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2004 Cattlemen's Day

Report of Progress 923

Kansas State University
Agricultural Experiment Station
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UPDATE ON BOVINE SPONGIFORM ENCEPHALOPATHY

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Bovine Spongiform Encephalopathy, commonly called "mad cow disease" by members of the media, found its way into the United States and was diagnosed in December, 2003, in a Holstein dairy cow of Canadian origin. A significant disruption to the beef cattle industry immediately followed the announcement of this finding; within a matter of weeks, however, a degree of normalcy began to return to the industry. When consumers and cattle producers alike learned of the extensive firewall system that had been put in place years earlier by the USDA and the FDA to reduce the likelihood of entry of this disease into the nation's cow herd and into the human food supply, coupled with immediate further tightening of the control program requirements, their confidence that the threat of this disease was being handled properly was heightened.

BSE History

The first case of bovine spongiform encephalopathy (BSE) was discovered in the United Kingdom (U.K.) in 1986. United States animal-health officials began following the situation as additional new cases were reported in the United Kingdom. When it was finally determined that U.K. officials were dealing with a new cattle disease that was affecting additional herds, the USDA reacted proactively to reduce the likelihood that the disease would find its way into the United States cattle herd. BSE was made a notifiable disease in the United States in 1987, months before it was made a notifiable disease in the United Kingdom. In 1989, the United States imposed a ban on import of live ruminants and most ruminant products from countries having BSE. At that time, a trace back was also initiated on all cattle imported to the United States from the United Kingdom since 1986. Imported herds were depopulated or quarantined, and individual cattle were checked when they died or were retired from production. In 1990, the United States began a BSE surveillance program, performing histological examinations of brains of cattle. Federal and state animal diagnostic laboratories began checking for lesions of BSE any time cattle brains were submitted for other diagnostic testing. In 1997, the FDA instituted a ban on mammalian protein in ruminant feed. In 2000, the USDA began targeted, intensified surveillance of non-ambulatory cattle. In 2003, approximately 20,000 animals were tested for BSE. These firewalls were all in place before the first case of BSE was found in the United States. Routine surveillance found the BSE-positive animal from Canada when she was offered for slaughter. The system worked.

The firewalls in place in the United States are similar to those implemented in the United Kingdom after BSE began to expand in their cattle herds. The success of such firewalls in reducing new cases of BSE in the United Kingdom are shown in Figure 1.

Additional Changes

Once BSE was confirmed in the dairy cow from Canada, the USDA put additional safe-

guards in place to further ensure the safety of the human food supply. Non-ambulatory cattle were banned from the human food chain. Specific risk material (SRM), including skull, brain, trigeminal ganglia, eyes, vertebral column, spinal cord, and dorsal root ganglia of cattle more than 30 months of age, and the lower portion of the small intestine of cattle of all ages, were also banned from the human food chain. The carcasses of normal cattle being targeted or randomly tested for BSE would be held until test results indicated the cattle were negative for BSE. The air-injection stunning of cattle was banned. Mechanically separated meat was banned from human food. The head and vertebral column were banned for use in advanced meat recovery (AMR). And last, but not least, a verifiable system of national animal identification was to be instituted.

Next Steps

The USDA will continue trace-back efforts to find all animals that came from Canada with the initial BSE cow. USDA surveillance will be stepped up at all levels of cattle production. Cattle producers, veterinarians, animal-feed manufacturers, rendering-plant operators, and processors producing food for human consumption need to assume their respective roles in keeping the firewalls up and ensuring that the effects of any incursion of BSE into the United States are minimized.

References

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Stokka et al., 2000. Bovine Spongiform Encephalopathy. Kansas State University.

USDA News Release. 2003. Veneman announces additional protection measures to guard against BSE. www.usda.gov

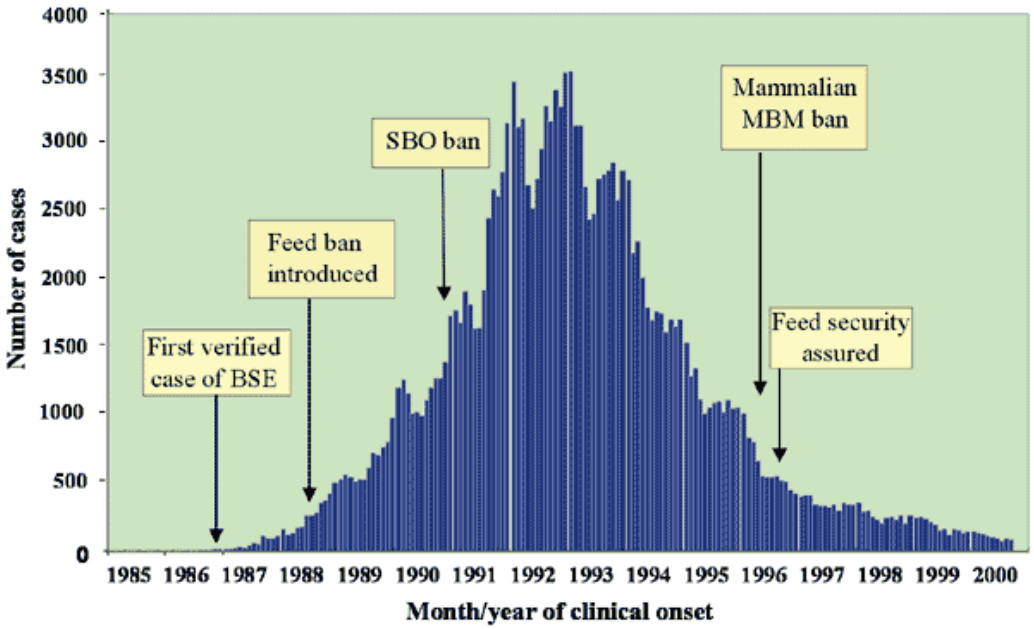

Figure 1. New Cases of BSE in the United Kingdom.

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Bovine Spongiform Encephalopathy

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Bovine spongiform encephalopathy (BSE) is a slowly progressing fatal disease affecting the central nervous system of cattle. The disease was first diagnosed in Great Britain in 1986 and belongs to a family of disease known as transmissible spongiform encephalopathies (TSE's). A number of diseases of animals including scrapie, chronic wasting disease, and transmissible mink encephalopathy; as well as the human diseases, Creutzfeld-Jacob disease, kuru, and Gerstmann-Straussler-Scheinker syndrome are other example of TSE's. The causative agent of these TSE's is an incompletely characterized infectious agent known as an unconventional virus or prion.

BSE Epidemic

Since 1986, approximately 176,000 cases of BSE have occurred among nearly 34,000 herds mostly in the United Kingdom (UK). The epidemic peaked in January 1993 with nearly 1,000 new cases reported weekly. Approximately two-thirds of the dairy herds in the UK have had at least one case of BSE, while only one in six beef herds have reported cases. The outbreaks in the UK are believed to have resulted from the feeding of scrapie-containing sheep meat-and-bone meal. Accordingly, there is general agreement that the outbreak was increased by feeding bovine meat-and-bone meal to young calves. Subsequently, in July 1988, ruminant protein in ruminant feed was banned. The ban significantly diminished the incidence of new clinical cases in five years, which is the incubation period of the disease. However, approximately 36,000 new cases have been diagnosed since the ban, which indicates the ban was not totally effective. Consequently, a ban from feeding any mammalian protein to any farm animal species was implemented in the United Kingdom in 1996. The number of new cases continues to decline at a steady rate.

Clinical Signs

Affected animals may display changes in temperament, such as nervousness or aggression, abnormal posture, incoordination, difficulty in rising, and decreased milk production despite continued appetite. Initial clinical signs may be quite subtle and mainly behavioral in nature. The signs progress over weeks to months with the animals condition deteriorating from 2 to 6 months and most reaching a terminal state by 3 months. Upon clinical diagnosis with some certainty, euthanasia is advisable as animals may become unmanageable and their welfare is at risk.

Diagnosis

There is no reliable test to detect the disease in live animals. Microscopic examination of brain tissue at necropsy is the primary laboratory method used to confirm a diagnosis of bovine spongiform encephalopathy. Also, immunohistochemistry and immunoblotting are used to detect the disease agent.

PREVENTION

There has not been one reported case of BSE in native cattle in North America, although Canada has one confirmed case of an infected

cow imported from Great Britain. Because treatment of BSE has proved ineffective, the infected cow was destroyed as well as all herd mates and any animals that were determined at risk.

Many countries and governmental agencies have implemented programs to slow and prevent the spread of the disease. The United States Department of Agriculture (USDA) has formed a proactive and preventive policy, which has taken measures in surveillance, prevention, education, and response. The Animal Plant Health Inspection Service (APHIS) has created a TSE working group to analyze risks to the United States and is sharing information with the Center for Disease Control, Food and Drug Administration, the National Institute of Health, and the Food Safety and Inspection Service.

Restrictions began in 1989 with the banning of importation of ruminants, bovine serum, embryos, and meat-and-bone meal from the United Kingdom. Surveillance began in 1990 with a program including histological examination of brain tissue of high risk cattle, and the traceback of cattle imported from the UK. Accordingly, on August 4, 1997, the FDA established guidelines that prohibit the feeding of most mammalian proteins to ruminants. As of December 1997, APHIS has prohibited the importation of live ruminants and most ruminant products from Europe until a thorough assessment of the risk is made.

Under title 9 code of federal regulations, parts 71 and 161, BSE is a reportable disease by accredited veterinarians. The USDA has trained more than 250 state and federal veterinarians located throughout the United States in the recognition of BSE. Any person or veterinarian suspecting an animal of BSE should report the animal immediately to the nearest diagnostic laboratory and the state veterinarian.

Further Reading

Center for Disease Control
http://www.cdc.gov/

European Government
http://www.maff.goc.uk/animal/bse

Food and Drug Administration
http://www.fda.gov/cvm

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

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ESTRUS SYNCHRONIZATION OF REPLACEMENT BEEF HEIFERS BY USING GnRH, PROSTAGLANDIN $F_{2\alpha}$ (PGF), AND PROGESTERONE (CIDR): A MULTI-LOCATION STUDY[1]

J. E. Larson[2], G. C. Lamb[2], T. W. Geary[3], J. S. Stevenson, S. K. Johnson, M. L. Day[4], D. J. Kesler[5], J. M. DeJarnette[6], D. G. Landblom[7], and D. Whittier[8]

Summary

Our objectives were to determine whether a fixed-timed artificial insemination (TAI) protocol could yield similar fertility rates to a protocol requiring detection of estrus and whether an injection of gonadotropin hormone-releasing hormone (GnRH) at CIDR (vaginal insert containing progesterone) insertion enhances pregnancy rates. Replacement beef heifers (n=2,077) from 12 locations were assigned randomly to each of four estrus-synchronization protocols. All heifers received a CIDR for 7 days, and an injection of prostaglandin $F_{2\alpha}$ (PGF) on the day of CIDR removal. For treatment EAI, heifers were observed for estrus for 84 hours after PGF administration and were inseminated 6 to 12 hours after observed estrus. Any heifer not detected in estrus was injected with GnRH, followed by TAI. For treatment GnRH+EAI, heifers were treated as those for EAI, but also received GnRH at the time of CIDR insertion. For treatment TAI, heifers received a single TAI at 60 hours after PGF administration. For treatment GnRH+TAI, heifers were treated as those for TAI, but also received GnRH at CIDR insertion. The percentage of heifers cycling at the initiation of estrus-synchronization was 91%; the percentage of cycling heifers among locations ranged from 78 to 100%. Overall pregnancy rates among locations ranged from 38 to 74%. Pregnancy rates were 57.3, 54.5, 53.1, and 49.1% for GnRH+EAI, EAI, GnRH+TAI, and TAI, respectively. Although no statistically significant differences in pregnancy rates among treatments were observed, the GnRH+EAI treatment achieved the numerically greatest pregnancy rates. In addition, the GnRH+TAI protocol provides an alternative that allows producers to synchronize heifers without detection of estrus.

Introduction

Synchronization of estrus shortens the calving season, increases calf uniformity, and enhances the possibilities for using artificial

[1]Sincere appreciation is expressed to Whisper Alexander, Chad Bailey, Sue Bellows, Matt Bartlett, Brian Gray, Tony Krizek, Keith Harmoney, Dan Brown, John Hall, George Perry, and Rud Wasson for their support in data collection and technical service. We acknowledge Losey Land and Cattle Co. for their participation in this study.

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insemination (AI). The EAZI-BREED CIDR® (CIDR; Pharmacia Animal Health, Kalamazoo, MI) was recently approved by the U.S. Food and Drug Administration for synchronizing estrus in replacement beef heifers. The CIDR is a vaginal insert that contains 1.38 g of progesterone, which is gradually released over a period of days. Until the approval of the CIDR, the orally administered melengestrol acetate (MGA) was the primary progestin used for synchronizing estrus in beef heifers. Although excellent pregnancy rates can be achieved by using a protocol with MGA and prostaglandin $F_{2\alpha}$ (PGF), the time from initiating the protocol until insemination is more than 33 days, and this can be a drawback. In addition, no reliable TAI protocol exists for synchronizing estrus in beef heifers. Therefore, the objectives of this study were to determine whether: 1) a TAI protocol could yield fertility similar to a protocol requiring detection of estrus; and 2) an injection of GnRH at CIDR insertion enhances pregnancy rates.

Materials and Methods

Estrus in 2,077 replacement beef heifers from 12 locations was synchronized, and artificial insemination occurred after four treatments (Figure 1): 1) heifers received a CIDR insert for 7 days, with 25 mg of PGF on the day of CIDR removal, followed by detection of estrus and AI during 84 hours. Any heifer not detected in estrus by 84 hours received 100 μg of GnRH and was inseminated (**EAI**; n=517); 2) heifers were treated and inseminated as EAI heifers, but also received 100 μg of GnRH at the time of CIDR insertion (**GnRH+EAI**; n=504); 3) heifers received a CIDR insert for 7 days, with 25 mg of PGF on the day of CIDR removal, followed in 60 hours by a second injection of GnRH and one TAI (**TAI**; n=531); and 4) heifers were treated and inseminated as TAI heifers but also received 100 μg of GnRH at the time of CIDR insertion (**GnRH+TAI**; n=525).

Pregnancy was diagnosed by transrectal ultrasonography between 30 and 35 days after AI. Clean-up bulls were not introduced until a minimum of 10 days after treatment inseminations.

Blood samples were collected on days –17 and –7 relative to the injection of PGF. Blood sera were analyzed for progesterone concentration to determine cycling status. Body condition scores were assessed on day –17. The statistical model to evaluate pregnancy rates included treatment, location, and cycling status, with body condition score as a regression variable.

Results and Discussion

Percentage of heifers cycling at the initiation of estrus-synchronization was 91.0% (1,350 of 1,518 heifers). Percentages of cycling heifers among locations ranged from 78 to 100%. Overall pregnancy rates at days 30 to 35 after AI ranged from 38 to 74% among locations (Figure 2).

Pregnancy rates were 57.3, 54.5, 53.1, and 49.1% for GnRH+EAI, EAI, GnRH+TAI, and TAI, respectively (Figure 3). Although no differences in pregnancy rates were detected among treatments, heifers that were inseminated in the estrus-detection treatments (EAI and GnRH+EAI; 56%) had greater ($P<0.05$) pregnancy rates than heifers in the TAI treatments (TAI and GnRH+TAI; 51%). However, the GnRH+TAI treatment provides a reliable TAI estrus-synchronization protocol for beef producers.

For the two estrus-detection protocols (EAI and GnRH+EAI), pregnancy rates for heifers detected in estrus before 84 hours were 44.6 and 45.0%, respectively. The clean-up TAI at 84 hours enhanced pregnancy rates by 9.9 and 12.3 percentage points for EAI and GnRH+EAI treatments, respectively. These results indicate that clean-up TAI after a period of estrus detection enhances the potential

for improving pregnancy rates to exceed those of estrus detection alone.

The time from PGF injection to detection of estrus, and to AI for those heifers exhibiting estrus, was similar between EAI (49.9 and 61.7 hours, respectively) and GnRH+EAI (49.8 and 61.3 hours, respectively).

Our results demonstrate that estrus in heifers can be synchronized effectively with GnRH, PGF, and a CIDR. The GnRH+EAI treatment most frequently produced the greatest pregnancy rates and provided a reliable alternative to a protocol based on MGA and PGF.

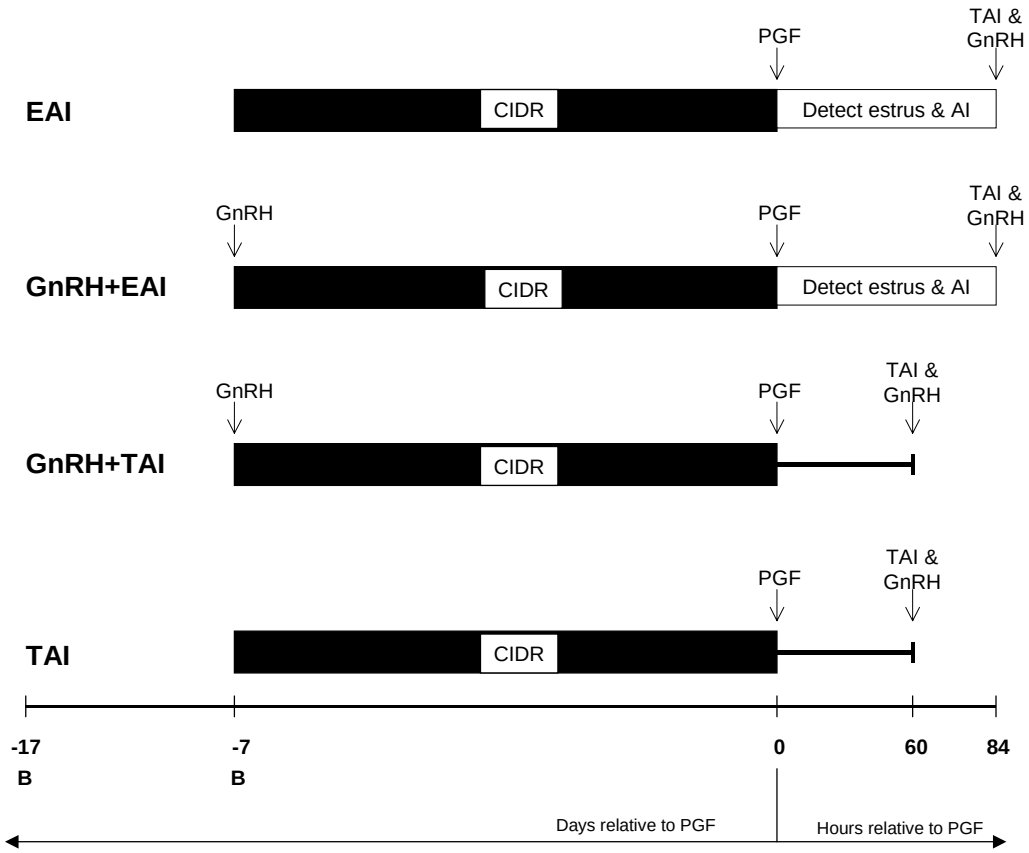

Figure 1. Schematic of Experimental Protocols for Replacement Beef Heifers Treated with GnRH, PGF, and a CIDR.

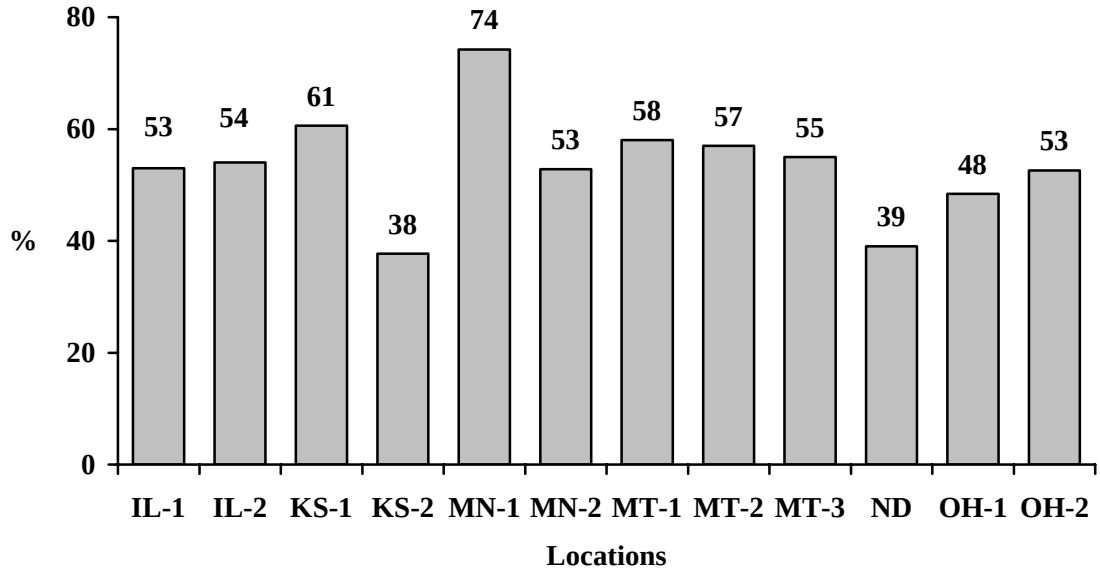

Figure 2. Distribution in Overall Pregnancy Rates Among Locations for Replacement Beef Heifers Treated with GnRH, PGF, and a CIDR.

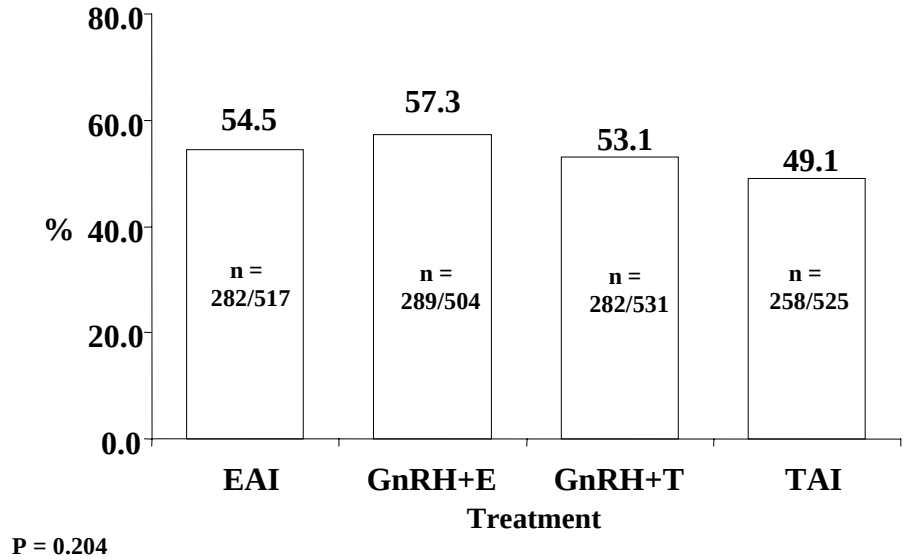

Figure 3. Pregnancy Rates (%) for Replacement Beef Heifers Treated with GnRH, PGF, and CIDR.

Cattlemen's Day 2004

ESTRUS SYNCHRONIZATION OF SUCKLED BEEF COWS BY USING GnRH, PROSTAGLANDIN $F_{2\alpha}$ (PGF), AND PROGESTERONE (CIDR): A MULTI-LOCATION STUDY[1]

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Summary

Our objectives were to determine whether a fixed-time artificial insemination (TAI) protocol could yield pregnancy rates similar to a protocol requiring detection of estrus and whether inclusion of a CIDR (a vaginal insert containing progesterone) in protocols using gonadotropin-releasing hormone (GnRH) and prostaglandin $F_{2\alpha}$ (PGF) would enhance fertility. Postpartum suckled beef cows (n = 2,630) from 14 locations were assigned randomly to each of five estrus-synchronization protocols using PGF with GnRH and(or) a CIDR. Protocols were Control, CO-Synch, CO-Synch+CIDR, Hybrid-Synch, and Hybrid-Synch+CIDR. The percentage of cows cycling at the initiation of estrus synchronization was 66.8%, the percentage of cycling cows ranging from 38 to 90% among locations. Overall pregnancy among locations ranged from 39% to 67%. Pregnancy rates were greatest for the Hybrid-Synch+CIDR (57.9%) treatment, although not significantly different from the CO-Synch+CIDR (53.6%) and Hybrid-Synch (53.0%) treatments, but greater than the Control (52.3%) and CO-Synch (43.4%), which yielded the poorest pregnancy rates. Overall, the Hybrid-Synch+CIDR protocol (AI after detected estrus for 3 days, and then a clean-up TAI) achieved the greatest pregnancy rates, but CO-Synch+CIDR is a reliable, fixed-time AI protocol that gives producers the option to eliminate detection of estrus.

Introduction

Synchronization of estrus shortens the calving season, increases calf uniformity, and enhances the possibilities for using artificial insemination (AI). The EAZI-BREED CIDR® (CIDR; Pharmacia Animal Health, Kalamazoo, MI) was recently approved by the U.S. Food and Drug Administration for synchronizing estrus in beef cows. The CIDR is a vagi-

[1]Sincere appreciation is expressed to Whisper Alexander, Chad Bailey, Sue Bellows, Tony Krizek, Chris Blevins, Dan Brown, George Perry, Marcelo Portaluppi, Doug Eborn, Adam Thompson, Wayne Adolph, Gary Ritter, Brian Gray, and Rud Wasson for their support in data collection and technical service.
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nal insert that contains 1.38 g of progesterone, which is gradually released over a period of days, and it can be used effectively with prostaglandin $F_{2\alpha}$ (PGF) with or without gonadotropin-releasing hormone (GnRH) to synchronize estrus or ovulation in beef cows. To enhance the use of estrus synchronization of suckled beef cows by beef producers, systems must reduce time and labor, be user friendly, and obtain satisfactory fertility. The objectives of this study were to determine whether: 1) a TAI protocol could yield pregnancy rates similar to a protocol requiring detection of estrus; and 2) inclusion of a CIDR to GnRH and PGF-based protocols would enhance fertility.

Materials and Methods

Estrus in 2,630 suckled beef cows from 14 locations was synchronized, and artificial insemination occurred after five treatments (Figure 1): 1) cows received a CIDR insert for 7 days, with 25 mg of PGF on the day of CIDR removal, followed by detection of estrus and AI for 84 hours, with any cow not detected in estrus by 84 hours receiving 100 μg of GnRH and a clean-up TAI at 84 hours (**Control**; n = 511); 2) cows received 100 μg of GnRH, followed in 7 days with 25 mg of PGF, followed in 60 hours by a second injection of GnRH and one TAI (**CO-Synch**; n = 551); 3) CO-Synch plus a CIDR during the 7 days between the first injection of GnRH and administration of PGF (**CO-Synch+CIDR**; n = 547); 4) cows received 100 μg of GnRH, followed in 7 days with 25 mg of PGF, followed by detection of estrus and AI for 84 hours, with any cow not detected in estrus by 84 hours receiving 100 μg of GnRH and a clean-up TAI at 84 hours (**Hybrid-Synch**; n = 513); and 5) Hybrid-Synch plus a CIDR during the 7 days between the first injection of GnRH and administration of PGF (**Hybrid-Synch+CIDR**; n = 508).

Pregnancy was diagnosed by transrectal ultrasonography between 30 and 35 days, and again between 80 and 100 days after AI. Clean-up bulls were not introduced until a minimum of 10 days after treatment inseminations.

Blood samples were collected on days –17 and –7 relative to the injection of PGF. Blood serum was analyzed for progesterone concentration to determine cycling status. Body condition scores were assessed on day –17. The statistical model to evaluate pregnancy rates included treatment, location, cycling status, parity, and body condition scores, with days postpartum as a regression variable.

Results and Discussion

Percentage of cows cycling at the initiation of treatments was 66.8% (1,534 of 2,296 cows). Percentages of cycling cows ranged from 38 to 90% among locations. In addition, overall pregnancy rates at days 30 to 35 ranged from 39% to 67% among locations (Figure 2).

The greatest pregnancy rates were achieved by using the Hybrid-Synch+CIDR (57.9%) treatment, although not significantly different from the CO-Synch+CIDR (53.6%) and Hybrid-Synch (53.0%) treatments, but greater than the Control (52.3%) and CO-Synch (43.4%), which yielded the poorest pregnancy rate (Figure 3). Perhaps the lesser pregnancy rate associated with CO-Synch was a result of delaying the TAI to 60 hours compared with previous reports in which timed AI was at 48 hours, and that indicate pregnancy rates between 47 and 52%.

For the protocols in which estrus was detected (Control, Hybrid-Synch, and Hybrid-Synch+CIDR), pregnancy rates for cows inseminated after detected in estrus were 37.1, 40.7, and 44.8%, respectively. Additional cows that conceived after the clean-up TAI at 84 hours enhanced pregnancy rates by 15.2, 12.3, and 13.1 percentage points for Control, Hybrid-Synch, and Hybrid-Synch+CIDR treatments, respectively. These results indicate

the TAI protocol alone would yield greater pregnancy rates than protocols involving a short period of detected estrus without the clean-up TAI.

In addition, the time from PGF injection to detection of estrus, and to AI for those cows exhibiting estrus, was similar among Control (52.6 and 64.0 hours, respectively), Hybrid-Synch (51.4 and 63.6 hours, respectively), and Hybrid-Synch+CIDR (53.5 and 65.2 hours, respectively).

In summary, producers have several good options for synchronization of estrus and AI in suckled cows; the options differ in treatment costs and labor requirements. For a strict fixed-time AI protocol, the CO-Synch+CIDR protocol yielded pregnancy rates greater than 50% at 9 of 14 locations. The treatment that most consistently yielded the greatest pregnancy rates was the Hybrid-Synch+CIDR treatment, with pregnancy rates greater than 50% at 10 of 14 locations.

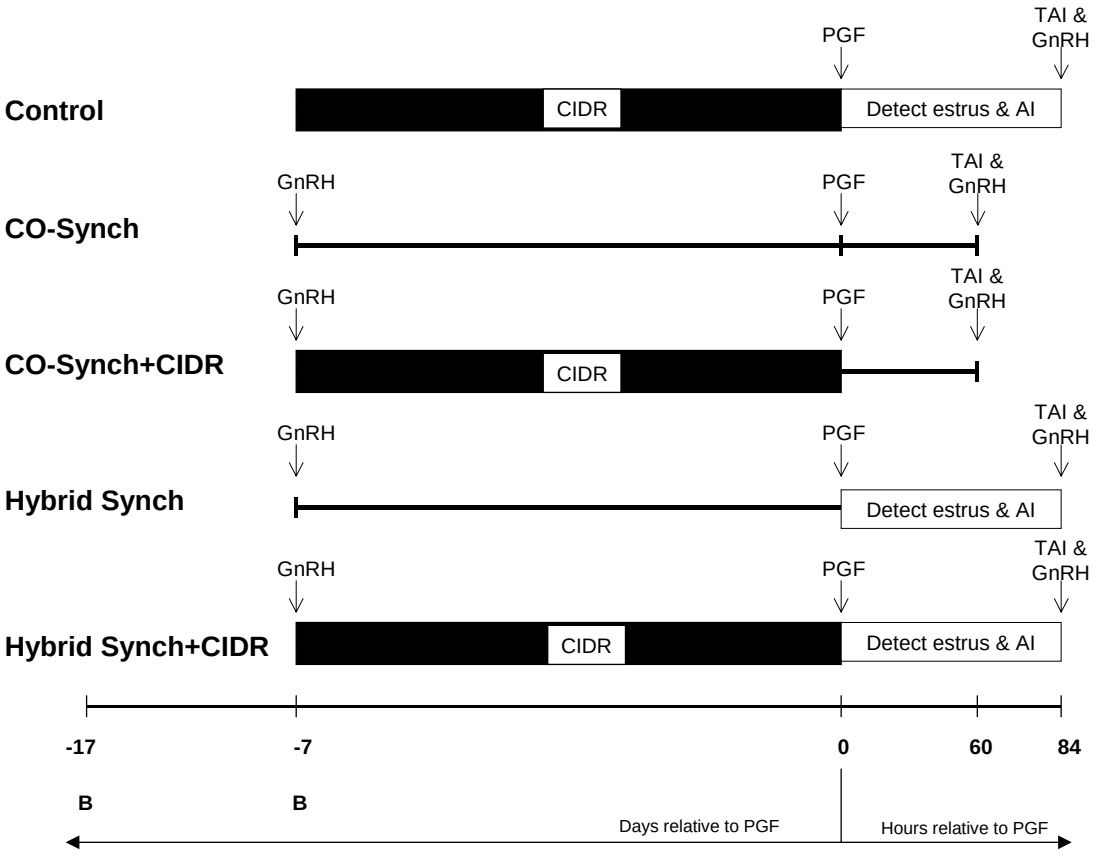

Figure 1. Schematic of Experimental Protocols for Suckled Beef Cows Treated with GnRH, PGF, and a CIDR.

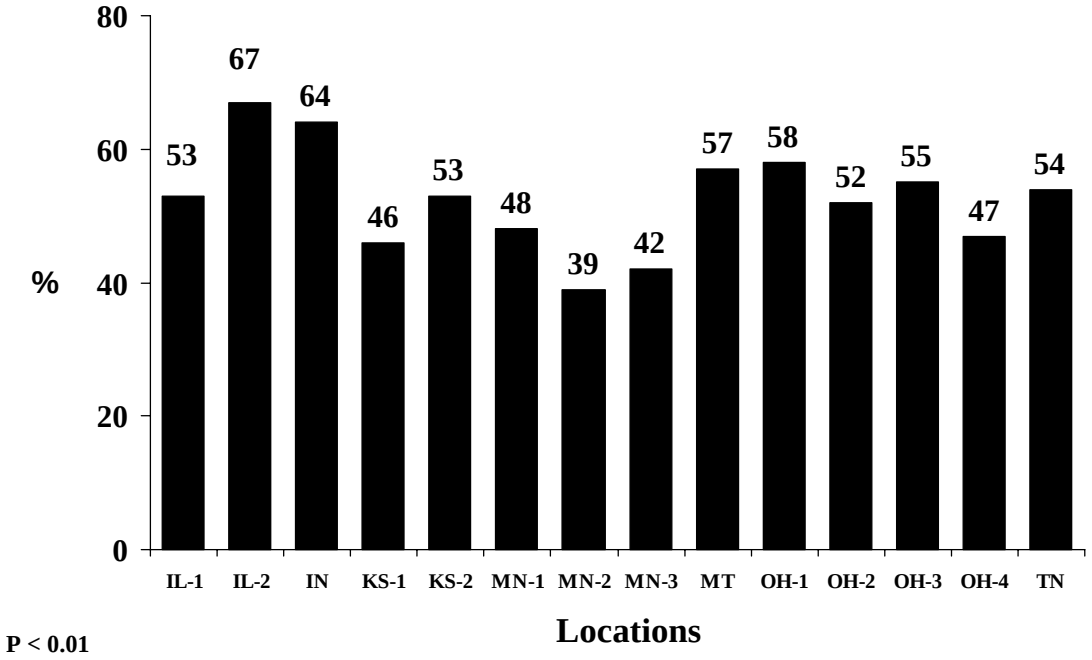

Figure 2. Distribution in Overall Pregnancy Rates Among Locations for Suckled Beef Cows Treated with GnRH, PGF, and a CIDR.

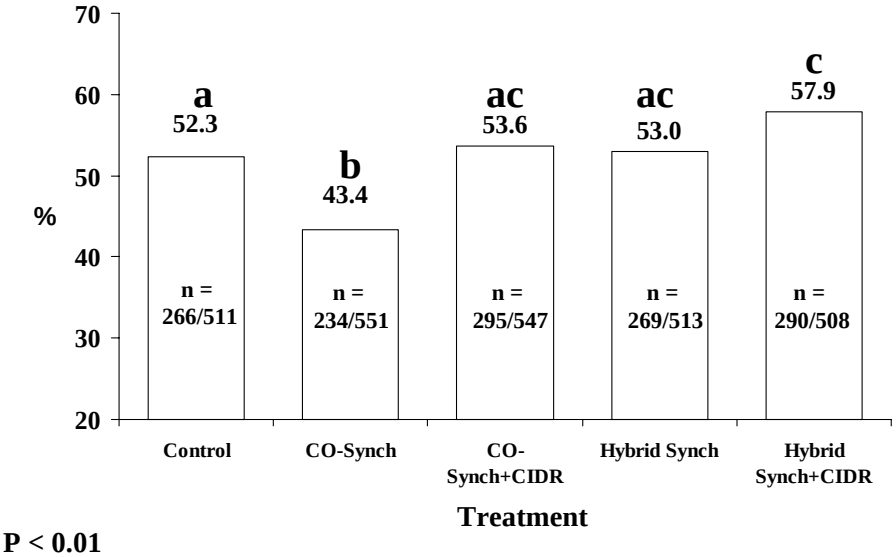

Figure 3. Pregnancy Rates for Suckled Beef Cows Treated with GnRH, PGF, and a CIDR.

SHORT-TERM PROGESTIN ESTRUS SYNCHRONIZATION WITH TIMED INSEMINATION FOR BEEF HEIFERS: CIDR VS. MGA

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Summary

Recently, a new product, Eazi-Breed CIDR (a vaginal insert containing progesterone), was approved for estrus synchronization in beef heifers. In previous studies the CIDR has produced excellent estrus synchrony, but it is more costly than the commonly used progestin, melengestrol acetate (MGA). Therefore, the objective of this study was to compare the CIDR to MGA in a shorter-term timed breeding program. Seventy-seven commercial beef replacement heifers were assigned to one of two treatments, CIDR (n=38) or MGA (n=39). Each heifer in the CIDR treatment group received a CIDR on day 1, which was removed on day 7. The MGA treatment group received MGA in the feed each day from day 1 to day 6. All heifers in both treatment groups received an injection of prostaglandin $F_2\alpha$ (PGF) on day 7. Forty-eight hours after the PGF injection (day 9), all heifers received an injection of gonadotropin hormone-releasing hormone (GnRH) and were artificially inseminated. Pregnancy status was determined by ultrasonography 29 days postbreeding. A greater percentage (P=0.05) of heifers were pregnant in the CIDR treatment (55%) than in the MGA treatment (33%).

Introduction

Less than six percent of the nations beef cows are artificially inseminated every year. This translates into an opportunity for many beef producers to improve genetics and improve profitability. The problem is convenience. There are many tools available to producers, but no tool available will ever be as convenient as turning in bulls for natural service. The purpose of any estrus-synchronization system is to maximize the number of pregnant animals, while minimizing time and labor costs. Estrus synchronization provides unique opportunities for beef producers to group calf ages for uniform calf crops and to choose when calving season will begin and end. It also allows producers to improve genetics without purchasing a superior sire. For some producers, the use of timed insemination would be preferred to eliminate estrus detection.

There are several different methods of synchronizing estrous cycles. Progestins are used to extend the luteal phase of the cycle. Progestin use synchronizes estrus, but does not synchronize ovulation; therefore, it does not allow for effective timed insemination. Other synchronization systems use gonadotropin hormone-releasing hormone (GnRH) in combination with prostaglandin $F_2\alpha$ (PGF) to synchronize both the luteal and follicular phases of the estrous cycle. These systems allow for the use of timed insemination.

The standard synchronization protocol for beef replacement heifers requires feeding the oral progestin, melengestrol acetate (MGA), for 14 days, followed by an injection of PGF 17 to 19 days later, and then several days of estrus detection. Although this is an effective system, it requires 31 to 33 days before estrus detection begins. The purpose of the current experiment was to test a shorter-term timed artificial insemination system for heifers, us-

ing progestins in combination with PGF and GnRH.

Experimental Procedures

Seventy-seven commercial replacement heifers were stratified by weight and assigned to one of two treatments. Blood was collected from the heifers on days -20 and -8 and assayed for progesterone concentrations to determine pubertal status before treatments. The heifers were preconditioned to weigh 65% of mature weight at the time of breeding.

One treatment group (CIDR, n=38) received a CIDR, on day one for seven days. Heifers also received a carrier of grain sorghum and soybean meal. Heifers in the other treatment group (MGA, n=39) were fed MGA (0.5 mg/heifer daily), in a carrier of grain sorghum and soybean meal, for six days, starting on day 1.

All heifers in both treatment groups received an injection of PGF on day 7. Forty-eight hours after the PGF injections and CIDR removal, and 72 hours after the last MGA feeding, all heifers were given an injection of 100 µg of GnRH and artificially inseminated (Figure 1). Heifers were randomly assigned to be inseminated by one of two inseminators, using semen from one of four bulls. Ultrasonography was used to determine pregnancy status at 29 days post-breeding.

Results and Discussion

Overall, 34 of 77 (44.2%) heifers were confirmed pregnant by ultrasonography at 29 days after insemination. A greater (P=0.05) number of heifers were pregnant in the CIDR group (21/38; 55.3%) compared with the MGA group (13/39; 33.3%; Figure 1). There was no sire or inseminator effect on pregnancy rate.

All of the heifers except two were pubertal at the beginning of the experiment. The prepubertal heifers were assigned one per treatment. Neither heifer obtained pubertal status during the experiment.

The purpose of this experiment was to compare different progestins in two similar estrus synchronization protocols for timed artificial insemination. The treatment that used the CIDR resulted in 22% more heifers becoming pregnant than the treatment that used MGA.

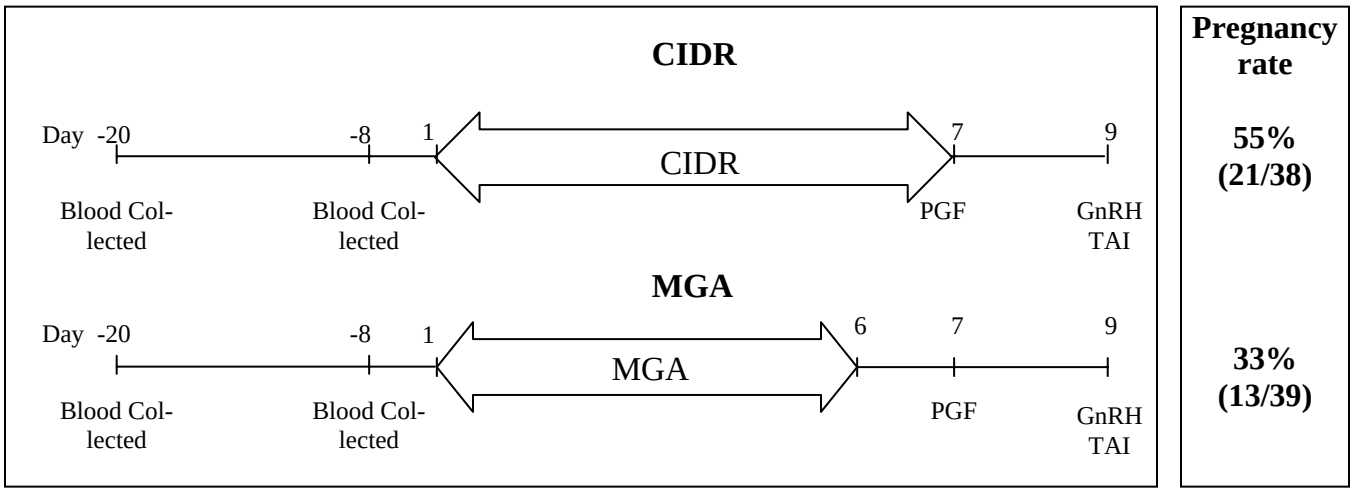

Figure 1. Experimental Protocol and Resulting Pregnancy Rate.

ADDITION OF ESTRADIOL CYPIONATE AND(OR) CALF REMOVAL TO A MODIFIED MGA + CO-SYNCH PROTOCOL FOR FIXED-TIME ARTIFICAL INSEMINATION OF BEEF COWS[1]

S. K. Johnson, K. Harmoney, and J. S. Stevenson

Summary

A study was conducted in 735 suckled beef cows to determine if synchronization of ovulation could be improved with estradiol cypionate (ECP) and(or) 48-hour calf removal in a modified MGA + CO-Synch protocol. All cows were fed melengestrol acetate (MGA) (0.5 mg/cow) daily for 14 days (days -32 to -19 of the experiment) and received an injection of gonadotropin-releasing hormone (GnRH) on d -7, an injection of prostaglandin $F_{2\alpha}$ (PGF) on day 0, and received a fixed–time artificial insemination (AI) at 72 hours after PGF. Treatments were applied in a 2 x 2 factorial arrangement. Calves either remained with cows (suckled) or were removed for 48 hours, beginning 24 hours after PGF and continuing until after the fixed-time AI (calf removal). Cows received either ECP at 24 hours after PGF or received GnRH concurrent with the fixed-time AI. AI pregnancy rates were similar for cows receiving ECP (48%) or GnRH (45%). Cycling status influenced the response to calf removal. Noncycling cows whose calves were removed had greater AI pregnancy rates than suckled cows, 37% vs. 27%, respectively. When calves were not removed, GnRH given at fixed-timed AI resulted in pregnancy rates similar to ECP and did not require additional handling of the cows. In the herd of mature cows with body condition scores near 5 and that had calved 75 to 80 days before the time of AI, the MGA + CO-Synch system used in this study produced AI pregnancy rates of 50% or better without heat detection.

Introduction

Early estrus-synchronization protocols were designed to shorten the artificial insemination (AI) period, but today's protocols are designed to synchronize ovulation. This may seem like an insignificant difference, but in reality it is a big improvement. The estrogen that produces behavioral estrus is also responsible for inducing the luteinizing-hormone (LH) surge that causes ovulation. Reducing or eliminating the time variability between the onset of estrus and the timing of the LH surge should facilitate fixed-time inseminations.

Tools available to synchronize ovulation include administration of estrogen and removing the suckling stimulus. An injection of estrogen synchronizes the onset of the LH surge by giving each cow the appropriate signal at the same time, regardless of current concentrations of endogenous estrogen. Short-term calf removal has been shown to induce ovulation in non-cycling cows. Removal of the suckling

[1]We acknowledge and appreciate the support and cooperation of: Troy Marple (Purebred Beef Unit); Twig Marston, Gary Ritter, and Wayne Adolph (Cow/Calf Unit); Tony Krizek (Agriculture Research Center-Hays); and many graduate and undergraduate students.

stimulus may also tighten the synchrony of estrus and ovulation in cycling cows. Calf removal can provide several logistical benefits to a synchronization program, particularly in a large-pasture setting. When calves are locked up, cows will remain close to working pens, so when cows express estrus early, they are more easily detected and gathered for AI. At fixed-time AI, less effort is required to gather cows and calves that are already sorted.

The objective of this study was to determine if synchronization of ovulation in a modified MGA + CO-Synch system is improved with the addition of estradiol cypionate (ECP) and(or) calf removal.

Experimental Procedures

Purebred suckled Angus, Simmental, and Hereford cows and crossbred suckled cows (n=735) from three university herds were used (Agriculture Research Center-Hays, Cow-Calf Unit, and Purebred Unit) over two years. All cows were fed melengestrol acetate (MGA; 0.5 mg/cow) daily for 14 days (days -32 to -19 of the experiment) and received an injection of gonadotropin-releasing hormone (GnRH; (Factrel; 2 cc) on d -7, an injection of prostaglandin $F_{2\alpha}$ (PGF; Lutalyse; 5 cc) on d 0, and a fixed-time AI at 72 hours after PGF. The MGA was incorporated into 4 lb of a cubed supplement and fed on the ground at ARC-Hays and fed as part of a grain mix at other locations

Within herd, treatments were assigned by breed and age of cow and by calving date. Treatments were applied in a 2 x 2 factorial arrangement (Figure 1). Calves either remained with cows (suckled) or were removed for 48 hours, beginning 24 hours after PGF and continuing until after the fixed-time AI (calf removal). Cows received either ECP (0.5 mg; i.m.) at 24 hours after PGF or received GnRH (Factrel; 2 cc) concurrent with the fixed-time AI.

During the 48 hours of calf removal, calves were offered good quality oat or alfalfa hay and had access to water.

Blood samples were collected on days -17, -7, 0, and at fixed-time AI for later analysis of serum concentrations of progesterone. Cows with low concentrations of progesterone (<1 ng/ml) on day -17 and -7 were classified as noncycling, whereas those with high concentrations (>1 ng/ml) on either or both days were classified as cycling. Body condition scores (1 = thin and 9 = fat) were assessed on day 0.

Cows observed in estrus within 36 hours after PGF were inseminated 6 to 12 hours after observed estrus, but were classified nonpregnant for purposes of calculating AI pregnancy rates among treatments. Detection of estrus and AI continued, for at least 10 days after treatment inseminations lapsed, before clean-up bulls were turned out with cows. Pregnancy rate to AI was determined by transrectal ultrasonography 33 to 36 days after timed AI.

Results and Discussion

Number of cows, body condition score, average days postpartum at time of AI, proportion cycling, and AI pregnancy rates are summarized in Table 1. Cows in these herds were close to, or fell within, the recommended average days postcalving at the start of a long-term MGA treatment of 40 to 45 days or 75 to 80 days at the time of AI. When body condition was lower and the interval since calving shorter, overall AI pregnancy rate was less.

AI pregnancy rate was similar for cows receiving ECP (48%) or GnRH (45%). Cycling status influenced the response to calf removal (Table 2). Noncycling cows whose calves were removed had a greater ($P<0.05$) AI pregnancy rate than suckled noncycling cows. For cows classified as cycling, AI pregnancy rates were similar between calf-removal and suckled cows. Age of cow (first calf vs.

mature) did not influence pregnancy rates. No interactions of calf removal or hormone treatment with body condition score or calving date were detected.

Of cows classified as noncycling, 89 of 183 (48.6%) had high progesterone (>1 ng/ml) at the time of PGF, indicating that GnRH given 1 week before PGF had induced ovulation, or in a few instances, that spontaneous ovulations had occurred. Pregnancy rates in these cows were 23% (42 of 183), which contributed 5.7% of the entire group AI pregnancy rate. Because the proportion of cows cycling in this study was fairly large (75%), the benefit of GnRH given 1 week before PGF might be even greater in herds with more noncycling cows.

The most concentrated effort to detect estrus before fixed-timed AI was made at the ARC-Hays in 2002, where 15.1% were inseminated 24 hours or more before fixed-time AI. At this location, cows whose calves were removed remained fairly close to the working pens, facilitating detection of estrus, despite the cows being in a pasture of about 720 acres. AI pregnancy rate was increased 9% when pregnancies from these early heats were included with those cows that received the fixed-timed AI. No attempt was made to detect early heats at the Cow-Calf Unit. Across all locations, 32 cows were detected in estrus early, and 66% were diagnosed pregnant.

Immediately after AI at the ARC-Hays, pairs were sorted and relocated to new pastures. This decision resulted in some calves crossing fences during the next few days, but that was not considered a major problem. Herds that left pairs in the same pastures before and after AI did not experience problems with calves mothering up after calf removal.

Calf removal did not influence final weaning weights of 548 lb for suckled calves and 546 lb for calves that experienced the 48-hour calf removal before fixed-time AI.

Table 1. Description of Herds

				Days Between Calving and AI		%	AI Pregnancy
Herd[a]	Age	No.	BCS[b]	Average	Range	Cycling	Rates[c]
2002							
ARC-Hays	First Calf	18	5.3	108	73 - 130	83	67
	Mature	88	5.2	74	39 - 98	84	53
CCU	First Calf	53	5.0	90	56 - 112	34	28
	Mature	63	4.6	74	55 - 96	54	37
PBU	First Calf	46	5.4	91	39 - 110	74	46
	Mature	100	5.0	67	33 - 89	82	55
2003							
ARC-Hays	First Calf	53	5.5	112	75 - 132	94	60
	Mature	162	5.4	70	25 - 94	77	48
PBU	First Calf	34	4.9	90	65 - 105	57	46
	Mature	117	5.3	69	30 - 94	86	38
TOTAL		735	5.2	78	25 - 132	75	47

[a]CCU=Cow-Calf Unit, PBU=Purebred Unit.
[b]Body Condition Score.
[c]Percentage of pregnant to single fixed-time AI of all cows treated.

Table 2. Response of Cycling and Noncycling Cows to Calf Removal

	Cycling		Noncycling	
Item	Calf Removal	Suckled	Calf Removal	Suckled
Total number	281	271	94	89
Number pregnant	135	150	35	24
AI pregnancy rate, %	48.0	55.4	37.2[a]	27.0[b]

[ab]Means differ for noncycling cows (P<0.05).

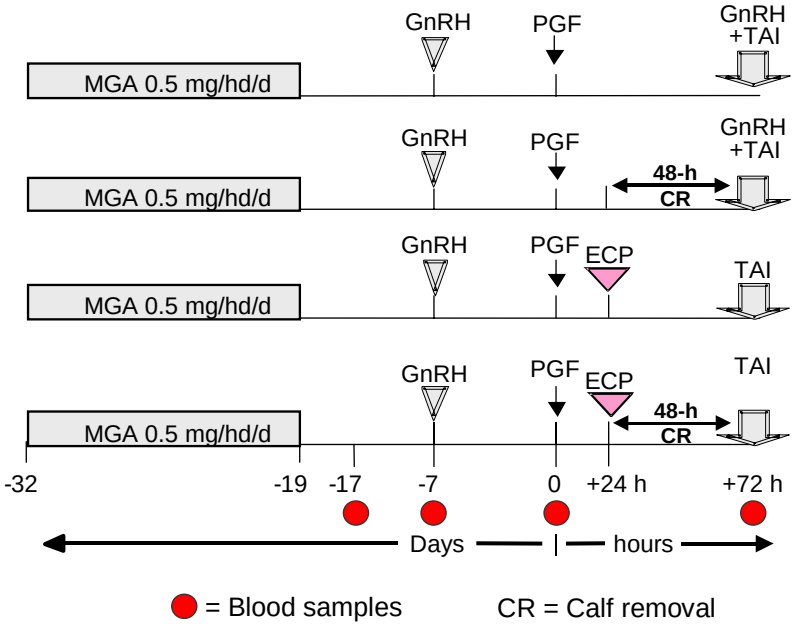

Figure 1. Experimental Design of Synchronization Protocol.

CHANGES IN BREEDING SOUNDNESS EVALUATION DURING A BREEDING SEASON

A. W. Thompson, T. T. Marston, M. Sanderson, and P. Chenoweth

Summary

Breeding-soundness evaluations are a common tool in the beef industry to test a bull's potential fertility. These evaluations place a bull into one of three categories: satisfactory, unsatisfactory, or deferred. These categories only refer to the bull at a specific time, and his status can and will change over time. The purpose of this report is to explain and demonstrate the changes in a bull's breeding-soundness evaluations during a breeding season.

Introduction

Reproductive management of a cattle herd has many different components. Most of the emphasis is placed on female reproduction. Non-pregnant cows are typically culled from herds. If artificial insemination is not used, then the "bull power" of the herd is responsible for ensuring that cows are bred. Because 95% of the beef cows in the United States are bred by bulls, bull fertility is a substantial area for reproductive management.

The most common tool of reproductive management of bulls is a breeding-soundness evaluation just before the beginning of the breeding season. The components of a breeding-soundness evaluation provide a picture of potential fertility at that time. The most common components of a breeding-soundness evaluation include a general physical exam, an examination of the male reproductive tract, assessment of semen, and a measurement of size of the testes. The breeding-soundness evaluation should be performed by a qualified veterinarian. The Society for Theriogenology, a veterinary society that specializes in animal reproduction, has set guidelines to standardize the results of breeding-soundness evaluations. These guidelines are research-based, minimum standards that give producers fertility criteria for selection of bulls.

The examination of the reproductive tract typically includes a trans-rectal examination of internal organs to ensure that there are no problems that will affect the bull's performance. The exam also looks at the external genitalia because, if a bull cannot extend and obtain an erection, he will not be able to breed any cows. Palpation of the testes is also performed to ensure that there are no problems or injuries.

A sample of semen is obtained from the bull. The sample is evaluated for individual motility (the percentage of sperm that are moving forward). A recommended minimum threshold for motility is 30%, which is termed "fair" (Table 1). Morphology (structural correctness of the sperm) is also evaluated. The minimum threshold for structural correctness is 70%. Neither non-motile sperm nor sperm with incorrect morphology are likely to fertilize an egg.

An evaluation of scrotal circumference is used to predict the bull's sperm production. In yearling bulls, scrotal circumference is associated with the age that the sire's heifer progeny will attain puberty. These factors have led to standards of acceptability (Table 2).

The combination of evaluations will result in a category rating of Satisfactory, Deferred, or Unsatisfactory. A satisfactory rating means that a bull has passed all of the minimum requirements just stated. An unsatisfactory rating indicates the bull did not pass at least one of the minimum requirements and is not likely to recover normal fertility. Deferred ratings are used to describe bulls that do not fit into either of the other two categories, and for which subsequent testing will be required before the bull can be classified as satisfactory or unsatisfactory.

As previously stated, the breeding-soundness evaluation provides a picture of potential fertility at a point in time. It does not mean that, once a bull has been deemed acceptable, he remains acceptable throughout the breeding season. To illustrate this point, bulls used in the commercial cow herd were subjected to a breeding-soundness evaluation before, during, and at the end of the breeding season.

Experimental Procedures

At the beginning of the 2003 breeding season, 12 bulls exposed to cows were subjected to a breeding-soundness evaluation. Four bulls were purchased at the beginning of the breeding season and had previously undergone a breeding-soundness evaluation. The bulls were rechecked during the breeding season, and were checked again at the conclusion of the breeding season (Figure 1).

Results and Discussion

Two bulls received an unsatisfactory rating at the start of the breeding season and were sold. One bull received a deferred rating and passed when rechecked two weeks later. This illustrates the need for every bull to be tested before the breeding season.

The testing in the middle of the breeding season yielded three bulls with a deferred rating. One of these bulls (No. 364) had a dilute semen sample that could not be evaluated. This is not uncommon for bulls "in work" because of frequent breeding. Bulls that received a deferred rating were not rechecked until the end of the breeding season.

At the conclusion of the breeding season, three bulls again produced deferred ratings. Interestingly, one bull that was deferred in the middle of the breeding season was deferred at the end of the breeding season. These results demonstrate how the fertility of the bull can change in a relatively short time (Figure 2).

Such variations between breeding soundness evaluations can be attributed to a number of factors. The environment can potentially play a key role in fertility. A bull's fertility can be affected by both hot and cold temperatures. Although the bull has many mechanisms to regulate the temperature of the testes, extremes on either end of the spectrum can cause problems. This breeding season occurred during the summer months, and hot temperatures may have affected the bulls' fertility results. Heat and cold stress, unless severe, usually do not cause permanent sub-fertility.

Another factor that could possibly play a role in variations between exams is injury or sickness. Injuries to the scrotum, testes, or internal reproductive organs will affect fertility. Sickness can also play a role in fertility. A fever will change the bull's temperature, and can cause damage to sperm. These conditions are not typically permanent, but may render a bull sub-fertile for a period of time. If a bull sustains an injury to his penis or testes, however, unsatisfactory fertility may be permanent.

A bull's fertility is a constantly changing condition. A breeding-soundness evaluation

is an extremely useful tool for determining the breeding potential of a bull, but it is important to realize that these evaluations are just a picture in time of the workings of the bull's reproductive tract.

Table 1. Guidelines for Sperm Motility and Rating from a Breeding-Soundness Evaluation[a]

Mass Activity	Rating	Individual
Rapid Swirling	Very Good	70%
Slower Swirling	Good	50-69%
Generalized Oscillation	Fair	30-49%*
Sporadic Oscillation	Poor	<30%

Adapted from BIF Guidelines.
*A minimum recommended motility is 30% or Fair.

Table 2. Minimum Recommended Scrotal Circumference

Age	Scrotal Circumference, cm
15 months	30
>15 <18 months	31
>18 <21 months	32
>21 <24 months	33
>24 months	34

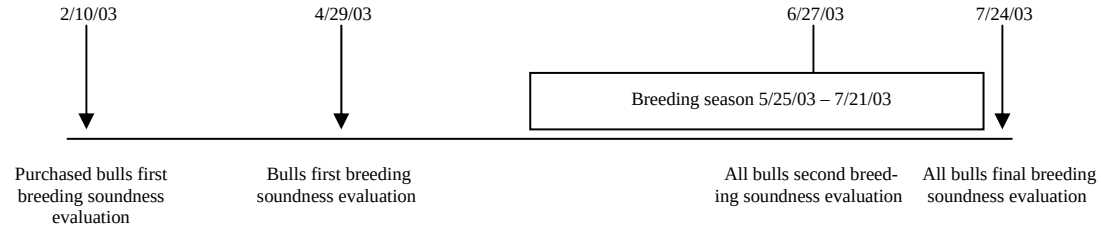

Figure 1. Timeline of Breeding-Soundness Examinations in Relation to the Breeding Season.

Bull ID	Rating at the Beginning of the Breeding Season	Rating in the Middle of the Breeding Season	Rating at the End of the Breeding Season
202	Satisfactory	Deferred	Satisfactory
10M	Satisfactory	Satisfactory	Satisfactory
15	Satisfactory	Satisfactory	Satisfactory
102	Satisfactory	Satisfactory	Deferred
418	Satisfactory	Satisfactory	Satisfactory
205	Satisfactory	Deferred	Deferred
599	Satisfactory	Satisfactory	Satisfactory
0030	Satisfactory	Satisfactory	Deferred
0041	Satisfactory	Satisfactory	Satisfactory
391	Deferred*	Satisfactory	Satisfactory
364	Satisfactory	Deferred	Satisfactory
204	Satisfactory	Satisfactory	Satisfactory

*Rechecked and passed breeding-soundness evaluation.

Figure 2. Breeding-Soundness Evaluation Ratings Across the Breeding Season.

INFLUENCE OF FALL PROTEIN SUPPLEMENTATION WITH A SELF-FED LIQUID SUPPLEMENT ON PERFORMANCE OF BEEF COWS GRAZING TALLGRASS-PRAIRIE RANGE

D. A. Llewellyn, B. T. Gray, T. T. Marston, and C. A. Bandyk[1]

Summary

We evaluated the effect of providing a liquid, high-protein supplement during the fall grazing period on beef cow and calf performance. Mature, pregnant, spring-calving cows (n=122) grazing native range were assigned to supplementation treatments. All calves were weaned on October 15. Control cows received no fall supplementation and then were hand-fed a dry supplement (40% crude protein; as-fed basis) from December 17 until calving. Supplemented cows were either allowed access to a liquid protein supplement (40% crude protein; as-fed basis) approximately 2 months before weaning until calving (fall supplementation from August 14 to December 17) or from weaning until calving (fall supplementation from October 15 to December 17). Supplement intake of the control cows from December 17 until calving was adjusted to match the estimated supplement intake of the liquid-fed groups and was prorated and fed 3 days/week. Supplementation was terminated upon calving, at which time all cows were treated similarly. Provision of liquid supplement during the fall increased cow body weight and body condition in the post-weaning period. However, cows not supplemented during the fall phase were able to overcome their lesser previous nutrition when they were suitably supplemented during the winter phase. The pre-weaning rate of gain of calves was not affected by fall supplementation. Calves produced by cows receiving no fall supplementation gained more weight from birth to the start of the summer grazing season. Subsequent pregnancy rate was not affected by fall supplementation.

Introduction

Forage quality in the tallgrass-prairie region of Kansas typically declines during late summer and fall. This is exhibited by the decrease in crude protein and the increase in the fibrous fractions of the forage. Previous research at Kansas State University has demonstrated that providing ruminally degradable protein (protein that is available for use by the ruminal microbes) improves production of grazing beef cows. Moreover, the magnitude of response to supplementation is commonly the greatest with the first increment (i.e., least amount) of degradable protein provided.

Generally, the nutrient requirements of spring-calving cows are least during the fall. The relationship between beef cow body condition at calving and subsequent reproductive performance is well established. Efficiently building mobilizable energy reserves in the fall may result in the maintenance of reproduction during the subsequent breeding season. Previously at Kansas State University, investigations into fall protein supplementa-

[1]Quality Liquid Feeds, Inc., Dodgeville, Wisconsin.

tion focused on supplements in various forms (i.e., self-fed pellet, molasses blocks, and hand-fed meal). Liquid protein supplements have the advantages of continuous accessibility and reduced labor.

The objective of our study was to evaluate the impact of providing supplemental protein via a liquid supplement during the fall. The time at which supplementation was initiated was evaluated to determine if the provision of supplement before or after weaning resulted in performance advantages.

Experimental Procedures

An experiment was conducted from August 14, 2002, through the beginning of the summer grazing season (May 2, 2003). One-hundred twenty-two mature, pregnant, spring calving, Hereford x Angus cow/calf pairs were assigned to treatments. All calves were weaned and weighed on October 15. Treatments were: 1) control, no fall supplementation (a hand-fed high-protein supplement [40% crude protein; as-fed basis] was provided from December 17 until calving); 2) pre-and post-weaning supplementation (liquid; 40% crude protein, as-fed basis) approximately 2 months before weaning until calving; or 3) post-weaning supplementation (same supplement as treatment 2) fed from October 17 until calving. Initial body weights of the cows and calves and body condition scores of the cows were recorded at the initiation of the study (August 14, 2002) and approximately every 60 days thereafter. Cow body weights and birth weights of calves were recorded within 48 hours of calving, and cow and calf body weights were obtained at the start of the summer grazing season (May 2, 2003). The three fall supplementation treatments were randomly assigned to 12 fall pastures (60 to 100 acres/pasture), allowing for four pasture replications per treatment. Stocking rate across all fall pastures was based on the cow/calf pair weights obtained at the beginning of the experiment. A 50:50 mix of salt and dicalcium phosphate was provided during the fall phase, and a commercial mineral mix was provided to all cattle from December 15 until the end of the experiment.

The fall-supplemented cows were provided the self-fed, liquid supplement containing urea (40% crude protein; as-fed basis) throughout their respective supplementation periods. Calves did have access to the supplement during the pre-weaning period. During the winter grazing period, all cows resided in three large pastures (approximately 340 acres/pasture). Each treatment was managed together within one pasture. To ensure that pasture did not become a source of variation in the experiment, cows were rotated every two weeks such that each group resided in each pasture before calving. Throughout the winter grazing period, the liquid-supplemented cows (those cows that received supplement before and after weaning, as well as those that received supplement only after weaning) continued to be provided with free access to the same supplement they received during the fall phase. The control cows were provided with a high-protein (40% crude protein; as-fed basis) hand-fed supplement in meal form fed at a rate to match the approximate intake of the liquid-supplemented cows. The ingredients of the hand-fed supplement were approximately 83.0% soybean meal, 13.7% rolled milo, 3.0% molasses, 0.2% trace mineral mix, and 10,215 IU/lb Vitamin A. The hand-fed supplement was bunk-fed 3 days per week (Monday, Wednesday, and Friday; prorated to deliver the designated daily quantity). Additional bromegrass hay was provided to cows on all treatments from February 10, 2003, to April 4, 2003, because of weather conditions and limited forage availability. The protein supplementation treatments were terminated upon calving, at which time the cows and their calves were removed from their respective supplementation treatments and handled similarly (provided with 12 lbs of

alfalfa hay per cow daily). Pregnancy was confirmed by rectal palpation on October 31, 2003.

Result and Discussion

During the pre-weaning period, cows that received supplementation did not exhibit significantly different body weight (P=0.41; Table 1) or body condition (P=0.34; Table 2) changes than the cows that received no supplement. Likewise, the weight gain of the calves nursing fall-supplemented cows during this period was not different (P=0.83; Table 3) from that of calves of unsupplemented cows. During the period after weaning (October 15 to December 17), the cows receiving fall supplement tended (P=0.08) to gain more weight and more (P=0.03) body condition. Cumulative body weight (P=0.13) and body condition (P=0.06) gains tended to be greater for the cows receiving fall supplement during the entire fall period (August 14 to December 17). Before the start of the calving season (February 5), no significant differences in body weight or body condition score changes were observed between those cows that were provided with supplement before and after weaning and those that started receiving their supplement only after weaning. Furthermore, cumulative body weight and body condition changes of the cows were not significantly affected by the time of initiation of supplementation.

During the winter grazing period (December 17 to February 5), the control cows gained more weight and body condition (P<0.01) than the cows that had previously received fall supplementation. At calving, the control cows were heavier (P=0.03) and had greater (P=0.04) body condition scores than the fall-supplemented cows. This implies that the cows that did not have access to fall supplementation had the ability to compensate, at least in part, for their poorer nutritional status during the fall phase.

No effects of fall supplementation (P=0.39) were observed in calf birth weights (2003 calf crop). Calves produced by the control cows gained more weight (P<0.01) from birth until the start of the summer grazing season (May 2) than the cows receiving fall supplementation. In addition, calves produced by the control cows were heavier (P<0.01) at the start of the summer grazing season. The greater gains of calves produced by the control cows, when considered together with the tendency for the control cows to lose more weight (P=0.07) and body condition score (P=0.14) during the same period, suggest that the calves from the control cows may have benefited from increased milk production at the expense of maternal reserves.

No significant differences were observed between the supplementation treatments with regard to pregnancy rate (Table 3).

In conclusion, the provision of a self-fed liquid supplement to beef cows grazing poor-quality forage resulted in body weight and body condition gains during the period from weaning until the start of the winter grazing period. Those cows not receiving supplementation during the fall had the ability to compensate for their earlier nutritive status during the pre-calving period when they were suitably supplemented during the winter.

Table 1. Influence of Fall Liquid-Protein Supplementation on Beef Cow Body Weight (BW) Changes

	Treatment[a]				Statistical Comparisons (P-values[b])		
Item	Control	Pre+post-weaning	Post-weaning	SEM[c]	Pre-wean vs none	Pre+post vs Post	Control vs Pre+post and Post
No. of cows	45	39	38				
Initial BW, lb	1097	1094	1095	11			
Period BW changes, lb							
Aug 14-Oct 15	92	105	80	19	0.41	NA	NA
Oct 15-Dec 17	39	84	67	15	NA	0.47	0.08
Dec 17-Feb 5	89	16	37	13	NA	0.28	< 0.01
Feb 5-Calving	- 138	- 165	- 152	8	NA	0.30	0.07
Calving-May 2	- 97	- 69	- 76	10	NA	0.63	0.07
Cumulative BW changes, lb							
Aug 14-Dec 17	131	189	147	18	NA	0.15	0.13
Aug 14-Feb 5	220	205	184	13	NA	0.29	0.15
Aug 14-Calving	82	40	32	14	NA	0.69	0.03
Dec 17-Calving	- 49	- 149	- 115	18	NA	0.22	< 0.01
Aug 14-May 2	- 16	- 29	- 44	12	NA	0.40	0.18
Calving BW, lb[d]	1179	1134	1127	15	NA	0.75	0.03
May 2 BW, lb	1082	1065	1047	13	NA	0.35	0.11

[a]Treatment: Control = no fall supplementation; Pre + post-weaning = supplementation during the entire fall period; Post-weaning = supplementation beginning after calves were weaned on Oct. 15.

[b]NA = not applicable. Statistical comparison under consideration was not applicable to the designated period.

[c]SEM = standard error of the mean.

[d]Average calving date = mid March.

Table 2. Influence of Fall Liquid-Protein Supplementation on Beef Cow Body Condition Score (BCS[a])

	Treatment[b]				Statistical Comparisons (P-values[c])		
Item	Control	Pre+post-weaning	Post-weaning	SEM[d]	Pre-wean vs none	Pre+post vs Post	Control vs Pre+post and Post
No. of cows	45	39	38				
Initial BCS	4.76	4.80	4.74	0.04			
Period BCS changes							
Aug 14-Oct 15	0.27	0.37	0.16	0.13	0.34	NA	NA
Oct 15-Dec 17	- 0.10	0.18	0.24	0.10	NA	0.70	0.03
Dec 17-Feb 5	0.42	- 0.12	- 0.07	0.05	NA	0.56	< 0.01
Feb 5-Calving	- 0.36	- 0.39	- 0.42	0.07	NA	0.80	0.62
Calving-May 20	- 0.14	- 0.03	- 0.07	0.05	NA	0.59	0.14
Cumulative BCS changes							
Aug 14-Dec 17	0.17	0.55	0.39	0.11	NA	0.36	0.06
Aug 14-Feb 5	0.58	0.43	0.32	0.11	NA	0.48	0.16
Aug 14- Calving	0.22	0.05	- 0.10	0.08	NA	0.23	0.03
Dec 17-Calving	0.06	- 0.50	- 0.49	0.11	NA	0.92	< 0.01
Aug 14-May 2	0.09	0.02	- 0.13	0.09	NA	0.27	0.19
Calving BCS[e]	4.98	4.84	4.64	0.08	NA	0.13	0.04
May 2 BCS	4.85	4.81	4.58	0.08	NA	0.07	0.12

[a]Body condition score: 1 = emaciated; 9 = obese.

[b]Treatment: Control = no fall supplementation; Pre + post-weaning = supplementation during the entire fall period; Post-weaning = supplementation beginning after calves were weaned on Oct. 15.

[c]NA = not applicable. Statistical comparisons under consideration were not applicable to the designated period.

[d]SEM = standard error of the mean.

[e]Average calving date = mid March.

Table 3. Influence of Fall Liquid-Protein Supplementation on Calf Body Weight (BW) and Beef Cow Reproductive Performance

	Treatment[a]				Statistical Comparisons (P-values[b])		
Item	Control	Pre+post-weaning	Post-weaning	SEM[c]	Pre-wean vs none	Pre+post vs Post	Control vs Pre+post and Post
2002 Calf Crop							
No. of calves	45	39	38				
Initial BW, lb	406	393	401	3.7			
Pre-weaning BW gain, lb							
Aug 14-Oct 15	148.6	150.2	149.6	4.2	0.83	NA	NA
2003 Calf Crop							
Calf birth BW, lb	90.8	85.2	92.7	1.9	NA	0.02	0.39
Calf BW on May 2, lb	199.6	173.5	187.6	3.9	NA	0.04	< 0.01
Calf BW gain,							
birth-May 2, lb	108.2	88.4	94.6	2.3	NA	0.09	< 0.01
Reproductive Performance							
No. of cows	43	38	35				
Cows pregnant on							
Oct 31[d], %	98	95	100				

[a]Treatment: Control = no fall supplementation; Pre + post-weaning = supplementation during the entire fall period; Post-weaning = supplementation beginning after calves were weaned on Oct. 15.

[b]NA = not applicable. Statistical comparisons under consideration were not applicable to the designated period.

[c]SEM = standard error of the mean.

[d]Chi-Square, P=0.36.

GRAZING CATTLE ON WINTER CEREAL PASTURE ON THE SANDY SOILS OF SOUTH-CENTRAL KANSAS

V. L. Martin[1] and R. Hale[2]

Summary

Rye, wheat, and triticale pasture were evaluated during the winters of 2000-01, 2001-02, and 2002-03 for their ability to increase cattle weight from late fall through mid-spring. Large-scale studies were conducted on two 80-acre sites divided into either 25- or 40-acre pastures. Cattle at these sites were stocked at one head per acre, with an average initial weight between 500 and 550 lb. At the Sandyland Experiment Field, small-scale studies were conducted by using the same winter cereals for forage, but at greater stocking rates, ranging from two to three head per acre. Supplemental feeding, as necessary, included summer annual forage hay, prairie hay, and grain consisting of wheat middlings and processed grain sorghum. Winter cereals were planted at 100 lb/acre in September of each year. Rye provided the best pasture in terms of cattle weight gain and needed the least supplemental feeding. Wheat was next in producing pounds of beef, and triticale produced less gain than either rye or wheat. These data suggest that rye and wheat were able to support greater stocking rates than triticale.

Introduction

Annually, forage in Kansas supports more than 1.5 million beef cows and calves, 0.8 million dairy cows, and 4 to 5 million yearling cattle. Cattle and the production of forage and grain for feed represent a significant portion of agricultural revenues in Kansas. Dryland grain production in the Lower Arkansas Basin is variable due to both soil type and climate. Typically, adequate moisture is available for good pre-flowering vegetative growth, but available soil moisture, erratic rainfall, and high temperatures often severely impact grain yield. Winter cereal vegetative growth and early reproductive growth are normally good because of adequate rainfall and moderate temperatures.

More efficient and consistent use can be made of available moisture if dryland producers focus on harvesting vegetative growth instead of grain. Using summer annual forages and winter cereals as forage for hay and grazing directly connects to the market for which most of their production is already geared, cattle. These forages, and systems integrating their use, are well adapted for cattle production, are less expensive than traditional grain production, and decrease risk. Forage/grazing systems are not without additional costs and risks, however, requiring inputs ranging from machinery to fencing. Forages used for pasture require additional investments and are labor and time intensive.

The primary objective of this study was to determine actual cattle weight gain on dryland winter-cereal pasture and develop production systems/best management practices to optimize cattle production.

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[2]Southwest Area Extension Office, Garden City, Kansas.

Experimental Procedures

All costs were the same each year for each pasture, with the exception of seed costs. Rye seed costs were $7 per acre, wheat $10 per acre, and triticale $20 per acre. Rye, wheat, and triticale pastures were all treated identically, with the exception of stocking rates during the 2001-02 year. Wheat pasture was planted to 'Jagger' except for one field of 'Betty' during the 2001-02 grazing year, triticale pasture was Trical 2+2, and rye pasture seed variety was not stated.

Fertilization each year consisted of 100 lb/acre 18-46-0 and 50 lb/acre N broadcast as urea (46-0-0). Fertilizer was incorporated with the final tandem disking before planting winter cereals. In rotations where summer annual forage was planted, the 18-46-0 was applied before planting the summer annual forage.

Sites at the Sandyland Field were all fine, sandy loams. Two 80-acre, off-site locations were established. Each was split into three 25-acre pastures and treated and planted as were the small-scale Sandyland sites. One site was a loamy fine sand and the other a fine sandy loam. The only difference between the off-site and Sandyland studies was stocking rate. Sandyland heifers were stocked at greater rates than the large-scale studies (rates are provided in data tables).

Cattle were penned for 36 to 48 hours and fed/watered before initial weighing. Cattle were weighed individually immediately before being turned out onto assigned pastures. All cattle weights were taken individually throughout the study, directly after cattle were rounded up.

Each year, tillage consisted of tandem disking two times, with fertilizer incorporation before final tillage. Winter cereals were planted by using a double-disk drill with a target seeding rate of 90 lb/acre.

2000 – 2001 Grazing Season

Heifers were turned out on November 29 and pastured for 68 days. As the result of poor pasture conditions, cattle were placed in a drylot and fed for 38 days (February 5 – March 16). Cattle were then pastured for an additional 61 days (March 16 – May 16). Total days on winter pasture was 129 days.

2001 – 2002 Grazing Season

Extremely dry fall/early winter conditions prevented turning cattle out until April 11. Cattle were turned out on irrigated corn stalks for 141 days before grazing the cereal pastures. Cattle were pastured on winter cereals for 43 days (April 11 – May 23). Stocking rates were determined by qualitative examination of growth (height and degree of tillering) and are presented in Table 3.

2002 – 2003 Grazing Season

At the Sandyland site, rye, wheat, and triticale pasture were preceded by a summer annual forage on some lots, a winter-cereal/summer-feed rotation. Another treatment was continuous wheat pasture after summer fallow. Rye was seeded after mechanical summer fallow, and cattle were turned out on the 3 acres of rye, plus 9 acres of sorghum stubble. Stocking rates for each treatment are listed in Table 4.

At the JLC Ranch, the stocking rate was one acre per head. One pasture (Table 5) had been in continuous wheat, with mechanical summer fallow. The other treatment was in continuous wheat/rye pasture, with mechanical summer fallow.

Dry conditions prevented pasturing cattle until February 19. Sandyland cattle were pasture for 78 days, until May 8. The lesser stocking rate at the JLC Ranch permitted an additional 14 days of pasturing, until May 22.

Results

2000 – 2001

Winter gain was not different between rye and wheat, but triticale pasture significantly outperformed both rye and wheat, by about 0.1 lb/head daily for the initial 68-day grazing period (Table 2). After cattle were returned to their respective pastures on March 16, rye pasture significantly outperformed both wheat and triticale pasture during the 61-day period. Triticale outperformed wheat. It was expected that triticale would outperform both rye and wheat during spring grazing. Rye pasture likely benefited from greater than normal spring precipitation.

2001 – 2002

During 2001-2002, extremely dry conditions from August through March (6.6 inches or 50% of the long-term average) prevented turning cattle out until April. Before the grazing study, cattle were placed on a circle of irrigated Bt corn stalks and were supplemented with summer annual forage hay.

Rye and wheat were able to support greater stocking rates than the triticale pasture (Table 3). Daily gain was significantly greater for rye and triticale than wheat pasture, although, in part, the gain of cattle grazing triticale may have been supported by the greater amount of grain provided to them. When stocking rates were used to determine lb/acre daily, however, gains on rye were still significantly better than wheat, and wheat outperformed the triticale pasture. Both Jagger and Betty wheat pasture increased the gain/acre by 80% compared with triticale. This study evaluated only spring grazing, so this data does not support the suitability of Betty wheat for late fall/early winter pasture.

2002 – 2003

After production of a summer annual forage, winter-cereal pasture resulted in less cattle weight gain/acre than did winter cereals after summer fallow (Table 4) at the Sandyland site. Allowing cattle to graze grain-sorghum stubble in addition to rye allowed for a stocking rate (0.3 acres rye pasture per head) that was greater than could be achieved for the other treatments. This treatment resulted in less gain/head but a greater lb/acre gain.

In the experiment at the Sandyland site, for pastures following summer annual forage production, the amount of hay supplemented per heifer was less for the rye pasture than for the triticale and wheat pastures (Table 4). Also, the amount of supplemental hay required was less when heifers pasturing rye after summer fallow were given access to the grain-sorghum residue.

At the JLC Ranch, Table 5, wheat pasture produced significantly greater weight gain than the rye/wheat pasture (3.02 vs. 2.28 lb/head daily).

General Discussion

Stocking rates affected average daily gain/acre (Tables 3 and 4). Increased stocking rates resulted in significantly greater weight gain/acre and did not significantly decrease gain per head. More supplemental feeding was necessary, but increased production offset the cost.

Over the period of the study, rye provided better, more consistent weight gain and supported greater stocking rates than wheat or triticale. Cattle gain on wheat pasture was less than on rye pastures, but wheat pastures were significantly better than triticale. As expected, dry conditions limited the pasture season and increased the need for supplemental feeding.

Although greater stocking rates sometimes required more supplemental feeding, beef production per acre was significantly greater at the greater stocking rates. The ability of triticale to support cattle performance was affected by soil moisture more than were the other cereals.

Under conditions of adequate soil moisture, triticale supported stocking rates greater than did wheat (Table 4). Under moisture-limiting conditions (Table 3), however, the ability of triticale to support stock was less than that of wheat.

Under the dryland conditions on the sandy soils represented in the study, rye produced the best gains and was able to support the greatest stocking rates. Wheat and triticale pasture resulted in less gain overall. Under conditions of good soil moisture, wheat and triticale pasture productivity was close to the same. When soil moisture was limited, however, wheat pasture outperformed triticale pasture.

Table 1. Monthly Precipitation Totals at Sandyland Experiment Field

Month	2000-2001	2001-2002	2002-2003	Long-Term Average
	---------- inches ----------			
July	5.2	4.6	1.5	3.1
August	0.05	1.1	3.1	2.4
September	0.8	3.4	1.3	2.2
October	4.6	0.0	7.1	2.3
November	0.5	0.0	0.1	1.0
December	0.6	0.06	0.4	0.9
January	2.7	0.6	0.3	0.8
February	2.3	0.9	0.6	1.0
March	1.7	0.5	5.0	2.3
April	1.5	1.9	2.5	2.4
May	6.7	1.4	3.5	3.8
Total	19.95	13.7	25.4	18.3

Table 2. 2000-2001 Winter Grazing Study at Sandyland Experiment Field and Off-Site Fields

Item	Rye	Triticale	Wheat
Number of heifers	52	52	52
Number of pens	3*	3*	3*
November 29 – February 5 grazing			
Grazing days	68	68	68
Initial weight, lb	509	514	539
Final weight, lb	558	569	587
Gain, lb/head	49[a]	55[b]	48[a]
Gain, lb/head daily	0.73[a]	0.81[b]	0.71[a]
Drylot, February 5 – March 16			
Final weight, lb	544	541	567
Gain, lb/head	-14[a]	-28[b]	-20[ab]
Gain, lb/head daily	-0.37[a]	-0.74[b]	-0.52[ab]
March 16 – May 16 grazing			
Grazing days	61	61	61
Final weight, lb	680	661	660
Gain, lb/head	136[b]	120[b]	93[a]
Gain, lb/head daily	2.22[c]	1.96[b]	1.52[a]

*One 2-acre pasture stocked at 0.5 acres/heifer and two 27-acre pastures stocked at 1.11 acres/heifer.
[abc]Within a row, means not having the same superscript letter differ (P<0.05).

Table 3. 2001-2002 Winter Grazing Study at Sandyland Experiment Field

Item	Jagger Wheat	Betty Wheat	Rye[*]	Triticale[#]
Number of heifers	6	6	10	4
Stocking rate (acres/head)	0.5	0.5	0.3	0.7
Grazing days	43	43	43	43
April 11 weight, lb	616[b]	562[a]	602[b]	584[a]
May 23 weight, lb	676[b]	622[a]	672[b]	652[b]
Weight gain, lb/head	60[a]	60[a]	70[b]	68[b]
Daily gain, lb/head daily	1.40[a]	1.40[a]	1.62[b]	1.58[b]
Gain, lb/acre	120[b]	120[b]	232[c]	97[a]
Gain, lb/acre daily	2.8[b]	2.8[b]	5.4[c]	2.3[a]
Grain fed, lb/head	108	108	108	323

[abc]Within a row, means not having the same superscript letter differ (P<0.05).
[*]Variety not stated.
[#]Trical 2+2.

Table 4. 2002-2003 Winter Grazing Study at Sandyland Experiment Field

	After Summer Annual Forage			After Summer Fallow	
	Rye	Triticale	Wheat	Wheat	Rye + GSR[a]
Number of heifers	3	3	3	6	9
Stocking rate, acres/head	0.8	0.8	1.0	0.5	0.3
Grazing days	78	78	78	78	78
Initial weight, lb (Feb. 19)	644	634	755	649	644
Final weight, lb (May 8)	818	809	930	838	768
Gain, lb/head	174	175	175	189	124
Gain, lb/head daily	2.23	2.24	2.24	2.42	1.59
Gain, lb/acre	218	219	175	378	416
Gain, lb/acre daily	2.79	2.80	2.24	4.84	5.30
Bales[b] fed	2	4	5	9	7

[a]3 acres rye plus 9 acres grain-sorghum residue, with an average grain yield of 75 bushels/acre.
[b]Bale weight = 1200 lb.

Table 5. 2002-2003 Winter Grazing Study at JLC Ranch

	After Summer Fallow	
	Wheat	Wheat/rye
Number of heifers	18	75
Stocking rate, acres/head	1.0	1.0
Grazing days	92	92
Initial weight, lb (Feb. 19)	674	664
Final weight, lb (May 22)	952	874
Gain, lb/head	278	210
Gain, lb/head daily	3.02	2.28
Gain, lb/acre	278	210
Gain, lb/acre daily	3.02	2.28

EVALUATION OF NITROGEN AVAILABILITY IN LIQUID FEEDSTUFFS

E. A. Elwakeel, E. C. Titgemeyer, and J. S. Drouillard

Summary

We developed an in vitro assay to assess ruminal availability of protein in liquid feeds containing soluble protein/nitrogen. Microbial mass accumulating as a result of assimilation of dietary nitrogen by ruminal microbes during an in vitro fermentation is measured. In the assay, microbial growth is most limited by the availability of protein/nitrogen, so microbial mass is proportional to the amount of available nitrogen in the sample. In liquid feeds that we generated in the laboratory, ruminal nitrogen availability decreased in response to mild heating, and the decline was greater for feedstuffs containing true protein rather than urea. Addition of salt to the products decreased nitrogen availability by an average of 21%, whereas addition of 4% phosphoric acid decreased nitrogen availability by 50%. Future research will be needed to fully characterize these effects so that negative impacts of manufacturing on protein availability can be prevented.

Introduction

Under many conditions, protein supplements provided to ruminants are of optimal value when the protein (nitrogen) is completely available for use by the ruminal microbes. Although nitrogen from urea is considered to be completely available to the ruminal microbes, its availability can be reduced during processing as a result of various reactions that can occur. Similarly, true proteins that are predominantly available in the raw form may be unavailable to ruminal microflora when incorporated into various types of feeds.

Various approaches are available to assess the ruminal availability of proteins in feedstuffs. These include measures conducted in live animals, in situ disappearance of nitrogen from Dacron bags, and in vitro ammonia release (and similar assays in which other end-products of protein degradation are measured).

Live animal evaluations are ideal, but are too slow and costly for routine evaluation of a wide range of feeds. In situ incubation of substrates in Dacron bags provides a good measure for many feedstuffs, but it measures the insoluble proteins that remain after fermentation and, as such, is of little value in measuring availability of soluble nitrogenous compounds in liquid feeds. Moreover, in situ methodologies are based on the premise that protein solubility is synonymous with degradability, but this is not true. Many soluble nitrogen compounds are not ruminally degraded, and, conversely, nitrogen in some insoluble compounds can be degraded by ruminal microbes. Test-tube assays measuring ammonia release work well for some feeds, but feeds that have a low protein concentration or an easily fermentable carbohydrate component are difficult to evaluate because microbes will take up much of the ammonia that is produced from the feed.

The objective of this research was to evaluate how several processing characteristics alter the ruminal availability of nitrogen from liquid feeds by using a microbial growth assay developed for this purpose.

Experimental Procedures

We previously developed an in vitro assay to assess ruminal availability of protein in liquid feeds containing soluble protein/nitrogen. In this assay, we measure the microbial mass that accumulates as a result of assimilation of dietary nitrogen by ruminal microbes during an in vitro fermentation. In the assay, microbial growth is most limited by the availability of protein/nitrogen and, therefore, the microbial mass is proportional to the amount of available nitrogen in the sample. Buffered rumen fluid is incubated with the nitrogen source to be tested in the presence of an excess amount of energy (starch). After 12 hours of incubation, the amount of cytosine (a marker of microbial mass) is measured.

In initial work with this assay, similar responses were achieved when true proteins and non-protein nitrogen sources, such as urea, were tested. Thus, the assay is relatively robust with regard to the type of substrates that can be evaluated.

We also were concerned that the addition of carbohydrates other than the starch, which we purposely added as an energy source, could impact the relationship between available nitrogen and microbial cell mass. The practical concern was that sugars provided by some low-protein supplements might impact the results. In tests, addition of sugars to the fermentations led to small, but significant, increases in cytosine production. Thus, we added sugars to the standard curves and corrected for the amount of cytosine that was produced from carbohydrate rather than nitrogen supply.

In these experiments, we evaluated some of the processing variables that might impact the ruminal availability of nitrogen in liquid feeds. We tested the effects of base ingredient, heating, and addition of minerals. We prepared the test products from the following base ingredients: cane molasses, steep liquor, distiller's solubles, and concentrated separator byproduct. We also made products from purified components to mimic the base ingredients but with "contaminants" removed. The goal of using the purified components was to model the effects of individual components that might be provided by the various base ingredients. The purified components included 1) 55% sucrose, 2) 33% sucrose plus 11% glucose plus 11% fructose, 3) 30% starch, partly hydrolyzed by amylase, plus 4.5% lactic acid, and 4) 5% soluble starch. Products were made by adding either casein or urea as the nitrogen source to mimic true protein and non-protein nitrogen in feeds, respectively. Most of the crude protein contained in the products was supplied by the casein or the urea. To assess mineral additions, we added salt (NaCl) at 2% of the product weight, and phosphoric acid was added at 4% of the product weight. The products were heated by placing the samples in a boiling water bath for 15 minutes, whereas unheated products were maintained at room temperature throughout the process. The samples were stored frozen between the time they were produced and the time they were analyzed.

Results and Discussion

The base ingredient used to manufacture the product impacted the availability of the protein (Table 1). Notably, products made with concentrated separator byproduct had less ruminal availability of nitrogen than the other products. In general, products made with typical feed ingredients had lesser availability than those made with the purified components.

The decrease in ruminal nitrogen availability in response to heating was rather dramatic, and this response was dependent upon whether the primary source of nitrogen was casein or urea (Table 2). There was a much greater decline in nitrogen availability in response to heating for products that contained casein than for those that contained urea. This difference suggests that intact proteins are

more able to enter into heat-dependent reactions that impact availability. Interestingly, the base ingredient used to make the product did not greatly affect the response to heating (data not shown). We expected that products with more reducing sugars would be more impacted by heating, but this was not observed. For example, heating decreased the availability of nitrogen in products made with sucrose by 42%, but ruminal nitrogen availability was only decreased 33% by heating in products made with a mixture of sucrose, glucose, and fructose.

Mineral additions to unheated products (as salt or phosphoric acid) also had a large impact on nitrogen availability. Addition of salt to the products decreased nitrogen availability by an average of 21%, whereas addition of 4% phosphoric acid decreased nitrogen availability by 50%. However, the responses to the mineral additions were somewhat dependent upon the source of protein (casein vs. urea, Table 3) and the base ingredient used to make the product (data not shown). For example, the negative effect of salt was greater for those products made with urea than for those made with casein. In contrast, the negative effect of phosphoric acid additions was similar and dramatic for products made with either casein or urea. Based on our data, we cannot determine if the effects of phosphoric acid resulted from changes in acidity or from the addition of phosphate to the sample. This information would be helpful in predicting if other acids or phosphate-containing compounds would alter nitrogen availability.

In summary, processing characteristics can impact the availability of nitrogen from liquid feeds. Important variables include the base ingredient, the source of nitrogen, mineral additions, and heating. In addition, significant interactions between some of these variable were present. Future research will be needed to fully characterize these effects so that negative impacts of manufacturing on protein availability can be prevented.

Table 1. Ruminally Available Nitrogen in Liquid Feed Products Containing Casein or Urea as the Primary Nitrogen Source and Manufactured from Different Base Ingredients

Base ingredient[1]	Ruminally available nitrogen
	--- % ---
Cane molasses	73
Concentrated separator byproduct	47
Distiller's solubles	67
Steep liquor	72
55% sucrose	81
33% sucrose, 11% glucose, 11% fructose	87
30% hydrolyzed starch, 4.5% lactic acid	69
5% soluble starch	100
Standard Error	6.4

[1]Products contained 2% added salt and represent averages of unheated products and products heated in a boiling water bath for 15 minutes.

Table 2. Effects of Heating and Nitrogen Source on Ruminally Available Nitrogen in Liquid Feeds[1]

Nitrogen source	Unheated	Heated[2]
	---------- % available nitrogen ----------	
Casein	106	45
Urea	80	67
Standard Error	4.5	

[1]Values represent averages across products manufactured with a range of base ingredients.
[2]Products were heated in a boiling water bath for 15 minutes.

Table 3. Effect of Mineral Additions and Nitrogen Source on Ruminal Nitrogen Availability in Liquid Feeds[1]

	Nitrogen source	
Mineral addition	Casein	Urea
	---------- % available nitrogen ----------	
None	110	124
2% Salt	106	80
4% Phosphoric acid	61	55
Standard Error	4.8	

[1]Values represent averages across products manufactured with a range of base ingredients.

IN VITRO EVALUATION OF FIBROLYTIC ENZYMES TO INCREASE DIGESTION OF FIBROUS FEEDSTUFFS

E. A. Elwakeel, E. C. Titgemeyer, and B. J. Johnson

Summary

Fermentations were conducted to identify enzyme activities and amounts that would optimize digestion of high-fiber feed ingredients (soybean hulls, alfalfa, corn silage, and corn gluten feed). In general, adding enzymes increased in vitro dry matter disappearance, but total volatile fatty acid concentrations were not improved by enzyme treatments. The response to enzymes was similar across substrate, suggesting that substrate specificity of the enzymes is not important. The most effective enzyme preparation had greater cellulase activity than the other enzyme preparations, suggesting that cellulase might be the most important enzymatic activity for improving digestion of fibrous feedstuffs.

Introduction

Soybean hulls are a feedstuff that has excellent digestibility when measured in vitro, but this often does not translate to high digestibilities when the product is fed to cattle. This discrepancy between in vitro and in vivo observations probably is caused by the relatively rapid rate of passage of soybean hulls from the rumen. Thus, this feedstuff would likely benefit from treatments that would increase the fermentation rate. One such product would be enzyme treatment.

A previous digestion trial demonstrated that we could improve in vivo digestion of soybean hulls by adding fibrolytic enzymes to the diet. The goals of the present study were to more exactly identify the enzyme activities and amounts that are needed to optimize digestion of soybean hulls and to expand this work to encompass several other high-fiber feed ingredients (alfalfa, corn silage, corn gluten feed) that are available for use in the cattle industry.

Experimental Procedures

Fermentations were conducted in 50-mL centrifuge tubes fitted with rubber stoppers containing gas-release valves. The substrate weight was 0.30 g, suspended in a mixture of McDougall's buffer (20 mL) and strained rumen fluid (10 mL). Rumen fluid was collected from two animals fed mixed diets and pooled together before conducting the experiment. After fermentation at 39°C, the tubes were centrifuged (20,000 × g) and the liquid portion decanted. A sample of the liquid was mixed with meta-phosphoric acid and prepared for analysis of volatile fatty acids (VFA) by gas chromatography. The pellet was solubilized in an acid/pepsin solution and incubated at 39°C. The residue was then filtered through Whatman 541 filter paper, dried, and weighed to determine the undigested residue. In vitro dry matter disappearance (IVDMD; an estimate of digestibility) was then calculated. Each treatment was run in duplicate tubes, and the "no enzyme" controls were run in quadruplicate to ensure that we had an accurate value for the negative control.

Experiment 1. Seven enzyme preparations were provided by Saf Agri. The activities of the enzymes, as provided by Saf Agri,

were: **FP800** (cellulase = 25 units; xylanase = 700 units, ß-glucanase = 1400 units), **XP500** (high xylanase activity), **Mix A** (cellulase = 8 units; xylanase = 700 units, ß-glucanase = 1400 units), **Mix B** (same as Mix A, plus 250 units pectinase), **Mix C** (same as Mix A, plus 1400 units galactomannase), **Mix D** (same as Mix C, plus 1300 units papain), and **Mix E** (same as Mix C, plus 44 units fradiase).

For this study, all seven enzyme products were tested at four different inclusion levels. A control treatment with no enzyme addition also was evaluated. The enzyme levels were determined on the basis of amounts that would be provided to a lactating dairy cow and consisted of 1, 5, 15, or 30 g/day. The amounts used for the fermentations were scaled by calculating the substrate provided to each in vitro tube (0.30 grams) relative to daily feed intake by a dairy cow (55 pounds/day). The amounts required for application to beef cattle diets would be less, likely in proportion to feed intake. This study used soybean hulls and alfalfa as substrates. The fermentations were conducted for 24 and 48 hours, and data in Table 1 represents an average from these two fermentation times.

Experiments 2 and 3. Experiments 2 and 3 were identical except for the substrates (feedstuffs) that were tested. Exp. 2 used alfalfa and soybean hulls as substrates, whereas Exp. 3 used corn silage and corn gluten feed as substrates. These experiments evaluated the effects of the enzymes at different inclusion levels. Enzyme levels were selected on the basis of data from Exp. 1. For all products, we tested 5 g/d, but we also tested additional levels that showed promise in Exp. 1. Each enzyme amount was incubated with the substrate for 1 or 18 hours before starting the fermentation. The presented data is the average of these two pre-incubation times. Fermentations were conducted for 24 or 48 hours, and the presented data is the average of these two incubation times.

Results and Discussion

Experiment 1. In general, enzyme treatments increased in vitro dry matter disappearance (IVDMD), and there were differences among the enzymes and enzyme levels. In some instances, the lesser amounts of the enzymes were more effective than the greater amounts in increasing IVDMD. This was evident for FP800 and Mix C, in which the 1 and 5 g/d treatments yielded better IVDMD than any other of the enzyme treatments. There were several enzymes for which the response was the same for all of the levels tested (XP500, Mix A, B, and D), and for Mix E the response seemed to be better for the higher levels (15 and 30 g/d) than for the lower levels (1 and 5 g/d). Although enzyme treatments significantly increased IVDMD, total VFA concentrations were not affected by enzyme treatment in this experiment.

The response to enzymes was similar between alfalfa and soybean hulls (data not shown). Thus, within the limits of the two substrates and the range of enzymes evaluated, the best choice of an enzyme did not seem to be dependent upon dietary ingredients.

Experiments 2 and 3. As in Exp. 1, the response to enzymes was similar among the substrates (data not shown). Thus, there was no evidence to suggest that different enzymes would be needed for each feedstuff. Effects of enzyme additions on IVDMD and VFA concentrations are presented in Table 2. The FP800 enzyme increased IVDMD to a greater extent than did the other enzymes. Responses to FP800 were achieved with lesser amounts (0.3 or 1.0 g/day), with no further response to the greater amounts in either experiment. The enzyme XP500 (at 5 g/day) seemed to be nearly as efficacious as FP800 in Exp. 3, but response to it was somewhat less than FP800 in Exp. 2.

Among the products Mix A, B, C, D, and E, comparisons can be made of the 5 g/d

treatments to assess the advantages of adding additional enzyme activities. Mix A represents the basic activities, with the other mixes representing addition of different activities. In general, Mix A did not improve IVDMD. However, addition of pectinase activity (Mix B) or galactomannase activity (Mix C) seemed to improve IVDMD. Interestingly, the addition of papain activity to Mix C (in creating Mix D) or the addition of fradiase activity to Mix C (in creating Mix E) resulted in less IVDMD than the Mix C alone (5 g/d). Responses to the addition of pectinase and galactomannase are a little surprising because the substrates for these enzyme activities (pectins, nonlignified hemicelluloses) are readily degraded by ruminal microbes.

Changes in VFA production in response to enzyme treatment were not related to the changes in IVDMD. This was particularly evident in Exp. 3 in which there was a negative relationship between IVDMD and VFA across the enzyme treatments. We would expect that, as digestion of a feedstuff increases (as indicated by IVDMD), there would be a concomitant increase in the end-products of that fermentation (i.e., VFA). We do not have an explanation for the lack of a relationship between these two responses in these experiments.

It is unknown if the same amounts of enzymes would be effective in production settings. However, the response to small amounts of the FP800 certainly provides us with optimism about its potential effectiveness. The greater activity of cellulase in the FP800 than in the other enzyme mixes suggests that cellulase might be the most important enzyme activity.

Table 1. Effect of Enzyme Treatment on In Vitro Dry Matter Disappearance (IVDMD) from Alfalfa and Soybean Hulls and Subsequent Volatile Fatty Acid (VFA) Concentration (Exp. 1)

Enzyme	Amount	IVDMD[a]	VFA
	g/day*	----- % -----	----- m*M* -----
None	0	68.7	93.4
FP800	1	75.4	90.1
	5	75.2	89.9
	15	71.6	93.0
	30	71.1	91.8
XP500	1	71.6	92.9
	5	71.6	92.3
	15	71.6	94.0
	30	71.7	90.1
Mix A	1	70.1	92.9
	5	69.4	91.2
	15	71.4	90.1
	30	71.6	90.8
Mix B	1	68.5	91.2
	5	70.3	90.2
	15	73.0	92.7
	30	72.5	92.9
Mix C	1	74.8	93.5
	5	73.9	91.8
	15	69.0	92.8
	30	68.7	92.0
Mix D	1	71.9	91.2
	5	72.0	90.9
	15	72.8	91.9
	30	73.6	91.0
Mix E	1	70.0	95.7
	5	70.0	93.3
	15	73.5	93.8
	30	72.7	94.1
SEM		0.88	1.5

[a]Significant effect of enzyme treatment ($P<0.0001$).

*Amount relative to a dairy cow consuming 55 pounds of feed daily. Required amounts would be less, in proportion to feed intake, for beef cattle.

Table 2. Effect of Enzyme Addition on In Vitro Dry Matter Disappearance (IVDMD) and Total Volatile Fatty Acid (VFA) Concentrations from Fermentation of Alfalfa and Soybean Hulls (Exp. 2) or Corn Silage and Corn Gluten Feed (Exp. 3)

		Experiment 2		Experiment 3	
Enzyme	Amount	IVDMD [a]	VFA [a]	IVDMD [a]	VFA [b]
	g/day*	-- % --	-- m*M* --	-- % --	-- m*M* --
None	0	65.9	83.0	71.3	75.3
FP800	0.3	67.7	83.0	74.0	73.6
FP800	1	69.3	84.3	75.1	72.0
FP800	3	67.5	80.5	72.0	73.2
FP800	5	69.9	82.3	75.3	70.9
XP500	5	67.0	78.2	74.6	74.5
Mix A	5	64.4	77.5	72.2	74.7
Mix B	5	68.6	77.3	73.9	75.2
Mix C	1	66.4	84.8	71.8	74.1
Mix C	5	67.9	79.1	76.7	75.2
Mix D	5	65.7	84.0	73.5	73.8
Mix D	15	66.8	83.1	74.7	70.3
Mix E	5	65.3	82.1	70.9	75.3
SEM		0.9	1.5	1.2	1.3

[a]Significant effect of enzyme treatment, $P<0.01$.
[b]Tendency for an effect of enzyme treatment, $P=0.07$.
*Amount relative to a dairy cow consuming 55 pounds of feed daily. Required amounts would be less, in proportion to feed intake, for beef cattle.

EFFECTS OF AMMONIA LOAD ON AMINO ACID UTILIZATION BY GROWING STEERS

M. S. Awawdeh, E. C. Titgemeyer, K. C. McCuistion, and D. P. Gnad

Summary

Ruminally cannulated steers were used in two experiments to study effects of rumen ammonia load on methionine and leucine utilization. All steers were limit-fed a diet based on soybean hulls, received ruminal infusions of volatile fatty acids and abomasal infusions of glucose to provide energy, and received an abomasal infusion containing a mixture of all essential amino acids except methionine in Exp. 1 or leucine in Exp. 2. Treatments were arranged as 3 × 2 factorials and included urea (0, 40, or 80 g/day) infused ruminally and methionine (2 or 5 g/day) infused abomasally in Exp. 1 and leucine (0, 4, or 8 g/day) infused abomasally and urea (0 or 80 g/day) infused ruminally in Exp. 2. In Exp. 1, supplementation with the greater amount of methionine improved retained nitrogen, but urea infusions did not alter nitrogen retention. In Exp. 2, leucine linearly increased retained nitrogen, and urea infusions also increased nitrogen retention. The efficiency of deposition of supplemental methionine ranged between 18 and 27%, whereas that for leucine ranged from 24 to 43%. Increasing ammonia load did not negatively impact whole-body protein deposition in growing steers when either methionine or leucine was limiting.

Introduction

Ammonia is generated within the rumen from the degradation of protein and non-protein nitrogenous compounds, subsequently absorbed, and detoxified predominantly into urea in the liver. Some previous studies indicate that ammonia detoxification might require additional nitrogen from non-ammonia nitrogen to support ureagenesis and that ammonia load might have metabolic costs that could decrease protein deposition by the animal. This negative effect of an ammonia load has been used to explain the inefficient utilization of nitrogen in forage-fed animals. In contrast, some studies have demonstrated little or no effect of ammonia loading on animal performance. Our objective was to study the effects of rumen ammonia loading on methionine and leucine utilization by growing cattle.

Experimental Procedures

Experiment 1. Six ruminally cannulated Holstein steers (initially weighing 428 pounds) fitted with ruminal and abomasal infusion lines were used in a 6 × 6 Latin square to study the effects of ammonia load on methionine utilization. Steers were housed in individual metabolism crates in a temperature-controlled room. All steers received the same basal diet at 5.7 lb/day dry matter in equal proportions at 12-hour intervals. The basal diet contained 83% soybean hulls and was formulated to provide adequate ruminally degraded protein but small amounts of amino acids to the small intestine. All steers received continuous ruminal infusions of volatile fatty acids, as well as abomasal infusions of glucose to supply additional energy without increasing microbial protein supply. All steers received continuous abomasal infusions of an amino acid mixture that supplied all essential

amino acids, except methionine, to ensure that methionine was the most limiting amino acid for nitrogen retention.

Treatments were arranged as a 3 × 2 factorial and included three levels of urea (0, 40, and 80 g/day) infused continuously into the rumen to serve as ammonia loads and two levels of L-methionine (2 and 5 g/day) infused continuously into the abomasum. Each experimental period lasted for 6 days, consisting of 2 days for adaptation to treatment and 4 days for fecal and urinary collections.

Experiment 2. Six ruminally cannulated Holstein steers (initially weighing 417 pounds) were used to study the effects of ammonia load on leucine utilization. Experimental housing, periods, diet, treatment administration, and collections were the same as for Exp. 1 except that leucine was restricted instead of methionine. Treatments were arranged as a 3 × 2 factorial, and included three levels of L-leucine (0, 4, and 8 g/day) infused abomasally and two levels of urea (0 and 80 g/day) infused ruminally.

Results and Discussion

Experiment 1. There were no methionine × urea interactions for diet digestibilities or nitrogen-retention data (Table 1). Nitrogen intake was increased in response to both methionine and urea infusions as a result of the additional nitrogen infused. Fecal nitrogen excretions were not altered by treatments. The higher level of methionine supplementation increased nitrogen retention from 22.0 to 27.5 g/day. The observed increase in retained nitrogen was a result of the decreased urinary nitrogen excretions from 68.8 to 64.8 g/day because of methionine supplementation. Although urea infusions linearly increased urinary nitrogen excretions, from 48.5 to 67.3 and 84.5 g/day for steers infused with 40 and 80 g/day urea, respectively, retained nitrogen was not affected by the ammonia load provided by the urea supplementation.

If we assume that retained nitrogen was deposited completely as tissue protein (retained nitrogen × 6.25) and that the protein of tissue gain contains 2.0% methionine, the calculated efficiencies of methionine utilization were 23, 27, and 18% for steers receiving 0, 40 and 80 g/day urea, respectively. Thus, our average efficiency of utilization of supplemental methionine (23%) was similar to previous observations from our laboratory, but much less than the 65% efficiency value utilized by the current Beef NRC publication.

Experiment 2. There were no leucine × urea interactions for diet digestibilities or nitrogen retention data (Table 2). Diet digestibilities of dry matter were linearly increased in response to leucine supplementation, which matches the observed decrease in fecal nitrogen excretions in response to leucine supplementation (Table 2). Changes in fecal output are not typically observed in response to changes in supply of a limiting amino acid, so we have no explanation for these small, but significant, changes in fecal output. Digestibilities of dry matter were not affected by urea infusion.

Nitrogen retention linearly increased with leucine supplementation, from 21.4 to 24.5 and 26.9 g/day for 4 and 8 g/day leucine, respectively. The increase in retained nitrogen in response to leucine supplementation was a result of decreases in both urinary and fecal nitrogen excretions. Leucine supplementation linearly decreased urinary nitrogen excretions, from 65.3 to 63.2 and 62.2 g/day for 4 and 8 g/day leucine, respectively, and linearly decreased fecal nitrogen excretions, from 22.1 to 21.2 and 19.9 g/day for 4 and 8 g/day leucine, respectively. The increase in retained nitrogen in response to supplementation of leucine in our study was an expected result. The ob-

served linear responses to leucine suggest that steer requirements for supplemental leucine are clearly more than 4 g/day and probably close to 8 g/day under our experimental conditions.

Nitrogen intake was increased with urea infusions as a result of the additional nitrogen infused. Retained nitrogen increased from 22.4 to 26.2 g/day when 80 g/day urea was infused. Fecal nitrogen excretions were not affected by urea infusions. Urea infusions increased total urinary nitrogen excretion from 47.1 to 80.0 g/day (Table 2).

The increase in retained nitrogen with urea infusions is in contrast to our initial hypothesis that an ammonia load might decrease nitrogen retention by increasing catabolism of the limiting amino acid (leucine). The reasons for the increased nitrogen retention with urea infusion are unknown, but it is possible that the observed increase in retained nitrogen in response to ammonia loading in our study was a result of decreasing the rate of leucine transamination (catabolism) by altering the substrate available for this reaction.

If we assume that retained nitrogen was deposited completely as tissue protein (retained nitrogen x 6.25) and that the protein of tissue gain contains 6.7% leucine, the calculated efficiency of leucine utilization between 0 and 4 g/day of leucine supplementation was 24 and 43% for steers receiving 0 and 80 g/day urea, respectively. The seemingly greater efficiency of leucine utilization in the presence of the urea infusion might be explained by ammonia loading decreasing the degradation of leucine, the limiting amino acid in our study, which resulted in increases in retained nitrogen and utilization efficiency.

Most typical diets fed to growing cattle, particularly diets containing significant amounts of corn protein, would not be expected to be limiting in leucine supply. Thus, there is not a great opportunity to directly apply the benefits of improving leucine utilization to a production setting.

General Discussion. The utilization efficiency of methionine and leucine was less than the 65% efficiency value utilized by the current Beef NRC to predict the requirements of growing cattle for amino acids. The NRC assumes the same utilization efficiency value for all amino acids, and the efficiency is based only on the equivalent body weight of the animal. Recently, our lab has observed an efficiency of utilization for supplemental histidine (65%) greater than that for methionine and leucine. The efficiency of histidine utilization was close to the value utilized by the NRC, suggesting that there are differences among amino acids in how efficiently they are used by cattle.

In light of our results, the utilization efficiency for amino acids should be considered separately for each amino acid when calculating the amino acid requirements of growing steers. It is clear that amino acids can have different efficiency values. Moreover, our data suggest that, at least for leucine, the efficiency may depend upon the nutritional status of the animal. For example, leucine requirements might be less for cattle fed diets containing a higher concentration of crude protein. However, formulating diets for cattle on the basis of individual amino acids may be difficult at the present time because of the lack of information for each amino acid.

In both experiments, we studied the effects of ammonia load under conditions in which amino acid supply was limiting. To achieve that, the diet was formulated to provide deficient amounts of amino acids, and all essential amino acids, except the amino acid under study, were supplemented. Ammonia loading did not have negative effects on nitrogen re-

tention or on the utilization of supplemented methionine or leucine by growing steers. Rather, increasing ruminal ammonia in excess of the concentrations recommended to optimize ruminal fermentation improved whole-animal protein deposition (nitrogen retention) in Exp. 2. Although increasing the ruminal ammonia load beyond that needed to optimize ruminal fermentation led to improvements in whole-animal protein deposition when leucine supply limited animal performance, environmental and economical costs may not justify the use of ammonia loading as a means of improving cattle performance.

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Table 1. Effects of Methionine Supplementation and Ammonia Load on Nitrogen Balance in Growing Steers (Exp. 1)

	2 g/day L-methionine			5 g/day L-methionine			
Item	No urea	40 g/day urea	80 g/day urea	No urea	40 g/day urea	80 g/day urea	SEM
Nitrogen, g/day							
Total intake[a,b]	91.0	110.0	128.7	92.6	111.5	129.3	0.6
Fecal	18.4	19.7	18.8	17.8	20.2	18.5	1.1
Urinary[a,b]	50.1	70.0	86.2	46.8	64.7	82.9	1.4
Retained[a]	22.5	20.2	23.5	28.0	26.6	27.9	1.7
Dry matter digestibility, %	69.7	68.8	69.4	69.5	69.3	69.3	1.0

[a]Effect of methionine (P<0.05).
[b]Linear effect of urea (P<0.05).

Table 2. Effects of Leucine Supplementation and Ammonia Load on Nitrogen Balance in Growing Steers (Exp. 2)

	No Urea			80 g/day Urea			
Item	No leucine	4 g/day leucine	8 g/day leucine	No leucine	4 g/day leucine	8 g/day leucine	SEM
Nitrogen, g/day							
Total intake[b]	90.4	90.5	91.0	127.1	127.1	127.0	0.5
Fecal[a]	22.7	20.7	19.9	21.4	21.4	19.9	1.2
Urinary[a,b]	47.6	47.3	46.4	83.0	79.0	77.9	1.3
Retained[a,b]	20.1	22.4	24.7	22.6	26.7	29.2	2.0
Dry matter digestibility, %[a]	72.9	75.5	75.3	72.5	74.9	75.7	1.2

[a]Linear effect of leucine (P<0.05).
[b]Effect of urea (P<0.05).

EFFECTS OF ENERGY LEVEL ON METHIONINE UTILIZATION BY GROWING STEERS

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Summary

The objective of this study was to evaluate the effect of energy level on amino acid utilization in growing steers. Six ruminally cannulated Holstein steers (503 lb) were limit-fed (6.2 lb/day dry matter) a diet based on soybean hulls (83%), wheat straw (7.6%), and cane molasses (4.1%). The treatments consisted of the infusion of two methionine levels (0 or 3 g/d) and three energy levels (0, 1.3, or 2.6 Mcal ME/day) in a 2 x 3 factorial arrangement. Energy was supplied through ruminal infusion of acetate, propionate, and butyrate and through abomasal infusion of glucose and fat in increasing amounts. No interactions between methionine and energy level were observed. Nitrogen balance was increased by methionine supplementation, indicating that this amino acid limited protein deposition. A linear increase in nitrogen retention was found with the increase in energy. These improvements in protein deposition were related to reductions in urinary nitrogen excretion, reduced plasma-urea concentrations, and greater circulating concentrations of insulin and insulin-like growth factor-I. The results of this study suggest that amino acid utilization can be improved by increasing energy. These effects could be partly explained by variations in plasma concentration of key hormones involved in the control of protein deposition.

Introduction

Energy supply affects protein deposition when the amino acid supply is not limiting. In pigs, when energy is limiting, protein deposition does not respond to increases in dietary protein supply. However, when energy supply is adequate, protein deposition increases with an increase in dietary protein intake. This type of relationship between energy and protein supply and protein deposition, which is observed in monogastric animals, has been described as protein- and energy-dependent phases of growth. These relationships indicate that exact dietary amino acid requirements can be specified for each level of protein deposition. Although this type of relationship is assumed for cattle by most nutrient-requirements systems, it has seldom been studied. The objective of our study was to determine the effect of energy supply on methionine utilization in growing steers.

Experimental Procedures

Six ruminally cannulated Holstein steers (503 lb initially) were allocated in a 6 x 6 balanced Latin square design. The steers were limit-fed (6.2 lb/day dry matter) a diet based on soybean hulls (83%), wheat straw (7.6%), cane molasses (4.1%) and vitamin-mineral mix. All steers received supplemental energy by ruminal infusion of 400 g/day of acetic acid. The treatments were arranged as a 3 x 2 factorial, and consisted of two methionine levels (0 or 3 g/day) and three energy levels [0 (**0x**), 1.3 (**1x**), or 2.6 (**2x**) Mcal ME/day; Table 1]. The amounts of methionine were selected in the range of linear response for our experimental model. Ruminal infusion of acetate, propionate, and butyrate and abomasal infusion of glucose and fat allowed increases in the energy supply to the animal without increasing ruminal protein synthesis.

Table 1. Energy Sources Infused

	Energy Level		
Energy sources, g/day	0	1x	2x
Acetate	0	90	180
Propionate	0	90	180
Butyrate	0	30	60
Glucose	0	30	60
Fat[a]	0	30	60
Energy, Mcal ME/day	0	1.3	2.6

[a]Composed of 20% C18:0, 50% C18:1, and 30% corn oil.

The basal diet was formulated to provide a low protein:energy ratio, small amounts of ruminally undegradable protein, and enough ruminally available nitrogen to support adequate microbial growth. Feed restriction maintained a limited supply of amino acids to create a limitation in methionine, such that a response to its supplementation could be achieved. A mixture containing all of the essential amino acids except methionine was continuously infused abomasally to prevent limitations in protein synthesis by an amino acid other than methionine. Thus, protein deposition should be limited by methionine supply. Nitrogen balance was used as a measure to estimate protein deposition by the steers.

Results and Discussion

The interaction between methionine and amount of supplemental energy was not significant (P>0.10) for any variable analyzed. As expected, the infusion of 3 g/day of methionine increased nitrogen retention (Figure 1), indicating that this amino acid was limiting protein deposition. If we assume that the empty body of Holstein steers contains 19.7% protein, the extra 4.2 g/day nitrogen retained would represent an increase of 0.29 lb/day in daily gain. If we assume that nitrogen retained is directly converted to protein deposition (nitrogen retention x 6.25) and that protein in the whole empty body contains 2% methionine, the calculated efficiency of methionine utilization was 17%. This estimate for efficiency of methionine use is similar to what we have observed in other research trials.

Increasing the energy supply linearly increased nitrogen retention regardless of methionine infusion (Figure 1). This improvement in nitrogen retention was related to a decrease in urinary nitrogen excretion without changes in fecal nitrogen output. The results indicate that increasing energy supply increased protein deposition, even when there was a clear limitation in protein supply, suggesting that energy level affects the efficiency of amino acid utilization. The increases in nitrogen retention as energy supplementation increased would represent added gains of about 0.15 and 0.33 lb/day, respectively, for 1x and 2x compared with 0x.

Dietary dry matter digestion was linearly decreased with the increase of energy supply (Table 2). These results could be associated with the increasing amounts of volatile fatty acids infused into the rumen that could reduce ruminal fiber digestion. Because of the decrease in diet digestibility (Table 2), the increases in total energy supply may have been slightly less than the planned amounts.

Plasma urea concentration decreased linearly with the increase of energy supply and with the addition of methionine (Table 2), agreeing with the increase in nitrogen retention (Figure 1) and the reduction in urinary nitrogen excretion. Plasma insulin concentration increased quadratically with energy. Insulin-like growth factor I (**IGF-I**) concentration was linearly increased with the increase in energy, with no effects of supplemental methionine (Table 2). Enhancement in the circulating concentrations of insulin and IGF-I has been associated with a decrease in muscle protein breakdown and an increase in protein

synthesis, resulting in a greater protein deposition.

Overall, nitrogen retention was increased linearly with the increase in energy supply, even when methionine was deficient. These results suggest that the efficiency of amino acid utilization was improved by increasing energy supply. The increase in nitrogen retention could be partly explained by changes in plasma concentration of some key hormones involved in the regulation of protein deposition.

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Table 2. Effects of Energy Supply and Methionine Supplementation on Diet Digestion and Blood Metabolites

		0 g/d L-Methionine			3 g/d L-Methionine			
Item	Energy =	0x	1x	2x	0x	1x	2x	SEM[a]
Dry matter digestibility, %[a]		75.5	73.0	69.7	75.5	74.6	73.8	1.5
Blood metabolites								
Urea, mM [a, b]		2.95	2.65	2.20	2.63	2.29	1.90	0.24
Glucose, mM		4.66	4.89	4.92	4.71	4.86	4.80	0.15
Insulin, ng/mL [c]		0.39	0.52	0.46	0.38	0.43	0.39	0.04
IGF-I, ng/mL [a]		691	728	734	698	764	902	80

[a]Linear effect of energy supply (P<0.05).
[b]Effect of methionine (P<0.05).
[c]Quadratic effect of energy supply (P<0.05).

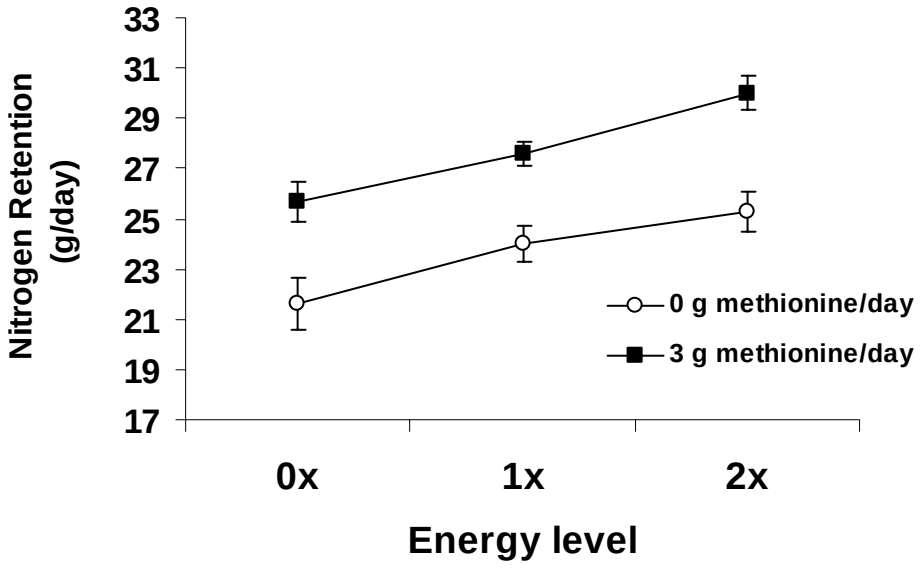

Figure 1. Effects of Energy Supply and Methionine Supplementation on Nitrogen Retention. Effect of methionine (P<0.05). Linear effect of energy supply (P<0.05).

PLASMA METABOLITES OF RECEIVING HEIFERS AND THE RELATIONSHIP BETWEEN BOVINE RESPIRATORY DISEASE, WEIGHT GAIN, AND CARCASS CHARACTERISTICS

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Summary

Six hundred sixty-five crossbred beef heifers initially weighing 495 lb were used to evaluate rectal temperature and plasma glucose, lactate, and urea nitrogen at initial processing as indicators of health status of newly arrived receiving cattle. We also evaluated the relationship between bovine respiratory disease (BRD), weight gain, and carcass characteristics. An increased number of treatments for BRD was associated with lower (linear, $P<0.01$) plasma glucose and lactate concentrations at initial processing. Elevated rectal temperatures at initial processing were associated with a greater number of treatments for BRD (linear, $P<0.03$). Initial body weight, final body weight, and average daily gain during the receiving period were progressively less (linear, $P<0.01$) as the number of treatments for BRD increased, whereas grazing-period gain was progressively greater with more frequent treatment for BRD during the receiving period (linear, $P<0.01$). Finishing-period gain, final body weight, hot carcass weight, fat thickness, and marbling score were linearly decreased ($P<0.05$) with increased treatment for BRD during the receiving period. These data suggest that initial plasma glucose and lactate concentrations might be associated with the health of newly arrived receiving cattle and that increased incidence of BRD in cattle is associated with lower weight gain and carcass quality.

Introduction

Bovine respiratory disease (BRD) continues to be a significant problem in receiving cattle. Stress associated with weaning, transport, commingling, processing, as well as feed and water deprivation, can compromise the immune system, thereby predisposing cattle to outbreaks of BRD. Antibiotic therapy is commonly employed to decrease the immediate impact of BRD on cattle performance; little is known, however, about the implications of BRD for subsequent growth performance and carcass values.

Current methods of BRD detection in receiving cattle consist of measuring rectal temperature and(or) visual appraisal of clinical symptoms. These methods are subjective and often lack the sensitivity necessary to detect BRD in its early stages of development. We theorized that the previously-mentioned stressors might affect plasma metabolites such as glucose, lactate, and urea nitrogen in newly arrived receiving cattle. The objectives of our study were to evaluate the association between rectal temperature, plasma glucose, lactate, and urea nitrogen measured at initial processing, and the incidence of BRD in newly arrived receiving cattle, as well as to evaluate the impact of BRD on subsequent growth performance and carcass characteristics of cattle.

Experimental Procedures

A total of 665 crossbred beef heifers initially weighing 495 lb was used in a completely randomized design. Heifers were processed within 24 hours of arrival, and processing included vaccination against common viral and clostridial diseases (Bovishield® 4 and Fortress® 7), recording of rectal temperature, treatment for internal and external parasites (Phoenectin®), and sampling of blood via jugular venipuncture for analysis of plasma glucose, lactate, and urea nitrogen concentrations.

Immediately after initial processing, heifers were assigned randomly to 28 pens, which contained 21 to 27 heifers depending upon pen size. Heifers were offered a diet containing 44% steam-flaked corn, 45% alfalfa hay, 6% corn steep liquor, 3.8% soybean meal, and 1.2% vitamins and minerals for ad libitum consumption. Heifers were subsequently monitored for clinical signs of BRD, including depression, lethargy, anorexia, coughing, rapid breathing, and nasal or ocular discharge. Heifers exhibiting signs of BRD received antibiotic therapy consisting of Micotil® as a first-time and second-time treatment for BRD, and Liquamycin® LA-200® and dexamethasone as a third-time treatment for BRD. The number of times a heifer was treated for BRD ranged between zero and three. After the 36-day receiving period, heifers were weighed, and six heifers identified as moribund were removed. The remaining heifers were implanted with Synovex C® and transported to native grass pastures for a 136-day grazing period. At the end of the grazing season, cattle were transported to a commercial feedyard, where they were implanted with Component TH® and offered a series of common diets for ad libitum consumption throughout a 124-day finishing period. At the end of the finishing period, heifers were transported to a commercial abattoir, where carcass data were collected. Final body weight was calculated by dividing hot-carcass weight by a common dressing percentage of 63.5%. These adjusted final weights were used to compute daily gains for each group of heifers.

Results and Discussion

Plasma glucose and lactate concentrations at initial processing were greater ($P<0.01$) for heifers not treated for BRD than for heifers subsequently treated for BRD, and they became increasingly lower (linear, $P<0.01$) as the number of times heifers were treated for BRD increased (Table 1). Heifers subsequently treated for BRD had lower initial plasma glucose and lactate concentrations, suggesting that their energy stores might have been less than that of healthy heifers, thereby possibly preventing them from mounting an effective immune response. Rectal temperature at initial processing increased (linear, $P<0.03$) with the number of times heifers were subsequently treated for BRD, although the range among group averages was only 0.23°F. Initial plasma glucose and lactate concentrations were negatively correlated with morbidity ($r = -0.20$, $P<0.01$ for glucose, and $r = -0.14$, $P<0.01$ for lactate; Table 2), indicating that, as initial plasma glucose and lactate concentrations increased, subsequent morbidity decreased. Although rectal temperature at initial processing was not significantly correlated with morbidity ($r = 0.04$, $P>0.34$), it was positively correlated with death loss ($r = 0.12$, $P<0.01$).

An increased number of treatments for BRD during the receiving period was linearly related to lesser ($P<0.01$) initial body weight, final body weight, and daily gains during the receiving period (Table 3), suggesting that lighter heifers were more susceptible to BRD infection and that BRD decreased weight gain during the receiving period. Grazing-period daily gains (Table 3) were linearly increased ($P<0.01$) with increased number of treatments for BRD, possibly as a result of less gastrointestinal tract fill at the start of the grazing period because of reduced feed intake during the

receiving period. Finishing-period gain, final body weight (Table 3), hot-carcass weight, fat thickness, and marbling score (Table 4) were decreased linearly (P<0.05) with increased number of treatments for BRD during the receiving period. The percentage of USDA Yield Grade 1 carcasses increased linearly (P<0.04) with increased number of treatments for BRD, whereas the percentage of USDA Yield Grade 3 carcasses decreased (quadratic, P<0.04). Because all heifers were marketed on a pen basis, the effect of BRD on USDA Yield Grade 3 carcasses was the result of delaying the marketing of healthier heifers to allow heifers previously treated for BRD to reach a marketable endpoint. Marketing healthier cattle earlier might avoid possible discounts from less favorable USDA Yield Grades. Total weight gain during the entire 296-day experiment was linearly decreased (P<0.04) with increased number of treatments for BRD during the receiving period, demonstrating the long-lasting effects that BRD infection can have on subsequent cattle weight gain.

These data suggest that initial plasma glucose and lactate concentrations are correlated with the health status of newly arrived receiving cattle; however, because of their great variability, glucose and lactate concentrations were not very efficacious in identifying individual cattle at risk for BRD infection. These data also indicate that increased incidence of BRD in cattle decreases growth rate and carcass quality.

Table 1. Plasma Glucose, Lactate, and Urea Nitrogen Concentrations and Rectal Temperatures of Heifers at Initial Processing

	Number of Times Treated for Respiratory Disease					Contrast[a]		
Item	0	1	2	3	SEM[b]	0 vs. T	Linear	Quadratic
No. of heifers	268	247	78	72	-	-	-	-
Glucose, m*M*	5.3	5.0	5.1	4.8	0.08	<0.01	<0.01	0.99
Lactate, m*M*	6.5	5.8	5.2	4.3	0.35	<0.01	<0.01	0.82
Urea N, m*M*	4.1	4.3	4.2	4.5	0.11	0.08	0.11	0.76
Rectal temp., ºF	102.48	102.50	102.71	102.71	0.085	0.06	0.03	0.92

[a]Contrasts: 0 vs T = heifers never treated for respiratory disease vs. treated heifers; Linear = linear effect of number of treatments for respiratory disease; Quadratic = quadratic effect of number of treatments for respiratory disease.
[b]Average SEM among groups of heifers.

Table 2. Coefficients of Correlation (r) Among Plasma Metabolites, Rectal Temperature, and Morbidity and Death Loss of Heifers During the Receiving Period

	Morbidity		Death Loss	
Item	r	P-value[a]	r	P-value[a]
Plasma glucose	-0.20	<0.01	-0.04	0.36
Plasma lactate	-0.14	0.01	-0.02	0.72
Plasma urea nitrogen	0.06	0.11	0.03	0.61
Rectal temperature	0.04	0.34	0.12	0.01

[a]P-values less then 0.05 indicate significant linear relationships between the variable and either morbidity or death loss.

Table 3. Effects of Bovine Respiratory Disease on Growth and Death Loss of Heifers During a Receiving Period and Subsequent Grazing and Finishing Periods

	Number of Times Treated for Respiratory Disease					Contrast[a]		
Item	0	1	2	3	SEM[b]	0 vs. T	Linear	Quadratic
Receiving period								
No. of heifers	268	247	78	72	-	-	-	-
Initial wt, lb	504	491	485	479	4.7	<0.01	0.01	0.47
Final wt, lb	610	589	564	538	6.0	<0.01	<0.01	0.71
Daily gain, lb	3.10	2.86	2.25	1.70	0.096	<0.01	<0.01	0.13
Death loss, %	0.38	0.40	2.53	4.00	0.90	0.03	0.01	0.44
Grazing period								
No. of heifers	268	244	76	65	-	-	-	-
Initial wt, lb	610	591	564	547	6.0	<0.01	<0.01	0.84
Final wt, lb	729	725	710	702	6.5	0.01	0.01	0.76
Daily gain, lb	0.88	0.99	1.07	1.14	0.029	<0.01	<0.01	0.55
Finishing period								
No. of heifers	267	244	76	65	-	-	-	-
Initial wt, lb	729	725	710	702	6.5	0.01	0.01	0.76
Final wt, lb[c]	1225	1210	1184	1174	11.5	0.01	0.01	0.87
Daily gain, lb	4.00	3.91	3.80	3.80	0.066	0.02	0.03	0.51
Total								
No. of heifers	267	244	76	65	-	-	-	-
Daily gain, lb	2.44	2.44	2.38	2.35	0.033	0.06	0.04	0.92

[a]Contrasts: 0 vs T = heifers never treated for respiratory disease vs. treated heifers; Linear = linear effect of number of treatments for respiratory disease; Quadratic = quadratic effect of number of treatments for respiratory disease.
[b]Average SEM among groups of heifers.
[c]Calculated by dividing hot-carcass weight by a common dressing percentage of 63.5%.

Table 4. Effects of Bovine Respiratory Disease on Carcass Characteristics of Heifers

	Number of Times Treated for Respiratory Disease					Contrast[a]		
Item	0	1	2	3	SEM[b]	0 vs. T	Linear	Quadratic
Hot carcass wt, lb	778	769	752	746	7.3	0.01	0.01	0.87
Fat thickness, inches	0.53	0.47	0.45	0.41	0.019	0.01	0.01	0.56
Kidney, pelvic, and heart fat, %	1.8	1.8	1.8	1.8	0.03	0.73	0.88	0.77
Longissimus muscle area, sq. inch	14.4	14.4	14.1	14.0	0.18	0.13	0.06	0.74
Marbling score[c]	298	312	296	277	7.8	0.69	0.04	0.05
USDA Prime, %	1.6	2.5	2.7	0.0	1.3	0.88	0.46	0.17
USDA Choice, %	44.2	48.5	38.7	34.9	4.6	0.43	0.09	0.40
USDA Select, %	48.8	43.0	56.0	57.1	4.6	0.46	0.09	0.48
USDA Standard, %	5.4	6.0	2.6	8.0	2.0	0.87	0.85	0.57
USDA Yield Grade 1, %	9.3	14.3	10.7	20.6	3.0	0.04	0.04	0.44
USDA Yield Grade 2, %	35.7	32.9	37.3	39.7	4.4	0.82	0.44	0.59
USDA Yield Grade 3, %	35.7	42.0	44.0	28.6	4.5	0.57	0.38	0.03
USDA Yield Grade 4 & 5, %	19.3	10.8	8.0	11.1	3.0	0.06	0.27	0.24
Dark cutters, %	0.8	0.0	0.0	1.6	0.63	0.69	0.43	0.08
Liver abscesses, %	5.4	5.1	4.0	6.3	2.0	0.89	0.87	0.53

[a]Contrasts: 0 vs T = heifers never treated for respiratory disease vs. treated heifers; Linear = linear effect of number of treatments for respiratory disease; Quadratic = quadratic effect of number of treatments for respiratory disease.
[b]Average SEM among groups of heifers.
[c]250 to 300 = Select^{+}, 301 to 350 = Choice.

COMPARISON OF BOVINE TRANSFER FACTOR AND MICOTIL®: EFFECTS ON HEALTH AND PERFORMANCE OF RECEIVING HEIFERS

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Summary

Transfer factors are antigen-specific products of T lymphocytes that are capable of transferring delayed-type hypersensitivity and cell-mediated immunity. We evaluated bovine transfer factor (TF) for use in receiving cattle. Crossbred beef heifers (n = 665) initially weighing 495 lb were used to determine the effects of TF on the health and performance of beef cattle during a 36-day receiving period. Heifers were processed within 24 hours after arrival. Treatments were subcutaneous injection with 1.5 ml of Micotil®/100 lb of body weight or oral administration of 700 mg of TF isolated from bovine colostrum. Heifers given TF during initial processing received an additional 700 mg/day of TF in the diet on days 2 through 5. The percentage of heifers treated at least one, two, or three times for bovine respiratory disease (BRD) was greater ($P<0.01$) for heifers given TF than for heifers given Micotil (72.5 vs. 47.1; 31.5 vs. 14.7; and 18.0 vs. 4.2, respectively). There were no differences between TF and Micotil with respect to dry matter intake, weight gain, or gain efficiency of heifers. Subsequent in vitro fermentations indicated that TF protein is readily degraded by ruminal microbes. Oral administration of TF was not as effective as Micotil injection in decreasing BRD in receiving cattle.

Introduction

Bovine respiratory disease (BRD) is the leading cause of morbidity and mortality in feedlot cattle. Treatment for BRD in feedlot cattle generally uses antibiotic therapy, which fosters public concern about antibiotic usage in livestock. Transfer factors are products of T lymphocytes, seem to consist entirely of protein, and are rather small. Transfer factors are antigen specific and possess the ability to transfer delayed-type hypersensitivity and cell-mediated immunity from an individual previously exposed to a specific antigen to a naïve recipient; but data is lacking about effects of oral administration of transfer factors in functional ruminants.

The objective of our experiment was to compare oral administration of transfer factors with the antibiotic Micotil as a prophylactic treatment against BRD in receiving cattle. We also characterized degradation of transfer factor protein by ruminal microbes in vitro.

Experimental Procedures

Experiment 1. A total of 665 crossbred beef heifers initially weighing 495 lb was used in a completely randomized design to determine the effects of bovine transfer factor (TF) on the health and performance of beef cattle during a 36-day receiving period. Heifers were processed within 24 hours after arrival, and processing included measurement of body weight, vaccination against common viral and clostridial diseases (Bovishield® 4 and Fortress® 7, respectively), recording of rectal temperature, and treatment for internal and external parasites (Phoenectin®). In addition, heifers received either a subcutaneous injection of 1.5 ml of Micotil/100 lb of body weight or received 50 ml of a solution consist-

ing of water and 28 grams of a commercially available source of TF isolated from bovine colostrom (Livestock Stress Formula™). The TF solution was administered orally via dose syringe to provide 700 mg of actual TF. Immediately after initial processing, heifers within each treatment were assigned randomly among 28 pens. Pens contained 21 to 27 heifers each, depending upon pen size, with 14 pens per treatment. Heifers given TF during initial processing received an additional 28 grams of Livestock Stress Formula daily in the diet as a top dress on days 2 through 5. Heifers were subsequently monitored for clinical signs of BRD, including depression, lethargy, anorexia, coughing, rapid breathing, and nasal or ocular discharge. Heifers exhibiting signs of BRD received antibiotic therapy consisting of Micotil as a first-time and second-time treatment for BRD, and Liquamycin® LA-200® and dexamethasone as a third-time treatment for BRD. The number of times heifers were treated for BRD ranged between zero and three. Heifers were offered a common receiving diet for ad libitum consumption once daily (Table 1). At the end of the 36-day receiving period, heifers were weighed.

Table 1. Diet Composition for Experiment 1 (% of Dry Matter)

Ingredient	% of Dry Matter
Steam-flaked corn	44.0
Alfalfa hay	45.0
Corn steep liquor	6.0
Soybean meal	3.8
Salt	0.4
Potassium chloride	0.2
Vitamin/trace mineral premix[a]	0.6
Chemical composition, analyzed	
Dry matter	81.5
Crude protein	17.0

[a]Formulated to provide the following (dry matter basis): 1,500 IU/lb vitamin A, 20 IU/lb vitamin E, 0.1 ppm cobalt, 10 ppm copper, 0.63 ppm iodine, 60 ppm manganese, 0.3 ppm selenium, 2 ppm iron, and 60 ppm zinc.

Experiment 2. In vitro incubations of rumen fluid alone (control), with casein, or with TF were conducted. Whole rumen contents were obtained from two ruminally cannulated steers fed a diet containing (dry matter basis) 76% steam-flaked corn, 10% alfalfa hay, 3% soybean meal, 1.2% urea, 5% cane molasses, and 4.8% of a mineral vitamin premix offered for ad libitum consumption. Ruminal contents were strained through two layers of cheesecloth, and mixed with buffer, and 200 ml of the rumen fluid/buffer mixture were added to flasks containing no added protein (control) or containing 40 mg of nitrogen from either casein or Livestock Stress Formula. Flasks were incubated for 1.5 hours at 102°F, and a 1-ml sample from each flask was collected every 30 minutes. Products of protein degradation were measured in the resulting samples. Twelve flasks were used, providing four replications per treatment.

Results and Discussion

Experiment 1. Heifers that received Micotil during initial processing required fewer first-time, second-time, and third-time treatment for BRD ($P<0.01$) compared with heifers receiving TF (Table 2), suggesting that Micotil was more effective as a prophylactic treatment against BRD than TF. The percentage death loss for heifers receiving Micotil was 1.1% and for those receiving TF was 1.0%; this was not different between treatments.

Treatment did not affect dry matter intake, average daily gain, or gain efficiency of heifers during the receiving period (Table 2), in spite of differences in the percentage of heifers treated for BRD.

Experiment 2. Rate of in vitro protein degradation was greater for TF than for casein (Figure 1). Casein is commonly used as a standard for measuring protein degradability, and it is rapidly and extensively degraded by ruminal microbes. The TF protein was degraded at a greater rate than casein, indicating

that TF protein is rapidly degraded by ruminal microbes. Degradation of TF protein by ruminal microbes might have contributed to the failure of TF to protect against BRD as effectively as Micotil in our experiment.

The results of these experiments suggest that orally administering TF as a prophylactic treatment against BRD in cattle is not as effective as prophylactic medication with Micotil, possibly because of extensive degradation of TF protein by ruminal microbes.

Table 2. Treatment Incidence for Bovine Respiratory Disease (BRD), Percentage Death Loss, and Growth Performance of Newly Arrived Heifers After Prophylactic Treatment with Either Micotil® or Bovine Transfer Factor

Item	Micotil	Transfer Factor	SEM	P-value
No. of pens	14	14	-	-
No. of heifers	333	332	-	-
Initial body weight, lb	493	495	6.2	0.71
Final body weight, lb	594	596	11.2	0.88
Treatments for BRD, % of heifers				
at least one	47.1	72.5	3.6	<0.01
at least two	14.7	31.5	3.5	0.01
three	4.2	18.0	2.3	0.01
Death loss, %	1.1	1.0	0.57	0.88
Dry matter intake, lb/day	12.5	12.3	0.37	0.73
Dry matter intake, % of body weight daily	2.31	2.26	0.05	0.47
Daily gain, lb	2.79	2.77	0.19	0.92
Gain:feed	0.220	0.221	0.011	0.95

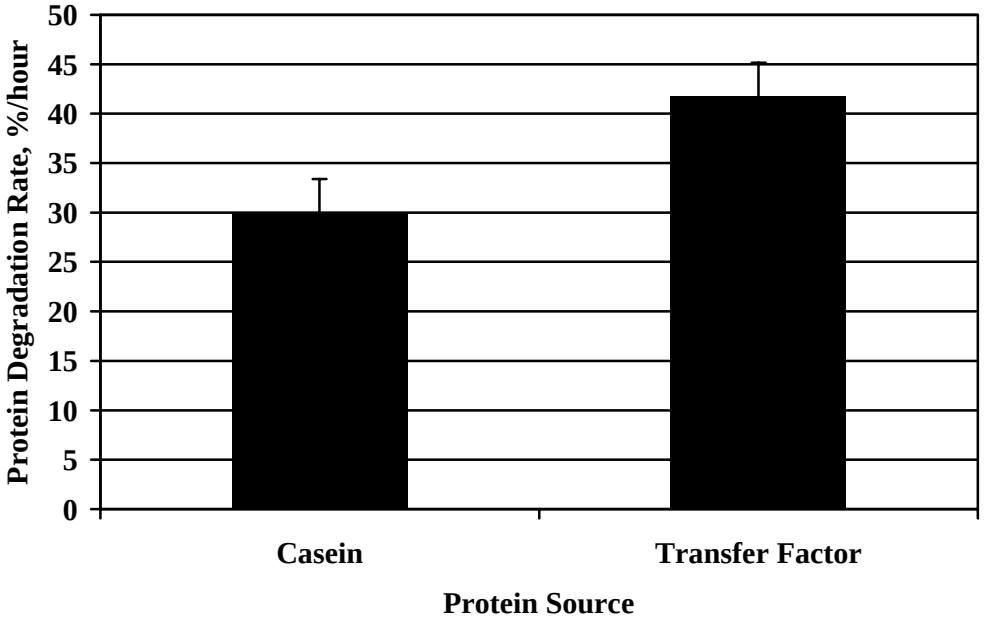

Figure 1. Rates of In Vitro Protein Degradation. Effect of protein source (P<0.05).

GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING BEEF STEERS IMPLANTED WITH COMPONENT TE-S OR COMPONENT TE-S WITH TYLAN

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Summary

Component TE-S and Component TE-S with Tylan growth-promoting implants were compared in an experiment conducted at a commercial feedlot operation (Ward Feed Yard; Larned, Kansas) to evaluate effects on growth performance and carcass characteristics. Crossbred steers (n=1843; 827 lb body weight) were implanted with either Component TE-S or Component TE-S with Tylan and were fed a finishing ration based on steam-flaked corn for an average of 116 days before slaughter. Cattle were assigned randomly to the implant treatments at processing and were allotted to 12 pens, containing an average of 154 steers each. No differences were detected in dry matter intake (P=0.18), average daily gain (P=0.41), or feed efficiency (P=0.59) of cattle administered the different implants. Component TE-S with Tylan produced fewer (P<0.05) buller steers. Cattle implanted with Component TE-S with Tylan were more heavily conditioned than cattle implanted with Component TE-S. Cattle with the implant including Tylan had a greater percentage of USDA Choice or Prime carcasses (P=0.11) and a greater percentage of USDA Yield Grade 4 carcasses (P=0.03). Component TE-S with Tylan also tended to produce fewer (P=0.12) USDA Yield Grade 1 carcasses compared with cattle implanted with Component TE-S. Total carcass value was also greater for the Component TE-S with Tylan cattle, as calculated by either a muscle-based or quality-based marketing grid. Inclusion of a pellet of the antibiotic Tylan within Component TE-S implants seems to result in modest changes in carcass fattening, as well as significant reductions in the incidence of buller activity among feedlot steers.

Introduction

Growth-promoting implants are widely used in the feedlot industry to improve animal performance and feed efficiency. Implant effectiveness is a function of proper administration. Aseptic techniques, such as cleaning the surface of ears and using clean needles, are important factors contributing to effectiveness of implants. Even with proper techniques and visually clean ears and needles, problems can still exist. Bacteria may be present on the surface of the ear and may be introduced to the subcutaneous tissue of the ear during implanting. Abscess formation due to contamination may account for 50 to 60% of the observed problems with implants. Inflammation around the abscessed site may increase localized blood flow, potentially increasing payout of active components. As scar tissue develops,

[1]Cattleman's Consulting, Lincoln, Nebraska.
[2]University of Nebraska-Lincoln.
[3]Vetlife, Overland Park, Kansas.

release of growth-promoting compounds may ultimately be reduced, thereby decreasing overall effectiveness of the implant. Component TE-S with Tylan implants include a single blue pellet containing 29 mg tylosin tartrate, which goes into the ear first and dissolves quickly to release the antibiotic. Tylosin tartrate is a broad-spectrum antibiotic that is added to deliver a localized antibacterial dose in an attempt to prevent abscess formation and, hence, improve animal performance.

Experimental Procedures

Yearling crossbred steers (n=1,843; 827 lb body weight) were transported to a commercial feedlot in Larned, Kansas. Upon arrival, a standard processing regimen was applied to each animal, which consisted of animal identification, vaccination against common viral diseases, and treatment for internal and external parasites. Steers received a single implant of either Component TE-S or Component TE-S with Tylan at the time of processing.

Cattle within each load were blocked by arrival date, and one of every two animals was assigned randomly to either Component TE-S or Component TE-S with Tylan by using a predetermined randomization schedule. Each block was represented by one pen of steers receiving Component TE-S and one pen of steers receiving Component TE-S with Tylan. Six pens were assigned to each treatment. Pens contained an average of 154 steers, which were placed on feed between June 3 and June 14, 2003. Feedlot personnel were blinded to implant treatments and were responsible for daily observations of each pen for symptoms of sickness or buller activity. Cattle identified as sick were treated in accordance with standard procedures of the feedlot. Cattle identified as bullers were removed from the pen immediately and placed into a separate pen. Buller steers were combined with their contemporaries immediately before shipping to a commercial abattoir in Emporia, Kansas.

Steers were adapted to their final finishing ration (Table 1) during a period of two to three weeks after arrival and were fed for an average of 116 days. Cattle were offered ad libitum access to feed and water.

Total weight of cattle in each pen was determined upon initiation of the experiment and immediately before cattle were transported for slaughter. Cattle were shipped by replicate (one pen Component TE-S and one pen Component TE-S with Tylan). Shipping order within each block was randomized. Closeout data for each pen included daily gain, feed intake, feed efficiency, and percent bullers. Cattle were slaughtered on the same day they were shipped. Carcasses were chilled for 24 hours before USDA yield and quality grading.

Table 1. Composition of Finishing Diet

Ingredient	% of Dry Matter
Steam-flaked corn	63.2
Wet distillers grain	15.4
Tallow	2.5
Mixed silage	7.0
Wheat middlings	4.0
Liquid supplement[a]	5.3
Corn screenings	2.6
Nutrient, calculated	
Crude protein	15.3
Fat	7.45
Calcium	0.74
Phosphorus	0.39

[a]Provided 320 mg Rumensin, 90 mg Tylan, 40,000 IU vitamin A, 4000 IU vitamin D, and 100 IU vitamin E per steer daily.

Results and Discussion

Animal performance is reported in Table 2. Initial body weights were similar between treatments. No differences were detected for dry matter intake, average daily gain, or feed efficiency. Component TE-S with Tylan produced fewer ($P<0.05$) buller steers than Com-

ponent TE-S. Overall, cattle implanted with the Tylan-enriched implants were more heavily conditioned, with a tendency for fewer (P=0.12) USDA Yield Grade 1 carcasses and a greater (P=0.03) percentage of USDA Yield Grade 4 carcasses (Table 2). Hot carcass weights for cattle implanted with Component TE-S with Tylan were numerically larger (P=0.32) than those of cattle administered the implant without the added antibiotic. Cattle implanted with Component TE-S with Tylan tended to have greater (P=0.11) percentages of carcasses that graded USDA Choice or Prime, with a concomitant non-significant reduction in the percentage of "No Roll" carcasses.

Total carcass value was calculated by using a quality-based (Figure 1) and muscle-based (Figure 2) marketing grid. The base price was set at $125/cwt and the Choice-Select spread was varied from $0 to $20/cwt in two-dollar increments. Carcass value from the muscle-based grid was greater (P<0.05) for Component TE-S with Tylan cattle at the Choice-Select range of $10 through $20/cwt. Likewise, carcass value from the quality-based grid was greater (P<0.05) for Component TE-S with Tylan cattle at the Choice-Select range of $8 through $20/cwt.

Key differences between implants used in this study are the smaller percentage of bullers and the tendency for an increase in carcass quality with the addition of Tylan in the growth-enhancing implant. The mechanisms for the reduction of buller steers with the addition of Tylan to the implant are not well understood. It is plausible that cattle implanted Component TE-S with Tylan had fewer abscesses and resulting scar tissue immediately surrounding the implant site, thereby retaining greater implant effectiveness. It also is possible that the addition of Tylan to implants may reduce variation in uptake of the growth-promoting compound. An infection due to an ear abscess may cause an increase in localized blood flow to the infected ear, resulting in rapid payout of the active ingredient, which could result in abnormal behavior, including increases in the incidence of buller-related activity. Results of this study suggest that the addition of Tylan to Component TE-S implants can result in significant reductions in buller activity of feedlot steers, as well as modest changes in carcass weight and carcass composition.

Table 2. Finishing Performance and Carcass Characteristics of Yearling Steers Implanted with Component TE-S or Component TE-S with Tylan

Item	Component TE-S	Component TE-S with Tylan	SEM	*P*-value
No. of head	919	924	-	-
No. of pens	6	6	-	-
Days on feed	116	116	-	-
Initial weight, lb	826	828	1.85	0.77
Final weight, lb[a]	1289	1297	5.21	0.32
Dry matter intake, lb/day	21.6	22.0	0.24	0.25
Average daily gain, lb/day	3.84	3.86	0.040	0.67
Feed:gain	5.61	5.69	0.06	0.42
Bullers, %	3.83	1.71	0.56	0.04
Hot carcass weight, lb	818	824	3.31	0.32
Dressing percentage, %	65.94	65.79	0.2	0.56
Liver abscess, %	10.8	8.5	0.94	0.15
USDA Yield Grade 1, %	18.8	14.8	1.47	0.12
USDA Yield Grade 2, %	52.2	49.6	1.59	0.30
USDA Yield Grade 3, %	27.2	32.0	1.94	0.14
USDA Yield Grade 4, %	1.6	3.4	0.42	0.03
USDA Yield Grade 5, %	0.1	0.2	0.08	0.36
USDA Prime, %	0.0	0.1	0.08	0.36
USDA Choice, %	26.6	33.1	2.41	0.11
USDA Select, %	61.7	58.8	2.86	0.51
No roll, %	11.1	7.5	1.57	0.17
Dark cutters, %	0.1	0.1	0.12	0.97

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

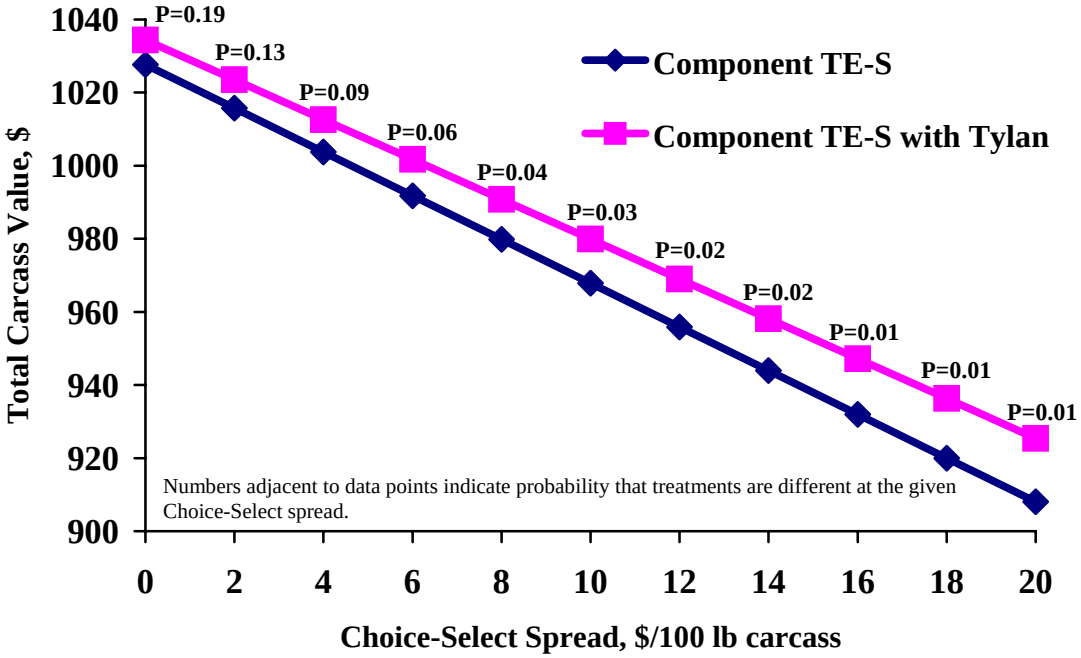

Figure 1. Total Carcass Value in Dollars at Different Choice-Select Spreads as Calculated by Using a Quality-Based Grid.

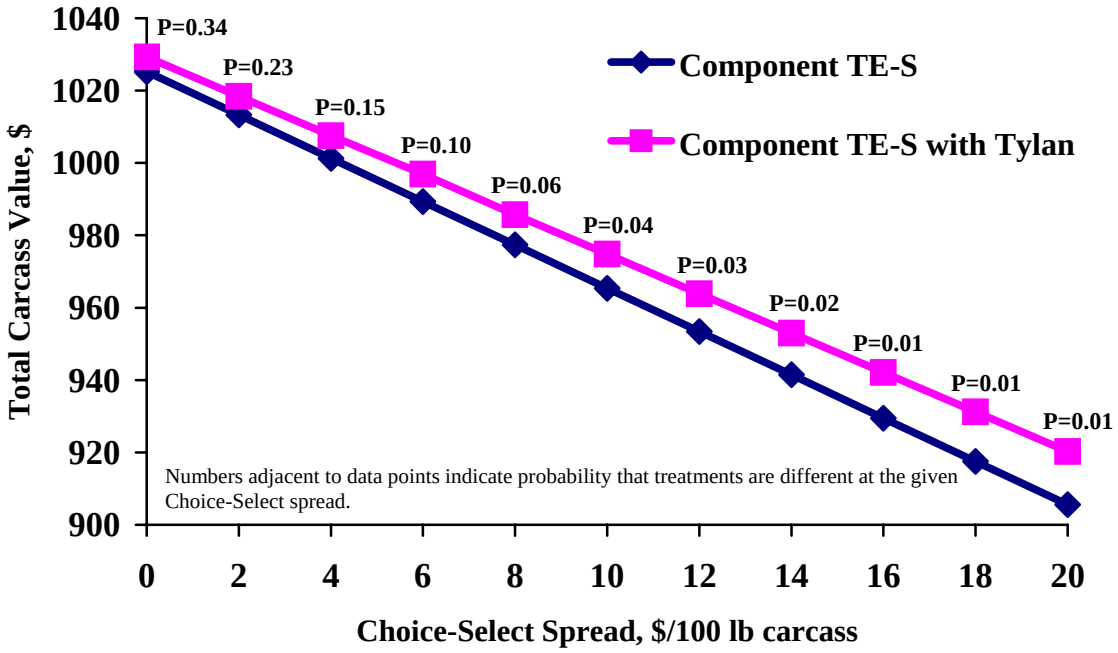

Figure 2. Total Carcass Value in Dollars at Different Choice-Select Spreads as Calculated by Using a Muscle-Based Grid.

EFFECT OF CORN ENDOSPERM TYPE AND CORN CONTAINING THE CRY1F PROTEIN ON PERFORMANCE OF BEEF HEIFERS FED FINISHING DIETS BASED ON STEAM-FLAKED CORN

J. J. Sindt, J. S. Drouillard, E. R. Loe, T. J. Kessen, M. J. Sulpizio, S. P. Montgomery, and F. N. Owens

Summary

Eighty beef heifers (initial body weight = 795 ± 18 lb) were individually fed finishing diets based on steam-flaked corn for 118 days. Dietary treatments consisted of corn hybrids containing vitreous (HARD), opaque (SOFT), or intermediate (INT) types of corn endosperm. Within the HARD endosperm type, a transgenic hybrid (HARD-GMO) containing the Herculex I Cry1F protein was compared with its nontransgenic, conventional (HARD-CONV) counterpart. Dry matter intake, average daily gain, and gain efficiencies were similar among treatments. Likewise, hot carcass weight, dressing percentage, and ribeye area were unaffected by dietary treatment. Heifers fed HARD-CONV were fatter than heifers fed HARD-GMO, having fewer ($P<0.01$) USDA Yield Grade 1 and 2 carcasses. In this experiment, feeding flaked corn finishing diets that contained different endosperm types did not alter performance or carcass characteristics. Feeding heifers HARD-GMO compared with HARD-CONV corn resulted in similar performance, although heifers fed HARD-CONV had higher USDA Yield Grades, perhaps because of greater starch availability of HARD-CONV flaked corn than HARD-GMO corn.

Introduction

Physical characteristics of corn kernels can differ depending on how the starch is embedded in the protein-starch matrix. Corn having a very densely packed endosperm is vitreous or glassy in appearance, whereas starch that is less tightly bound with endosperm protein is present in a more floury or opaque form. Hardness of endosperm starch may contribute to differences in starch utilization by ruminants. Increased accessibility of starch to ruminal microflora may increase ruminal digestibility, although excessive rates of starch digestion may predispose cattle to digestive disorders. Steam flaking of grain increases the ruminal and total tract digestibility of corn by improving the utilization of starch that is embedded in the protein matrix. Currently, there is little information pertaining to the relative suitability of different endosperm types for steam flaking.

Widespread use of transgenic crops for improving agronomic productivity has led to an abundance of modified grains that are used for livestock feed. Grain that is modified with the Herculex I Cry 1F protein resists many of the insects that damage yields and productivity. Determining the nutritional bioequivalency of corn hybrids that are genetically altered will support future agronomic endeavors that seek to enhance crop production.

The objective of this experiment was to evaluate corn hybrids that differed in endosperm type when fed in finishing diets based on steam-flaked corn. We also compared the feeding value of a transgenic hybrid containing the Herculex I Cry1F protein with its isogenic, conventional counterpart.

Experimental Procedures

In the spring of 2003, 80 beef heifers (initial body weight = 795 ± 18 lb) were vaccinated for common viral and bacterial diseases, treated for internal and external parasites, identified, implanted with Revalor-H, weighed, and assigned to one of four individual barns according to weight. Barns contained twenty individual stalls that allowed for individual access to feed. Cattle were blocked by barn and stratified by weight within each barn to one of four treatments. Treatments consisted of finishing diets based on steam-flaked corn that contained hybrids with vitreous (HARD), opaque (SOFT), or intermediate (INT) types of endosperm (Table 1). Additionally, within HARD endodsperm type, a hybrid containing the Herculex I Cry1F protein (GMO) was compared with its nontransgenic, conventional (CONV) counterpart. Because of the extreme dryness (≅ 94% dry matter) of three hybrids (HARD-GMO, HARD-CONV, and INT), all corn was tempered to 84% dry matter before flaking. Each hybrid was flaked approximately twice per week. Corn was steam-flaked to a density of 26 lb/bushel, and diets were fed for 118 days. Flaked-grain samples were collected daily and analyzed for dry matter. Starch availability was determined by incubating whole flakes in a buffered, 2.5% amyloglucosidase solution for 15 minutes. The resultant soluble supernatant was measured on a commercial refractometer.

Cattle were fed once daily at approximately 2 p.m. and were allowed ad libitum access to diets. One heifer died during the experiment, and another heifer became lame and was consequently removed from the experiment. Because crude protein of each of the corn sources was different, the concentration of soybean meal differed among diets to maintain similar amounts of dietary crude protein. All diets were formulated to contain excess crude protein to ensure that differences among grain sources were due to differences in energy availability. We used a non-genetically modified soybean meal to eliminate the possibility of confounding our results with other genetically modified ingredients. On day 53, diets were altered because of an anticipated shortage in non-genetically modified soybean meal. Diet compositions after day 53 are presented in Table 1.

At the completion of the experiment, heifers were weighed and transported to a commercial abattoir in Emporia, Kansas, where carcass data were collected. Hot carcass weight and liver scores were obtained at harvest. The percentages of kidney, pelvic, and heart fat; subcutaneous fat thickness; ribeye area; marbling score; and USDA quality and yield grades were determined after a 24-hour chill.

Results and Discussion

No statistically significant differences were observed among treatments for any of the performance data, including dry matter intake, average daily gain, and feed efficiency (Table 2). However, final weight, average daily gain, and gain efficiency were numerically improved as corn endosperm became softer in texture. Other research has demonstrated improvements in cattle performance by feeding corn hybrids with opaque endosperm in diets based on dry-rolled corn. Steam flaking may disrupt the extensive protein-starch matrix in vitreous hybrids however, and create a flake with feeding value similar to that of the opaque hybrid. Heifers fed HARD-GMO performed comparably to those fed HARD-CONV, in as much as intakes, gains, and efficiencies were similar for these treatments. The incidence of liver abscesses was extremely small (2.5%) and was not different among treatments. No differences were observed between treatments for hot carcass weight; dressing percentage; kidney, pelvic, and heart fat; or ribeye area. Cattle fed the INT endosperm type tended (P=0.09, quadratic) to have less fat over the 12th rib and

numerically had the most USDA Yield Grade 1 and 2 carcasses. Cattle fed HARD-CONV had the fewest (P<0.01) USDA Yield Grade 1 and 2 carcasses and tended (P=0.06) to have more carcasses with better marbling scores. Interestingly, starch availability measured throughout the experiment was greater (P<0.001; Table 1) for HARD-CONV flakes than for HARD-GMO flakes. Previous research conducted at Kansas State has indicated that cattle consuming flakes with greater starch availability deposit adipose to a greater extent than cattle consuming less available flakes.

Performance of cattle fed a corn hybrid containing the Herculex Cry1F protein was similar to that of cattle fed its isogenic, conventional counterpart. Furthermore, corn endosperm hardness did not alter performance of beef heifers fed steam-flaked corn, based diets.

Table 1. Composition of Experimental Diets (% of Dry Matter)

	Corn Endosperm Type[a]							
Ingredient	HARD-GMO		HARD-CONV		INT		SOFT	
Steam-flaked corn	74.9	(76.4)[b]	74.4	(76.0)	75.3	(76.9)	76.8	(78.4)
Alfalfa hay	7.7	(7.7)	7.7	(7.7)	7.7	(7.7)	7.6	(7.6)
Soybean meal	6.8	(5.3)	7.3	(5.7)	6.4	(4.8)	5.1	(3.5)
Cane molasses	4.7	(4.7)	4.7	(4.7)	4.7	(4.7)	4.6	(4.6)
Tallow	3.0	(3.0)	3.0	(3.0)	3.0	(3.0)	3.0	(3.0)
Limestone	1.4	(1.4)	1.4	(1.4)	1.4	(1.4)	1.4	(1.4)
Urea	1.1	(1.1)	1.1	(1.1)	1.1	(1.1)	1.1	(1.1)
Salt	0.3	(0.3)	0.3	(0.3)	0.3	(0.3)	0.3	(0.3)
Premix[c]	0.1	(0.1)	0.1	(0.1)	0.1	(0.1)	0.1	(0.1)
Nutrient, analyzed								
Crude protein	14.6	(13.9)	14.6	(13.9)	14.8	(14.0)	14.5	(13.8)
Calcium	0.7	(0.7)	0.7	(0.7)	0.7	(0.7)	0.7	(0.7)
Phosphorus	0.3	(0.3)	0.3	(0.3)	0.3	(0.3)	0.3	(0.3)
Crude protein of corn	7.7		7.4		8.0		8.7	
Starch availability of flaked corn, %[d]	53.1		55.3		53.7		53.7	

[a]Steam-flaked corn originated from corn hybrids expressing vitreous (HARD), opaque (SOFT), or intermediate (INT) types of corn endosperm. Within HARD endosperm type, a hybrid containing the Herculex I Cry1F protein (HARD-GMO) was compared with its nontransgenic, conventional (HARD-CONV) counterpart.

[b]Diets were reformulated on day 53. Diet composition from day 53 to day 118 is shown in parentheses.

[c]Formulated to provide the following (total diet dry matter): 1,280 IU of vitamin A/lb, 15 IU of vitamin E/lb, 0.1 ppm cobalt, 8.3 ppm copper, 0.5 ppm iodine, 0.1 ppm iron, 50 ppm manganese, 0.25 ppm selenium, 67 ppm zinc, 30 g/ton Rumensin, 9 g/ton Tylan, and 0.05 g/ton MGA.

[d]HARD-GMO was significantly less than HARD-CONV, P<0.001, SEM=0.44; 107 samples analyzed for each hybrid.

Table 2. Performance and Carcass Characteristics of Heifers Fed Finishing Diets Based on Steam-Flaked Corn from Corn Hybrids Containing Hard (HARD), Intermediate (INT), or Soft (SOFT) Textured Endosperm

	Corn Endosperm Type[a]					Treatment Comparison[b]		
Item	HARD-GMO	HARD-CONV	INT	SOFT	SEM	GMO vs. CONV	HARD vs. SOFT	Quad[c]
No. of heifers	19	20	20	19				
Initial body weight, lb	796	795	795	795	4.1	0.96	0.91	1.00
Final body weight, lb[d]	1186	1182	1191	1202	15	0.83	0.34	0.90
Dry matter intake, lb/day	17.67	18.15	17.70	18.09	0.52	0.53	0.78	0.63
Average daily gain, lb	3.31	3.27	3.35	3.45	0.12	0.83	0.30	0.90
Gain/feed	0.189	0.181	0.189	0.190	0.0047	0.22	0.34	0.84
Liver abscesses, %	5.0	5.0	0.0	0.0	3.5	0.98	0.29	0.51
Hot carcass weight, lb	753	750	756	763	9.6	0.83	0.33	0.90
Dressing percentage	66.1	65.6	65.6	65.1	0.40	0.37	0.16	0.83
Kidney, pelvic & heart fat, %	2.31	2.38	2.33	2.45	0.078	0.58	0.28	0.44
12th rib fat, inches	0.59	0.66	0.51	0.62	0.053	0.36	0.96	0.09
Ribeye area, square inches	12.7	12.7	12.8	12.9	0.31	0.92	0.56	0.98
Marbling[e]	Sm^{22}	Sm^{89}	Sm^{54}	Sm^{36}	23.3	0.06	0.52	0.76
USDA Yield grade						P-value[b]		
Yield grade 1 & 2, %	32	5	35	26		<0.01		
Yield grade 3, %	36	50	40	42		0.86		
Yield grade 4, %	21	40	20	21		0.47		
Yield grade 5, %	11	5	5	11		0.84		
USDA quality grade								
Prime and Choice, %	68	85	60	58		0.14		
Select and Standard, %	32	15	40	42		0.14		

[a]Within hard endosperm type, a transgenic hybrid containing the Herculex I Cry1F protein (GMO) was evaluated with its conventional, isogenic counterpart (CONV).
[b]P-values indicate the probability that differences of the magnitude observed were due to random chance.
[c]INT vs. average of HARD and SOFT.
[d]Estimated as hot carcass weight/0.635.
[e]Sm=small.

NIGHT FEEDING TO REDUCE BIRD PREDATION IN FEEDLOTS

M. A. Greenquist, J. S. Drouillard, C. D. Lee, J. J. Sindt, T. J. Kessen, E. R. Loe, S. P. Montgomery, and M. J. Sulpizio

Summary

During times of heavy infestations by birds, feedlots can have 25 to 30% increases in feed usage, thereby resulting in large economic losses. Because starlings, blackbirds, grackles, and other avian pests normally feed during daylight hours, we hypothesized that feeding cattle at night would minimize feed contamination and feed loss due to bird infestation. Crossbred beef heifers (n=96; 770 lb) were used to evaluate the effects of feeding at night on performance and carcass characteristics. Heifers were fed for 107 days during the months of November to March, when large bird populations were observed. Feed was delivered once daily at approximately 10:00 a.m. for heifers with continuous access to feed and 30 minutes before dusk for heifers that had access to feed only at night. Feed calls for heifers fed at night were managed so that no feed remained in the bunk at dawn, whereas the control heifers were allowed ad libitum access to feed. Daily feed deliveries per animal (21.51 vs. 18.15 lb for heifers fed continuously or only at night, respectively) were decreased by 16% ($P<0.01$) when cattle were provided access to feed only at night, but daily gain was not different. Feed efficiency was improved by 14% ($P=0.05$) with night time feeding, but carcass weights and dressing percentage remained similar. Overall, feeding cattle only during hours of darkness yielded similar growth performance compared to cattle fed continuously. However, feed efficiency was improved substantially, which we attribute to reduced theft by birds.

Introduction

Thievery by birds can be an enormous economic burden to agriculture systems in some areas of the country. Feedlots located in traditional migratory flyways can be overwhelmed by starlings, blackbirds, grackles, and other birds that take advantage of an accessible food source during the winter months. Starling intakes have been estimated to be near 1.0 lb/bird monthly directly from the feed bunk, and total feed usage in some feedlots may be increased by as much as 25% during heavy infestations. In addition to the economic impact, bird infestation creates sanitation issues, can cause physical destruction of properties, and may serve as a vector for transmission of disease to cattle and humans. However, steps to reduce bird infestation are heavily scrutinized by the general public and, ideally, would be conducted in a manner that is acceptable by public standards. Because the birds are drawn to the feedlot by the accessible feed supply, it is conceivable that simply by taking the feed supply away, the birds can be discouraged from congregating in these areas.

Studies have shown that access to feed by cattle can be restricted to 9 to 15 hours daily with no detrimental effects on feed intake, average daily gain, or feed efficiency. In theory, due to the roosting habits of most species of birds, limiting access of feed for cattle to night hours may help to control bird infestation and resulting theft and sanitation problems.

The objective of this experiment was to limit access of finishing cattle to feed to only

night hours and to determine the impact of this strategy on feed intake, gain, feed efficiency, and carcass attributes of cattle fed during times of extensive bird infestation.

Experimental Procedures

The experiment was conducted in concrete-surfaced pens at the Kansas State University Beef Cattle Research Center from November 2002 to March 2003. Yearling crossbred heifers (n=96; 770 lb body weight) were allocated to one of two experimental treatments. A common finishing diet was fed to cattle at 10:00 a.m. each day to provide continuous 24-hour access to feed, or was fed approximately 30 minutes before dusk in amounts sufficient to ensure nearly complete consumption by 7:00 a.m. the next day.

Heifers were individually weighed, blocked by initial weight, stratified by receiving date, and then allotted, within strata, to one of 12 randomly assigned pens (8 animals/pen; 6 pens/treatment).

Heifers were acclimated to a steam-flaked corn finishing diet (Table 1) during a period of approximately two weeks, during which time the night-access heifers were acclimated to the change in feeding time by advancing feeding time 1 hour per day until the desired feeding time was achieved. The continuous-access heifers were fed once daily at approximately 10:00 a.m. The continuous-access heifers were given ad libitum access to feed, and the night-access cattle were managed so that no feed remained in the bunk at daybreak. Heifers were fed for 107 days. Final shrunk weights were determined by dividing carcass weight by a common dressing percentage of 64%.

Results and Discussion

Feed deliveries (21.51 vs. 18.15 lb for continuous-access and night-access heifers, respectively) were decreased by 16% ($P<0.01$) for night-access heifers, but daily gain was not different. Apparent feed efficiency was improved by 14% (8.33 vs. 7.14 for continuous access and night access, respectively; $P=0.05$) with night feeding. Carcass weights and dressing percentages were similar. Night-access heifers tended ($P=0.08$) to be leaner (0.34 vs. 0.39 inch backfat) than heifers fed continuously, whereas marbling and USDA quality grades were not different.

Taking into account a 3.36 lb difference in feed usage ($0.06/lb for 107 days), feed cost was $21.57 greater for heifers given continuous access to feed. This cost can be attributed to the combination of bird thievery, reduced feed efficiencies, and changes in digestive function. Because previous studies have shown that cattle can be limited to 9 to 15 hours per night of eating time by adjusting feed calls without detrimental effects on feed intake, daily gain, and feed efficiency, we speculate that a significant part of the difference in intake can be attributed to bird thievery. Further research is necessary to separate effects of bird thievery from those of changes in digestive patterns.

Table 1. Composition of Finishing Diets

Ingredient	% of Diet Dry Matter
Steam-flaked corn	75.6
Alfalfa hay	8.0
Steep liquor	7.0
Tallow	3.0
Limestone	1.4
Soybean meal	1.3
Urea	1.0
Vitamin/mineral premix[1]	2.7

[1]Formulated to provide 0.13 ppm cobalt, 10 ppm copper, 0.63 ppm iodine, 1.1 ppm iron, 60 ppm manganese, 0.25 ppm selenium, 60 ppm zinc, 30 grams/ton monensin, and 10 grams/ton tylosin.

Table 2. Finishing Performance and Carcass Characteristics of Heifers with Continuous Access or Night Access to Feed

	Treatment[a]			
Item	Continuous Access	Night Access	SEM	P-value
No. of head	48	48	-	-
No. of pens	6	6	-	-
Days on feed	107	107	-	-
Initial weight, lb	770	770	4.1	0.98
Final weight, lb[b]	1047	1042	11.0	0.76
Dry matter intake, lb/day	21.51	18.15	0.42	<0.01
Weight gain, lb/day[b]	2.59	2.55	0.10	0.78
Feed:gain	8.33	7.14	0.51	0.05
Hot carcass weight, lb	670	667	7.0	0.76
Dressing percentage, %	63.39	62.90	<0.01	0.29
Ribeye area, inch^2	12.95	12.78	0.18	0.54
Marbling[c]	Sl ^{2}	Sl ^{16}	18	0.61
Backfat, inch	0.39	0.34	0.02	0.08
Kidney, pelvic & heart fat, %	2.13	2.18	0.03	0.31
USDA Yield grade 1, %	4.1	12.5	4.2	0.19
USDA Yield grade 2, %	45.8	52.1	4.2	0.32
USDA Yield grade 3, %	47.9	31.3	4.7	0.35
USDA Yield grade 4, %	2.1	4.1	2.6	0.58
USDA Prime, %	0.0	4.2	1.5	0.08
USDA Choice, %	56.3	45.8	8.8	0.43
USDA Select, %	41.7	50.0	7.4	0.45
USDA Standard, %	2.1	0	1.5	0.35
Dark cutter, %	0	0	-	-
Liver abscess, %	6.3	4.2	0.04	0.69

[a]Heifers were fed for 107 days from November to March, when large bird populations were observed. Feed was delivered once daily at approximately 10:00 a.m. for heifers with continuous access to feed and 30 minutes before dusk for heifers with night access to feed. Feed calls for night-access heifers were managed so that no feed remained in the bunk at dawn, whereas continuous-access heifers were allowed ad libitum access to feed.

[b]Carcass adjusted final weight was calculated by dividing hot carcass weight by a common dressing percentage of 64%.

[c]Sl = slight amount of marbling.

EFFECTS OF *LACTOBACILLUS ACIDOPHILUS* AND *PROPIONIBACTERIUM FREUDENREICHII* ON GROWTH PERFORMANCE AND CARCASS CHARACTERISTICS OF FINISHING BEEF CATTLE

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Summary

There have been contradicting reports of the efficacy of direct-fed microbials in finishing cattle diets. Some researchers have observed improvements in daily gain and feed efficiency when direct-fed microbials are included in finishing diets, whereas others have reported no differences in dry matter intake or ruminal and blood pH. Many of these studies have been conducted on a relatively small scale and used few animals per pen compared with that of typical commercial feedlot operations. In our study, yearling crossbred beef steers and heifers (n=3,539; 796 lb body weight) were used in an experiment conducted at a commercial feedlot operation to characterize growth performance and carcass characteristics associated with the supplementation of direct-fed microbials (*Lactobacillus acidophilus* and *Propionibacterium freudenreichii*) in finishing cattle diets. Including direct-fed microbials in the diet throughout a 122-day finishing period had no measurable impact on growth performance or carcass characteristics of finishing cattle.

Introduction

Direct-fed microbials used in ruminant feed supplements include live microbial cells (yeasts, molds, and bacteria) and(or) their metabolites to alter the rumen and lower-gut microflora. The concept of inoculating ruminants with beneficial microorganisms is not a new practice. Increased interest in direct-fed microbials has stemmed from the concern about the widespread use of antibiotics in the cattle feeding industry, reports of improvements in finishing cattle performance, and the potential to inhibit food-borne pathogens such as *Escherichia coli* O157:H7. Previous research with cattle has demonstrated the ability to improve daily gain and efficiency by supplementation with strains of *Lactobacillus acidophilus* and *Propionibacterium freudenreichii*. More recent reports show no differences in dry matter intake or ruminal and blood pH when cattle are fed combinations of lactate-producing and lactate-utilizing microorganisms. Many of these studies were conducted in small pens with relatively few animals. The objective of this study was to assess the impact of supplementing direct-fed microbials on performance of cattle fed in a commercial feedlot facility.

Experimental Procedures

Yearling crossbred beef steers and heifers (n=3,539; 796 lb BW) were transported to a commercial feedlot in central Kansas. Upon

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arrival, a standard processing regimen was applied to each animal that consisted of animal identification, vaccination against common viral diseases, and treatment for internal and external parasites. Heifers identified as pregnant were administered 5 cc of prostaglandin and 5 cc of vitamin E and immediately returned to their home pen. Steers less than 850 lb and heifers less than 750 lb were implanted with an estrogenic implant (Compudose®) at processing and reimplanted after approximately 50 to 70 days with a combination trenbolone acetate/estradiol implant (Component TES® for steers or Component TEH® for heifers). Steers exceeding 850 lb and heifers exceeding 750 lb initial body weight received a single implant (Component TES for steers or Component TEH for heifers) at the time of processing. Cattle within each load were split into two groups on the basis of order of processing, such that even-numbered cattle were placed into one group and odd-numbered cattle were placed into another. Groups were placed into 20 feedlot pens (average of 177 animals per pen) and treatments were assigned randomly within paired pens for the ten replications.

Throughout the experiment, cattle identified as sick were treated in accordance with standard operating procedures of the feedlot, with the exception that cattle were returned to their home pen immediately after therapeutic treatment. Cattle identified as bullers were removed from the experiment permanently, and feed consumption for the pen was adjusted by prorating intake based on the number of head days.

Cattle were adapted to their final finishing ration during a period of two to three weeks after arrival and were fed for an average of 122 days. Direct-fed microbials were incorporated into a steam-flaked corn finishing diet (Table 1) by using a microingredient application system installed at the feedlot by the manufacturer. The experimental diets provided doses of 1×10^9 CFU *Propionibacterium freudenreichii* strain NP 24, 1×10^6 CFU *Lactobacillus acidophilus* strain NP 45, and 1×10^9 CFU *Lactobacillus acidophilus* strain NP 51 per animal daily. The direct-fed microbials were added to the diet after the addition of corn, supplement, and roughage, but before the addition of wheat middlings. A separate truck was used for mixing and delivery of each experimental diet to prevent the possibility for cross-contamination of the control diet with the direct-fed microbial supplement.

Total body weight for each pen of cattle was determined at the start of the experiment and immediately before being transported to a commercial abattoir. Pens of cattle were harvested when they achieved an estimated 12th rib fat thickness of 0.4 inches. All pens within a given replicate were shipped and slaughtered on the same day. Data obtained for each pen of cattle included daily gain, feed intake, feed efficiency, carcass weight, dressing percentage, USDA yield and quality grades, incidence of dark cutting beef, and incidence of liver abscesses. Carcass adjusted final weights were calculated by using a common dress yield of 64%, and weight gain and feed efficiency were calculated from the adjusted final weight.

Results and Discussion

Growth performance and carcass characteristics are reported in Table 2. Initial body weights were similar between treatments. Direct-fed microbial supplementation had no significant effects on dry matter intake (21.35 vs 21.33 lb/day; P=0.92), daily gain (3.38 vs 3.33 lb; P=0.41), or feed efficiency (6.33 vs 6.43; P=0.27) of cattle fed control or supplemented diets, respectively. Final adjusted weights and carcass characteristics also were similar (P>0.10) between the two treatments.

The mechanisms for reported improvements in animal performance in response to direct-fed microbials are not fully understood, but several hypotheses have been proposed.

The presence of some lactate-producing bacteria, *Lactobacillus and Enterococcus*, may create environments in which ruminal microflora can adapt to lactic acid, reducing the risk of subclinical acidosis. Recently though, other studies have shown no differences in intake or ruminal and blood pH when direct-fed microbials have been fed. The data from our large-scale experiment suggest that *Lactobacillus acidophilus* and *Propionibacterium freudenreichii* fed at the amounts included in this experiment do not influence growth performance or carcass characteristics of feedlot cattle. These results are in contrast to other published experiments which have shown significantly greater final body weights and tendencies for improvements in gain when these direct-fed microbials are administered to finishing cattle. In addition, previous studies reported improvements in hot carcass weight, but observed no differences in other carcass characteristics. Another report suggested a 6.9% increase in gain when a cracked-corn and rolled-wheat diet was supplemented with similar microbial treatments. Direct comparison of the results obtained in all of these studies is complicated by variations in feed ingredients, pen size, and inoculation amounts and strains of direct-fed microbials.

The results of this experiment indicate that growth performance and carcass characteristics of yearling crossbred beef steers and heifers fed in a commercial feedlot environment are not influenced by daily supplementation with 1×10^9 CFU *Propionibacterium freudenreichii* strain NP 24, 1×10^6 CFU *Lactobacillus acidophilus* strain NP 45, and 1×10^9 CFU *Lactobacillus acidophilus* strain NP 51.

Table 1. Composition of Experimental Diets (% of Dry Matter)

Item	Control	Direct-fed Microbials
Steam-flaked corn	65.8	65.8
Wet distillers grain	15.4	15.4
Mixed silage	7.0	7.0
Wheat middlings	4.0	4.0
Tallow	2.5	2.5
Liquid supplement[a]	5.3	5.3
Direct-fed microbials[b]	-	+
Nutrient, calculated		
Crude protein	14.0	14.0
Calcium	0.74	0.74
Phosphorus	0.37	0.37
Sodium chloride	0.3	0.3

[a]Formulated to provide 320 mg Rumensin, 90 mg Tylan, 40,000 IU vitamin A, 4,000 IU vitamin D, 100 IU vitamin E per animal daily.
[b]Formulated to provide 1×10^9 CFU *Propionibacterium freudenreichii* strain NP 24, 1×10^6 CFU *Lactobacillus acidophilus* strain NP 45, and 1×10^9 CFU *Lactobacillus acidophilus* strain NP 51 per animal daily.

Table 2. Finishing Performance and Carcass Characteristics of Cattle Fed Direct-Fed Microbials

	Treatment			
Item	Control	Direct-fed Microbials	SEM	P-value
No. of head	1769	1770	-	-
No. of pens	10	10	-	-
Days on feed	122	122	-	-
Initial weight, lb	795	797	2.8	0.69
Final weight, lb[a]	1207	1202	6.3	0.61
Dry matter intake, lb/day	21.35	21.33	0.16	0.92
Weight gain, lb/day[a]	3.38	3.33	0.04	0.41
Feed:gain	6.33	6.43	0.06	0.27
Hot carcass weight, lb	772	769	4.0	0.60
Dressing percentage, %	64.55	64.35	0.11	0.24
USDA Yield grade 1, %	12.7	12.2	1.1	0.72
USDA Yield grade 2, %	41.8	41.3	1.3	0.79
USDA Yield grade 3, %	40.0	40.8	1.5	0.69
USDA Yield grade 4, %	4.7	5.1	0.61	0.69
USDA Yield grade 5, %	0.3	0.3	0.11	0.92
USDA Prime, %	0.9	1.3	0.22	0.19
USDA Choice, %	45.2	41.9	1.6	0.17
USDA Select, %	45.7	50.5	1.9	0.10
USDA Standard, %	5.0	3.7	0.84	0.29
Dark cutters, %	2.4	1.4	0.69	0.32
Liver abscess, %	7.1	6.9	0.55	0.86

[a]Carcass adjusted final weight calculated by dividing hot carcass weight by a common dress yield of 64%.

FEEDLOT PERFORMANCE AND CARCASS TRAITS OF SERIALLY SLAUGHTERED FINISHING HEIFERS

R. L. Hale[1], G. L. Bishop, J. R Brethour, and T. T. Marston

Summary

Two experiments were conducted at the KSU Agricultural Research Center, Hays, Kansas, to measure feedlot gain and carcass traits of serially slaughtered, yearling crossbred heifers. In Exp. 1, 159 heifers averaging 792 lbs were randomly assigned to one of four slaughter groups, and slaughtered at 21-day intervals beginning at 92 days on feed. In Exp. 2, 181 heifers averaging 759 lbs were randomly assigned to one of four slaughter groups, and slaughtered at intervals of 19, 23 and 21 day, respectively, starting at 127 days. In both experiments, final weight, gain, and carcass weight increased with days on feed. Heifers did not gain body weight between 134 and 155 days on feed in Exp. 1, but heifers continued to gain body weight through 190 days on feed in Exp. 2. Despite having a lighter starting weight, final body weights and hot carcass weights were greater for heifers in Exp. 2 than in Exp. 1 because they had more time on feed. Ribeye area increased with time, although the ratio of ribeye area to carcass weight decreased over time. Increases in backfat and kidney, pelvic, and heart fat suggest that carcass gain increases in fat content over time. Yield grade and marbling scores also increased with each successive slaughter group. Quality grade improved with more days on feed in Exp. 1. Carcass quality was, however, hampered by significantly increased carcass maturity in Exp. 2. Although it is not well defined, the greatest increase in carcass fat deposition seemed to occur between 92 and 113 days on feed in Exp. 1, whereas the increases in carcass fat seemed to increase continually between 127 and 188 days on feed in Exp. 2.

Introduction

In many feedlots, heifers are fed and marketed the same as steers. A comparison of data from heifer and steer closeouts demonstrates differences between steer and heifer feedlot performance and carcass development. Although these differences are related to the time required to reach maturity, they also may be associated with management practices developed for steers yet applied to heifers. This research was conducted to develop a database to better predict heifer growth and marbling characteristics because more of the data currently available has been collected from steers.

Experimental Procedures

Two serial slaughter experiments were conducted at the KSU Agricultural Research Center, Hays, Kansas, by using crossbred yearling heifers with a predominance of Angus genetics. The heifers in each experiment were randomly assigned to one of four harvest dates with approximately 21-day intervals. The cattle were fed in multiple pens, with each harvest group represented within each pen.

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The heifers were vaccinated with BoviShield 4 and Fortress 7, dewormed with ivermectin, and implanted with Synovex Plus on day 0. They were stepped up to the finishing ration in approximately three weeks. Composition of the finishing diet is listed in Table 1.

Table 1. Finishing Diet

Ingredient	% of Diet Dry Matter
Ground milo	65.0
Corn silage	30.0
Soybean meal	2.3
Urea	0.5
Ammonium sulfate	0.5
Vitamin and trace mineral premix	0.5
Limestone	1.0
Sodium chloride	0.3

Heifers (n=159) in Exp. 1 averaged 792 lb initially. They were started on feed in March 2001, and groups of them were slaughtered on days 92, 113, 134, and 155. Body weights were measured on all heifers on days 0, 54 and 89. Heifers not yet slaughtered were also weighed within 3 days of each slaughter date. Heifers in Exp. 2 (n=181) averaged 759 lb initially. They were started on feed in December 2001, and groups of them were slaughtered on days 127, 146, 169, and 190. All heifers were weighed on days 0 and 106. Final weights for each group were taken within two days of slaughter. Hot carcass weights were recorded at harvest. Backfat; ribeye area; kidney, pelvic, and heart fat; marbling; and maturity data were collected after a 24-hour carcass chill. Because maturity scores were not collected for the second slaughter group in Exp. 2, USDA quality grades could not be determined for that group.

Slaughter group differences for body weight, gain, and carcass characteristics were evaluated by analysis of variance using the General Linear Model procedure of SAS. Categorical data were analyzed by using chi-square analysis. The two experiments were analyzed separately because of the differences in days on feed and body weights.

Results and Discussion

Initial body weights did not differ between slaughter groups in either experiment (Table 2). Final weights and total gain increased ($P<0.05$) with more days on feed, except between the last two slaughter groups in Exp. 1. Table 3 presents the interim weight and gain data for Exp. 1. Performance of all four slaughter groups was similar through 89 days on feed. Heifers slaughtered at 155 days on feed had the best gains ($P<0.05$) between 89 and 112 days on feed, and had a numerical advantage between 112 and 133 days on feed, but ended the study with a slight weight loss between 134 and 155 days on feed.

During Exp. 2, there were no differences among the slaughter groups in gain between 0 and 106 days on feed (Table 4). In Exp. 2, daily gains were similar among groups between day 106 and the day of slaughter, regardless of the length of these periods.

Hot carcass weights increased ($P<0.05$) over time in both experiments. Carcass weights and dressing percentages were greater for heifers in Exp. 2 than those in Exp. 1. Dressing percentage increased ($P<0.05$) across the slaughter groups in Exp. 1, but did not change over time in Exp. 2. Ribeye area increased ($P<0.05$) with more days on feed, but, as a ratio to carcass weight, ribeye area decreased over time.

Backfat thickness increased ($P<0.05$) from 92 to 155 days on feed in Exp. 1 (from 0.30 to

0.47 inches) and from 127 to 188 days on feed in Exp. 2 (from 0.33 to 0.50 inches). Kidney, pelvic, and heart fat increased with days on feed in Exp. 1 ($P<0.05$), but not in Exp. 2.

Yield grade in Exp. 1, whether measured as an average grade or as percentages for each grade, demonstrated an increase ($P<0.05$) between 92 and 113 days on feed, but did not increase further over time. In Exp. 2, Yield grade continued to increase during the entire 188-day feeding period.

Marbling scores increased over time in both experiments. Marbling ranged between Slight and Small in Exp. 1, but averaged greater than Small in Exp. 2. Average carcass maturity did not change across days on feed in Exp. 1; the "B" and "C" maturity percentages were the result of one such carcass in each group. In contrast, in Exp. 2, the average maturity score for heifers slaughtered after 188 days on feed was greater ($P<0.05$) than those slaughtered after 127 days on feed. In Exp. 2, percentages of heifers fitting into each maturity category also showed ($P=0.01$) increases in carcass maturity with more days on feed. Quality grade (percentage of carcasses grading Choice or above) improved over time on feed in Exp. 1. In Exp. 2, however, any potential grade improvement as a result of increased marbling was offset by the increases in carcass maturity.

The data from these two experiments suggest that, as body weight increases throughout the feeding period, the proportion of carcass fat increases. This is supported by increases in backfat and kidney, pelvic, and heart fat, as well as decreases in ribeye area in relation to carcass weight. Although it is not well defined, the greatest increase in carcass fat deposition seemed to occur between 92 and 113 days on feed in Exp. 1, whereas carcass fat seemed to increase continually between 127 and 188 days on feed in Exp. 2. Differences in initial weight and the number of days on feed before the first harvest could account for some of the differences between the experiments, but other factors such as genetics and weather may also have contributed importantly to these differences.

Table 2. Feedlot Performance and Carcass Characteristics

	Experiment 1					Experiment 2				
	Days on test					Days on test				
Item	92	113	134	155	SEM	127	146	167	188	SEM
Number of heifers	41	40	37	41	–	50	45	41	45	–
Live measurements										
Initial wt, lb	798	793	785	794	4.8	757	763	766	751	4.6
Final wt, lb	1056[a]	1144[b]	1179[c]	1190[c]	4.6	1141[a]	1191[b]	1240[c]	1297[d]	5.6
Total gain, lb	262[a]	352[b]	388[c]	397[c]	4.8	382[a]	433[b]	481[c]	537[d]	5.6
Daily gain, lb	2.94[b]	3.14[b]	2.92[b]	2.61[a]	0.04	3.01	2.96	2.88	2.86	0.04
Carcass measurements										
Hot carcass wt, lb	634[a]	678[b]	721[c]	743[d]	3.0	711[a]	754[b]	782[c]	814[d]	3.7
Dressing percentage	60.0[a]	59.3[a]	61.1[b]	62.5[c]	0.14	62.3	63.3	63.1	62.8	0.14
Ribeye area, inch^2	13.30[ab]	13.06[a]	13.77[bc]	14.00[c]	0.12	13.08[a]	13.72[b]	14.01[b]	13.92[b]	0.10
Ribeye/carcass wt	2.09[a]	1.93[b]	1.92[b]	1.89[b]	0.02	1.85[b]	1.82[b]	1.79[ab]	1.73[a]	0.02
Backfat, inch	0.30[a]	0.44[b]	0.42[b]	0.47[b]	0.01	0.33[a]	0.38[a]	0.44[b]	0.50[c]	0.01
Kidney, pelvic, and heart fat, %	1.84[a]	2.01[ab]	2.16[b]	2.12[b]	0.03	2.37	2.54	2.49	2.52	0.03
Yield Grade, average	1.80[a]	2.39[b]	2.28[b]	2.44[b]	0.05	2.31[a]	2.42[ab]	2.62[bc]	2.88[c]	0.05
Yield Grade 1, %[f]	61	25	30	27	–	30	29	22	9	–
Yield Grade 2, %	39	52	65	51	–	56	53	49	51	–
Yield Grade 3, %	0	22	5	22	–	14	18	24	31	–
Yield Grade 4, %	0	0	0	0	–	0	0	5	9	–
Maturity, average	169	171	172	180	2.0	165[a]	NA[g]	180[ab]	195[b]	4.0
"A" maturity, %[h]	98	97	97	98	–	96	NA	85	66	–
"B" maturity, %	2	3	0	0	–	2	NA	10	27	–
"C" maturity, %	0	0	3	2	–	2	NA	5	5	–
"D" maturity, %	0	0	0	0	–	0	NA	0	2	–
Marbling score[e]	4.07[a]	4.44[b]	4.87[c]	4.98[c]	0.05	5.05[a]	5.03[a]	5.17[ab]	5.44[b]	0.06
Choice and better, %[i]	17	22	30	51	–	48	NA	51	47	–
Select and worse, %	83	77	70	49	–	52	NA	49	53	–

[a,b,c,d] Means on same row within the same experiment and having different superscripts differ (P<0.05).
[e]4.0 = Sl^0, 5.0 = Sm^0, 6.0 = Mt^0.
[f]Chi-square, Exp. 1, P=0.01; Exp. 2, P=0.11.
[g]Data not available because maturity scores were not collected.
[h]Chi-square, Exp. 1, P=0.67; Exp. 2, P=0.01.
[i]Chi-square, Exp. 1, P=0.01; Exp. 2, P=0.86.

Table 3. Weight, Total Gain, and Average Daily Gain by Period (Exp. 1)

		Days on Test				
Period	Item	92	113	134	155	SEM
Day 0-54	Ending wt, lb	965	966	972	968	3.0
	Total gain, lb	172	173	181	176	3.0
	Daily gain, lb	3.18	3.21	3.36	3.25	0.06
Day 54-89	Ending wt, lb	1056	1064	1069	1060	3.9
	Total gain, lb	90	98	97	92	2.9
	Daily gain, lb	2.57	2.79	2.78	2.62	0.08
Day 89-112	Ending wt, lb		1144	1146	1150	4.5
	Total gain, lb		81[a]	77[a]	92[b]	2.2
	Daily gain, lb		3.50[a]	3.35[a]	4.00[b]	0.10
Day 112-133	Ending wt, lb			1179	1189	5.4
	Total gain, lb			33	39	2.8
	Daily gain, lb			1.57	1.86	0.13
Day 133-152	Ending wt, lb				1190	10.2
	Total gain, lb				-1	6.2
	Daily gain, lb				-0.06	0.33

[a,b]Means on same row that have different superscripts differ significantly (P<0.05).

Table 4. Weight, Total Gain, and Average Daily Gain by Period (Exp. 2)

		Days on Test				
Period	Item	127	146	169	190	SEM
Day 0-106	Ending wt, lb	1105	1097	1096	1114	4.1
	Total gain, lb	346	338	337	355	4.1
	Daily gain, lb	3.27	3.19	3.18	3.35	0.04
Day 106-127	Ending wt, lb	1141				7.7
	Total gain, lb	36				3.3
	Daily gain, lb	1.69				0.16
Day 106-146	Ending wt, lb		1191			10.2
	Total gain, lb		94			5.1
	Daily gain, lb		2.36			0.13
Day 106-169	Ending wt, lb			1240		12.8
	Total gain, lb			144		7.7
	Daily gain, lb			2.36		0.13
Day 106-190	Ending wt, lb				1297	14.2
	Total gain, lb				182	9.4
	Daily gain, lb				2.22	0.11

STEROID HORMONE PROFILES AND BRAIN MONOAMINE OXIDASE TYPE A (MAO-A) ACTIVITY OF BULLER STEERS

M. P. Epp, D. A. Blasi, B. J. Johnson, J. P. Kayser, and D. M. Grieger

Summary

A grazing/feedlot field study was conducted to evaluate the steroid hormone profile and brain monoamine oxidase type A (MAO-A) activity of steers exhibiting characteristics attributed to the Buller Steer Syndrome in a feedlot environment. Differences of serum progesterone, testosterone, and estrogen were found in bullers at different phases of production. Brain MAO-A activity was greater in bullers than in non-bulling steers. This study suggests that MAO-A activity, under potential influence of steroidal hormones in the steer brain, may be a plausible mechanism that induces Buller Steer Syndrome.

Introduction

The Buller Steer Syndrome is a behavioral condition normally encountered in a feedlot setting in which several steers within a pen will persistently ride one or sometimes two steers within a small group. Although the syndrome is more prevalent in a feedlot setting, it may also occur in pastures. The National Animal Health Monitoring System (NAHMS) 1999 beef feedlot survey reported that incidence of bullers ranked as the second most prevalent disease in feedlots (2.2% of all cattle) behind conditions of Bovine Respiratory Disease (USDA, 2002).

Bulling behavior is economically detrimental to the cattle-feeding industry. Recent estimates place the cost of bulling to the cattle industry between $23 and $70 per buller.

Several different mechanisms have been postulated to trigger Buller Steer Syndrome. These include social hierarchy, growth implants, weather, season of the year, poor bunk management, pen size and density, entry weight and/or age, pheromones, and phytoestrogenic substances in the feed. Although all of these factors may play a role in eliciting the bulling behavior, there has been no agreement that any one factor may exclusively cause it.

Monoamine oxidase (MAO) is an enzyme that can be located throughout the body, but it plays a role in the regulation of behavior, dependent on the amount in the brain. Like any enzyme in the body, MAO is needed in an appropriate amount so that an individual can function properly. Too much or too little of an enzyme can have a direct impact on an individual's health and personality. In humans, a relationship has been established between undesirable social behavior and monoamine oxidase type A (MAO-A) activity. The expression of MAO has been found to be concurrent with the genotyping ability of an organism to produce the enzyme, and transcriptional regulation of MAO can come under modulation from steroidal hormones. Very

[1]Sincere appreciation is expressed to Pratt Feeders, Pratt, Kansas, and Irsik and Doll Feedlots, Cimarron, Kansas, for providing cattle, facilities, and financial support.

recently, subordinate mice were reported to have significantly greater amounts of MAO-A mRNAs when compared with normal counterparts.

The objective of this study was to evaluate steroidal hormone levels of steers at three different production phases and to measure brain MAO-A mRNA activity in the frontal cortex of buller and non-buller steers.

Experimental Procedures

Sera were harvested from 600 crossbred steers of eastern Missouri origin 7 to 14 days before placement on five different intensive early stocked pastures (pre-grass) in south central Kansas. In mid to late July of 2002, all steers were sent directly to a commercial feedlot in western Kansas (initial body weight 887 lb), where serum was again harvested from all steers (feedlot arrival). Each pasture group was maintained as a separate pen. When any steer was removed from its home pen for exhibiting classic buller-steer characteristics, blood was collected from that animal (buller) before moving it to a separate pen. For the MAO-A analysis, brains were harvested at the end of the feeding period from 12 buller and 12 non-buller steers at a commercial packing plant.

Results and Discussion

A total of 27 steers were classified as bullers during the feedlot period. Pre-grass progesterone was less ($P<0.05$) in sera obtained from buller compared with non-buller sera (Figure 1). From feedlot arrival to buller, there was a reduction ($P<0.05$) of progesterone in buller steers. There was an increase ($P<0.01$) of testosterone in buller steers from feedlot arrival to buller (Figure 2). Estrogen increased ($P<0.01$) from pre-grass to feedlot arrival in both buller and non-buller steers (Figure 3). This is an expected difference, because the implant given at the pre-grass time would still be releasing estrogen. Brain MAO-A mRNA levels were 74.5% greater ($P=0.03$) in buller than in non-buller steers (Figure 4). Western blots have confirmed the presence of MAO-A protein in brain samples (Figure 5).

These data indicate that MAO-A activity in the frontal cortex region of some buller animals differs from non-buller steers. More research is needed to see if a direct correlation exists between the differences in systemic steroidal hormone levels and MAO-A activity in the bovine brain.

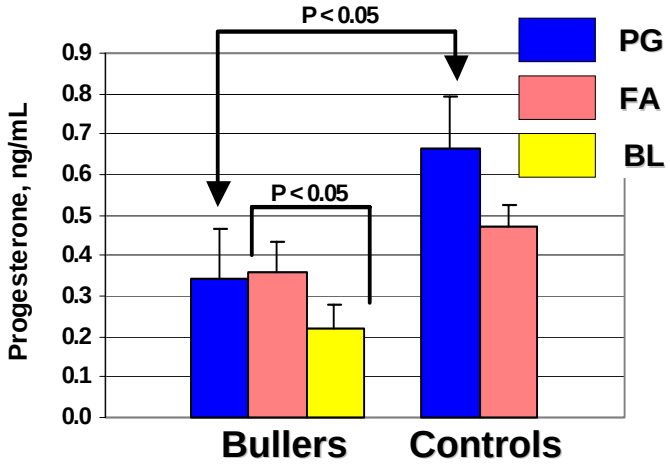

Figure 1. Progesterone Levels of Bullers vs. Controls (Non-Bullers) at Different Phases of Production. Time of sampling: PG = Pre-grass; FA = Feedlot arrival; BL = Buller.

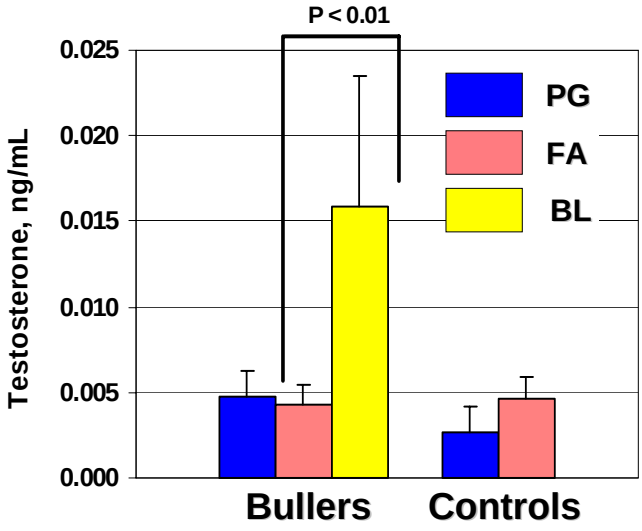

Figure 2. Testosterone Levels of Bullers vs. Controls (Non-Bullers) at Different Phases of Production. Time of sampling: PG = Pre-grass; FA = Feedlot arrival; BL = Buller.

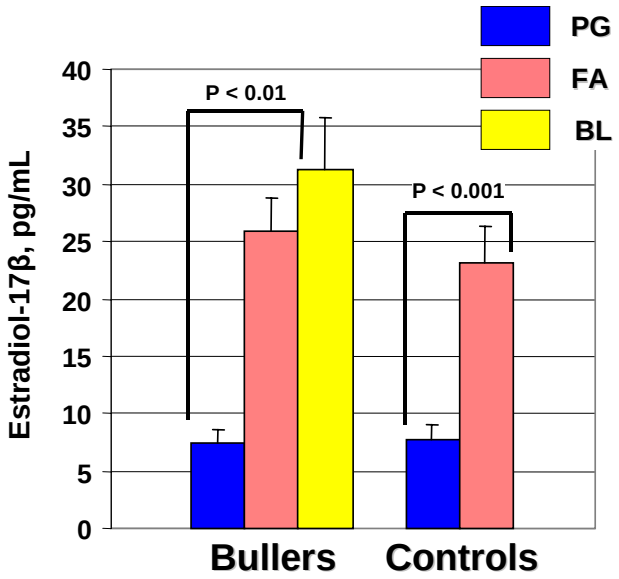

Figure 3. Estradiol-17ß Levels of Bullers vs. Controls (Non-Bullers) at Different Phases of Production. Time of sampling: PG = Pre-grass; FA = Feedlot arrival; BL = Buller.

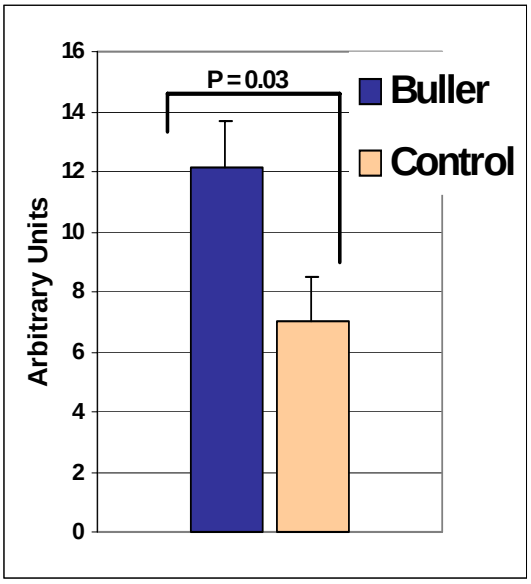

Figure 4. Brain mRNA MAO-A Levels of Bullers vs. Controls (Non-Bullers).

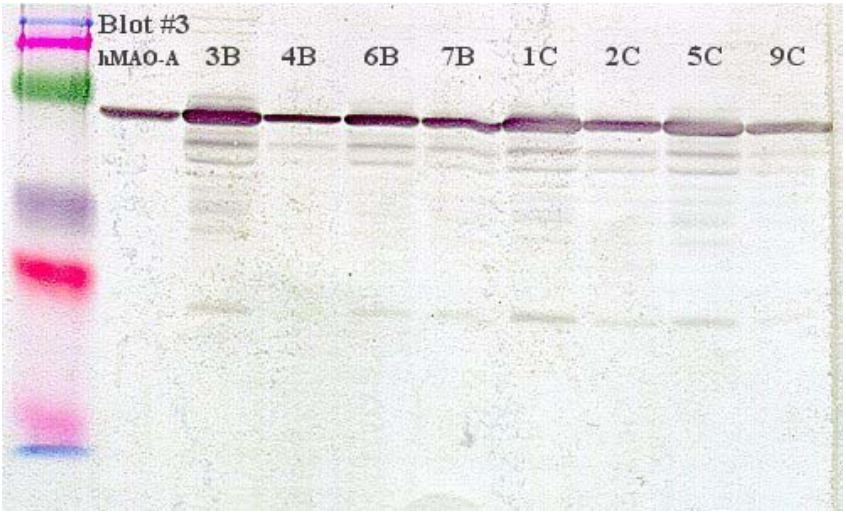

Figure 5. Western Blot Representing that Protein has been Translated (i.e., been made) from mRNA. The band labeled hMAO-A is human MAO-A and is used as a positive control. Labels 3B, 4B, 6B, 7B are buller steers and 1C, 2C, 5C, 9C are control (non-buller) steers. Notice that buller steer bands are darker than controls, an indicator that MAO-A protein may be in larger quantities.

EFFECTS OF EARLY WEANING ON PERFORMANCE OF COW/CALF PAIRS

E. A. Koch, R. M. Breiner, J. A. Christopher, T. T. Marston, and J. A. Unruh

Summary

Commercial cow/calf pairs (Angus based, n=103) were used to determine the effect of calf weaning age on cow body weight and body condition score (scale=1 to 9) and calf performance in terms of subcutaneous fat and marbling deposition. Only cows with male progeny (steers, n=52; bulls, n=51) were used in this study. Treatments were: 1) early-weaned bulls, 2) early-weaned steers, 3) traditionally weaned bulls, and 4) traditionally weaned steers. Cow/calf pairs grazed pastures at four different locations. Calving began February 1, 2003, and ended in early April. In the early-weaned treatment group, calves were weaned June 25, with an average age of 115 days. In the late-weaned treatment group, calves were weaned October 6, with an average age of 218 days. The data indicate that the cows in the early-weaned treatment group gained 121 lb more weight ($P<0.0001$), had 0.13 inches more external backfat ($P<0.0001$), and had an average body condition score 1.2 greater ($P<.0001$) than their late-weaned counterparts. All steer calves were implanted before they entered the feedlot. Early weaning and subsequent feedlot placement produced heavier calves at approximately nine months of age. Ultrasound technology indicated that early-weaned calves had greater backfat and marbling scores 26 days after feedlot placement than did traditionally weaned calves. However, the early–weaned bulls had less backfat at a similar average weight to their steer contemporaries.

Introduction

Traditionally, calves are weaned when they are approximately 205 days of age. Nutrient requirements of the cow are much greater when she is lactating. Several research studies have indicated that early weaning will help alleviate the effects of limited nutrient intake associated with limited precipitation on young cows. In addition, some producers have voiced concerns about effects of early weaning on calf performance and health.

The objectives of this study were to determine if weaning age affects cow body weight and condition score and to investigate the effects of early weaning on male calf performance.

Experimental Procedures

Commercial cows (Angus based, n=103) nursing crossbred male calves (average birth date=March 2) were blocked by calf birth date and calf sire and randomly allotted to treatments. The four treatments consisted of weaning calves early (June 25) or at the traditional time (October 6) and as steer or bull calves. Therefore, treatments were: 1) early-weaned bulls, 2) early-weaned steers, 3) traditionally weaned bulls, and 4) traditionally weaned steers. Cow/calf pairs from all treatments were commingled within four native-grass pastures near Manhattan, Kansas (average stocking rate = 8 acres/cow-calf pair). All pastures were supplemented with a free-choice

salt/mineral mixture. Health maintenance programs and breeding seasons (May 21 to July 21) were similar between pastures and treatments. All calves were injected with Fortress 7 (Pfizer Animal Health) on May 27. Calves assigned to the steer group were castrated and received an implant of Component E-C (Vet-Life). Cows were examined for pregnancy in the fall.

Lactation periods for the early-weaned and traditional treatments averaged 115 days and 218 days, respectively. On both weaning dates, cows were weighed and body condition was scored. Body condition (scale = 1, emaciated; 9, obese) was the average of four independent estimates made by trained individuals. Additionally, on the late weaning date, external backfat of cows was measured by using ultrasound.

Calves weaned on June 25 were assigned to pens according to treatment and were fed a commercially available, complete starter ration. Daily feed intake was recorded for the pens, and calves were treated for illness as necessary. Feed intake averaged 11.3 lb (as fed) per day. On July 14, calf weight was recorded, and all weaned calves were shipped to the Agriculture Research Center in Hays, Kansas. Calves were assigned to feedlot pens by sex status, birth date, and sire. The feedlot grower ration for early-weaned calves is presented in Table 1. On September 1, the calves were adjusted to a high-protein finishing ration.

The calves designated for traditional weaning remained with the cows on native grass near Manhattan, Kansas, with no creep feed throughout the summer. Traditionally weaned calves were weaned and weighed on October 6. They were fed an average of 4.0 lb/day of a commercial grower ration and 10.3 lb/day of prairie hay until October 29, at which time calves were weighed and shipped to the Agriculture Research Center in Hays, Kansas. Early-weaned calves were also weighed on October 29 at the Agriculture Research Center. Feedlot rations are listed in Table 1. On November 25, all calves were weighed and ultrasound measurements were taken.

Results and Discussion

Table 2 illustrates the effect of the treatments on cow body weight, body condition score, and backfat measurements. Because cow weight and condition score were not affected by calf sex, data were pooled, and comparisons for cow parameters were made between weaning treatments. Cows on different treatments had similar body weights and conditions when the early-weaned calves were removed from their dams (June 25). Cows with calves weaned early in the summer weighed more and achieved greater body condition scores ($P<0.0001$) during the summer grazing period (June 25 to October 6) than the cows still nursing their calves. The additional 121 lb of body weight gain corresponded to 1.2 units of body condition. Furthermore, cows from the early weaned treatment averaged 0.13 inches greater backfat ($P<0.0001$) than the dams with later-weaned calves. Because cows were not measured for backfat on June 25, we cannot verify that backfat changes were different between treatments. However, correlation analysis indicates that ultrasound backfat measurements and body condition scores are positively related ($r=0.77$; $P<0.0001$). Almost all cows were diagnosed pregnant the subsequent fall, regardless of weaning treatment (early=96%; late=100%).

Average daily gains of early-weaned bulls and steers were 1.86 and 2.40 lb/day, respectively, from weaning until the calves were shipped to Hays (20 days). The traditionally weaned bulls and steers gained 1.17 and 1.20 lb/day, respectively, from weaning until the

calves were transported to Hays (23 days). The immediate post-weaning average daily gains were not compared between weaning treatments because different rations were fed.

On October 29, the early-weaned calves weighed more (P<0.05) than the traditionally weaned calves (Table 3). Regardless of weaning strategy, bulls and steers had similar (P>0.05) body weights within the weaning groups.

On November 24, after all calves had received a common feedlot diet for 25 days, calves were weighed at the Hays facility as well as measured by ultrasound for backfat and marbling. The early-weaned cattle weighed more than the traditionally weaned cattle on November 24 (P<0.05). Ultrasound indicated that the early-weaned steers had more (P<0.05) backfat than the early-weaned bulls. As would be expected, both of the early-weaned groups had more (P<0.05) backfat than either of the traditionally weaned groups. Based on ultrasound measurements, early-weaned steers had more (P<0.05) marbling than the traditionally weaned calves. The early-weaned bulls had marbling intermediate to the early-weaned steers and traditionally weaned cattle (Table 3).

During the summer, when the traditionally weaned calves were still on grass, some of the early-weaned calves (four steers, two bulls) experienced bloat and pneumonia in the feedlot. Three early-weaned calves were eventually removed from the trial because of chronic bloat, and three more early-weaned calves died. Although the cause of these deaths was not determined, they seemed to be caused by respiratory disease. The death loss for the early-weaned calves was nearly 6%. Meanwhile, no traditionally weaned calves were removed from the trial or lost for health reasons.

This study indicates that weaning age can be an effective means of increasing spring-calving cow body weight and condition, as well as backfat. Manipulating the length of lactation by adjusting the weaning date can be a useful management decision under a variety of production systems, especially those incorporating young cows, limited feed resources, and harsh weather conditions.

Table 1. Composition of Diets Fed to Weaned Calves at Agricultural Research Center – Hays, Kansas

Ingredient	Growing (7/14 to 8/31)	Finishing (9/1 to 10/29)	Finishing (10/30 to 11/24)
	---------- %, as fed basis ----------		
Sorghum silage	43.9	32.3	32.4
Milo	43.2	58.8	59.1
Soybean meal	8.9	6.1	6.0
Rumensin/Tylan premix	1.0	0.7	0.5
Ammonium sulfate	0.4	0.3	0.2
Limestone	2.1	1.5	1.1
Urea	-	-	0.3
Salt	0.5	0.4	0.4

Table 2. Effect of Weaning Age on Changes in Cow Body Weight, Body Condition Score, and External Backfat of Spring-Calving Cow/Calf Pairs

	Treatment			
Item	Early[b]	Traditional[c]	SE	P-value
No. of cows	52	51		
Average calving date	March 2	March 2		
Body weight, lb				
June 25	1181	1176	18.8	
October 6	1322	1201	8.3	0.0001
Gain, 6/25 to 10/6, lb	143	22	8.3	0.0001
Body Condition Scores[a]				
June 25	5.0	4.9	0.08	
October 6	6.2	4.9	0.07	0.0001
Change in BCS, 6/25 to 10/6	1.2	0.0	0.07	0.0001
Backfat on October 6, inch	0.30	0.17	0.009	0.0001
Pregnant, %	96	100		0.49

[a]Body condition scale: 1=emaciated; 9=obese.
[b]Early treatment group=calves weaned June 25.
[c]Traditional treatment group=calves weaned October 6.

Table 3. Weights and Ultrasound of Early-Weaned and Traditionally Weaned Steers and Bulls

	Early Weaned		Traditionally Weaned	
Item	Steers	Bulls	Steers	Bulls
Average calving date	March 2	March 4	March 1	March 5
Initial weight, lb	369	350	368	369
Post-weaning daily gain, lb				
June 25 to July 14	2.40[a]	1.86[b]	-	-
October 6 to October 29	-	-	1.17[a]	1.20[a]
Weight on October 29, lb	719[a]	716[a]	654[b]	674[b]
November 24				
Weight, lb	786[a]	781[a]	706[b]	714[b]
Backfat, inch	0.23[a]	0.19[b]	0.12[c]	0.11[c]
Marbling score	4.49[a]	4.36[ab]	4.04[b]	4.03[b]

[abc]Means within a row that have different superscript letters differ (P<0.05).
[d]Measurement of ultrasonic speckle generated by the cell walls of unfilled pre-adipocytes.

EVALUATION OF EXPRESS™ 5-PHM AND TITANIUM® 5-PHM BAC®-1 ON HIGH-RISK RECEIVING STEERS[1]

M. P. Epp, D. A. Blasi, L. C. Hollis, and B. B. Barnhardt

Summary

One backgrounding field study was conducted at two locations to compare the health and performance of high-risk receiving steers given an Express™ 5-Pasteurella Haemolytica-Multocida (PHM) vaccine or a Titanium® 5-PHM Bac®-1 vaccine. At one location, calves given the Titanium 5-PHM vaccination had fewer first and second repulls ($P<0.05$). At the other location, calves given the Express 5-PHM vaccination had fewer initial pulls for respiratory disease and more hospital pen days at initial pull ($P<0.05$) than those given Titanium 5-PHM. No differences were measured at either location for mortality and average daily gain.

Introduction

Throughout the marketing chain, beef cattle can be introduced to many types of stressors and degrees of trauma, such as weaning, exposure to pathogens and handling at salebarns, and long-distance hauling. Cattle that are "high-risk" have experienced many excessive-trauma stressors over an extended period and are classified as likely to acquire Bovine Respiratory Disease complex (BRD). This disease is ranked first among all disease conditions in U.S. feedyards (NAHMS, 1999) and accounts for millions of dollars of loss to producers every year.

There are several types of BRD, pneumonia being the most prevalent form. Three factors must be present for pneumonia to develop: (1) stress, (2) viral infection, and (3) bacterial infection. To help prevent the onset of a viral infection, a modified live vaccine with common respiratory antigen components is used. Common respiratory viruses in cattle include infectious bovine rhinotracheitis (IBR), parainfluenza 3 (PI3), bovine virus diarrhea (BVD) type I and II, and bovine respiratory syncytial virus (BRSV). Two of the most predominate types of bacterial infections involved in pneumonia are *Mannheimia (Pasteurella) haemolytica* (PHM) *and Pasteurella multocida*.

The objective of this study was to evaluate two different modified live virus-pasteurella combination vaccines, Express 5-PHM and Titanium 5-PHM, on subsequent health and performance of seriously stressed steers. Both vaccines contain the same five modified live viral components: IBR, PI3, BVD type I and II, and BRSV. The vaccines differ in the form of the *Pasteurella haemolytica-multocida*

[1]Sincere appreciation is expressed to Porter Farms, Reading and Moxley Ranch, Council Grove, for providing cattle, facilities, and assistance, and to Boehringer Ingelheim Vetmedica and Elanco Animal Health for support of this study.

component: Express 5-PHM is in a killed form, whereas in Titanium 5-PHM it is in a modified live form.

Experimental Procedures

Location 1. A total of 736 steers (average 352 lb initial body weight) from the southeastern United States, were used at location 1 in East-Central Kansas. These cattle were poorer quality, light-weight, and high-risk calves. Animals were randomly assigned to vaccine treatments and given a metaphylactic treatment of Micotil®, an endectocide pour-on, Revalor®-G growth implant, and were castrated/dehorned upon arrival. The cattle were *not* assigned vaccine treatments on the basis of castration status at time of arrival. Approximately 10 days later, a booster of the original vaccine product without the *Pasteurella haemolytica- multocida* component was given to all steers except those in the hospital pen. Sick animals were pulled and treated according to the standard protocol in use at this location. All cattle were fed a high-energy diet based on corn silage. Uniform health and management procedures were used throughout the study. A final weight was taken of all steers after an average of 93 days.

Location 2. All treatments and procedures at location 2 were the same as those used at location 1, except that a 7-way clostridial vaccine and a Synovex®-S growth implant were given at initial processing. A total of 422 steers (average 532 lb initial body weight) originating from the southeastern United States were used at location 2, which was also in East-Central Kansas. These cattle were better quality than those at location 1 and carried moderate flesh, but they were still considered to be high-risk calves. A final weight was taken of all steers after an average of 84 days.

Results and Discussion

Health and performance data for the locations were not pooled because of the wide range of differences in cattle quality and associated risk level. At location 1, there were fewer first repulls ($P<0.05$) of non-castrate calves (steers upon arrival) that had been given the Titanium 5-PHM treatment (Table 1). There were fewer second repulls ($P<0.05$) of castrates (bulls upon arrival). There were no other significant differences among treatments at location 1 for initial pulls for respiratory disease, hospital pen days, percentage death loss, and average daily gain.

At location 2, there were fewer initial pulls for respiratory disease and more average hospital days when initially pulled ($P<0.05$) in non-castrate calves (steers upon arrival) that had been given the Express 5-PHM treatment (Table 2). There were no other significant differences for the remaining measurements taken at location 2.

Because performance between non-castrates (steers) and castrates (bulls) upon arrival was not the primary focus of this study, statistical analyses were not conducted for these differences. Differences can be seen, however, in initial pulls, death loss, and average daily gain. These differences were particularly marked for the cattle type used at location 1.

Table 1. Performance Differences Between Express 5-PHM Vaccine and Titanium 5-PHM Vaccine on % Pulls for Respiratory Disease, Treatment Days in Hospital Pen for Each Pull Occasion, % Death Loss, and Average Daily Gain at Location 1

	Non-Castrate (Steers)[a]		Castrate (Bulls)	
Item	Express™	Titanium®	Express™	Titanium®
Head	89	74	282	291
Initial Pulls, %*	38.8	23.3	51.2	54.5
First Repulls, %*	22.3[b]	9.1[c]	23.4	26.4
Second Repulls, %*	5.6	1.1	9.2[b]	4.2[c]
Average Hospital Days				
Initial Pulls*	5.1	4.5	5.1	5.4
First Repulls*	5.4	5.1	4.5	4.7
Second Repulls*	4.3	1.3	3.9	4.2
Death Loss, %*	7.1	10.0	16.3	18.0
Daily gain, lb*	2.0	2.2	1.7	1.8

[a]Data analyzed separately according to castration status upon arrival.
[bc]Different superscripts between vaccines differ (P<0.05).
*Means blocked by load.

Table 2. Performance Differences Between Express 5-PHM Vaccine and Titanium 5-PHM Vaccine on % Pulls for Respiratory Disease, Treatment Days in Hospital Pen for Each Pull Occasion, % Death Loss, and Average Daily Gain at Location 2

	Non-Castrate (Steers)[a]		Castrate (Bulls)	
Item	Express™	Titanium®	Express™	Titanium®
Head	52	58	162	150
Initial Pulls, %*	23.1[b]	43.1[c]	42.0	48.0
First Repulls, %*	3.5	13.0[c]	16.0	16.0
Second Repulls, %*	0.5	8.3	5.6	4.0
Average Hospital Days				
Initial Pulls*	5.8[b]	3.5[c]	4.5	4.7
First Repulls*	3.3	4.8	4.2	4.8
Second Repulls*	0.0	4.9	3.3	6.2
Death Loss, %*	6.1	2.5	6.1	5.2
Daily gain, lb*	2.7	2.7	2.3	2.2

[a]Data analyzed separately according to castration status upon arrival.
[bc]Different superscripts between vaccines differ (P<0.05).
*Means blocked by load.

EFFECTS OF ROUTE OF ADMINISTRATION OF A COMMERCIALLY AVAILABLE *MANNHEIMIA* (PASTEURELLA) *HAEMOLYTICA* VACCINE ON TITER LEVELS

T. T. Marston, L. C. Hollis, D. A. Llewellyn, and G. L. Stokka[1]

Summary

One hundred thirteen Hereford x Angus heifer calves (average weight = 515 lb) were allotted to one of three treatments: 1) control, no vaccine; 2) a 2-cc subcutaneous injection of One-Shot® (Pfizer Animal Health), a *Mannheimia* (pasteurella) *haemolytica* vaccine, three weeks before weaning; or 3) a ½-cc intradermal injection of One-Shot, three weeks before weaning. All heifers were weighed and blood samples harvested at time of injection, three weeks later at weaning, and then 28 days later. After weaning, heifers were confined to a common pen and fed free-choice brome hay and approximately 5 lb/head daily of a concentrate. Blood samples from 30 heifers were shipped to a laboratory for titer analysis. No differences were found in animal performance and sickness during the preconditioning period. Heifers injected by the subcutaneous route had greater increases in whole-cell and leukotoxin-neutralizing antibody titer levels than the intradermal or control treatments. These data suggest that beef producers should follow label recommendations for dosage and route of administration to maximize vaccine efficacy.

Introduction

Mannheimia haemolytica is the major bacterium responsible for severe disease (bovine respiratory disease) and economic losses in cattle. Research has indicated that weanling calves vaccinated subcutaneously for *M. haemolytica* with One-Shot® (Pfizer Animal Health) responded with a significant increase in whole-cell and leukotoxin-neutralizing antibody titers. Increasing titers would indicate that the animal's immune system reacted to the vaccine and is better prepared to defend the body against disease challenges. This study was conducted to determine if use of an intradermal route of administration with a smaller dosage would elevate antibody titers and have the potential to reduce morbidity and increase performance in cattle.

Experimental Procedures

One hundred thirteen Hereford x Angus, spring-born heifers were randomly assigned to treatments three weeks before weaning (September 24, 2002). Heifers were weighed, and blood samples were harvested before vaccination and were properly stored. Heifers were then processed with FORTRESS 7® (Pfizer

[1]Pfizer Animal Health, Cooperstown, North Dakota.

Animal Health) and CATTLEMASTER 4® (Pfizer Animal Health). According to treatment assignment, heifers received one of three injection treatments of a *M. haemolytica* vaccine (One-Shot®, Pfizer Animal Health): 1) control, no vaccine administered; 2) a 2-cc subcutaneous injection of the *M. haemolytica* vaccine; or 3) a ½-cc intradermal injection of the *M. haemolytica* vaccine. Twenty-one days later (October 14), heifers were again weighed and blood samples taken and properly stored. Samples from both sampling days were forwarded to Oklahoma State University for whole-cell and leukotoxin-neutralizing antibody analysis. Two blood samples were not analyzed. All injections were given in the calves' neck region, following standard KSU/ KVMA/KLA Beef Quality Assurance guidelines.

Results and Discussion

The initial weight of heifers treated intradermally was less than heifers in other treatments, but initial weight had no effect on gain or blood-work results (Table 1). Weight gains and morbidity were similar between treatments. No differences in basal titer levels were noted between treatments groups (Table 2). Changes in whole-cell titer in response to vaccination were not different among treatments ($P>0.55$). However, the leukotoxin-neutralizing antibody tests indicated that the subcutaneous treatment resulted in a greater increase in antibody concentration than either the control ($P=0.004$) or intradermal ($P=0.21$) treatments.

These heifers were neither transported nor commingled with externally sourced cattle during this trial. Health records reflected this management program, in as much as no heifers were treated for bovine respiratory disease or died during the preconditioning period.

One-Shot vaccine was effective in increasing the leukotoxin-neutralizing antibody titer levels in weaning-age calves, whereas whole-cell titers were less responsive. The recommended route of administration and dosage seems to give best results.

Table 1. Effects of Volume and Route of Administration of a *Mannheimia haemolytica* Vaccine (One-Shot®, Pfizer Animal Health) on Animal Performance

Item:	Control/ No Vaccine	2 cc Subcutaneous	½ cc Intradermal	SEM
Initial weight, lb	512[a]	521[a]	500[b]	6.2
Average daily gain, lb/day				
September 24 to October 15	1.6	1.7	1.7	0.12
October 15 to November 12	1.3	1.4	1.2	0.10
September 24 to November 12	1.5	1.5	1.5	0.04

[ab]Means with different superscripts within row differ (P<0.05).

Table 2. Effects of Volume and Route of Administration of a *Mannheimia haemolytica* Vaccine (One-Shot®, Pfizer Animal Health) on Serological Test Results

Item:	Control/ No Vaccine	2 cc Subcutaneous	½ cc Intradermal	SEM
Titer level, September 24				
Whole cell	0.28	0.32	0.43	0.11
LktNA*	0.16	0.18	0.15	0.050
Titer level, October 14				
Whole cell	0.37	0.64	0.54	0.12
LktNA*	0.22[a]	0.48[b]	0.33[a]	0.063
Change in titer level, September 24 to October 14				
Whole cell	0.04	0.30	0.21	0.12
LktNA*	0.05[a]	0.33[b]	0.17[a]	0.069

*Leukotoxin-neutralizing antibody.

[ab]Means with different superscripts within row differ (P<0.10).

FAILURE TO ELIMINATE THE CARRIER STATE OF *ANAPLASMA MARGINALE* BY USING LONG-ACTING INJECTABLE OXYTETRACYCLINE

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Summary

Thirty-four *Anaplasma marginale* seropositive cows from a herd of 236 were allocated to treatments: 5 animals served as untreated controls, and 29 animals were treated with three injections of long-acting oxytetracycline at three-day intervals. Fourteen days after initiation of treatment, 100% of control cows and 89% of treated cows were found to have *Anaplasma marginale* present. Seventy-four days after initiation of treatment, 100% of control cows and 86% of treated cows were found to have *Anaplasma marginale* present. Use of injectable long-acting oxytetracycline was not effective in eliminating the carrier state of *Anaplasma marginale* from infected animals.

Introduction

Treatment with long-acting injectable oxytetracycline has long been recommended as one means of clearing the carrier state of *Anaplasma marginale* from infected cattle. Older diagnostic methods, such as the complement-fixation test and card-agglutination test have indicated the success of such treatment. Newer diagnostic methods, such as enzyme-linked immunosorbent assay (ELISA) and polymerase chain reaction (PCR) have enhanced the ability to assess the presence of antibodies to those organisms or the organisms themselves. The objective of this study was to use ELISA and PCR diagnostic methodologies to determine the efficacy of three injections of long-acting injectable oxytetracycline.

Experimental Procedures

A commercial cow herd of 236 animals was screened for antibodies to *Anaplasma marginale* by using the card-agglutination test; 75 animals tested positive. Sixty-three of these 75 animals were found to be positive for *Anaplasma marginale* when confirmatory testing with both ELISA and PCR technology was conducted 20 days before the start of the study (day -20). Twenty-nine of the 63 positive animals were reserved for another study, and 34 animals were included in this study. At the start of the study (day 0), 5 of the 34 animals were randomly allocated to a control group, and the remaining 29 were allocated to the oxytetracycline treatment group. On the basis of an average estimated weight of 1200 lb, animals in the oxytetracycline-treated group received 60 mL of a long-acting, injectable oxytetracycline product containing 200 mg/mL oxytetracycline solution. All injections were given subcutaneously in the neck, with the 60 mL dose being distributed among four injection sites on one side of the neck on each treatment day. Treatment was repeated at three-day intervals for a total of three treatments per animal. Blood samples were taken from all animals 14 days after initiation of

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treatment (day 14), and again 60 days later (day 74). Blood samples were forwarded for PCR testing on day 14 and 74 and for ELISA testing on day 74.

Results and Discussion

On day 14, 5 of 5 control animals (100%) and 25 of 28 oxytetracycline-treated animals (89%) were PCR positive for the presence of *Anaplasma marginale* organisms (Table 1). The sample from one oxytetracycline-treated cow was lost from the samples submitted for PCR testing on day 14. ELISA testing was not conducted on samples collected on day 14 because this testing method measures the serological status of animals, which was not expected to change that rapidly after death of *Anaplasma marginale* organisms. On day 74, 2 of 5 control animals (40%) and 16 of 29 oxytetracycline-treated animals (55%) were ELISA positive for antibodies to *Anaplasma marginale*, whereas 5 of 5 control animals (100%) and 25 of 29 oxytetracycline-treated animals (86%) were PCR positive for the presence of *Anaplasma marginale* organisms.

All study animals had access to a free-choice mineral mix containing 4.25 g chlortetracycline/lb mix during the period of mid-May through mid-October, before initial serological screening. Consumption of the mineral mix during that period was approximately 0.25 lb cow daily. Precautions were not taken to preclude the needle-borne transmission of *Anaplasma marginale* during late-October herd vaccinations. Initial serological screening was completed during the months of December and January. Study animals were not treated with any antimicrobial product by injection or feed additive after initial screening or during the study period. Precautions were taken to prevent the likelihood that needle-borne transmission of *Anaplasma marginale* would occur during springtime vaccinations. Day 14 blood samples were drawn before the start of the biting fly season, when *Anaplasma marginale* transmission could occur. Day 74 blood samples were drawn after the biting fly season was under way.

Repeated injections of long-acting oxytetracycline were not effective in eliminating the carrier state of *Anaplasma marginale* from infected animals (Table 1). PCR testing was able to detect the presence of *Anaplasma marginale* organisms even when ELISA testing did not detect serological evidence of their presence (Table 1).

The declining ELISA results from day -20 to day 74 in both control and oxytetracycline-treated animals (Table 1) were unexpected and suggested a degree of non-treatment-related recovery or reversion to non-seropositive status in both groups. However, the PCR results indicated that *Anaplasma marginale* organisms were present on both day 14 and day 74. If treatment with three injections of long-acting oxytetracyline had been successful in eliminating the carrier state of *Anaplasma marginale*, PCR test results were expected to have been negative on both test dates.

Table 1. Lack of Efficacy of Treatment with Long-Acting Oxytetracycline as Indicated by Number and Percentage of Animals Still Positive for *Anaplasma marginale* on the Basis of ELISA and PCR Testing on Each Study Day

	Control		Long-Acting Oxytetracycline	
	ELISA	PCR	ELISA	PCR
Study Day	Positive (%)	Positive (%)	Positive (%)	Positive (%)
−20	5/5 (100)	5/5 (100)	29/29 (100)	29/29 (100)
14		5/5 (100)		25/28 (89)
74	2/5 (40)	5/5 (100)	16/29 (55)	25/29 (86)

NEAR INFRARED SPECTROSCOPY AS A POTENTIAL METHOD TO DETECT BOVINE RESPIRATORY DISEASE

J. T. Fox[1] and M. F. Spire[1]

Summary

Bovine respiratory disease continues to be the leading cause of illness and death loss from weaning through finishing. There is no objective method to evaluate a live animal's severity of sickness or their response to treatment. A pilot study was conducted at a commercial feedyard to evaluate the ability of near infrared spectroscopy to differentiate between cattle identified as healthy and those identified as having undifferentiated Bovine Respiratory Disease (BRD). At processing, 215 randomly selected 900 lb heifers were evaluated to determine tissue oxygen saturation (StO_2) levels. Mean ranks of the StO_2 values were 176.86 ± 5.50. One hundred cattle pulled for clinical signs of bovine respiratory disease were evaluated in the hospital. Animals were classified as: 1st pull, 2nd pull, and 3rd pull on the basis of clinical observations. First-pull animals were those having no previous history of being treated for respiratory disease and having signs of BRD, with rectal temperature at or above 104°F. Second pulls and 3rd pulls were those animals failing to respond to either a first treatment or a second treatment for BRD as evidenced by no improvement in clinical appearance or by rectal temperature remaining above 104°F. Mean StO_2 ranks were 110.42 ± 11.29, 120.08 ± 14.48, and 132.83 ± 19.00 for 1st, 2nd, and 3rd pulls, respectively. A significant difference was found between the rank of the StO_2 values in cattle at processing and those classified as 1st, 2nd, or 3rd pulls ($P<0.05$). No difference was found between the three pull classifications. Results provide the basis for further research in the evaluation of BRD with near infrared spectroscopy.

Introduction

Pulse oximetry is a technique used in human medicine as an objective measure of arterial oxygen saturation. When used in cattle, pulse oximetry has shown less arterial oxygen tension in animals with respiratory disease. Pulse oximetry has limitations because readings can be influenced by the color of the hide and placement of the probe. A similar technology, near infrared spectroscopy, uses reflected energy waves to measure tissue saturation of oxygen (StO_2). It is not limited by color of the hide or other factors that limit pulse oximetry. This paper describes results of using near infrared spectroscopy in cattle with and without clinical bovine respiratory disease.

Near infrared spectroscopy is a noninvasive technique that has many different applications in human medicine. It is commonly used to evaluate compartmental syndrome, exercise tolerance, and peripheral vascular disease. Near infrared spectroscopy uses specific, calibrated wavelengths of near infrared light to noninvasively illuminate the

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tissue underlying the skin. These wavelengths, between 650 nm and 810 nm, scatter in the tissue and are absorbed differently, depending on the amount of oxygen attached to hemoglobin in the arterioles, venules, and capillaries. Light that is not absorbed is returned as an optical signal and analyzed to produce a ratio of oxygenated hemoglobin to total hemoglobin, expressed as % StO_2. The selected wavelengths and accompanying unit algorithms quantify tissue hemoglobin dynamics. StO2 values determined with a near infrared spectroscopy system are comparable to arterial-blood-gas values obtained concurrently in the same animal when the measurement is taken directly over an artery.

Previous research showed that all cattle having a pulse oximetry reading of less than 80% at the time of presentation for bovine respiratory disease (BRD) died. This study looked at the nasal septum, vulva, scrotum, ear, tongue, and tail as sites from which to take pulse oximetry readings. The tail was the only placement on the animals that did not bring about objectionable behavior and had no adverse implications for the animals. Pulse oximetry is limited in that it is not able to take measurements through hair or measure cattle with dark skin pigmentation. Because of the many uses of near infrared spectroscopy in human medicine and because of the limitations of pulse oximetry, the hypothesis has been made that near infrared spectroscopy can be used to assess lung function in cattle.

Experimental Procedures

A total of 315 cattle were evaluated to determine percentage StO_2. Two hundred fifteen 900-pound heifers were randomly assessed at processing by using near infrared spectroscopy on the ventral aspect of the tail. Hutchinson Technology Near-Infrared Spectrometer (InSpectra™) was used with the 20 mm probe. The probe was oriented such that the tip of the probe was cranial, with light reflected dorsally into the ventral aspect of the tail and the coccygeal artery being the target of interest. One hundred cattle, which were not part of the original 215, were evaluated in the hospital by using the same technique. These animals ranged in weight from 450 pounds to approximately 750 pounds. The cattle from the hospital were assigned to three groups on the basis of feedlot records. The three groups were: 1st pull, 2nd pull, and 3rd pull. Cattle never having been identified previously with bovine respiratory disease were placed in the 1st pull group. Cattle that required treatment for BRD a second time were placed in the 2nd pull group, and cattle that had to receive a third treatment for BRD were placed in the 3rd pull group. All cattle enrolled in the study from the hospital had to meet the requirements of having a rectal temperature greater than or equal to 104°F and/or seem clinically ill according to standard treatment protocol for this particular feedyard.

Initial statistical analysis revealed that the data was not normally distributed, so ranks were assigned to the StO_2 values and these ranks were then analyzed with the mixed procedure in SAS.

Results and Discussion

Cattle at processing had a mean StO_2 rank of 176.86 ± 5.50 (Table 1), with a StO_2 range of 78 to 98. Of the 100 cattle sampled at the hospital, 51 were in the 1st pull category, 31 in the 2nd pull group, and 18 in the 3rd pull group. The mean ranks were 110.42 ± 11.29, 120.08 ± 14.48, and 132.83 ± 19.00, with StO_2 values ranging from 42 to 98, 70 to 98, and 84 to 98, respectively. A significant difference was found between the rank of the StO_2 values in cattle at processing and those classified as 1st, 2nd, or 3rd pulls ($P<0.05$). No differences were found between the three pull classifications.

BRD is the primary cause of feedlot mortality and has an enormous economic impact on the industry. According to the 1999

NAHMS study, 56.8% of all feedlot mortalities are due to respiratory disease. This study also states that 14.4% of 11.75 million cattle were treated for BRD, at a cost of $12.59 per animal, for a total of $21.3 million, for the year in which the study was conducted. There is currently no technique available that will allow producers and practitioners to objectively evaluate an animal for BRD and attempt to control these costs. Near infrared spectroscopy may give the industry the ability to make objective decisions about the management and treatment of BRD. Because of the significant difference between the ranks of cattle at processing and the cattle identified as being ill, near infrared spectroscopy may prove to be a good technique to aid in the management of BRD.

Near infrared spectroscopy can potentially be used in purchasing, sorting, and treating cattle with BRD. Cattle could be assessed at purchase to determine if there is any pre-existing lung pathology. StO_2 may also be able to detect cattle that will perform better than others in both the feedyard and the packinghouse. Near infrared spectroscopy may be able to reveal if cattle have too much existing pathology to be treated effectively or if cattle that we think are "treated out" can still benefit from antibiotic therapy. Near infrared spectroscopy has the potential to drastically affect the way BRD is managed. Using near infrared spectroscopy, producers and veterinarians may be able to make informed, objective decisions about the management of their cattle.

Table 1. Blood Oxygen Content in Different Categories of Feedlot Cattle

Item	Healthy at Receiving	Unhealthy		
		1st Pull	2nd Pull	3rd Pull
Number of cattle	215	51	31	18
StO_2 rank (± Std. Dev.)	176.86 ± 5.50[a]	110.42 ± 11.29[b]	120.08 ± 14.48[b]	132.83 ± 19.00[b]
Median (StO_2 %)	98	94	96	96
Range (StO_2 %)	78 to 98	42 to 98	70 to 98	84 to 98

[ab]Means that have different superscripts differ ($P<0.05$).

EFFECTS OF ROUND BALE FEEDING SITES ON SOIL FECAL BACTERIA AND NUTRIENT CONCENTRATIONS[1]

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Summary

An experiment was conducted over seven months (January to July 2003) to evaluate fecal bacteria and nutrient concentrations in soil surrounding round bale feeders at winter feeding sites. Six-inch soil samples were taken each month from a total of ten feeding sites, at distances of 10, 40, 70, and 100 feet from each feeder. Soil samples were taken before (January) livestock access to the sites, during (February, March, and April) the feeding period, and after (May, June, and July) cattle had been removed from the sites. Results indicate that fecal bacteria concentrations increased over the duration of feeding period and were greatest at close proximity to round bale feeders. The data suggest that environmental contamination due to fecal bacteria in the soil can occur up to 100 feet from the feeding site. For soil nutrients, the greatest increase generally occurred at 10 feet from the feeders, with few differences thereafter.

Introduction

Winter feeding sites have the potential for manure accumulation from greater animal density and mud accumulation after rainfall or snowstorms. These conditions may impact animal health and performance, as well as the environment. Often, winter feeding sites are located in areas that use streams or other waters of Kansas as their water source. Runoff, seepage, erosion, and direct access of livestock to water sources are among the means by which pollution can occur from winter feeding sites. However, both backgrounding and cow-calf producers use winter feeding sites, and do not fall into the EPA definition of a confined animal feeding operation. This does not, however, exempt producers from using management practices to prevent or reduce runoff into open water sources. Consequently, this study was designed to investigate the occurrence and concentration of bacteria and nutrients in the area surrounding round bale feeders to help producers make decisions about location of feeding sites to minimize environmental impacts.

Experimental Procedures

In 2003, a total of 10 winter feeding areas using round bale feeders, located in Riley, Washington, and Wabaunsee counties, were used. Soil samples were obtained monthly, before (January), during (February, March,

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April), and after (May, June, July) cattle were fed at each site. Twelve to fifteen 6-inch soil samples were taken and mixed within each distance of 10, 40, 70, and 100 feet surrounding each round bale feeder, at each sample date. A 6-inch sample was taken as a standard agronomic soil test measuring depth.

Subsamples of soil for fecal bacteria analysis were thoroughly mixed with sterile water or physiological saline and were subsampled for analysis of fecal coliforms, fecal *Escherichia coli* and fecal *Streptococci.* The membrane-filter technique was used for all bacteriological assays. Soil samples were also analyzed for nitrogen, sulfur, phosphorus (Bray P-1), magnesium, zinc, copper, organic matter, and dry matter, using methods from Recommended Chemical Soil Test Procedures for the North Central Region.

Data were analyzed as a completely randomized design according to the PROC MIXED procedures of SAS. Linear and quadratic polynomial contrasts were performed to determine the effects of increasing distance from the feeder on bacteria and nutrient concentrations. All bacteria and nutrient values were adjusted for dry matter before statistical analysis.

Results and Discussion

Soil Bacteria Analysis

As expected, no fecal bacteria, or only traces, were present at all distances in January, before the introduction of cattle to the feeding site (Table 1). Fecal coliforms were greater ($P<0.01$) for March, April, and May, compared with all other months, at distances of 10 and 40 feet. In addition, fecal coliform concentrations at 70 and 100 feet were greatest ($P<0.01$) for April, compared with all other sampled months, with May having greater ($P<0.04$) amounts than all other months except March. Linear increases in fecal coliforms were observed ($P<0.04$) for all months except January as samples were taken closer to the feeding site. By July, when cattle had been removed from the sites for 3 months, fecal coliform concentrations had returned to similar concentrations as in the pre-feeding period, except at 10 feet from the feeder.

Fecal *E. coli* concentrations reached their greatest concentrations of 3.67 $\log_{10}$ CFU/g and 2.25 $\log_{10}$ CFU/g in April for distances of 10 and 40 feet, respectively, and were greater ($P<0.03$) than all other months except March. At 70 and 100 feet from the feeder, fecal *E. coli* concentrations were greater ($P<0.01$) in April than all other months. A quadratic increase ($P<0.04$) was observed for fecal *E. coli* concentrations in March as distance from the feeding area decreased, whereas linear increases ($P<0.02$) occurred in the other months of the study.

At 10 feet from the feeding area, fecal *Streptococci* concentrations were greater ($P<0.01$) in March and April (4.12 $\log_{10}$ CFU/g) compared with all other months. The highest concentration at 40 feet was observed in March, and was similar to concentrations in both April and May, but was greater ($P<0.05$) than the other months. At 100 feet from the feeder, concentrations of fecal *Streptococci* reached the greatest concentration in July, and were similar to concentrations observed in April and May. There was a quadratic decrease ($P<0.02$) in fecal *Streptococci* concentrations from 10 to 100 feet in February, April and July, whereas there was a linear increase ($P<0.01$) in fecal *Streptococci* concentrations in March as distance from the feeder decreased.

Results indicate that fecal bacteria concentrations increased over duration of feeding period, and were greater at closer proximity to round bale feeders. The data suggest that envi-

ronmental contamination due to fecal bacteria in the soil can occur as much as 100 feet from the feeding site. Although bacteria levels did decrease after cattle removal from the sites, bacterial concentrations remained greater in July, when samples were taken at 10 feet from the feeders, compared with the other distances.

Soil Nutrient Analysis

Producers fed all feed and mineral supplements well outside the 100-foot range from the bale feeders. In addition, because of the producers' management practices, the type and amount of supplementation differed among sites. We do not believe, however, that feed and mineral supplementation impacted the soil-nutrient analysis data in this experiment.

The greatest concentration of soil phosphorus at 10 feet was recorded in April, the final month of feeding, and concentrations exceeded ($P<0.02$) those in January, February, and May (Table 2). Although there were changes in phosphorus concentrations observed at 10 feet from the feeder, there were no significant differences $P>0.05$) in concentrations observed at 40, 70, or 100 feet from the feeding area. There were linear increases ($P<0.02$) in soil phosphorus concentrations in March, April, June, and July as distance from the feeder decreased.

Concentration of soil nitrogen at 10 feet from the feeding area peaked in July at 70 ppm, and was greater ($P<0.01$) than in all other months except June. At 40 and 70 feet, the greatest concentration of nitrogen was in March, being greater ($P<0.03$) than concentrations in the final three months of the study when cattle had been removed from the sites. There was a quadratic increase ($P<0.02$) in nitrogen concentration in the soil in June and July as distance from the feeder decreased.

Soil sulfur concentrations at 10 and 40 feet from the feeder were greater ($P<0.05$) in March and February than in any other month at every distance in the study. Sulfur concentrations at 70 and 100 feet from the feeder were not different during the experiment. There was a quadratic increase ($P<0.01$) for March, April, June, and July, and linear increases ($P<0.04$) for February and May in soil sulfur concentrations as distance from the feeder decreased.

Soil zinc concentrations at all distances from the feeding area were greater ($P<0.02$) in July than in all other months. There were linear increases ($P<0.05$) in zinc concentrations in March, June, and July as samples were taken closer to the feeder.

Concentrations of soil copper at 10 feet from the feeding area was greatest in June, with the concentration being similar to the concentration in July, and greater ($P<0.01$) than in all other months in the study. At 40 feet from the feeder, the concentration of copper was the greatest in February, which was greater ($P<0.01$) than both January and July. Copper concentrations at 70 and 100 feet in February and April were greater ($P<0.05$) than concentrations in the pre-feeding period (January) of the study. There was a quadratic increase ($P<0.03$) in soil copper concentrations from March to July, as distance from the feeding area decreased.

For soil nutrients, the greatest increase generally occurred at 10 feet from the feeders, with few differences thereafter.

Similar concentrations of organic matter were present at 10, 40, 70 and 100 feet from the feeder in January. From February to May, the greatest concentration of organic matter was observed at 10 feet from the feeder because of a build-up of waste hay and manure. A linear increase ($P<0.02$) in organic matter

occurred in March and June as distance from the feeder decreased, whereas a quadratic increase ($P<0.02$) was seen in April.

After cattle access to the sites in February, dry matter of the soil was consistently less for samples taken at 10 feet from the feeder than for those taken at the other distances. There were quadratic decreases ($P<0.02$) in dry matter in March, April, and July as distance from the feeding area decreased, whereas linear decreases ($P<0.01$) were observed in May and June.

Producers should adopt management practices that allow for the removal of manure, wasted feed, or bedding after cattle departure from feeding sites to reduce future environmental impacts.

Table 1. Influence of Time and Distance on Soil Bacteria Concentrations from Round Bale Feeding Sites[a]

	Month[b]							
Item	1	2	3	4	5	6	7	SED
Fecal Coliforms	---------- log10 CFU/gram ----------							
10 feet	0^{c}	0.66^{cd}	3.38^{f}	3.68^{f}	3.02^{f}	1.51^{e}	0.77^{de}	0.40
40 feet	0.11^{c}	0.21^{c}	1.89^{d}	2.32^{d}	1.61^{d}	0.42^{c}	0^{c}	
70 feet	0.41^{c}	0.16^{c}	0.68^{cd}	2.38^{e}	1.40^{d}	0.40^{c}	0^{c}	
100 feet	0^{c}	0^{c}	0.47^{cd}	2.17^{e}	0.83^{d}	0^{c}	0^{c}	
Probability (P<)								
Linear	0.60	0.04	0.0001	0.004	0.0001	0.001	0.01	
Quadratic	0.05	0.50	0.03	0.07	0.20	0.19	0.04	
SED	0.12	0.21	0.31	0.45	0.36	0.30	0.19	
Fecal *E. coli*	---------- log10 CFU/gram ----------							
10 feet	0^{c}	0.45^{c}	3.36^{ef}	3.67^{f}	2.67^{e}	1.49^{d}	0.69^{c}	0.38
40 feet	0.11^{c}	0^{c}	1.73^{de}	2.25^{e}	1.40^{d}	0.41^{c}	0^{c}	
70 feet	0.11^{c}	0^{c}	0.68^{cd}	2.32^{e}	1.16^{d}	0.40^{c}	0^{c}	
100 feet	0^{c}	0^{c}	0.30^{c}	2.14^{d}	0.65^{c}	0^{c}	0^{c}	
Probability (P<)								
Linear	1.00	0.06	0.0001	0.004	0.0001	0.001	0.02	
Quadratic	0.17	0.15	0.03	0.06	0.20	0.20	0.07	
SED	0.08	0.15	0.32	0.45	0.35	0.30	0.18	
Fecal *Streptococci*	---------- log10 CFU/gram ----------							
10 feet	0.85^{c}	2.80^{d}	3.82^{e}	4.12^{e}	2.67^{d}	1.14^{c}	2.53^{d}	0.41
40 feet	0.32^{c}	1.57^{d}	2.65^{e}	2.26^{de}	1.90^{de}	0.58^{c}	1.83^{d}	
70 feet	0.36^{c}	0.83^{cd}	1.79^{e}	2.02^{e}	2.10^{e}	0.82^{cd}	1.41^{de}	
100 feet	0.17^{c}	1.11^{de}	0.97^{cde}	1.67^{ef}	1.60^{ef}	0.42^{cd}	1.93^{f}	
Probability (P<)								
Linear	0.02	0.0001	0.0001	0.0001	0.06	0.09	0.03	
Quadratic	0.35	0.004	0.42	0.01	0.69	0.73	0.01	
SED	0.22	0.28	0.23	0.27	0.39	0.33	0.31	

[a]Soil samples were taken at distances of from 10, 40, 70 and 100 feet from each round bale feeder.
[b]Month 1 = January (before feeding); Months 2 to 4 = February, March, April (feeding period); and Months 5 to 7 = May, June, July (post-feeding period).
[cdef]Means in the same row not having the same superscript letter differ (P<0.05).

Table 2. Influence of Time and Distance on Soil Nutrient Concentrations From Round Bale Feeding Sites[a]

	Month[b]							
Item	1	2	3	4	5	6	7	SED
Phosphorus, ppm								
10 feet	64[c]	66[c]	122[de]	154[e]	93[cd]	129[de]	129[de]	25
40 feet	41	83	59	63	64	53	66	
70 feet	38	39	47	58	71	45	46	
100 feet	45	48	55	53	54	39	53	
Probability (P<)								
Linear	0.39	0.27	0.02	0.003	0.15	0.01	0.02	
Quadratic	0.35	0.82	0.08	0.06	0.72	0.14	0.11	
SED	20	25	25	26	21	29	26	
Nitrogen, ppm								
10 feet	31[c]	24[c]	27[c]	9[d]	26[c]	53[e]	70[e]	9.0
40 feet	23[c]	33[cd]	48[d]	34[cd]	21[c]	22[c]	28[c]	
70 feet	30[cd]	30[cd]	47[d]	19[c]	25[c]	17[c]	26[c]	
100 feet	28	27	30	26	16	19	26	
Probability (P<)								
Linear	0.99	0.83	0.83	0.14	0.46	0.0002	0.002	
Quadratic	0.46	0.35	0.008	0.10	0.83	0.004	0.02	
SED	6.2	8.0	8.6	6.6	8.2	6.1	10.2	
Sulfur, ppm								
10 feet	12[c]	28[d]	73[f]	43[de]	37[de]	41[de]	45[e]	8.0
40 feet	6[c]	26[d]	10[c]	12[cd]	11[cd]	7[c]	9[c]	
70 feet	6	7	8	8	17	9	6	
100 feet	12	9	9	8	7	12	8	
Probability (P<)								
Linear	0.98	0.04	0.0001	0.0001	0.01	0.0003	0.001	
Quadratic	0.05	0.82	0.0003	0.0001	0.25	0.0004	0.01	
SED	4.1	8.1	8.0	4.2	6.6	5.0	6.9	
Zinc, ppm								
10 feet	4.5[c]	4.6[c]	6.4[de]	6.0[d]	5.6[cd]	5.9[d]	7.4[e]	0.65
40 feet	4.1[c]	5.0[cd]	5.3[cd]	5.6[de]	6.0[de]	5.2[cd]	6.8[e]	
70 feet	4.0[c]	4.2[cd]	5.2[cdef]	6.1[f]	5.4[def]	4.7[cde]	5.7[ef]	
100 feet	3.6[c]	4.0[cde]	4.9[def]	5.2[def]	5.2[ef]	3.9[cd]	5.9[f]	

Table 2. Continued

Probability (P<)								
Linear	0.16	0.28	0.004	0.28	0.21	0.02	0.05	
Quadratic	0.95	0.54	0.23	0.60	0.40	0.97	0.55	
SED	0.50	0.63	0.64	0.88	0.58	0.79	0.82	
Copper, ppm								
10 feet	1.35^{c}	1.46^{cd}	1.69^{d}	2.20^{e}	2.10^{e}	2.70^{f}	2.67^{f}	0.13
40 feet	1.20^{cd}	1.52^{e}	1.40^{de}	1.44^{de}	1.23^{cd}	1.43^{de}	1.15^{c}	
70 feet	1.16^{c}	1.41^{e}	1.34^{cde}	1.41^{de}	1.31^{cde}	1.39^{cde}	1.22^{cde}	
100 feet	1.14^{c}	1.44^{e}	1.38^{cde}	1.44^{e}	1.18^{cd}	1.40^{de}	1.25^{cde}	
Probability (P<)								
Linear	0.06	0.61	0.005	0.0001	0.0002	0.0001	0.0001	
Quadratic	0.39	0.88	0.03	0.0001	0.01	0.0001	0.0001	
SED	0.15	0.16	0.16	0.18	0.19	0.13	0.16	
Organic Matter, %								
10 feet	5.23^{c}	5.85^{cd}	7.18^{e}	6.37^{de}	5.97^{cde}	6.36^{de}	6.73^{de}	0.46
40 feet	5.49^{cd}	5.51^{cd}	6.03^{d}	4.69^{c}	5.54^{cd}	5.60^{d}	7.12^{e}	
70 feet	5.51^{cd}	5.23^{d}	6.16^{c}	4.76^{d}	5.29^{cd}	5.40^{cd}	6.59^{e}	
100 feet	5.44^{cd}	5.43^{cd}	5.95^{ce}	4.75^{d}	5.71^{ce}	5.12^{cd}	6.55^{e}	
Probability (P<)								
Linear	0.54	0.37	0.01	0.003	0.37	0.02	0.46	
Quadratic	0.48	0.48	0.09	0.02	0.11	0.54	0.50	
SED	0.42	0.43	0.42	0.44	0.41	0.40	0.38	
Dry Matter, %								
10 feet	83.9^{c}	79.1^{de}	77.0^{ef}	75.7^{f}	74.6^{f}	78.8^{de}	79.7^{d}	1.4
40 feet	84.1^{c}	80.3^{d}	82.4^{cd}	81.3^{d}	81.5^{cd}	81.8^{cd}	87.4^{e}	
70 feet	84.1^{c}	80.9^{d}	82.6^{cd}	81.5^{cd}	80.8^{d}	82.7^{cd}	88.0^{e}	
100 feet	83.7^{c}	81.0^{d}	83.2^{cd}	81.8^{cd}	81.6^{cd}	83.8^{c}	88.1^{e}	
Probability (P<)								
Linear	0.78	0.10	0.0003	0.0001	0.01	0.002	0.0001	
Quadratic	0.60	0.52	0.02	0.0006	0.06	0.38	0.0001	
SED	0.84	1.10	1.14	1.09	1.58	1.05	1.32	

[a]Soil samples were taken at distances of 10, 40, 70, and 100 feet from each round bale feeder.
[b]Month 1 = January (before feeding); Months 2 to 4 = February, March, April (feeding period); and Months 5 to 7 = May, June, July (post-feeding period).
[cdef]Means in the same row not have the same superscript letter differ (P<0.05).

EFFECT OF CASTRATION TIME ON FEEDLOT PERFORMANCE, CARCASS CHARACTERISTICS, AND BEEF TENDERNESS

J. W. Homm, T. T Marston, J. A. Unruh, and J. R. Brethour

Summary

Crossbred Angus calves (n=120) were randomly assigned to early-castrated, early-castrated plus implant, and late-castrated treatment groups. After weaning, calves were placed on feed at the Western Kansas Agricultural Research Station in Hays, Kansas, for finishing. On-feed weights and final weights were similar among treatments. During the first 132 days on feed, the steers castrated early and implanted had a lower average daily gain than early- and late-castration treatments. Early castrates tended (P=0.08) to have a lower feed-to-gain ratio for the first 132 days on feed. Hot carcass weight, internal fat, and marbling scores were not affected by treatment. Carcasses from steers castrated late had less backfat, larger ribeye areas, and lesser yield grades (greater cutability) than carcasses from steers castrated early, with or without an implant. Carcasses from steers castrated early and implanted had a greater percentage grading USDA choice (60%) than did carcasses from steers castrated early (45%) or late (41%). Warner-Bratzler shear force and sensory-panel traits were similar for all treatment groups.

Introduction

Cow/calf producers have several options for selling their calves. Traditionally, calves have been sold at weaning, sold after a preconditioning period, or retained through the feedlot phase. The time of castration can affect selling weight. Previous research conducted at KSU has shown that early castration plus an implant can increase weaning weights of early castrates to the same weight as late castrates. Little is known, however, about the impact of castration strategy on subsequent feedlot performance, carcass characteristics, and beef tenderness. Therefore, our objective was to determine the effect of castration time on feedlot performance, carcass characteristics, and beef tenderness attributes.

Experimental Procedures

One hundred and twenty male beef calves were randomly assigned to one of three treatments: early castration, early castration plus an implant, and late castration. Early-castrated calves were castrated at approximately 75 days of age (summer grass turnout time) and, within this group, 40 randomly selected calves received a SYNOVEX® C (Ft. Dodge) implant. The remaining 40 calves were castrated on the day of weaning (October 15, 2002) at approximately 220 days of age. Three weeks before weaning, calves were processed with FORTRESS 7® (Pfizer) and CATTLEMASTER 4® (Pfizer). At weaning, calves were given a CATTLEMASTER 4 booster injection, dewormed (DECTOMAX® pour-on, Pfizer), and weighed. After a 28-day postweaning feeding period, all steers were weighed, given a BOVISHIELD 4 injection, and shipped to the Western Kansas Agricultural Research Station in Hays, Kansas, for finishing.

After arrival, all steers were weighed, implanted with SYNOVEX® S (Ft. Dodge), and randomly placed into pens according to treatment. After 64 days on feed, steers were reweighed and reimplanted with SYNOVEX S.

Steers were harvested in two kill groups when ultrasound data showed the greatest probability of grading choice while minimizing the number of USDA yield grade 4 carcasses and before reaching a 950-pound carcass weight. The remaining cattle (second slaughter group) were marketed at the same endpoint. Steers were slaughtered at a federally inspected, commercial packing facility, where carcass characteristics were measured.

Sub-samples of 36 ribs (12 per treatment) were collected from each slaughter group for sensory and Warner-Bratzler shear force (WBSF) analysis. All ribs were aged in vacuum-packaged bags for 14 days postmortem. After aging, ribs were faced and fabricated into two 1-inch thick *longissimus* muscle steaks, starting at the posterior end. One steak was randomly assigned to WBSF and one to sensory-panel evaluation. Steaks assigned to WBSF were cooked fresh immediately after the 14-day aging period. Steaks for sensory-panel evaluation were vacuum packaged and stored at –20ºF until analysis. All steaks were cooked to an internal temperature of 158ºF in a Blodgett dual-air-flow convection gas oven. Steak temperature was monitored by using thermocouples attached to a Doric mini trend. Steaks for WBSF were then stored overnight at 37ºF, before eight 0.5-inch diameter cores were taken parallel to muscle fibers and sheared perpendicular to muscle fibers with a WBSF attachment on a Universal Instron.

Steaks for sensory-panel analysis were thawed for 24 hours at 37ºF and cooked by using the same procedures as steaks for WBSF measurements. Cooked steaks were cut into 0.5 x 0.5 inch cubes and placed in pre-heated double boilers. Sensory-panel trials were conducted in individual booths with a mixture of red and green lighting. Duplicate samples were presented to trained panelists in random order. Samples were evaluated for five sensory attributes by using an eight-point numerical scale, and were scored to the nearest 0.5. Traits assessed were: myofibrillar tenderness (1=extremely tough, 8=extremely tender), connective tissue amount (1=abundant, 8=none), overall tenderness (1=extremely tough, 8=extremely tender), juiciness (1=extremely dry, 8=extremely juicy), and beef flavor intensity (1=extremely bland, 8=extremely intense).

Feedlot performance data was analyzed as a one-way ANOVA, and differences were separated by using the Least Squares Means procedure in SAS. All carcass and WBSF data were analyzed as a completely randomized block design, with the slaughter date serving as the block. Sensory-panel data were analyzed as a completely randomized block design, with panel within a slaughter group serving as the block.

Results and Discussion

Effect of castration time on feedlot performance is presented in Table 1. During the first 132 days on feed, the steers castrated early and implanted had ($P<0.05$) poorer daily gains than the early- or late-castrated steers. The second slaughter group was left on feed for 48 days after the first slaughter group. During this period, daily gain was similar ($P>0.05$) among treatment groups. However, these gains were greater than that during the feeding period when both slaughter groups were combined. We speculate that this result was caused by slaughtering the early-maturing, slower-gaining cattle in the first slaughter group. The early-castration group tended ($P=0.08$) to have a smaller feed-to-gain ratio during the first 132 days on feed. The feed-to-gain ratio for the last 48 days on feed for the second slaughter group was smaller than for the first 132 days on feed that included both slaughter groups. Again, this may be because of slaughtering the earlier-maturing, less efficient cattle in the first slaughter group.

Effects of castration time on carcass characteristics and meat quality are presented in Table 2. Hot carcass weight, internal fat, and mar-

bling scores were not affected (P>0.05) by castration treatment. Carcasses from late-castrated steers had (P<0.05) less backfat, larger ribeyes, and lesser yield grade numbers (greater cutability) than carcasses from both early-castration groups. Even though marbling was similar (P>0.05) for all treatment groups, the carcasses from steers castrated early and implanted seemed to have the greatest percentage of USDA Choice carcasses. All sensory-panel scores and WBSF traits of carcasses were similar (P>0.05) for all castration groups.

Previous research indicated that weaning weights for intact bulls (or castrates at weaning) and early castrates having implants were similar, and greater than early castrates with no implant. The group of cattle that were castrated early and implanted had calves with the greatest dollar value at weaning, when compared with castration at weaning because of post-castration weight loss.

This research extends the previous work by following these calves through the feedlot phase. If a producer retains ownership through the feedlot, late castration may increase cutability (reduce yield grade number) by decreasing backfat and increasing ribeye area. This could be advantageous for cattle marketed on a grid that emphasizes cutability. However, cattle castrated early and implanted seemed to have the greatest percentage of USDA Choice carcasses, indicating potential benefits when marketing on a grid that emphasizes quality. Also, calves castrated early do not suffer the post-weaning weight losses caused by castration at weaning.

Table 1. Effect of Castration Time on Feedlot Performance

Item	Early Castration	Early Castration Plus Implant	Late Castration	Standard Error
On-feed weight, lb[a]	626	624	611	7.4
Final weight, lb[b]	1243	1215	1222	103.8
Feedlot daily gain, lb				
0 to 132 days on feed	3.8[d]	3.6[e]	3.8[d]	0.06
133 to 181 days on feed	4.6	4.6	4.2	0.18
Feed-to-Gain Ratio[c]				
0 to 132 days on feed	5.8	6.4	6.1	0.20
133 to 181 days on feed	5.7	5.3	5.5	0.13

[a]On-feed weights were taken on November 21, 2002.
[b]Final weights were taken before two kill dates (4/2/03 and 5/22/03).
[c]Feed is on dry matter basis.
[de]Means within a row and having different superscripts differ (P<0.05).

Table 2. Effects of Castration Time on Carcass Characteristics and Meat Quality

Item	Early Castration	Early Castration Plus Implant	Late Castration	Standard Error
Hot carcass weight, lb	775	767	768	46.9
Back fat, inches	0.67[e]	0.69[e]	0.60[d]	0.022
Ribeye area, sq. inches	12.3[d]	12.4[d]	12.8[e]	0.74
Internal fat, %	2.8	2.7	2.8	0.06
USDA Yield Grade	3.8[e]	3.7[e]	3.4[d]	0.08
Marbling[a]	40.3	40.8	39.9	1.59
USDA Choice, %	45	60	41	–
WBSF[b]	8.6	9.0	8.6	0.29
Sensory Panel[c]				
Myofibrillar Tenderness	5.7	5.8	5.8	0.09
Connective Tissue	7.0	7.0	6.9	0.06
Overall Tenderness	5.9	6.0	5.9	0.09
Juiciness	5.7	5.8	5.9	0.05
Flavor	5.9	5.9	5.9	0.04

[a]Marbling scores (30=Slight zero, 40=Small zero).

[b]Warner-Bratzler Shear Force (lbs peak force).

[c]Sensory-panel evaluations were scored on an eight-point scale; (myofibrillar and overall tenderness 1=extremely tough, 8=extremely tender; connective tissue 1=abundant, 8=none; juiciness;1=extremely dry, 8=extremely juicy; flavor, 1=abundant, 8=none).

[de]Means within a row and having different superscripts differ ($P<0.05$).

EFFECT OF FREEZING THE BEEF *LONGISSIMUS* MUSCLE ON WARNER-BRATZLER SHEAR FORCE

J. W. Homm and J. A. Unruh

Summary

Seventy-two ribeye rolls (IMPS 112) were used to compare Warner-Bratzler shear force (WBSF) from fresh steaks and previously frozen steaks. Ribeye rolls were aged (32ºF) in vacuum-packaged bags for 14 days postmortem and fabricated into 1-inch thick *longissimus* muscle (ribeye) steaks. Steaks from each ribeye roll were either cooked fresh (158ºF) or stored at –20ºF before they were thawed and cooked for WBSF determination. Sensory panel determinations were also conducted on steaks stored frozen before cooking. Previously frozen steaks had lesser WBSF values (were more tender) than fresh (not previously frozen) steaks. Sensory panel attributes of myofibrillar tenderness, connective tissue amount, and overall tenderness were negatively correlated with WBSF for both fresh (r = –0.54, –0.53, and –0.58) and frozen (r = –0.63, –0.56, and –0.62) steaks, respectively. The WBSF of fresh steaks was also correlated (r = 0.48) with the WBSF of frozen steaks.

Introduction

A commonly accepted measurement of tenderness is Warner-Bratzler shear force (WBSF). It is a common protocol in research to freeze steaks before further sensory panel and/or WBSF determinations are performed. Freezing allows for flexibility in scheduling trained panels, handling of very large sample numbers and replications, and better control of product. Another common protocol for WBSF is to conduct analysis on fresh (not previously frozen) steaks. Previous work has shown that WBSF of fresh steaks may be greater (less tender) than WBSF values of previously frozen steaks. Therefore, the objective of this study was to compare fresh aged steaks to steaks that are aged and frozen before storage.

Experimental Procedures

Seventy-two ribeye rolls (IMPS 112) obtained from a commercial packing facility were stored at 32 ± 2ºF for 14 days postmortem. Ribeye rolls were faced and fabricated into three 1-inch thick *longissimus* muscle steaks, starting at the posterior end. One steak from each ribeye roll was randomly assigned to fresh (non-frozen) WBSF, frozen WBSF, and sensory panel. Steaks assigned to fresh WBSF were immediately cooked after the 14-day aging period. All other steaks were vacuum packaged and stored at –20ºF until analysis. Frozen WBSF steaks were thawed for 24 hours at 37ºF. All fresh and frozen steaks were cooked to an internal temperature of 158ºF in a Blodgett dual-air-flow convection gas oven. Steak temperature was monitored by using a thermocouple attached to a Doric mini trend. Steaks for WBSF were then stored overnight at 37ºF. After storage, eight 0.5-inch diameter cores were taken parallel to muscle fibers and sheared perpendicular to muscle fibers by a Universal Instron with a WBSF attachment.

Sensory-panel steaks were thawed and cooked by using the same procedures as for the WBSF steaks. Cooked steaks were cut into 0.5- × 0.5-inch cubes and placed in pre-heated double boilers. Sensory panels were con-

ducted in individual booths with a mixture of red and green lighting. Duplicate samples were presented to a minimum of six trained panelists in a random order. Samples were evaluated for six sensory attributes according to an eight-point numerical scale and were scored to the nearest 0.5. Traits assessed were: myofibrillar tenderness (1 = extremely tough, 8 = extremely tender), juiciness (1 = extremely dry, 8 = extremely juicy), beef-flavor intensity (1 = extremely bland, 8 = extremely intense), connective-tissue amount (1 = abundant, 8 = none), overall tenderness (1 = extremely tough, 8 = extremely tender), and off-flavor intensity (1 = abundant, 8 = none).

All data were analyzed as a randomized complete block design with ribs serving as the block. Means were separated by the least significant differences procedure in SAS.

Results and Discussion

Previously frozen steaks had lesser ($P<0.05$, standard error = 0.17) WBSF values than fresh steaks (Table 1). The improved tenderness that occurred during freezing may be attributed to ice crystal formation causing muscle fibers to rupture, connective tissue to extend, and/or some proteolysis. All steaks were evaluated as slightly tender (score of 5) or better by the sensory panel. Sensory-panel scores for tenderness attributes of myofibrillar tenderness, connective tissue amount, and overall tenderness were negatively correlated with WBSF for both fresh and frozen steaks (Table 2). Fresh WBSF values were correlated ($r = 0.48$) with those from previously frozen steaks, but both were more closely correlated with sensory panel tenderness. Steaks that were previously frozen seemed to have similar, to slightly greater, correlations for myofibrillar tenderness (–0.63 vs. –0.54), connective tissue (–0.56 vs. –0.53), and overall tenderness (–0.62 vs. –0.58) compared with fresh steaks, respectively. The regression for sensory-panel scores for overall tenderness compared with WBSF of fresh and previously frozen steaks are presented in Figures 1 and 2. The relationship between overall sensory panel scores for tenderness and WBSF from fresh and previously frozen steaks seems similar, with a regression coefficient (R^2) of 0.36 and 0.39, respectively. However, WBSF means are greater for fresh steaks than for previously frozen steaks.

The relationship between sensory-panel scores for tenderness and WBSF from fresh steaks or frozen steaks seems similar. This indicates that using WBSF values from fresh or previously frozen steaks would be equally effective in predicting tenderness in beef *longissimus* steaks. Warner-Bratzler shear force values from fresh steaks, however, were significantly greater than WBSF values from frozen steaks. Therefore, researchers should be equally confident in WBSF results from fresh or previously frozen steaks when determining treatment differences in tenderness, but need to be aware that overall means may differ because of storage procedures.

Table 1. Descriptive Statistics for Warner-Bratzler Shear Force (WBSF) and Sensory Panel Evaluations of *Longissimus* Muscle Steaks

Item	Mean	SD[a]	Minimum	Maximum
WBSF (lbs)				
Fresh[b]	8.7	2.00	4.7	18.4
Frozen[c]	8.1	2.08	3.7	17.6
Sensory Panel[d]				
Myofibrillar Tenderness	5.7	0.36	5.2	6.3
Connective Tissue Amount	7.0	0.30	6.1	7.5
Overall Tenderness	6.0	0.41	5.1	7.1
Juiciness	5.8	0.29	5.2	6.6
Flavor	5.9	0.21	5.3	6.4

[a]Standard deviation.
[b]Steaks were cooked at 14 days postmortem.
[c]Steaks were frozen at 14 days postmortem.
[d]Sensory-panel scores were evaluated on an eight-point scale; (myofibrillar and overall tenderness 1 = extremely tough, 8 = extremely tender; connective tissue 1 = abundant, 8 = none; juiciness 1 = extremely dry, 8 = extremely juicy; flavor, 1 = abundant, 8 = none).

Table 2. Correlations between Warner-Bratzler Shear Force (WBSF) and Sensory Panel Attributes

Item	Fresh WBSF[a]	Frozen WBSF[b]	MT[c]	CT[d]	OT[e]	Juiciness
Frozen WBSF[b]	0.48*					
Myofibrillar Tenderness	–0.54*	–0.63*				
Connective Tissue	–0.53*	–0.56*	0.68*			
Overall Tenderness	–0.58*	–0.62*	0.95*	0.79*		
Juiciness	–0.07	–0.19	0.43*	0.26*	0.43*	
Flavor Intensity	0.07	–0.06	0.15	0.10	0.13	0.46*

[a]Steaks cooked and sheared at 14 days postmortem.
[b]Steaks frozen at 14 days postmortem.
[c]Myofibrillar tenderness.
[d]Connective tissue amount.
[e]Overall tenderness.
*$P<0.05$.

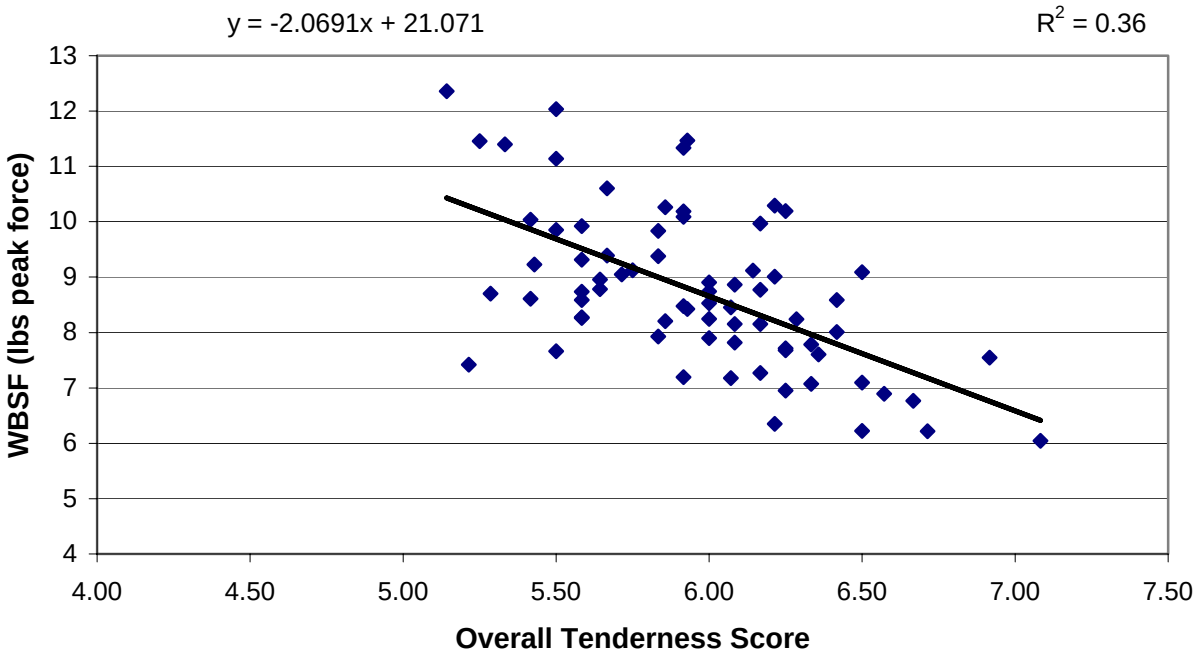

Figure 1. Warner-Bratzler Shear Force (WBSF) and Sensory-Panel Overall Tenderness Scores for Fresh *Longissimus* Muscle Steaks.

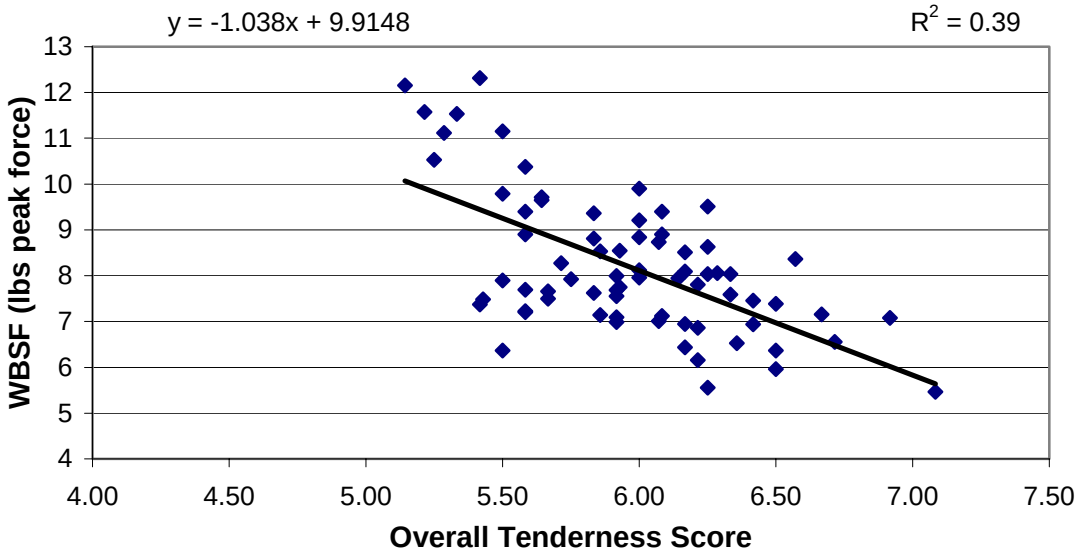

Figure 2. Warner-Bratzler Shear Force (WBSF) versus Sensory-Panel Overall Tenderness Scores for Frozen *Longissimus* Muscle Steaks.

Cattlemen's Day 2004

ENDPOINT TEMPERATURE, COOKING METHOD, AND MARBLING DEGREE HAVE DIFFERENT EFFECTS ON WARNER-BRATZLER SHEAR FORCE OF BEEF STRIP LOIN, BOTTOM ROUND, AND BRISKET MUSCLES

E. Obuz, J. W. Stephens, M. E. Dikeman, J. P. Grobbel, and T. M. Loughin

Summary

Our objective was to determine the effects of endpoint temperature, cooking method, and marbling on Warner-Bratzler shear force (WBSF; an objective method for determining tenderness) of three beef muscles. Eighteen subprimals of a muscle containing low content of connective tissue, *longissimus lumborum* (strip loin), and two muscles containing a high content of connective tissue, *biceps femoris* (bottom round) and *deep pectoralis* (brisket), were selected from USDA Select and Choice (Certified Angus Beef) carcasses. After 14 days of aging, subprimals were frozen, fabricated into steaks, and stored frozen until cooking. Steaks were assigned to one of two cooking methods, the Magikitch'n® electric belt grill (a rapid conduction method) or a water bath (a slower, convection method); and one of nine endpoint cooking temperatures, 104, 113, 122, 131, 140, 149, 158, 167, or 176°F. According to WBSF results, optimum tenderness for the strip loin occurred around 131°F. Higher marbling protected tenderness at higher endpoint temperatures. Tenderness increased in bottom round and brisket muscles as endpoint temperature increased from 104 to 140°F, then tenderness decreased as endpoint temperature rose from 149 to 176°F. Endpoint temperature was the only significant factor affecting bottom round tenderness. Steaks cooked in the water bath had higher WBSF and, therefore, were less tender than those cooked on the belt grill. This was true for both the strip loin and brisket. The effect of increasing endpoint temperature on WBSF of the strip loin was different than for the bottom round and brisket.

Introduction

Tenderness is the most important beef palatability attribute, and the effects of cooking temperature and method on tenderness are important to both meat researchers and consumers. It is generally known that meat toughens when it is cooked to higher endpoint temperatures, but interactions with cooking method and marbling score can have an effect on the rate of toughening. Because of different amounts of connective tissue, different muscles are affected by endpoint temperature, cooking method, and marbling differently. Therefore, our objective was to evaluate the effects of endpoint temperature, cooking method, and marbling on Warner-Bratzler shear force (WBSF; an objective measure of tenderness) of three beef muscles. The muscles studied were the *longissimus lumborum* (strip loin), a muscle containing a low content of connective tissue, and the *biceps femoris* (bottom round roast) and *deep pectoralis* (brisket), muscles that contain a high content of connective tissue.

Experimental Procedures

Eighteen subprimals (boneless strip loin, bottom round, and brisket) from USDA Select (low marbling score) and Choice (high marbling score; Certified Angus Beef) carcasses were purchased and divided into the respective muscles. Muscles were vacuum packaged

and held at 34°F for 14 days and then frozen (-35°F). Each frozen muscle was sawed into 1-inch-thick steaks, vacuum packaged, and stored frozen until cooking. Steaks were thawed at 39°F before cooking. Steaks were randomized into one of two cooking treatments, a Magikitch'n® electric belt grill at 199°F (rapid, conduction cooking) or a water bath at 199°F (slower, convection cooking), and one of nine endpoint temperatures: 104, 113, 122, 131, 140, 149, 158, 167, or 176°F. The center temperatures of steaks were monitored by using copper-constantan thermocouples. Cooked steaks were then refrigerated overnight at 34°F. Six cores were removed parallel to the muscle fiber direction from each steak, and WBSF was measured by using an Instron® Universal testing machine.

Results

Strip Loin. Figure 1 shows the effects of endpoint temperature and quality grade on WBSF of strip loin steaks for the two cooking methods. Strip loin steaks cooked by the slower, convection, water-bath method had greater WBSF ($P<0.0001$) values (tougher) than those cooked on the more rapid, conduction, belt-grill method. The combination of low marbling score (USDA Select) and cooking to higher endpoint temperatures resulted in higher ($P<0.05$) WBSF (tougher steaks) than high marbling score and cooking to lower endpoint temperatures.

Bottom Round. Two distinct phases of tenderization/toughening occurred for bottom round steaks as endpoint cooking temperature increased. Between 104 and 140°F, WBSF decreased, whereas between 140 and 158°F, WBSF increased (Figure 3). There were no differences ($P>0.05$) in WBSF among bottom round steaks that were due to quality grade or cooking method.

Brisket. Values of WBSF for brisket steaks decreased (became more tender) as endpoint temperature increased from 113 to 149°F (Figure 4). This was followed by an increasing WBSF trend between 149 and 176°F. As with the strip loin steaks, water-bath cookery resulted in greater ($P=0.0001$) WBSF than belt-grill cookery. Quality grade did not have a significant effect on WBSF of brisket steaks.

Discussion

Endpoint temperature and cooking method were more important factors than quality grade for WBSF of the three muscles studied, and quality grade was significant only in the strip loin. Other researchers have reported a distinct toughening trend between 104 and 122°F, but we did not observe this trend. We did, however, observe an increasing trend for WBSF for all three muscles between 149 and 176°F, but this increase was not as steep as that reported in previous research.

Our results suggest that optimum tenderness (lowest WBSF) for the strip loin occurs around 131°F (very rare), and optimum tenderness for the bottom round and brisket occur at 140 and 149°F, respectively. USDA Choice strip loin steaks were less affected by increasing endpoint temperatures than their Select counterparts, suggesting a protection of tenderness with the greater amounts of marbling in this low connective tissue muscle. More rapid cookery on the belt grill resulted in lower WBSF (more tender) than the slower, convection, water-bath cooking for strip loin and brisket steaks. The effects of increasing endpoint temperature on WBSF of muscle containing a low content of connective tissue (strip loin) were different from those of muscles containing greater amounts of connective tissue (bottom round and brisket). Endpoint temperature and cooking method had a greater effect on WBSF than did quality grade, especially in muscles with a high content of connective tissue.

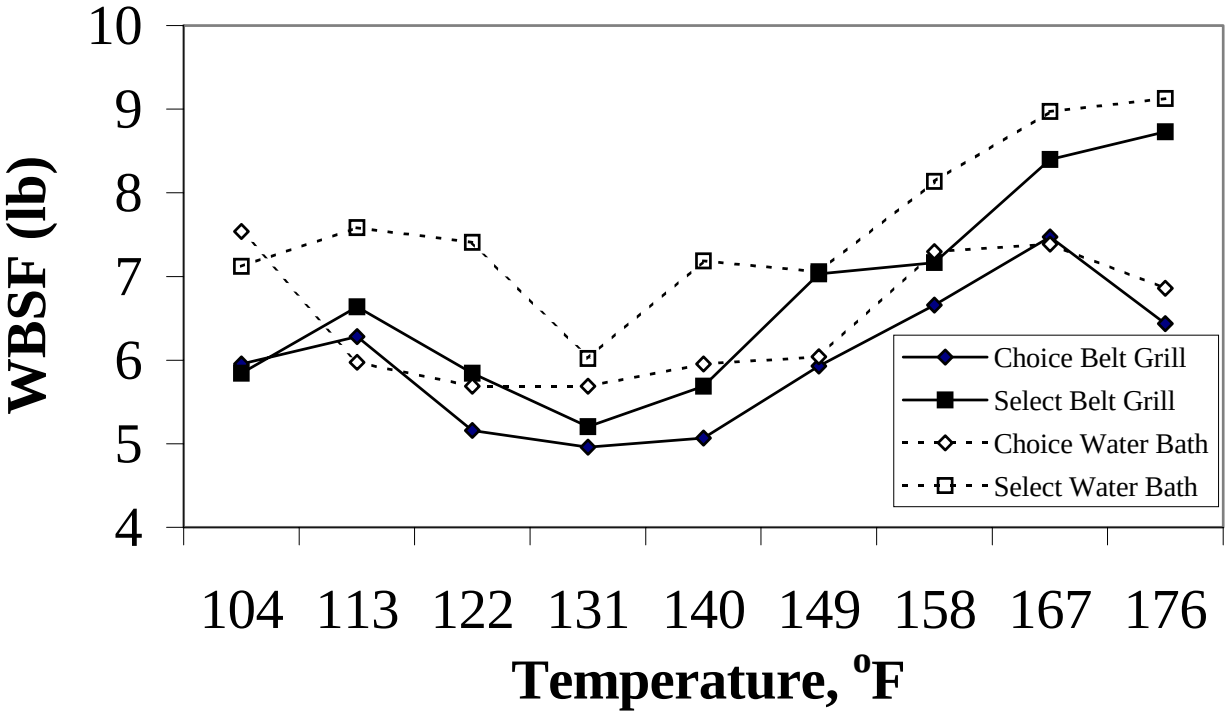

Figure 1. Effects of Endpoint Temperature and Quality Grade on Warner-Bratzler Shear Force (WBSF) of Strip Loin Steaks Cooked on the Belt Grill or in the Water Bath.

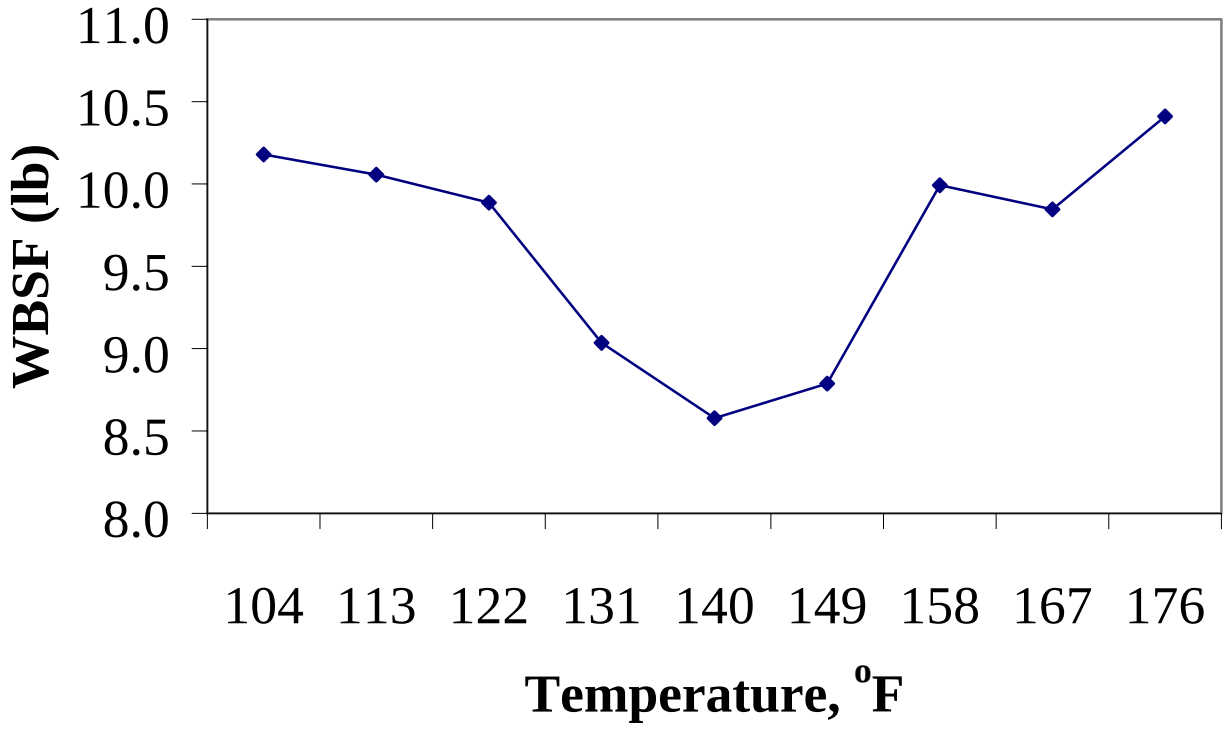

Figure 2. Effects of Endpoint Temperature on Warner-Bratzler Shear Force (WBSF) of Bottom Round Steaks.

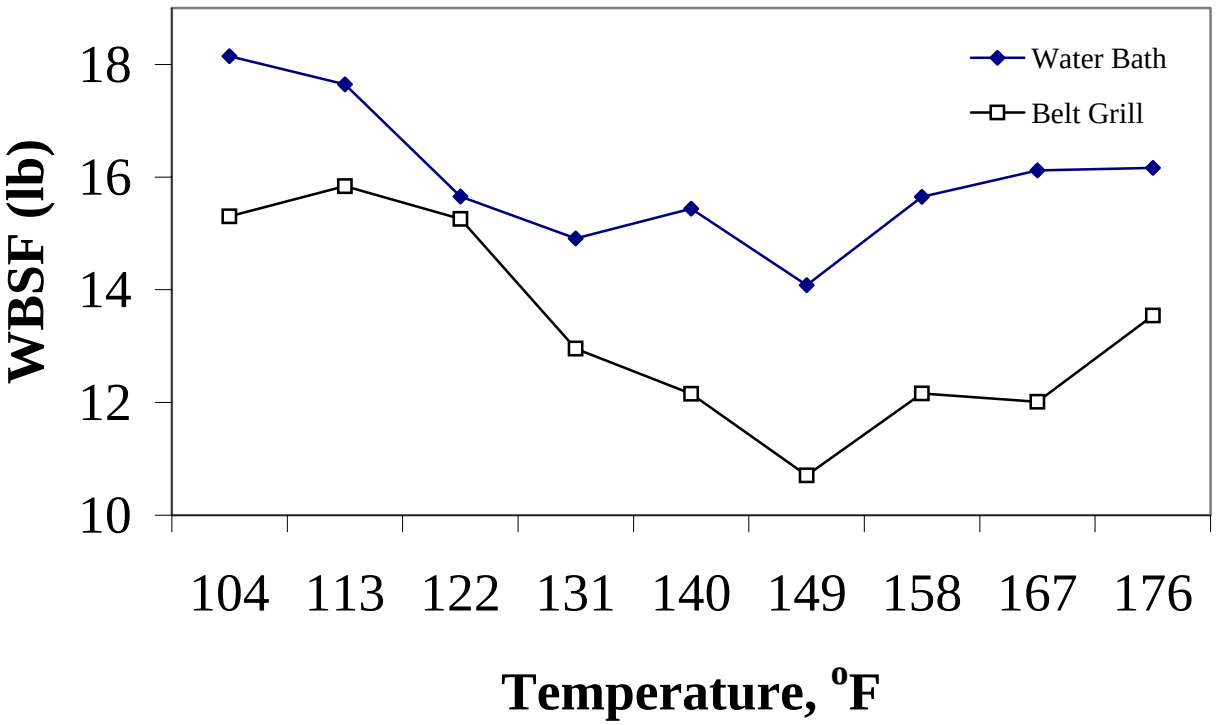

Figure 3. Effects of Endpoint Temperature on Warner-Bratzler Shear Force (WBSF) of Brisket Steaks Cooked in the Water Bath or on the Belt Grill.

Cattlemen's Day 2004

RELATIONSHIP OF WARNER-BRATZLER SHEAR FORCE AND TRAINED SENSORY PANEL TENDERNESS OF STRIP LOIN STEAKS COOKED TO 131 AND 158°F

J. W. Stephens, E. Obuz, M. E. Dikeman, and J. P. Grobbel

Summary

In a previous study, eighteen strip loins from USDA Select and premium Choice carcasses were cooked on a Magikitch'n® belt grill to determine tenderness at nine different endpoint temperatures. That study revealed that optimum Warner-Bratzler shear force (WBSF) values occurred in strip loin steaks cooked to 131°F, but current WBSF protocol requires steaks to be cooked to 158°F. Therefore, trials employing trained sensory panels (TSP) were conducted to determine the relationship of WBSF with TSP tenderness from steaks cooked to 131 and 158°F on the belt grill. As expected, panelists found steaks cooked to 131°F more tender than those cooked to 158°F. The relationship of WBSF with TSP ratings for tenderness was not significant ($P>0.05$) when both steaks were cooked to 158°F. When both steaks were cooked to 131°F, however, there was a moderate relationship ($r = -0.52$) of WBSF with TSP tenderness. The relationship of WBSF from steaks cooked to 131°F with TSP ratings for tenderness from steaks cooked to 158°F was the strongest ($r = -0.66$). More research is needed to determine the feasibility of cooking steaks to 131°F, rather than 158°F, to improve WBSF determination.

Introduction

Determining tenderness of steaks is important to beef research. Studies in genetics, nutrition, management, and meat science all depend on accurate tenderness measurement. The most popular and efficient method for determining beef tenderness is the Warner-Bratzler shear force (WBSF), in which greater force indicates tougher steaks. Another popular method for determining tenderness is by trained sensory panel (TSP) evaluation, but this method is costly and time consuming when a large number of samples need to be evaluated. Therefore, it is pertinent to ensure that WBSF determinations and TSP values are closely related.

In a previous study, we cooked strip loin steaks to nine different endpoint temperatures on a belt grill for WBSF determination. The minimum WBSF for strip loin steaks occurred at an endpoint temperature of 131°F. Nevertheless, current research protocols to evaluate tenderness require steaks to be cooked to 158°F for WBSF and TSP determinations. The higher endpoint temperature has the potential to decrease mean tenderness and increase the variation in steak tenderness. Our objective was to determine the correlation between WBSF and TSP values of strip loin steaks cooked on a belt grill to 131°F or 158°F.

Experimental Procedures

Eighteen wholesale beef strip loins (*longissimus lumborum*) from USDA Select and Choice (Certified Angus Beef) carcasses were purchased and transported to the Kansas State University meat laboratory. The meat was aged at 34°F until 14 days postmortem and then frozen at -35°F. One-inch thick steaks

were cut on the band saw, vacuum packaged, and stored frozen until cooking.

After thawing overnight at 39°F, steaks were cooked on a Magikitch'n® belt grill to one of nine endpoint temperatures (104, 113, 122, 131, 140, 149, 158, 167, or 176°F). Cooked steaks were then refrigerated at 34°F overnight before six 0.5-in cores were taken parallel to the muscle fibers and sheared once with the Warner-Bratzler shear attachment on an Instron Universal Testing Machine. The WBSF peak-force measurements from steaks cooked on the electric belt grill to 131 or 158°F were used in the current study.

Steaks prepared for tenderness determination by TSP were randomly allotted to endpoint temperatures of 131 or 158°F. After thawing overnight at 39°F, steaks were cooked on a Magikitch'n® belt grill set at 199°F. Two cubes from each steak were served to a six-member TSP and were scored on an eight-point scale for tenderness (1=extremely tough and 8=extremely tender).

Results

Steaks cooked to 131°F had lower WBSF values and greater TSP tenderness scores than those cooked to 158°F (Table 1). Moreover, steaks cooked to 131°F had a smaller standard deviation for both WBSF and TSP tenderness scores.

Steaks from USDA Select carcasses were tougher ($P<0.05$) than USDA Choice steaks according to the trained sensory panel determinations. Nevertheless, WBSF scores were not significantly different ($P>0.05$) for the two quality grades (Table 2).

The correlation coefficients of WBSF values and TSP scores for steaks cooked to 131 and 158°F are presented in Table 3. The relationship between WBSF values from steaks cooked to 158°F and TSP scores for steaks cooked to 158°F was not significant ($P>0.05$). However, the relationship of WBSF values from steaks cooked to 131°F were significantly correlated with TSP scores of steaks cooked to 131 and 158°F ($r = -0.52$ and -0.66, respectively). The TSP scores of steaks cooked to 131°F were moderately well correlated with the TSP scores from steaks cooked to 158°F ($r = 0.60$). However, the WBSF values of steaks cooked to 131°F and those cooked to 158°F were not significantly related ($P>0.05$).

Discussion

In a previous study, we found that WBSF values of strip loin steaks cooked to 131°F were lowest and had a smaller standard deviation than those from steaks cooked to 158°F.

As with WBSF, trained sensory panelists found steaks cooked to 131°F to be more tender than those cooked to 158°F. The standard deviation was lower for steaks cooked to 131°F. Lower endpoint temperatures require less cooking time and less opportunity for variation to be introduced during the cooking process.

Our study indicated that the relationship between WBSF and TSP tenderness was not significant when steaks had been cooked to 158°F. Researchers have found that the relationship between WBSF and ratings of TSP tenderness ranges from non-significant to well related ($r = -0.90$). Our steaks were cooked on a belt grill. The belt grill is a relatively new cooking method and has been proven to be less variable in WBSF values than the forced-air convection oven or open-air electric grill.

We also found that there was a significant relationship between WBSF and TSP ratings of tenderness when steaks were cooked to 131°F. Moreover, the relationship of WBSF from steaks cooked to 131°F with TSP scores for steaks cooked to 158°F was stronger. The

lower endpoint temperature created less variation in the WBSF measurement, and panelists are more familiar with the flavor and texture of steaks cooked to 158°F. Therefore, it is recommended that more research be conducted to investigate the relationship between WBSF values from steaks cooked to 131°F and TSP scores.

Table 1. Warner-Bratzler Shear Force and Trained Sensory Panel (TSP) Scores for the Tenderness of Strip Loin Steaks Cooked to 131 and 158°F*

	Mean	SD	Min	Max	n
Warner-Bratzler shear force (lb)					
131°F	5.43[a]	1.19	3.53	9.15	23
158°F	7.19[b]	1.34	4.95	9.58	26
Trained sensory panel tenderness[c]					
131°F	6.19[a]	0.58	4.67	7.00	29
158°F	5.54[b]	0.76	3.92	7.17	26

*Mean, standard deviation (SD), minimum (min.), and maximum (max.) values and number of observations (n).
[a,b]Means differ between temperatures ($P<0.05$).
[c](1=extremely tough; 8=extremely tender).

Table 2. Mean Values for Warner Bratzler Shear Force and Trained Sensory Panel Scores for the Tenderness of Strip Loin Steaks from USDA Choice and Select Carcasses

	Choice	Select
Warner-Bratzler shear force (lb)	6.09	6.57
Trained sensory panel tenderness[c]	6.20[a]	5.60[b]

[a,b]Means within a row differ ($P<0.05$).
[c](1=extremely tough; 8=extremely tender).

Table 3. Correlation between Trained Sensory Panel (TSP) Scores for the Overall Tenderness of Strip Loin Steaks and Warner-Bratzler Shear Force (WBSF) Values*

	TSP 158°F	WBSF 131°F	WBSF 158°F
TSP 131°F	0.60[a] (21)	-0.52[a] (22)	-0.03 (22)
TSP 158°F		-0.66[a] (16)	-0.37 (19)
WBSF 131°F			0.06 (17)

*Coefficients and number of comparisons (in parentheses) from steaks cooked to 131 and 158°F.
[a]$P < 0.05$.

RELATIONSHIP OF TOTAL IRON CONTENT IN BEEF TO FLAVOR ATTRIBUTES[1]

J. P. Grobbel, M. E. Dikeman, G. A. Milliken[2], E. J. Yancey[3]

Summary

The objective of our study was to evaluate the relationships among total iron content, myoglobin/total iron ratio, hemoglobin/total iron ratio, and flavor attributes in beef top sirloin, shoulder clod, and tenderloin muscles. Top sirloin (n=74), shoulder clod (n=68), and tenderloin (n=73) muscles from A or B maturity carcasses that were either USDA Slight or USDA Small marbling and of either normal pH ($\leq$5.7) or high pH (>6.0) were vacuum packaged, aged 35 days at 35ºF, and stored at -4ºF until analysis. A well trained, flavor-profile sensory panel determined flavor attributes on charbroiled steaks. Flavor attributes included beef flavor identification, bloody/serumy, brown roasted, livery, metallic, rancid, and sour. Concentrations of myoglobin and hemoglobin were determined by using high-pressure liquid chromatography. Total iron concentration was determined by using an atomic absorption spectrophotometer. The shoulder clod had greater total iron (P<0.05) than the top sirloin or tenderloin. Livery flavor increased (P<0.05) and beef flavor identification and brown roasted flavor decreased (P<0.05) in the top sirloin as total iron increased. Compared with the top sirloin and shoulder clod, the tenderloin had lower (P<0.05) myoglobin/total iron ratios and greater (P<0.05) hemoglobin/total iron ratios. At medium and high myoglobin/total iron ratios, samples with Slight marbling had more (P<0.05) livery flavor. At low myoglobin/total iron ratios, A-maturity samples had more (P<0.05) rancid off-flavor than B maturity samples. There were no relationships between hemoglobin/total iron ratios and flavor attributes. Total iron may contribute to livery flavor in the top sirloin, but total iron is not a reliable indicator of livery flavor.

Introduction

Livery flavor has been cited as a problem in beef top loin and tenderloin steaks by steak purveyors. The true cause of livery flavor is not completely understood. Previous research has found positive correlations (P<0.05) between myoglobin concentrations and livery flavor within the top sirloin, shoulder clod, and tenderloin. Although statistically significant, these correlations were somewhat small, and it may be that total iron may be related to livery flavor. Iron content in beef is relatively high and is greater in muscles in which livery flavor seems to be more prevalent. The objective of our study was to evaluate the relationships among total iron content, myoglo-

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

[2]Department of Statistics.
[3]Tyson Foods, Springdale, Arkansas.

bin/total iron ratio, hemoglobin/total iron ratio, and flavor attributes in beef top sirloin, shoulder clod, and tenderloin muscles.

Experimental Procedures

Samples. Top sirloin (n=74), shoulder clod (n=68), and tenderloin (n=73) muscles from either A- or B-maturity carcasses that were either USDA Slight^{00} to Slight^{50} (Select^{-}) or USDA Small^{00} to Modest^{00} (Choice^{-}) marbling and of normal pH ($\leq$5.7) or high pH ($\geq$6.0) were collected from two different commercial abattoirs at six different times. Samples were aged for 35 days at 35ºF in a vacuum package and then stored frozen (-4ºF) until analyses were completed.

Flavor Attributes. A well-trained, flavor-profile sensory panel evaluated charbroiled steaks for beef flavor identification, bloody/serumy, brown roasted, livery, metallic, rancid, and sour flavors.

Myoglobin and Hemoglobin Concentrations. High-pressure liquid chromatography was used to determine myoglobin and hemoglobin concentrations.

Total Iron Content. Duplicate 3.0- to 3.5-g, pulverized samples were weighed into ceramic crucibles and then ashed in a muffle furnace (model 85A, Neytech, Bloomfield, CT) at 1,112ºF for 4 hours. Samples were cooled to 68ºF and digested with 2.5N HCl for 50 minutes. Digested samples were diluted to 50 ml with distilled, deionized water and mixed. An atomic absorption spectrophotometer (AAnalyst 100, Perken Elmer, Norwalk, CT) was used to measure sample absorbance at 248.3 nm. Comparisons were made to a standard curve using 0, 1, 2, 5, and 10 ppm of iron to determine total iron content.

Statistical Analysis. The PROC MIXED procedure of SAS was used to analyze the data as a 3 x 2 x 2 x 2 factorial design with three muscles (top sirloin, shoulder clod, and tenderloin), two maturities (A and B), 2 pH levels ($\leq$5.7 and $\geq$6.0), and 2 marbling groups (USDA marbling scores of Slight^{00} to Slight^{50} (Select^{-}) and Small^{00} to Modest^{00} (Choice^{-})).

Results and Discussion

The shoulder clod had greater total iron ($P<0.05$) than the top sirloin or tenderloin (Table 1). Livery flavor increased ($P<0.05$, Table 2) and beef flavor identification (Table 3) and brown roasted flavor (Table 4) decreased ($P<0.05$) in the top sirloin as total iron increased. Compared with the top sirloin and shoulder clod, the tenderloin had lower ($P<0.05$) myoglobin/total iron ratios (Table 5) and higher ($P<0.05$) hemoglobin/total iron ratios (Table 6). At medium and high myoglobin/total iron ratios, samples with Slight marbling had more ($P<0.05$) livery flavor than those with Small marbling (Table 7). At low myoglobin/total iron ratios, A-maturity samples had more ($P<0.05$) rancid off-flavor than B maturity samples (Table 8). There were no relationships between hemoglobin/total iron ratios and flavor attributes. Total iron may contribute to livery flavor in the top sirloin muscle, but total iron is not a reliable indicator of livery flavor.

Table 1. Total Iron Concentration of Muscles

Muscle	Total Iron (ppm)	Standard Error
Top sirloin	21.39[a]	0.56
Shoulder clod	22.78[b]	0.58
Tenderloin	20.97[a]	0.60

[a,b]Means that have a different superscript differ (P<0.05).

Table 2. Livery Flavor for Different Levels of Total Iron

Muscle	Total Iron Level	Livery Flavor[a]	Standard Error
Top sirloin	Low	0.1[b]	0.13
Shoulder clod	Low	0.4[bc]	0.35
Tenderloin	Low	0.5[c]	0.47
Top sirloin	Medium	0.4[c]	0.06
Shoulder clod	Medium	0.3[c]	0.07
Tenderloin	Medium	0.3[c]	0.31
Top sirloin	High	0.6[c]	0.63
Shoulder clod	High	0.2[b]	0.15
Tenderloin	High	0.1[b]	0.10

[a]Scale for livery flavor (1=least intense, 15=most intense).
[b,c]Means having the same value for total iron and not having the same superscript letter differ (P<0.05).

Table 3. Beef Flavor Identification For Difference Levels of Total Iron

Muscle	Total Iron Levels	Beef Flavor Identification[a]	Standard Error
Top sirloin	Low	10.4[b]	0.13
Shoulder clod	Low	9.6[c]	0.16
Tenderloin	Low	10.2[b]	0.09
Top sirloin	Medium	10.0[c]	0.07
Shoulder clod	Medium	9.7[d]	0.07
Tenderloin	Medium	10.2[b]	0.06
Top sirloin	High	9.4[c]	0.17
Shoulder clod	High	9.9[b]	0.13
Tenderloin	High	10.2[b]	0.12

[a]Scale for beef flavor identification (1=least intense, 15=most intense).
[b,c,d]Means having the same value for total iron and not having the same superscript letter differ ($P<0.05$).

Table 4. Brown Roasted Flavor for Different Amounts of Total Iron

Muscle	Total Iron Level	Brown Roasted Flavor[a]	Standard Error
Top sirloin	Low	10.4[b]	0.14
Shoulder clod	Low	9.5[d]	0.16
Tenderloin	Low	10.0[c]	0.09
Top sirloin	Medium	10.1[c]	0.07
Shoulder clod	Medium	9.7[b]	0.07
Tenderloin	Medium	10.1[c]	0.05
Top sirloin	High	9.7[c]	0.17
Shoulder clod	High	9.9[bc]	0.13
Tenderloin	High	10.1[b]	0.12

[a]Scale for brown roasted flavor (1=least intense, 15=most intense).
[b,c,d]Means having the same value for total iron and not having the same superscript letter differ ($P<0.05$).

Table 5. Myoglobin/Total Iron Ratios

Muscle	Myoglobin/Total Iron	Standard Error
Top sirloin	0.183[b]	0.01
Shoulder clod	0.179[b]	0.01
Tenderloin	0.145[a]	0.01

[a,b]Means that have different superscripts differ (P<0.05).

Table 6. Hemoglobin/Total Iron Ratios

Muscle	Hemoglobin/Total Iron	Standard Error
Top sirloin	0.039[a]	0.002
Shoulder clod	0.043[a]	0.003
Tenderloin	0.067[b]	0.005

[a,b]Means that have different superscripts differ (P<0.05).

Table 7. Livery Flavor for Different Levels of Myoglobin/Total Iron

Marbling[1]	Myoglobin/Total Iron	Livery Flavor[a]	Standard Error
Select	Low	0.29[b]	0.07
Choice	Low	0.19[b]	0.07
Select	Medium	0.42[b]	0.06
Choice	Medium	0.20[c]	0.06
Select	High	0.55[b]	0.07
Choice	High	0.22[c]	0.07

[a]Scale for livery flavor (1=least intense, 15=most intense).
[b,c]Means having the same myoglobin/total iron and having different superscripts differ (P<0.05).

Table 8. Rancid Flavor for Different Levels of Myoglobin/Total Iron

Maturity[1]	Myoglobin/Total Iron	Rancid Flavor[a]	Standard Error
A	Low	0.58[b]	0.06
B	Low	0.33[c]	0.07
A	Medium	0.49[b]	0.05
B	Medium	0.37[b]	0.06
A	High	0.41[b]	0.06
B	High	0.42[b]	0.06

[a]Scale for rancid flavor (1=least intense, 15=most intense).
[b]Means having the same myoglobin/total iron and having different superscripts differ (P<0.05).

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 C the probability exceeds 95% that the difference is true and was caused by the treatment.

Some papers report correlations C 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 B1. 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.

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