Jess L. Miner, associate professor, Animal Science, Lincoln.

Relationship Between Metabolizable Protein Balance and Feed Efficiency of Steers and Heifers

Grant I. Crawford
Stephanie A. Quinn
Terry J. Klopfenstein
Galen E. Erickson[1]

Summary

Two individual feeding experiments were analyzed for the relationship between metabolizable protein (MP) balance and feed efficiency (G:F) in individually-fed steers and heifers. In Experiment 1, 29 crossbred steers were fed steam-flaked corn (SFC)-based diets containing either 0% or 1.2% urea (DM basis). In Experiment 2, 75 crossbred heifers were fed SFC-based diets with either 0% or 1.5% urea. The NRC (1996) MP model was used to determine individual degradable intake protein and MP balances. In both experiments there was a negative relationship within treatment between MP balance and G:F. These results were not expected, and three potential causes were proposed: conversion of MP to net protein; ruminal pH; and/or residual feed intake.

Introduction

Metabolizable protein (MP) is the sum of digestible microbial protein and digestible undegradable intake protein (UIP). Beef cattle feedlot diets often contain excess MP, but may be deficient in degradable intake protein (DIP). In these situations, urea is often added to diets to provide adequate DIP. It is unknown, however, what the relationship is between MP balance and feed efficiency (G:F). Therefore, the objective of this data analysis was to determine the relationship between MP balance and G:F in individually-fed steers and heifers.

Procedure

Data from two individual feeding experiments were analyzed to determine the relationship between MP balance and G:F. In Experiment 1, 29 crossbred steers (743 lb initial BW) were fed diets containing 84% steam-flaked corn (SFC), 11% sorghum silage, 5% molasses, and 5% dry supplement with either 0 (NEG) or 1.2% (POS) urea included in the dry supplement for 83 days. Corn gluten meal was also included in the POS treatment at 3.0% of DM. These diets resulted in dietary CP concentrations of 8.9% and 14.4% for NEG and POS, respectively. In Experiment 2, 75 crossbred heifers (897 lb initial BW) were fed diets containing 85% SFC, 10% sorghum silage, and 5% dry supplement with either 0 (NEG) or 1.5% (POS) urea included in the dry supplement for 84 days. This resulted in dietary CP concentrations of 9.6% and 13.7% for NEG and POS, respectively. In both experiments, cattle receiving the NEG treatment were in a negative MP balance and cattle receiving the POS treatment were in a positive MP balance based on feed efficiency and calculated (NRC, 1996) MP balance. Cattle were individually fed once daily using Calan gates, and orts were subtracted from the daily feed offering to determine daily DMI for each animal.

Each animal's individual ADG and DMI for the experiment were used for performance variable inputs in the 1996 NRC model to estimate MP balance of each individual animal within treatment. Individual animal final BW was adjusted to expected BW at 28% empty body fat using the procedures of Guiroy et al. (2001 *Journal of Animal Science*, Vol. 80, pp. 1791-1800) to calculate adjusted final BW. Feed ingredient nutrient compositions were also adjusted in the model to account for actual feed CP and DM during the experiment. The resulting MP balance from the model for each individual animal was compared to G:F for that animal.

Results

Performance data for each experiment are presented in Table 1. In Experiment 1 no statistical differences ($P > 0.10$) were observed for DMI, ADG, and G:F. Steers consuming POS did have numerically greater ($P = 0.16$) G:F compared to steers consuming NEG. In Experiment 2, DMI, ADG, and G:F were all greater ($P > 0.01$) with POS compared with NEG.

Cattle fed POS (balanced) diets had better G:F than those deficient in MP, however, the relationship of MP balance and G:F within treatments where the cattle were fed the same diet, was examined.

There was a significant relationship between MP balance and G:F for each treatment within experiment. In Experiment 1, the relationships observed had an $r^2 = 0.95$ and 0.60 for NEG and POS, respectively (Figure 1), while in Experiment 2, the relationships were $r^2 = 0.45$ and 0.40 for NEG and POS, respectively (Figure 2). In all cases, an increase in MP balance was associated with a decrease in G:F. This indicates that a lower MP balance resulted in an improvement in feed efficiency, suggesting that cattle in these experiments either had a greater MP supply than calculated by the model, or MP was used more efficiently by MP-deficient cattle.

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Table 1. Feedlot performance of cattle used for this analysis[a].

	Treatment			
Item	NEG	POS	SEM	*P*-Value
Experiment 1				
DMI, lb/day	20.3	20.1	0.6	0.75
ADG, lb	3.29	3.55	0.40	0.27
G:F	0.162	0.177	0.008	0.16
Experiment 2				
DMI, lb/day	17.4	19.5	0.3	< 0.01
ADG, lb	2.44	3.52	0.11	< 0.01
G:F	0.141	0.181	0.008	< 0.01

[a] NEG = Cattle consuming SFC-based diets with no supplemental urea; POS = Cattle consuming SFC-based diets with either 1.2% (Exp 1) or 1.5% (Exp 2) supplemental urea.

We expected that an increase in MP would result in an increase in feed efficiency. Therefore, these results seem counterintuitive, and may be largely due to individual animal variation. Possible causes may be variation in conversion of MP to net protein (NP), variation in ruminal pH, and variation in residual feed intake.

It is assumed that MP is converted to NP with decreasing efficiency as animal BW increases. However, studies to confirm these assumptions have only used animals with a BW range of approximately 330-660 lb, with an assumed conversion of MP to NP of 0.492 thereafter. It is unknown how efficient heavier animals are in converting MP to NP, and the variation among animals at these heavier weights is also unknown.

A second potential source of animal variation is ruminal pH. Low ruminal pH may affect fiber and protein degradation and efficiency of microbial synthesis. Low ruminal pH may also decrease the efficiency with which microbes convert feed energy and nitrogen into protein. Individual animals can vary dramatically in their ability to adjust to a high-concentrate diet. Therefore, it would be expected that ruminal pH would vary considerably within and between treatments fed to cattle in a typical feedlot setting. Although ruminal pH was not measured in either of the experiments used for this analysis, previous work (*2007 Nebraska Beef Report*; pp. 100-102) suggests significant animal variation exists in ruminal pH patterns. In this previous experiment with rumen pH measured continuously with submersible pH probes in the rumen, pH can vary for animals fed the same diet. For example, Crawford et al. observed individual average pH varied from 5.16 to 5.89 for steers fed the same steam-flaked corn diet. For steers fed a byproduct based diet in the same experiment, ruminal pH varied from 5.68 to 6.12. These data demonstrate animal variation certainly exists for rumen pH which would likely affect MP balance and utilization by individual cattle.

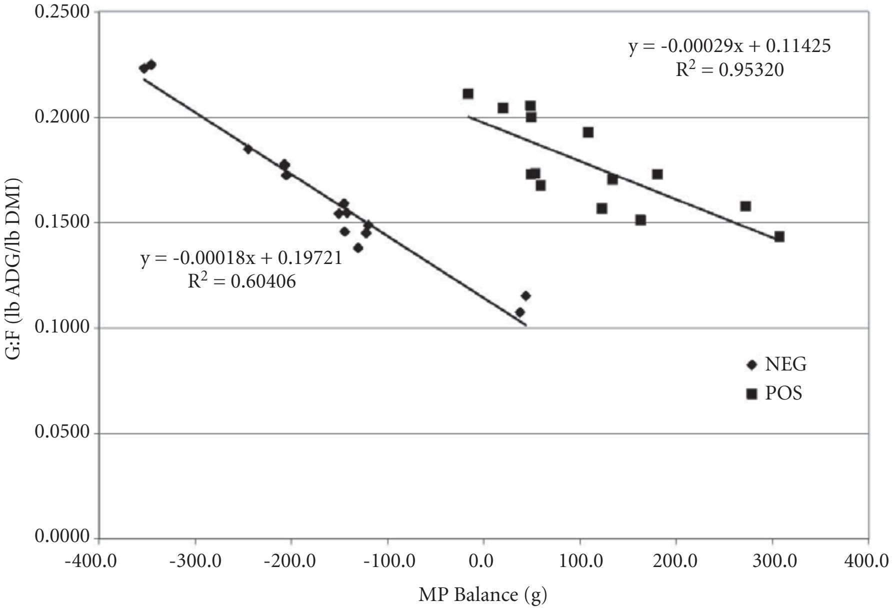

Figure 1. **Regression of individual animal gain:feed on individual animal MP balance when steers were fed SFC-based diets with 0 or 1.2% urea (Data from Experiment 1).**

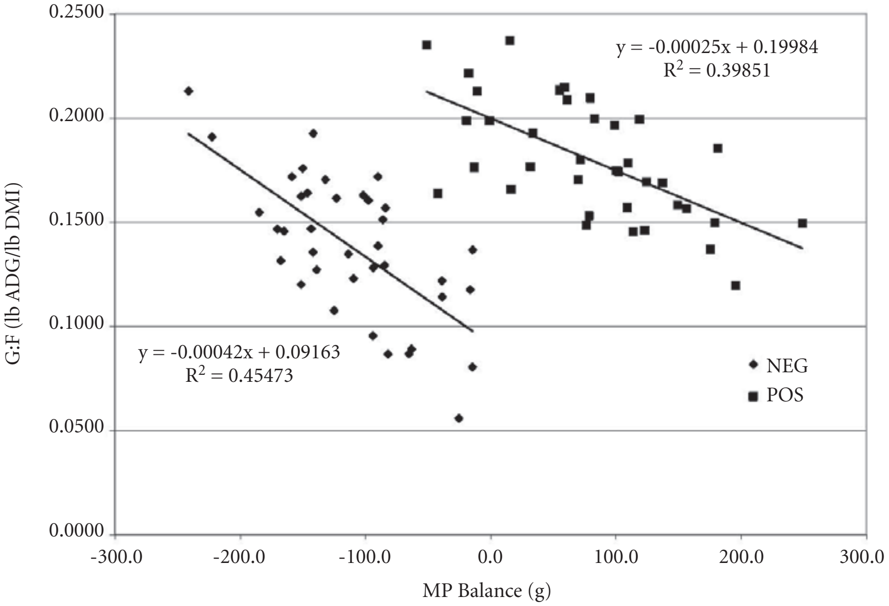

Figure 2. **Regression of individual animal gain:feed on individual animal MP balance when heifers were fed SFC-based diets with 0 or 1.5% urea (Data from Experiment 2).**

There is considerable animal variation in feed intake above and below that expected or predicted based on size and growth rate. This difference in intake is termed residual feed intake (RFI). Variation in RFI is indicative of differences in efficiency of energy use. If RFI can vary due to differences in efficiency of energy utilization, it is logical to assume that variation in efficiency of protein utilization is also present, and could further explain the G:F responses to MP supply in these experiments.

In summary G:F in cattle was negatively related to MP balance. This result seems counterintuitive, as one would expect an improvement in animal efficiency as MP availability increased. Individual animal variation could be the primary cause of this relationship. Specifically, individual animal variation in conversion of MP to NP, ruminal pH, and RFI may help explain these results.

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[1] Grant I. Crawford and Stephanie A. Quinn, former graduate students; Terry J. Klopfenstein, professor; and E. Galen Erickson, associate professor, Animal Science, Lincoln.

Microbial Characteristics, Microbial Nitrogen Flow, and Urinary Purine Derivative Excretion in Steers Fed at Two Levels of Feed Intake

Grant I. Crawford
Matt K. Luebbe
Josh R. Benton
Terry J. Klopfenstein
Galen E. Erickson[1]

Summary

Ruminally and duodenally fistulated Holstein steers were fed at 40% and 85% of ad-libitum intake. Microbial purine:N ratio did not differ between intake levels, which makes estimating microbial protein easier in production or experimental settings. Urinary purine derivatives (PD):creatinine (PD:C) ratio and microbial CP flow estimated from the duodenum increased with the higher feeding level. Urinary PD:C and duodenal purine flow were related, suggesting that urinary PD:C ratio can be used to estimate relative differences in microbial CP flow.

Introduction

The urinary purine derivative:creatinine ratio (PD:C) is a useful tool for estimation of microbial CP (MCP) flow in feedlot cattle (*2007 Nebraska Beef Report*, pp. 100-102 and pp. 103-105).

Two major factors limiting the application of the urinary PD:C method to estimate MCP flow are the contribution of endogenous PD to total urinary PD excretion and the purine content of ruminal microbes. Therefore, the objectives of this experiment were to characterize the purine:N ratio of ruminal microbes, estimate endogenous PD contribution to total urinary PD excretion, and evaluate use of spot samples of urine to estimate MCP flow in cattle.

Procedure

Five ruminally and duodenally fistulated Holstein steers (1,254 ± 88 lb) were assigned randomly to one of two treatments. The two treatments were either 40% or 85% ad-libitum intake of a diet consisting of 70% high-moisture corn, 20% corn bran, 5% alfalfa hay, and 5% dry supplement. Steers were fed through automatic feeders programmed to deliver feed every 4 hours in six equal portions throughout the day. Diets contained 33 g/ton monensin and 10 g/ton tylosin. Steers were not implanted for this experiment.

The experiment consisted of four 21-day periods. Each period consisted of a 17-day adaptation phase followed by a 4-day sample collection phase. Chromic oxide was used as an indigestible marker for estimating duodenal flow. Urinary creatinine was used as a marker to estimate urine volume, and the ratio of urinary PD to creatinine was used to estimate relative differences in MCP flow. Spot samples of urine and duodenal flow were collected on days 18 to 20 of each period at 0700, 1200, 1700, and 2200 hours. On day 21, ruminal contents were collected from each steer at 0730 hour.

Ruminal bacteria were isolated from ruminal contents by differential centrifugation to separate bacteria from feed and supernatant. Purines were determined in duodenal and isolated bacterial samples using adenine and guanine as standards. Purines were determined by spectrophotometry, while urinary PD and creatinine were determined by HPLC.

Urinary PD excretion was calculated from urinary PD and creatinine output assuming creatinine output of 28 mg/kg BW. These values were regressed upon duodenally absorbed purines assuming an intestinal absorption of 83% for purines reaching the duodenum.

Data were analyzed using the Proc MIXED procedure of SAS for a crossover design. For ruminal digestibility and microbial characteristics, the model included period, level of intake, and previous period level of intake. Duodenal purine flow and urine data were analyzed as repeated measures. Urine spot sample and duodenal flow sampling time were also analyzed for linear, quadratic, and cubic responses. Treatment differences were considered significant at $P < 0.05$.

Results

Feed offering for the 40% and 85% ad libitum treatments averaged 11.7 and 24.9 lb/day, respectively. No treatment differences ($P > 0.10$) were observed for any microbial characteristic measured (Table 1). Microbial N content averaged 6.12% at the 40% intake level and 6.30% at the 85% intake level. Purine:N ratio averaged 0.195 and 0.208 for the 40% and 85% intake levels, respectively. Among all samples, the purine:N ratio ranged from 0.127 to 0.251, with an overall average of 0.205.

This experiment was designed to produce wide ranges in MCP flows through altering individual animal DMI with the hypothesis that

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Table 1. Ruminal microbial characteristics from steers fed at 40% and 85% of ad libitum DMI[a].

	Level of Intake (%)[a]			
Item	40	85	SEM	*P*-value
OM, % of DM	84.1	85.1	0.7	0.19
Purines, % of DM	1.19	1.34	0.18	0.49
N, % of DM	6.12	6.30	0.44	0.66
Purine:N	0.195	0.208	0.019	0.59

[a]Diets were fed at either 40% or 85% of previously determined ad libitum DMI.

increased DMI would result in an increase in MCP flow and urinary PD excretion. As expected, we observed large ranges in MCP flow estimated from both duodenal purine flow and urinary PD:C (Table 2). Urinary PD:C increased from 0.510 at 40% ad libitum intake to 0.916 at 85% ad libitum intake. Microbial protein flow increased from 305.6 g/day at 40% ad libitum intake to 755.5 g/day at 85% ad libitum intake. Microbial efficiency tended ($P = 0.08$) to improve with the 85% intake level compared with the 40% intake level. An improvement in MCP flow and microbial efficiency at the higher intake level can be attributed at least partially to a greater amount of energy supplied by increased DMI. In addition, a reduction in recycling of nutrients by ruminal bacteria at higher intakes reduces maintenance requirements and provides more nutrients for microbial growth.

Upon regressing urinary PD excretion on absorbed purines (Figure 1), we observed a relationship between the two with an equation of 0.412x + 57.77 where x = absorbed purines in mmol/d and a good fit ($r^2 = 0.60$). This indicates that urinary PD excretion is related to microbial protein flow at the duodenum. Ideally, the slope of this equation would equal 1, which would indicate that all purines absorbed from the small intestine are quantitatively recovered in the urine. However, our value of 0.412 indicates that only 41.2% of absorbed purines are recovered in the urine, and non-renal losses of PD account for 59% of absorbed purines. The intercept of the equation in Figure 1 (57.77 mmol/day) represents endogenous PD contribution to urinary PD excretion. Endogenous PD are PD that do not originate from duodenally absorbed microbial purines, and must be accounted for when making MCP flow estimates from urinary PD:C ratios.

An alternative explanation for the low (41.2%) recovery of purines as PD is that the estimate of purine digestibility (83%) from the literature is too high. If PD recovery is regressed on total dudodenal purine flow the

Table 2. Urinary purine derivative:creatinine ratio, microbial protein flow, and microbial efficiency in steers fed at 40% or 85% of ad libitum DMI.

	Level of Intake (%)[a]			
Item	40	85	SEM	*P*-value
PD:C[b]	0.510	0.916	0.027	< 0.01
MCP flow, g/day[c]	305.6	755.5	45.6	< 0.01
Microbial efficiency				
g of CP/100 g OMTD[cd]	10.2	12.2	0.7	0.08

[a]Diets were fed at either 40% or 85% of previously determined ad libitum DMI.
[b]Urinary purine derivative:creatinine ratio.
[c]Derived from duodenal purine flow assuming purine:N ratio of 0.205.
[d]Organic matter truly digested in the rumen.

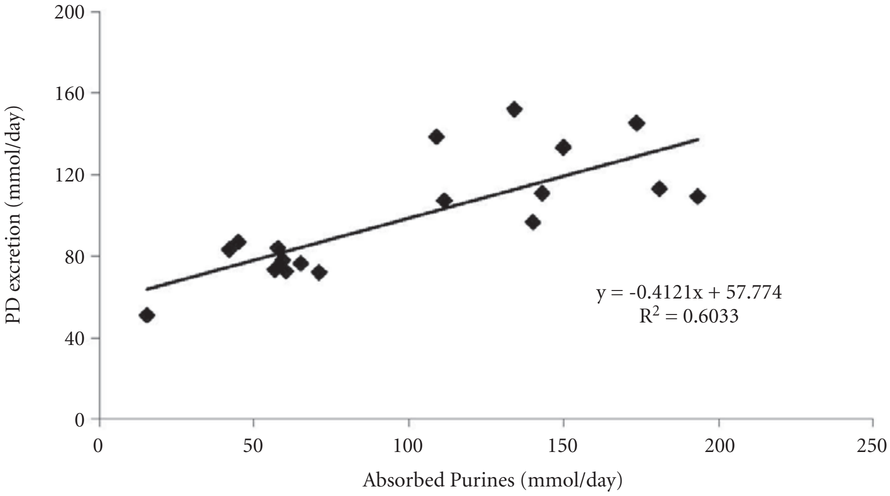

Figure 1. Urinary purine derivative (PD; mmol/day) excretion regressed on absorbed duodenal purines (mmol/day). Duodenal purine absorption assumed to be 83% of duodenal purine flow. SEM: slope ± 0.084; intercept ± 9.5.

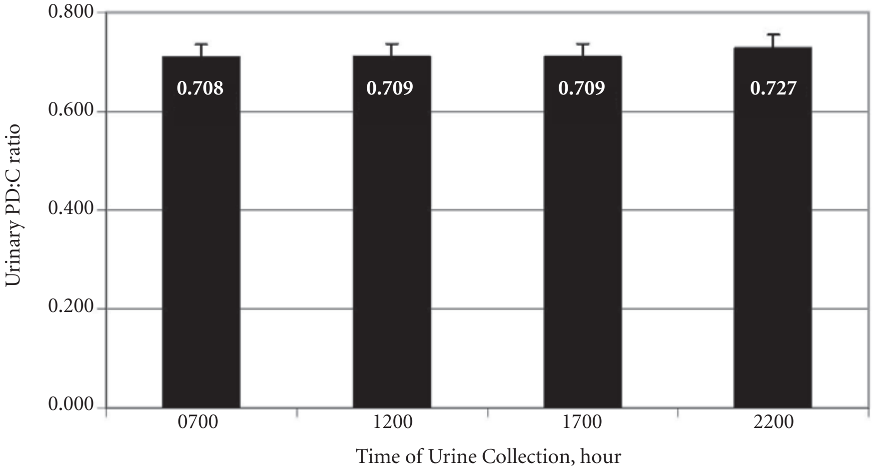

Figure 2. Effect of time of urine spot sample collection on urinary purine derivative:creatinine (PD:C) ratio. Urine collection time linear $P = 0.53$; quadratic $P = 0.65$; cubic $P = 0.83$. Level of intake x urine collection time $P = 0.77$.

recovery of PD declines to 34.2%. The 65.8% of purines not accounted for as PD could be explained by lower digestibility than 83%, secretion in saliva and salvage for use in nucleic acid synthesis in the body. At the present time, we do not know the magnitude of each of these uses (losses).

One of the major concerns with the use of the PD:C ratio to estimate MCP flow in ruminants is the possible impact of diurnal variation in PD and creatinine excretion. Previous data (*2007 Nebraska Beef Report*, pp. 100-102 and 103-105) suggested that urinary PD:C increased when spot samples of urine were collected in the afternoon rather than the morning. In those studies, animals were fed once daily at either 0730 or 0800 hours. In the current experiment, no diurnal differences in urinary PD:C ratio were observed (Figure 2) when steers were fed meals in six evenly spaced portions throughout the day. These findings suggest that the previously observed diurnal effect is likely a function of feeding time.

In conclusion, a microbial purine:N ratio of 0.205 was observed, and was not affected by level of DMI. Microbial CP flow and urinary PD:C ratio responded similarly to increasing DMI, and the relationship between the two indicates that urinary PD:C ratio from urine spot samples adequately represented relative treatment differences in MCP flow, though lower than expected purine recoveries were observed. Urinary PD:C was not affected by sampling time when steers were fed in six equal and evenly spaced portions throughout the day, indicating that diurnal variation in PD:C was a function of feeding time.

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[1] Grant I. Crawford, former graduate student; Matt K Luebbe and Josh R. Benton, research technicians; Terry J. Klopfenstein, professor, and Galen E. Erickson, associate professor, Animal Science, Lincoln.

Predicting Aged Beef Tenderness with a Hyperspectral Imaging System

Lauren M. Grimes
Govindarajan Konda Naganathan
Jeyam Subbiah
Chris R. Calkins[1,2]

Summary

A hyperspectral imaging apparatus was developed to predict, at 2-day postmortem, the 14 day aged tenderness of beef. USDA Choice and Select grade longissimus steaks (n = 314) from between the 12th and 13th ribs were scanned at 2 days postmortem, vacuum packaged, aged to 14 days, and frozen. For tenderness determination, steaks were thawed overnight, scanned, cooked in an impingement oven, and slice shear force values were obtained. The model predicted three tenderness categories (tender, intermediate, tough) with 77.1% accuracy, and two tenderness categories (acceptable, tough) with 93.7% accuracy. This hyperspectral imaging system was effective in predicting 14-day aged beef tenderness from 2-day scans.

Introduction

The development of an accurate, noninvasive, on-line beef tenderness predictor has been a long time interest of the beef industry because tenderness is commonly cited among consumers as a major concern, and they are willing to pay a premium for guaranteed tender product. The prediction device would need to accurately forecast 14-day aged tenderness from scans of the product at 2-day postmortem, since product typically reaches the consumer at 14-day postmortem.

Hyperspectral imaging captures multiple reflectance images, giving each pixel in an image its own spectral data. These imaging systems have been used to determine nutrient deficiency in plants, fecal contamination in chicken, and fungal/bacterial contamination in fruits. In the *2007 Nebraska Beef Report*, pp. 97-99, our research group reported a 96.4% accuracy in predicting 14 day beef tenderness from 14-day scans. Due to the success of the previous research, the objective of this research was to develop and validate an accurate, non-invasive tenderness instrument that accurately predicts 14-day aged beef tenderness from scans of 2-day aged beef.

Procedure

Hyperspectral imaging apparatus

A hyperspectral imaging apparatus (Figure 1) was constructed by integrating an InGaAs digital video camera and a spectrograph. The spectrograph has a spectral range of 900-1700 nm. Complete system specifications are described in *2007 Nebraska Beef Report*, pp. 97-99.

Data Collection

USDA Choice and Select grade longissimus steaks from between the 12th and 13th ribs at 2 day postmortem were cut to 1-inch thickness and scanned by the imaging system. Prior to the first scan, and periodically throughout data collection, a reference measure was obtained by measuring a 100% and 0% reflectance plate. Steaks were placed on a Teflon-coated plate mounted on a linear slide that utilized a stepper motor for movement. The steak was then scanned by the camera to obtain a three-dimensional data cube (reflectance by two-dimensional position). Images were obtained at wavelength intervals of 2 nm. After imaging, 2 day aged steaks were vacuum packaged, aged to 14 days and frozen. Steaks were later thawed overnight, scanned and cooked immediately on an impingement oven to an internal temperature of 157-162°F. Slice shear force (**SSF**) values were obtained by an Instron Texture Analyzer.

Statistical Analysis

From each image, a region-of-interest (**ROI**) was selected corresponding to the approximate shear

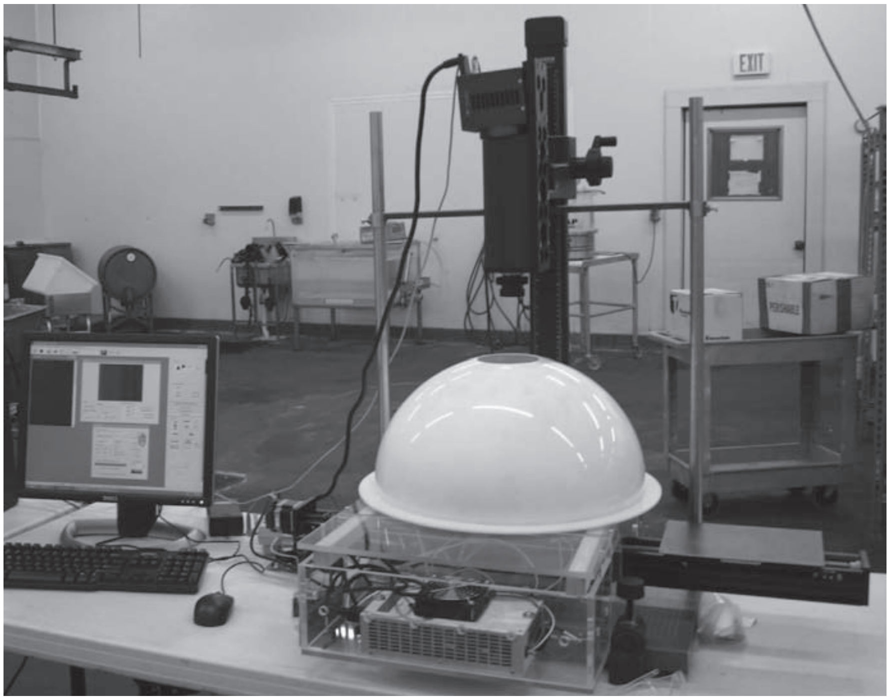

Figure 1. Hyperspectral imaging apparatus.

Table 1. Hyperspectral tenderness prediction vs. actual shear force tenderness.

	Predicted Categories			
Actual Categories	Tender[a]	Intermediate[b]	Tough[c]	Total
Tender[a]	200	47	9	256
Intermediate[b]	8	32	2	42
Tough[c]	3	3	10	16
Total	211	82	21	314

[a] ≤ 46.30 lb SSF.
[b] 46.31-57.1 SSF.
[c] ≤ 57.32 lb SSF.

location, and further image processing was performed on the ROI. By averaging the spectra of all ROI pixels, a mean spectrum of the ROI was obtained. The mean spectra (n = 314) were then analyzed with partial least squares (**PLS**) regression, and the loading vector was obtained. Each pixel of the ROI was then multiplied by the loading vector, thus generating PLS bands. To extract the textural features from the PLS bands, textural co-occurrence matrix analysis was conducted, and from these extracted textural features, a canonical discriminant model was developed. By implementing a leave-one-out cross-validation procedure, the developed model (from 2 day scans) predicted the three tenderness categories (defined by 14 day SSF), which are: tender ≤ 46.30 lb; 46.31 ≤ intermediate ≤ 57.31 lb; tough ≥ 57.32 lb.

Results

Of the 256 tender SSF steaks, 200 were accurately classified by the system as tender, 47 were misclassified as intermediate and 9 were misclassified as tough, for an accuracy of 78.1%. From the 42 intermediate SSF steaks, the system correctly classified 32, but misclassified 8 as tender and 2 as tough, for an accuracy of 76.2%. Of the 16 tough SSF steaks, 10 were classified by the system as tough, while 3 were misclassified as tender and 3 were misclassified as intermediate, for an accuracy of 62.5%. These results yielded an overall accuracy of the imaging system to be 77.1%. Intermediate SSF values are actually "acceptable" in tenderness to consumers. By merging the tender and intermediate groups together, thus only sorting two categories (acceptable from tough), this system correctly classified 287 out of 298 consumer acceptable steaks (96.3%). This yields an overall accuracy of 93.7% for sorting acceptable from tough. Table 1 shows the classification of steaks by the hyperspectral imaging system vs. the actual SSF categories of those steaks.

Implications

This hyperspectral imaging system was effective at predicting 14 day tenderness of beef longissimus steaks from 2-day postmortem scans. Implementation of a noninvasive tenderness prediction system may result in "guaranteed tender" premiums for beef products that may benefit producers and the industry as a whole.

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[1] Lauren M. Grimes, graduate student Animal Science; Govindarajan Konda Naganathan, graduate student, Biological Systems Engineering; Jeyam Subbiah, assistant professor, Biological Systems Engineering, Lincoln; and Chris R. Calkins, professor, Animal Science, Lincoln.

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

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 or 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. Animal Science majors can also easily 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
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Scholarships – Thanks to the generous contributions of our supporters listed below, each year the Animal Science Department offers 44 scholarships to Animal Science students.

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