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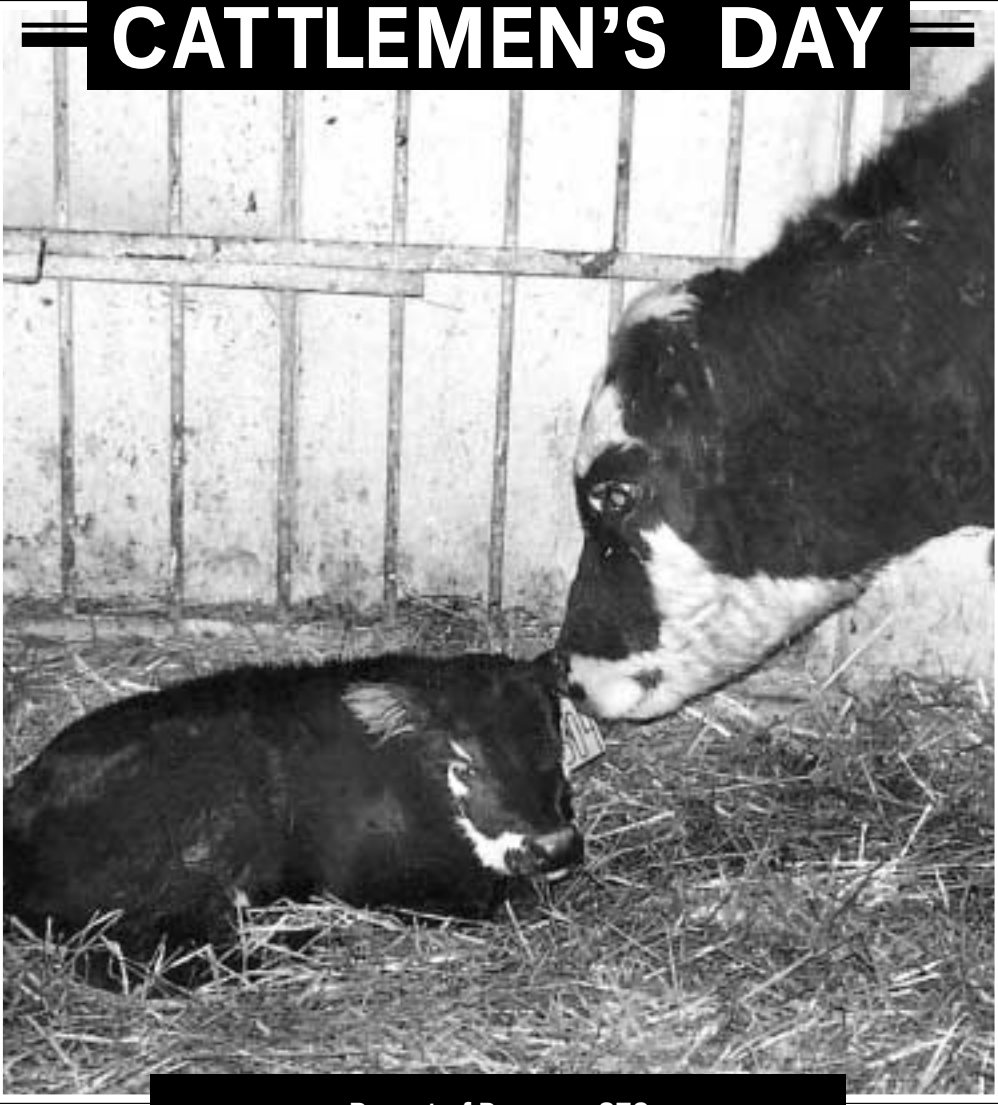

Report of Progress 873
Kansas State University
Agricultural Experiment Station and
Cooperative Extension Service

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Cattlemen's Day 2001

GENETIC RELATIONSHIPS AMONG BREEDING SOUNDNESS TRAITS IN YEARLING BULLS

R. A. Christmas, D. W. Moser, M. F. Spire[1], J. M. Sargeant[1], and S. K. Tucker[1]

Summary

Breeding soundness examination data on over 1,200 yearling Angus bulls were analyzed to determine heritability of and genetic relationships among breeding soundness traits. Breeding soundness exam procedures were consistent with those currently recommended by the Society of Theriogenology. Presence of seminal white blood cells (an indicator of seminal vesiculitis), penile warts and persistent frenulums were noted and recorded. Data were adjusted for age at measurement and contemporary group effects. Heritability was high for scrotal circumference, moderate for percentage of abnormalities, low for sperm motility, and near zero for semen white blood cells, persistent frenulum, and penile warts. Genetic correlations between scrotal circumference and both sperm motility and abnormalities were favorable, indicating that selection for increased scrotal circumference should result in higher fertility.

(Key Words: Bulls, Breeding Soundness Exam, Heritability, Genetic Correlation, Scrotal Circumference.)

Introduction

Most beef producers use yearling bulls as at least part of their bull battery. Many factors may influence a cow-calf producer's bull selection decisions, including growth and performance, carcass traits, and fertility. Of all these factors, fertility is the most economically important. For a bull to be considered fertile, he must be able to copulate normally and have semen of adequate quality. Currently, the breeding soundness examination (BSE) is the best predictor of fertility in beef bulls. The most common defects in the BSE of yearling beef bulls are inadequate semen quality, persistent penile frenulum, and penile warts.

We conducted this study to estimate the heritabilities of scrotal circumference, sperm motility, semen abnormalities, and common defects of the penis. Additionally, we determined estimates of the genetic correlation of these components with scrotal circumference.

Experimental Procedures

A BSE was performed on 1,282 registered Angus bulls developed at three private producers in the Kansas Flint Hills, or at the K-State Purebred Beef Unit between 1994 and 2000. Scrotal measurements were recorded to the nearest 0.5 cm. Semen was collected via electroejaculation and analyzed for motility, morphology, and the presence of white blood cells. Birth dates and complete five-generation pedigrees for all bulls were obtained from the American Angus Association, St. Joseph, MO. Average age at examination was 383 days, with a range of 288 to 455 days. Bulls outside this age range were excluded from analysis. Data in this study were from initial examinations; no data from rechecks were included. Averages for the analyzed traits are shown in Table 1.

Semen abnormalities were classified as primary or secondary, as described by the

[1]College of Veterinary Medicine.

Society for Theriogenology, and recorded as a percentage of the total sperm counted. Primary and secondary abnormalities were added to get percent total abnormalities. If motility was <30% or total abnormalities were >30% the bull was collected at least two more times on the day of examination. The results from the best sample (highest motility and lowest number of total abnormalities) were recorded. All slides were evaluated for the presence of white blood cells, an indicator of seminal vesiculitis. The presence of persistent penile frenulum or penile warts was recorded.

The statistical model used adjusted measurements for age in days at the time of evaluation and contemporary group effects. Contemporary groups defined the bull's origination from a common herd and management system in the same year. Heritability estimates were obtained from single trait analyses. Genetic correlations were determined by pair-wise analyses of each trait with scrotal circumference. A derivative-free REML algorithm was used to estimate variance components for estimates of heritabilities and genetic correlations, similar to procedures used in most breeds' national cattle evaluation programs for other traits.

Results and Discussion

Estimates of heritabilities and genetic correlations for the analyzed traits are shown in Table 2. As expected, scrotal circumference was highly heritable (0.56), and can easily be improved through selection. Primary, secondary, and total abnormalities were moderately heritable, ranging from 0.26 to 0.35. Heritability of sperm motility was low (0.07), and presence of white blood cells, persistent frenulum, and penile warts were found to have little or no genetic cause, perhaps because their incidence in this study was very low.

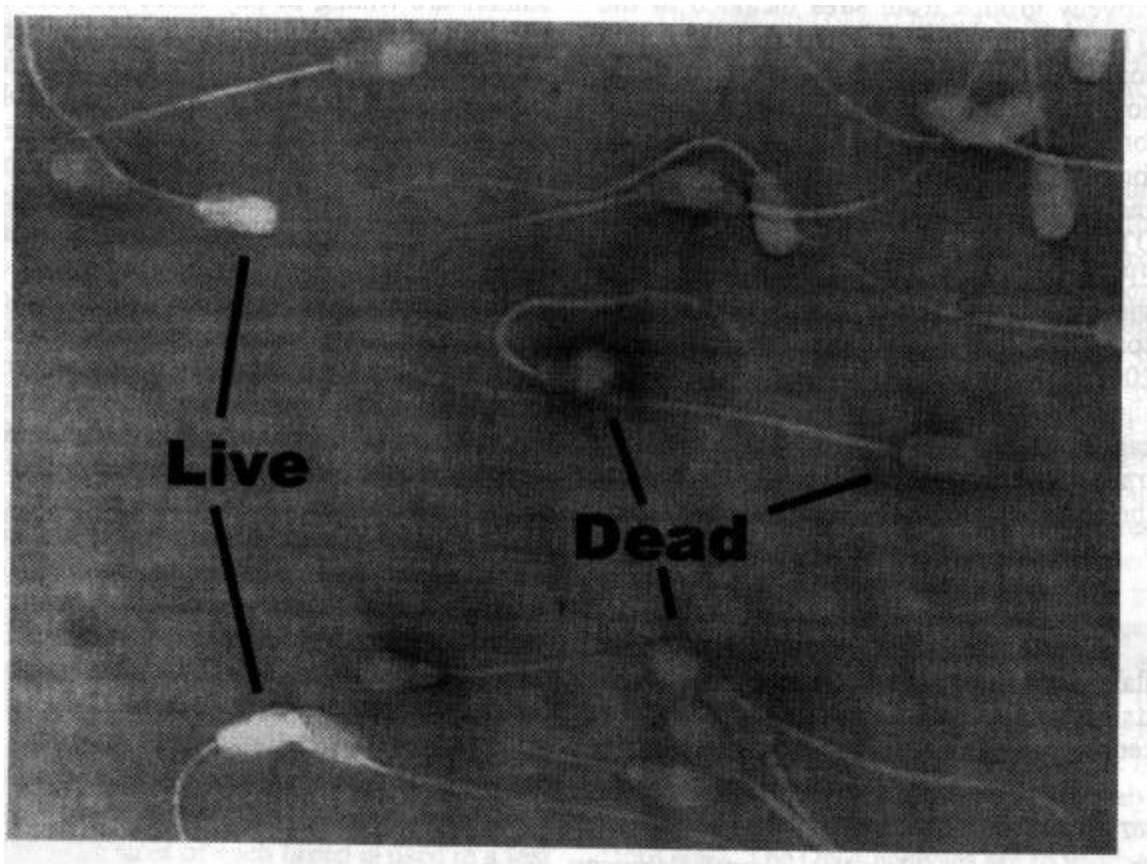
Genetic correlations between scrotal circumference and semen quality were moderate and in a favorable direction. Increased scrotal circumference was associated with increased motility (0.56), and decreased primary (-0.25), secondary (-0.40), and total (-0.32) abnormalities. The genetic correlation between scrotal circumference and presence of white blood cells was low (-.09) and in a favorable direction, indicating slightly lower incidence of seminal vesiculitis in large scrotal circumference bulls.

Table 1. Averages, Standard Deviations (SD), and Ranges for Breeding Soundness Components and Common Reproductive Abnormalities in Yearling Angus Bulls

Trait	Average	SD	Minimum	Maximum
Scrotal Circumference, cm	35.00	2.57	21.00	43.00
% Motile Sperm	44.36	12.34	0.00	85.00
% Primary Abnormalities	13.76	16.82	2.00	100.00
% Secondary Abnormalities	12.16	10.26	0.00	90.00
% Total Abnormalities	25.92	19.87	6.00	100.00
Percent with:				
Seminal White Blood Cells	5%			
Persistent Penile Frenulum	1%			
Penile Warts	3%			

Table 2. Heritabilites and Genetic Correlations for Breeding Soundness Exam Traits of Yearling Angus Bulls

Trait	Heritability	Genetic Correlation with Scrotal Circumference
Scrotal Circumference, cm	**0.56**	
% Motile Sperm	**0.07**	**0.56**
% Primary Abnormalities	**0.35**	**-0.25**
% Secondary Abnormalities	**0.26**	**-0.40**
% Total Abnomalities	**0.29**	**-0.32**
Seminal White Blood Cells	**0.02**	**-0.09**
Persistent Penile Frenulum	**0.00**	
Penile Warts	**0.00**	



This photo taken through a microscope, live sperm cells with healthy membranes have rejected the Eosin/Nigrosin stain and dead sperm with damaged membranes accept it. photo courtesy of Dr. Peter Chenoweth, Department of Clinical Sciences, College of Veterinary Medicine.

CARCASS MERIT PROJECT: DEVELOPMENT OF EPDS AND GENETIC MARKER VALIDATION

M. E. Dikeman, E. J. Pollak[1], R. D. Green[2], J. Taylor[3], S. Davis[3], T. Holm[4], S. Koontz[5], C. Gill[6], D. Moser, and E. A. Westcott[7]

Summary

Carcass and Warner-Bratzler shear force data on strip loin steaks have been obtained on over 4,200 cattle from contemporary progeny groups from the most widely used sires in 15 beef cattle breed associations (16 breeds). Trained sensory panel evaluations have been conducted on over 1,500 strip loin steaks from a sample of contemporary progeny groups from sires included in the QTL (quantitative trait loci) validation component of the project. One breed association has published Warner-Bratzler shear force Expected Progeny Differences (EPDs) for 57 sires of two breeds. DNA analyses and screening have been completed for 11 QTL on eight sires from several breeds. EPDs for carcass traits, Warner-Bratzler shear force, and sensory panel traits may be completed for several breeds within the year 2001. Information from this project should allow seedstock producers to improve carcass traits, tenderness, and other palatability traits through classical genetic selection or through DNA marker-assisted selection.

Introduction

Consumers eat beef primarily for its great flavor, but there have been complaints about its palatability associated with unacceptable tenderness. The National Beef Tenderness Study published in 1987 found that, except for the tenderloin, tenderness varies considerably, and significant proportions of nearly all beef cuts were unacceptable in tenderness. Tenderness is generally measured on the longissimus (loin-eye) muscle because it has the most total value, and is almost always cooked by dry heat. It is expected by consumers to be tender, juicy, and flavorful. Recent market studies have shown that consumers are willing to pay more for beef of known tenderness. Although consumers are the ultimate judges of tenderness, Warner-Bratzler shear force is a highly repeatable and economical method for measuring tenderness. Reviews of published literature on the genetic control of tenderness show that the heritability of Warner-Bratzler shear force is moderately high (29%) and that of marbling is high (38%), indicating that progress can be made through selection. However, selecting for palatability is difficult and expensive. EPDs have become "user friendly" tools for cattlemen to use in selecting for numerous traits, but until the implementation of this project, no cattle breed association had EPDs for Warner-Bratzler shear force or sensory-evaluated palatability traits. Recently, the American Simmental Association published Warner-Bratzler shear force EPDs as a result of this project. DNA markers have been identified at Texas A & M University for tenderness and other quality traits and, if

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validated in this project, could be used in 'marker-assisted' selection. With EPDs and(or) DNA marker-assisted selection, the beef cattle industry then can make significant progress toward improving meat palatability through genetic selection.

The Carcass Merit Project is an extensive 3½ year project involving four universities, 15 beef cattle breed associations (16 breeds), and Celera AgGen. The project is funded and coordinated by NCBA and the Cattlemen's Beef Board, the breed associations, and Celera AgGen. Its objectives are:

1. Collect information to develop EPDs for carcass merit traits.

2. Measure longissimus lumborum (strip steak) Warner-Bratzler shear force of contemporary groups of progeny from multiple sires within each breed.

3. Measure longissimus lumborum sensory attributes on a sample of contemporary groups of progeny from sires included in DNA 'marker' validation.

4. Validate DNA markers to be used in industry-wide 'marker-assisted' selection programs for improvement of carcass merit traits.

5. Determine DNA genotypes of these progeny for previously identified carcass merit markers.

6. Measure direct and opportunity costs and returns of implementing EPDs for carcass merit traits.

Experimental Procedures

The 15 breed associations (16 breeds) are providing approximately 11,000 AI progeny of their more widely used sires, primarily from commercial cow herds. One or more reference sires of each breed is used in a test herd in which a breed is being tested (reference sires are used to tie contemporary groups together for the breeds being tested). BIF guidelines for sire evaluation must be followed. The number of progeny from each breed is determined by the number of registrations of each breed calculated as a proportion of the total number registered by the cooperating breed associations. Each breed association is responsible for providing leadership for progeny testing; costs of synchronizing and mating cows; coordinating progeny testing; blood sampling; feeding; carcass data collection; and the development of EPDs for their breed. Consequently, the breed associations are funding about 50% of the total costs. The NCBA is providing funds for shear force and sensory panel evaluation, graduate student assistantships, travel for carcass data collection, and one-half of the DNA analyses. Celera AgGen is funding the other half of the DNA analyses. Sires will be **compared only within breed** and **NOT across breeds**. Breed identity is coded to prevent associations or breeders from comparing breeds. Dan Moser is the facilitator and liaison to the breed associations.

The selection of test herds, sires, feedlots and feedlot regimen, slaughter endpoint, and processing plants are at the discretion of each breed association.

Each association is allocated a minimum of 10 sires plus additional sires, based on the number of registrations for each breed, resulting in 10 to 54 sires per association. Ten sires within each breed will be designated as DNA sires, with a target of 50 progeny per sire. For non-DNA sires, the target is 15 progeny per sire, although this is at the discretion of each breed association. Carcass and Warner-Bratzler shear force data are obtained on all progeny from all sires. For five of the DNA sires within each breed, trained sensory panel evaluations will be conducted on all progeny. Progeny data can be accumulated over the 3½ year period, as long as reference sires are repeated. Prior to or upon entering the feedlot, blood samples are sent to both Clare Abbey at Texas A & M and to Tom Holm at Celera AgGen for analyses. Semen samples are also analyzed for the DNA sires. The DNA analyses are to validate the presence of 'markers' for shear force, sensory panel traits, and carcass traits that have been identified by Jerry Taylor and Scott Davis at Texas A & M through the checkoff and the Texas A & M-funded Genome Mapping Project.

A small muscle tissue sample from all progeny is obtained at the time of slaughter for backup DNA analyses and verification of animal identity. Detailed carcass data are obtained after chilling. One steak from each progeny of every sire and two steaks from progeny DNA sires are obtained and shipped overnight to Michael Dikeman at Kansas State University for Warner-Bratzler shear force and sensory panel evaluation. Shear steaks are cooked at 14 days postmortem. Sensory panel steaks are frozen and later thawed for trained sensory panel evaluations.

The database maintained by John Pollak at Cornell University is secure and updated almost daily. The development of carcass, shear force, and sensory panel EPDs is the responsibility of the breed associations, although John Pollak will be conducting those analyses for at least two breeds. The NCBA and breed associations own all carcass, shear force, and sensory panel data. Marker identities, genotypes produced by scoring the markers, and protocols for marker identification remain the property of Texas A & M and NCBA. However, this information, as well as the phenotypic data, will be provided to the breed associations for their use in computing EPDs.

Economic analyses will be conducted by Steve Koontz at Colorado State University. The first phase will measure direct costs of developing carcass merit EPDs and implementing management systems necessary to use the information. The second phase will measure the expected returns for implementing a carcass merit-based production system. The third phase addresses the marketing system for cattle, carcasses, and meat.

Elizabeth Westcott, the NCBA project coordinator, is responsible for implementation and oversight of the project. An NCBA Producer Steering Committee consists of Kathy Hawkins, chair, from MI; Rob A. Brown from TX; Dave Nichols from IA; James Bradford from IA; John Grande from MT; and James Bennett from VA. That Committee is responsible for giving oversight as needed and providing insight on future use of the DNA information.

Preliminary Results

To date, carcass and Warner-Bratzler shear force data have been collected on over 4,300 cattle. Sensory panels have evaluated steaks from over 1,500 cattle. Warner-Bratzler shear force EPDs have been developed and published for 47 Simmental and 10 Simbrah sires and are reported in the following paper in this report. Publishing EPDs for shear force is a first for the beef industry. Several other breeds may be developing EPDs within the year 2001. For breeds in which sufficient progeny have been slaughtered, variation appears sufficient to allow for genetic progress.

Several breeds have provided enough progeny to date for complete DNA analyses on several sires. A minimum of 66 markers are to be screened for each sire (11 Quantitative Trait Loci, QTL). There are seven QTLs for shear force and sensory panel tenderness, three for marbling, and one for ribeye area. The markers are not genes, but are random segments of DNA found at specific locations. Validation will determine if the QTL discovered in the Texas A & M experiment using Angus and Brahman cross cattle segregate within the various breeds in this project and, if so, which are heterozygous. In an example where a sire is heterozygous for a marker, such as Warner-Bratzler shear force, the progeny with markers that flank the QTL on one of the pair of chromosomes will be associated with having a lower or higher shear force value than those with the other markers. Therefore, DNA marker analysis could be used in selection, if a sire is heterozygous for the QTL of interest.

Some markers identifying QTL have been validated in several sires of the breeds where DNA analysis is complete. This suggests that the markers can be used as a selection tool for at least some traits for sires of some breeds.

CARCASS MERIT TRAITS: DEVELOPMENT OF EPDS FOR WARNER-BRATZLER SHEAR FORCE AND DNA MARKER VALIDATION

M. E. Dikeman, E. J. Pollak[1], S. L. Stroda, R. J. Lipsey[2], and E. A. Westcott[3]

Summary

Warner-Bratzler shear force data on strip loin steaks were obtained on 761 steers from contemporary groups of progeny from the most popular 38 Simmental sires, and 133 steers from nine Simbrah sires. The range for Warner-Bratzler shear force EPDs for the Simmental sires was from -0.51 lb (more tender) to +0.48 lb (less tender). The range in EPDs for the Simbrah sires was from -0.73 to +0.73 lb. In addition, DNA analyses and screening have been completed for 11 quantitative trait loci on several Simmental and Simbrah sires. Information from this project should allow cattle producers to improve carcass traits, tenderness, and other palatability traits through classical genetic selection or through DNA marker-assisted selection.

Introduction

The Carcass Merit Project is described in the preceding article. The specific objective reported here was to measure longissimus muscle (strip loin steak) Warner-Bratzler shear force and to calculate EPDs based on 761 progeny from 38 Simmental sires and 133 progeny from nine Simbrah sires.

Experimental Procedures

Strip loin steaks were obtained from 761 progeny of the 38 most widely used Simmental sires and 133 progeny from nine of the most widely used Simbrah sires, both mated to commercial cows. Steaks were retrieved at the time of carcass data collection. One or more reference sires was used in each test herd. BIF guidelines for sire evaluation were followed. Steaks were vacuum packaged and aged at 33-37°F until 14 days postmortem. They were cooked in a Blodgett oven at 325°F to an endpoint temperature of 158°F. Eight ½-inch cores were removed and sheared on an Instron Universal Testing Machine using the Warner-Bratzler shear device. Researchers at Cornell University conducted the genetic evaluations and calculations of EPDs, using a heritability estimate of 30% for Warner-Bratzler shear force.

Preliminary Results

Table 1 lists Simmental and Simbrah sires that had seven or more progeny evaluated, their sire and maternal grandsire, their EPDs, the EPD accuracy, and the number of progeny slaughtered. The most tender Simmental sire had an EPD for Warner-Bratzler shear force of -0.51 lb and the least tender sire had an EPD of +0.48 lb. The most tender Simbrah sire had an EPD of -0.73 lb and the least tender, +0.73 lb. The accuracies are relatively low for some of the sires because of small progeny numbers. The differences in the accuracy values are somewhat analogous to meteorologists predicting a 20% versus a 40% chance of rain. In other words, an accuracy of 0.42 means that the EPD value is

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more reliable than one with an accuracy of 0.16. The differences in these EPD values are large enough to allow for genetic improvement in tenderness when used in selection, particularly in the Simbrah breed.

Table 1. Simmental and Simbrah Sire Names, Their Sire and Maternal Grandsire, Expected Progeny Difference, Accuracy, and Number of Progeny Evaluated

		WBSF[1]		No. of
Simmental Sire Name	Sire/Maternal Grandsire	EPD	Accuracy	Progeny
3C Pasque 8773	Mr Abondance/Siegfrieds Powerthe	0.03	0.33	22
3C Wally C240	Emmons Black Hercules/HPS Night Rider	0.35	0.26	13
ALR Mr Lincoln	Cherithbrook Mr Abe/DS Polltime	0.24	0.16	9
ASR Cactus Red Z002	Polled Stretch/Alpine Polled Proto	0.3	0.35	42
Black Irish Kansas	Irish Black Knight/Kansas Black Jim	-0.09	0.42	37
Black Mick	Black Knight U2/Irish Rover	-0.04	0.31	20
Bold Future	Bold Ruler/H&S Pete	0.28	0.33	20
Boz Red Jet	Red Brother/Landridge Jet Black	-0.01	0.2	9
Burns Bull X339U	Black Max/Buck	0.14	0.29	17
Charles Pride	Copper Black S72/Landridge Jet Black	0.2	0.39	28
Circle S Leachman 600U	Landridge Jet Black/Steelman	-0.41	0.46	50
DS Zinger 141B	Hercules 538P/3X	0.15	0.29	15
DS Pollfleck 809	ABR Sir Arnold G809/Urspring	-0.24	0.29	15
Emmons Black Hercules	Landridge Jet Black/Hercules 538P	-0.21	0.31	21
ER Americana 537B	Black Max/Hercules 538P	-0.11	0.26	13
ER Big Sky 545B	ER Black Mack 568Y/Siegfried	-0.2	0.36	26
ER Mackfrid 550B	ER Black Mack 568Y/Siegfried	-0.25	0.32	21
F Nichols Black Advantage	Nichols Dynamite 9X/Buck	-0.18	0.33	19
Five Oaks Black Stretch	Polled Stretch/Buck	-0.35	0.21	11
GW Tailor Made 515A	Meyers Black Equalizer/T N T Mr T	0.45	0.27	16
HF/GF1 Powerline 7F	MV Red Light 406/Black Max	-0.51	0.23	11
J&C Black Maxi Van	J & C Black Maximizer W5/Extra	-0.19	0.21	17
Klondike Arnie GNM 250Z	SRF Mr Bigfoot S138/Bold	0	0.33	21
KSR Dr Pepper D405	Red Pepper/Grand Desire	0.03	0.27	21
LSR Preferred Stock 370C	Circle S Leachman 600U/Irish Black Knight	-0.16	0.28	12
Meyers Blacktop 206Y	Buck/Eagle	-0.33	0.31	17
Meyers Red Top	Meyers Blacktop 206Y/Chocolate Chip K34	-0.21	0.26	11
Nichols Big Easy D56	Nichols Dynamite 9X/Leachman Blk Baron 235X	-0.16	0.16	9
Nichols Black Destiny D12	CircleS Leachman 600U/Buck	-0.08	0.44	59
Nichols Blockbuster D100	Nichols Dynamite 9X/Buck	-0.3	0.25	30
Nichols Prime Rib E160	Nichols Prime Rib C139/F Nichols Black Advantage	-0.05	0.3	51
NLC Good A Nuff 33G	NLC 64 Tomcat/Leachman Red Baldy 438W	0.02	0.27	25
PVF-BF26 Black Joker	Harts Black Casino B408/Hercules 538P	-0.13	0.16	7
SRS Franchise F601	LRS Preferred Stock 370C/Meyers Black Power	-0.13	0.19	8
SSS Craftsman 004F	DS Black Zinger 141B/Black Polled Dakota	0.48	0.19	8
SV Red Charlie	Charles Pride/TT Red Delight	0.12	0.22	8
TKBS Mr Pride F164	Charles Pride/Meyers Blacktop 206Y	0.13	0.21	8
WHF Desperado 212G	PLT Cutting Edge D209/LRS Preferred Stock 370C	0.11	0.15	7
Simbrah Sire Name				
HR Nile King	PRR King Aurthur/Mr Pete 535P	0.46	0.31	21
K Bar Southern Comfort	RBR Leggacy/Red Rajah	-0.32	0.26	14
LL&L Blaze of Mississip	Mississippi	0.44	0.24	12
LMC Accountant 5A/174	LMC Money 8412P/5P Baliia 659	0.73	0.28	17
LMC Energizer 5B/155	Sir Nick 24Y/Wards Bravo 1/09	0.05	0.13	8
Parthenon Matador B218	K Bar Southern Comfort/Counter Sign	-0.48	0.29	18
PRR Pacesetter 205C	ISB MrX108X/RBR Net Profit	-0.06	0.28	16
RX Banner's B200	RX Polled Banner Zo2/AFI Honcho Supreme	-0.47	0.25	13
RX Colorado C332	HS Nail Z490 Abundance/RX Cognac 202	-0.73	0.26	14

[1]Warner-Bratzler shear force.

OVULATION SYNCHRONIZATION WITH PROGESTINS PRIOR TO A COSYNCH PROTOCOL IN BEEF COWS

J. S. Stevenson, M. A. Medina-Britos, A. M. Richardson, G. C. Lamb[1], B. A. Hensley, T. J. Marple, and S. J. Johnson[2]

Summary

A multi-location study was conducted using suckled beef cows in Minnesota and Kansas to test the benefit of adding a source of progestin to the Cosynch ovulation synchronization protocol (injections of GnRH, 7 days before and 48 hr after an injection of $PGF_{2\alpha}$, with a fixed-time artificial insemination (AI) administered at the same time as the second GnRH injection). Feeding melengestrol acetate (MGA) for 14 days followed in 12 days by the Cosynch protocol was compared to the Cosynch protocol with the addition of a progesterone-impregnated insert (CIDR) placed in the vagina for 7 days concurrent with the first GnRH injection. Pregnancy rates after the first AI (timed AI) were 22% greater with the CIDR insert, whereas conception rates for those cows returning to estrus were greater for cows previously fed MGA. Total pregnant cows after two inseminations were 64% for CIDR cows and 59% for MGA cows.

(Key Words: Ovulation Synchronization, Cows, Embryo Survival, MGA, CIDR.)

Introduction

During the past 6 years we have experimented with various hormonal protocols to synchronize estrus and ovulation in suckled beef cows without calf removal. Using an injection of GnRH 7 days before an injection of $PGF_{2\alpha}$, has successfully increased the percentage of cows showing heat during the first week of the breeding season, the percentage of cows cycling, and the percentage of cows conceiving to a fixed-time insemination.

Further improvement in these results has occurred when a progestin treatment was included during the 7 days before $PGF_{2\alpha}$. Norgestomet ear implants and the intravaginal progesterone-impregnated CIDR insert have served this purpose. In combination with GnRH, the progestin exposure reduces the short estrous cycles that sometimes follow GnRH-induced ovulation in suckled cows.

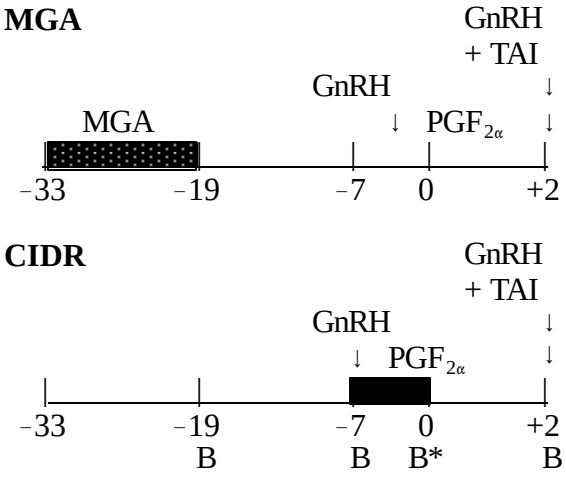
The objective of the present experiment was to determine whether or not feeding melengestrol acetate (MGA; orally active progestin) would serve a similar purpose as the CIDR insert. Neither the norgestomet implant nor the CIDR are market-available. However, it is anticipated that the CIDR insert (Pharmacia & Upjohn, Kalamazoo, MI) may be available later this year. It is not known whether the norgestomet implant (part of the Syncro-Mate B estrus-synchronization system) will return to the market.

Experimental Procedures

We used 609 suckled beef cows in two treatments at four locations (Kansas State University Purebred Beef Unit, Manhattan, KS; Thielen Ranch, Dorrance, KS; North Central Research and Outreach Center, Grand Rapids, MN; and DarLynn Ranch, Pierz, MN). The two treatments are illustrated in Figure 1. In the first treatment, cows

[1]North Central Research and Outreach Center, University of Minnesota, Grand Rapids, MN.
[2]Northwest Area Extension Office, Colby.

were fed MGA (0.5 mg per cow per day) for 14 days, followed in 12 days by the first injection of GnRH, followed in 7 days by an injection of prostaglandin $F_{2\alpha}$ ($PGF_{2\alpha}$), followed in 48 hr by a second GnRH injection at the same time as timed artificial insemination (TAI). The second treatment consisted of feeding the carrier without MGA for 14 days, with the injections as for the MGA treatment. In addition, cows receiving no MGA received a new intravaginal progester-one-releasing insert (CIDR®-1380 insert, Hamilton, New Zealand) containing 1.38 g of progesterone on day -7 and removed on day 0. The diets of all cows were supplemented with grain mix or a premix containing 4 lb of a pelleted formulation that contains either 0 or 0.5 mg of MGA for a 14-day feeding (days -33 to -19).



Days from $PGF_{2\alpha}$
(beginning of the breeding season)

* = Body condition scores
B = Blood sample to determine concentration of progesterone
= 0.5 mg of melengestrol acetate per day
= New CIDR (1.38 g of progesterone)

Figure 1. Experimental Protocol.

Blood samples were collected at days −19, −7, 0, and +2 for later analysis of serum progesterone. Body scores were assessed on day 0. Cows were observed for returns to estrus beginning 20 days after the TAI and continued until day 23. Cows were inseminated between 8 and 12 hr after first detected return to estrus. Pregnancy diagnoses were made by transrectal ultrasonography on days 29-33 (all locations) and again on days 57-61 (three locations) after TAI. Pregnancy rates were calculated as the number of cows determined pregnant divided by the number of cows treated and inseminated. Embryo loss was calculated for cows in which two pregnancy diagnoses were made.

Results and Discussion

Number of cows, breed composition, body condition scores, and days postpartum at the onset of the breeding season are summarized by location in Table 1.

Results for all locations combined are summarized in Table 2. Pregnancy rates after the first TAI were greater ($P<0.05$) for cows treated with the CIDR insert than after feeding MGA. This difference was consistent at three of four locations, whereas at location D, pregnancy rates were identical between treatments.

Rates of return to the first eligible estrus and average interval to estrus after the first insemination were not different between treatments.

Conception rates of cows that were reinseminated were 22% greater ($P<0.05$) in those previously fed the MGA than those receiving the CIDR inserts. However, because the reverse was true for pregnancy rates at the TAI, the total proportion pregnant after two inseminations was similar between treatments.

About 11% of the embryos first detected by ultrasonography on days 29-33 did not survive to days 57-61 when the second diagnosis of pregnancy was measured.

Our results from past studies have clearly demonstrated that pregnancy rates achieved after the Cosynch protocol (injections of GnRH 7 days before and 48 hr after an injection of $PGF_{2\alpha}$, with a fixed-time AI adminis-

tered at the same time as the second GnRH injection) are variable. Pregnancy rates ranged from 30 to 55%. When a progestin (one norgestomet ear implant or a CIDR) is included in the system during the 7 days between the injections of GnRH and $PGF_{2\alpha}$, pregnancy rates ranged from 55 to 66%.

The present study demonstrates again that the addition of a progestin produces pregnancy rates >50% after a TAI (2000 Cattlemen's Day, pp 104-106). Response to the MGA + Cosynch protocol was less at three locations, but at one location it was equal to that of the CIDR insert. Some difficulty arises when attempting to feed MGA to cows once they have been moved to pasture. The carrier for the MGA must be highly palatable and easy to feed in pasture situations. In contrast, the cost of feeding MGA may be less than the cost of the inserting the CIDR.

Table 1. Characteristics of Synchronized Suckled Cows

	Location				
Trait	A	B	C	D	Total
No. of cows	149	161	81	218	609
Breed composition	Crosses of: Angus, South Devon, and Charolais	Purebred Simmental, Hereford, and Angus	Angus	Crosses of: Simmental, Hereford, and Angus	
Body condition score at onset of breeding season	5.4	4.7	5.2	5.1	5.1
Days postpartum at onset of breeding season	69	79	86	70	75

Table 2. Reproductive Traits of Suckled Cows

	Treatment	
Trait	CIDR	MGA
No. of cows	304	305
Pregnancy rates after first AI, %	55	45*
Rates of return to estrus after first AI, %	58	57
Average days to return estrus after first AI	21.3	21.4
Conception rates after second AI, %	50	61*
Total pregnant after two inseminations, %	64	59
Embryo survival after days 29-33 to days 57-61, %	90	88

*Different ($P<0.05$) from CIDR treatment.

RESYNCHRONIZATION OF ESTRUS WITH PROGESTERONE AND ESTROGEN IN PREVIOUSLY INSEMINATED BEEF COWS

J. S. Stevenson, M. A. Medina-Britos, A. M. Richardson, G. C. Lamb[1], B. A. Hensley, T. J. Marple, and S. J. Johnson[2]

Summary

A study was conducted in 609 beef cows to determine whether or not estrus might be resynchronized in previously inseminated beef cows to accommodate a second artificial insemination (AI) early in the breeding season. Previously inseminated cows were treated for 7 days with progesterone (via a previously used intravaginal progesterone-releasing insert [CIDR]) beginning 13 days after AI. In addition, injections of estrogen (estradiol benzoate [EB] or estradiol cypionate [ECP]) were given at insertion and removal of the CIDR insert. Rates of return to estrus and total pregnancy rates were increased after treatments with progesterone and estrogen compared with controls. No harm to pregnancies occurred in pregnant cows and a second AI period was facilitated by the end of the first 23 days of the breeding season.

(Key Words: Cows, Resynchronization of Estrus, Estrogen, Progesterone, Pregnancy Rates.)

Introduction

Unfortunately, the pregnancy outcome after first inseminations is unknown until cows have a repeat estrus (20 to 22 days after first service), are diagnosed pregnant at about 28 days via transrectal ultrasonography, or are diagnosed by palpation after 35 to 40 days. In all such cases, the full advantage gained from synchronizing follicular maturation and luteolysis is not fully realized. Because all cows are closely synchronized after first insemination, all open cows can easily be resynchronized for their second (and even subsequent) services.

At least two approaches have been attempted to set up a resynchronization of second services. The first attempt included reinsertion of a progesterone-releasing intravaginal device or the feeding of a progestin after previous inseminations. Results were variable.

A second approach included administration of supplemental progestin plus estrogen (to control follicular growth) at the time of insertion of a progesterone-releasing device, and estrogen administration (to induce estrus and the preovulatory LH surge) 0 or 24 hr after the progesterone insert is removed. In those studies, estradiol benzoate (EB) was used. The only estrogen product available in the U.S. is estradiol cypionate (ECP®, Pharmacia & Upjohn Co., Kalamazoo, MI). Using a combination of estrogen and progesterone to reset follicular dynamics and synchronize the next eligible estrus has met with success in dairy cattle. Inseminated cows were exposed to progesterone (a used CIDR) for 7 days between days 13 and 20 after insemination. These treatments did not reduce pregnancy rates of dairy cows that had conceived at first service but increased the probability that all nonpregnant cows exhibited estrus within 3 days after progesterone withdrawal, or within 2 days if a second estrogen (EB) injection was given 0 to 24 hr after progesterone withdrawal. Only rarely

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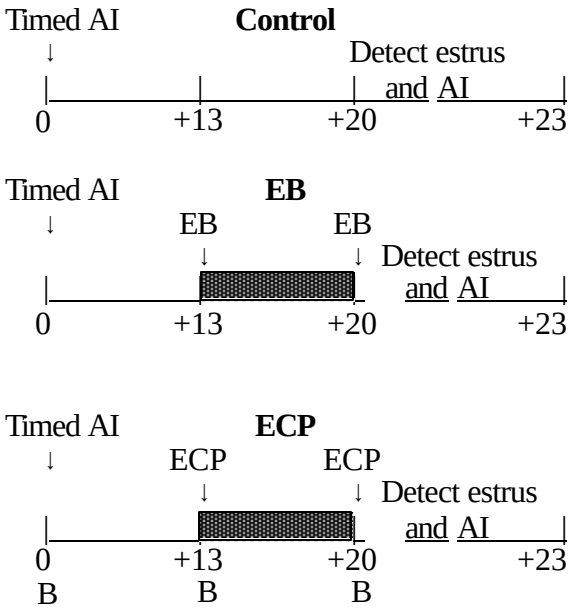
do pregnant cows show estrus in response to this treatment.

The purpose of our study was to determine if resynchronization of estrus with progesterone and estrogen was feasible in pregnant and nonpregnant suckled beef cows without harm to the ongoing pregnancy of pregnant cows.

Experimental Procedures

We used three resynchronization treatments on the 609 suckled beef cows described in the previous report (see pages 9 to 11). The three treatments are illustrated in Figure 1.



B = Blood sample to determine concentration of progesterone
▒ = Used CIDR (1.38 g of progesterone)
EB = Estradiol benzoate (1 mg)
ECP = Estradiol cypionate (0.5 mg)

Figure 1. Experimental Protocol.

Thirteen days after AI, 50% of the cows received no further treatment (controls); 25% received 1 mg of estradiol benzoate (EB) plus a used CIDR (progesterone-releasing intravaginal insert originally containing 1.38 g of progesterone; CIDR®-1380 insert, Hamilton, New Zealand); and 25% received 0.5 mg of estradiol cypionate (ECP) plus a used CIDR. Seven days later, the controls received no further treatment. The used CIDR was removed from EB cows and they received an additional 1 mg of EB. The used CIDR was removed from ECP cows and they received an additional 0.5 mg of ECP.

Cows were observed for estrus twice daily between 20 and 23 days after the timed AI. Any cow detected in estrus after the second EB or ECP injection was re-inseminated between 8 and 12 hr later. Blood samples were collected prior to each injection of estrogen (EB or ECP) for later analysis of serum progesterone. Pregnancy diagnoses were made by transrectal ultrasonography on days 29-33 (all locations) after timed AI (6 to 10 days after the second estrogen injection) and again 31 to 34 days later.

Results and Discussion

Results of this experiment are summarized in Table 1. The resynchronization protocols were not detrimental to already pregnant cows because pregnancy rates after the first timed AI were similar for two estrogen treatments compared to the controls.

Rates of return to estrus were increased by more than twofold (EB = 2.7×; ECP = 2.3×) with the use of the used CIDR and estrogen treatments. Average days to returned estrus after the timed AI were greater ($P<0.01$) for the longer-acting estrogen (ECP) than for the shorter–acting estrogen (EB). Conception rates of cows after treatment with progesterone and estrogen tended ($P=0.11$) to be less than those of controls, primarily because of the EB source of estrogen. Most importantly, total pregnant cows after two syncronizations and inseminations was increased by 11-23%. Embryo survival was unaffected by estrogen treatments. These results demonstrate that repeat estrus can be successfully resychronized after a timed AI program by using a combination of a CIDR and either of

two estrogen products. Estradiol benzoate has been used successfully in similar protocols for seasonal-calving dairy cows in New Zealand and Australia. Unfortunately, EB is not available in our market, but ECP is available to "correct anestrus (absence of heat period) in the absence of follicular cysts in some cases" (labeled indication for ECP®; Pharmacia & Upjohn, Kalamazoo, MI). Even though the treatment is given to all cows regardless of pregnancy status, no harm occurred to the ongoing pregnancy in our study or in other studies. In fact, the total number of pregnancies was increased after using our protocol so that more than 60% of the cows were pregnant to AI sires after 23 days of the breeding season.

Table 1. Reproductive Traits of Suckled Cows after Resynchronization with the CIDR (Progesterone) and Estrogen

	Treatment		
Trait	Control	EB	ECP
No. of cows	189	96	94
Pregnancy rates after first AI, %	52	44	51
Rates of return to estrus after first AI, %	27[X]	73	63
Average days to return estrus after first AI	21.3	21.2[Y]	21.7
Conception rates after second AI, %	62[Z]	48	63
Total pregnant after two inseminations, %	56[X]	62	69
Embryo survival after days 29-33 to days 57-61, %	84	92	96

[X]Control vs. estrogen (EB+ECP) ($P<0.01$).
[Y]EB vs. ECP ($P<0.01$).
[Z]Control vs. estrogen (EB+ECP) ($P=0.11$).

TIMED-INSEMINATION OF BEEF HEIFERS USING COSYNCH WITH OR WITHOUT MGA

D. M. Grieger, T. A. Wickersham and R. C. Cochran

Summary

Our purpose was to determine if feeding melengesterol acetate (MGA) for 1 week in combination with gonadotropin-releasing hormone (GnRH) and prostaglandin-$F_{2\alpha}$ (PGF) would better synchronize heifers for timed artificial insemination. Sixty-nine yearling beef heifers received an injection of GnRH 7 days before receiving an injection of PGF. Half of the heifers were fed MGA between the GnRH and PGF injections (Cosynch+MGA), whereas the remaining heifers were not (Cosynch). All heifers were given a second GnRH injection 2 days after PGF and inseminated at that time. Pregnancy rate for the Cosynch group (43%) was greater ($P<0.05$) than that for the Cosynch+MGA group (15%). This experiment suggests that short-term feeding (7 days) of MGA in concert with a Cosynch protocol was detrimental to fertility in beef heifers.

(Key Words: Heifers, AI, Synchronization, MGA, GnRH, $PGF_{2\alpha}$)

Introduction

Previous research at Kansas State and other locations has shown that using combinations of GnRH and PGF has resulted in pregnancy rates ranging from 40-60% with timed insemination of lactating mature beef cows. However, using these same protocols in heifers results in pregnancy rates at least 10% lower. In mature cows, the better pregnancy rates (>50%) have resulted from protocols using a progestin (e.g., ear implant of norgestomet or an intravaginal insert containing progesterone) between the initial GnRH injection and the PGF injection. Therefore, we conducted this experiment using an oral progestin (MGA) combined with GnRH and PGF to see if timed insemination results for beef heifers could be improved.

Experimental Procedures

Sixty-nine crossbred yearling beef heifers (avg 735 lb) received an injection (i.m.) of GnRH (100 µg Cystorelin®; Merial Ltd., Iselin, NJ), on day –7. One week later (day 0), all heifers received 25 mg of PGF (Lutalyse®; Pharmacia & Upjohn, Kalamazoo, MI) followed by a second injection of GnRH (100 µg) on day 2. All heifers were inseminated at the time of the second GnRH injection. This ovulation synchronization protocol is referred to as Cosynch. Half of the heifers (n=34) were fed MGA (0.5 mg/head/day) for 7 days from day –6 until day 0 (see Figure 1). The remaining heifers (n=35) received the same supplement without MGA. Blood samples for later measurement of progesterone were collected at days –18, –7 and 0 to determine the number of pubertal animals prior to treatment. Pregnancy was determined in all heifers 30 days after insemination using ultrasonography.

Results and Discussion

Prior to the first GnRH injection (Day –7) there was no difference in the number of heifers cycling between the Cosynch (86%) and the Cosynch+MGA (91%) groups. The pregnancy rate for heifers in the Cosynch+ MGA treatment (15%) was lower ($P<0.05$) than that for the Cosynch treatment group (43%). Feeding MGA during the first week of the Cosynch treatment was detrimental to fertility in these heifers. This study indicates that MGA may not be a suitable progestin to use in combination with Cosynch. The timed insemination may have been too soon after MGA withdrawal. Long-term fertility was not affected

however, as overall pregnancy rates at the end of a 45-day pasture-breeding season were the same for the Cosynch+MGA group (88%) as compared to the heifers that did not receive MGA (91%).

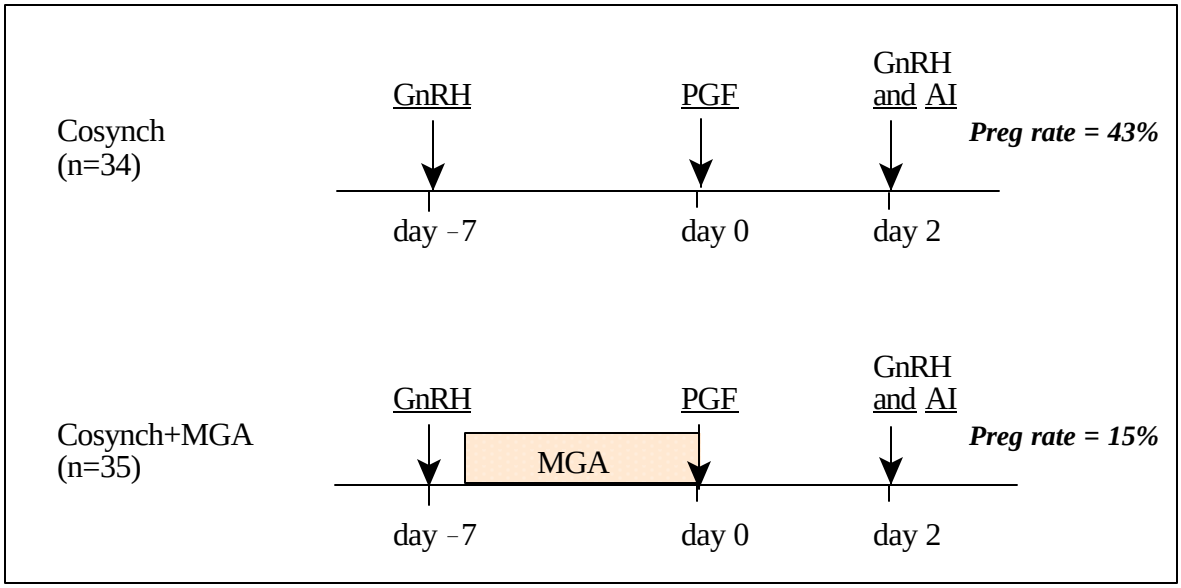


Figure 1. Synchronization Treatments and Pregnancy Rates for Cosynch vs. Cosynch+ MGA.

SHORT-TERM FEEDING OF MGA TO POSTPARTUM COWS PRIOR TO THE BREEDING SEASON

J. F. Gleghorn, T. T. Marston, and L. E. Wankel

Summary

A protocol to make anestrous cows more likely to cycle prior to estrous synchronization would greatly enhance reproductive efficiency. Ease of application, availability, and low cost make feeding melengestrol acetate (MGA) a good choice in such a protocol. MGA, used as a progestin "primer," has no detrimental effects on cows that are already cycling and reduces the number of cows expressing short cycles.

(Key Words: MGA, Postpartum Interval, Pregnancy Rate, Short Cycle.)

Introduction

Fifteen to twenty percent of the nation's cows fail to wean a calf annually, primarily because they do not become pregnant within the relatively short breeding season. The purpose of our experiments was to test a protocol that would "progestin-prime" multiparous beef cows so that all would be cycling at the start of the breeding season. Such a procedure would be useful in many operations that are unable to justify labor-intensive synchronization systems.

Experimental Procedures

Experiment 1

Thirty-nine multiparous, crossbred cows were exposed to progestin (MGA) treatment beginning 30 days postpartum (Spring, 1999). Cows were blocked according to calving date and assigned randomly to treatment. Treatments consisted of feeding MGA for 8, 4, 2, or 0 (controls) days at 0.5 mg/head daily.

Blood was collected before and after MGA supplementation and analyzed for progesterone concentration (>1 ng/ml was evidence for luteal activity).

Cows were synchronized with prostaglandin $F_{2\alpha}$ (Lutalyse®, Pharmacia & Upjohn) at the beginning of the breeding season, inseminated upon standing heat, and exposed to bulls 6 days following the second Lutalyse injection. Pregnancy and conception dates were determined by uterine palpation and actual calving dates.

Only cows anestrus before treatment were included in the statistical analysis of initial rise in blood progesterone, days to conception, incidence of short cycles, and response to prostaglandin $F_{2\alpha}$. However, both cycling and noncycling cows at 30 days postpartum were included in determination of pregnancy rates and conception rates to AI.

Experiment 2

Ninety-three multiparous, black baldy, fall-calving cows were used in 1999. Cows were assigned randomly to receive MGA (0.5 mg per head daily for 4 days) (n=44) or no MGA (n=49). Suckled cows grazed fescue pastures and were group-fed the supplement. Treatment began 35 days prior to the breeding season. Bull exposure was for 60 days.

Experiment 3

Thirty-six multiparous Angus and Angus × Hereford cows were used in April 2000. Cows were blocked by calving date and assigned randomly to MGA (0.5 mg per head daily for 4 days) or no MGA. Suckled cows were individually fed the MGA supplement

starting 30 days prior to the breeding season, while grazing native grass pasture. Bull exposure was for 60 days.

Results and Discussion

Experiment 1

Blood samples revealed 20.5% of cows were cycling 30 days prior to the beginning of the breeding season. Cycling percentages for each treatment group were: 33% (8 days), 20% (4 days), 18% (2 days), and 11% (0 days).

Treatment with MGA influenced (P<.05) days to the first postpartum luteal activity (progesterone>1 ng/ml) (Table 1). The 0- and 2-day treatments produced earlier (P<0.05) postpartum rises in serum progesterone than either 4- or 8-day treatments. A trend was also noted in days from MGA withdrawal to progesterone rise. The 2-day treatment increased blood progesterone 3.6 days following withdrawal. The 4- and 8-day treatments delayed first luteal activity to 11.7 and 13.5 days, respectively. Treatment had no effect on days to conception following calving.

The incidence of short cycles tended to decrease (P=0.28) with increased days of MGA treatment. Ninety-one percent of the controls exhibited short cycles, versus none for 8-day MGA-treated cows.

A decrease in calving interval was noted with MGA treatment. The 2-day cows averaged 355 ± 7 days between calves, whereas controls averaged 377 ± 8 days (P<0.10). The other treatments (4 day and 8 day) were intermediate; 366 ± 8 days and 371 ± 8 days, respectively.

An overall pregnancy rate of 92% was achieved for all cows. The percentages of cows artificially inseminated were greater in MGA-treated cows than controls. More (P<0.05) 2-day MGA-treated cows (86%) were inseminated during the AI period than controls (33%).

Experiment 2

Pregnancy rates were similar for control (95%) and MGA-treated (97%) cows (Table 2). Fetal ages (by palpation) were similar between treatments.

Experiment 3

An overall pregnancy rate of 88% was achieved for all cows. Pregnancy rates were greater (P<0.05) for MGA-treated cows (100%) than for controls (76%). Neither days pregnant (fetal age) nor calendar date of conception was influenced by MGA treatment.

It is clear that progestin is necessary for the induction of normal estrous cycles in postpartum beef cows. Whether the progestin is from an endogenous source or exogenous treatment (MGA), progestin is necessary to prepare the female reproductive tract for the subsequent pregnancy. It is thought that progesterone acts as a "primer" to enable gonadotropins to regulate reproductive function. The decrease in short, non-fertile cycles achieved by feeding MGA is of interest, because decreasing short cycles tightens the calving season. Progestin may also elicit more distinct estrus response from hormonal challenge, and possibly improve conception rates to AI at the beginning of the breeding season.

Table 1. Effects of Temporal Feeding MGA to Postpartum Cows (Experiment 1)

	Days MGA Fed			
Item	0	2	4	8
Calving to 1st luteal activity, days	38.8[a]	34.8 [a]	45.0[b]	48.5[b]
1st Luteal activity following the end of MGA feeding, days	--	3.6	11.7	13.5
Cows exhibiting a short cycle, %	91	53	32	0
AI pregnancy rates, %	33	86	57	63
Subsequent calving interval, days	377	355	366	371

[a,b]Means with uncommon superscript letters differ (P<0.05).

Table 2. Effects of Feeding MGA Prior to the Breeding Season

	Days MGA Fed	
	0	4
Experiment 2, Fall-calving Cows		
Pregnancy rate, %	95	97
Fetal age, days	85	82
Days postpartum conceived	84	88
Experiment 3, Spring-calving Cows		
Pregnancy rate, %	76	100
Fetal age, day	68	70

FACTORS AFFECTING BEEF DEMAND[1]

J. Mintert[2], T. Schroeder[2], and T. Marsh[2]

Summary

We investigated factors that have affected beef demand over the last two decades. Beef demand is typically modeled as a function of beef prices, competing meat prices, prices of all other goods, and consumer expenditures. Our comprehensive model also investigated the impact on beef demand of food safety issues, health concerns, and changes in consumer lifestyle and demographics. Results from this analysis help explain changes in beef demand that occurred during the 1980s and 1990s. First, consumer concerns about food safety, as measured by increases in beef recalls, had a negative impact on beef demand over the last two decades. Second, consumer awareness of the linkage between cholesterol and heart disease also contributed to the decline in beef demand. In contrast, as the net number of medical journal articles linking cholesterol and heart disease increased, poultry demand actually increased. Finally, increased labor force participation by females had a negative impact on beef demand, because an increase in female employment outside the home likely resulted in a decline in time available for food preparation. Because poultry demand benefitted from this consumer demographic shift and because of beef's negative health image, these results suggest that beef industry efforts to provide consumers with more convenient, high quality products have lagged behind those of the poultry industry.

(Key Words: Beef Demand, Food Safety, Health Concerns, Consumer Demographics.)

Introduction

Beef demand improved modestly during 1999 and 2000, increasing an average of about 4% in each of the last 2 years. However, prior to the recent rebound, the beef industry was plagued with nearly 20 years of declining demand. Inflation-adjusted, retail-beef prices were collapsing at the same time per capita consumption was declining. For example, a beef-demand index that accounts for changes in per capita beef consumption and inflation-adjusted, retail-beef prices indicates that 1998 Choice retail-beef prices were 50% lower than they would have been if beef demand had been held constant at its 1980 level (Figure 1). If the beef industry is to successfully improve long-term demand, the impact of individual demand determinants on beef demand must be quantified. Our study was designed to determine the major factors causing beef demand to shift over time.

Procedures

It is impossible to accurately assign relative demand shifts to individual demand determinants through casual observation of trends and beef demand shifts because many beef-demand determinants, as well as beef production, change at the same time. As a result, a meat demand system was estimated using quarterly time series data over the 1982 through the 1998 period. The system included factors accounting for prices of competing meats and total consumer expenditures, changing consumer demographics,

[1]This research was supported by Beef Checkoff program funds.
[2]Department of Agricultural Economics.

food safety problems, health information, and seasonality.

Results and Discussion

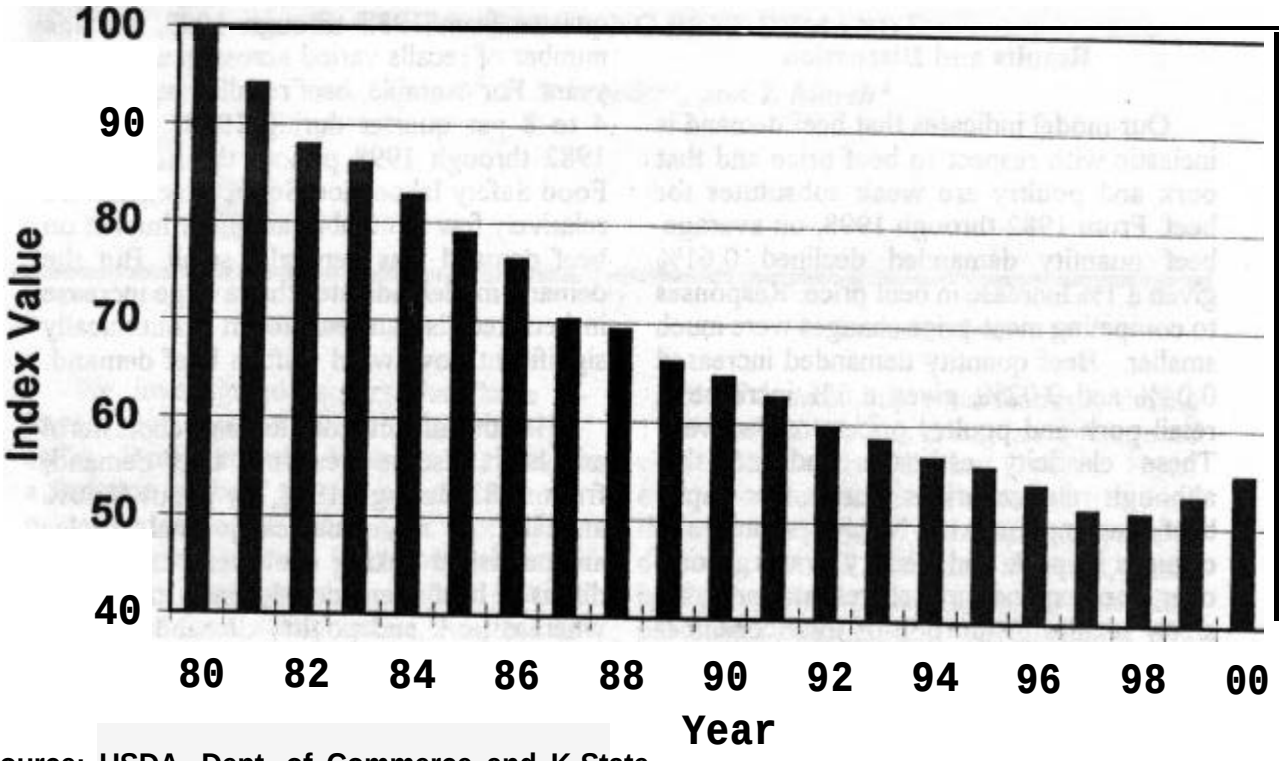
Our model indicates that beef demand is inelastic with respect to beef price and that pork and poultry are weak substitutes for beef. From 1982 through 1998, on average, beef quantity demanded declined 0.61% given a 1% increase in beef price. Responses to competing meat-price changes were much smaller. Beef quantity demanded increased 0.04% and 0.02%, given a 1% increase in retail pork and poultry prices, respectively. These elasticity estimates indicate that although relative prices matter, per capita beef consumption is not highly responsive to changes in pork and poultry prices. Moreover, beef expenditures represent a progressively smaller proportion of total consumer expenditures. This implies that beef demand could become even more inelastic (i.e., quantity demanded could be less responsive to price changes) in the future.

Beef demand is highly responsive to changes in total per capita expenditures on all goods. Changes in total per capita expenditures occur when personal disposable income increases, consumer willingness to spend income increases, or a combination of the two. Consumer willingness to spend a larger proportion of total income has been an important source of economic growth for the U.S. economy in recent years. For example, consumer expenditures rose from less than 90% of disposable income in the early 1980s to near 98% by 1999. Demand-model results indicate that beef demand increases 0.90% for a 1% increase in total per capita expenditures. This means that beef demand was a major beneficiary of increasing consumer expenditures. However, if consumers choose to increase savings in the future (in lieu of consumption), or if disposable income declines, it will have a negative impact on beef demand.

Beef demand declines when beef-safety recalls occur. Beef recalls averaged 2.1 per quarter from 1982 through 1998, but the number of recalls varied across quarters and years. For example, beef recalls ranged from 4 to 8 per quarter during 1998. Over the 1982 through 1998 period, the number of Food Safety Inspection Service recalls were relatively few in number and their impact on beef demand was generally small. But the demand model indicates that a large increase in beef recalls can lead to an economically significant downward shift in beef demand.

Health information linking cholesterol and heart disease weakened beef demand, from 1982 through 1998, by about 0.60% annually. As more medical journal articles are published linking cholesterol and heart disease, beef demand declines modestly, whereas pork and poultry demand actually increase. Importantly, the negative impact of heath information on beef demand increased over the study period.

Changing demographics suggest that consumers are placing more emphasis on how quickly meat items can be prepared for consumption. The percentage of females in the labor force rose from 52% in 1982 to 60% in 1998. As a greater proportion of females enter the labor force, less time is available for at home food preparation. This change had a negative effect on beef demand, but a positive effect on poultry demand. Beef demand declined an average of 1.3% annually over the 1992-99 period as a result of an increasing female labor force. Assuming that consumer demand for convenience is related to female labor force participation, this suggests that the poultry sector benefitted over time by offering more convenient products to consumers. At the same time, beef demand suffered through 1998 as time allocated for food preparation declined and the beef industry failed to offer consumers high quality, convenient, easy-to-prepare beef products.



Source: USDA, Dept. of Commerce and K-State Research & Extension, 2000 partially estimated.

Figure 1. Choice Retail Beef Demand Index, 1980 = 100.

MOTIVATION FACTORS FOR BEEF PROCESSOR-PRODUCER LINKAGES

T. C. Schroeder[1], J. D. Lawrence[2], and M. L. Hayenga[2]

Summary

A survey was conducted of the 15 largest beef processors to identify the mix of procurement practices being used and to understand reasons motivating recent processor-producer linkages. Processors are shifting away from cash-market live, fed-cattle trade, which represents only 36% of cattle procured by survey respondents in 1999. Processor-owned cattle feeding represents only approximately 5%, where it has been for more than a decade. Various other forms of pricing such as carcass weight, grid, and formula represented the largest portion of purchases at 49%. Processors indicated the two most important reasons they get involved in contracts and marketing agreements with producers is to secure higher and more consistent quality cattle. Assuring food safety was also a motivation for linking more closely with cattle producers. In the future, processors felt these motivational factors would increase in importance. As cattle feeders explore grid pricing and alliance opportunities, it is important they understand why processors desire to enter into contracts and marketing agreements.

(Key Words: Beef Processors, Contracts, Marketing Agreements, Cattle Marketing.)

Introduction

The U.S. beef industry is undergoing marked transitions in the way livestock and meat products are marketed and the way price discovery occurs. The once dominant negotiated cash markets are shifting to long-term contracts and marketing agreements. The purpose of this study was to determine current marketing and pricing methods being used by beef processors. The current and expected mix of pricing methods for fed cattle were estimated by the processors. In addition, major motivating factors for changing beef processor-producer linkages were assessed.

Results of this study will contribute to a better understanding of the important coordination mechanisms that affect market efficiency and performance in these industries. This study will also offer insights into the changing industry organization that will be useful in strategic planning by industry members. The complexities of mandatory livestock- and meat-price reporting (from recent federal legislation) will become more clear as the variety of methods employed in the marketing system are documented. Finally, the information from these surveys should be useful in assessing issues raised in court cases alleging illegalities associated with "captive supplies" in the beef industry, and proposed legislation to eliminate processor vertical integration and long-term contracts with livestock producers.

Procedures

During April 2000 the largest 15 beef processing firms were surveyed to determine current procurement practices and to discern processor perceptions on why the beef value chain has moved to more formal agreements.

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[2]Department of Economics, Iowa State University.

Survey responses were received from 11 of the 15 packing firms, representing 72% of cattle slaughtered. The processors were telephoned, asked to participate in the study, and were faxed a survey form.

Results and Discussion

Processors are shifting away from live cattle cash market purchases to more long-term contractual and/or value-based grid purchases. However, negotiated cash market pricing arrangements still remain dominant. Only 5% of cattle slaughtered by survey respondents were owned by them and either fed in their own lots or other feedlots. This represents little change over the last 15 years. In 1999, survey respondents reported 36% of cattle were purchased on the cash market on a live weight basis, and 29% on a carcass weight or grid (carcass merit) basis (Table 1). Thus, approximately two-thirds of cattle slaughtered were cash market acquisitions.

Long term (more than 14 days) formula-priced contracts linked to the cash market accounted for 20 percent of 1999 purchases. "Cash market" included live cattle or wholesale beef prices reported by USDA, processor cattle purchase cost averages, retail beef prices, or futures market prices. Four percent of cattle purchased were via short-term contract arrangements based on the Chicago Mercantile Exchange (basis contracts, or fixed price based on futures-market prices, with deliveries typically several months in the future). Three percent of the cattle were acquired under risk and profit-sharing, market contract arrangements with cattle feeders, but not owned by processors while in the feedlot.

Cash market purchases by processor buyers are based on their expectations of likely carcass quality. However, a large number of cattle feeders sell all of their pens, perhaps with several owners, at the same live or carcass price, allowing little distinction for quality on a lot-by-lot, or carcass-by-carcass basis. Cash market purchases based on carcass merit are increasing in the cash and contract markets. In 1999, at least 35% of cattle purchased on contract or in the cash market were priced based on carcass merit but some processors did not break that out in their responses. Most cattle fed by processors were also transferred to their processing operations based on carcass merit.

Processors were queried regarding the importance of specific reasons they and cattle producers enter into contracts and marketing agreements. The two most important reasons cited by processors were to "secure higher quality cattle," and to "secure more consistent quality cattle" (Table 2). Both of these responses had an average score of 4.0, with 1 being *not important* to 5 being *very important*. These were also expected to be most important (and even more important at 4.2) in 2004. Improving risk management, reducing plant operating costs by maximizing slaughter plant capacity utilization, and assuring food safety were the next most important reasons (average scores of 2.8 to 3.0 in 1999). All three of these items also are expected to become more important, with 2004 ratings for food safety at 3.7 and plant operating efficiency at 3.5. The low importance (average score of 1.8) attached to the assertion that contracts enabled processors to purchase cattle for a lower price may be because contracts and agreements do not enable processors to lower prices paid for cattle, as shown in recent USDA-sponsored studies. Securing adequate cattle quality and quantity are the primary factors motivating beef processor use of contracts and marketing agreements with cattle producers.

Processors perceived that producers' primary incentives to enter into contracts and marketing agreements were to secure a quality premium and obtain a higher price for cattle (Table 3). Processors felt that, in the next five years, producers would benefit from marketing agreements primarily for these reasons, as well as to obtain detailed carcass data.

Table 1. Percentage of Cattle Procured via Various Methods, 1999

Procurement Method	Percent
Cash-market purchases on live weight basis	36
Cash-market purchases on a carcass-weight or grid basis	29
Formula-priced contract purchases based on a reported live cash market, reported dressed price, plant average price, CME cattle futures price, quoted boxed beef ,or retail-beef price	20
Processor-fed cattle	5
Fixed-price or basis-contract purchases based on CME futures	4
Risk-sharing contract purchases	3
Other purchases	4
Total	100

Table 2. Processor Survey Responses Regarding Importance of Contract and Marketing Agreement Incentives to Beef Processors [a]

Importance to Processors	1999 Average	2004 Expected Average
Reduce plant operating costs due to improved slaughter plant capacity utilization	2.9	3.5
Secure higher quality cattle	4.0	4.2
Secure more consistent quality of cattle	4.0	4.2
Assure food safety	3.0	3.7
Improve long-run price-risk management	2.8	3.1
Improve week-to-week supply/price management	2.2	2.9
Reduce costs of searching for cattle to procure	2.3	2.4
Able to purchase cattle for lower price	1.8	1.8

[a]Scale: 1 = not important, 5 = very important.

Table 3. Processor Survey Responses Regarding Importance of Contract and Marketing Agreement Incentives to Cattle Producers [a]

Importance for Producers	1999 Average	2004 Expected Average
Secure a buyer for cattle	2.6	2.8
Secure a quality premium/discount	4.0	4.0
Reduce price risk	3.3	3.3
Reduce costs of searching for a cattle buyer	2.4	2.8
Able to sell cattle for higher price	3.8	3.8
Easy to get loans	3.1	3.4
Provide detailed carcass data	3.4	3.6

[a]Scale: 1 = not important, 5 = very important.

EVALUATION OF RALGRO® ON PASTURE AND SUBSEQUENT FEEDLOT PERFORMANCE AND CARCASS MERIT OF MEXICAN CROSSBRED STEERS[1]

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Summary

A pasture/feedlot field study was conducted to evaluate the effects of a single Ralgro® implant during the stocker phase on steer grazing performance and subsequent feedlot performance and carcass merit. A total of 2,764 steers of Mexican origin averaging 449 lb were assembled in Texas and shipped to Kansas, where they grazed on three intensively-early-stocked Flint Hills pastures. At initial processing, the steers were individually weighed and randomly assigned to either a non-implanted control group or a Ralgro implant group. Ralgro steers gained more (23 lb; P<0.01) than controls during the 82- to 93-day grazing phase. Following the grazing phase, all steers were shipped to a commercial feedlot in southwestern Kansas where steers from each pasture were individually weighed and given a single Component E-S® implant. Immediately after processing, steers from each pasture were sorted into either a light- or heavy-weight pen, regardless of pasture implant treatment, resulting in six feedlot pens. Days on feed ranged from 127 to 197. Control steers gained faster (P<0.01) during the feedlot phase; however, Ralgro steers had higher cumulative weight gains across the combined pasture and feedlot phases (P<0.01) and averaged three fewer days on feed (P<0.05). There were no significant differences for marbling, fat thickness, rib-eye area, KPH fat, or yield grade. Ralgro steers had lower (P<0.05) quality grades because of a higher incidence (P<0.001) of steers with B and C carcass maturities.

(Key Words: Growth Implant, Ralgro, Steers, Pasture, Feedlot, Carcass Traits.)

Introduction

Previous studies have demonstrated that the growth benefit obtained with pasture implants is generally retained through the finishing phase, provided sufficient hormonal stimulation is maintained by a feedlot implant program. Our objective was to evaluate the effects of a single Ralgro implant administered during the stocker phase on steer grazing performance and subsequent feedlot performance and carcass merit.

Experimental Procedures

A total of 2,764 steers from Mexico were assembled, vaccinated against common viral and bacterial diseases, and backgrounded in Texas until shipment to Kansas. The study was initiated during April, 1999, using three Flinthills pastures, and concluded with the feedlot phase ending Jan./Feb., 2000.

Pasture phase - As cattle were delivered to facilities adjacent to designated pastures, they were individually identified with two

[1]Sincere appreciation is expressed to National Farms, Cottonwood Falls, and S-Bar Ranch Feedlot, Sublette, for providing cattle facilities and assistance and to Schering-Plough Animal Health for financial support.

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[4]Technical Services Nutritionist, Schering-Plough Animal Health.

numbered ear tags, alternately allotted to one of two treatments (Ralgro or no implant) and weighed. Steers averaged 449 lb initially across all pastures, and they grazed burned or unburned native grass Flint Hill pastures for 82 to 93 days (Table 1). Uniform health and management procedures were used throughout the study. Grazing performance was calculated using individual weights taken immediately prior to turnout and during initial processing at the feedlot.

Feedlot phase - Steers from each pasture were shipped to a single feedlot in southwestern Kansas. All were dewormed and implanted with one Component E-S implant, and individually weighed and sorted into either a heavy or a light pen based on desired out-weight (total of six pens). Feedlot gain was based on a carcass-adjusted final weight using the average dressing percentage determined for each pen.

Results and Discussion

Table 2 presents steer performance by treatment during the successive phases. Initial pasture weights were similar (P=0.71) for both treatments. The increased weight gain (P<0.01) observed for Ralgro vs. control calves (+23 lbs/11.44%) is consistent with previously reported Kansas results. Sorting steers from each pasture into two pens (heavy and light) based on initial feedlot weight, created 100 lb difference in initial average pen weights. This difference in on-test weights translated into an added 21 to 31 days on feed for the lighter pens. Daily gains in the feedlot ranged from 2.78 to 3.12 lb/day for the feeding period for all pens.

During the feedlot phase, the steers not implanted on pasture gained about 16 lb more than the Ralgro-implanted steers. But at least 9 lb of that difference could be attributed to the fact that the controls were fed an average of 3 days longer (160 vs. 163 days). Nevertheless, the steers implanted during grazing had higher cumulative (pasture plus feedlot) weight gains (P<0.05).

Carcass weights of Ralgro-implanted steers tended to be greater (P<0.10) than controls. There were no significant differences in marbling, ribeye area, KPH fat, fat thickness, or yield grade. There was a decrease (P<0.05) in quality grade in pasture-implanted steers. However, much of that difference may have been due to severe quality grade discounts of a few cattle due to maturity. There were more (P<0.01) pasture-implanted cattle with B maturity carcasses. Thus carcasses with slight and small marbling (Select and low Choice quality grades for A- maturity carcasses) are downgraded to Standard for B maturity.

Table 1. Grazing Performance of Ralgro-Implanted Steers[a]

	Flint Hills Native Pasture[b]			
Item	A	B	C	P-value
No. steers on test	796	583	1385	
Prescribed burn	Yes	Yes	No	
Grazing days	87	93	82	
Starting date	April 23, 1999	April 20, 1999	April 7, 1999	
Ending date[b]	July 18/19, 1999	July 21/22, 1999	June 24/28, 1999	
Stocking rate, acres/steer	1.76	1.89	0.92[c]	
Animal Performance[d]				
Initial wt, lb	466[e]	462[e]	414[f]	<0.01
Final wt, lb	684[e]	721[f]	574[g]	<0.01
Pasture weight gain, lb	217[e]	258[f]	161[g]	<0.01
Daily gain, lb/day	2.50[e]	2.78[f]	1.96[g]	<0.01

[a]One-half of the steers from each pasture received one Ralgro implant at the initiation of grazing.
[b]Ending weights were taken upon arrival at S-Bar feedlot, Sublette, KS. Dates reflect the dates that cattle were removed from pasture, and weighed at the feedlot, respectively. [c]Stocking rate does not account for adjacent brome pasture in C pasture. [d]Least squares means for each pasture. [e,f,g]Means with unlike superscripts within rows differ (P<0.05).

Table 2. Effect of Ralgro Implants During Grazing on Subsequent Feedlot Performance and Carcass Merit[a]

	Pasture Implant Treatment[b]			
Item	Control (no implant)	Ralgro®[c]	SE	P-value
Grass Phase:				
No. steers	1316	1321		
Initial wt, lb	448	447	1.6	0.71
Final wt, lb[d]	649	671	1.8	<0.01
Pasture weight gain, lb	201	224	1.1	<0.01
Daily gain, lb/day	2.28	2.54	0.013	<0.01
Feedlot Phase:				
Initial wt, lb[d]	649	671	1.6	<0.01
Final wt, lb[e]	1132	1139	2.7	0.08
Feedlot days on feed[f]	163	160	0.3	<0.01
Feedlot weight gain, lb	484	468	2.3	<0.01
Daily gain, lb/day	2.99	2.94	0.015	<0.01
Cumulative (grass plus Feedlot) weight gain, lb	685	692	2.5	<0.05
Carcass Merit:				
Carcass wt, lb	730	734	1.7	0.10
Dressing %	64.50	64.50	--	--
Marbling[h]	372	368	2.3	0.13
Fat thickness, in	0.47	0.48	0.005	0.25
Ribeye area, in^2	12.68	12.67	0.041	0.81
KPH fat, %	2.12	2.11	0.012	0.85
Carcass Maturity[g], actual head				0.0024
A	1296	1283		
B	19	36		
C	1	2		
Yield grade	2.81	2.84	0.02	0.17
Quality grade[i]	460	451	3.1	0.05

[a]Steers grazed 3 intensive early stocked (IES) Flint Hills pastures for 82, 87, or 93 days.
[b]Least squares means.
[c]Steers received one Ralgro® implant at the initiation of the grazing phase. All steers received one Component E-S® implant at initial feedlot processing.
[d]Ending weights for all steers were taken upon arrival at S-Bar Ranch feedlot near Sublette, KS.
[e]Final weight calculated using hot carcass weight divided by pen average dressing percent.
[f]During initial processing at the feedlot, cattle from each pasture were sorted by weight into heavy and light pens. Due to the additional weight gain while on pasture, implanted cattle were placed primarily in heavy pens, resulting in differences in days fed between control and implanted steers.
[g]Carcass maturity scores: A maturity = approx. 9 to 30 mo. of chronological age at slaughter, B maturity = approximately 30 to 42 mo., C maturity = approximately 42 to 72 mo. (USDA 1997). Chi-square exact methods used.
[h]Marbling score: 100 = Practically devoid^{00}; 200 = Traces^{00}; 300 = Slight^{00}; 350 = Slight^{50}; 400 = Small^{00} 500 = Modest^{00}; 600 = Moderate^{00}
[i]Quality grade: 300 = Select, 400 = Select, 500 = Choice^{-}, 600 = Choice^{0}, 700 = Choice^{+}.

EFFECTS OF VACCINATING BEEF DAMS PRECALVING AND CALVES PREWEANING WITH A *PASTEURELLA HAEMOLYTICA* VACCINE

L. E. Wankel, T. T. Marston, G. L. Stokka, T. G. Rozell, and J. R. Brethour [1]

Summary

Our objective was to determine if vaccinating dams precalving and calves preweaning for *Pasteurella haemolytica* could effect serum antibody titers in dams, and the pre- and post-weaning health and performance of their calves. Vaccination increased serum antibody titers in multiparous cows, but not first-calf heifers. Precalving vaccination had minimal effects on mortality and morbidity of calves before or after weaning. Subsequent steer feedlot gains were unaffected by precalving and preweaning vaccinations and carcasses were not affected. However, heifers' weight gains were greater from weaning to one year of age when reared by vaccinated dams.

(Key Words: Passive Immunity, Vaccination, Antibody.)

Introduction

Pasteurella haemolytica is the major pathogen in bovine respiratory disease in weaned beef calves. Vaccination has proven effective in the prevention of *P. haemolytica* disease. However, little research has been done regarding the vaccine's role in preventing disease through passive immunity. Therefore, the objectives of our study were to determine:

- if *P. haemolytica* vaccine could increase serum antibody titers in beef cows
- if passive immunity would enhance disease resistance and increase calf performance
- if preweaning *P. haemolytica* calf vaccination in conjunction with maternal precalving treatments is effective.

Experimental Procedures

In January 1999, multiparous (n=233) beef cows and primiparous (n=47) heifers received an injection of *P. haemolytica* vaccine (VAC) or no injection (CON) three weeks prior to the start of the calving season. Blood samples were collected on the day of treatment to establish existing serum antibody titers. Three weeks post treatment, serum antibody titers were measured again to evaluate vaccine effectiveness. Titers were measured via enzyme-linked immunoassay. Calves were blocked statistically by cow treatment and randomly allotted to receive *P. haemolytica* vaccine (VAC2) or no injection (CON2) three weeks preweaning. Thus, calf treatment groups were VAC/VAC2, VAC/CON2, CON/VAC2, and CON/CON2. Calf health and performance were evaluated from birth to slaughter for steers and birth to one year of age for heifers. Steer carcass data and lung lesion scores were collected.

Results and Discussion

VAC multiparous cows (Figure 1) had a greater titer response than their non-vaccinated counterparts ($P<0.05$). However, the primiparous heifers did not respond to vaccination ($P>0.13$). Because primiparous cows were naive to *P. haemolytica*, this could have jeopardized their ability to significantly increase serum titers.

[1]Western Kansas Agricultural Research Center, Hays.

No differences (P>0.64) in calf preweaning or postweaning illness or gain were recognized. Steers were weaned and placed into feedlot pens at the Western Kansas Agricultural Research Center, Hays. Two slaughter dates were used to optimize feedlot performance and carcass traits. Steers averaged 469 ± 25 days of age and weighed 1320 ± 104 lb at slaughter. Feedlot gains were not effected by dam or calf vaccination (P>0.48). There were no treatment differences in dressing percent, yield grade, marbling score, or back fat (P>0.23). There were also no differences in number of lung lesions (P>0.51). However, heifers from VAC dams had greater had greater (P<0.05) total postweaning weight gain (39.5 lb) than heifers from CON dams. Most of the weight gain advantage occurred during the second month after weaning (P<0.05). Calf vaccination had no effect on heifer performance (P>0.16).

Our data indicate that *P. haemolytica* vaccine increased serum antibody titers in multiparous cows, but not in primiparous heifers. However, vaccination of calves had little effect on their health status and performance, which could be attributed to the low level of illness observed throughout the study. Perhaps under conditions of stressors, such as commingling, transportation, and dietary changes, vaccine effects would be recognized.

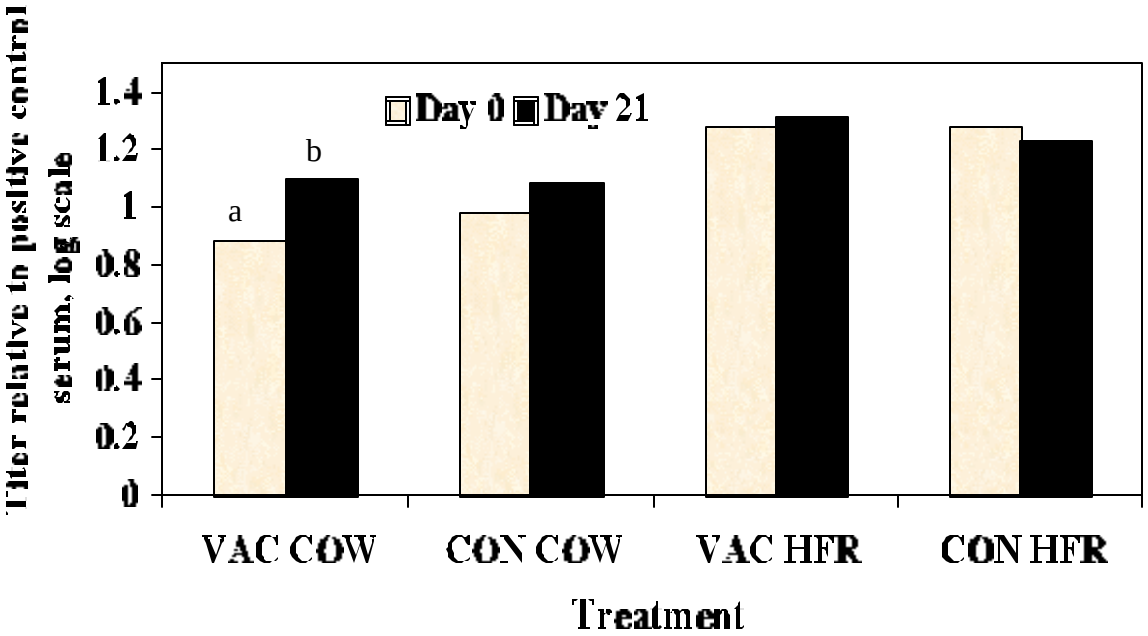

Figure 1. Serum Antibody Titers for Maternal Treatment Groups.
a,b indicate statistical differences (P<0.05).

EVALUATION OF SOUTHWESTERN KANSAS NATIVE GRASSES

T. T. Marston and D. O. Yauk[1]

Summary

Native grass samples were collected monthly for five years and analyzed for nutrient content. Crude protein and ADF content indicate that grass quality is highest in May and June, then steadily declines until October. Stocker operators may need to begin protein supplementation as early as July to sustain weight gains. Trace mineral values were erratic from year to year and month to month between and within years, indicating that trace mineral supplementation should probably be maintained throughout the grazing season.

(Key Words: Native Grass, Protein, Minerals, Nutrition.)

Introduction

Considerable data have been compiled on the nutrient value of native grasses during the grazing season. From these data, supplementation programs have been recommended for beef producers. Most Kansas data has come from the Manhattan area or the Western Kansas Agricultural Research Center, Hays. Little information is available from southwest Kansas. Our objective was to measure and record nutrient profiles of native grasses grown in Clark County, Kansas.

Experimental Procedures

From May 1995 through October 1999, 16- by 16-foot cages were placed in various grazing sites across Clark County. Sites were selected to represent the different soil types within the county. Once the cages were in place, monthly samples (mid-May to mid-October) were harvested from within the cages. Grass species common to most of the sampling sites were little bluestem, side oats grama, blue grama, sand bluestem, and buffalograss. Hand clipped samples were of all standing plant material (dead and growing) within a half inch of the ground. Samples were weighed, sealed in plastic bags and sent to a commercial laboratory for analysis. Each year the cages were moved to a new site within the same soil type. Samples were analyzed for dry matter, crude protein, acid detergent fiber (ADF), calcium, phosphorus, copper, manganese, iron, zinc, and molybdenum contents. Data were combined across soil types for reporting purposes.

Results and Discussion

Nutrient contents are summarized in Tables 1, 2, and 3. There was considerable variation from year to year and month to month, which was probably a reflection of weather patterns. As native grasses mature through the grazing season, they decline in crude protein and increase in ADF. Cattle performance would be expected to decline correspondingly. Research from Kansas State and other universities has indicated that supplementing with degradable intake protein should enhance cattle performance when protein requirements of the animal and its rumen microflora are not met. Assuming that a 600-pound, medium-framed steer might select a diet that contains 2% more crude protein than our samples, and that forage availability is non-limiting, producers

[1]County Extension Agricultural Agent, Clark County.

may need to consider protein supplementation as early as July if their goal is to obtain daily gains of 2 pounds or greater. This is earlier than most producers supplement stocker cattle in southwest Kansas.

Trace minerals can affect performance and immunity status of the grazing animal. Our data indicated that content can be quite variable for copper, manganese, zinc and molybdenum. One third of the monthly copper means (10 of 30 sample months) were less than 50% of the daily requirements (NRC, 1996). Because of the erratic changes in trace mineral content, it may be appropriate to provide 50 to 100% of the trace mineral requirement of summer grazing animals as a supplement.

Table 1. Statistical Values of Major and Trace Minerals from Native Grass Samples Harvested During the Growing Season, Dry Matter Basis (1995-1999)

Item	No. of Samples	Mean	Standard Deviation	Minimum	Maximum
Calcium, %	273	0.51	0.20	0.14	1.56
Phosphorus, %	274	0.15	0.05	0.06	0.32
Copper, ppm	274	15.1	9.7	2.29	52.7
Iron, ppm	274	306	164	60.6	1320
Manganese, ppm	274	41.0	15.2	13.7	104.0
Molybdenum, ppm	273	1.7	0.95	0.42	6.73
Zinc, ppm	274	34.2	9.8	13.0	81.5

Table 2. Yearly Average Nutrient Content in Native Grass Samples Collected in Southwest Kansas, Dry Matter Basis (1995 – 1999)

	Year				
Item	1995	1996	1997	1998	1999
Crude protein, %	6.57	7.66	6.16	6.30	5.70
ADF, %	41.6	44.8	46.7	45.3	45.5
Calcium,%	0.69	0.46	0.50	0.46	0.49
Phosphorus, %	0.17	0.18	0.15	0.15	0.13
Copper, ppm	13.3	10.4	8.8	15.9	24.4
Manganese, ppm	45.8	33.9	37.1	38.6	48.8
Zinc, ppm	32.1	31.6	29.8	35.1	40.5
Molybdenum, ppm	1.41	1.52	1.98	1.65	1.91

Table 3. Monthly Average Nutrient Content in Native Grass Samples Collected in Southwest Kansas, Dry Matter Basis (1995-1999)

	Month					
Item:	May	June	July	Aug.	Sept.	Oct.
Crude protein, %	7.82	7.59	6.90	6.20	5.69	4.66
ADF, %	44.1	42.6	43.9	44.7	45.3	48.1
Calcium,%	0.56	0.24	0.52	0.51	0.48	0.50
Phosphorus, %	0.17	0.17	0.18	0.16	0.15	0.11
Copper, ppm	12.4	18.1	11.9	17.3	15.1	12.8
Manganese, ppm	50.0	42.1	39.9	39.0	34.0	40.2
Zinc, ppm	35.8	32.8	33.1	38.4	29.3	33.5
Molybdenum, ppm	1.33	1.67	1.84	2.03	1.68	1.61

Table 4. Percentage of Yearly and Monthly Trace Mineral Mean Values Meeting NRC Recommendations[a]

	Percentage of Samples Greater than NRC Requirements		
	Copper	Manganese	Zinc
Yearly mean values:			
1995	50.3 ± 1.4	69.9 ± 6.4	48.0 ± 5.4
1996	50.2 ± 1.3	35.5 ± 5.9	61.7 ± 5.0
1997	31.8 ± 1.2	28.3 ± 5.6	37.9 ± 4.8
1998	83.5 ± 1.1	35.2 ± 4.8	80.1 ± 4.1
1999	98.6 ± 1.1	63.9 ± 4.8	84.6 ± 4.1
Monthly mean values:			
May	60.2 ± 1.3	65.8 ± 6.0	67.8 ± 5.1
June	60.2 ± 1.3	51.0 ± 6.0	59.1 ± 5.1
July	60.2 ± 1.3	48.5 ± 6.0	67.6 ± 5.1
August	58.4 ± 1.3	39.6 ± 6.0	67.3 ± 5.1
September	80.2 ± 1.3	31.0 ± 6.0	48.8 ± 5.1
October	58.0 ± 1.3	43.3 ± 6.0	64.2 ± 5.1

[a]NCR (1996) mineral requirements: copper, 10 ppm; manganese, 40 ppm; and zinc, 30 ppm.

A SURVEY OF PHYTOESTROGENIC ACTIVITY IN KANSAS FLINT HILLS PASTURES [1]

D.A. Blasi, S. I. Paisley [2], W. V. Welshons [3], G. E. Rottinghaus [3], M. S. Holder [4], J. L. Davidson [4], D. E. Kehler [4], and J. Higgins [5]

Summary

The botanical composition and basal cover of three Kansas Flint Hills pastures located in Butler and Chase counties was surveyed to estimate the incidence of plant species that contain appreciable levels of estrogenic activity. Many-flowered scurfpea and Ladino clover were the only plant species classified as high in estrogenic activity. Although significant estrogenic activity existed in specific species, the willingness of livestock to consume those species is unclear.

(Key Words: Flint Hills Pastures, Phytoestrogen, Buller Steer Syndrome.)

Introduction

Incidence of the buller steer syndrome in feedlots is typically less than 4%, but can occasionally reach 10%. However, several Kansas feedlot managers have observed individual pen bulling rates as high as 30% in steers previously grazed on Kansas Flint Hills native pastures. Factors such as social hierarchy, aggressive behavior, seasonality, entry weights, stress, pheromones, and growth promoting implants have been suggested as factors contributing to the occurrence of the buller steer syndrome. More recently, plant estrogens have been implicated as an additional factor that might increase bulling activity or reduce the efficacy of growth-promoting implants.

More than 40 plant species have been shown to contain estrogenic activity. Estrogenic activity is widespread among many legumes, including subterranean (*Trifolium subterran*), white (*Trifolium repens*), and red (*Trifolium pratense*) clovers, as well as alfalfa. Many leguminous plants, such as purple prairieclover, Illinois bundleflower, catsclaw sensitive briar, showy partridgepea, and many-flowered scurfpea, naturally inhabit Flint Hills native-grass pastures. Moreover, introduced species such as Korean lespedeza, which was extensively air-seeded during the 1950's, may be present (Owensby, personal communication, 1999). However, it is not known if plant species found in Flint Hills pastures contain estrogenic activity in appreciable concentrations or if they are consumed in sufficient quantities to elicit bulling activity. Consequently, during July we determined the phytoestrogenic activity in a variety of pasture plants, as well as in alfalfa collected at a commercial feedlot.

Experimental Procedures

Botanical composition and basal cover estimates from three pastures in the Flint Hills were determined in July, 1999, using a

[1]Sincere appreciation is expressed to National Farms, Kansas City and S-Bar Ranch Feedlot, Sublette for cooperation and to Schering-Plough Animal Health for financial support.

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[4]County Extension Agricultural Agents in Chase, Greenwood, and Butler Counties, respectively.

[5]Department of Statistics.

modification of the step-point system outlined by Owensby (1973). Individual plant species were collected over three sampling periods during the latter stages of intensive-early grazing (early to mid-July). All forage samples were frozen and shipped overnight to a University of Missouri laboratory for phytoestrogen analyses.

The bioassay (Welshons et al., 1990; J. Vet Diagn Invest. 2:268) measures estrogen-stimulated growth of MCF-7 cells in tissue culture. It is both specific in that it detects only estrogens and inclusive, detecting all estrogenic compounds. The assay is exceptionally sensitive, requires minimal sample preparation, and allows a large number of feed/forage samples to be screened.

Results and Discussion

Table 1 illustrates the plant species composition of the three Flint Hills pastures. Major warm season perennial grass such as big bluestem, little bluestem, indiangrass and switchgrass, represented about 70% of the the plant species counted in pastures A and B, with leguminous plants and forbs representing 7 to 12%. Pasture C contained more cool season grasses, forbs and sedges.

Estrogenic activity varied dramatically among the species assayed. Table 2 shows the results of the bioassay expressed in zearalenone equivalents, which is the amount of zearlenone required to give the observed response. The highest estrogenic activity was found in Ladino clover and many-flowered scurfpea (*Psoralea tenuiflora* Pursh). Intermediate levels of activity were found in alfalfa, black medic, and Korean lespedeza. Because Korean lespedeza is an introduced species, its presence is variable and depends upon the original seeding. Low levels of activity were found in roundhead lespedeza, wood sorrel, and yellow sweet clover. Only traces of activity were found in the grasses.

Native and introduced legumes comprised only 3 to 4% of the plant species in the three pastures we studied. This raises questions regarding their potential contribution to the buller steer syndrome. Collecting samples throughout the grazing season and measuring actual plant selection by animals will answer that question.

Table 1. Plant Species Composition of Three Flint Hills Pastures (1999)

	Pasture		
	A	B	C
	---------- Count (Percentage)----------		
Major warm season[a]	72.24%	70.27%	58.74%
Minor warm season[b]	12.07%	12.41%	10.72%
Cool season[c]	2.24%	0.86%	7.15%
Misc. grass[d]	2.41%	0.86%	1.94%
Forbs[e]	3.28%	5.78%	8.39%
Native Legume[f]	4.14%	2.99%	3.26%
Sedge	3.62%	6.84%	9.79%
Total	100%	100%	100%

[a]Big blue, little blue, indian, switch. [b]Buffalo, grama, sideoats. [c]Annual, fescue, Brome, Poa. [d]Panic, dropseed. [e]Annual, field pussytoe, ragweed, aster, oxalis, yarrow, Goldenrod, daisy fleabane, milkweed, dandelion, many-flowered scurfpea, wood sorrel, western yarrow, western ragweed, showy partridge pea, purple prairie coneflower, Illinois bundleflower, catsclaw sensitive briar, California loosestrife. [f]Black medic, Korean lespedeza, iron weed, leadplant, ladino clover, roundhead lespedeza.

Table 2. Zearalenone equivalent of Kansas Flint Hills Native Plant Species

	Zearalenone Equivalent, ppm dry basis			
Plant Species	No. of Samples	Ranges[a]	Average	Range
Ladino clover	5	high	10.9624	2.032 - 36.239
Many-flowered scurfpea	2	high	43.6929	39.39 - 47.9958
Alfalfa hay	6	medium	7.5120	3.103 - 13.051
Black medic	9	medium	5.0318	1.037 - 15.429
Korean lespedeza	13	medium	8.4032	0.8063 - 27.558
Blue wild indigo	1	low	3.2650	3.265
Roundhead lespedeza	3	low	1.2004	0.4266 - 2.355
Wood sorrel (oxalis)	1	low	1.9690	1.969
Yellow sweet clover	1	low	1.0140	1.014
California loosestrife	1	< 1 ppm	0.0412	0.0412
Catsclaw sensitive briar	9	< 1 ppm	0.0513	0.0133 - 0.145
Grazed grass	8	< 1 ppm	0.1063	0.0274 - 0.2602
Illinois bundleflower	3	< 1 ppm	0.2454	0.225 - 0.7363
Leadplant	11	< 1 ppm	0.2766	0.0831 - 0.595
Non-grazed grass	2	< 1 ppm	0.0186	0.0212 - 0.01602
Purple prairie clover	4	< 1 ppm	0.0771	0.0311 - 0.121
Sedge	1	< 1 ppm	0.1780	0.178
Showy partridge pea	1	< 1 ppm	0.7039	0.7309
Ungrazed grass	2	< 1 ppm	0.0120	0.01089 - 0.0131
Western ragweed	3	< 1 ppm	0.7760	0.293 - 1.041
Western yarrow	3	< 1 ppm	0.1077	0.0596 - 0.174

[a]High = ≥10 ppm; medium = ≥5 and <10 ppm; low = ≥and < 5ppm.

INFLUENCE OF LOW-LEVEL FALL SUPPLEMENTATION WITH A SELF-FED, HIGH-PROTEIN SUPPLEMENT AND LEVEL OF WINTER SUPPLEMENTATION ON PERFORMANCE OF BEEF COWS GRAZING TALLGRASS-PRAIRIE RANGE

T. A. Wickersham, R. C. Cochran, D. V. Dhuyvetter, D. M. Grieger, and C. G. Farmer

Summary

An experiment was conducted to determine the effect of providing a small amount of a high-protein supplement during the fall and effects of increasing subsequent level of winter supplementation on cow-calf performance. One hundred-sixty spring-calving Hereford × Angus cows grazing tallgrass-prairie range were used. During the fall, cows either had access to a self-fed, high-protein supplement (30% CP) or were not supplemented. During the winter, range cubes (20% CP) were fed at a daily equivalent of 1, 2, 3, or 4 lb/head and all cows had access to the same self-fed supplement used during the fall period. Cumulative performance (as measured by changes in body condition score and body weight) tended to show limited response to low-level fall supplementation, but was significantly improved as level of winter supplementation increased.

(Key Words: Protein, Range, Beef Cattle, Supplementation, Self-Feeding.)

Introduction

During the period between weaning and initiation of winter supplementation, a spring-calving cow's nutrient demands are typically at their lowest, enabling cows to recover body weight and condition before entering winter. However, forage protein concentration during this period is often low enough to prevent optimum utilization of available nutrients, hampering the cow's ability to improve body condition. Previous research at Kansas State University demonstrated that utilization of low-quality forage is improved by protein supplementation, with the greatest improvements from the first increments of supplement. Our initial objective was to evaluate the capability of small quantities of a self-fed, high-protein supplement to improve forage utilization during the fall period, thereby increasing the cow's ability to recover condition during this period and enabling her to enter winter in better nutritional status. Improved condition and weight entering the winter period may reduce the amount of supplementation required to maintain desirable levels of performance. Therefore, an additional objective was to evaluate the response to increasing levels of winter supplement among groups of cows managed both with and without fall supplementation.

Experimental Procedures

During the fall and winter of 1999-2000, 160 Hereford × Angus cows were used to examine the effect of different fall and winter supplementation treatments on performance. Cows were weighed and body condition scored (1 = extremely emaciated, 9 = extremely obese) on October 4, 1999, stratified by body condition score and body weight, and assigned randomly within strata to one of four pastures. Initial condition score averaged 5.2 and initial body weight averaged 1,139 lbs.

Pasture groups were randomly assigned to two fall (10/4/1999 through 11/30/1999) treatments (two pasture groups per treatment); either free-choice access to a high protein (30% CP) self-fed, cooked molasses supplement or no supplementation. In addition, within each pasture group, cows were stratified by body condition and weight and randomly assigned within strata to one of

four winter (12/1/1999 to calving) supplementation treatments; free-choice access by all cows to the same self-fed supplement used during the fall period plus an average daily equivalent of 1, 2, 3, or 4 lb/head of a commercial range cube (20% CP). Range cubes were delivered on Monday, Wednesday, and Friday and were prorated to match the described daily intake averages. On supplementation days, all cows were gathered and sorted into their appropriate treatment groups and group-fed their supplement. Intake of the self-fed supplement was regulated throughout the fall and winter periods by manipulating container (250 lb tubs) placement and/or number. Our intended consumption was 0.5 – 1.0 lb/head daily. Consumption of the self-fed product was measured through both fall and winter periods, ending in late February with the beginning of the calving season.

After calving (average calving date = 3/5/00) all cows continued to graze tallgrass-prairie, but were switched to a common supplementation program (12 lb/head daily of high-quality alfalfa hay) until sufficient green grass was available (mid- to late-April). In addition to the initial weight and body condition measurement in early October, cows were weighed and body condition scored again on November 30, January 6, February 8, within 48 hours after calving, May 9, and at weaning (10/4/2000). Calves were weighed within 48 hours after calving, on May 9, and at weaning. Pregnancy rate was determined by rectal palpation at weaning.

Results and Discussion

Daily intake of the self-fed supplement by cows during the fall period averaged 1.40 lb/head, slightly higher than the targeted consumption level (Table 1). However, fall supplementation under our conditions did not significantly improve body condition score change or weight change. Daily intake of the self-fed supplement during the winter period was not affected (P=0.54) by previous fall treatment (approximately 0.95 lb/head). Increasing level of range cube supplementation decreased cumulative body condition loss and cumulative weight loss (linear, P<0.01) during the winter period (Table 2). Although cow performance during the fall period was not significantly altered by consumption of the self-fed supplement, body weight at calving for supplemented cows tended (P=0.08) to be heavier.

Only one interaction (P=0.05) was observed; BCS for the fall-supplemented group was slightly higher across all winter supplement levels except at the highest level of winter supplementation.

Changes in BCS and BW after calving tended ($P \leq 0.06$) to be inversely related to BW and BCS changes during the prepartum period. As a result, cows supplemented during the fall or those receiving more winter supplement tended ($P \leq 0.08$) to lose more body condition, or show less improvement in body condition, from calving through May 9. Increasing the level of winter supplementation linearly increased calf birth weight (P=0.02). Neither fall nor winter supplementation treatments elicited a response in calf ADG from birth until weaning (10/4/200). Fall supplementation had little effect on percent of cows pregnant at weaning. However, it is noteworthy that the lowest level of winter supplementation exhibited the lowest pregnancy rates, being at least nine percentage units lower (Table 5) than other treatments. Differences between winter supplementation treatments were significant (P=0.04).

This experiment indicated that although most performance characteristics were improved in proportion to level of winter supplementation, providing a limited amount of protein for a short period during the fall exerted only minimal effects on subsequent livestock response.

Table 1. Effect of Fall Supplementation and Subsequent Winter Supplementation Level on Changes in Fall Body Weight (BW), Condition Score[a] (BCS), and Self-Fed Supplement Consumption of Beef Cows Grazing Dormant, Tallgrass-Prairie Forage

	Treatment			
Item	No Fall Supplementation	Fall Supplementation	SE	P[b]
No. of Cows	80	80		
Initial BCS	5.20	5.21	0.038	0.89
Period BCS change				
4 Oct – 30 Nov	-0.16	-0.07	0.049	0.34
Initial BW, lb	1131	1147	5.8	0.20
Period BW change, lb				
4 Oct – 30 Nov	15	22	14.8	0.79
Self-fed supplement consumption, lb/d				
4 Oct – 30 Nov	--	1.40	--	--
1 Dec – 22 Feb	0.92	0.99	0.067	0.54

[a]Body condition scale: 1=extremely emaciated; 9=extremely obese.
[b]Probability of a greater F-value.

Table 2. Effect of Fall Supplementation and Subsequent Winter Supplementation Level on Changes in Cow Body Condition Score[a] (BCS), Cow Body Weight (BW), and Calf Performance for Beef Cattle Grazing Tallgrass-Prairie

	Treatment								
	No Fall Supplementation				Fall Supplementation				
	lb/head/day				lb/head/day				
Item	1	2	3	4	1	2	3	4	SE
No. of Cows	20	20	20	20	19	20	20	20	
Initial Cow BCS	4.98	5.05	5.08	5.09	5.15	5.16	5.21	5.09	0.081
Initial Cow BW, lb	1112	1172	1137	1165	1162	1168	1171	1175	12.3
Cow Performance - Cumulative Changes									
BCS 12/1 – Calving[b]	-1.55	-1.30	-1.01	-0.86	-1.47	-1.34	-0.84	-0.93	0.094
BW 12/1 – Calving[b]	-228	-201	-154	-152	-224	-207	-159	-138	12.5
BCS Calving[c]	3.43	3.75	4.06	4.23	3.70	3.83	4.38	4.13	0.061
BW Calving, lb[b]	879	972	983	1014	938	961	1012	1037	11.3
BCS Calving – 5/9	0.22	0.19	-0.13	0.14	0.13	0.06	-0.02	-0.19	0.126
BW Calving – 5/9[b]	-24	-48	-74	-52	-28	-47	-62	-87	10.1
Cow Weaning BCS	5.13	5.15	5.18	5.30	5.24	5.19	5.24	5.17	0.081
Cow Weaning BW, lb	1106	1172	1136	1188	1179	1151	1167	1183	21.1
No. of Cows Calving	19	20	19	20	18	20	20	19	
Calf Performance									
Birth wt, lb[d]	81.3	84.2	82.3	89.4	84.6	84.3	87.0	86.6	1.66
Calf Weaning BW, lb	514	516	548	542	534	533	550	538	11.9
Calf ADG, lb	2.04	2.03	2.13	2.14	2.13	2.12	2.18	2.13	0.040

[a]Body condition scale: 1 = extremely emaciated; 9 = extremely obese.
[b]Contrasts for supplementation level across fall supplementation treatments were linear ($P<0.05$).
[c]Interaction between fall and winter supplementation was significant ($P<0.05$); additionally, linear, quadratic, and cubic contrast for supplementation level across fall supplementation treatments were significant $P<0.05$).
[d]Contrasts for supplementation level across fall supplementation treatments were linear ($P<0.05$).

Table 3. Effect of Fall Supplementation and Subsequent Winter Supplementation Level on Changes in Cow Body Condition Score[a] (BCS), Cow Body Weight (BW) from October 4, 1999 to October 4, 2000 on Beef Cattle Grazing Tallgrass-Prairie

	Treatment								
	No Fall Supplementation				Fall Supplementation				
	lb cube/head/day				lb cube/head/day				
Item	1	2	3	4	1	2	3	4	SE
Initial Cow BCS	5.26	5.23	5.13	5.18	5.15	5.32	5.20	5.18	0.053
Initial Cow BW, lb[b]	1103	1158	1118	1147	1135	1147	1151	1155	8.9
Cow Performance - Cumulative changes									
Change in BCS[c]	-.14	-.08	.15	.12	.04	-.16	.04	-.05	0.068
Change in BW, lb	7	14	26	41	42	2	15	24	16.2
Ending Cow BCS	5.13	5.15	5.18	5.30	5.24	5.19	5.24	5.17	0.081
Ending Cow BW, lb	1106	1172	1136	1188	1179	1151	1167	1183	21.1

[a]Body condition scale: 1 = extremely emaciated; 9 = extremely obese.
[b]Contrasts for supplementation level across fall supplementation treatments were linear and cubic ($P<0.05$).
[c]Contrasts for supplementation level across fall supplementation treatments were cubic ($P<0.05$).

Table 4. Effect of Fall Supplementation on Pregnancy Rate of Beef Cows Grazing Tallgrass-Prairie Forage

	Treatment		
Item	No Fall Supplementation	Fall Supplementation	Chi-Square (P[a])
No. of Cows	74	74	
Pregnancy Rate, %	96	92	0.31

[a]Probability of a greater F-value.

Table 5. Effect of Winter Supplementation Level on Pregnancy Rate of Beef Cows Grazing Tallgrass-Prairie Forage

	Winter Supplement lb cube/head/day				
Item	1	2	3	4	Chi-Square (P[a])
No. of Cows	35	38	37	38	
Pregnancy Rate, %	86	95	97	97	0.04

[a]Probability of a greater F-value.

ESCHERICHIA COLI O157:H7 RISK ASSESSMENT FOR PRODUCTION AND COOKING OF RESTRUCTURED BEEF STEAKS

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Summary

Distribution of *Escherichia coli* O157:H7 in restructured beef from artificially inoculated meat pieces and destruction of *E. coli* O157:H7 in restructured beef steaks prepared from artificially inoculated meat was evaluated following broiling and grilling. In Study I, *longissimus dorsi* trimmings were inoculated with fluorescently marked *E. coli* O157:H7 cells to microscopically identify bacterial distribution throughout restructured steak cross-sections. *E. coli* O157:H7 fluorescent density was observed along the glue lines where meat pieces were enzymatically attached. Study II quantified the level of *E. coli* O157:H7 throughout the entire thickness of restructured beef. Cross-sectional slices of core samples from the steaks showed that bacterial contamination was evenly distributed (ca. 10^6 CFU/g). Study III determined the extent of *E. coli* O157:H7 reduction achieved during cooking. Beef trimmings were inoculated to a level of 10^7 CFU/g and used to prepare restructured beef chubs. Restructured steaks of three thicknesses (0.5, 1.0, and 1.5 inches) were sliced from the chubs and cooked to one of six target internal temperatures (120, 130, 140, 150, 160, or 170°F) by commercial gas grill or oven broiler. Broiling was more effective than grilling, although *E. coli* O157:H7 survival decreased as endpoint temperatures increased incrementally. To achieve an adequate level of safety confidence, restructured steaks should be cooked in a manner similar to ground beef; to an internal temperature of at least 160°F.

(Key Words: *E. coli* O157:H7, Restructured Beef Steaks, Cooking.)

Introduction

Meat restructuring using cold set binding technologies like fibrinogen and thrombin enzymes provide quality, economic, nutritional, and marketing advantages in meat processing. Food poisoning outbreaks with *Escherichia coli* O157:H7 have frequently been attributed to ground beef consumed after cooking that was insufficient to destroy pathogens that were translocated from the surface to the meat interior. Restructured steaks may be perceived as more like intact muscle steaks than as ground beef. Because of this perception, restructured steaks may be cooked at temperatures inadequate to destroy surface microbial contamination that may have been carried to the interior of the restructured product. The objectives of our research were to determine the extent of *E. coli* O157:H7 translocation in restructured beef and to determine adequate cooking protocols to eliminate *E. coli* O157:H7 from their interior.

Experimental Procedures

Study I:

Five strains of *Escherichia coli* O157:H7 (USDA-FSIS 011-82, ATCC 43888, 43889, 43890, and Eh 7-4) were grown and marked using a fluorescent probe, live-cell nucleic acid stain. *Longissimus dorsi* beef trimmings were mist inoculated (ca. 7 $\log_{10}$ CFU/g) and allowed to attach at 39°F for 1 hr. Thawed proportional parts of fibrinogen and thrombin enzymes, were mixed with the *longissimus dorsi* trimmings for 90 sec and stuffed into perforated casings using an Aligned Grain System™. The formed meat was hung at 41°F for 10 hr for setting the meat pieces, and frozen for 1.5 hr to form a

surface crust to facilitate sample collection. A sterile stainless steel coring device coupled to an electric drill was used to core the sample along the width of the cylindrical meat piece. The cores were fixed in a mixture of paraformaldehyde (2%) and glutaraldehyde (0.2%) in neutral buffer solution (pH 7) for 6 hr, sectioned and visualized under a confocal laser microscope.

Study II:

A strain of *E. coli* O157:H7 (USDA-FSIS 011-82, rifampcin resistant) was mist inoculated (ca. 7 $\log_{10}$ CFU/g) onto the surface of *longissimus dorsi* beef trimmings. The restructuring procedure from Study I was followed. The formed beef roll (crust frozen) was sampled as previously described at three different locations about 4 inches apart. The meat cores were aseptically sliced into cross-sectional strips of 0.8, 0.4, 0.4, 0.4, and 0.8 inches. Each cross-sectional strip was plated onto TSA-rif and the *E. coli* O157:H7 population was reported.

Study III:

The inoculation and restructuring procedures from Study I were followed. The cylindrical restructured beef chub (2.8" inch diameter) was sliced into steaks of 0.5, 1.0, and 1.5 inch thickness. Steaks were randomly assigned to six target internal temperature groups (120, 130, 140, 150, 160, and 170°F) and were cooked under a typical kitchen oven broiling element set at 500°F, or cooked using a commercial gas grill. Steaks were flipped upon reaching the midpoint between original and final temperature. Internal temperatures were constantly monitored using a type T thermocouple threaded through the steak edge to the steak's geometric center. After reaching the target internal temperature, steaks were removed from the grill or broiler, placed in heat resistant bags and immersed in an ice bath. Steaks were blended in a sterile food processor and a 25 g sample stomached in peptone water to provide a 1:5 w/v dilution. Surviving *E. coli* O157:H7 populations were enumerated on MacConkey Sorbitol Agar (MSA) and Phenol Red Sorbitol Agar (PRSA). PRSA agar provided an estimate of the level of thermally injured cells that may not have been detected on MSA agar. Samples testing negative by direct plating were qualitatively evaluated following a modified USDA method. Presumptive *E. coli* O157:H7 colonies were confirmed biochemically and serologically. Three replications were performed for each study.

Results and Discussion

Study I:

Confocal laser scanning microscopy revealed a high level of *E. coli* O157:H7 contamination along cross-sections of the restructured beef chub. The fluorescent bacteria present midway through the cylindrical restructured meat piece shows that the restructuring process translocates surface contamination into the interior.

Study II:

E. coli O157:H7 was uniformly distributed ($P>0.05$) across the diameter (5 individual cross sections) of the restructured beef chub, indicating translocation of surface inoculated *E. coli* O157:H7 into the interior of the chubs during restructuring. Section 3, corresponding to the geometric center of the core, revealed a mean bacterial population of 6.16 $\log_{10}$ CFU/g. This section would be the coldest point during cooking.

Study III:

Broiling steaks from restructured beef trimmings to endpoint temperatures of 120, 130, 140, 150, 160, and 170°F resulted in *E. coli* O157:H7 reductions of 1.03, 1.94, 2.70, 4.32, 6.27, and 6.08 log CFU/g, respectively, when plated on PRSA (1 log = 90%, 4 log = 99.99% reduction). Greater reductions were obtained when a selective medium (MSA) was used for plating, indicating sub-lethal injury to *E. coli* O157:H7 cells during cooking. Cooking of thicker steaks (1.0 and 1.5 inches) resulted in consistently larger reductions in *E. coli* O157:H7 compared to the 0.5 inch steaks. This probably was due to thicker steaks requiring longer cooking times. The post-cook temperature rise was higher for 1.5-inch thick steaks (9 to 22°F) compared to steaks 1.0 and 0.5 inch thick (3 to 8°F and 7 to 12°F for 0.5 and 1.0 inch thick steaks, respectively). The additional microbial destruction in thicker steaks due to longer cook times and higher post-cook

temperature rise results in a safer steak, compared to thinner steaks.

Cooking restructured steaks on a gas grill to endpoint temperatures of 120, 130, 140, 150, 160, and 170°F resulted in *E. coli* O157:H7 reductions of 0.87, 1.16, 1.25, 2.62, 3.73, and 4.51 log CFU/g, respectively, when plated on PRSA. These reductions were greater when a selective medium (MSA) was used for plating the samples, indicating a significant number of injured but not killed *E. coli* O157:H7 cells. These reductions were lower than the reductions attained using oven broiling. This was probably due to the commercial grill using higher temperatures and shorter cooking times to reach target temperatures.

Initial studies indicated that some restructured steaks curled during cooking, probably due to different fiber alignment than normal steaks. Use of cook weights (1 lb steel plates with a handle) minimized but did not eliminate the curling. Using commercial grill systems can result in cold spots on steaks due to curling, and thus reduce microbial destruction. In addition, when cooked on a grill, the top surface of the steak is exposed to near ambient temperatures. On the contrary, in oven broiling, the temperature is more consistent and uniform because steaks are heated from the top (broiling element). The surface of the holding grill is close to the oven temperature, resulting in larger reductions in *E. coli* O157:H7 populations.

Grilling thicker steaks (1.0 and 1.5 inches) resulted in larger reductions of *E. coli* O157:H7 compared 0.5 inch thick steaks, probably due to the longer cook times and higher post-cook temperature rise. As observed in oven broiling, the post-cook temperature rise was greater in steaks of 1.0 and 1.5 inches (1 to 16°F and 6 to 19°F).

This study incorporated the use of an ice bath to rapidly halt destruction of bacteria after steaks were removed from the broiler, to provide more accurate information concerning microbial destruction achieved at the identified target internal temperatures. However, even after transfer to the ice bath, internal temperature of the steaks continued to rise above the target temperatures by as much as 4 to 29°F. In food service applications, the finished product would not be cooled. Therefore, internal temperatures would likely rise to higher endpoints and be maintained longer, thereby increasing margin of safety in pathogen destruction.

TEMPERATURE ACCURACY OF AN ELECTRIC BELT GRILL, A FORCED-AIR CONVECTION OVEN, AND AN ELECTRIC BROILER

T. E. Lawrence, D. A. King, and M. E. Dikeman

Summary

We evaluated the temperature variation of an electric belt grill set at four temperatures, a forced-air convection oven set at three temperatures, and an electric broiler that has no temperature control. After finding that the actual temperatures of the electric belt grill and the forced-air convection oven were higher than the targeted temperature, we used regression techniques to correct for the temperature biases of both cooking methods. The forced-air convection oven was very precise when the doors were kept closed, as was the electric belt grill after adjustments were made. Temperature of the electric broiler was not consistent across surface positions or among replications. We suggest that when used for cooking experiments, each meat-cooking instrument be validated for temperature and corrected when necessary. This will improve cooking consistency and related results among various instruments and research institutions.

(Key Words: Cooking, Temperature, Methods, Meat.)

Introduction

Many researchers consider actual oven temperatures to be constant with the thermostat settings, with little or no variation. Cooking methods used for research should achieve the desired target temperature and maintain that temperature for the duration of the cooking process so that measures such as cooking loss and shear force values will be reliable and repeatable. Cooking methods for research have often utilized electric broilers, forced-air convection ovens, or more recently, electric belt grills. We evaluated the temperature variation and accuracy of a single example of each of these instruments.

Experimental Procedures

We monitored the temperature at 18 locations (9 for each platen) on an electric belt grill (TBG-60 Magigrill, MagiKitch'n Inc., Quakertown, PA) set at 160, 242, 325, and 408°F; 18 locations in a forced-air convection oven (Blodgett, model DFG-102 CH3, G.S. Blodgett Co., Burlington, VT) set at 225, 325, and 425°F; and 12 locations on an electric broiler (Open Hearth electric broiler, Farberware, Yonkers, NY). The electric belt grill cooks by moving a product between two heated platens using conveyor belts. In this conduction type of heating, a product is heated from the top and bottom simultaneously. Unloaded temperature of each oven was monitored using copper-constantan thermocouples (Omega Engineering, Stamford, CT) connected to a Doric temperature recorder (Vas Engineering, San Francisco, CA). The electric belt grill and forced-air convection oven were monitored for two replications, and the electric broiler was monitored for three. Linear regression analysis was used to correct for temperature bias in the electric belt grill and forced-air convection oven.

Results and Discussion

The electric belt grill was 8, 13, 20, and 26°F high when set at 160, 242, 325 and 408°F, respectively. The forced-air convection oven produced temperatures 5, 4.5, and 1.4°F higher than it was supposed to at settings of 225, 325, and 425°F. Linear regression equations developed to correct for the

temperature bias of the electric belt grill and forced-air convection cooking methods are reported in Table 1. Based on the regression equations, the set points of the electric belt grill and forced-air convection oven were adjusted to obtain the desired temperatures. Results before and after adjustment are shown in Table 2 for the electric belt grill and Table 3 for the forced-air convection oven. Temperature variation from point to point was relatively high for the electric belt grill (Table 2) but was small for the forced-air convection oven (Table 3). The electric broiler had a mean operating temperature of 245.1°F; but varied from 194.4°F to 292.8°F depending upon location. These data emphasize that temperature for each cooking instrument used for research should be validated and corrected when necessary. These quality control measures will assure accurate reporting of procedures and reduce variation in cooking and related results (cooking loss, shear force value) among instruments and research institutions.

Table 1. Linear Regression Equations to Correct for Temperature Bias of Cooking Methods

Cooking Method	Intercept	Slope	R^2	P > F
Electric belt grill (top platen)	4.523	.932	.99	.001
Electric belt grill (bottom platen)	6.050	.921	.99	.001
Forced-air convection oven	10.342	.979	.99	.001

Table 2. Mean Top and Bottom Electric Belt Grill Platen Temperatures Before and After Temperature Adjustment (°F)

Targeted Temperature	Top Platen Unadjusted	Bottom Platen Unadjusted	Range Unadjusted	Top Platen Adjusted	Bottom Platen Adjusted	Range Adjusted
160°F	168.3	168.3	164.4-171.1	160.0	160.5	156.3-163.9
242°F	254.3	256.5	247.1-263.5	243.9	245.5	236.3-252.2
325°F	343.4	346.1	332.0-356.9	325.9	326.7	312.1-334.7
408°F	432.7	435.7	419.2-451.8	410.2	410.5	396.1-425.1

Table 3. Mean Temperature Before and After Temperature Adjustment for the Forced-Air Convection Oven (°F)

Targeted temperature	Unadjusted	Range	Adjusted	Range
225°F	219.9	219.3-220.7	225.0	222.9-225.8
325°F	320.4	320.2-323.0	324.9	323.3-326.3
425°F	423.9	422.2-426.3	425.3	423.6-427.2

TENDERNESS AND COOKING CHARACTERISTICS OF BEEF COOKED BY ELECTRIC BELT GRILL, FORCED-AIR CONVECTION OVEN, OR ELECTRIC BROILER

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Summary

We used an electric belt grill, a forced-air convection oven, and an electric broiler to cook 170 bottom round, 142 brisket, 177 top sirloin, 176 strip loin, and 136 eye of round steaks from USDA Select carcasses to determine the effects of cooking method and muscle on shear force values, cooking traits, and repeatability of duplicate measurements. All cooking treatments allowed differences to be detected ($P<0.05$) in Warner-Bratzler shear force, although the differences were inconsistent. Shear force values of strip steaks and eye of round steaks were similar across cooking treatments; however, shear force values of bottom round, brisket, and top sirloin steaks were different ($P<0.05$) among cooking treatments. Based on poor repeatability, shear force values for top sirloin steaks appear unreliable. Poor repeatability for shear force values from steaks cooked by the forced-air convection oven are a result of drastic temperature changes that occur when the doors are opened to remove steaks. We do not recommend using a forced-air convection oven to test treatment effects on shear force values when cooking multiple steaks simultaneously. Belt grill cooking resulted in the highest shear force repeatability R = 0.07 to 0.89) of strip steaks. Electric broiling resulted in acceptable R = 0.60) repeatability of shear force measurements for all classes of steaks. The electric broiler and electric belt grill are both satisfactory cooking methods when measuring shear force of bottom round, brisket, strip loin, and eye of round steaks.

(Key Words: Beef, Cooking, Repeatability, Tenderness.)

Introduction

Cooking method is one of the most important factors influencing the tenderness of beef. Cooking methods used for research should give highly repeatable results; and should neither mask nor enhance treatment effects. Previous research has suggested the use of an electric belt grill instead of an electric broiler for steak tenderness research, based on increased precision and repeatability of duplicate measurements. Other research has suggested not using forced-air convection cooking because of inconsistent cooked product characteristics. Our objectives were: (1) to determine if differences in Warner-Bratzler shear force (WBSF) can be detected among steaks from five muscles cooked on an electric belt grill, in a forced-air convection oven, or on an electric broiler; and (2) to determine the repeatability of WBSF values and cooking traits.

Experimental Procedures

We cut one-inch thick steaks from 18 briskets (NAMP 120), 18 top sirloin butts (NAMP 184), 18 loin strips (NAMP 180), 17 bottom rounds (NAMP 170), and 17 eye of rounds (NAMP 170) from USDA Select carcasses. Identification of subprimal and steak location within subprimal were maintained. All steaks were aged 14 days at 34°F. Consecutive pairs of steaks were randomly assigned to one of five cooking treatments: electric belt grill (TBG-60 Magigrill, MagiKitch'n Inc., Quakertown, PA) at 200, 242, or 325°F; forced-air convection oven (Blodgett, model DFG-102 CH3, G.S. Blodgett Co., Burlington, VT) at 325°F; or electric broiler (Open Hearth electric broiler, Farberware, Yonkers, NY). The electric broiler had no temperature control. All

steaks were cooked to an internal temperature of 158°F and then removed from the cooking device. Total cooking loss, cooking time, and endpoint temperature (maximum temperature reached after removal from the cooking device) of each steak was recorded. After cooking, steaks were refrigerated overnight (39°F). We removed six round cores (1/2 inch in diameter) parallel to the muscle fiber direction and sheared each one once through the center with a V-shaped WBSF attachment on an Instron Universal Testing Machine. We analyzed the data by two-way analysis of variance with five levels of each factor. Our model included the fixed effects of muscle, cooking treatment, and muscle × cooking treatment interaction as well as the random effects of subprimal, steak location within subprimal, and replication. Muscle × cooking treatment interaction means were generated and separated when significant ($P<0.05$). Repeatability for consecutive steaks within cooking treatments was calculated as follows: (variance of subprimal + variance of steak location within subprimal) ÷ (variance of subprimal + variance of steak location within subprimal + error variance).

Results and Discussion

All cooking treatments allowed detection of differences ($P<0.05$) in WBSF values across the five muscles (Table 1); however differences were inconsistent. Bottom round and eye of round steaks had similar WBSF values when cooked by the belt grill at 200°F, the forced-air convection oven, or the electric broiler; however, bottom round steaks were tougher ($P<0.05$) than eye of round steaks when cooked on the belt grill at 325°F. Top sirloin steaks were tougher ($P<0.05$) than strip steaks when cooked in the forced-air convection oven; however, they were similar for all other cooking treatments. Top sirloin steaks were more tender ($P<0.05$) than eye of round steaks for all cooking treatments except for the belt grill at 325°F.

Endpoint temperatures were similar for all muscles within a cooking treatment (Table 2). Cooking loss was higher ($P<0.05$) for eye of round steaks than for all other muscles when cooked by the belt grill at 200°F or the forced-air convection oven (Table 3). Cooking times were similar across the five muscles when cooked in the belt grill at any temperature; however, differences ($P<0.05$) in cooking times were detected for the forced-air convection and electric broiler cooking treatments (Table 4). In the forced-air convection oven, strip steaks cooked faster ($P<0.05$) than bottom round and top sirloin steaks, which cooked faster ($P<0.05$) than eye of round steaks. In the electric broiler, strip steaks cooked faster ($P<0.05$) than brisket steaks, which cooked faster ($P<0.05$) than bottom round or eye of round steaks.

WBSF values for bottom round, brisket, and top sirloin steaks were not consistent ($P<0.05$) across the five cooking treatments (Table 1); however, values for strip steaks and eye of round steaks were consistent across all cooking treatments. Bottom round steaks were tougher ($P<0.05$) when cooked by the belt grill at 325°F than by any other cooking treatment. Brisket steaks were tougher ($P<0.05$) when cooked by the electric broiler than when cooked by the belt grill at 200 or 242°F. Top sirloin steaks were tougher ($P<0.05$) when cooked by the forced-air convection oven than when cooked by the belt grill at 200°F.

Belt grill cooking at 325°F resulted in the highest post-cooking temperature rise for all five muscles, which were higher than for the belt grill at 200°F, the forced-air convection oven, or the electric broiler (Table 2). Electric broiling did not result in a significant post-cooking temperature rise, whereas the belt grill at 325°F resulted in a consistent 7°F post-cooking temperature rise for all muscles. Cooking losses for bottom round, brisket, top sirloin, and strip steaks tended to be higher for the electric broiler treatment than any other (Table 3), while the lowest ($P<0.05$) cooking losses resulted from belt grill cooking at 200°F. Cooking time was longest for the electric broiler followed by the forced-air convection oven and belt grill cooking at 200, 242, and 325°F, respectively (Table 4).

Repeatability of shear force values was acceptable (repeatability ≥ 0.60) for bottom round and eye of round steaks cooked by all treatments (Table 5). Strip steak repeatability was highest when cooked by the belt grill at 242 or 325°F and unacceptable for the forced-air convection oven. Only the electric broiler provided acceptable repeatability for top sirloin steaks. Repeatability was unacceptable for brisket steaks cooked by the belt grill at 242°F. The electric broiler was the only cooking method that provided acceptable shear force repeatability for all muscles. The forced-air convection oven provided poor shear force repeatability, which can best be explained by the drastic temperature changes that occur when the oven is opened to remove steaks. Endpoint temperature repeatability was not acceptable for any steak cooked by any treatment (Table 5). Cooking time repeatability was acceptable only for bottom round steaks cooked in the forced-air convection oven and top sirloin steaks cooked by the belt grill at 242°F. Cooking time range was 3.7 minutes for bottom round, 7.4 for brisket, 5.8 for top sirloin, 3.8 for strip, and 7.0 for eye of round steaks. Repeatability of cooking losses was acceptable only for brisket steaks cooked by the belt grill at 200°F, top sirloin cooked by the belt grill at 242°F or electric broiler, and eye of round steaks cooked in the forced-air convection oven. Endpoint temperature, cooking time and cooking loss repeatabilities are important because variations in each can affect repeatability and reliability in WBSF.

Table 1. Warner-Bratzler Shear Force Measurements (Least Squares Means, lb) of Steaks from Five Muscles and Five Cooking Treatments

Cooking Treatment	Bottom Round	Brisket	Top Sirloin	Strip	Eye of Round
Belt grill (200°F)	$10.21^{r,w}$	$13.51^{q,x}$	$8.29^{s,w}$	8.31^{s}	9.57^{r}
Belt grill (242°F)	$10.32^{r,w}$	$14.02^{q,w,x}$	$8.38^{s,v,w}$	8.07^{s}	-
Belt grill (325°F)	$11.84^{r,v}$	$14.99^{q,v,w}$	$9.17^{s,t,v,w}$	8.55^{t}	9.81^{s}
Forced-air convection (325°F)	$10.25^{q,r,v}$	-	$9.35^{r,v}$	8.20^{s}	10.56^{q}
Electric broiler	$10.78^{r,v}$	$15.92^{q,v}$	$8.62^{s,v,w}$	8.33^{s}	10.47^{r}

n = 32-36 per cell.
^{q,r,s,t}Within a row, means lacking a common superscript letter differ (P<0.05).
^{v,w,x}Within a column, means lacking a common superscript letter differ (P<0.05).

Table 2. Endpoint Temperature (Least Squares Means, °F) of Steaks from Five Muscles and Five Cooking Treatments*

Cooking Treatment	Bottom Round	Brisket	Top Sirloin	Strip	Eye of Round
Belt grill (200°F)	161.3^{w}	160.5^{w}	161.3^{x}	161.3^{w}	161.9^{w}
Belt grill (242°F)	164.1^{v}	164.6^{v}	$165.8^{v,w}$	165.3^{v}	-
Belt grill (325°F)	165.7^{v}	166.2^{v}	166.1^{v}	166.1^{v}	166.8^{v}
Forced-air convection (325°F)	160.7^{w}	-	$161.7^{w,x}$	$160.2^{w,x}$	$160.6^{w,x}$
Electric broiler	158.8^{x}	159.8^{w}	159.4^{y}	159.2^{x}	159.1^{x}

n = 32-36 per cell
^{v,w,x,y}Within a column, means lacking a common superscript letter differ (P<0.05).
*No muscle differences were found within a cooking method.

Table 3. Percentage Cooking Loss (Least Squares Means) of Steaks from Five Muscles and Five Cooking Treatments

Cooking Treatment	Bottom Round	Brisket	Top Sirloin	Strip	Eye of Round
Belt grill (200°F)	$19.86^{r,x}$	$20.78^{r,x}$	$20.98^{r,x}$	$21.54^{r,w}$	$25.34^{q,x}$
Belt grill (325°F)	$27.42^{q,r,w}$	$26.49^{r,w}$	$27.08^{q,r,w}$	$26.17^{r,v}$	$28.69^{q,w}$
Forced-air convection (325°F)	$28.03^{r,w}$	-	$29.63^{r,v}$	$25.89^{s,v}$	$33.40^{q,v}$
Electric broiler	$30.63^{q,v}$	$30.18^{q,v}$	$30.63^{q,v}$	$27.60^{r,v}$	$31.66^{q,v}$

n = 32-36 per cell
*Cooking loss of the Belt grill (242°F) was excluded due to a mechanical malfunction.
^{q,r,s}Within a row, means lacking a common superscript letter differ (P<0.05).
^{v,w,x}Within a column, means lacking a common superscript letter differ (P<0.05).

Table 4. Cooking Time (Least Squares Means, Minutes) of Steaks from Five Muscles and Five Cooking Treatments

Cooking Treatment	Bottom Round	Brisket	Top Sirloin	Strip	Eye of Round
Belt grill (200°F)	10.64^{x}	10.53^{w}	10.48^{w}	10.87^{x}	10.80^{w}
Belt grill (242°F)	8.33^{y}	7.45^{x}	7.64^{x}	8.04^{y}	-
Belt grill (325°F)	7.13^{y}	6.40^{x}	6.72^{x}	6.93^{y}	6.67^{x}
Forced-air convection (325°F)	$25.32^{r,w}$	-	$26.44^{r,v}$	$21.09^{s,w}$	$32.80^{q,v}$
Electric broiler	$31.78^{q,v}$	$26.28^{r,v}$	$26.07^{r,s,v}$	$25.23^{s,v}$	$31.33^{q,v}$

n = 32-36 per cell
^{q,r,s} Within a row, means lacking a common superscript letter differ (P<0.05).
^{v,w,x,y} Within a column, means lacking a common superscript letter differ (P<0.05).

Table 5. Repeatability of Warner-Bratzler Shear Force Measurements and Cooking Traits

Variable	Belt Grill (200°F)	Belt Grill (242°F)*	Belt Grill (325°)	Forced-Air Convection (325°F)	Electric Broiler
			Bottom Round		
Endpoint temperature (°F)	0.44	0.00	0.00	0.00	0.38
Cooking loss (%)	0.37	-	0.16	0.37	0.38
Cooking time (min)	0.36	0.06	0.00	0.67	0.39
Shear force (lbs)	0.79	0.66	0.83	0.87	0.89
			Brisket		
Endpoint temperature (°F)	0.41	0.13	0.26	-	0.08
Cooking loss (%)	0.77	-	0.43	-	0.31
Cooking time (min)	0.01	0.16	0.00	-	0.18
Shear force (lbs)	0.62	0.55	0.76	-	0.68
			Top Sirloin		
Endpoint temperature (°F)	0.39	0.26	0.18	0.21	0.00
Cooking loss (%)	0.38	-	0.00	0.14	0.70
Cooking time (min)	0.56	0.71	0.00	0.18	0.53
Shear force (lbs)	0.35	0.58	0.09	0.09	0.66
			Strip		
Endpoint temperature (°F)	0.00	0.10	0.05	0.27	0.30
Cooking loss (%)	0.07	-	0.12	0.13	0.44
Cooking time (min)	0.06	0.51	0.35	0.08	0.19
Shear force (lbs)	0.70	0.89	0.83	0.50	0.63
			Eye of Round		
Endpoint temperature (°F)	0.45	-	0.04	.030	0.00
Cooking loss (%)	0.48	-	0.24	0.60	0.40
Cooking time (min)	0.26	-	0.04	0.34	0.04
Shear force (lbs)	0.83	-	0.86	0.79	0.67

n = 32-36 per cell
*Cooking loss excluded due to a mechanical malfunction.

HEAT PENETRATION PATTERNS OF OUTSIDE ROUND, LOIN STRIP AND EYE ROUND MUSCLES COOKED BY ELECTRIC BROILER, ELECTRIC BELT GRILL, OR FORCED-AIR CONVECTION OVEN

E. Obuz, E. J. Yancey, T. E. Lawrence, D. A. King, and M. E. Dikeman

Summary

We used an electric belt grill, a forced air convection oven, and an electric broiler to cook steaks from three beef muscles; outside round (biceps femoris), loin strip (longissimus lumborum) and eye round (semitendinosus). Belt grill cookery gave the fastest heat penetration into steaks regardless of temperature interval. Eye round had the slowest heat transfer rate for each cooking method perhaps partially explained by its fiber orientation. Heat penetration rate into outside round and loin strip was not different (P>0.05) for cooking method within a given temperature range. Heat penetration into muscles between 140 and 158°F was slowest because energy-expensive reactions (collagen and protein denaturation) occur in that temperature and temperature differential between the heat source and meat is less. Heat penetration also was slow between 122 and 140°F due to the denaturation of contractile proteins.

(Key Words: Heat Penetration, Belt Grill, Forced-Air Convection Oven, Electric Broiler.)

Introduction

Heat penetration into meat is affected by many factors. The energy supply rate, heat conduction within the meat, shape and size of the meat, meat composition, changes induced in meat by heat, for example, protein and collagen denaturation and melting of fat affect heat penetration. Heat penetration is faster when heat is applied parallel to product fibers. The rate of heat penetration is generally most rapid between 50 and 104°F because energy-expensive processes such as protein denaturation have not occurred. On the other hand, heating rate between 140 and 158°F is the slowest due to collagen and protein denaturation and a smaller temperature differential between the heat source and meat. Contact cooking equipment such as a belt grill should result in the fastest heat penetration because of its very high heat transfer coefficient. The heat loss from the open surface of an electric broiler causes heat transfer into meat to be slower than contact cooking. Forced-air convection ovens give effective but slow heat penetration. Air has low thermal conductivity, so heat transfer between air and meat product in a forced-air convection oven is slower than in a belt grill.

Experimental Procedures

We purchased USDA Select subprimals [(beef strip loin, boneless (NAMP 180) and beef round, bottom (gooseneck) (NAMP 170)] (n=17 or 18 each) and removed outside round (biceps femoris, BF, n=17), loin strip (longissimus lumborum, LL, n=18), and eye round (semitendinosus, ST, n=17). Muscles were vacuum packaged and held at 34°F for 14 days, then frozen and stored at -35°F.

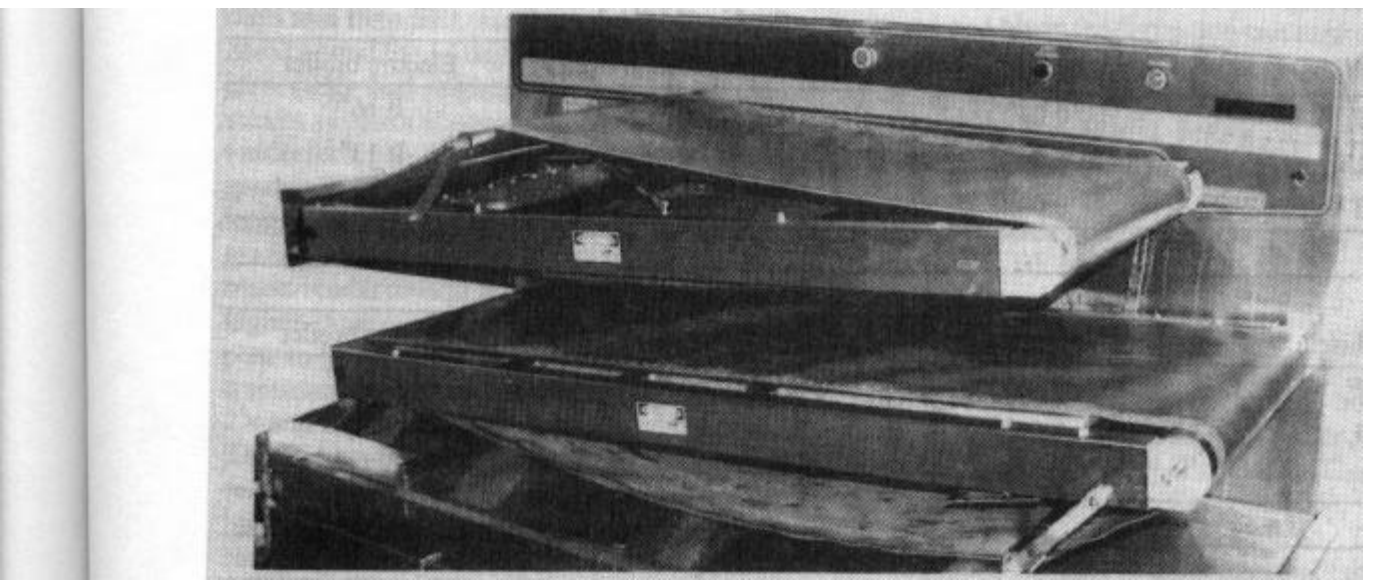
Frozen muscles were sawed into 1-inch thick steaks, which were vacuum packaged and stored. We thawed steaks at 39°F for 24 hours before cooking and cooked them by one of three cooking methods: electric belt grill at 325°F, forced-air convection oven at 325°F, or electric broiler (no temperature control). We cooked all steaks to the end-point temperature of 158°F. The center temperature of steaks was monitored using copper-constantan thermocouples. Temperature was recorded and heat penetration rate for each muscle was calculated as minutes/°F.

Results were analyzed in a completely randomized design using the General Linear Model procedure (SAS, 1998).

Results and Discussion

Belt grill cookery gave the fastest heat penetration rate for muscles studied (Table 1). Forced air convection oven and electric broiler gave similar results in most cases. Heat penetration rate into any given muscle decreased above 104°F since denaturation of contractile proteins, which starts at about 104°F, leads to slower heat penetration. The slowest heating rates occurred in the 140-l 58°F interval, followed by 122-140°F interval. At all temperature intervals, eye round required more energy. Heat penetration for eye round muscle between 50 and 68°F was almost three times faster than between 140 and 158°F, when cooked by either forced-air convection oven or electric broiler. Although loin strip and outside round showed the same trend both required less heat between 140 and158°F than eye round. Belt grill cookery resulted in no differences in heat transfer rate due to muscle in any temperature interval studied because heat transfer was very fast.

Different heat penetration rates for the three muscles may be explained by differences in fat, collagen water, and elastin content and fiberorientation.



Steaks enter the belt grill on the right and exit on the left. During operation the distance between the two belts is adjusted so that the hot belts touch both the top and bottom of the steaks.

Table 1. Heat Penetration (min/°F) Cooking Treatment × Muscle Interaction Means

50 to 68°F			
	Cooking Method		
Muscle	Belt grill	Forced-air convection oven	Electric broiler
BF	0.04^{a,x}	0.13^{b,x}	0.12^{b,x}
LL	0.04^{a,x}	0.14^{b,x}	0.15^{c,x}
ST	0.04^{a,x}	0.16^{b,y}	0.16^{b,y}
68 to 86°F			
	Cooking Method		
Muscle	Belt grill	Forced-air convection oven	Electric broiler
BF	0.04^{a,x}	0.13^{b,x}	0.12^{b,x}
LL	0.04^{a,x}	0.12^{b,x}	0.14^{c,x}
ST	0.04^{a,x}	0.17^{b,y}	0.17^{b,y}
86 to 104 °F			
	Cooking Method		
Muscle	Belt grill	Forced-air convection oven	Electric broiler
BF	0.04^{a,x}	0.17^{b,x}	0.19^{b,x}
LL	0.04^{a,x}	0.15^{b,x}	0.13^{b,y}
ST	0.04^{a,x}	0.22^{b,y}	0.17^{c,xy}
104 to 122°F			
	Cooking Method		
Muscle	Belt grill	Forced-air convection oven	Electric broiler
BF	0.04^{a,x}	0.21^{b,x,y}	0.16^{b,x}
LL	0.04^{a,x}	0.18^{c,x}	0.13^{b,x}
ST	0.04^{a,x}	0.26^{b,y}	0.25^{b,y}
122 to 140°F			
	Cooking Method		
Muscle	Belt grill	Forced-air convection oven	Electric broiler
BF	0.05^{a,x}	0.23^{b,x}	0.26^{b,y}
LL	0.06^{a,x}	0.22^{c,x}	0.18^{b,x}
ST	0.05^{a,x}	0.32^{b,y}	0.33^{b,z}
140 to 158°F			
	Cooking Method		
Muscle	Belt grill	Forced-air convection oven	Electric broiler
BF	0.07^{a,x}	0.33^{b,x}	0.38^{b,y}
LL	0.07^{a,x}	0.37^{b,x}	0.31^{b,x}
ST	0.07^{a,x}	0.46^{b,y}	0.47^{b}

^{a,b,c}Within a row, means lacking a common superscript letter differ ($P<0.05$).
^{x,y,z}Within a column, means lacking a common superscript letter differ ($P<0.05$).

THE EFFECTS OF QUALITY GRADE, POSTMORTEM AGING, AND BLADE TENDERIZATION ON WARNER-BRATZLER SHEAR FORCE AND COOKERY TRAITS OF BICEPS FEMORIS STEAKS

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Summary

We used 108 top sirloin butts to determine the influence of quality grades, postmortem aging periods, and blade tenderization passes on percentages of thawing and cooking losses and Warner-Bratzler shear (WBS) force of biceps femoris muscles. Top sirloin butts that qualified for either USDA Select (SEL, n=36), USDA Choice (CHO, n=36), or Certified Angus Beef™ Program (CAB, n=36), were aged for 14 or 21 days and blade tenderized zero (0X), one (1X), or two (2X) times. Steaks with higher quality grades (CHO and CAB) aged for 21 days had lower thawing losses than steaks aged 14 days and than SEL steaks aged for 21 days. Steaks aged for 14 days and not blade tenderized (0X) had higher thawing losses than steaks aged for longer periods (21 days) and tenderized 0X, 1X, and 2X. Lower quality grade steaks (SEL) blade-tenderized 2X had longer cooking times than other quality grade×blade tenderization treatments. More blade tenderization passes (1X and 2X) for higher quality grades (CHO and CAB) appear to lower WBS values. The most tender treatments were CHO steaks blade tenderized 2X and CAB steaks blade tenderized 1X and 2X. Biceps femoris tenderness was inconsistent among all treatments, although aging, blade tenderization, and higher quality grades reduce variation. For reliable, acceptable quality this muscle should not be included in top sirloin butt steaks.

(Key Words: Quality, Blade Tenderization, Postmortem Aging, *Biceps femoris*, Tenderness.)

Introduction

Consumers are willing to pay a premium for cuts of meat they know are tender. Of steaks offered in a restaurant setting, those from the top sirloin butt are among the more variable, less tender cuts. To help alleviate this problem and decrease variation in tenderness, the cap (*biceps femoris*, BF) muscles are removed from the top sirloin butts prior to fabrication into steaks. The BF is considered highly variable in tenderness and is a tougher muscle, which reduces the eating satisfaction of sirloin steaks, compared to the main muscle of the top sirloin butt, (*gluteus medius*, GM). Postmortem technologies such as aging and blade tenderization can improve tenderness uniformity and overall acceptability of the BF. This might allow the BF to remain on the top sirloin during fabrication into steaks. Our objective was to determine the influence of quality grades, postmortem aging, and blade tenderization passes on tenderness of BF muscle.

Experimental Procedures

One hundred eight top sirloin butts (IMPS 184A) that qualified for either the Certified Angus Beef™ Program (CAB; n=36), USDA Choice (CHO; n=36), or USDA Select (SEL; n=36) were tested. Top sirloin butts were sent to a commercial fabrication plant and aged for 14 or 21 days postmortem at 32°F. After aging, they were either not blade tenderized (0X) or passed through a blade tenderizer (Model T7001, Ross Industries Inc., Midland, VA) one (1X) or two (2X) times. The BF muscle was removed from each top sirloin butt, labeled for identification, then individually vacuum packaged (Model M860, Multivac Inc.,

Calhoun, Germany) and frozen for 40 min at -35°F in a spiral freezer. Once frozen, BF were transported to Kansas State University Meat Laboratory and stored at -29°C until analysis.

Each BF muscle was sawed into 1 inch thick steaks, weighed, and thawed at 37°F for 24 hours. Steaks were cooked to 160°F internally by a Blodgett dual-air-flow gas convection oven. Internal steak temperature was monitored by a 30-gauge, type-T thermocouple attached to a Doric 205 temperature recorder. Steaks were allowed to cool overnight in a refrigerator at 37°F. Six, ½ inch cores were taken parallel to the muscle fibers and sheared perpendicular to the core using an Instron Universal Testing Machine with a V-shaped blade on a Warner-Bratzler Shear force (WBS) attachment. Percent thawing losses [(Frozen wt.–Thawed wt.)/ Frozen wt.]×100 and percent cooking loss [(Thawed wt.-Cooked wt.)/ Thawed wt.]×10-0 were calculated. Results were analyzed in a 3×2×3 factorial design using the SAS General Linear Model procedure.

Results and Discussion

Steaks aged 14 and 21 days had similar (P>0.05) percentages of cooking loss, cooking times, and WBS values (Table 1). Neither quality grade nor number of blade tenderization passes influenced cooking loss (P>0.05). However, both aging period × quality grade and aging period × number of blade tenderization passes interactions (P<0.05) were observed for percentage of thawing losses (Table 2). Choice and CAB steaks aged 21 days had lower (P<0.05) thawing losses than SEL steaks aged 21 days and all steaks aged 14 days regardless of quality grades. Steaks aged 21 days and blade tenderized 0X and 2X had lower (P<0.05) thawing losses than steaks aged 14 days and blade tenderized 0X and 2X, respectively. Also, steaks aged 21 days and blade tenderized 1X had less (P<0.05) thawing loss than steaks aged 14 days and blade tenderized 0X. Higher quality grades (CHO and CAB) combined with prolonged aging (21 days) resulted in lower thawing losses. Longer aging periods (21 days) resulted in less thawing loss for steaks blade tenderized for 0X or 2X.

A quality grade × blade tenderization pass interaction (P<0.05) was observed for cooking time and WBS values. Select steaks blade tenderized 2X had the longest (P<0.05) cooking times, while CAB steaks tenderized 1X cooked in the shortest time (P<0.05). Blade tenderizing improved (P<0.05) WBS of CHO and CAB steaks but not SEL steaks (P>0.05). Choice steaks blade tenderized 2X were the most tender, while CAB steaks not blade tenderized were the toughest.

For foodservice, a WBS value of 8.6 lbs. or less has been used as a threshold for a rating of at least "slightly tender." All SEL steaks aged 21 days and blade tenderized 2X and CAB steaks aged 21 days and blade tenderized 1X or 2X had WBS values below 8.6 lbs (Table 3). All choice steaks aged 14 days and blade tenderized 2X had WBS values below 8.6 lbs. While not conclusive, retailers could maximize the probability of "slightly tender" steaks by utilizing higher quality steaks, aged for at least 21 days, and blade tenderized 2X. Purveyors can use postmortem aging and blade tenderization technologies to increase the acceptability of BF steaks. However, steaks from the BF were tougher than steaks originating from the GM (KSU Cattleman's Day, 2000) in all treatments. Because postmortem aging and blade tenderization technologies fail to increase the tenderness of the BF muscles to a level equal to the GM, removing the BF to reduce the variation in tenderness of top sirloin butt steaks is still recommended.

Table 1. Thawing Losses (TL), Cooking Losses (CL), Cooking Time (CT), and Warner-Bratzler Shear Force (WBS) Means of Biceps Femoris Steaks of Different Quality Grades, Aging Periods, and Blade Tenderization Passes

	USDA Quality Grade[a]			Aging Period		Blade Tenderization			
	SEL	CHO	CAB	14	21	0X	1X	2X	SE
TL, %[b]	*[d]	*	*	*	*	*	*	*	*
CL, %	30.4	29.1	28.6	29.9	29.8	30.2	28.2	29.7	0.67
CT,[c] Min/100 g	*[d]	*	*	14.7	14.6	*	*	*	0.57
WBS, kg[c]	*	*	*	3.51	3.47	*	*	*	0.08

[a]Quality Grades (SEL=Select, CHO=Choice, CAB=Certified Angus Beef™); Blade Tenderization (0X= Not blade tenderized, 1X=Blade tenderized one time, 2X=Blade tenderized two times).
[b]Quality Grade × Postmortem Aging Period and Blade Tenderization Pass × Postmortem Aging Period interactions.
[c]Quality Grade ×Blade Tenderization Pass interaction.
[d]Interaction means are presented on Table 2.

Table 2. Thawing Loss (TL), Cooking Time (CT), and Warner-Bratzler Shear Force (WBS) Means of Biceps Femoris Steaks as Affected by Interactions (P<0.05) of Quality Grade, Aging Period, and Blade Tenderization Passes[d]

	Quality Grade × Postmortem Aging Period						
	SEL		CHO		CAB		
	14 days	21 days	14 days	21 days	14 days	21 days	SE
TL, %	6.74[b]	6.70[b]	6.16[b]	4.87[a]	6.40[b]	4.69[a]	0.31

	Postmortem Aging × Blade Tenderization Passes						
	14 days			21 days			
	0X	1X	2X	0X	1X	2X	SE
TL, %	7.10[c]	5.95[abc]	6.24[bc]	5.28[a]	5.70[ab]	5.27[a]	0.31

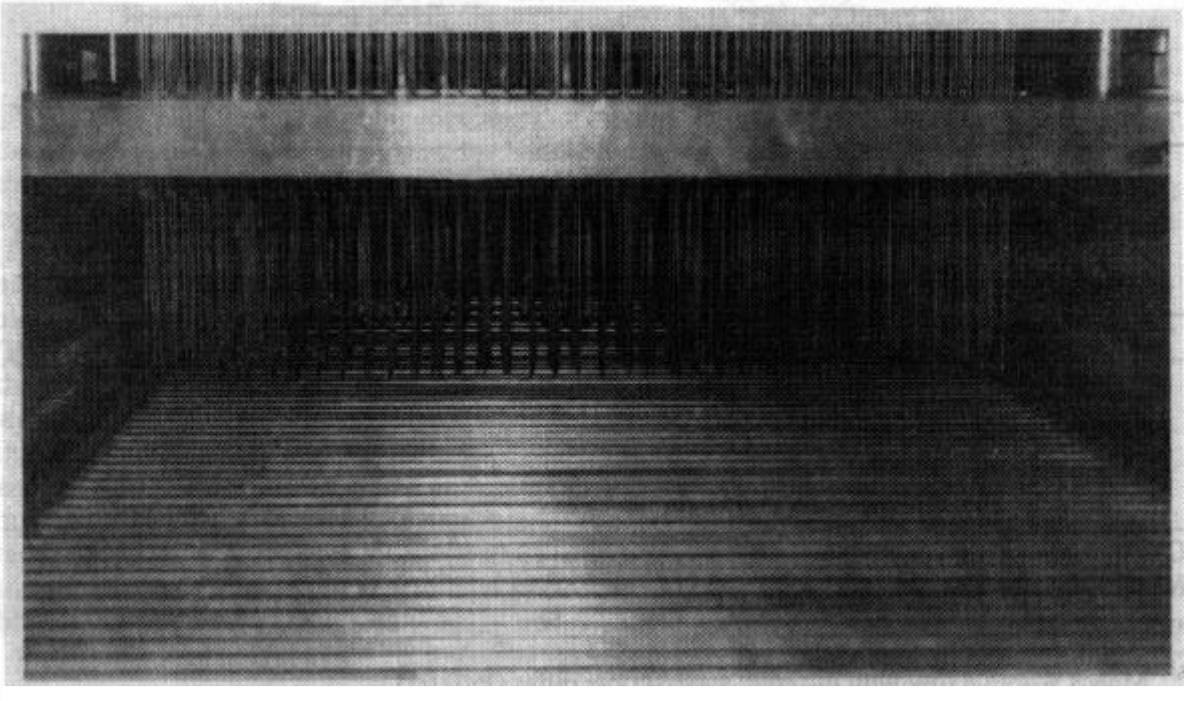
	Quality Grade × Blade Tenderization Passes									
	SEL			CHO			CAB			
	0X	1X	2X	0X	1X	2X	0X	1X	2X	SE
CT, Min/100 g	14.13[ab]	15.10[b]	18.94[c]	15.06[b]	14.99[b]	12.27[ab]	13.00[ab]	11.48[a]	12.27[ab]	1.19
WBS, kg	3.43[bc]	3.69[bc]	3.66[bc]	3.68[bc]	3.54[bc]	2.95[a]	3.84[c]	3.33[ab]	3.27[ab]	0.17

[a,b,c]Means within a row with different superscripts differ (P<0.05).
[d]Quality Grades (SEL=Select, CHO=Choice, CAB=Certified Angus Beef™); Blade Tenderization (0X=not blade tenderized, 1X=blade tenderized one time, 2X=blade tenderized two times).

Table 3. Percent of "Slightly Tender" Steaks with Warner-Bratzler Shear Force (WBS) Values Below 8.6 Lbs

		SEL[a]		CHO		CAB		
Blade	Passes[b]	14[c]	21	14	21	14	21	Total
0X		83[d]	83	50	50	67	33	22
1x		67	83	83	67	67	100	28
2x		67	100	100	83	83	100	32
Total		72	89	78	67	72	78	76

[a]SEL=Select, CHO=Choice, CAB=Certified Angus Beef Program*.
[b]OX=Not blade tenderized, lX=Blade tenderized once, 2X=Blade tenderized twice.
[c]Aging period
[d]n=6 for each cell, total of 108 steaks is represented in this table.



During blade tenderization, meat is carried under the blades and the blades move up and down, penetrating the meat. During a single pass, the blades make about 35 penetrations per square inch.

INFLUENCES OF AGING ON TENDERNESS AND COLOR OF BEEF STEAKS

R. R. Timm, J. A. Unruh, S. L. Stroda, K. A. Hachmeister, L. M. Sammel, and A. E. Rasor

Summary

Aging loin strip, bottom, and eye of round steaks for 21 days decreased Warner-Bratzler Shear (WBS) values (increased tenderness). For the top round, aged semimembranosus muscle steaks tended to have lower WBS values (more tender) than non-aged steaks, while aged adductor steaks were similar to non-aged steaks. Furthermore, instrumental L* color values were higher (lighter) for aged strip and eye of round steaks than non-aged steaks, and instrumental a* color values were higher (redder) for aged bottom round, eye of round, and top round (*semimembranosus*) steaks than non-aged steaks. Aging steaks is effective for improving tenderness and color of strip, bottom, top (*semimembranosus*) and eye of round steaks.

(Key Words: Aging, Beef, Color, Tenderness.)

Introduction

Tenderness is a very important component of consumer satisfaction. Many factors affect tenderness such as breed type, animal age and sex, type of muscle, and cooking method. Aging requires storing meat at refrigeration temperatures for varying lengths of time. During aging, protein breakdown contributes to tenderness. In a recent survey, 71% of North American Meat Processor members aged some product for an average of 20 days (7 to 60 days) to increase tenderness. Our objective was to examine the effects of aging on tenderness and instrumental color of loin strip, bottom round, eye of round, and top round steaks.

Experimental Procedures

We purchased USDA Select strip loins (*longissimus dorsi*; IMPS 180; n=30), top rounds (IMPS 169A; n=18), and goosenecks (IMPS 170; n=27) from a commercial packing facility. Top and gooseneck rounds were randomly selected; however, strip loins were pre-selected for toughness. Top rounds were fabricated into *semimembranosus* (SM) and adductor (AD) steaks, and goosenecks were fabricated into bottom round (*biceps femoris*) and eye of round steaks (*semitendinosus*). One 1-inch thick steak from each muscle type was not aged, and the other vacuum packaged and aged at 32 ± 2°F. Color was analyzed after at least one-hour "bloom" using a Hunterlab MiniScan XE Spectrophotometer with a minimum of two color measurements per steak. Color of top round (SM) steaks was analyzed on the exterior portion of the steak. Steaks were cooked in a Blodgett dual-air-flow convection gas oven set at 325°F. Steaks were monitored using a 30-gauge, type T thermocouple and removed when they reached 158°F. After cooked steaks were stored overnight at 37°F, a minimum of six 1/2-inch diameter cores were taken parallel to the fiber orientation from each steak. Tenderness was measured using an Instron Universal Testing Machine with a Warner-Bratzler Shear (WBS) attachment. Data were analyzed as a randomized complete block design (blocking by steak) using Mixed Procedure in SAS (2000).

Results and Discussion

We found that aging steaks for 21 days lowered ($P<0.01$) WBS values for loin strip, bottom, and eye of round steaks (Table 1).

WBS values for aged top round (SM) steaks tended to be lower (P<0.06) than non-aged steaks and aged top round (AD) steaks were similar (P=0.58) to non-aged steaks. The difference between aged and non-aged steaks was greatest for pre-selected tough strip loin steaks. A partial explanation for this difference in aging rate is that muscles from the round have a greater amount of connective tissue, which may partially mask the myofibrillar improvement in tenderness due to aging.

Aged loin strip and eye of round steaks had higher (lighter) instrumental L* color values (P<0.01) than non-aged steaks. Furthermore, aged bottom round, top round (SM), and eye of round steaks had higher (redder) instrumental a* color values (P<0.01) when compared to non-aged steaks. Also, instrumental b* color values were higher (more yellow; P<0.01) for bottom round, top round (SM), and eye of round and strip loin (P=0.02) steaks than non-aged steaks. No difference (P=0.37) in color was found for the top round (AD). Higher L* and a* values indicate a better "bloom." This improvement is partially due to an increase in protein degradation and a decrease in oxygen consuming enzymes. This allows oxygen to penetrate more deeply below the surface; thus the steak has a brighter cherry-red color.

Aging is effective for improving tenderness and color of strip, bottom round, and eye of round steaks. It improved "bloom" of loin strip, bottom round, eye of round, and top round (SM) steaks. However, aging had no effect on tenderness or color of the top round (AD) steaks.

Table 1. Effects of Aging on Warner-Bratzler Shear (WBS), L* (Lightness), a* (Redness), and b*(Yellowness) Values for Five Different USDA Select Muscles

Item	Non-Aged	21-day Aged	SEM	P-value
Loin Strip (*longissimus*; n = 30)				
WBS, lbs	13.65	10.03	0.55	<0.01
L*	42.8	46.5	0.44	<0.01
a*	23.7	24.2	0.26	0.17
b*	15.0	15.6	0.24	0.02
Bottom Round (*biceps femoris*; n = 27)				
WBS, lbs	11.16	9.57	0.31	<0.01
L*	44.2	45.2	0.49	0.10
a*	23.9	27.0	0.34	<0.01
b*	15.1	18.7	0.32	<0.01
Eye of Round (*semitendinosus*; n = 27)				
WBS, lbs	13.51	11.13	0.33	<0.01
L*	48.1	50.4	0.59	<0.01
a*	26.1	27.4	0.35	<0.01
b*	18.7	20.5	0.38	<0.01
Top Round (*semimembranosus*; n = 18)				
WBS, lbs	8.25	7.71	0.26	0.06
L*	44.3	44.7	0.67	0.56
a*	25.8	27.5	0.40	<0.01
b*	16.9	19.1	0.40	<0.01
Top Round (*adductor*; n = 18)				
WBS, lbs	8.71	8.97	0.33	0.58
L*	44.0	44.5	0.75	0.57
a*	25.4	25.9	0.40	0.37
b*	16.7	17.0	0.39	0.46

IMPROVING COLOR STABILITY OF BEEF TOP ROUND

L. M. Sammel, M. C. Hunt, and D. H. Kropf

Summary

The beef inside round muscle, especially the deep portion, has poor color stability, a troublesome condition for the meat industry. We examined influences of pre-rigor temperature and pH decline on chemistry of the inside (deep) *semimembranosus* (ISM) and outside (surface) *semimembranosus* (OSM) in relation to initial color and stability. Cold-boned ISM had a slower chill rate; faster pH decline; more denatured protein; less metmyoglobin reducing ability, oxygen consumption, and water holding capacity; and a lighter, less stable color than the OSM. Cold-boned steaks were two-toned in color and discolored by day 3 of display. Hot-boned ISM and OSM chilled at the same rate, had similar pH declines, similar chemical characteristics, and acceptable color traits up to day 5 of display. Techniques that chill the entire beef SM faster produced a more uniform stable color, extended the color life of the ISM, and minimized rework and discounting.

(Key Words: Beef, *Semimembranosus*, Color Stability, Metmyoglobin, Reducing Activity.)

Introduction

The beef *semimembranosus* (SM) is a large, thick muscle of the inside round that extends from the carcass surface to the femur bone. Following slaughter, the inner (deep) portion of the muscle chills slower than the outer (surface) portion, causing differences in temperature/pH conditions. These influence the oxidation and reduction of the muscle pigment and myoglobin, thus affecting color stability. In case-ready packaging systems, the ISM discolors faster than the OSM. Providing for more rapid chill of the deep portion (ISM) can slow pH decline and may influence muscle biochemistry in a way that provides more color stability. Industry recognizes the color difference within the SM muscle, but most color stability research on the muscle does not identify from what portion the samples were taken. We examined the effects of temperature and pH declines of the ISM and OSM on initial color, color uniformity and stability, and muscle pigment chemistry.

Experimental Procedures

Ten carcasses (A-maturity; quality grades high Select to low Choice; yield grades 2 to 3) were chosen randomly at a commercial slaughter plant. Five carcasses were electrically stimulated (continuous 48 volts for 30 seconds); the other five carcasses were not. One side of each carcass was assigned randomly to be hot boned at 30-90 min after stunning and the other half was left intact for chilling. The hot-boning technique involved cutting the SM loose from the outside round and tip muscles. The SM was left intact at the ventral surface of the hipbone such that it hung away from the rest of the carcass, allowing chilled airflow to reach the inner surface. All 10 carcasses were chilled at 0°C and spray chilled 5 min every hour for 24 hours.

Temperature declines were monitored for 24 hours in the ISM and OSM and pH measurements were taken at 1, 3, 5, 7, 9, 11, and 24 hours postmortem. At 24 hours postmortem, inside rounds (NAMP #168) were boned, trimmed, and vacuum packaged and stored until 9 days postmortem. The SM was cut into six steaks, each an inch thick. Each

steak was assigned randomly for analyses, which were conducted on both the inside (inner 1/3) and outside (outer 1/3) portions. One steak was displayed for 6 days, with instrumental and visual color measurements taken daily. The remaining five steaks were used for analysis of shear force, metmyoglobin (Metmb) reducing ability, enzyme cofactors (NAD and NADH), myoglobin concentration, heme iron, nonheme iron, protein denaturation, lipid oxidation, oxygen consumption, water holding capacity, pH, and fiber type (succinic dehydrogenase activity).

Data were analyzed as a completely randomized split-split plot design where the SM muscle was the whole plot and storage was the whole-plot treatment. Steaks were the split-plots, and muscle location was the split-split plot. Proc Mixed procedure of SAS was used to determine treatment differences, and means were separated ($P<0.05$) using least significant differences.

Results and Discussion

With traditional cold-boning methods, the ISM chilled slower ($P<0.05$) than the OSM. However, hot boning allowed the ISM to chill faster ($P<0.05$), resulting in temperature declines similar to cold-boned (CB) and hot-boned (HB) OSM (Fig. 1). Temperature decline affects postmortem glycolysis, and as a result, the pH decline of CB ISM was faster ($P<0.05$) than for other treatments (Fig. 2). The ultimate pH at 24 hours postmortem was not affected by boning method. Therefore, with cold-boning and hot-boning, we successfully produced postmortem conditions within the ISM and OSM that could result in chemical differences affecting color.

Color characteristics were similar between CB OSM and both HB portions, whereas CB ISM was distinctly different. On day 0 of display, CB ISM was visually a brighter ($P<0.05$) cherry-red than the other treatments; however, the more desirable appearance was lost quickly (Fig. 3). No visual differences between treatments were found on day 1 of display, but CB ISM was the most discolored on day 2 through 5. Both HB portions remained visually acceptable throughout 5 days of display. CB ISM had less ($P<0.05$) oxymyoglobin, greater ($P<0.05$) Metmb and lighter color (higher L* values) than CB OSM or both HB portions on day 2-5 of display. Panelists classified CB steaks as moderately two-toned and HB steaks as uniformly colored during 5-day display. Faster temperature and slower pH declines of the ISM with hot boning within 30 to 90 min. following slaughter produced a more uniform, stable color.

Of the chemical characteristics measured, Metmb reducing ability, oxygen consumption, protein denaturation, and water holding capacity influenced the color stability of the ISM and OSM. Cold-boned ISM had less ($P<.05$) Metmb reducing ability than CB OSM and both HB portions. Metmb reducing ability of HB portions was higher ($P<0.05$) on day 0 of display than for CB portions, with no differences on day 2 or 4. Oxygen consumption was greater in CB OSM than CB ISM, with no differences between HB portions. Proteins were more denatured in CB ISM than in CB OSM and both HB portions, which were not different. Low pH at high temperatures following slaughter apparently denatured proteins in CB ISM, whereas the faster chill of HB ISM reduced protein denaturation. Denatured proteins bind water poorly; therefore, CB ISM had greater ($P<0.05$) expressible fluids than did CB OSM. Electrical stimulation had a minimal affect on chemical characteristics of the ISM and OSM.

No differences in myoglobin, heme iron, and nonheme iron and only small differences in pH, NAD, NADH, fiber type, and lipid oxidation were found between the ISM and OSM. Therefore, these characteristics were not related to color or color stability. Warner-Bratzler shear force values were not affected ($P>0.05$) by electrical stimulation or boning method, meaning we were able to improve color stability of the ISM by hot boning, without altering tenderness.

Techniques that chill the entire beef SM faster, with or without electrical stimulation, should be used to produce uniform, stable color by conserving reducing ability and

lessening protein denaturation. Extending the color life of the SM can increase profitability to the meat industry by lowering retail rework and discounting.

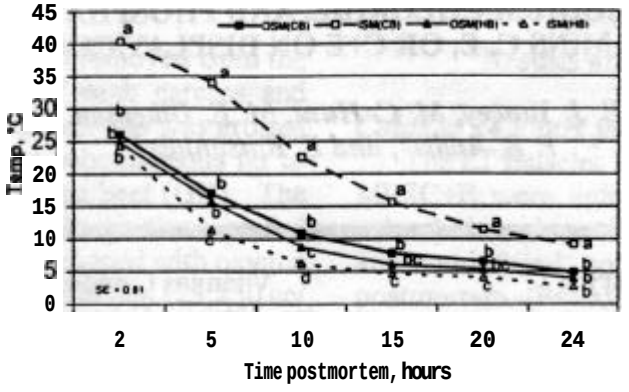


Figure 1. Means for Temperature Declines Postmortem of Outer and Inner Portions of the Inside Round Muscle (Semimembranosus = SM) That Were Intact or Hot Boned Before Chilling. Means at the times postmortem with a different letter are different (P<0.05).

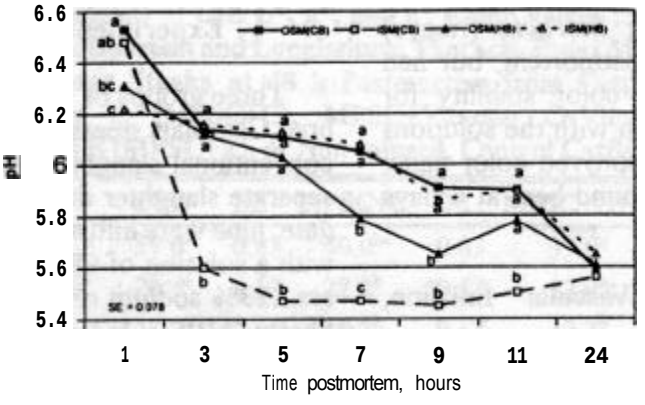


Figure 2. Means for pH Declines Postmortem of Outer and Inner Portions of the Inside Round Muscle (Semimembranosus = SM) That Were Intact or Hot Boned Before Chilling. Means at the times postmortem with a different letter are different (P<0.05).

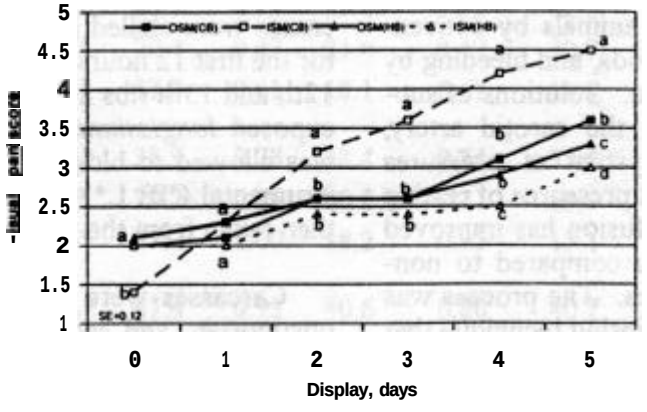


Figure 3. Means for Visual Color Scores of Inside Round Steaks (Semimembranosus = SM) During Retail Display (Lower Visual Scores Are Redder and Less Discolored; Scores at 3.5 or Higher Are Unacceptable Color). Half of the steaks were from carcasses with the SM muscle intact or hotboned during chilling. Means on a display day with a different letter are different (P<0.05).

EFFECTS OF VASCULAR INFUSION WITH A SOLUTION OF SUGARS, SODIUM CHLORIDE, AND PHOSPHATES PLUS VITAMINS C, E, OR C+E ON DISPLAY COLOR

E. J. Yancey, M. C. Hunt, M. E. Dikeman, P. B. Addis[1], and E. Katsanidis[1]

Summary

Three groups of 12 (n=36) grain-finished, crossbred Charolais steers were humanely slaughtered, and nine in each group were infused via the carotid artery with an aqueous solution of sugars, sodium chloride, and phosphates plus either vitamin C, E, or C plus E. Three in each group served as non-infused controls. Vascular infusion improved redness of *longissimus thoracis* (ribeye) muscles at 24 hours postmortem, but had little effect on display color stability for steaks. Vascular infusion with the solutions containing vitamin E improved color panel visual evaluations of ground beef at 4 days simulated retail display.

(Key Words: Beef, Vascular Infusion, Color.)

Introduction

Vascular infusion near the end of bleeding is a relatively new process developed by MPSC, Inc. of Eden Prairie, MN. The process involves stunning animals by conventional captive bolt methods, and bleeding by severing the jugular vein. Solutions of substrates are infused via the carotid artery, utilizing a pumping system at pressures slightly below the blood pressures of resting live cattle. Vascular infusion has improved dressing percentages as compared to non-infused control carcasses. The process was developed as a carcass rinsing technique that alters the postmortem pH decline of beef muscles and could improve beef color stability.

Vitamins C and E have antioxidant activity. Vitamin C has improved color stability of ground beef when added during processing, and vitamin E improves steak and ground beef display color stability when fed to cattle at supranutritonal levels. Our study was designed to evaluate the effects of postmortem infusion of vitamins C and E on beef display color stability.

Experimental Procedures

Three groups of 12 grain-finished, crossbred Charolais steers were slaughtered using conventional slaughter procedures on three separate slaughter dates. At each slaughter date, nine were infused at 10% of live weight with a solution of 98.52% water, .97% sugars, .23% sodium chloride, and .28% phosphates (MPSC, Inc. Eden Prairie, MN) plus either 500 ppm vitamin C (n=3; MPSC+C), 500 ppm vitamin E (n=3; MPSC+E), or 500 ppm vitamin C plus 500 ppm vitamin E (n=3; MPSC+C+E). The remaining three at each slaughter date were bled conventionally and served as non-infused controls. Carcasses were chilled at 35°F, with spray chill for the first 12 hours, and ribbed between the 12th and 13th ribs after 24 hours chill. The exposed *longissimus thoracis* (LT) muscle was allowed to bloom for 20 minutes. Instrumental CIE L*, a*, and b* values were then taken from the exposed LT.

Carcasses were fabricated at 48 hours postmortem and sections of the LT, *psoas major* (PM), *semimembranosus* (SM), and *quadriceps* muscles were removed. Steaks 1 inch thick were cut from LT, PM, and SM,

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and then L*, a*, and b* color values were obtained from the steaks after air exposure for 20 min.

Subcutaneous fat was removed from the rib and loin sections of each carcass and frozen. The *quadriceps* muscle was ground and combined with the subcutaneous fat to produce a 20% fat ground beef (GB). The GB was mounded into 1 lb. portions, placed on foam trays, and overwrapped with oxygen permeable polyvinylchloride film (23,250 cc/ m^2/24 h). GB displayed for 4 days at 35°F under 150 foot candles of deluxe-warm-white fluorescent light with twice daily defrost. GB was evaluated for CIE L*, a*, and b* color values and visual color by a trained panel. The color panel utilized a five-point color scale (1 = very bright cherry red, 5 = dark red to tan or brown).

Results and Discussion

Color at 24 hours postmortem

The LT muscles from cattle infused with MPSC+E were lighter colored (higher L* values) than those from both MPSC+C+E and non-infused, control cattle at 24 hours postmortem ($P<0.05$; Table 1). The LT muscles from all infused cattle were more red (higher a* values) and more yellow (higher b* values) than those from non-infused, control cattle ($P<0.05$).

Table 1. Least Squares Means of CIE L*, a*, and b* Color Values for Longissimus Thoracis Muscles 24 h Postmortem and Longissimus Thoracis, Psoas Major, Outside and Inside Semimembranosus Steaks at 48 h Postmortem from Cattle Infused[a] with Either MPSC+Vitamin C (MPSC+C), MPSC+Vitamin C+Vitamin E (MPSC+C+E), MPSC+Vitamin E (MPSC+E), or Non-infused, Control Cattle (CON)

Muscle		CON	SE	MPSC+C	SE	MPSC+C+E	SE	MPSC+E	SE
Longissimus	24 h L*	39.0[c]	0.83	40.0[bc]	0.83	39.9[c]	0.83	42.4[b]	0.83
thoracis	24 h a*	20.5[c]	0.53	22.2[b]	0.53	22.0[b]	0.53	23.2[b]	0.53
	24 h b*	17.2[c]	0.65	19.7[b]	0.65	19.3[b]	0.65	21.1[b]	0.65
	48 h L*	41.4[c]	0.79	41.4[c]	0.84	42.5[bc]	0.79	44.4[b]	0.79
	48 h a*	18.8	0.50	19.7	0.57	19.3	0.54	19.3	0.54
	48 h b*	16.6	0.65	17.3	0.69	17.0	0.65	18.0	0.65
Psoas	48 h L*	40.7[c]	0.72	39.6[c]	0.72	42.8[b]	0.72	43.4[b]	0.72
major	48 h a*	20.4	0.47	21.0	0.47	20.7	0.47	20.2	0.47
	48 h b*	17.9	0.61	18.1	0.61	18.5	0.61	18.4	0.61
Outside	48 h L*	38.9	0.78	38.4	0.74	39.6	0.74	40.8	0.70
Semimembranosus	48 h a*	20.2	0.75	20.8	0.71	19.9	0.71	21.4	0.71
	48 h b*	17.2	1.00	18.2	0.95	17.1	0.95	19.3	0.90
Inside	48 h L*	41.4	0.91	40.6	0.86	40.7	0.86	42.0	0.81
Semimembranosus	48 h a*	22.7	0.56	23.0	0.53	23.2	0.53	23.5	0.50
	48 h b*	21.3	0.71	20.7	0.67	21.4	0.67	22.1	0.64

[a]98.52% water, 0.97% saccharides, 0.23% sodium chloride, and 0.28% phosphates infused at 10% of live weight.

[b,c]Means within a row having different superscript letters differ ($P<0.05$).

Color at 48 Hours Postmortem

At 48 hours postmortem, LT steaks from cattle infused with MPSC+E were lighter colored (higher L* values) than those from both MPSC+C-infused and non-infused, control cattle (P<.05; Table 1). The PM steaks from both MPSC+E and MPSC+C+E-infused cattle were lighter colored (P<0.05) than from MPSC+C-infused and non-infused, control cattle. No differences existed among treatments for a* or b* values (P>0.05). No treatment differences existed for SM L*, a*, or b* values.

Display Color Evaluation

No time × treatment interaction (P>0.05) existed for GB L*, a*, or b* values. However, a time x treatment interaction existed for the GB visual color panel scores (Table 2). On display days 1 through 4, the GB from MPSC+E-infused cattle was more cherry red (P<0.05) than that from MPSC+C-infused cattle. The panel also found the GB from MPSC+E and MPSC+C+E-infused cattle to be more red (P<0.05) than that from non-infused, control cattle on display day 4. Postmortem application of vitamin E via vascular infusion can improve GB display color stability.

Table 2. Time × Treatment Interaction Least Squares Means for Display Color Scores[1] for Ground Beef Obtained from Cattle Infused[a] with Either MPSC+Vitamin C, MPSC+Vitamin C+Vitamin E, MPSC + Vitamin E, or Non-infused, Control Cattle

Display Day	CON	SE	MPSC+C	SE	MPSC+C+E	SE	MPSC+E	SE
0	1.2	0.17	1.2	0.17	1.2	0.17	1.2	0.15
1	2.7^{bc}	0.15	2.8^{b}	0.13	2.5^{bc}	0.15	2.4^{c}	0.13
2	3.9^{b}	0.17	3.9^{b}	0.15	3.5^{bc}	0.17	3.1^{c}	0.15
3	4.5^{b}	0.17	4.3^{bc}	0.16	3.9^{cd}	0.17	3.5^{d}	0.15
4	5.0^{b}	0.17	4.7^{bc}	0.15	4.4^{cd}	0.17	4.1^{d}	0.15

[a]98.52% water, 0.97% saccharides, 0.23% sodium chloride, and 0.28% phosphates infused at 10% of live weight.

[b,c]Means within a row having different superscript letters differ (P<0.05).

[1]Display Color Score: 1 = Very bright cherry red or pale red, 2 = Bright cherry red or pale red, 3 = Slightly dark red to tan or brown, 4 = Moderately dark red to tan, 5 = Dark red to tan or brown.

3.5 = Margin of acceptability.

RELATIONSHIPS AMONG BEEF CARCASS QUALITY AND CUTABILITY INDICATORS[1]

T. E. Lawrence, D. A. King,
T. H. Montgomery[2], and M. E. Dikeman

Summary

We evaluated beef carcass data (12th rib fat thickness, hot carcass weight, ribeye area, percentage of kidney-pelvic-heart fat, USDA yield grade, and USDA quality grade) from 60,625 A-maturity steer and heifer carcasses. Data were analyzed to evaluate changes in quality grade with increasing fat thickness, changes in cutability indicators across quality grades, and the association of hot carcass weight with ribeye area. Percentage of USDA Standard and Select carcasses decreased, while Low Choice and Premium Choice increased as fat thickness increased. Percentage of Low Choice remained steady for fat thickness of 0.56 - 0.60 in. and higher. Percentage of yield grade 4.0 or greater carcasses increased dramatically as fat thickness increased beyond 0.60 in. Fat thickness, hot carcass weight, percentage of kidney-pelvic-heart fat, and USDA yield grade increased, while ribeye area decreased as quality grades improved. The association between hot carcass weight and ribeye area differs from USDA requirements. Our recently collected data indicate that as hot carcass weight increases, ribeye area increases at a slower rate than indicated by USDA guidelines. Feeding cattle to a backfat thickness of 0.51-0.55 in. will maximize quality grade while minimizing discounts for yield grade 4.0 or higher.

(Key Words: Carcass, Cutability Indicators, Quality Grade, Yield Grade.)

Introduction

USDA Quality and Yield grades are inversely related. To maximize carcass value, producers must adopt management practices that allow fed steers and heifers to be marketed promptly when they have reached their quality grade potential, while minimizing waste fat. The USDA yield grade formula was developed and adopted in the 1960's when the majority of cattle were small-framed, British-breed type. Changes in cattle type during the last 40 years indicate that the USDA yield grade formula may need re-evaluation to reflect the current beef cattle population. Our objectives were to evaluate relationships among quality grade and yield grade traits; and to make recommendations for optimizing quality grade and yield grade.

Experimental Procedures

Carcass data (n=60,625) were collected from multiple plants throughout the nation during 1995-1997 by the NCBA Cattlemen's Carcass Data Service (CCDS). Carcasses were sorted into five quality grades: Standard, Select, Low Choice, Premium Choice, and Prime, and analysis of variance was used to determine differences in cutability indicators by quality grade. Percentage of each quality grade was calculated by 0.05 in. fat thickness increments to illustrate changes in quality grade with increased fat thickness. The data were also sorted by USDA hot carcass weight groupings that correspond to ribeye area requirements for calculating yield

[1]Appreciation is expressed to the NCBA Cattlemen's Carcass Data Service, West Texas A&M University for providing the data.
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grade. The USDA yield grade formula assumes a relationship between hot carcass weight (HCW) and ribeye area (REA) as follows: REA = 0.012 * HCW + 3.8. Adjustments to the yield grade of a carcass are applied when the actual ribeye area is above or below this assumption. Ribeye area means and standard deviations were calculated at each USDA carcass weight increment from 484 to 1034 lbs. to illustrate the relationship between USDA ribeye area requirements and actual data from current cattle types.

Results and Discussion

Cutability trait averages changed linearly ($P<0.05$) as USDA quality grade increased (Table 1). Fat thickness, hot carcass weight, percentage of kidney-pelvic-heart fat, and USDA yield grade all increased as quality grade increased, but ribeye area decreased. Lower cutability carcasses, with smaller ribeyes, had higher quality grades than more heavily muscled, high cutability carcasses.

Percentage of Standard and Select decreased steadily as fat thickness increased, while percentage of Premium Choice steadily increased (Figure 1). Percentage of Low Choice increased up to a fat thickness of 0.56-0.60 in., then leveled off. Percentage of Prime slowly increased to a high of 3.4% at a fat thickness of 0.96-1.0 in. If cattle feeders target for an endpoint fat thickness of 0.40 in., our data indicate that they could expect 2.5% Standard, 51.1% Select, 38.9% Low Choice, 7.2% Premium Choice, and 0.3% Prime while incurring only 0.1% yield grade 4.0 or higher. If cattle feeders target for at least 50% Choice cattle, our data indicate they should feed to a fat thickness of 0.41-0.45 in. Feeding cattle to a fat thickness of 0.51-0.55 in. maximized quality grade while minimizing heavily discounted yield grade 4.0 or higher carcasses. Percentage of yield grade 4.0 or higher carcasses increased dramatically as fat thickness increased beyond 0.56-0.60 in.

Ribeye area increased at a slower rate (slope of 0.0082 vs. 0.012 $in.^2$/lb) in relation to hot carcass weight than USDA standards suggest (Figure 2). From 784 to 808 lbs. USDA standards and our data agree. However, carcasses weighing less than 784 lbs. tend to have larger ribeyes than USDA guidelines require, which mathematically lowers their yield grades below what our data suggest. Likewise, carcasses weighing more than 808 lbs. tend to have smaller ribeyes than required by USDA guidelines, which mathematically raises their yield grades above what our data suggest. USDA ribeye area ($in.^2$) requirements versus our mean ribeye area ($in.^2$) of selected hot carcass weights are shown in Table 2. These data suggest that the USDA yield grading standards should be revised to reflect ribeye area × hot carcass weight relationships of current cattle types.

Table 1. Least Squares Means for Cutability Indicators of USDA Quality Grades

Variable	Standard	Select	Low Choice	Premium Choice	Prime
n	1792	25,868	25,120	7377	468
Fat thickness (in.)	0.27[a]	0.42[b]	0.50[c]	0.57[d]	0.60[e]
Hot carcass weight (lbs.)	719.0[a]	755.5[b]	763.5[c]	771.4[d]	772.3[d]
Ribeye area ($in.^2$)	13.45[e]	13.21[d]	12.81[c]	12.67[b]	12.44[a]
Kidney-pelvic-heart fat %	1.92[a]	2.10[b]	2.13[c]	2.21[d]	2.30[e]
USDA yield grade	2.00[a]	2.60[b]	2.98[c]	3.25[d]	3.41[e]

[a,b,c,d,e]Within a row, means lacking a common superscript letter differ ($P<0.05$).

Table 2. Comparison of the USDA Ribeye Area Requirement (in^2) and Our Mean Ribeye Area (in^2)

	Hot Carcass Weight							
	400	500	600	700	800	900	1000	1100
USDA ribeye area	8.6	9.8	11.0	12.2	13.4	14.6	15.8	17.0
Our mean ribeye area	10.1	10.9	11.7	12.5	13.4	14.2	15.0	15.8

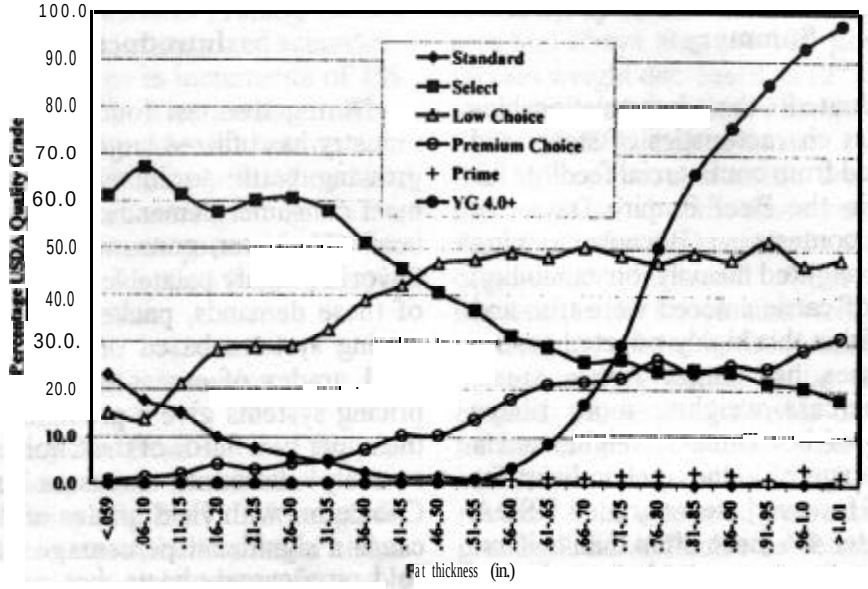

Figure 1. Relationship between USDA Quality Grade and Increasing 12th Rib Fat Thickness.

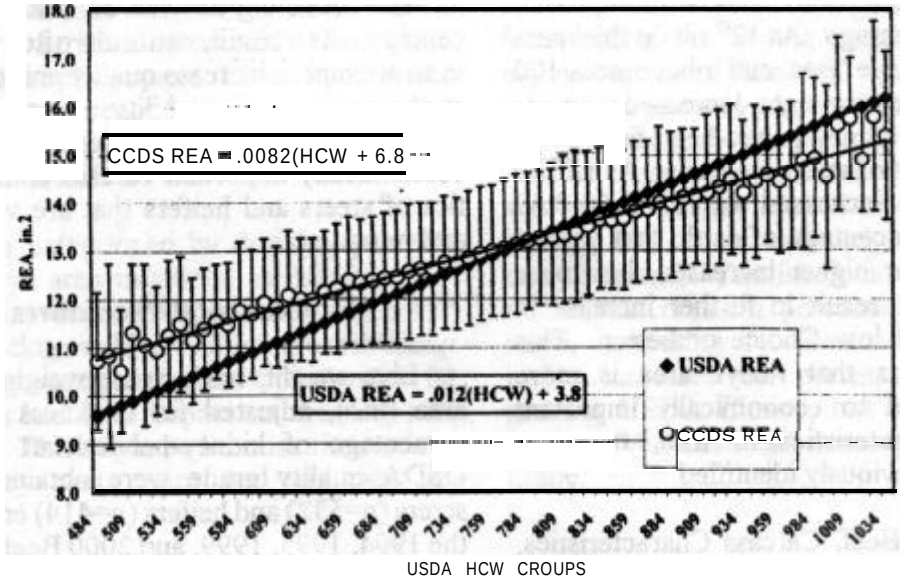

Figure 2. Comparison of USDA Ribeye Area x Hot Carcass Weight Requirements to Actual Data.

INTERRELATIONSHIPS AMONG CARCASS CHARACTERISTICS OF FEEDLOT STEERS AND HEIFERS SELECTED FOR COMPETITION

D. A. King, T. E. Lawrence, M. E. Dikeman, and D. E. Schafer

Summary

We evaluated the interrelationships among carcass characteristics of steers and heifers selected from commercial feedlots for competition in the Beef Empire Days live and carcass contests. Because judging criteria are weighted heavily on cutability, the majority of cattle entered were trim and muscular. Within this highly selected group, heifer carcasses had larger ribeye areas, lower hot carcass weights, more ribeye area/100 lbs. of hot carcass weight, and a higher percentage of kidney-pelvic-heart fat than steers. However, steers graded USDA Choice or better 4% more often than heifers. Ribeye area, ribeye area/100 lbs. of hot carcass weight, and percentage of kidney-pelvic-heart fat increased as dressing percentage increased; however, 12th rib fat thickness had no effect on dressing percentage. Percentage of carcasses grading USDA Choice or better tended to decrease with improved dressing percentage. As 12th rib fat thickness increased, ribeye area and ribeye area/100 lbs. of hot carcass weight decreased whereas percentage of kidney-pelvic-heart fat and hot carcass weight of steers increased. As 12th rib fat thickness increased up to 0.50-0.59 inches, the percentage of cattle that graded low Choice or higher increased, but more finish did not result in further increase in percentage of low Choice or better. This study indicates that ribeye area is more closely related to economically important carcass characteristics in trim, muscular cattle than previously identified.

(Key Words: Beef, Carcass Characteristics, Ribeye Area, Fat Thickness, Quality Grade.)

Introduction

During the past four decades, the beef industry has utilized large-framed, trim, fast growing cattle to increase efficiency and meet consumer demands for lean, lower fat beef. However, consumers still demand a flavorful, highly palatable product. Because of these demands, packers have developed pricing systems based on both quality and yield grades of carcasses. Most of these pricing systems give a premium to cattle in the upper two thirds of the Choice grade, and severely discount carcasses below low Choice or with yield grades of 4 or 5. Because a significant percentage of cattle are sold on a carcass basis, hot carcass weight and dressing percentage are also important to producers. Visual appraisal of live animal finish is often the primary means of determining when to market cattle. A common belief is that increasing fat thickness will increase marbling as well as dressing percentage. As a result, cattle are often overfed in an attempt to increase quality grades, often at the expense of cutability. Our objective was to evaluate the relationships among economically important carcass characteristics of steers and heifers that are very trim and muscular.

Experimental Procedures

Live weight, hot carcass weight, ribeye area ($in.^2$), adjusted fat thickness (inches) percentage of kidney-pelvic-heart fat and USDA quality grade were obtained from steers (n=532) and heifers (n=414) entered in the 1994, 1995, 1999, and 2000 Beef Empire Days live and carcass contests, because live weights were available only from these years. Beef Empire Days is a live animal and car-

cass contest for feedlot cattle held annually in Garden City, KS. Fat thickness, ribeye area, ribeye area/100 lbs. of hot carcass weight, hot carcass weight, percentage of kidney-pelvic-heart fat, and percentage of carcasses grading USDA Choice or better were categorized according to gender (steer or heifer). Likewise, fat thickness, ribeye area, ribeye area/100 lbs. of hot carcass weight, percentage of kidney-pelvic-heart fat, and percentage of carcasses grading USDA Choice or better were categorized according to dressing percentage in increments of 1% (range $\leq$60 to $\geq$69 %). Furthermore, ribeye area, ribeye area/100 lbs. of hot carcass weight, percentage of kidney-pelvic-heart fat, and percentage of carcasses grading USDA Choice or better were categorized by 12th rib fat thickness (range $\leq$0.20 to $\geq$0.80 inches) in 0.1 inches fat increments.

Results and Discussion

Because they had been selected for carcass competition, cattle in this study were muscular and trim (Table 1). Although fat thicknesses were equal, heifers had a higher percentage of kidney-pelvic-heart fat and a higher dressing percentage (64.8 vs. 64.3) than steers. This is consistent with conventional thinking that heifers generally are fatter than steers. However, heifers also had larger ribeye areas and ribeye areas per 100 lb. of hot carcass weight than steers, which contradicts a traditional belief that heifers are less muscular than steers. Steers had heavier live and hot carcass weights, and a higher percentage of carcasses grading USDA Choice or better.

When categorized by dressing percentage, ribeye area increased as dressing percentage increased (Table 2). Adjusted 12th rib fat thickness did not differ across dressing percentage categories. This indicates that fat thickness had little impact on dressing percentage. This might be because the cattle in this study were trim and did not represent a large range in fat thickness. In high cutability cattle, muscling has a greater impact on dressing percentage than does fat thickness. The percentage of cattle grading USDA Choice or better tended to decline as dressing percentage increased.

When categorized by 12th rib fat thickness, percentage of kidney-pelvic-heart fat increased as 12th rib fat thickness increased (Table 3), up to 0.40 to 0.49 inches. Ribeye area and ribeye area per 100 pounds of hot carcass weight decreased as 12th rib fat thickness increased, but little change occurred at 0.60 to 0.69 inches or fatter. This indicates that lighter muscled cattle are fatter than heavier muscled at the same carcass weight. As 12th rib fat thickness increased, hot carcass weight increased slightly in steers; however, heifer hot carcass weights were not consistently related to fat thickness, remaining relatively constant as fat thickness increased. Steers had heavier carcasses than heifers for all fat thickness categories. Increased fat thickness up to 0.50-0.59 inches resulted in an increased percentage of cattle grading USDA Choice or better (Figure 1). However, increasing 12th rib fat thickness beyond 0.59 inches resulted in no further increase in the percentage of cattle grading USDA Choice or better. These results suggest that feeding high cutability cattle to a 12th rib fat depth of 0.50-0.59 inches will allow cattle to express their genetic potential for marbling, but feeding cattle like these to higher degrees of finish will not increase the percentage of cattle grading Choice or better.

For these trim, muscular cattle, ribeye area is more highly related to dressing percentage and hot carcass weight than previously believed. Twelfth rib fat thickness did not impact dressing percentage. Furthermore, increasing fat thickness up to 0.5 inches increased the percentage of cattle grading USDA Choice, but feeding cattle beyond 0.5 inches did not improve quality grade.

Table 1. Least Squares Means of Carcass Characteristics of Cattle Selected for Competition Categorized by Gender

Gender	n	Fat thickness (inches)	Ribeye area ($in.^2$)	Ribeye area/100 lbs. hot carcass weight	Hot carcass weight	Kidney-pelvic-heart fat (%)	Percentage USDA Choice or better
Steer	532	0.43	14.42^{a}	1.85^{a}	782.3^{b}	1.62^{a}	48.68
Heifer	414	0.43	14.80^{b}	2.06^{b}	720.2^{a}	1.76^{b}	44.69

^{a,b}Within a column, means with a common superscript letter do not differ ($P<0.05$).

Table 2. Least Squares Means of Carcass Characteristics of Cattle Selected for Competition Categorized by Dressing Percentage

Dressing percentage	n	Fat thickness (inches)	Ribeye area ($in.^2$)	Ribeye area/100 lbs. hot carcass weight	Kidney-pelvic-heart fat (%)	Percentage USDA Choice or better
≤60	16	0.31	12.85^{a}	1.97^{abc}	1.67^{bc}	44.00
61	41	0.38	13.90^{bc}	1.99^{abc}	1.67^{bc}	48.00
62	84	0.38	13.97^{bc}	1.97^{ab}	1.56^{a}	54.76
63	140	0.40	13.83^{bc}	1.92^{a}	1.67^{bc}	44.94
64	182	0.41	14.43^{c}	1.94^{a}	1.66^{b}	50.27
65	204	0.42	14.71^{c}	1.96^{ab}	1.72^{bc}	40.53
66	134	0.43	15.14^{d}	1.96^{ab}	1.74^{c}	45.45
67	80	0.42	15.58^{e}	2.03^{c}	1.68^{bc}	37.25
68	42	0.42	15.81^{e}	2.02^{bc}	1.87^{d}	53.85
≥69	23	0.49	15.90^{e}	2.01^{abc}	1.91^{d}	35.29

^{a,b,c,d,e}Within a column, means with a common superscript letter do not differ ($P<0.05$).

Table 3. Least Squares Means of Carcass Characteristics of Cattle Selected for Competition Categorized by Fat Thickness (inches)

Fat thickness	n	Ribeye area ($in.^2$)	Ribeye area/100 lbs. hot carcass weight	Kidney-pelvic-heart fat (%)	Hot carcass weight (steers)	Hot carcass weight (heifers)
≤.19	48	16.87^{e}	2.26^{f}	1.42^{a}	765^{a}	730^{b}
.20-.29	152	15.37^{d}	2.09^{e}	1.60^{b}	765^{a}	712^{a}
.30-.39	219	14.79^{c}	2.00^{d}	1.69^{c}	773^{a}	708^{a}
.40-.49	218	14.43^{b}	1.92^{c}	1.75^{cd}	778^{a}	730^{b}
.50-.59	155	14.08^{a}	1.87^{b}	1.74^{cd}	794^{b}	714^{ab}
.60-.69	82	13.82^{a}	1.82^{a}	1.82^{d}	801^{b}	724^{ab}
≥.70	72	13.81^{a}	1.80^{a}	1.83^{d}	811^{b}	726^{ab}

^{a,b,c,d,e,f}Within a column, means with a common superscript letter do not differ ($P<0.05$).

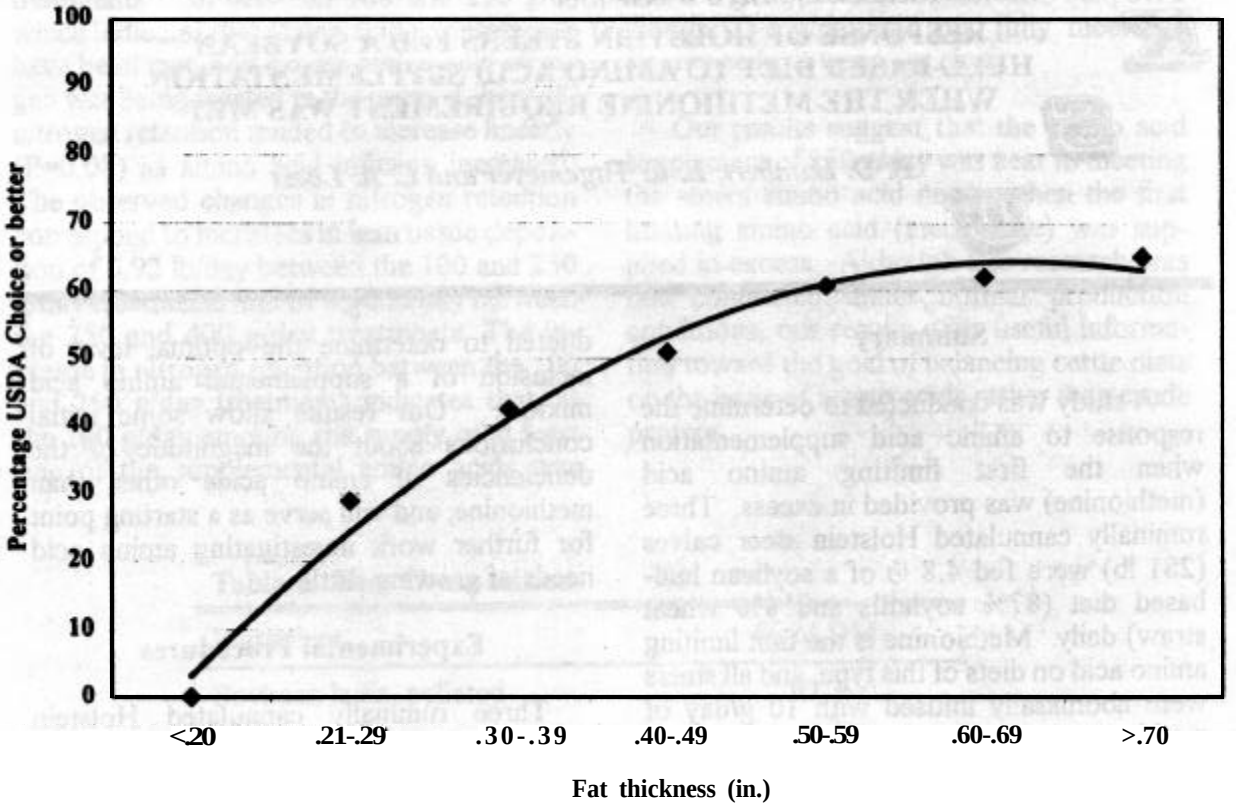

Figure 1. Relationship Between Fat Thickness and Percentage of Carcasses Grading USDA Choice or Better.

RESPONSE OF HOLSTEIN STEERS FED A SOYBEAN HULL-BASED DIET TO AMINO ACID SUPPLEMENTATION WHEN THE METHIONINE REQUIREMENT WAS MET

B. D. Lambert, E. C. Titgemeyer and C. A. Löest

Summary

A study was conducted to determine the response to amino acid supplementation when the first limiting amino acid (methionine) was provided in excess. Three ruminally cannulated Holstein steer calves (281 lb) were fed 4.8 lb of a soybean hull-based diet (87% soyhulls and 8% wheat straw) daily. Methionine is the first limiting amino acid on diets of this type, and all steers were abomasally infused with 10 g/day of methionine to ensure that this requirement was met. Treatments consisted of increasing amounts (100, 250, or 400 g/day) of an amino acid mixture supplied abomasally. Calves received decreasing amounts of supplemental energy in the form of volatile fatty acids and dextrose as amino acid infusion increased in order for treatments to remain isoenergetic. Nitrogen balance increased as amino acid supply increased, indicating that amino acids other than methionine limited protein deposition. The nitrogen balance change between the 100 and 250 g/day amino acid treatments was greater than that from 250 to 400 g/d, suggesting that 250 g/day supplied amounts of amino acids near the requirement.

(Key Words: Amino Acids, Requirements, Steers.)

Introduction

Methionine is often the first limiting amino acid for growing cattle. We have previously evaluated the methionine requirement of growing steers. However, little research has been conducted to quantify the requirement of growing cattle for other amino acids. The current study was conducted to determine the optimal level of inclusion of a supplemental amino acid mixture. Our results allow some initial conclusions about the magnitude of the deficiencies of amino acids other than methionine, and will serve as a starting point for further work investigating amino acid needs of growing cattle.

Experimental Procedures

Three ruminally cannulated Holstein steer calves (281 lb initial weight) were used in a 3 × 3 Latin square design. Steers were maintained in individual metabolism crates to allow for collection of feces and urine. We used nitrogen retention as an indicator of lean protein deposition. Treatments consisted of abomasal infusion of three graded amounts (100, 250, or 400 g/day) of an amino acid mixture (Table 2). Steers were fed 4.84 lb/day (dry matter basis) of a soybean hull-based diet (Table 1) twice daily. All steers received 10 g/day L-methionine in their infusate, which meets their requirement for this first growth-limiting amino acid. Across treatments, the ratio of amino acids remained constant (except for methionine). As supplemental energy, steers received acetate, propionate, and butyrate intraruminally. Steers also received supplemental energy abomasally in the form of glucose (Table 2). Glucose and volatile fatty acids decreased as the amount of amino acids increased to maintain constant energy supply across treatments.

Results and Discussion

Urinary nitrogen increased linearly (P=0.05) as infused amino acids increased. The magnitude of change in urinary nitrogen

was greater between the 250 and 400 g/day treatments than between 100 and 250 g/d, which indicates that amino acid requirements have been met, and excess amino acid nitrogen was being wasted in the urine. Likewise, nitrogen retention tended to increase linearly (P=0.08) as amino acid infusion increased. The observed changes in nitrogen retention correspond to increases in lean tissue deposition of 0.92 lb/day between the 100 and 250 g/day treatments and of 0.30 lb/day between the 250 and 400 g/day treatments. The increase in nitrogen retention between the 100 and 250 g/day treatments indicates that, at the 100 g/day amount, the supply of at least one of the supplemental amino acids was limiting. The smaller increase between 250 and 400 g/day treatments indicates that, even though 250 g/day did not fully meet the steers needs, it was very close.

Our results suggest that the amino acid supplement of 250 g/day was near to meeting the steers amino acid needs when the first limiting amino acid (methionine) was supplied in excess. Although this research was not conducted under normal production conditions, our results offer useful information toward the goal of balancing cattle diets on the basis of amino acids rather than crude protein.

Table 1. Diet Composition

Ingredient	% of DM
Soybean hulls, pelleted	83.3
Wheat straw	7.6
Molasses, cane	3.7
Dicalcium phosphate	2.0
Sodium bicarbonate	1.0
Calcium carbonate	1.0
Urea	0.49
Magnesium oxide	0.40
Trace mineralized salt[a]	0.29
Vitamin A, D, E[b]	0.10
Sulfur	0.10
Bovatec-68[c]	0.02

[a]Composition (%): NaCl (95 to 99), Mn (>0.24), Cu (>0.032), Zn (>0.032, I (>0.007), and Co (>0.004).
[b]Supplied per lb of DM: 4090 IU vitamin A, 682 IU vitamin D and 18 IU vitamin E.
[c]Supplied 15 mg lasalocid per lb of DM.

Table 2. Amino Acid, Volatile Fatty Acid, and Dextrose Infusates for Steer Calves

	Amino acid supply (g/day)		
Infusate	100	250	400
L-Glutamate	37	92.5	148
Glycine	12.5	31.25	50
L-Valine	5	12.5	20
L-Leucine	7.5	18.75	30
L-Isoleucine	5	12.5	20
L-Lysine-HCl (feed grade; 78.8%)[a]	10	25	40
L-Histidine-HCl-H_2O (74.0%)[b]	2.5	6.25	10
L-Arginine	5	12.5	20
L-Threonine (feed grade; 98%)[c]	5	12.5	20
L-Phenylalanine	8.75	21.875	35
L-Tryptophan (feed grade; 98%)[d]	1.75	4.375	7
L-Methionine	10	10	10
Glucose	400	350	300
Acetate	276	228	180
Propionate	248	214	180
Butyrate	53	46	40

[a]To provide 31.5, 19.7 and 7.9 g/day L-Lysine.
[b]To provide 7.4, 4.6, and 1.9 g/day L-Histidine.
[c]To provide 19.6, 12.3 and 4.9 g/day L-Threonine.
[d]To provide 6.9, 4.3 and 1.7 g/day L-Tryptophan.

Table 3. Nitrogen Balance Data for Steer Calves Receiving Graded Levels of Amino Acid Mixtures

	Amino acids (g/day)				Contrast P value[a]	
Item	100	250	400	SEM	Linear	Quadratic
n	3	3	3			
Nitrogen, g/day						
Infused	13.7	33.0	52.2	-	-	-
Dietary	45.0	45.0	45.0	-	-	-
Total Intake	58.8	78.0	97.2	-	-	-
Fecal	19.8	22.1	19.7	2.0	0.97	0.43
Urinary	13.4	16.8	34.1	3.3	0.05	0.23
Retained	25.6	39.0	43.4	3.9	0.08	0.44

[a]Probability of obtaining a difference of the observed magnitude by chance.

BRANCHED-CHAIN AMINO ACIDS FOR GROWING CATTLE LIMIT-FED DIETS BASED ON SOYBEAN HULLS

C. A. Löest, E. C. Titgemeyer, B. D. Lambert, and A. M. Trater

Summary

This study evaluated the effects of branched-chain amino acids on nitrogen retention and plasma branched-chain amino acid concentrations. Five ruminally cannulated Holstein steers (387 lb) were used in a 5 × 5 Latin square. Steers were limit-fed soybean hull-based diets twice daily (7.5 lb/day, as fed basis). Energy in the form of acetate (400 grams/day) was continuously infused into the rumen. Treatments were continuous abomasal infusions of 1) 115 grams/day of a mixture of 10 amino acids, 2) 10 amino acid mix with leucine removed, 3) 10 amino acid mix with isoleucine removed, 4) 10 amino acid mix with valine removed, and 5) 10 amino acid mix with all three branched-chain amino acids removed. Nitrogen retention decreased ($P<0.06$) in response to removal of leucine, valine, or all three branched-chain amino acids. Changes in nitrogen balance of growing cattle limit-fed soybean hull-based diets demonstrate limitations in the basal supply of leucine and valine, but not isoleucine.

(Key Words: Leucine, Isoleucine, Valine, Steers.)

Introduction

For optimal lean muscle growth in cattle, the supply of postruminal amino acids (metabolizable protein) needs to meet animal requirements. Therefore, the deficiency of a single dietary essential amino acid may limit cattle growth. Although several reports suggest that methionine is often first-limiting, other amino acids, such as lysine, arginine, histidine, or threonine, have also been reported as limiting. However, there is little research to support these findings.

Recent research at Kansas State University demonstrated that an inadequate supply of a branched-chain amino acid mixture containing leucine, isoleucine, and valine restricted protein deposition of cattle limit-fed soybean hull-based diets. It was unclear, however, which of the branched-chain amino acids were limiting. In the current study, we evaluated the effects of individual branched-chain amino acids on lean muscle growth that was estimated from nitrogen retention and on plasma branched-chain amino acid concentrations in cattle limit-fed soybean hull-based diets.

Experimental Procedures

Five ruminally cannulated steer calves averaging 387 lb initial body weight were housed in individual metabolism crates and were fed 7.5 lb/day as fed basis of a soybean hull-based diet that consisted of 72% soybean hulls, 19% alfalfa, 5% molasses, and 4% minerals/vitamins in equal portions twice daily. To supply additional energy without increasing ruminal microbial growth, steers received continuous infusions of acetate into the rumen at a rate of 400 grams/day.

A 5 × 5 Latin square design was used, with 7-day periods; 3 days for adaptation to treatments and 4 days for collection of feces and urine. Treatments were abomasal infusions of 115 grams/day of a mixture of 10 amino acids, or the 10 amino acid mixture with the branched chain amino acids, leucine, isoleucine, valine, or all three of these amino acids removed. The daily 10 amino acid mixture infusion consisted of : L-

leucine (20 g), L-isoleucine (10 g), L-valine (10 g), L-lysine (15.8 g), L-methionine (10 g), L-threonine (10 g), L-phenylalanine (10 g), L-arginine (10 g), L-histidine (7.4 g), and L-tryptophan (4.9 g). Infusions into the abomasum were made by extending flexible tubing through the rumen cannula and reticulo-omasal orifice.

On days 4 through 7 of each period, total feces and urine were collected for determination of nitrogen balance. Blood samples for plasma amino acid analysis were collected from the jugular vein of each steer.

Results and Discussion

Because protein in soybean hulls is mostly degraded and utilized by rumen microbes, microbial protein is the primary source of amino acids supplied to the small intestine of cattle fed soybean hull-based diets. Limit feeding such a diet created a situation where both the energy and protein (amino acid) supplies were inadequate and likely limited performance. To evaluate limitations in the amino acid supply from the basal diet, we ensured that energy would not be the first nutrient to limit performance by supplying energy in the form of acetate. Also, to evaluate which single amino acids from the basal diet restricted performance, we ensured that performance was not limited by any of the other essential amino acids by abomasally infusing the steers with mixtures of those essential amino acids. Infusing a mixture that supplies slight excesses of all 10 essential amino acids allowed the steers to perform at a rate that should not have been restricted by inadequate supplies of any essential amino acids. Measuring changes in nitrogen balance when a single amino acid is removed from the 10 amino acid mixture determined if the basal supply of that amino acid by the soybean hull-based diet was inadequate and therefore limiting. No change in nitrogen balance when an amino acid is removed from the 10 amino acid mixture would demonstrate that the removed amino acid was not limiting.

Nitrogen retention decreased ($P<0.05$) when all three branched-chain amino acids were removed from the 10 amino acid mixture (Table 1). Nitrogen retention also decreased in response to the removal of leucine ($P<0.06$) or valine ($P<0.05$), but the removal of isoleucine had no effect. Thus the basal supplies of leucine and valine were deficient and may limit animal performance.

Removal of all three branched-chain amino acids from the mixture of 10 amino acids decreased ($P<0.05$) plasma concentrations of these branched-chain amino acids (Table 1). Removal of leucine alone decreased its plasma concentrations ($P<0.05$), but increased plasma concentrations of both isoleucine and valine ($P<0.05$). However, removal of isoleucine or valine decreased ($P<0.05$) only their own concentrations in plasma, and did not significantly alter plasma concentrations of the other branched-chain amino acids. These decreases in plasma leucine, isoleucine, and valine concentrations demonstrate that their supplies exceeded the requirements when steers were infused with these amino acids in the 10 amino acid mixture.

The nitrogen balance results demonstrate that the branched-chain amino acids, leucine and valine, but not isoleucine, are limiting when ruminal microbial protein is the primary source of amino acids to the small intestine of growing steers.

Table 1. Effects of Removing Leucine, Isoleucine, Valine, or All Three Branched-Chain Amino Acids from Postruminal Amino Acid Infusions on Nitrogen Balance and Plasma Branched-Chain Amino Acid Concentrations of Growing Steers

	Treatments[a]					
Item	10AA	-LEU	-ILE	-VAL	-BCAA	SEM
Steers/treatment	5	4	5	5	5	
Nitrogen	---------- grams/day ----------					
Intake	76.5	74.2	75.4	75.3	72.1	-
Fecal	27.9	28.5	27.7	29.0	28.8	0.74
Urinary	22.9	22.8	22.9	23.8	22.1	0.81
Retained	25.7	23.1[c]	24.8	22.4[b]	21.2[b]	0.79
Plasma	---------- μM ----------					
Leucine	200	60[b]	190	217	60[b]	7.8
Isoleucine	148	296[b]	55[b]	154	88[b]	14.5
Valine	298	530[b]	289	123[b]	162[b]	20.8

[a]10AA = mixture of 10 essential amino acids; -LEU = leucine removed from 10AA; -ILE = isoleucine removed from 10AA; -VAL = valine removed from 10AA; -BCAA = leucine, isoleucine, and valine removed from 10AA.
[b]Different from 10AA ($P<0.05$).
[c]Different from 10AA ($P<0.06$).

EFFECTS OF WET CORN GLUTEN FEED AND INTAKE LEVEL ON DIET DIGESTIBILITY AND RUMEN PASSAGE RATE IN STEERS

S. P. Montgomery, J. S. Drouillard, E. C. Titgemeyer, J. J. Sindt, T. B. Farran, N. J. Pike, C. M. Coetzer, A. M. Trater, and J. J. Higgins [1]

Summary

Including 40% wet corn gluten feed (WCGF) in the diet increased total tract digestion of organic matter and neutral detergent fiber (P<0.01), reduced total volatile fatty acid concentration (P<0.01), increased rumen NH_3 concentration (P<0.01), increased rumen pH, and tended (P<0.06) to increase total tract digestion of starch. Furthermore, WCGF increased rumen passage rate of solid digesta (P<0.01) compared to diets containing no WCGF. Limit feeding reduced total tract digestion of organic matter and neutral detergent fiber (P<0.01), decreased total volatile fatty acid concentration (P<0.01), increased rumen NH_3 concentration (P<.01), increased rumen pH at 0 and 12 hours after feeding, reduced rumen pH at 4 hours after feeding, and increased rumen liquid passage rate (P<0.02).

(Key Words: Wet Corn Gluten Feed, Limit Feeding, Digestibility, Passage Rate.)

Introduction

When cattle are allowed *ad libitum* access to feed, they typically eat several small meals over a 24-hour period, establishing relatively steady-state rumen conditions conducive to optimal fermentation. In contrast, cattle that are limit-fed diets once daily generally consume their entire daily allotment of feed in large meals, at times consuming their entire ration in only a few hours. With high-energy diets, meal-eating behavior may negatively impact rumen fermentation due to rapid intakes of highly fermentable carbohydrates. Our study was conducted to determine the effects of WCGF on diet digestibility when included in diets fed *ad libitum* or limit-fed once daily.

Experimental Procedures

Twelve ruminally cannulated steers weighing 1175 lb were used in an incomplete Latin square design experiment with a 2 × 2 factorial arrangement of treatments to determine the effects of WCGF and total intake level on diet digestibility and rumen passage rate. Treatments consisted of diets (Table 1) formulated to contain 20% alfalfa hay and steam-flaked corn, with either 40% *Sweet Bran*® WCGF (dry basis) replacing steam-flaked corn or no WCGF. Cattle were fed once daily, either *ad libitum* or limited to 1.6% of body weight (dry basis). Two consecutive 24-day periods were used; 18 days for adaptation, 4 days for collection, and a 2-day *in situ* period. Chromic oxide (digestion marker, 10 g/head) was top dressed daily beginning on day 11, and on day 19 steers were ruminally dosed with 100 g of ytterbium (Yb)-labeled alfalfa hay (solid phase marker) and 200 mL of a cobalt ethylenediamine tetraacetate (Co-EDTA) solution (liquid phase marker). Rumen samples were collected 24, 48, 72, and 96 hours later and analyzed for concentrations of Yb and Co. On days 19 to 22, rumens were sampled once daily at 0, 4, 8, or 12 hours after feeding, and fecal grab samples were obtained three times daily. On day 23, dacron bags containing 5 g of either steam-flaked corn, WCGF, or ground (2-mm) alfalfa hay were placed into the rumens of all

[1]Department of Statistics.

steers and removed after 3, 6, 12, or 48 hours.

Table 1. Diet Composition (% of Dry Matter)

	Treatments	
Ingredients	WCGF	Corn
Steam-flaked corn	39.9	65.9
Alfalfa hay	19.9	19.4
Wet corn gluten feed	38.3	-
Soybean meal	-	7.4
Cane molasses	-	4.8
Urea	0.1	1.0
Limestone	1.2	0.8
Calcium phosphate	-	0.3
Sodium chloride	0.4	0.3
Potassium chloride	0.1	-
Vitamin/trace mineral premix[a]	0.1	0.1
Crude protein, analyzed	16.8	16.3

[a]Formulated to provide (total diet dry matter): 1,200 IU/lb vitamin A, 0.1 ppm cobalt, 10 ppm copper, 0.6 ppm iodine, 60 ppm manganese, 0.2 ppm selenium, 60 ppm zinc, and 30 g/ton of Rumensin®.

Results and Discussion

Digestibility and passage rate data are shown in Table 2. WCGF increased dry matter intake of *ad libitum* fed steers (P<0.01), increased total tract digestibility of organic matter and neutral detergent fiber (P<0.01), and reduced ruminal total volatile fatty acid concentration (P<0.01)(Table 3). This reduced volatile fatty acid concentration may have contributed to the higher rumen pH at 8 and 12 hours after feeding (Figure 1) for WCGF. WCGF also increased rumen NH_3 concentration (P<0.01), suggesting its protein is rapidly degraded. Steers fed WCGF had higher rumen solid digesta passage rates (P<0.01) than those without WCGF. Limit feeding decreased total tract digestion of both organic matter and neutral detergent fiber (P<0.01), reduced total volatile fatty acid concentration (P<0.01), and increased rumen NH_3 concentration (P<0.01). The lower rumen pH at 4 hours after feeding, along with an increase in rumen liquid passage rate (P<0.02), may be responsible for the reduction in digestibility. Total tract starch digestion was not affected by intake level. During the *in situ* trial (data not shown) no differences in rate of dry matter disappearance for alfalfa hay, steam-flaked corn, or WCGF were observed. We conclude that inclusion of WCGF at 40% of dietary dry matter may increase organic matter and neutral detergent fiber digestion. Limit feeding of high-energy diets once daily may depress organic matter and neutral detergent fiber digestibility due to a lack of steady-state rumen conditions.

Table 2. Effect of Wet Corn Gluten Feed and Intake Level on Total Tract Apparent Digestibility, Rumen Passage Rate, and Rumen Volume

	Treatment							
	WCGF		Corn			P-value[a]		
Item	Ad Lib	Limit-Fed	Ad Lib	Limit-Fed	SEM	Diet	Intake	D × I
Intake, lbs								
Dry matter	30.2	19.5	24.6	19.5	0.97	0.03	<0.01	0.03
Organic matter	28.1	18.2	23.3	18.4	0.90	0.04	<0.01	0.03
Neutral detergent fiber	9.2	6.0	5.0	4.0	0.29	<0.01	<0.01	<0.01
Starch	9.6	6.1	11.6	9.0	0.43	<0.01	<0.01	0.40
Digestibility, %								
Organic matter	86.9	80.2	84.0	79.5	0.50	<0.01	<0.01	0.08
Neutral detergent fiber	76.1	62.7	58.4	47.9	2.1	<0.01	<0.01	0.51
Starch	97.2	96.9	93.1	94.5	1.4	0.06	0.70	0.59
Particulate kinetics								
Passage rate, %/hour	3.7	3.4	2.7	2.9	0.15	<0.01	0.58	0.11
Turnover time, hour	27.3	30.9	38.1	36.4	1.7	<0.01	0.62	0.18
Fluid kinetics								
Passage rate, %/hour	2.2	3.0	2.3	2.9	0.22	0.97	0.02	0.50
Turnover time, hour	47.3	33.3	46.1	38.2	3.8	0.65	0.03	0.46
Rumen volume, liters	209.2	100.1	146.4	99.5	16.9	0.11	<0.01	0.12

[a]Probability that differences of the magnitude observed were due to random chance.

Table 3. Effect of Wet Corn Gluten Feed and Intake Level on Total VFA Concentrations, Acetate:Propionate Ratios, Molar Percentages of VFA, and Rumen Ammonia Concentrations

	Treatment							
	WCGF		Corn			P-value[a]		
Item	Ad Lib	Limit-Fed	Ad Lib	Limit-Fed	SEM	Diet	Intake	D x I
Total VFA, m*M*	111.7	96.8	127.8	111.3	4.1	co.01	co.01	0.77
Acetate, %	50.0	53.9	49.2	52.3	1.1	0.30	0.01	0.72
Propionate, %	28.0	24.5	36.1	29.5	1.9	0.01	0.01	0.41
Butyrate, %	15.9	13.4	11.1	11.8	0.82	co.01	0.16	0.03
Isobutyrate, %	1.2	2.1	0.7	1.1	0.21	0.01	0.01	0.31
Valerate, %	3.5	3.5	1.4	2.2	0.42	co.01	0.29	0.27
Isovalerate,%	1.4	2.6	1.5	3.1	0.49	0.45	0.02	0.65
Acetate:propionate	1.9	2.3	1.4	1.9	0.16	0.01	0.02	0.53
NH_3, m*M*	6.8	10.0	3.1	5.4	0.92	co.01	0.01	0.61

[a] Probability that differences of the magnitude observed were due to random chance.

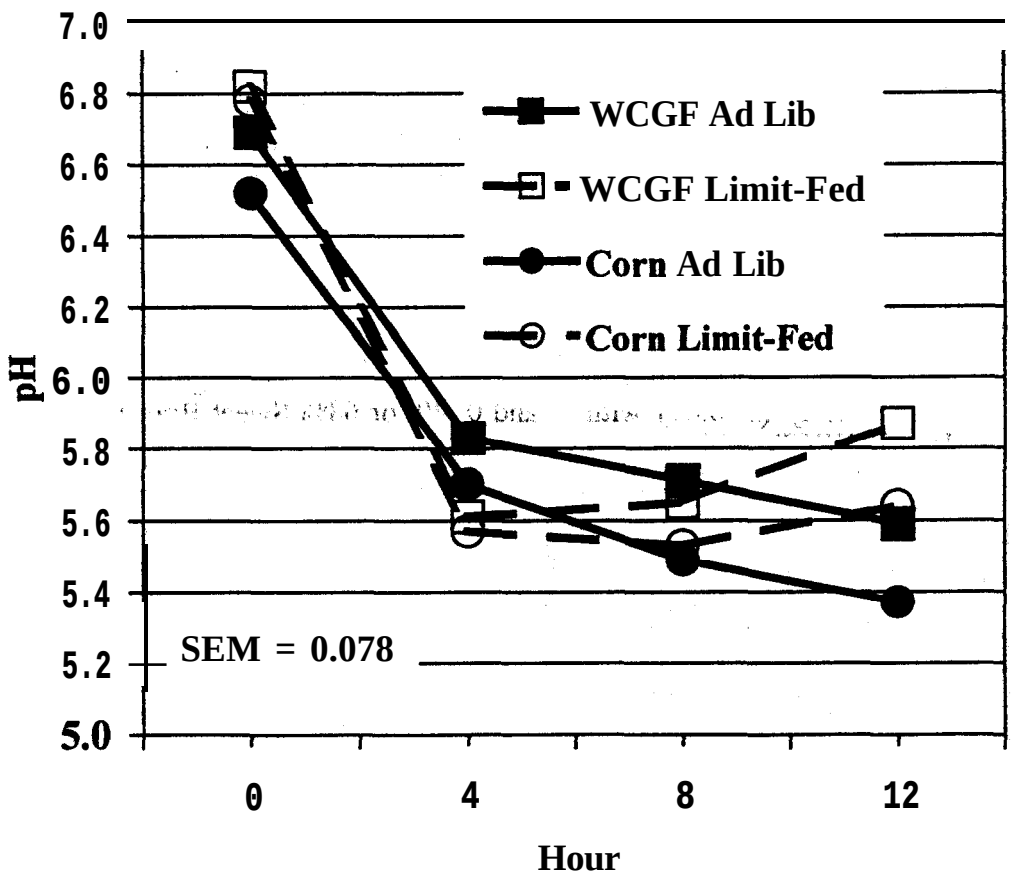

Figure 1. Effect of Wet Corn Gluten Feed and Intake Level on Rumen pH.

PERFORMANCE OF BEEF HEIFERS LIMIT-FED GROWING DIETS CONTAINING ALFALFA HAY AND WET CORN GLUTEN FEED

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Summary

Three hundred thirty-nine crossbred beef heifers were used in a 99-day growing study to identify optimum combinations of alfalfa hay and wet corn gluten feed (WCGF) in limit-fed growing diets. Diets contained 10, 20, or 30% ground alfalfa hay, and 0, 40, or 68% *Sweet Bran*® WCGF (dry basis) in a 3 × 3 factorial arrangement of treatments. An interaction occurred ($P<0.05$) between level of alfalfa hay and level of WCGF for both average daily gain and feed efficiency. Increasing the levels of alfalfa hay or WCGF reduced cattle performance, with the exception of the 30% alfalfa hay and 40% WCGF diet, which supported average daily gains similar ($P>0.10$) to diets containing 20 or 30% alfalfa hay and no WCGF. Feed efficiencies for the 30% alfalfa hay and 40% WCGF diet were better ($P<0.05$) than the diet containing 30% alfalfa hay and no WCGF. Dry matter intake as measured two hours after feeding increased linearly ($P<0.01$) with increasing levels of alfalfa hay, and decreased linearly ($P<0.01$) with increasing levels of WCGF. This study suggests that including WCGF at 40% of the diet (dry basis) can effectively replace steam-flaked corn in limit-fed diets containing 20 or 30% alfalfa hay.

(Key Words: Wet Corn Gluten Feed, Alfalfa Hay, Limit Feeding, Growing.)

Introduction

Wet corn gluten feed, a by-product of corn wet milling, consists mainly of corn bran and corn steep liquor. Because of high levels of corn bran, WCGF can supply additional energy for maintenance and growth without the reduction in fiber digestion often seen when substantial quantities of high-starch ingredients (grain) are fed to cattle consuming high-roughage diets. This study was conducted to identify optimum combinations of alfalfa hay and WCGF in limit-fed growing diets containing steam-flaked corn.

Experimental Procedures

Three hundred thirty-nine crossbred beef heifers averaging 609 lb were used in a randomized complete block experiment. To minimize differences in gastrointestinal tract fill, heifers had *ad libitum* access to a common diet for 15 days preceding the growing study. Heifers were then blocked by weight and allotted to pens containing four to seven head per pen, with six pens per treatment. Treatments (Table 1) consisted of diets containing 10, 20, or 30% ground alfalfa hay, and 0, 40, or 68% Sweet Bran WCGF (dry basis) in a 3 × 3 factorial arrangement. All diets provided 30 grams of Rumensin® per ton of dry matter and were fed once daily at 1.6% of body weight (dry basis) for 84 days. On days 8, 22, 37, 51, 64, and 79, unconsumed feed was removed from the feed bunks 2 hours after feeding, immediately weighed, and returned to the bunk in order to measure rate of feed consumption. Prior to obtaining final weights, heifers had *ad libitum* access to a common diet for 15 days.

[1]Cargill Corn Milling, Blair, NE.

Results and Discussion

Performance data are shown in Figures 1 and 2. There was an interaction between alfalfa hay and WCGF level in the diet. Increasing the level of alfalfa hay and WCGF reduced growing performance of heifers, with the exception of the diet containing 30% alfalfa hay and 40% WCGF. Heifers fed that diet had average daily gains similar ($P>0.10$) to those consuming diets containing 20 or 30% alfalfa hay and no WCGF. They also had improved feed efficiencies compared to heifers fed the diet containing 30% alfalfa hay and no WCGF ($P<0.05$). Dry matter intake was not different among treatments ($P>0.05$) (11.4 ± .4 lb/day), so these results indicate a positive associative effect of WCGF on the digestibility of alfalfa hay in the diet containing 30% alfalfa hay and 40% WCGF. Increasing the level of alfalfa hay in the diet increased ($P<0.01$) dry matter intake as measured 2 hours after feeding (Figure 3), whereas increasing the level of WCGF decreased ($P<0.01$) dry matter intake. We conclude that the value of WCGF relative to steam-flaked corn increases in diets containing greater amounts of roughage when WCGF is included at 40% of the diet dry matter.

Table 1. Experimental Diets (% of Dry Matter)

	Treatments								
% Alfalfa Hay	10	10	10	20	20	20	30	30	30
Ingredients % WCGF	0	40	68	0	40	68	0	40	68
Steam-flaked corn	73.4	48.6	20.0	65.3	39.2	10.0	57.1	29.5	-
Alfalfa hay	9.8	9.9	10.0	19.6	19.9	20.1	29.5	30.0	30.3
Wet corn gluten feed	-	38.9	67.1	-	39.0	67.3	-	39.1	67.6
Soybean meal	9.0	-	-	7.6	-	-	6.2	-	-
Cane molasses	4.9	-	-	4.9	-	-	4.9	-	-
Urea	1.0	0.3	-	1.0	0.1	-	1.0	-	-
Limestone	1.2	1.6	2.3	0.8	1.2	2.0	0.5	0.9	1.6
Calcium phosphate	0.2	-	-	0.3	-	-	0.3	-	-
Sodium chloride	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Potassium chloride	-	0.2	0.1	-	0.1	0.1	-	-	-
Vitamin/trace mineral premix[a]	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Crude protein, analyzed	16.1	16.5	20.1	16.1	16.8	20.8	16.1	17.0	21.4

[a]Formulated to provide (total diet dry matter): 1,200 IU/lb vitamin A, 0.1 ppm cobalt, 10 ppm copper, 0.6 ppm iodine, 60 ppm manganese, 0.2 ppm selenium, 60 ppm zinc and 30 g/ton of Rumensin.

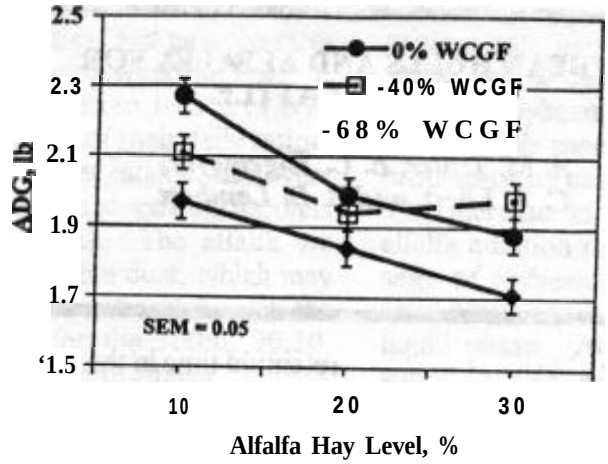

Figure 1. Average Daily Gain of Heifers Limit-Fed Growing Diets Containing 10, 20, or 30% Alfalfa Hay and 0, 40, or 68% Wet Corn Gluten Feed. Interaction between alfalfa hay and WCGF level in diet (P<0.05).

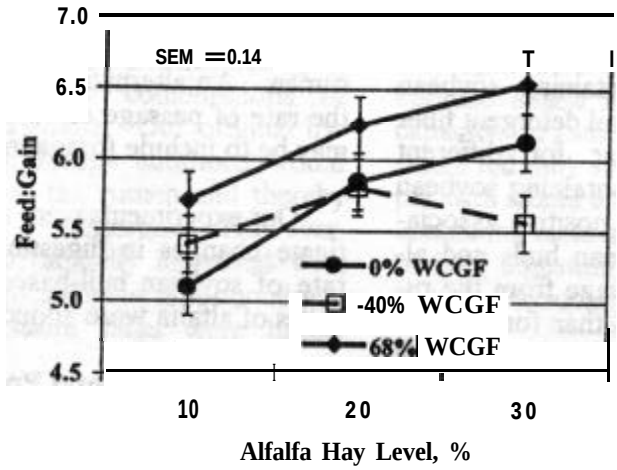

Figure 2. Feed:Gain of Heifers Limit-Fed Growing Diets Containing 10, 20, or 30% Alfalfa Hay and 0, 40, or 68% Wet Corn Gluten Feed. Interaction between alfalfa hay and WCGF level in diet (P<0.05).

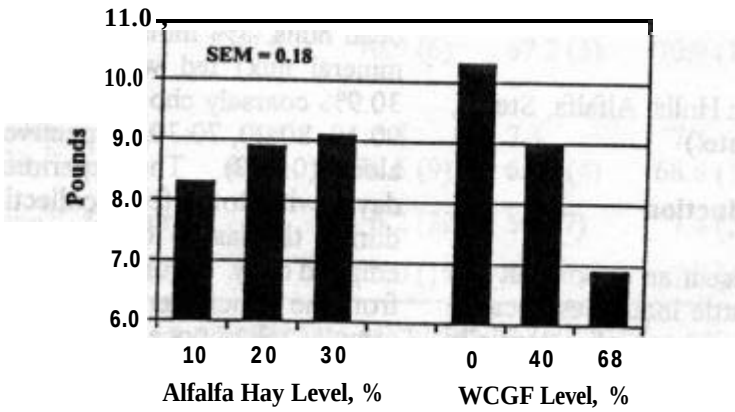

Figure 3. Dry Matter Intake as Measured Two Hours After Feeding. Linear effect of alfalfa hay (P<0.01) and linear effect of WCGF (P<0.01).

SOYBEAN HULLS AND ALFALFA FOR LIMIT-FED CATTLE

A. M. Trater, E. C. Titgemeyer, C. A. Löest, and B. D. Lambert

Summary

We evaluated the optimal level of alfalfa inclusion in limit-fed, soybean hull-based diets. Steers were fed soybean hull-based diets containing 0 to 30% alfalfa or alfalfa alone. Feed intakes were lower for alfalfa than for soybean hull-based diets. Digestibilities of dry matter and neutral detergent fiber were lower ($P<0.05$) for alfalfa than for diets containing soybean hulls. Dry matter and neutral detergent fiber digestibilities were similar for different levels of alfalfa in diets containing soybean hulls, although there were positive associative effects between soybean hulls and alfalfa. Rates of liquid passage from the rumen were higher for alfalfa than for soybean hull-containing diets, and increased as alfalfa was added to the soybean hull diets. Solid passage rates also increased with increasing amounts of alfalfa in soybean hull-containing diets. Adding 30% alfalfa to primarily soybean hull diets led to positive associative effects on diet digestibility, but alfalfa additions increased liquid and solid passage rates, suggesting that the benefit was not a result of slower passage of soybean hulls from the rumen.

(Key Words: Soybean Hulls, Alfalfa, Steers, Digestion, Passage Rate.)

Introduction

Soybean hulls present an opportunity to the beef and dairy cattle industries because they contain a large amount of potentially digestible fiber. Consequently, they may be included in high-forage diets to increase energy content without decreasing fiber digestibility. However, they have a short retention time in the rumen due to their small particle size and high specific gravity, which may limit their digestibility and subsequent animal performance. Previous research at Kansas State University indicated that restricting the intake of soybean hull-based diets to 1.5 or 2.25% of body weight (BW) in an attempt to slow passage did not change digestibility, and, therefore, probably did not change the passage rate of soyhulls from the rumen. An alternative method to decrease the rate of passage of feed from the rumen may be to include forage in the diet.

Our experiments were designed to investigate changes in digestibility and passage rate of soybean hull-based diets as graded levels of alfalfa were added.

Experimental Procedures

Twenty Holstein steers (702 lb initial BW) were used in a randomized complete block design. They were housed in partially covered, individual pens, and had free access to water. Diets were fed once daily at 1.75% of body weight (dry matter basis). Treatments were a soybean hull mix (95.7% soybean hulls, 3% molasses, 0.5% urea, 0.8% mineral mix) fed with 0, 10.4, 20.7, and 30.9% coarsely chopped alfalfa hay (100:0, 90:10, 80:20, 70:30, respectively), or alfalfa alone (0:100). The experiment lasted 16 days, with total fecal collection (in bags) during the last 6 days. Fecal bags were emptied daily. Liquid and solid passage rates from the rumen were determined using fecal samples taken once daily, immediately prior to fecal bag emptying. These samples were analyzed for concentrations of liquid (chromium EDTA) and solid (ytterbium chloride) ingesta markers.

Results and Discussion

Intakes, digestibilities, and passage rates (liquid and solid) are presented in Table 1. Despite restriction of feed to 1.75% of BW, some steers refused part of their daily ration. This produced dry matter intakes that were lower (P<0.05) for alfalfa alone than for diets containing soybean hulls. The alfalfa we used contained appreciable dust, which may have contributed to the lower intakes for the 0:100 diet. Intakes for the 100:0, 90:10, 80:20, and 70:30 diets were similar.

Dry matter digestibility was lower for alfalfa alone (P<0.05) than for diets containing soybean hulls. Similar results have been found with other forage sources. There was no significant difference in dry matter digestibility among diets containing soybean hulls, although there were positive associative effects on dry matter and neutral detergent fiber digestibilities for combinations of soybean hulls and alfalfa. Our original hypothesis was that forage additions would slow passage from the rumen and thereby allow more time for digestion. However, solid passage rate actually increased with alfalfa additions to soybean hull-containing diets. Liquid passage rates were higher (P<0.05) for alfalfa alone than for diets containing soybean hulls. Further, liquid passage rate increased linearly (P<0.05) as alfalfa was added to the soybean hull mix. Because soybean hull particles are small and have a high specific gravity, they have the propensity to pass rapidly from the rumen. The increase in liquid passage rate with alfalfa addition may have hastened the passage of soybean hulls by carrying the small solid particles out of the rumen as part of the liquid phase. Although pH was not measured in this experiment, other research indicates that diets consisting primarily of soybean hulls can result in low ruminal pH. At a low rumen pH, fiber digestion can be inhibited. Thus, the positive associative effects for digestion with the addition of alfalfa might have resulted from an increase in rumination and salivary flow and, therefore, a higher rumen pH. Ruminal pH also may have been affected by alfalfa addition because alfalfa itself has a high buffering capacity. If rumen pH was sub-optimal for steers fed only soybean hulls, an increase in pH with alfalfa addition to the soybean hull-containing diets may have increased the rate of fiber digestion, and this may explain the observed associative effects.

Table 1. Intakes, Digestibilities, Passage Rates, and Associative Effects[a] for Digestibilities and Passage Rates for Mixtures of Soybean Hulls and Alfalfa

	Soybean Hull Mix:Alfalfa					
Item	100:0	90:10	80:20	70:30	0:100	SEM
Dry matter						
Intake[b], lb/day	11.9	11.2	12.1	12.5	9.9	0.70
Digestibility[b], %	67.5	70.9 (6)	67.2 (3)	70.9 (10[e])	56.2	2.00
Neutral detergent fiber						
Intake[b], lb/day	7.0	6.8	7.3	7.3	5.5	0.37
Digestibility[b], %	66.1	70.5 (9)	65.4 (4)	68.6 (11[e])	47.4	2.30
Liquid passage[b,c], %/hour	4.6	6.2 (22)	5.6 (7)	7.4 (24[e])	7.7	0.53
Solid passage[c,d], %/hour	4.1	5.0 (18)	4.2 (4)	7.0 (42[e])	4.0	0.47

[a]Associative effects (%, in parentheses) calculated as (observed - expected)/expected, where expected was calculated as a weighted average based on the proportions of soybean hulls and alfalfa in the diet. [b]Alfalfa vs soybean hull-containing diets (P<0.05). [c]Linear effect of alfalfa within soybean hull-containing diets (P<0.05). [d]Cubic effect of alfalfa within soybean hull-containing diets (P<0.05). [e]Associative effect different from 0 (P<0.05).

RUMENSIN®-TYLAN® COMBINATIONS IN LIMIT-FED GROWING DIETS: EFFECTS ON GROWING AND FINISHING PERFORMANCE AND CARCASS CHARACTERISTICS

S. P. Montgomery, J. S. Drouillard, T. B. Farran, J. J. Sindt, C. M. Coetzer, J. N. Pike, A. M. Trater, H. J. LaBrune, R. D. Hunter, and S. B. Laudert [1]

Summary

Five hundred seventy-two crossbred beef heifers were used to compare gain and feed efficiency of cattle consuming restricted quantities of energy-dense growing diets containing varying concentrations of Rumensin® and Tylan®. Growing treatments consisted of providing Rumensin at 30 grams per ton of dry matter (R30), or 250 mg per head per day (R250). A third treatment consisted of a Rumensin/Tylan combination, providing 250 and 90 mg per head per day of Rumensin and Tylan, respectively (R250/T90). Average daily gain and feed efficiency during the growing phase were not different (P>0.90) among treatments. Heifers that received R250/T90 during the growing phase exhibited lower dry matter intakes (P<0.05) during the finishing phase. Although not significant (P>0.50), R250/T90 increased finishing-phase feed efficiency by 6.1 and 3.5% compared to R30 and R250, respectively. Liver abscesses were lower (P<0.10) for R250/T90 and R30 than R250.

(Key Words: Rumensin, Tylan, Limit Feeding.)

Introduction

Food and Drug Administration regulations currently limit Rumensin concentrations to not more than 30 grams per ton of diet (90% dry basis). Although this level is adequate to enhance growth and increase feed efficiency in cattle fed *ad libitum*, it may be less than optimum when cattle are fed restricted amounts of high-concentrate growing diets. Furthermore, cattle grown on high-concentrate diets and then subsequently fed finishing diets are subjected to prolonged periods of high grain intake. Feeding high-grain diets for extended periods may predispose cattle to ruminitis, thus increasing the incidence of liver abscesses. This study was conducted to determine if higher levels of Rumensin as well as the use of Tylan in limit-fed, high-energy growing diets would improve cattle performance during the growing phase and subsequent finishing period.

Experimental Procedures

Five hundred seventy-two crossbred beef heifers weighing 593 lb were used in a randomized complete block design. Heifers were fed a common diet *ad libitum* for 14 days preceding the growing study to minimize differences in gastrointestinal tract fill. Heifers were blocked by weight and allotted to pens containing 47 to 48 animals per pen, with four pens per treatment. Growing diets (Table 1) provided 30 grams of Rumensin per ton (dry matter basis), 250 mg of Rumensin per head per day, or 250 mg of Rumensin plus 90 mg of Tylan per head per day. Diets were fed once daily at 1.6% of body weight (dry matter basis) for 99 days. Intakes were adjusted weekly, assuming an average gain of 2 lb per head daily. Prior to obtaining final weights for the growing phase, cattle were provided *ad libitum* access to a common diet for 14 days. Heifers were then stepped up to a common finishing diet, fed for 80 days, and slaughtered. The final finishing diet provided 300 mg of Rumensin

[1]Elanco Animal Health, Indianapolis, IN.

and 90 mg of Tylan per day and was fed once daily *ad libitum*.

Results and Discussion

Increasing Rumensin intake of heifers consuming limit-fed growing diets did not effect weight gain or feed efficiency (P>0.90) during the growing phase (Table 2), which suggests that 30 grams of Rumensin per ton was sufficient to elicit maximal growth response. Heifers receiving the R30 treatment averaged 168 mg of Rumensin per head per day. Finishing average daily gains were not significantly different (P>0.80) among treatments (Table 3). Finishing dry matter intakes were lower (P<0.05) for heifers that had received R250/T90 during the growing phase, resulting in a numerical improvement in feed efficiency compared to R30 and R250 (6.1% and 3.5% respectively). Liver abscesses were lower (P<0.10) for R250/T90 and R30 compared to R250, and the percentage of yield grade 2 carcasses was greater (P<0.05) for R250/T90 compared to R30. The results of this study suggest that feeding 250 mg of Rumensin as well as 90 mg of Tylan per day to heifers consuming limit-fed, high-energy growing diets may reduce dry matter intake during the subsequent finishing period without negatively affecting gain.

Table 1. Experimental Diets (% of Dry Matter)

	Growing[1]			
Ingredient	R30	R250[2]	R250/T90[3]	Finishing[4,5]
Steam-flaked corn	66.4	67.8	67.8	80.7
Alfalfa hay	14.7	15.0	15.0	6.8
Soybean meal	8.5	8.7	8.7	3.0
Cane molasses	3.9	4.0	4.0	4.4
Tallow	2.1	2.1	2.1	2.1
Urea	1.1	1.1	1.1	1.3
Limestone	1.0	1.0	1.0	1.2
Sodium chloride	0.4	0.4	0.4	0.3
Potassium chloride	-	-	-	0.1
Ammonium sulfate	-	-	-	0.2
Calcium phosphate	0.3	0.3	0.3	0.1
Vitamin/trace mineral premix	0.1	0.1	0.1	0.1
Rumensin premix	2.1	-	-	-
Rumensin	30 g/ton	250 mg/day	250 mg/day	300 mg/day
Tylan	-	-	90 mg/day	90 mg/day
Melengestrol Acetate	-	-	-	.5 mg/day
Crude protein, analyzed	15.8	16.0	16.0	14.5

[1]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,200 IU/lb vitamin A, 0.1 ppm cobalt, 10 ppm copper, 0.6 ppm iodine, 60 ppm manganese, 0.3 ppm selenium, and 60 ppm zinc.
[2,3] Rumensin/Tylan supplement fed at 0.22 lb per head per day (dry matter basis).
[4]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,200 IU/lb vitamin A, 0.1 ppm cobalt, 8 ppm copper, 0.5 ppm iodine, 50 ppm manganese, 0.3 ppm selenium, and 50 ppm zinc.
[5]Rumensin/Tylan/Melengestrol Acetate supplement fed at 0.44 lb per head day (dry matter basis).

Table 2. Performance During the Growing Phase for Heifers Limit-Fed Growing Diets Providing 30 Grams/Ton of Rumensin (R30), 250 mg of Rumensin per Heifer Daily (R250), or 250 mg of Rumensin plus 90 mg of Tylan per Heifer Daily (R250/T90)

	Growing Diet			
Item	R30	R250	R250/T90	SEM
No. of heifers	190	192	190	
Initial weight, lb	595	587	596	13.1
Final weight, lb	811	801	811	13.0
Dry matter intake, lb/day	11.2	11.3	11.4	0.20
Average daily gain, lb	2.18	2.16	2.17	0.04
Feed:gain	5.15	5.21	5.24	0.15

Table 3. Finishing Performance and Carcass Characteristics Following a Growing Period During Which Heifers Were Fed Diets Providing 30 Grams/Ton of Rumensin (R30), 250 mg of Rumensin per Heifer Daily (R250), or 250 mg of Rumensin plus 90 mg of Tylan per Heifer Daily (R250/T90)

	Previous Growing Diet			
Item	R30	R250	R250/T90	SEM
No. of heifers	190	192	190	
Initial weight, lb	811	801	811	13.0
Final weight, lb[1]	1054	1044	1049	14.7
Dry matter intake, lb/day	20.0[a]	19.5[a]	18.4[b]	0.32
Average daily gain, lb	3.04	3.05	2.98	0.10
Feed:gain	6.55	6.39	6.17	0.26
Hot carcass weight, lb	675	669	672	9.4
Dressing percentage[2]	61.5	61.5	61.5	0.1
Ribeye area, in[2]	12.8	12.8	12.7	0.2
Fat thickness, in	0.40	0.39	0.37	0.02
Kidney, pelvic & heart fat, %	2.2	2.2	2.2	0.05
Liver abscesses, %	0.5[e]	4.2[f]	1.0[e]	1.1
Yield grade 1, %	18	16	11	3.0
Yield grade 2, %	38[a]	43[a,b]	50[b]	3.6
Yield grade 3, %	41	39	35	3.9
Yield grade 4 & 5, %	3	2	4	2.0
Marbling score[g]	Sl[79]	Sl[82]	Sl[77]	6.3
USDA Prime, %	0.5	1	0	0.46
USDA Choice, %	47	44	45	4.4
USDA Select, %	47	50	48	3.8
USDA Standard, %	5	5	7	1.4
Dark cutters, %	0	0.5	0	0.3

[1]Shrunk weight = hot carcass weight ÷ common dressing percent of 64.05%.
[2]Dressing percent = hot carcass weight ÷ live weight before shrink.
[a,b]Means within same row without a common superscript differ (P<0.05).
[c,d]Means within same row without a common superscript differ (P<0.01).
[e,f]Means within same row without a common superscript differ (P<0.10).
[g]Sl = Slight.

EFFECT OF COOKED MOLASSES TUBS ON PERFORMANCE AND HEALTH OF NEWLY RECEIVED STOCKER CALVES

S. I. Paisley[1], G. L. Stokka, and F. K. Brazle[2]

Summary

Eight paired comparisons conducted at three field sites with 1059 newly-received lightweight stocker calves were used to determine the effect of free-choice cooked molasses tubs designed for receiving cattle on 28-day receiving period performance, percentage of cattle treated for respiratory disease, and death loss. At all sites, cattle received similar management with the exception that cooked molasses tubs were added to half of the pens immediately following initial processing. Weight gains were similar (P=0.36) for cattle with or without access to tubs (43 and 38 lb, respectively). The addition of tubs also did not affect the number of cattle treated (P=0.48) or percent death loss (P=0.61); however, there was a numerical decrease in death loss for cattle with access to tubs (2.7 vs 1.8%). Tub consumption (0.245 lb/day) based on beginning and ending weights of the tubs, was below the desired level of 0.5 lb/day. Low tub consumption may have compromised any potential for improved performance or overall health response for cattle offered free access to cooked molasses tubs.

(Key Words: Receiving, Cattle, Cooked Molasses Tubs.)

Introduction

A recent Kansas survey estimated that 65% of cattle entering Kansas originate in the Southeastern U.S. Additionally, more than 75% of stocker operators keep newly received cattle in confinement for a minimum of 7 days. Feed intake by these stressed calves is low, creating short-term nutritional deficiencies that could affect immune function and increase susceptibility to disease. However, few operations adjust rations for low feed consumption during this period. Providing additional vitamins and minerals may reduce morbidity, depending on previous nutritional status. Our objective was to determine if adding Rangeland Health Care Provider Stress Tubs (Farmland Industries, Inc.) to pens of newly-received cattle would improve receiving period weight gains and(or) reduce morbidity.

Experimental Procedures

Eight paired comparisons were conducted on three producer sites across Kansas between November 4, 1999 and February 16, 2000. Receiving periods ranging from 27 to 32 days. In all cases, cattle arrived on the same day and were randomly assigned to two pens. One of the pens received free-choice access to vitamin and trace mineral-fortified cooked molasses tubs provided by Farmland Industries, Inc. Tubs were placed with cattle immediately after initial processing at a rate of no more than 20 head/tub, with tubs placed throughout the pen. Health programs differed slightly across sites, but cattle with or without tubs received similar management at each location.

To determine whether providing Stress Tubs improved cattle's ability to respond to disease, performance data for each pen were

[1]South Central Area Extension Office, Hutchinson.
[2]Southeast Area Extension Office, Chanute.

further divided into two groups: 1) cattle that had never been treated for respiratory disease, and 2) cattle treated at least once for respiratory disease.

Results and Discussion

Cattle without access to Stress Tubs were slightly heavier (P=0.17; Table 1) than steers receiving tubs (433 vs 415 lb). This difference was maintained throughout the feeding period, and final weights of cattle without tubs tended (P=0.07) to be heavier than those with access to tubs. Total weight gain and daily gains were similar ($P \geq 0.36$) for both groups, although daily gains were numerically higher for cattle receiving tubs (1.28 vs 1.46 lb/day). Morbidity and death loss was similar ($P \geq 0.22$) for cattle with or without access to tubs. Daily supplement intakes were below the recommended 0.5 lb/day, despite an adequate number of tubs and unlimited access. Due to site difference in initial weights, tub intakes on a percent BW basis are also reported. Additional work is needed to determine if achieving desired intakes would produce a greater response in animal performance and decreased morbidity.

Performance and health differences at each site mainly reflect the type of cattle purchased, management prior to arrival, and environmental conditions during the receiving period. Initial weights were different (P<0.01; Table 2) for each site. Site 1 purchased heavier calves from a regional salebarn. Sites 2 and 3 purchased lighter calves from the Southeastern U.S. Weight gain during the receiving period was similar (P=0.84) for all three sites, resulting in different (P<0.01) final weights. Among sites, total number of cattle treated, or overall morbidity, bordered on significance (P=0.08); however, there were differences in treatment duration among sites. Percentages of cattle treated only once were similar (P>0.05) for Sites 1 and 3, and both were lower (P<0.05) than Site 2. Percentage of cattle treated twice were lower (P<0.05) for Site 3 than Site 2, while Site 1 was intermediate. Although there were no differences (P=0.20) in percentages of cattle treated three times, Sites 1 and 2 had the lowest percentage of chronics with 0 and 2%, respectively. Both were lower (P<0.05) than Site 3. Finally, death loss was lower (P<0.05) at Site 2 than Site 3, with Site 1 intermediate. The greater number of chronics and higher death loss associated with Site 3 may be partially attributed to the lighter weights of cattle at this site, as well as the fact that many of the cattle received at Site 3 were intact males that were castrated during initial processing.

Tub intakes by site show that only Site 1 achieved the recommended intake of 0.5 lb/day. Site 2 (0.31 lb/day) and Site 3 (0.11 lb/day) tub intakes were considerably lower than target. At all sites, tubs were placed near feed and water and at the recommended rate of not less than 1 tub per 20 steers. Because purchased steers were used at all three sites, previous exposure to molasses tubs is not known. Additional factors that could have affected tub intake include calf size and origin (Sites 2 and 3 purchased predominately lighter calves from Southeastern U.S.), as well as differences in receiving management.

To determine whether access to the cooked molasses tubs influenced the animals' ability to handle a disease challenge and respond to treatment, data from each pen was further divided between: 1) cattle that had never been treated and 2) cattle that had been treated a minimum of one time (deads removed). There were no interactions ($P \geq 0.50$) between treatment history and access to cooked molasses tubs; however, there was a site by treatment history interaction for all performance variables, so site-specific means are presented in Table 3.

Site means broken down by treatment history indicate that health management strategies may have been different for Site 1 as compared to Site 2 and 3. Receiving period weight gain for cattle treated at least once was considerably lower (P<0.05) at Site 1 than the other two sites, suggesting that disease exposure may have been more serious at Site 1. Actual within-pen means at each site (not shown) suggest that treated cattle at Site 1 with access to the tubs lost less weight than treated cattle without tubs (based on only 1 rep); however, this trend

was not evident at Sites 2 and 3. Our results suggest that management and environment play a big role in an animal's ability to recover from disease, and do not rule out the possibility that nutritional supplements may also play a role in overall health.

Table 1. Receiving Health and Performance Data of Cattle With or Without Cooked Molasses Tubs

Item	No Tubs[a]	Stress Tubs	SE	P-value
Number, deads in (pens)	532 (8)	527 (8)		
Initial wt, lb[b]	433	415	6.1	0.17
Final wt, lb[c]	471	459	2.5	0.07
Receiving period wt gain, lb[d]	38	43	3.0	0.36
Daily gain, lb/day	1.28	1.46	0.113	0.38
Observed sickness, %				
Total treated	36.7	36.7	0.77	0.48
Treated once (1X)	24.1	26.1	1.88	0.53
Treated twice (1X not included)	5.4	4.2	0.52	0.25
Treated 3X (1 and 2X not included)	2.4	2.0	0.54	0.65
Chronics (treated more than 3X)	2.0	3.4	0.55	0.22
Deads	2.7	1.8	1.00	0.61
Daily tub intake, lb/head	--	0.245	--	--
% BW	--	0.075	--	--

[a]Least squares means using pen as the experimental unit.
[b]Treatment by site interaction P=0.02.
[c]Final weight calculated using an unshrunk liveweight minus a 4% pencil shrink.
[d]Receiving period for sites 1, 2 and 3.

Table 2. Receiving Health and Performance Data of Cattle by Site

Item	Trial Location[a]			SE	Overall P-value
	Site 1	Site 2	Site 3		
Number, deads in (pens)	107 (2)	445 (8)	507 (6)		
Initial wt, lb[b]	533	414	325	2.4	<0.01
Final wt, lb[c]	570[g]	456[f]	368[e]	5.4	<0.01
Receiving period wt gain, lb[d]	39	42	40	2.9	0.84
Daily gain, lb/day	1.45	1.45	1.21	0.096	0.14
Observed sickness, %					
Total treated	29.0	43.1	39.4	3.00	0.08
Treated once (1X)	20.6[e]	31.9[f]	22.9[e]	1.55	<0.01
Treated twice (1X not included)	4.7[ef]	7.6[f]	2.2[e]	0.72	<0.01
Treated 3X (1 and 2X not included)	2.8	0.9	3.0	0.94	0.20
Chronics (treated more than 3X)	0[e]	2.0[e]	6.2[f]	1.06	0.02
Deads	0.9[ef]	0.7[e]	5.1[f]	1.10	0.03
Daily tub intake, lb/head	0.54	0.31	0.11	–	--
% BW	0.107	0.080	0.038	–	--

[a]Least squares means using pen as the experimental unit .
[b]Treatment by site interaction, P=0.02.
[c]Final weight calculated using an unshrunk liveweight minus a 4% pencil shrink.
[d]Receiving periods ranged from 27 to 32 days for sites 1, 2, and 3.
[e,f,g]Means within a row with different superscripts differ (P<0.05).

Table 3. Receiving Health and Performance Data of Cattle by Treatment History and Site

Item	Site 1		Site 2		Site 3		SE
	Healthy	Treated	Healthy	Treated	Healthy	Treated	
Number (groups)[a]	76 (2)	31 (2)	253 (8)	192 (8)	307 (6)	200 (6)	
Initial wt, lb	526[g]	550[g]	417[f]	410[f]	339[e]	302[d]	5.6
Final wt, lb[b]	581[h]	543[g]	461[f]	447[f]	391[e]	324[d]	6.2
Weight gain, lb	57[g]	-4[d]	44[fg]	37[f]	51[g]	19[e]	5.3
Daily gain, lb/day	2.09[g]	-0.14[d]	1.55[fg]	1.29[f]	1.54[fg]	0.60 [e]	1.70
Day of 1st treatment[c]	0	8.7[d]	0	7.7[d]	0	12.7[e]	0.81

[a]Data analyzed using group means for healthy and treated cattle within each pen.
[b]Final weight calculated using an unshrunk liveweight minus a 4% pencil shrink.
[c]Upon arrival, cattle at Site 3 received metaphylactic treatment using tilmicosin phosphate.
[d,e,f,g,h]Means within a row with different superscripts differ (P<0.05).

USING A MIXTURE OF COTTONSEED HULLS AND COTTONSEED MEAL TO REPLACE ALFALFA HAY IN DIETS FOR STRESSED FEEDER CALVES[1]

D. A. Blasi, J. S. Drouillard, T. B. Farran, R. D. Hunter, S. P. Montgomery, J. J. Sindt

Summary

One 28-day receiving experiment was conducted using 625 exotic × British cross heifers to evaluate growth performance and morbidity on receiving diets that contained either alfalfa hay or a pellet composed of 65% cottonseed hulls and 35% cottonseed meal as the roughage source. Heifers fed the cotton byproduct pellet consumed more feed ($P<0.01$) but tended to be less efficient than those fed alfalfa hay. Daily gain was comparable between diets ($P>0.05$), and the percentages of heifers diagnosed, treated, or retreated for respiratory disease were similar.

(Key Words: Cottonseed Hulls, Receiving Cattle, Health.)

Introduction

Typically, feed intake of stressed feeder calves is low and extremely variable following transportation and introduction into a receiving facility. Adequate energy intake is critical for mounting an effective immune response. Consequently, rations that are fed during the receiving period must be palatable and fortified with high levels of crude protein, energy, minerals, and vitamins. Furthermore, a roughage source that is palatable and promotes ruminal health is critical throughout the transition to a feedlot diet. Our objective was to compare the growth performance and morbidity/mortality rates of stressed calves fed receiving diets containing alfalfa hay or a mixture of cottonseed hulls and cottonseed meal.

Experimental Procedures

Six hundred twenty five crossbred heifers averaging 448 lb were fed receiving diets containing either alfalfa hay or a mixture of cottonseed hulls and cottonseed meal. Calves were purchased from sale barns in Kentucky and Tennessee and transported to the KSU Beef Cattle Research Center in Manhattan. They were placed into a large pen on arrival, given free access to long-stem prairie hay and water, and processed within 24 hours of arrival. Weight and rectal temperature were recorded, and heifers were given Cydectin® pour-on, Fortress-7®, a Ralgro® implant and a metaphylactic dose of Micotil® at 1.5 ml per 100 lb body weight. They were allotted randomly to their respective treatments and placed into one of 12 pens of 48 to 55 head each. A second dose of Fortress-7 was given 12 to 14 days after initial processing.

Diets are shown in Table 1. Heifers were fed their respective diets once daily, *ad libitum*. After the 28-day receiving trial all heifers were fed a common diet to equalize ruminal fill between treatments. Feed consumption and weight gain were monitored throughout the receiving period.

Animals that exhibited clinical signs of respiratory disease were identified each morning and were treated for respiratory disease if clinical signs were accompanied by a rectal temperature ≥103°F, or if they exhibited clinical signs on 2 consecutive days. The initial respiratory disease treatment was a subcutaneous injection of Micotil at 1.5 ml

[1]Sincere appreciation is expressed to the National Cottonseed Products Association for financial support.

per 100 lb body weight. Heifers were returned to their original pen following treatment. When necessary, calves were retreated after 48 hours, regardless of rectal temperature. The third-time treatment was a combination of 6 ml/100 lb body weight LA® 200 and 5 ml/100 lb body weight Tylan® 200, administered intramuscularly.

Results and Discussion

Table 2 summarizes the performance of heifers during the 28-day receiving experiment. Heifers fed the cotton byproduct pellet consumed more feed ($P<0.01$) but tended to be less efficient than the heifers that were fed alfalfa hay (5.61 vs 4.78 lbs of feed/lb gain). Whether calculated on a deads in or deads out basis, daily gain was comparable between diets. The percentage of heifers diagnosed and treated, or retreated, for respiratory disease were similar.

Our results indicate that a pelleted cottonseed byproduct (65% cottonseed hulls and 35% cottonseed meal) is comparable to alfalfa hay in receiving diets. The bulk density of cottonseed hulls is low and handling is therefore cumbersome. However, blending hulls with cottonseed meal and pelleting offers distinct advantages in terms of transportation, ease of handling, and protein content. When taken together, these factors improve the marketing radius of these byproducts. Therefore, use of cottonseed byproducts may be a viable alternative to alfalfa in receiving diets.

Table 1. Composition of Receiving Diets (100% Dry Basis)

Ingredient, %	Cottonseed Hulls/ Meal Pellet	Alfalfa Hay
Flaked corn	44.65	42.08
Alfalfa hay		40.00
Pelleted cottonseed hulls/meal[a]	40.00	
Cottonseed meal	5.31	8.00
Molasses	6.00	6.00
Vitamin premix	4.04	3.92
Nutrient Analysis		
Dry matter, %	84.7	83.5
Crude protein, %	15.6	15.3
ADF, %	19.4	22.1
Calculated NEg, Mcal/lb	0.51	0.47
Fat, %	3.45	2.46
Phosphorus, %	0.46	0.36
Potassium, %	1.40	1.63
Copper, ppm	10.3	16.8
Zinc, ppm	82.5	89.8
Total starch, %	48.1	41.1

[a]Contained (dry matter basis) 65% cottonseed hulls and 35% cottonseed meal; nutrient composition: 22.0% crude protein, 34.3% crude fiber, 48.6% ADF, 0.21 Mcal/lb NEg, 0.18% calcium, and 0.64% phosphorus.

Table 2. Performance of Feeder Heifers Fed Receiving Diets Containing Alfalfa Hay or Cottonseed Hulls (65%)/Cottonseed Meal (35%) Pellets as Sources of Roughage

Item	Pelleted Cottonseed Hull/Meal	Alfalfa Hay	P[a]
No. pens	12	12	
No. heifers	313	312	
Daily Gain, lb/day			
Deads in basis	2.15	2.22	0.83
Deads out basis	2.64	2.52	0.72
Dry Matter Intake, lb/day	11.8	10.7	<0.01
Feed:Gain			
Deads in basis	5.61	4.78	0.27
Deads out basis	4.52	4.23	0.54
Mortality	3.2	1.9	0.38
Pulled, %	48.8	45.3	0.44
Treated, %	35.7	35.2	0.89
Retreated, %	26.2	23.2	0.38

[a]Probability level that the difference is due to chance.

ALFALFA HAY AND WET CORN GLUTEN FEED LEVELS IN STEAM-FLAKED CORN FINISHING DIETS

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Summary

A 153-day finishing experiment was conducted using 631 heifers to determine optimum alfalfa hay and wet corn gluten feed (WCGF) combinations in steam-flaked, corn-based diets. Diets contained either 2 or 6% alfalfa hay and 25, 35, or 45% WCGF (dry basis). Performance was similar ($P>0.16$) for cattle fed 2 or 6% alfalfa hay. Gain efficiencies ($P<0.05$) and fat thickness ($P<0.10$) declined linearly with increasing amounts of WCGF. For heifers fed 2% alfalfa hay, ribeye area increased with increasing dietary WCGF. However for heifers fed 6% alfalfa hay, ribeye area decreased with increasing dietary WCGF. Liver abscesses were lowest for heifers fed 35% WCGF. Alfalfa hay fed at 2% of diet dry matter is sufficient for steam-flaked corn diets containing 25, 35 or 45% WCGF.

(Key Words: Wet Corn Gluten Feed, Steam-flaked Corn, Finishing Cattle.)

Introduction

Wet corn gluten feed (WCGF) has been incorporated into many feedlot diets in the Northern plains, usually as an energy replacement for grain, and has effectively replaced 30% of steam-flaked corn in finishing diets. However, a large fraction of WCGF is fermentable fiber. Due to their cost per unit of energy and potential to shrink, roughages such as alfalfa hay are burdensome in finishing diets. We hypothesized that WCGF could be utilized as both an energy and roughage source to replace a portion of both alfalfa hay and steam-flaked corn.

Experimental Procedures

Six hundred thirty-one crossbred heifers weighing 626 lb were used in a 153-day finishing experiment. Heifers were randomly allocated to pens and stratified by weight to six treatments (2 pens per diet, 48 to 58 heifers per pen). The steam-flaked corn-based diets consisted of 2 or 6% alfalfa hay and either 25, 35, or 45% WCGF (dry basis) in a 2 × 3 factorial arrangement of treatments. Diet compositions are shown in Table 1.

Heifers were implanted with Synovex®C on day 1 and were adapted to the final finishing diets within 21 days. Cattle were offered *ad libitum* access to diets once daily. Final finishing diets provided 300 mg Rumensin®, 90 mg Tylosin®, and 0.5 mg MGA® per heifer daily. On day 56 heifers were reimplanted with Synovex® Plus. Unconsumed feed was collected, weighed, analyzed for dry matter content, and subtracted from the original feed offered to determine actual feed intakes.

Average daily gain and gain efficiencies were calculated using final weights estimated as hot carcass weight divided by a common dressing percentage (63.3%).

Results and Discussion

Feeding performance and carcass characteristics are summarized in Table 2. Dry

[1]Minnesota Corn Processors Inc., Marshall, MN.

matter intake, average daily gain and gain efficiencies were similar (P>0.16) for cattle fed 2 or 6% alfalfa hay, which suggest that feeding 2% alfalfa hay is sufficient roughage for cattle fed these diets. Dry matter intake tended to increase (P=0.19) as the level of WCGF increased; however, average daily gain was not different (P>0.70). This resulted in poorer (P<0.05) feed efficiencies as dietary WCGF increased. We observed an interaction (P<0.10) between levels of alfalfa hay and levels of WCGF for ribeye area. For heifers fed 2% alfalfa hay, ribeye area increased with increasing WCGF. However for heifers fed 6% alfalfa hay, ribeye area decreased with increasing WCGF. Fat thickness decreased linearly (P<0.10) as the level of WCGF increased, suggesting a decline in dietary energy with additional WCGF. Although the occurrence of liver abscesses was low (averaging 2.7%), it was lowest when 35% WCGF was fed, implying that a more suitable rumen environment was maintained.

Heifer performance was not affected by reducing alfalfa hay levels to 2% of diet dry matter. Gains were less efficient and carcasses were leaner with increasing levels of WCGF. Alfalfa hay and wet corn gluten feed levels created an interaction for ribeye area.

Table 1. Composition of Experimental Diets (% of diet dry matter)

	Level of Wet Corn Gluten Feed					
	2% Alfalfa Hay			6% Alfalfa Hay		
Ingredient	25%	35%	45%	25%	35%	45%
Flaked corn	63.6	55.1	46.3	60.4	51.6	42.4
Wet corn gluten feed	23.5	33.2	43.1	23.6	33.3	43.2
Alfalfa hay	1.9	1.9	2.0	5.8	5.8	5.9
Tallow	3.0	3.0	3.0	3.0	3.0	3.0
R-T-MGA premix[1]	2.6	2.6	2.5	2.6	2.5	2.6
Soybean meal	2.0	1.0	-	1.4	0.7	-
Urea	1.0	0.9	0.8	1.0	0.9	0.8
Limestone	1.6	1.6	1.6	1.5	1.5	1.5
Sodium chloride	0.3	0.3	0.3	0.3	0.3	0.3
Potassium chloride	0.4	0.3	0.3	0.3	0.3	0.2
Vitamin/trace mineral premix[2]	0.1	0.1	0.1	0.1	0.1	0.1
Nutrient, analyzed						
Dry matter, %	69.3	64.0	59.3	69.2	63.9	59.3
Crude protein, %	14.7	15.0	15.2	14.7	14.9	15.3
Calcium, %	0.7	0.7	0.7	0.6	0.6	0.7
Phosphorus, %	0.3	0.3	0.4	0.3	0.3	0.4

[1]R-T-MGA premix formulated to provide: 300 mg/heifer/day Rumensin, 90 mg/heifer/day Tylosin, and 0.5 mg/heifer/day MGA.

[2]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,000 IU/lb Vitamin A, 0.13 ppm cobalt, 0.63 ppm iodine, 60 ppm manganese, 0.25 ppm selenium, 60 ppm zinc, 10 ppm thiamin, 10 ppm copper, and 2 ppm iron.

Table 2. Finishing Performance and Carcass Characteristics

	Level of Wet Corn Gluten Feed						
	2% Alfalfa Hay			6% Alfalfa Hay			
Item	25%	35%	45%	25%	35%	45%	SEM
No. of heifers	105	105	104	105	106	106	
Initial weight, lb	628	625	630	623	626	625	12.3
Final weight, lb	1109	1108	1110	1105	1114	1104	20.1
Dry matter intake, lb/day	16.7	17.5	17.3	17.2	17.9	17.6	0.37
Average daily gain, lb	2.55	2.55	2.55	2.56	2.58	2.51	0.049
Feed:gain[a]	6.54	6.85	6.80	6.67	6.94	6.99	0.015
Hot carcass weight, lb	672	673	672	676	683	662	12.6
Dressing percentage	63.1	63.3	63.1	63.7	63.8	62.5	0.38
Ribeye[b] area, in^2	12.5	12.5	12.9	12.6	12.5	12.2	0.16
KPH[c], %	2.3	2.3	2.2	2.4	2.5	2.3	0.11
Fat thickness[d], in	0.48	0.47	0.43	0.48	0.50	0.45	0.018
USDA yield grade							
Yield grade 1, %	9	10	10	6	7	6	2.6
Yield grade 2, %	32	27	42	34	32	37	6.0
Yield grade 3, %	46	56	44	50	48	47	5.3
Yield grade 4 & 5, %	14	5	14	8	10	10	3.8
Marbling score[e]	Sm^{20}	Sm^{20}	Sm^{14}	Sm^{65}	Sm^{24}	Sm^{29}	20.5
USDA quality grade							
Prime & Choice, %	59	55	57	68	60	60	8.6
Select, %	39	43	40	30	38	37	8.7
Standard, %	2	2	1	1	2	3	1.7
Dark cutters, %	0	0	1	0	0	0	0.4
Liver abscesses[f], %	2.7	1.9	2.8	4.7	0.9	2.9	.76

[a]Wet corn gluten feed level, linear effect ($P<0.05$).

[b]Alfalfa hay × wet corn gluten feed interaction ($P<0.10$).

[c]KPH = Kidney, pelvic & heart fat.

[d]Wet corn gluten feed level, linear effect ($P<0.10$).

[e]Sm = Small.

[f]Wet corn gluten feed level, quadratic effect ($P<0.05$).

ADDITION OF UREA TO FINISHING CATTLE DIETS CONTAINING STEAM-FLAKED CORN AND WET CORN GLUTEN FEED

S. P. Montgomery, J. S. Drouillard, J. J. Sindt, T. B. Farran, N. J. Pike, C. M. Coetzer, H. J. LaBrune, A. M. Trater, R. D. Hunter, and R. A. Stock [1]

Summary

Three hundred thirty-nine crossbred beef heifers were used in a 74-day finishing study to evaluate effects of adding 0.5% urea to finishing diets containing steam-flaked corn and 34% (dry basis) *Sweet Bran*® wet corn gluten feed (WCGF). Diets were fed once daily *ad libitum*. Urea addition tended (P<0.06) to increase finishing average daily gain, to improve (P<0.12) feed efficiency, and to increase (P<0.06) fat thickness. Heifers fed urea had a lower percentage (P<0.03) of carcasses grading USDA Choice. This study suggests that finishing diets containing a combination of steam-flaked corn and WCGF may benefit from addition of urea as a source of supplemental ruminally available nitrogen.

(Key Words: Wet Corn Gluten Feed, Urea, Finishing.)

Introduction

Cattle consuming corn-based finishing diets normally require supplemental ruminally available nitrogen sources such as urea or soybean meal to optimize ruminal starch fermentation. Because WCGF contains a degradable intake protein fraction similar to that of soybean meal, our objective was to determine if adding urea to diets containing WCGF would result in further performance improvements.

Experimental Procedures

Three hundred thirty-nine beef heifers averaging 804 lb were used in a randomized complete block design experiment. Heifers were blocked by previous nutritional regimen, and treatments were randomly assigned to pens containing four to seven heifers per pen, with 27 pens per treatment. Treatments (Table 1) consisted of steam-flaked corn finishing diets containing 34% *Sweet Bran* WCGF with or without 0.5% urea (dry matter basis). Diets were fed once daily *ad libitum* for 74 days, and then heifers were slaughtered and carcass data were obtained.

Results and Discussion

Performance data was shown in Table 2. Average daily gains (P<0.06) and feed efficiencies (P<0.12) tended to be improved with urea supplementation. Backfat thickness also tended (P<0.06) to be increased with urea supplementation. In spite of the tendency for increased 12th rib fat, the percentage of carcasses grading USDA Choice or Prime was greater for cattle fed no urea. We conclude that steam-flaked corn finishing diets containing 34% WCGF (dry matter basis) may benefit from the addition of a ruminally available nitrogen source such as urea.

[1]Cargill Corn Milling, Blair, NE.

Table 1. Experimental Diets

Ingredients	Treatments	
	No Urea	Urea
	----------% of Dry Matter----------	
Steam-flaked corn	55.8	55.3
Alfalfa hay	6.0	6.0
Wet corn gluten feed	33.8	33.8
Tallow	2.1	2.1
Urea	-	0.5
Limestone	1.6	1.6
Sodium chloride	0.3	0.3
Potassium chloride	0.3	0.3
Vitamin/trace mineral premix[a]	0.1	0.1
Crude protein, analyzed	14.9	16.1
	---------- Per Head Daily[b] ----------	
Rumensin®	300 mg	300 mg
Tylang	90 mg	90 mg
Melengestrol acetate	0.5 mg	0.5 mg

[a]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,200 IU/Ib vitamin A, 0. 1 ppm cobalt, 20 ppm copper, 0.5 ppm iodine, 50 ppm manganese, 0.2 ppm selenium, and 50 ppm zinc. [b]Rumensin/Tylan/Melengestrol Acetate supplement fed at 0.44 lb per head per day (dry matter basis).

Table 2. Effects of Urea on Performance and Carcass Characteristics

Item	Treatment		SEM	P-value
	Control	Urea		
No. of heifers	167	172		
Initial weight, lb	806	802	6.4	0.71
Final weight, lb[a]	1058	1066	8.4	0.52
Dry matter intake, lb/day	20.3	20.6	0.20	0.28
Average daily gain, lb	3.41	3.56	0.05	0.06
Feed:gain	5.95	5.78	0.07	0.12
Hot carcass weight, lb	670	676	5.3	0.52
Dressing percentage[b]	60.8	60.9	0.2	0.68
Ribeye area, in^2	12.5	12.5	0.14	0.93
Fat thickness, in	0.40	0.44	0.01	0.12
Kidney, pelvic & heart fat, %	2.2	2.2	0.03	0.15
Liver abscesses, %	3.6	2.3	1.3	0.52
Yield grade 1, %	13	11	2.5	0.54
Yield grade 2, %	40	40	3.8	0.96
Yield grade 3, %	42	43	3.8	0.83
Yield grade 4 & 5, %	5	6	2.4	0.50
Marbling score[c]	Sm^{22}	Sm^{14}	7.5	0.45
USDA Prime, %	3	4	1.2	0.57
USDA Choice, %	64	51	3.7	0.03
USDA Select, %	31	40	3.7	0.10
USDA Standard, %	1	4	1.1	0.15
Dark cutters, %	1	1	0.8	0.92

[a]Final weight = hot carcass weight ÷. common dressed yield of 63.36%. [b]Dressing percent = hot carcass weight ÷ live weight before shrink. [c]Sm = Small.

COMBINATIONS OF WET CORN GLUTEN FEED AND STEAM-FLAKED CORN IN FINISHING CATTLE DIETS: EFFECTS ON ACID-RESISTANT *E. COLI* AND COLIFORMS, VFA PROFILES AND PH

J. J. Sindt, J. S. Drouillard, H. Thippareddi, R. K. Phebus, D. L. Lambert, T. B. Farran, S. P. Montgomery, H. J. LaBrune, and J. J. Higgins [1]

Summary

Finishing beef steers (615 head) were used in a 152-day experiment to evaluate the effects of feeding 80:0, 60:30 or 30:60 ratios (dry basis) of steam-flaked corn and wet corn gluten feed (WCGF, 30WCGF, 60WCGF) on acid-resistant *E. coli* and coliforms. On days 114 to 118 ruminal and fecal samples were collected from 180 steers and analyzed for pH, VFA, and total and acid-resistant *Escherichia coli* (*E. coli*) and coliforms. Ruminal (P=0.13) and fecal (P=0.10) VFA tended to decrease linearly as CGF increased. Consequently, there was a corresponding numerical linear increase in ruminal pH and a significant linear increase in fecal pH (P<0.05). Total and acid-resistant *E. coli* and coliforms, however, were not affected (P>0.10) by dietary treatment.

(Key Words: *E. coli*, Food Safety, Finishing Cattle.)

Introduction

Recent research has indicated that adding hay to the diets of grain-fed cattle 4 days prior to slaughter can impact fermentation patterns and alter the acid-resistant microbial population in the feces, specifically *E. coli*. Feedlot diets typically contain a large portion of starch from grain sources. In highly processed grains, the rumen is the main site of starch digestion and volatile fatty acid production. However, some of this grain starch passes to the lower gastrointestinal tract and is fermented in the cecum and colon. This passage of starch and the resulting acid production may cause *E. coli* to develop acid-resistance.

Wet corn gluten feed (WCGF) is a high energy, low-starch feedstuff that has been used as an energy source in high-grain diets. We hypothesized that the fibrous, low-starch characteristics of WCGF, could be utilized to manipulate ruminal and fecal organic acid concentrations, thus preventing development of acid resistance among coliform bacteria.

Experimental Procedures

Six hundred fifteen crossbred beef steers (average wt 649 lb) were fed diets containing either 80:0 (WCGF), 60:30 (30WCGF), or 30:60 (60WCGF) ratios of steam-flaked corn and WCGF throughout a 152-day finishing experiment. Diet compositions are shown in Table 1. Steers were blocked by previous treatment and randomly allocated to the three diets (four pens per diet with 48 to 53 steers per pen). Rumen fluid (collected via rumenocenteses) and feces were obtained from 180 steers (three animals per pen on each sampling day) on days 114 to 118. Samples of rumen fluid and feces were incubated for 1 hour in citric acid/sodium phosphate buffer solutions at pH 2, 4, and 7 for determination of total and acid-resistant *E. coli* and coliforms. After incubation the samples subjected to the pH 2 and 4 buffers were neutralized with 1 M NaOH solution and placed on ice. Samples were serially diluted, plated onto Petrifilm™ plates, incubated at 37°C for 24 to 48 hours, and enumerated.

[1]Department of Statistics.

Results and Discussion

Ruminal volatile fatty acid (VFA) concentration and fecal VFA concentrations tended to decrease linearly as WCGF was added to the diet (Figure 1). Consequently, there was a corresponding linear increase for ruminal and fecal pH ($P<0.05$) (Figure 2). Despite the shift in fermentation patterns, *E. coli* and coliform counts in ruminal fluid and fecal samples of cattle fed different diets were similar ($P>0.10$) at pH buffer treatments 2, 4, and 7 (Table 2). This suggests that ruminal and fecal acid concentrations, which were all above pH 6, were not acidic enough for coliform bacteria to develop acid resistance. The molar proportion of ruminal and fecal acetate increased linearly ($P<0.05$), and the molar proportion of ruminal and fecal propionate decreased linearly ($P<0.05$) as WCGF was added to the diet, suggesting that fermentation of fiber replaced that of starch in both the rumen and hindgut as more WCGF was fed (Figures 3 and 4).

Addition of WCGF to finishing diets altered VFA concentrations and increased pH; however, no differences were observed with respect to numbers of *E. coli*, total coliforms, acid-resistant *E. coli*, or acid-resistant coliforms.

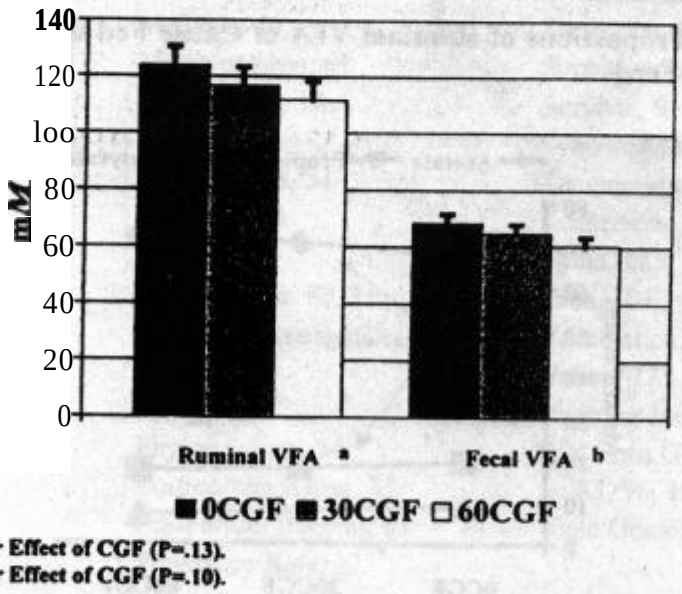
Table 1. Composition of Experimental Diets (% of diet dry matter)

	Dietary Wet Corn Gluten Feed		
Ingredient	0%	30%	60%
Flaked corn	81.60	58.37	30.21
Alfalfa hay	6.71	-	6.97
Molasses	3.72	-	-
Tallow	2.01	2.05	2.09
Wet corn gluten feed	-	28.64	58.51
Soybean meal	2.83	1.44	-
Urea	1.21	0.79	0.36
Limestone	1.18	1.28	1.39
Sodium chloride	0.29	0.29	0.30
Potassium chloride	0.04	0.02	-
Ammonium sulfate	0.19	0.10	0.10
Calcium phosphate	0.12	0.06	0.06
Vitamin/trace mineral premix[1]	0.10	0.10	0.10
Nutrient, analyzed			
Dry matter, %	83.4	65.0	53.0
Crude protein, %	14.9	15.2	15.4
Calcium, %	0.66	0.70	0.75
Phosphorus, %	0.29	0.35	0.41
Thiamin, ppm	-	7.5	15
Copper, ppm	8.3	12.2	16.0

[1]Vitamin/trace mineral premix formulated to provide (total diet dry matter): 1,200 IU/lb vitamin A, 0.10 ppm cobalt, 0.52 ppm iodine, 50 ppm manganese, 0.25 ppm selenium, 50 ppm zinc, 30 grams/ton Rumensin®, and10 grams/ton Tylan®.

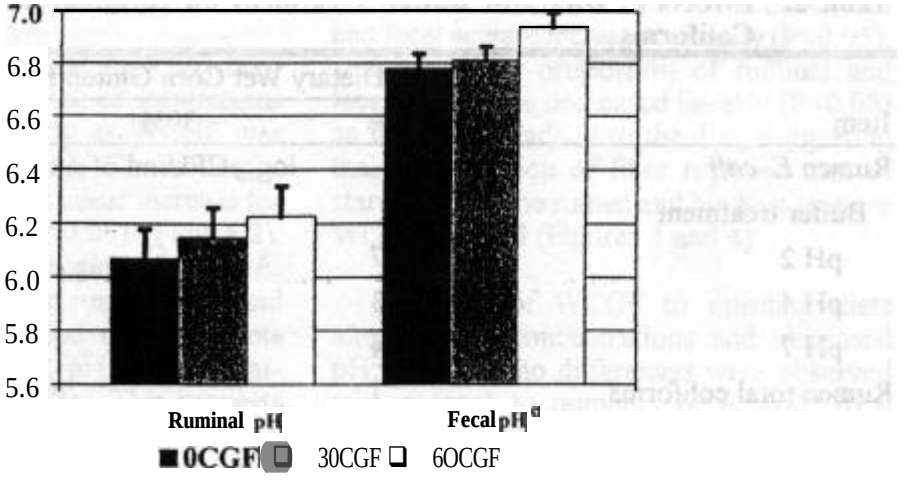
Table 2. Effects of Diet and Buffer Treatment on Ruminal and Fecal *E. coli* and Coliforms

item	Dietary Wet Corn Gluten Feed 0%	30%	60%	SEM
Rumen *E. Coli*	----------log_{10} CFU/ml of rumen fluid----------			
Buffer treatment				
pH2	1.7	1.5	1.5	0.27
pH4	3.3	3.9	3.2	0.29
pH7	4.4	4.6	4.5	0.25
Rumen total coliforms				
Buffer treatment				
pH2	1.8	1.6	1.6	0.29
pH4	3.8	4.4	3.8	0.30
pH7	4.6	4.8	4.8	0.25
Fecal *E. coli*	----------log_{10} CFU/g of dry feces----------			
Buffer treatment				
pH2	7.1	8.8	9.0	1.90
pH4	34.6	37.4	36.5	2.14
pH7	38.1	39.9	40.2	2.30
Fecal total coliforms				
Buffer treatment				
pH2	7.1	9.4	9.9	2.18
pH4	35.2	38.4	37.5	2.12
pH7	38.8	40.8	41.1	2.32



[a]Linear Effect of CGF (P=.13).
[b]Linear Effect of CGF (P=.10).

Figure 1. Total Ruminal and Fecal VFA Concentrations of Cattle Fed 0, 30, or 60% Wet Corn Gluten Feed.



'Linear effect of CGF (P<.05).

Figure 2. Ruminal and Fecal pH of Cattle Fed 0,30, and 60% Wet Corn Gluten Feed.

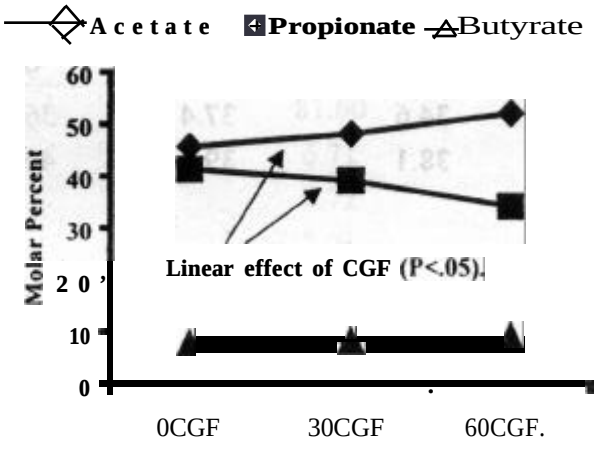


Figure 3. Molar Proportions of Ruminal VFA of Cattle Fed 0, 30, or 60% Wet Corn Gluten Feed.

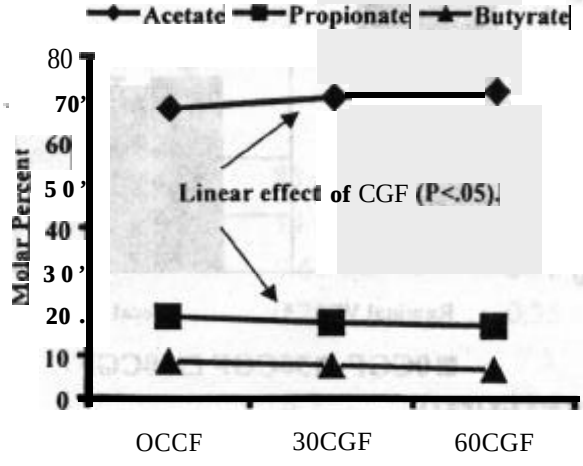


Figure 4. Molar Proportions of Fecal VFA of Cattle Fed 0,30, or 60% Wet Corn Gluten Feed.

INDEX OF KEY WORDS

Indexer's note: The numbers refer to the first pages of each article that uses the listed key word.

BIOLOGICAL VARIABILITY AND STATISTICAL EVALUATION OF DATA

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

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

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

You may see an average given as 2.5 ± .1. The 2.5 is the average; .1 is the "standard error." That means there is a 68% probability that the "true" mean (based on an unlimited number of animals) will be between 2.4 and 2.6. "Standard deviation" is a measure of variability in a set of data. One standard deviation on each side of the mean is expected to contain 68% of the observations.

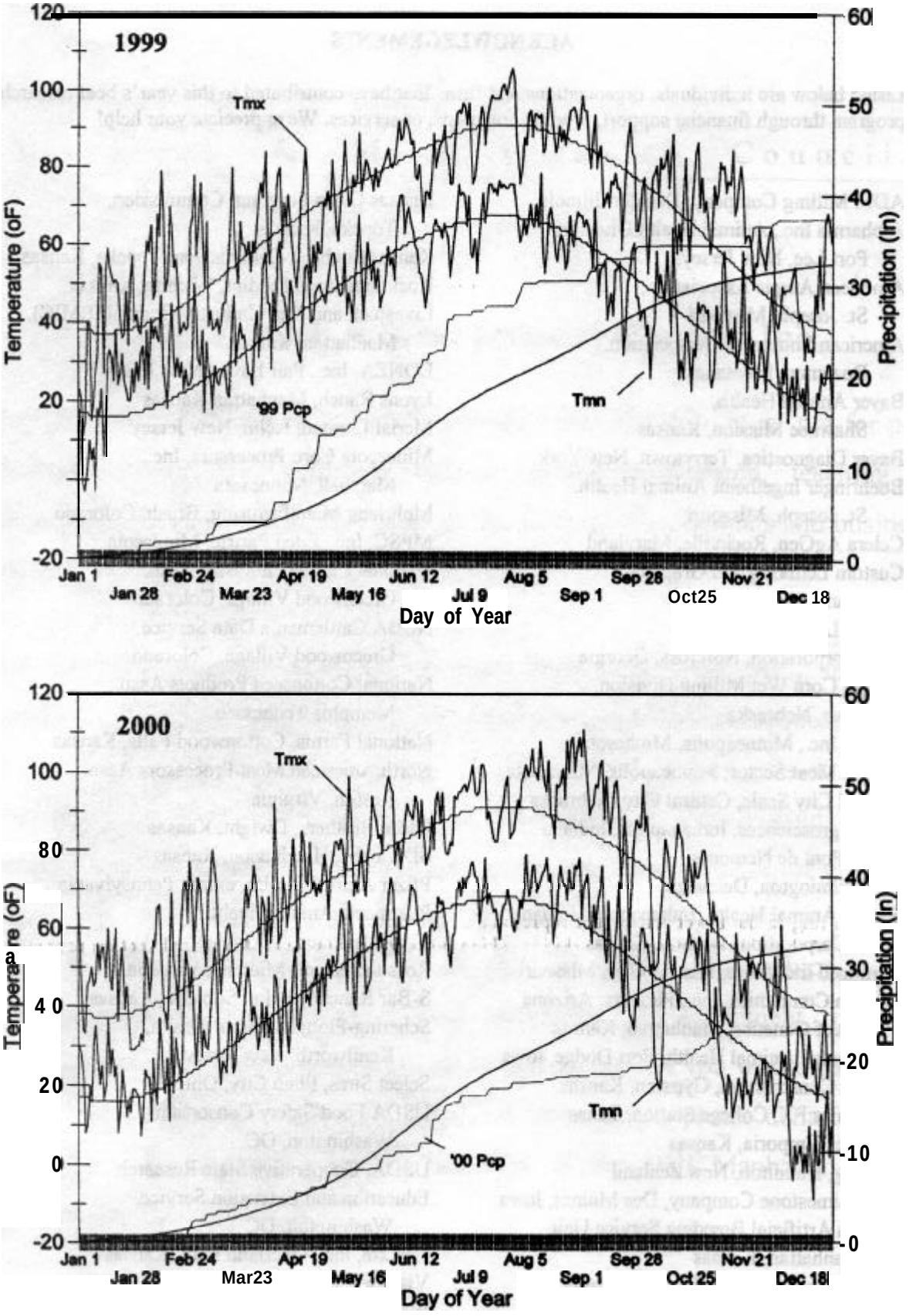
Many animals per treatment, replicating treatments several times, and using uniform animals all increase the probability of finding real differences when they actually exist. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals in an experiment. In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

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

WEATHER DATA, 1999-2000

On the following page are graphs of the 1999 and 2000 Manhattan weather. They were produced by the Kansas State University Weather Data Library. The smooth line that starts in the lower left corner of each graph is the normal accumulated precipitation since January 1. The rough line starting in the lower left corner represents actual accumulated precipitation. A long horizontal section of that line represents time during which no precipitation fell. A vertical section represents precipitation. The other two smooth lines represent average daily high and low temperatures, and the rough lines represent actual highs and lows.

These graphs are included because much of the data in this publication, especially data on animal maintenance requirements and forage yields, can be influenced by weather. Weather graphs have been included in Cattlemen's Day publications since 1985.



Summaries of Weather in Manhattan, KS, 1999 and 2000

ACKNOWLEGEMENTS

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

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American Simmental Association, Bozeman, Montana
Bayer Animal Health, Shawnee Mission, Kansas
Bayer Diagnostics, Terrytown, New York
Boehringer Ingelheim Animal Health, St. Joseph, Missouri
Celera AgGen, Rockville, Maryland
Custom Lettering and Graphics, Manhattan, Kansas
Borck, Larned, Kansas
Brill Corporation, Norcross, Georgia
Cargill Corn Wet Milling Division, Blair, Nebraska
Cargill Inc., Minneapolis, Minnesota
Cargill Meat Sector, Minneapolis, Minnesota
Central City Scale, Central City, Nebraska
Dow Agrosciences, Indianapolis, Indiana
E.I. duPont de Nemours, Wilmington, Deleware
Elanco Animal Health, Indianapolis, Indiana
Excel Corporation, Wichita, Kansas
Farmland Industries, Kansas City, Missouri
Farnam Companies, Inc., Phoenix, Arizona
Fink Beef Genetics, Manhattan, Kansas
Fort Dodge Animal Health, Fort Dodge, Iowa
Frisbie Construction, Gypsum, Kansas
Genomics FX, College Station, Texas
ibp, inc., Emporia, Kansas
InterAg, Hamilton, New Zealand
Iowa Limestone Company, Des Moines, Iowa
Kansas Artificial Breeding Service Unit, Manhattan, Kansas
Kansas Beef Council, Topeka, Kansas
Kansas Livestock Assn., Topeka, Kansas
Kansas Corn Commission, Topeka, Kansas
Kansas Grain Sorghum Commission, Topeka, Kansas
Kansas Soybean Commission, Topeka, Kansas
Kock Industries Feedlot, Wichita, Kansas
Livestock and Meat Industry Council (LMIC), Manhattan, Kansas
LONZA, Inc., Fair Lawn, New Jersey
Lyons Ranch, Manhattan Kansas
Merial Limited, Iselin, New Jersey
Minnesota Corn Processors, Inc., Marshall, Minnesota
Mohrlang Manufacturing, Brush, Colorado
MPSC, Inc., Eden Paririe, Minnesota
National Cattlemen's Beef Assn, Greenwood Village, Colorado
NCBA Cattlemen's Data Service Greenwood Village, Colorado
National Cottonseed Products Assn., Memphis Tennessee
National Farms, Cottonwood Falls, Kansas
North American Meat Processors Assn. Reston, Virginia
Oleen Brothers, Dwight, Kansas
SDK Labs, Hutchinson, Kansas
Pfizer Animal Health, exton, Pennsylvania
Pharmacia Animal Health, Kalamazoo, Michigan
Ross Industries, Midland, Virginia
S-Bar Ranch Feedlot, Sublette, Kansas
Schering-Plough Animal Health, Kenilworth, New Jersey
Select Sires, Plain City, Ohio
USDA Food Safety Consortium, Washington, DC
USDA, Cooperative State Research Education and Extension Service, Washington, DC
VetLife, Inc., Overland Park, Kansas
Viskase Corp., Chicago, Illinois
West Texas A&M University Canyon, Texas

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

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