EVALUATION OF ANIMAL WELFARE ISSUES IN THE BEEF INDUSTRY

by

MARGARET ERYAN STEPHENS

B.S., Kansas State University, 2012

A THESIS

submitted in partial fulfillment of the requirements for the degree

MASTER OF SCIENCE

Department of Biomedical Science
College of Veterinary Medicine

KANSAS STATE UNIVERSITY
Manhattan, Kansas

2015

Approved by:

Major Professor
Daniel Thomson

Abstract

Two studies were conducted to evaluate two animal welfare issues in the beef industry today. The welfare of animals has become a major discussion among consumers and producers. The objective of these studies was to evaluate if certain production practices are beneficial to the wellbeing of the animals in a production setting.

The first study evaluated if castration and implementation of growth promotion technologies of physically mature male beef cattle, which failed the breed soundness exam (BSE), improved carcass quality compared to male beef cattle left intact. Sixteen month old Angus bulls (n = 24; 606 $\pm$ 11.4 kg) were stratified by weight and randomly assigned to 2 treatments: intact control (BULL) and castrated with growth promotion technology (STR) to evaluate performance and carcass quality. Cattle assigned to STR treatment were implanted with 120 mg trenbolone acetate (TBA) and 24 mg estradiol on d 0, and were fed ractopamine hydrochloride (300 mg/d) the final 28 d prior to slaughter. Cattle were fed a dry-rolled corn-based finishing diet (1.41 Mcal/kg NEg) for 62 d (final wt = 697 +/- 24.3 kg) then harvested at a commercial abattoir. Carcass characteristics were recorded and longissimus muscle samples were obtained. There were no differences between treatments for quality grade, yield grade, HCW, back fat thickness, or dressing percent. Steak tenderness values based on Warner Bratzler shear force (WBSF), and sensory panel evaluation showed no difference between BULL and STR steaks in myofibrillar tenderness, juiciness, beef flavor intensity, connective tissue, overall tenderness, and off flavor intensity. Cattle within the BULL treatment tended to have improved average daily gain (ADG) and feed efficiency, with no difference in carcass characteristics,

WBSF, or sensory panel measurements compared to STR administered growth promotion technology.

The second study evaluated if cohorts with horns within a pen lot of cattle caused an increase in carcass bruising, and to determine if horn tipping and dehorning is necessary. Carcasses from (n = 4,287) feedlot cattle were observed at one commercial beef packing plant in southwest Kansas to investigate the relationship between the presence and size of horns in cattle and the prevalence, anatomical location, and severity of bruising of carcasses. Horn measurements taken were the length of the longest horn from base to tip and the tip-to-tip distance between the tips of both horns. Bruises were evaluated by location and severity. Bruise severity was scored at 3 levels: minor: ≤ 5 cm, moderate: 5 to 15 cm, and severe: > 15 cm. Within pen lots of cattle, the percentage of cattle with horns ranged from 0 to 26%. There were 4,287 carcasses evaluated and 2,295 had one or more bruises for a total, overall bruise prevalence of 53.5%. Of the total number of bruises, 25.6% were severe, 35.6% were moderate, and 38.8% were minor. The majority of bruises (61.8%) occurred on the dorsal mid-line with similar rates of bruising occurring on the left (18.6%) and right (19.5%) sides. There was no relationship found between the prevalence of horns and prevalence of bruising in a pen lot of cattle ($P = 0.90$).

These two studies conclude that feeding of bulls that fail the BSE could eliminate an animal welfare concern while removing the cost and management of growth promotion technology administration. Additionally to that there may be other factors causing carcass bruising at other than cohorts with horns.

Table of Contents

List of Figures

List of Tables

Acknowledgements

Chapter 1 - Review of the Literature

Feeding of Intact Male Cattle

Overview

In the past decade common husbandry practices have come under public scrutiny (Stafford and Mallord, 2005). Consumers are becoming more concerned with the welfare of the animals that provide the products they consume (Lyles and Calvo-Lorenzo, 2014). In response to consumer concerns, the beef industry continues to reevaluate husbandry practices to determine if physical and emotional stress can be reduced. Castration is a painful surgical procedure especially in mature male cattle (AVMA, 2014). Because painful procedures are coming under greater public scrutiny, cattlemen should be asking if such procedures contribute positively to the beef industry's production practices and public perception (Coetzee, 2013).

Breeding Soundness Exam

Yearling bulls across the world are subjected to a breeding soundness exam (BSE) prior to entering the breeding herd (Bruner et al., 1995). The BSE establishes criteria to determine whether a male is fit for commercial reproductive purposes. The seed stock industry currently castrates a portion of unsatisfactory bulls and this should be reevaluated due to animal welfare concerns. Males must be able to produce a sufficient quantity and quality of semen and be free of physical abnormalities (Maddox et al., 1959). The Society of Theriolgenology (1983) classifies bulls as satisfactory, questionable, or unsatisfactory breeders based on scrotal circumference (SC), semen morphology, and motility. Scrotal circumference is highly correlated to maturity and fertility status in young bulls (Cates, 1975). Young bulls produced for natural mating must be free of physical or reproductive abnormalities and be able to physically deposit

the semen in the genital tract females (Spitzer and Hopkins, 1997). Based on the above criteria young bulls either pass the BSE as satisfactory or are deemed unsatisfactory for breeding purposes. Bruner et al. (1995) evaluated 1,952 yearling bulls over a 12 yr period; he reported 85.3% satisfactory, 9.0% were questionable, and 5.7% were deemed unsatisfactory for breeding purposes. Reasons for bulls to be classified as unsatisfactory include; nutritional deficiency or over sufficiency, conformational faults, and sexual deformities (Bruner et al., 1995).

Nutritionally, the energy level and feed intake can impact age and weight at puberty of young bulls (Perry et al., 2008). Young bulls that are physically over conditioned can cause a decreased libido and leave the animal susceptible to heat stress. Over conditioning can also increase the accumulation of fat in the scrotum and can hinder testicular thermoregulation, and lead to defective spermatogenesis (Brito et al., 2012). Nutrient deficient young bulls during the growing phase delays puberty and reduces sperm cell production (Brito et al., 2012).

Young bulls can also be culled for conformation defects of the musculoskeletal system including the feet, legs and back including; sickle hocked, post-legged, cow hocked, or bow legged (Camp, 1997). Conformation defects inhibit the bull's ability to copulate.   The most common sexual deformities in breeds such as Angus, Shorthorn, polled Hereford, Hereford, and Beefmaster is a persistent frenulum, which may result in failure of the BSE and subsequent removal from being a herd bull prospective (Bruner et al., 1995). Persistent frenulum is the fusing of the skin of the penis and prepuce at birth and prevents the animal's penis from fully extending (Bruner et al., 1995; Camp, 1997).

A portion of unsatisfactory young bulls are castrated then sent into production as a steer. Reasons for castration include: 1) reduce aggressive behavior of intact males during the feeding phase, 2) prevent discounts at slaughter due to perception of a lower quality carcass associated with bulls, and 3) marketing of bull meat to consumers. Consumers perceive meat from bulls to be less palatable and an overall less positive eating experience than meat from steers (Field et al., 1971).

According to survey data, there are 7 million to 15 million castration in cattle events per year in the United States; 57% are surgical castration and 22% are nonsurgical-tension banding (Coetzee, 2013). Surgical castration with a knife envolves extracting the testicles through an incision in the scrotum and results in a wound that requires a healing period. Tension banding involves placing an elastic rubber band around the exterior top of the scrotum, resulting in loss of blood flow and necrosis of testes. Tension banding is gaining traction because it is bloodless and does not induce acute stress from wound healing (Petherick et al., 2014). Veterinarians tend to recommend knife castration for young males, and baning for males over 250 kg (T. L. Lee, personal communication), and also recommend that males be castrated before puberty.

Age at Castration

The older an animal is at castration the greater the pain and recovery time (AVMA, 2014a). Recovery time comes at a cost to performance of the animal and increase production cost for the producer (Fajt et al., 2011). Worrell et al. (1987) investigated castrating young bulls at heavier weights to maximize on performance due to testosterone. Bulls castrated at 410 kg

were less efficient then their cohorts left intact (Worrel et al., 1987). Worrel et al. (1987) reported that cattle castrated at 230 and 410 kg had the same marbling score as young bulls left intact and all three groups had similar yield grades. Heaton et al. (2006) concluded that castrating young bulls after 243 kg had negative impacts on carcass quality attributes; tenderness, juiciness, flavor, and overall acceptability. These reports suggest that castrating animals at heavier weights decreases the value of the animal and carcass.

Castration Technique

The castration technique used is of animal welfare importance. The amount of pain the technique imposes, acute (surgical) or delayed (non-surgical), impacts animal's recovery time and performance (Theur et al., 2007). Performance loss with late castration was investigated by Ford and Gregory (1983) who reported bulls continue to outperform males castrated at 13 mo for economically important characteristics; rate of gain, feed efficiency and percent yield. Gregory et al. (1985) compared late castration and implant treatments on growth rate, feed efficiency, and carcass meat traits in young males. Two forms of castration were used, emasculation and surgical castration. Both treatment groups continued to consume feed and water and gain weight immediately following the procedure (Gregory et al., 1985). However, it has been reported that males castrated via emasculation showed less discomfort than males castrated via the surgical technique (Gregory et al., 1985). A study done by Repenning et al. (2013) compared young bulls castrated via banding and surgical methods and found similar ADG over the duration of the 28 d feeding trial. Cattle castrated via surgical method had a significant decrease in DMI for the first week post castration compared to the banded group which did not have a decrease in DMI till 12 d post castration (Repenning et al., 2013). The banded group had a lower magnitude and delayed

DMI depression than surgical castrates (Repenning et al., 2013). This agrees with Rust et al. (2007) who reported bulls averaging 359 kg that were castrated surgically, had depressed DMI the first week compared to bulls castrated via the banding method. However, this authors reported that bulls castrated via banding had depressed DMI at week four (Rust et al., 2007). Banding caused a delayed stress response versus the acute stress surgical castration (Rust et al., 2007; Repenning et al., 2013).

Pain alleviation has been explored and is recommended for castration of young males (AVMA, 2011). However, Stafford and Mellor (2005) reported pain alleviation had no significant effect on weight gain when bulls were castrated via banding or surgical methods. However Fisher et al. (2001) noted that there was a delayed stress response to castration via banding because he reported a decrease in average daily gain (ADG) 14 days after castration. From these reports it is evident, that castrating maels at younger ages benefits both the animal and producer.

Growth Promoting Technologies

There is an increased demand for meat production as the world population grows and less land available for production as the world's population increases. There has also been an increased awareness by consumers of food animal production practices (Lyles and Calvo-Lorenzo, 2014). The use of growth promotion technologies has also become under scrutiny in the past decade (Lyles and Calvo-Lorenzo, 2014). Production of young bull meat provides potential for the beef industry to produce more edible protein more efficiently without use of growth promotion technologies (Winer et al., 1981).

Exogenous hormones given to steers in the form of implants have similar effects on performance characteristics as endogenous hormones that come from testes in intact males (Schoonmaker et al., 2002a). Arthaud et al. (1977); Seidman et al. (1982); and Ford and Gregory, (1983) report, bulls outperform steer counterparts, in average daily gain, feed efficiency, and produce more lean and edible protein product. Unruh et al. (1985) reported bulls that are aggressively implanted with zeranol at a young age and continually implanted throughout the finishing phase have an increase in marbling and more overall desirable carcass. However Unruh et al. (1985) reported implants have little effect in bulls implanted later in life. Lee et al. (1990) who showed implanting bulls resulted in no advantage to weight gain. This is an agreement with work showing no performance benefits implanting intact males with either trenbolone acetate (TBA) or estradiol (E_2), report no evidence of performance benefit (Hunt et al., 1991). Hunt et al. (1991) also found implanting bulls with TBA and E_2 increased sensory panel tenderness and connective tissue scores compared to bulls not implanted. These results indicate implanting bulls creates an advantage to sensory panel attributes by increasing the tenderness and flavor attributes of the meat. Carcasses of young intact males have similar characteristics as steers aggressively implanted if managed in an appropriate production setting. Schoomnaker et al. (2002a) found early weaned and aggressively implanted steers performed had similar ADG, G:F, and DMI as bulls also early weaned and not implanted. In a subsequent study, Schoonmaker et al. (2002b) found yearling bulls gained 5.6% faster and were heavier at harvest compared to yearling steers aggressively implanted. This is in contrast to Lee et al. (1990) who observed no difference in weight gain between bulls and aggressively implanted steers.

Performance

Bulls superior performance attributes such as greater average daily gain (ADG) and feed efficiency compared to steers make them attractive to produce. Koohmaraie et al. (1988) reported on average; intact males have the ability to grow 17% faster while consuming 13% less feed then steer counterparts. This agrees with Bidart et al. (1970) who observed bulls produced 20% more edible protein per day per unit of DE consumed than steer counter parts. Schoonmaker et al. (2002b) observed that bulls gained 5.7% more efficiently than steers that had been aggressively implanted. Gregory et al. (1985) castrated males at 13 mo of age via emasculator, surgically via knife castration, and intact controls. All animals were slaughtered at an average of 18 mo of age following feeding of a finishing diet. The results showed castrated males required 40.4 % more metabolizable energy (ME), compared to intact cohorts (Gregory et al., 1985). Cattle left intact had increased ADG compared to both both types of castration groups (Gregory et al., 1985). In a subsequent study Gregory et al. (1985) showed intact males gained 24% faster and consumed 22 % less feed/unit of gain than castrated cohorts. Average daily gain and feed efficiency favored intact males over castrates in all of these studies. This agrees with (Ford and Gregory, 1983) who noted intact males were 22% more feed efficient then steers castrated at 13 mo of age. Worrell et al. (1987) suggests bulls should be castrated before 230 kg or to allow bulls to remain intact to maximize on feedlot performance. The efficiency of bulls makes them an ideal animal to produce financially, but consumers must be on board to ensure there is success for the producer and packer in the market place.

Age at Slaughter

Another production setting that has been evaluated by researchers is the age at which steers and bull enter the feedlot stage. Schoonmaker et al. (2002b) noted bulls entering the feedlot at 13 mo or older, corresponds to a late introduction to a high-energy diet resulting in slower fat deposition. Cattle with slower fat deposition have to be on feed longer to achieve the desired fat thickness and result in overweight carcasses (Schoonmaker et al., 2002ab). Late introduction to a high energy diet also resulted in slower intramuscular fat deposition and increase in muscle fiber size. Duckett et al. (1999) suggest reduction in intramuscular fat associated with intact males and aggressively implanted steers is due to a dilution effect; the same amount of intramuscular fat is spread over a greater areas due to an increase in muscle fiber size. Carcasses of young intact males and steers aggressively implanted are similar if managed in an appropriated production setting.   Examples of these appropriate production settings include; introduction into a high energy diet and harvesting at young ages.

Harvesting males at younger ages has been reported to have positive effect on carcass characteristics (Jacobs et al 1977ab; Carroll et al 1975). Harvesting at younger ages would decrease the difficulty of production and marketing of young intact males (Field et al. 1966). Jacobs et al. (1977b) reported bulls slaughtered at 18 to 19 mo had less marbling and lower quality grades compared to steers of similar production system. Carroll et al. (1975) evaluated bulls and implanted steers slaughtered at 16 mo and found them to have similar carcass quality in the same production systems. Decrease in age at slaughter was evaluated by Field et al. (1966) who 10 yrs prior to Carroll et al (1975) suggested intact males should not be slaughtered after 15 mo of age.

Carcass Quality Characteristics

The industry accepts bulls have greater performance then steer counterparts, but marketing of bull carcasses creates difficulties. Producers, packers, and consumers perceive bull carcasses as inferior to steers (Jacobs et al. 1977a). This industry perception inhibits producers from raising, packers from processing, and consumers from buying bull meat.

Hunt et al. (1991) reported bulls have similar carcass characteristic, such as quality grade and marbling scores, as aggressively implanted steers, when slaughtered at similar ages. However steers aggressively implanted with TBA and E_2 did have improved sensory panel connective tissue, and tenderness scores compared to bulls (Hunt et al., 1991). Schoonmaker et al. (2002a) observe it took bulls 18 d longer to reach similar final fat thickness as steers aggressively implanted. This increased time for fat deposition is consistent with bulls partitioning energy towards muscle deposition over fat deposition.

Carroll et al. (1975) suggested early weaning of bull calves improves meat from intact males. Early weaning bull calves allows for production of meat from bulls at earlier ages. Early weaning allows reduction in chronological age at slaughter and improvement of feedlot management problems associated with feeding bulls.

A supportive argument to decreasing the age at which bulls are slaughtered is that as the age at slaughter increases so does the variation in the meat tenderness (Field, 1971). Increased meat tenderness variation results in an unpredictable product being presented to consumers

(Field, 1971). Increased meat tenderness variation shadows the potential for bulls to be high

quality product. Riley et al. (1986) and MacNeil et al. (1989) support feeding bull's high energy

diets allows them to reach a desirable weight and carcass composition at the youngest

chronological age possible.

Riley et al. (1986) also believes breed has detrimental effects on carcass quality. He

found British-type bulls had acceptable numerical scores sensory panel analysis including;

juiciness and beef flavor, compared to Brahman, Jersey, and Holstein-type bulls (Riley et al.,

1986). Another production procedure suggested is to increase postmortem aging. Increased

postmortem aging has shown to increase overall tenderness and palatability, while decreasing

amount of organoleptically detectable connective tissue (Johnson et al., 1988). Increased

postmortem aging also has shown to decrease shear force values of meat from bulls (Johnson et

al., 1981). Winer et al. (1981) agrees recording meat aged for 14 d received more desirable

scores for palatability and tenderness than samples aged for 2 d. Savell et al (1982) recorded

aging bull meat samples for 18 d in addition to blade tenderization had positive impacts on

tenderness. These methods improved the quality level of meat samples from bulls to the quality

levels of steers (Savell et al., 1982).

Another method to improve tenderness evaluated by Savell et al. (1982) was electrical

stimulation of carcasses, but reported it to have little to no effect on tenderness. However he

concluded it did have positive effects on color and texture (Savell et al., 1982). Electical

stimulation lightened the color of the bull meat and reduced the course texture of meat (Savell et

al., 1982). Results from Savell et al. (1987) disagree with Riley et al. (1983) who also

investigated effects of electrical stimulation on tenderness and concluded there are other factors

that affect the efficacy of the method. One factors was back fat thickness; bulls and steers

containing back fat thickness greater than 7.6 mm did not receive benefit from electrical

stimulation techniques. However, animals containing less than 7.6 mm did receive benefits from

electrical stimulation (Riley et al., 1983). These conclusions have led researchers to think that

tenderness is related to fat content of muscle (Koohmarale et al., 1988). Greater back fat

thickness is typically associated with greater marbling and increased tenderness (Koohmarale et

al., 1988).

Muscle Physiology

Other factors believed to affect bull's meat tenderness are the amount and type of

collagen. Gerrard et al. (1987) reported as bull's age their muscle collagen becomes more heat

stable at a faster rate than steers during the later stages in growth. Burson et al. (1986) agrees

reporting muscle samples from steers contained more heat soluble collagen then bulls of the

same age. The influence of testosterone on collagen synthesis has been investigated. Cross et al.

(1984) identified, as blood testosterone concentrations increase, amount of collagen synthesis in

the longissimus muscle also increases. These authors suggest the increase in testosterone is

correlated with age, and impact of puberty (Cross et al., 1984; Burson et al., 1986). Cross et al.

(1984) found a breed effect on the amount of collagen and testosterone levels, he also found as

an animal's chronological age increases the amount of soluble collagen decreases. Earlier

maturing breeds such as Hereford and Angus have been reported to have more total collagen but

with less soluble collagen then later maturing breeds (Cross et al., 1984). Cross et al. (1984)

indicates that the increased collagen synthesis that happens near puberty would increase the

11

amount of immature collagen. The increase in immature collagen results in less cross linkage and would indicate there would be greater solubilized collagen during cooking (Cross et al., 1984).

A bull younger in age at slaughter minimizes the proportion of cross linkage of the collagen. Slaughtering bulls at younger ages and being conscious of the breed are production tool that can be advantageous to the carcass of young bulls. The decision to produce bull meat should be made early in the production cycle. This timing ensures the animal can be introduced to a high grain and energy diet that ensures proper fat deposition. This decision ensures the animal is slaughtered at an age that takes advantage of the carcass quality young males possess. The suggestion of slaughtering at a younger age could help improve feedlot management problems associated with feeding bulls, for example aggressive and behavioral issues that plague feeding bulls.

Confined Feeding Management

Issues arise when comparing feeding bulls to steers in a confined feeding operation. Examples of issues are behavioral, cohort mingling, and facilities capabilities, all of which may not be of significance when feeding steers. A study done by Hinch (1978) looked at social behavior of bulls vs. steers. Hinch (1978) observed the social behaviors of bulls and steers are not much different up until 14 mo of age, and management strategies should not be different (Hinch, 1978). Older bulls are more susceptible to stressors then steers. Pre-slaughter stressors such as comingling and handling, and transportation cause a value decrease to the carcass in form of dark cutters.

Arthaud et al. (1977) and Jacob et al. (1977a) reported increased in dark colored meat from bulls vs. steers due to an increase in pre-slaughter stressors. Ford and Gregory (1983) however did not report an increase in dark colored meat from bulls, because they reduced pre-slaughter stressors. Pre-slaughter stress was reduced by ensuring animals penned together were transported together, and were immediately slaughtered upon arrival to the abattoir (Ford and Gregory, 1983). This is in agreement with Tennessen et al. (1984) who compared transport stressors between bulls and steers. Few differences were found between animals when transporting bulls as pen mates and steers as pen mate's together (Tennessen et al., 1984). Tennessen et al. (1984) also concluded if bulls are handled appropriately they are as cooperative, when handling and transporting, as steers.

Maximizing efficiency and elimination of behavioral issues has led to exploration of appropriate group size for confined bulls. Tarrant (1981) and Voisinet et al. (1997) suggest temperament and gender have an effect on the prevalence of dark-cutters. Tarrant (1981) and Voisinet et al. (1997) reported bulls and heifers have a higher probability of producing borderline dark-cutter meat than steers. The higher probability is because of more physical activity associated with estrus mounting in heifers, or the increased aggressive behavior of bulls when establishing dominance (Tarrant, 1981; Voisinet et al., 1997). MacNeil et al. (1989) showed that feeding bulls in 30 animal pens produced heavier carcass at slaughter then 60 animals per pens. Feeding of 30 animal pens also showed an increase in sub-cutaneous fat by 17% and tendencies for more efficient conversion of feed into body mass, at a rate of 17% (MacNeil et al., 1989).

However MacNeil et al. (1989) suggests a need for further research to find the optimal sized pen to gain maximum economical returns for feeding young bulls.

Types of stressors yearling bulls encounter are emotional and physical. Emotional stressors come with establishment of a social hierarchy (McVeigh et al., 1982). Physical stressors are induced by physical activity of establishing the hierarchical order (McVeigh et al., 1982). McVeigh et al. (1982) observed when young males were introduced into an established pen of males caused emotional and physical stress during the first 6 h until the social order was established again. There are management strategies to ensure meat produced by bulls is not unaffected. The introduction of pen mates early and maintaining of pen mates throughout the feeding systems (Tennessen et al., 1984) is a key to reducing stress. How animals are handled is a major cause or reducer to stress. Bulls are naturally more aggressive animals and they need to be handled with and transported as such.

Consumer Acceptance

Consumer acceptance sends a ripple up the production chain. Consumer acceptance adds incentives for producers to produce meat for young bulls, and for packers to create a market to sell the product. There is resistance from packers to invest in production of young bulls for meat production (Koohmaraie et al., 1988). Resistance comes from price discrimination due to reduction in quality grade young bull meat produces (Koohmaraie et al., 1988). Data from Jacob et al. (1977a) shows meat from bulls is more profitable to the packer and the retailer. Marketability of protein from bulls

is directly related to consumer's acceptance. Arthaud et al. (1977); Gregory et al. (1983); and Ford and Gregory (1983) have reported that steaks from young bulls are tougher than steaks from steers of similar background and age. Evaluation of taste is important to retailers and the consumer. Consumers want lean meat but still require the taste attributes that contribute to a positive eating experience (Jacob et al., 1977a). Reported differences between young bulls and steers for carcass quality attributes are small and steaks from young bulls was within consumer's acceptable preference range (Koohmaraie et al., 1988).

Gregory et al. (1983) compared meat from late castration, on palatability characteristics of bull's longissimus muscle. Gregory et al. (1983) involved bulls castrated at a year of age and bulls left intact. Results concluded no difference for Warner-Bratzler shear force and connective tissue amount score between castrate and intact treatment groups (Gregory et al., 1983). However, differences for marbling score and overall tenderness score, from the sensory panel, were found favoring castrates over intact groups (Gregory et al., 1983).

Consumer's preferences have ultimate say in what kind of beef is produced in the United States (Jacobs et al., 1977a). A preference for lean meat becomes important to consumers when price inflation is in effect, consumers are willing to settle for a less quality meat (Jacobs et al., 1977a). Jacobs et al. (1977b) found meat from steers 19 to 20 mo of age was more desirable by consumers than to meat from bulls same age in flavor, tenderness, and overall acceptability. However 85% of consumers rated the meat from bulls good or better than beef they normally purchased (Jacobs et al., 1977b). Jacobs et

al. (1977b) further reported that 90% of consumers rated bull cuts from the loin, rib, and chuck as good or better then cuts they normally purchased.

Taste panelists rated steers longissimus more desirable for tenderness, juiciness, and flavor fullness over bulls (Carroll et al., 1975). The longissimus from bulls was however rated within acceptable palatability range (Carroll et al., 1975). When looking at less tender cuts Jacobs et al. (1977b) reported 45% of consumers rated bulls round cuts as less satisfactory than what they normally purchase. This is in agreement with Carroll et al. (1975) that looked muscles that are considered less tender, such as the adductor and semimembranosus and showed there were no differences detected for the shear force values between bulls and steers. Less tender muscle groups were rated by the taste panel to be equivalent for bulls and steers (Carroll et al., 1975).

According to Arthaud et al. (1969), consumers were expressing interest in beef cuts with high proportion of lean in relation to fat, the kind of meat an intact male bovine produces faster and more efficient then steers or heifers. Today consumers are more health conscientious and still desire a lean cut of meat without giving up quality. Arthaud et al. (1969) stated bull carcasses were slightly lower in quality then steers in tenderness, grade, and marbling, but the bulls carcasses are still in the consumer's acceptable range. From the packers perspective bulls do hold valuable aspects, Jacobs et al. (1977a) recorded boxed beef yields for bull's increased 5.5% profit returns to the packer, compared to steers under equal marketing circumstances. Increased profit returns are due to reduction in "in-store" trim loss; bulls are worth approximately 32% more to retailers

than steers (Jacobs et al., 1977a). Not all the meat from a bull carcass is less acceptable to consumers. There are certain muscle groups for example; adductor and semimembranosus that hold as much value as steers (Jacobs et al., 1977a). Arthaud et al. (1969) states because changes in feeding and management practices emphasizing rate of gain and marketing at young ages, feeding bulls for beef production is a viable option. This is also true for bulls that are non-breeding potential yearling bulls.

Conclusions from the literature

Consumers want a lean meat with taste and marbling to ensure a positive eating experience. There are positive aspects to producing young bulls for example, meat from bulls yielded more edible meat with less fat than their steer counterparts (Jacobs et al., 1977a). Carcasses from young intact male's average more retail meat and greater longissimus area then steers of a similar age and origin (Arthaud et al., 1969). If young bulls are managed appropriately including an early introduced into a high plain of nutrition, then subsequent slaughter at a young chronological age, allows for a profitable marketing of non-breeding potential bulls.

The packers have the ability to increase profit margins with increase carcass size bulls provide. The ability for young bulls to outperform steers with natural testosterone opens up opportunity to decrease dependencies on growth promotion technologies and increase of turnover rate in the feedyard. The decreased dependencies of growth promotion technologies allows for production of a profitable and animal welfare

conscious product for consumers. These attributes make young bulls a prime candidate for beef production.

Carcass Bruising in Cattle

Overview

Animal welfare concerns have become a priority for the beef industry. Providing consumers with a humanely-produced product is important to the beef industry. Re-evaluating production procedures routinely to ensure animals are being humanely handled is a common practice. Procedures such as dehorning and castration have come under public scrutiny, which has enticed researchers to revisit these procedures and determine if they are beneficial for animals, producers, and the industry.

There are indicators of suboptimal animal handling, for example: carcass bruising can be an objective measure to aid researcher's evaluation of animal handling. A carcass bruise is an injury to tissue as a result of an impact from a blunt object with enough force to cause rupture of blood vesicles, causing accumulation of blood and serum in the affected tissue (Rezac et al., 2014). Bruises can occur in animals up to the point of exsanguination (McCausland and Dougherty, 1978). There are different opinions in the literature discussing the correlation of bruise color to bruise age. Gracey (1986) suggests a bruise bright red in color is associated with a trauma event happening within 10 h, while a dark red colored bruise is associated with a bruise approximately 24 h old, and a bruise yellow in color is thought to be at least three days old. In contrast, Hamdy et al. (1957) mentioned that red colored bruises are 15 min - 2 d old, while bruises green in color were associated with bruises 3 - 4 d of age, and yellow and orange bruises

are 4 - 6 d of age. Carcass bruising is a source of wastage to a beef carcass. Bruising, if severe enough, may deem meat unsatisfactory for its original purpose, devaluing the carcass (Weeks et al., 2002).

Carcass bruising cause's high quality cuts to be a lower quality product. Trimmed meat from bruises cannot be salvaged for human consumption (Hoffman et al., 1998), which makes carcass bruising expensive for the beef industry. A survey conducted by Weeks et al. (2002) observed 48,926 beef carcass at slaughter; of those carcasses 4.1% contained substantial bruising which warranted down-grading or rejection of the majority of the bruised meat. Results from a survey conducted by McNally and Warriss (1996) indicate that 6.5 % of carcasses were bruised severely enough to warrant down-grading or rejection of bruised meat. Reduction in beef carcass bruising is an indicator of improvement of animal handling techniques, such as low stress handling, which has been implemented and been of great benefit for the beef industry. There are inherent characteristics of some groups of cattle allowing for increased risk of bruising in some individuals compared to others. Examples of inherent characteristics are gender, age, back fat thickness, and individual's behavior. Other subjective causative agents of carcass bruising, such as cohorts with horns, need to be re-evaluated to ensure bruising is minimized and beef carcass utilization is maximized.

Physiological Differences of Cattle

Animals of different ages and genders are subject to different production chains and ultimately different end points. Stressors of production, handling, and transport affect genders of cattle differently. Weeks et al. (2002) observed that bulls had less bruising than steers or heifers

when slaughtered at the same abattoir. This author also observed that heifers had less bruising than steers (Weeks et al., 2002). This is in agreement with Jarvis et al. (1995), who reported that bulls had the least prevalence of bruising followed by heifers, with steers having the greatest prevalence of carcass bruising. The difference observed between different genders of cattle is thought to be due to a number of factors including back fat depth, hide thickness, age, and general responses to stimuli such as environment and facilities (Yeh et al., 1978).

The physical and physiological condition of the animal being transported influences how the animal will cope with the stress of transport. Cattle in different stages of production are affected by transport differently. Cattlemen should be aware of the condition of the animal being handled or transported to ensure that animals are being treated ethically and prevent animal welfare concerns. Animals of different physiological conditions can be affected by bruising differently. Jarvis et al. (1996) found a negative correlation between level of bruising and backfat thickness. As backfat thickness decreased, the prevalence of bruising increased. This correlation also helps explain the increased prevalence of carcass bruising in the cull cow and bullock industry.

Changes in animal behavior such as mixing, butting, mounting, etc., during stressful situations, including handling or transport, make cattle difficult to handle, which creates the potential for bruising (Eldridge and Winfield, 1988). For these reasons certain animals are more susceptible to bruising and other animal welfare concerns. Factors shown to affect the occurrence of carcass bruising up to and at slaughter include: distance traveled, stocking density of the trailer, animal BW, and presence of horns (Grandin, 1981; Hoffman et al., 1998).

Hoffman et al. (1998) reported that as distance from source to abattoir increased from 325 km to 646 km, so did the prevalence of bruising, but no difference was detected in prevalence of bruising when distances increased from 646 km to 949 km. Jarvis et al. (1996) found that when cattle traveled a distance greater than 64 km they had more bruising than cattle sourced closer. Distance traveled has proved to contribute to bruising, but as Jarvis et al. (1996) suggest there are other factors contributing to carcass bruising.

Jarvis et al. (1996) reported that 24% of bruises recorded were bright red in color, indicating a majority of bruising occurred prior to arrival at the abattoir. Further research in this area discovered other sources that contribute to carcasses bruising, such as space allowance on trailers. Eldridge and Winfield (1988) and Jarvis et al. (1996) found that cattle stocked at low space allowance had similar carcass bruising as cattle allowed a greater space allowance. Cattle stocked at the recommended level of 1.16 m^2/ animal, specified by Grandin (1981), presented significantly less bruising at the abattoir than low and high stocking density groups (Eldridge and Winfield, 1988). Cattle allowed ample space had more room to move and more access to all sides of the trailer which increased bruising risk. Cattle allowed low space allowance were subject to crowding and exposed cattle to becoming downers and unable to get up. Cattle that are tired and hungry are more susceptible to injury. Understanding an animal's condition before transporting is important in preventing bruising, but it is also important to understand how many times the animals will be handled before they are at their final destination.

Cattle Source

Additional handling increases the risk of carcass bruising and other animal welfare issues. Eldridge et al. (1984) reported that cattle sold directly to the abattoir had smaller and fewer bruises than animals sold on a live weight basis. McNally and Warriss (1996) observed that animals sourced from markets had a bruising prevalence of 7.8%. This bruising prevalence was greater than for animals sourced from a dealer (6.3%) and even greater than animals sourced directly from the farm (4.8%). According to Jarvis et al. (1995) cattle sourced from a market had an overall bruising prevalence of 97%, significantly more when compared to cattle sourced directly from the farm.

Handling

Although a portion of carcass bruising happens at the abattoir, there is considerable variation in cattle within the same lot. McCausland and Millar (1982) suggest that handling prior to slaughter has an effect on the prevalence of carcass bruising at the time of slaughter. During handling, cattle undergo changes to their social, physical, and emotional states. Conditions under which cattle are handled can either be encouraging to animals or detrimental by causing stress or injury. Stressful or inappropriate handling leads to an increase in difficulty of handling (Eldridge et al., 1988). Difficult handling results in bruising, trim loss, loss of time, and money. Grandin (1981) reported that cattle originating from feedlots with quiet handling techniques in contrast to cattle from feedlots with rough handling techniques presented substantially less bruising (8.35 verses 15.5%, respectively).

Causative Agents

Bruises shaped differently are often associated with different source or causative agents (Strappini et al., 2012). Examples of causative agents include handling, use of driving aids, facilities, and cohorts with horns. Barnett et al. (1984) observed that cattle subjected to stressful handling procedures were more susceptible to carcass bruising. Driving aids have been found to have a correlation to an increase in the prevalence of bruising. Barnett et al. (1984) and Jarvis et al. (1995) reported that the use of driving aids was correlated with the number of potentially traumatic events during unloading and pre-stunning phases at the abattoir. Driving aids are linked to parallel red marks, resulting in a thin line and small mottled bruise. Small mottled bruising has been reported to result from the use of the end of a driving stick (Weeks et al., 2002). McNally and Warriss (1996) recorded that animals sourced from a market presented more stick marks, which resulted in tissue loss of 401 g; animals sourced from a dealer loss 362 g of tissue, followed by animals that came directly from a farm, where stick marks resulted in 98 g of tissue loss. In a study by Jarvis et al. (1995), there were two abattoir facilities that carcasses were evaluated at and there was a difference between the two for number of potentially traumatic events and use of driving aids per animal. Handling cattle in a stressful manor and use of driving aids is a major source of bruising, but also additional handling of cattle increases the risk of bruising. Cattle in states conducting first point testing for brucellosis are subjected to additional handling, introducing the opportunity for potentially traumatic events causing carcass bruising. Hoffman et al. (1998) observed that cattle subjected to first point testing had more bruises affecting the loin and round regions, compared to cattle sourced from states not requiring a first point test.

Facilities have an impact on how cattle respond to being handled. Facilities that excite, stress, and do not allow for the natural flow of cattle lead to traumatic events.   Jarvis et al. (1995) observed cattle at the abattoir and recorded traumatic events that have the potential to cause carcass bruising. Cattle were followed through the unloading process and recorded that 40% of the total unloading events resulted in animals hitting up against structures, 22% resulted in falls, and 38% in slips. The same cattle were followed through pre-stunning, and 26% of total pre-stunning events resulted in hitting the race gate, 25% in animals hitting structures, 22% getting hit with vertical gates, 13% had slips, falls accounted for 8%, mounts 0.5%, and other 5% (Jarvis et al., 1995).

Dehorning or tipping is a production procedure practiced in the beef industry for several reasons including cohorts with horns being linked to an increase in carcass bruising (Shaw et al., 1976). Reasons for this procedure include improvement of behavioral issues, human and cohort safety, and handling ease. Dehorning and tipping practices are considered painful procedures, with tipping being less painful than dehorning (AVMA, 2014b). Both practices are still of animal welfare concern. According to USDA (2013), approximately 77% of cattle in feedlots have their horns tipped or removed.

Horns causing carcass bruising is a commonly held industry belief. This belief has led to research in the area of observing incidence of carcass bruising among cattle with horns, tipped horns, and polled cattle. Bruises thought to be resulting from cohorts with horns are linked to circular shaped bruises (Shaw et al., 1976). Shaw et al. (1976) recorded bruising trim losses to be almost doubled for horned cattle verses lots of polled cattle (8.8 versus 5.5 kg, respectively).

Meischke et al. (1974) also recorded double the carcass bruising from horned cattle to polled cattle (7.7 verses 3.7 kg, respectively). Wythes et al. (1979) observed no difference between cattle that had their horns tipped or un-tipped for carcasses bruising. Ramsay et al. (1976) recorded double in carcass bruising from dehorned cattle vs. tipped cattle (3.3 verses 6.4 kg, respectively). These authors conclude that tipping does not make a positive economic impact on carcass bruising for steers and cull cows.

Cost

Bruising in the cull cow industry creates a loss in profit due to the devaluation of the carcass (Smith et al., 1999). Considering the cull cow is marketed as primals and extra lean sub-primals, tissue loss due to bruising creates an economic loss for the packer (Smith et al., 1999). Wythes et al. (1979) suggests that cattle with horns should be produced and marketed separately to polled cattle to reduce the incidence of bruising.

Pain mitigation for dehorning and tipping has been evaluated and deemed an acceptable production practice. Pain mitigation, however, is not an economical option due to drug price, time, and labor (AVMA, 2014b). Due to horned cattle causing more carcass bruising than polled cattle, and the lack of incentive to use pain mitigation for dehorning, the ultimate goal for cattle destined for fattening is for all polled genetics.

Prevalence

Hoffman et al. (1998) studied beef cows at the abattoir and reported a mean bruising prevalence of 48.3%, while the mean prevalence of major bruises was 16.9%. Jarvis et al. (1995) reported that of 4,422 carcasses evaluated, 97% were bruised. The study done by Jarvis et al. (1995) indicated that the majority of bruising occurred among the forequarter and down the midline of the carcasses, indicative of vertical gates being closed prematurely. This is not in agreement with Eldridge and Winfield (1988) who observed that during the transport of cattle from the farm to the abattoir the most affected area of cattle was the hip. The National Beef Quality Audit (NBQA) from 2011 evaluated 18,000 carcasses and observed 77.0% without bruising, 18.8% with 1 bruise, 3.4% with 2 bruises, and 0.9% had 3 or more bruises. The location of the bruising occurred down the midline accounting for 50.1%, 21.3% occurred at the rib, 13.8% on the chuck, 7.3% on the round, and 7.5% was located on the flank/plate/brisket (NBQA, 2011). The bruising percentages from the 2011 audit were reduced from previous years (1991, 1995, 2000, and 2005; 39.2, 48.4, 46.7, and 35.2%, respectively), indicating animal handling and facilities have improved. This type of progress is beneficial for the beef industry, providing evidence that we are continually improving upon our practices and providing a humanely produced animal.

Conclusion from the Literature

Carcass bruising is not only an indicator of sub-optimal animal welfare, but also results in devaluation of carcasses and other economic implications. Excessive trimming is a financial loss for the producer and the packer. Trimming bruises out of carcasses has the potential to be labor intensive while congesting the production rail. Excessive trimming can introduce sanitary issues

for the abattoir. A motivational tool for improvement in animal care is financial risk. Review of the literature shows there are many causative agents for carcass bruising from facilities and handling, to cohorts with horns. Knowledge of causative agents that result in bruising is important for producers and packers who need to be informed and willing to ensure that the product they are producing is humanely produced and handled. According to the NBQA (2011), the prevalence of carcass bruising has decreased in the United States since previous audits. The decreased prevalence of carcass bruising is a positive sign indicating that the industry is headed in the right direction regarding animal welfare implications in production settings.

References

Arthaud, V. H., C. H. Adams, D. R. Jacobs, and R. M. Koch. 1969. Comparison of carcass traits of bulls and steers. J. Anim. Sci. 28: 742-745.

AVMA. 2014a. Literature Review on the Welfare Implications of the Dehorning and Disbudding of Cattle.
https://www.avma.org/KB/Resources/LiteratureReviews/Documents/dehorning_cattle_bgnd.pdf

AVMA. 2014b. Literature Review on the Welfare Implications of the Dehorning and Disbudding of Cattle.
https://www.avma.org/KB/Resources/LiteratureReviews/Documents/dehorning_cattle_bgnd.pdf

Barnett, J. L., G. A. Eldridge, I. P. McCausland, I. W. Caple, H. W. C. Millar, T. G. Truscott et al. 1984. Stress and bruising in cattle. Animal Production in Australia. 15: 653.

Brito, L. F. C., A. D. Barth, R. E. Wilde, and J. P. Kastelic. 2012. Effect of growth rate from 6 to 16 months of age on sexual development and reproductive function in beef bulls. Theriogenology. 77(7): 1398-1405.

Bruner, K. A., R. L. McCraw, M. D. Whitacre, and S. D. v. Camp. 1995. Breeding soundness examination of 1,952 yearling beef bulls in north carolina. Theriogenology. 44(1): 129-145.

Camp, S. D. v. 1997. Common causes of infertility in the bull. Veterinary Clinics of North America, Food Animal Practice. 13(2): 203-231.

Carroll, F. D., W. C. Rollins, K. A. Wagnon, and R. G. Loy. 1975. Comparison of beef from bulls and DES implanted steers. J. Anim. Sci. 41(4): 1008-1013.

Coetzee, J. F. 2013. Assessment and management of pain associated with castration in cattle. Veterinary Clinics of North America, Food Animal Practice. 29(1): 75-101.

Cross, H. R., B. D. Schanbacher, and J. D. Crouse. 1984. Sex, age and breed related changes in bovine testosterone and intramuscular collagen. Meat Sci. 10(3): 187-195.

Eldridge, G. A., J. L. Barnett, I. P. McCausland, H. W. C. Millar, and W. J. Vowles. 1984. Bruising and method of marketing cattle. Animal Production in Australia. 15: 675.

Eldridge, G. A., and C. G. Winfield. 1988. The behaviour and bruising of cattle during transport at different space allowances. Aust. J. Exp. Agric. 28(6): 695-698.

Eldridge, G. A., C. G. Winfield, and D. J. Cahill. 1988. Responses of cattle to different space allowances, pen sizes and road conditions during transport. Aust. J. Exp. Agric. 28(2): 155-159.

Fisher, A. D., T. W. Knight, G. P. Cosgrove, A. F. Death, C. B. Anderson, D. M. Duganzich, and L. R. Matthews. 2001. Effects of surgical or banding castration on stress responses and behavioral of bulls. Aust. Vet. J.79:279-284.

Ford, J. J., and K. E. Gregory. 1983. Effects of late castration and zeranol on feedlot performance and carcass characteristics of bovine males. J. Anim. Sci. 57(2): 286-291.

Gracey, J. F. 1986. Meat hygiene. . London, UK, Bailliere Tindall.

Gregory, K. E., J. J. Ford, S. C. Siedeman, and W. G. Hays. 1985. Effects of late castration and zeranol on growth rate, feed efficiency and carcass and meat traits of bovine males. Beef Research Progress Report, Roman L.Hruska US Meat Animal Research Center. (2): 36-40.

Gregory, K. E., S. C. Seideman, and J. J. Ford. 1983. Effects of late castration, zeranol and breed group on composition and palatability characteristics of longissimus muscle of bovine males. J. Anim. Sci. 56(4): 781-786.

Hamdy, M. K., L. E. Kunkle, M. S. Rheins, and F. E. Deatherage. 1957. Bruised tissue. III. some factors affecting experimental bruises. J. Anim. Sci. 16: 496-501.

Hinch, G. N. 1978. Social behaviour of young partially-castrated bulls and steers related to their management. Proc. Aust. Soc. Anim. Prod. 12: 265.

Hoffman, D., M. Spire, J. Schwenke, and J. Unruh. 1998. Effect of source of cattle and distance transported to a commercial slaughter facility on carcass bruises in mature beef cows. J. Am. Vet. Med. Assoc. 212(5): 668-672.

Hunt, D. W., D. M. Henricks, G. C. Skelley, and L. W. Grimes. 1991. Use of trenbolone acetate and estradiol in intact and castrate male cattle: Effects on growth, serum hormones, and carcass characteristics. J. Anim. Sci. 69(6): 2452-2462.

Jarvis, A. M., L. Selkirk, and M. S. Cockram. 1995. The influence of source, sex class and pre-slaughter handling on the bruising of cattle at two slaughterhouses. Livest. Prod. Sci. 43(3): 215-224.

Jarvis, A., C. Messer, and M. Cockram. 1996. Handling, bruising and dehydration of cattle at the time of slaughter. Anim. Welfare. 5(3): 259-270.

Lyles, J. L., and M. S. Calvo-Lorenzo. 2014. Bill E. Kunkle Interdisciplinary Beef Symposium: Practical developments in managing animal welfare in beef cattle: What does the future hold? J. Anim. Sci. 92(12): 5334-5344.

MacNeil, M. D., K. E. Gregory, and J. J. Ford. 1989. Management of yearling bulls in a feedlot. J. Anim. Sci. 67(4): 858-864.

McCausland, I. P., and R. Dougherty. 1978. Histological ageing of bruises in lambs and calves. Aust. Vet. J. 54(11): 525-527.

McCausland, I. P., and H. W. C. Millar. 1982. Time of occurrence of bruises in slaughtered cattle. Aust. Vet. J. 58(6): 253-255.

McNally, P. W., and P. D. Warriss. 1996. Recent bruising in cattle at abattoirs. Vet. Rec. 138(6): 126-128.

McVeigh, J. M., P. V. Tarrant, and M. G. Harrington. 1982. Behavioral stress and skeletal muscle glycogen metabolism in young bulls. J. Anim. Sci. 54(4): 790-795.

Meischke, H. R., W. R. Ramsay, and F. D. Shaw. 1974. The effect of horns on bruising in cattle. Aust. Vet. J. 50(10): 432-434.

Petherick, J. C., A. H. Small, D. G. Mayer, I. G. Colditz, D. M. Ferguson, and K. J. Stafford. 2014. A comparison of welfare outcomes for weaner and mature bos indicus bulls surgically or tension band castrated with or without analgesia: 1. behavioural responses. Appl. Anim. Behav. Sci. 157: 23-34.

Ramsay, W. R., H. R. Meischke, and B. Anderson. 1976. The effect of tipping of horns and interruption of journey on bruising in cattle. Aust. Vet. J. 52(6): 285-286.

Repenning, P. E., J. K. Ahola, R. J. Callan, J. T. Fox, J. T. French, R. L. Giles et al. 2013. Effects of pain mitigation and method of castration on behavior and feedlot performance in cull beef bulls. J. Anim. Sci. 91(10): 4975-4983.

Rezac, D. J., D. U. Thomson, M. G. Siemens, F. L. Prouty, C. D. Reinhardt, and S. J. Bartle. 2014. A survey of gross pathologic conditions in cull cows at slaughter in the great lakes region of the united states. J. Dairy Sci. 97(7): 4227-4235.

Riley, R. R., J. W. Savell, C. E. Murphey, G. C. Smith, D. M. Stiffler, and H. R. Cross. 1983. Palatability of beef from steer and young bull carcasses as influenced by electrical stimulation, subcutaneous fat thickness and marbling. J. Anim. Sci. 56(3): 592-597.

Riley, R. R., G. C. Smith, H. R. Cross, J. W. Savell, C. R. Long, and T. C. Cartwright. 1986. Chronological age and breed-type effects on carcass characteristics and palatability of bull beef. Meat Sci. 17(3): 187-198.

Rust, R. L., D. U. Thomson, G. H. Loneragan, M. D. Apley, and J. C. Swanson. 2007. Effect of different castration methods on growth performance and behavior responses of postpubertal beef bulls. Bovine Practitioner. 41(2): 111-118.

Savell, J. W., F. K. McKeith, C. E. Murphey, G. C. Smith, and Z. L. Carpenter. 1982. Singular and combined effects of electrical stimulation, post-mortem ageing and blade tenderisation on the palatability attributes of beef from young bulls. Meat Sci. 6(2): 97-109.

Schoonmaker, J. P., S. C. Loerch, F. L. Fluharty, T. B. Turner, S. J. Moeller, J. E. Rossi et al. 2002a. Effect of an accelerated finishing program on the performance, carcass characteristics and circulating insulin-like growth factor I concentration of early-weaned bulls and steers. J. Anim. Sci. 80(4): 900-910.

Schoonmaker, J. P., S. C. Loerch, F. L. Fluharty, H. N. Zerby, and T. B. Turner. 2002b. Effect of age at feedlot entry on performance and carcass characteristics of bulls and steers. J. Anim. Sci. 80(9): 2247-2254.

Strappini, A. C., K. Frankena, J. H. M. Metz, C. Gallo, and B. Kemp. 2012. Characteristics of bruises in carcasses of cows sourced from farms or from livestock markets. Animal. 6(3): 502-509.

Tarrant, P. V. 1981. A survey of the incidence, causes and economic consequences of dark-cutting in beef. Irish Journal of Food Science and Technology. 5(1): 80-81.

Tennessen, T., M. A. Price, and R. T. Berg. 1984. Comparative responses of bulls and steers to transportation. Canadian Journal of Animal Science. 64(2): 333-338.

Voisinet, B. D., T. Grandin, S. F. O'Connor, J. D. Tatum, and M. J. Deesing. 1997. Bos indicus-cross feedlot cattle with excitable temperaments have tougher meat and a higher incidence of borderline dark cutters. Meat Sci. 46(4): 367-377.

Weeks, C. A., P. W. McNally, and P. D. Warriss. 2002. Influence of the design of facilities at auction markets and animal handling procedures on bruising in cattle. Vet. Rec. 150(24): 743-748.

Winer, L. K., P. J. David, C. M. Bailey, M. Read, T. P. Ringkob, and M. Stevenson. 1981. Palatability characteristics of the longissimus muscle of young bulls representing divergent beef breeds and crosses. J. Anim. Sci. 53(2): 387-394.

Wythes, J. R., J. C. Horder, J. W. Lapworth, and R. C. Cheffins. 1979. Effect of tipped horns on cattle bruising. Vet. Rec. 104(17): 390-392.

Yeh, E., B. Anderson, P. N. Jones, and F. D. Shaw. 1978. Bruising in cattle transported over long distances. Vet. Rec. 103(6): 117-119.

Chapter 2 - Intact male cattle have superior performance versus male cattle castrated at 16 months of age with no difference in meat quality

Youngers, M.E‡., S.J. Bartle*, D.N. Rethorst‡, C.D. Reinhardt†, M.G. Siemens§, and D.U. Thomson‡

‡Diagnostic Medicine and Pathobiology, Kansas State University, Manhattan, KS 66506

*Beef Cattle Institute, Kansas State University, Manhattan, KS 66506

†Animal Science and Industry, Kansas State University, Manhattan, KS 66506

§Cargill Meats Solutions, Wichita, KS 67202

Abstract

Sixteen month old Angus bulls (n = 24; 606 + 11.4 kg) were stratified by weight and randomly assigned to 1 of 2 treatments: intact control (BULL) and castrated with growth promotion technology (STR) to evaluate performance and meat quality. Cattle assigned to STR treatment were implanted with 120 mg trenbolone acetate (TBA) and 24 mg estradiol on d 0, and were fed ractopamine hydrochloride (300 mg/d) the final 28 d prior to slaughter. Cattle were fed a dry-rolled corn-based finishing diet (1.41 Mcal/kg NEg) for 62 d (final wt = 697 +/- 24.3 kg) then harvested at a commercial abattoir. Carcass characteristics were recorded and Longissimus muscle samples were obtained. There were no differences between treatments for quality grade, yield grade, HCW, back fat thickness, or dressing percent. Longissimus muscle area (LMA) was greater in BULL compared to STR carcasses (106.9 vs. 96.8 cm^2; P < 0.01). Steak tenderness values based on Warner Bratzler shear force (WBSF) and sensory panel evaluation showed no difference (P > 0.07) between BULL and STR steaks in myofibrillar tenderness, juiciness, beef flavor intensity, connective tissue, overall tenderness, and off flavor intensity. Cattle in BULL treatment tended to have greater ADG (1.85 vs. 1.45 kg; P = 0.07) and G:F (0.12 vs 0.09 kg; P = 0.06) BULL vs. STR treatment respectively. Feed intake (P = 0.90) did not differ between treatments. Cattle within the BULL treatment tended to have improved performance with no difference in carcass characteristics, WBSF, or sensory panel measurements compared to STR administered growth promotion technology. Feeding bulls could eliminate an animal welfare concern while removing the cost and management of growth promotion technology administration. This study suggests that no differences detected between treatments for WBSF and sensory panel, castration may be unnecessary procedure for this age group of bulls.

Introduction

Castration is a common painful procedure, especially in physiologically mature male cattle, and is being questioned by the public as an animal welfare concern. Bulls have greater gain and performance than steers (Ford and Gregory, 1983; Cross et al., 1984; Gregory et al., 1985). However, a bull's ability to gain efficiently and produce a leaner carcass, with more value to the packer and retailer, is over-shadowed by the perception that meat from bulls is less tender than meat from steers (Ntunde et al., 1977; Gregory et al., 1985).

A portion of yearling bulls raised for breeding purposes fail the breeding soundness exam (Bruner et al., 1995). A portion of these bulls are routinely castrated, fed a grain diet, and then slaughtered for meat. Reasons given for castration are to prevent discounts at slaughter, improve carcass quality, and to reduce aggressive behavior (Arthaud et al., 1977; Tarrant, 1981). Other factors, such as genetic advances and feeding to heavier weights at a younger age improve carcass quality and palatability (Arthaud et al., 1969). Improved genetics, technologies, and feeding to heavier weights at younger ages also have the potential to improve carcass characteristics in steers and heifers. However, technological advances such as steroid implants and beta adrenergic agonists (BAA), which improve feed efficiency and growth rates, may have negative impacts on carcass quality, eating experience, and shear force (Garmyn and Miller, 2014).

With the potential animal welfare benefits and the increasing demand for meat there is a need to explore the option of feeding of intact males. The objectives of this study were to

explore if there are carcass quality differences or performance benefits to castrating or not castrating yearling bulls that are not fit for reproduction purposes.

Materials and Methods

Study procedures were approved by the Institutional Animal Care and Use Committee at Kansas State University (No. 3390).

The study was conducted at Kansas State University from June through August 2014. Upon arrival, Red Angus and Black Angus bulls (n = 30) were vaccinated against BVD, IBR, PI3, and BRSV (Pyramid 5; Boehringer Ingelheim, St. Joseph, MO), clostridum perfingens types C and D, and were given tetanus toxoid (Cavalry 9; Merck Animal Health, Millsboro, DE) and received an antiparasitic pour-on (Cydectin; Boehringer Ingelheim, St. Joseph, MO). Twenty-four of the 30 purebred bulls were selected based on weight uniformity. Selected bulls averaged 16 mo of age, and 606 ± 11.4 kg BW. Bulls were divided into groups by breed, and were stratified by weight within breed groups. Bulls were then randomly assigned within breed and weight to treatment and pen, so that breed distribution was similar among pens. Treatments included: intact (BULL) or castrated with addition of growth-promoting technologies (STR). There were 4 animals of the same treatment per pen. Cattle were fed in a Calan Gate individual animal feeding system in 6 outdoor dirt-floor pens approximately 18 m x 3.6 m with 5 gates per pen. One gate in each pen was locked open to allow for ad libitum access to water while the remaining 4 gates allowed individuals to have ad libitum access to feed. Cattle were acclimated to the pens and Calan Gate feeders for 26 d prior to trial initiation.

On study d 0 all cattle were weighed prior to feeding. Animals assigned to the STR treatment were subsequently castrated using a Callicrate bander (No-Bull enterprises, St. Francis, Kansas) and implanted with 120 mg of trenbolone acetate (TBA) and 24 mg of estradiol implant (Revalor-S, Merck Animal Health, Millsboro, DE). The last 28 d of feeding, the STR cattle were fed 0.45 kg/d of a pellet containing 660 mg/kg ractopamine hydrochloride (Optaflexx, Elanco Animal Health, Greenfield, IN) to provide 300 mg ractopamine hydrochloride. Cattle in the BULL treatment were not implanted and were fed a similar amount of a placebo pellet the last 28 d on feed. The placebo and BAA pellet consisted of corn, alfalfa meal, and liquid molasses.

Cattle were fed a rolled-corn based finishing diet for 62 d (Table 1). Diet samples were taken monthly to evaluate nutrient composition. Feed was delivered daily by 0800, with residuals collected and weighed prior to feed delivery. Cattle were weighed every 14 to 17 d prior to morning feeding. On d 35, the BAA or placebo pellet was introduced and fed for the remaining 28 d. On d 62, cattle were transported 4 h to a commercial abattoir. During lairage, animals from the same treatment were penned together to avoid pre-slaughter stress.

Thirty-six h post-mortem longissimus muscle samples 5.08 cm thick were taken from the left and right side of each carcass at the 12th rib. Longissimus muscle samples were vacuum sealed, placed on ice, and transported to Kansas State University meats lab for storage at 4°C. All other carcass data was collected at the abattoir.

Longissimus Muscle Preparation

Samples were aged 14 d postmortem at 4°C. Longissimus muscle samples were divided into right and left side groups, the right side was used to conduct Warner-Bratzler Shear Force test (WBSF) and left side was used to perform sensory panel evaluation. Samples for the sensory panel were frozen at -40°C after 14 d of aging, until the evaluations were completed. Samples for the WBSF test were cut to 2.54 cm thickness steaks and cooked in a gas-fired, forced-air-convection oven (Blodgett, Model DFG-102 CH3 G.S. Blodgett Co., Burlington, VT, USA) at 163°C. Copper-constantan thermocouples (Omega Engineering, Stamford, CT) were placed in the geometric center of the steak and steaks were cooked to an internal temperature of 71.1°C.

Warner-Bratzler Shear Force

After cooking, steaks were covered with polyvinyl chloride film and cooled to 2°C for 24 h according to AMSA (1995) procedures. Eight round cores per steak were collected parallel to the long axis of the muscle fibers using a coring machine. All 8 cores from all steaks were sheared through the middle using a Warner-Bratzler shear V-notch blade attached to an Instron Universal Testing Machine (Model 4201, Instron Corp., Canton, MA).

Sensory Panel

Samples were thawed at 4°C for 24 h then cut into 2.54 cm thickness steaks and cooked in a gas-fired, forced-air-convection oven (Blodgett, Model DFG-102 CH3 G.S. Blodgett Co., Burlington, VT, USA) at 163°C with a copper-constantan thermocouples (Omega Engineering, Stamford, CT) placed in the geometric center of the steak and cooked to an internal temperature

of 71.1°C. Samples were presented in a randomized order to each of the 8 to 10 panelists. The sensory panel was conducted over 3 d. Each sample was given a score (1 =being extremely undesirable; 8=extremely desirable) for each category: myofibrillar tenderness, juiciness, flavor intensity, overall tenderness, off flavor, and connective tissue amount. All scores were averaged for each steak and that mean value was used for statistical analysis.

Carcass and live animal data were analyzed using PROC GLIMMIX (SAS 9.3) with treatment, breed, and age as independent variables and pen as a random effect. Breed and age were not significant for any variable and were dropped from the model. Sensory panel scores were averaged for each individual animal and averages were used for analysis. Significance for all variables was defined as $P < 0.05$ and a trend as $P < 0.10$. Means were separated using the Tukey's test for least significant difference as measured using the Diff option in Glimmix.

Results

Cattle in the BULL treatment tended to have greater ADG (1.85 vs. 1.45 kg/d $P = 0.07$) and had greater feed efficiency (0.12 vs. 0.09 kg gain/kg feed $P = 0.06$) than cattle in the STR treatment. There was no difference in DMI between treatments ($P = 0.90$).

No differences were observed between treatments for HCW ($P = 0.36$), yield grade ($P = 0.15$), quality grade ($P = 0.30$), marbling score ($P = 0.98$) dressing percent ($P = 0.99$), or back fat thickness ($P= 0.85$). Cattle in the BULL treatment had greater longissimus muscle area than the STR group (106.9 vs. 96.8 cm^2; $P = 0.01$), with a score of moderate marbling. Treatment had very little effect on palatability and tenderness of the longissimus muscle samples for the 2

38

treatments. There was no difference found between groups for shear force tenderness (P = 0.10),

connective tissue amount (P = 0.15), and myofibrillar tenderness (P = 0.42). The remainder of

the categories from the sensory panel were also not different; beef flavor intensity (P = 0.83),

juiciness (P = 0.25), and off flavor intensity (P = 0.84). STR tended to have a more desirable

overall tenderness compared to the BULL treatment (5.26 vs. 5.53; P = 0.07).

Discussion

This study compared feeding bull, using the benefits from natural endogenous growth

promoting compounds, to the benefits from BAA and TBA implants on yearling, castrated,

culled bulls. These mature bulls are at the greatest risk for animal welfare concerns due to the

emotional and physical stressors castration imposes. Previous researchers have evaluated

performance benefits from natural testosterone that bulls possess in bulls at younger ages than

this study.   In the recent study the BULL treatment grew 25% faster while not consuming a

greater amount of feed during the experiment compared to the STR treatment, even though the

STR treatment was implanted and fed a BAA. Performance outcomes agree with Ford and

Gregory (1983) where bulls outperformed steer counterparts. Additionally Worrell, M.A et al.

(1987) found young bulls castrated at 410 kg, were less efficient than bulls castrated at a younger

age.

It is often stated that technologies are intended to replace the testosterone lost due to

castration. Researchers have investigated implanting bulls with TBA and estrogens to enhance

performance. Hunt et al. (1991) reported no performance benefits observed by implanting bulls.

These results agree with Lee et al. (1990) who showed implanting bulls resulted in no advantage

to weight gain over 12 mo of age. Beta adrenergic agonists are not approved for commercial use in bulls, and there has been limited research using the product in bulls.

Carcass quality is an important factor in consumer acceptability and profitability for the beef industry. Feeding bulls is shadowed by the industry perception that their meat is less acceptable and of lower quality then steers. However technology is also known to impact carcass quality. Exogenous hormones given to steers in the form of implants have similar effects on carcass characteristics as endogenous hormones that come from testes in intact males (Schoonmaker et al., 2002). This study was a comparison between meat produced from today's genetics represented by Angus and Red Angus bulls and meat produced from steers with similar genetics and using today's technologies. No differences were observed between the STR and BULL treatments for tenderness, juiciness, flavor, and overall acceptability, indicating that castration did not benefit the STR treatment's carcass quality. These results agree with Hunt et al. (1991) who reported bulls have similar carcass characteristics as aggressively implanted steers.

Miller et al. (2001) stated tenderness is the most important factor influencing consumer satisfaction for beef palatability and the ability of the consumer to evaluate tenderness levels is important in establishing the value of beef. In this study WBSF tenderness and the subjective taste panel tenderness were not different for the BULL and STR treatments. Increased focus on carcass quality, especially in earlier maturing breeds including Angus and Hereford provide 12 to 16 mo old bulls the potential to compete with steers in the market place for desirability carcass.

Genetic carcass characteristics should be taken into consideration when seed stock operators are determining a production route for yearling non-breeding potential bulls.

As in all studies there are limitations; bulls entered the trial at 16 mo of age, which was older than targeted. Castration of bulls at an earlier age and subsequent earlier slaughter would have better imitated the industry standard. Heaton et al. (2006) found castrating bulls after 243 kg has negative impacts on carcass quality, including tenderness, juiciness, flavor, and overall acceptability. Because of the age and weight of the cattle, they were slaughtered after a short feeding period. Feeding the cattle longer may have reduced the negative effects of the implant on carcass quality. Pre-trial power calculations indicated the number of animals used would be adequate to determine the effects of castration and technologies on carcass quality and characteristics, but not on performance.

This study was conducted to imitate a production chain for yearling bulls that are not bound for reproductive purposes. Results indicate castration and technologies did not add a carcass quality advantage for the STR group and suggest that feeding Angus bulls that fail their final breeding soundness exam as intact males produces acceptable carcass characteristics and eliminates a painful procedure. These attributes provide an animal welfare conscious and quality product for consumers.

References

Arthaud, V. H., C. H. Adams, D. R. Jacobs, and R. M. Koch. 1969. Comparison of carcass traits of bulls and steers. J. Anim. Sci. 28: 742-745.

Arthaud, V. H., R. W. Mandigo, R. M. Koch, and A. W. Kotula. 1977. Carcass composition, quality and palatability attributes of bulls and steers fed different energy levels and killed at four ages. J. Anim. Sci. 44(1): 53-64.

AVMA. 2014. Literature Review on the Welfare Implications of Castration of Cattle. https://www.avma.org/KB/Resources/LiteratureReviews/Documents/castration-cattle-bgnd.pdf

Bruner, K. A., R. L. McCraw, M. D. Whitacre, and S. D. v. Camp. 1995. Breeding soundness examination of 1,952 yearling beef bulls in north carolina. Theriogenology. 44(1): 129-145.

Coetzee, J. F. 2013. Assessment and management of pain associated with castration in cattle. Veterinary Clinics of North America, Food Animal Practice. 29(1): 75-101.

Cross, H. R., B. D. Schanbacher, and J. D. Crouse. 1984. Sex, age and breed related changes in bovine testosterone and intramuscular collagen. Meat Sci. 10(3): 187-195.

Field, R. A. 1971. Effect of castration on meat quality and quantity. J. Anim. Sci. 32(5): 849-858.

Ford, J. J., and K. E. Gregory. 1983. Effects of late castration and zeranol on feedlot performance and carcass characteristics of bovine males. J. Anim. Sci. 57(2): 286-291.

Garmyn, A. J., and M. F. Miller. 2014. Meat science and muscle biology symposium - implant and beta agonist impacts on beef palatability. J. Anim. Sci. 92(1): 10-20.

Gregory, K. E., J. J. Ford, S. C. Siedeman, and W. G. Hays. 1985. Effects of late castration and zeranol on growth rate, feed efficiency and carcass and meat traits of bovine males. Beef Research Progress Report, Roman L.Hruska US Meat Animal Research Center. (2): 36-40.

Heaton, K., D. R. Zobell, and D. Cornforth. 2006. A successful collaborative research project: Determining the effects of delayed castration on beef cattle production and carcass traits and consumer acceptability. Journal of Extension. 44(2): 2RB5.

Hunt, D. W., D. M. Henricks, G. C. Skelley, and L. W. Grimes. 1991. Use of trenbolone acetate and estradiol in intact and castrate male cattle: Effects on growth, serum hormones, and carcass characteristics. J. Anim. Sci. 69(6): 2452-2462.

Lee, C. Y., D. M. Henricks, G. C. Skelley, and L. W. Grimes. 1990. Growth and hormonal response of intact and castrate male cattle to trenbolone acetate and estradiol. J. Anim. Sci. 68(9): 2682-2689.

Miller, M. F., M. A. Carr, C. B. Ramsey, K. L. Crockett, and L. C. Hoover. 2001. Consumer thresholds for establishing the value of beef tenderness. J. Anim. Sci. 79(12): 3062-3068.

Ntunde, B. N., W. R. Usborne, and G. C. Ashton. 1977. Estimation of wholesale cuts and separable lean of carcasses from holstein-friesian bulls and steers fed to a constant finish. Canadian Journal of Animal Science. 57(4): 761-768.

Schoonmaker, J. P., S. C. Loerch, F. L. Fluharty, T. B. Turner, S. J. Moeller, J. E. Rossi et al. 2002. Effect of an accelerated finishing program on the performance, carcass characteristics and circulating insulin-like growth factor I concentration of early-weaned bulls and steers. J. Anim. Sci. 80(4): 900-910.

Tarrant, P. V. 1981. A survey of the incidence, causes and economic consequences of dark-cutting in beef. Irish Journal of Food Science and Technology. 5(1): 80-81.

Zhao, Q., M. E. Davis, and H. C. Hines. 2004. Associations of polymorphisms in the pit1 gene with growth and carcass traits in angus beef cattle. J. Anim. Sci. 82(8): 2229-2233.

Table 2-1. Finishing Diet Composition

Ingredient	% of DM
Corn grain, cracked	58.5
Dried Distiller's grains plus solubles	21.5
Cottonseed hulls	12.3
Molasses, cane	2.5
Supplement pellet[2]	5.2
Chemical composition, DM basis[3]	
Dry matter, %	86.6
Crude protein, %	13.8
NEm, Mcal/kg	2.07
NEg, Mcal/kg	1.41
Calcium, %	0.90
Phosphorus, %	0.45

Table 2-2. Top Dress Pellet Composition

Ingredient	% of Composition
Corn grain, ground	90.0
Alfalfa Meal	6.0
EZ GLO Molasses	4.0

Table 2-3. Performance and Carcass Characteristics Least Square Means and Standard Errors of the Means

	Treatments			
Item	BULL[a]	STR[b]	SEM[c]	P-Value
Initial wt., kg	602	609	1.6	0.65
Final wt., kg	705	689	25.3	0.30
Daily gain, kg	1.85	1.45	0.21	0.07
DMI, kg	15.8	15.9	1.04	0.90
G:F	0.12	0.09	0.012	0.06
HCW, kg	446	434	19.3	0.36
Dressing percentage	63.74	63.73	0.7	0.99
LMA, cm^{2d}	106.9	96.8	3.7	< 0.001
Backfat thickness, cm	1.04	1.02	0.1	0.85
Yield grade	2.73	3.08		0.15
Quality grade	Low Choice	Low Choice		0.34
Marbling score[e]	502	502		0.98

[a]BULL is defined as intact males given no technologies, values are the least square means with the appropriate standard error of the mean (SEM)

[b]STR is defined as steers given technologies, values are the least square means with the appropriate SEM

[c]Standard Error of Mean

[d]Longissimus Muscle Area

[e]Marbling score 500=modest

Table 2-4. Sensory Panel Analysis and Warner-Bratzler Shear Force Test Least Square Means and Standard Error of Means.

Traits	Treatment BULL[a]	STR[b]	SEM[c]	P-value
Juiciness[d]	5.22	5.03	0.13	0.29
Overall tenderness[e]	5.26	5.53	0.10	0.07
Beef flavor intensity[f]	5.27	5.24	0.21	0.86
Connective tissue amount[g]	5.93	6.22	0.41	0.15
Myofibrillar tenderness [h]	5.23	5.42	0.18	0.45
Off flavor intensity[i]	7.66	7.63	0.22	0.81
Warner-Bratzler Shear Force[j], kg	4.8	4.3	0.21	0.1

[a]BULL is defined as intact males given no technologies, values are the least square means with the appropriate standard error of the mean (SEM)

[b]STR is defined as steers given technologies, values are the least square means with the appropriate SEM

[c]Standard Error of Mean

[d]8 = Extremely juicy, 7 = very juicy, 6 = moderately juicy, 5 = slightly juicy, 4 = slightly dry, 3 = moderately dry, 2 = very dry, 1 = extremely dry

[e]8 = Extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, 1 = extremely tough

[f]8 = Extremely intense, 7 = very intense, 6 = moderately intense, 5 = slightly intense, 4 = slightly bland, 3 = moderately bland, 2 = very bland, 1 = extremely bland

[g]8 = None, 7 = practically none, 6 = traces, 5 = slight, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant

[h]8 = Extremely tender, 7 = very tender, 6 = moderately tender, 5 = slightly tender, 4 = slightly tough, 3 = moderately tough, 2 = very tough, 1 = extremely tough

[i] 8 = None, 7 = practically none, 6 = traces, 5 = slight, 4 = moderate, 3 = slightly abundant, 2 = moderately abundant, 1 = abundant

[j]Kg/3.2 cm^2

Chapter 3 - Prevalence of Horns and Bruising in Feedlot Cattle at Slaughter

M. E. Youngers‡, J. C. Simroth‡, S.J. Bartle*, C.D. Reinhardt†, M.G. Siemens§, and D.U. Thomson‡

‡Diagnostic Medicine and Pathobiology, Kansas State University, Manhattan, KS 66506

*Beef Cattle Institute, Kansas State University, Manhattan, KS 66506

†Animal Science and Industry, Kansas State University, Manhattan, KS 66506

§Cargill Meats Solutions, Wichita, KS 67202

Abstract

Carcasses from (n = 4,287) feedlot cattle were observed at one commercial beef packing plant in southwest Kansas to investigate the relationship between the presence and size of horns in cattle and the prevalence, anatomical location, and severity of bruising of carcasses. Horn measurements and bruise scoring were performed by 3 trained evaluators. Horn measurements taken were the length of the longest horn from base to tip and the tip-to-tip distance between the tips of both horns. Bruises were evaluated by location and severity. Bruise severity was scored at 3 levels: minor: ≤ 5 cm, moderate: 5 to 15 cm, and severe: > 15 cm. Within pen lots of cattle, the percentage of cattle with horns ranged from 0 to 26%. Average single horn length was 11.2 cm (range = 3.0 to 28.0 cm), and average distance from horn tip to horn tip was 39.6 cm. There were 4,287 carcasses evaluated and 2,295 had one or more bruises for a total, overall bruise prevalence of 53.5%. Of the total number of bruises, 25.6% were severe, 35.6% were moderate, and 38.8% were minor. The majority of bruises (61.8%) occurred on the dorsal mid-line with similar rates of bruising occurring on the left (18.6%) and right (19.5%) sides. The prevalence of bruising on the caudal third (21.8%) was a third of the prevalence of bruising that occurred on the center third (60.5%) and anterior third (17.6%) portions. There was no relationship found between the prevalence of horns and prevalence of bruising in a pen lot of cattle ($P = 0.90$). Additional data is needed to further evaluate the relationships between cattle with horns and carcass bruising. Further research during handling including loading and unloading techniques, transportation practices, and trailer design is also needed to effectively reduce the incidence of carcass bruising.

Introduction

Two animal welfare concerns in the beef industry today are painful surgeries such as dehorning and bruising of cattle during handling. Disbudding and dehorning are used to remove horns from cattle and to prevent injury to handlers, injury to other cattle, and bruising of carcasses. Another practice used to reduce the length of horns is called "tipping" and is considered less painful than dehorning (Wythes et al., 1985; Neely et al., 2014) because it is performed at the insensitive end of the horn. However, even horns which have been tipped are a concern for cattle welfare, carcass bruising, and handler safety due to the remaining portion of the horn (USDA, 2013). Tipping, dehorning, and disbudding are associated with pain and distress and are of animal welfare concern (AVMA, 2014).

Cattle with horns cause circular shaped bruising (Shaw et al., 1976), increased hide damage of cohorts, and injury to handlers (Rickenbacker, 1959; Bisschop, 1961; Sutton et al., 1967). Carcass bruising is an indicator of suboptimal cattle handling and an animal welfare concern (Jarvis et al., 1996) which causes a reduction in profit due to trim loss, sanitation risk from excessive trimming, and loss in time. Wythes et al. (1985) evaluated bruising due to horn status of cohorts, and reported that groups of horned cattle had more carcass bruises than groups of non-horned cattle.

According to the 1995 National Beef Quality Audit, carcass bruising costs the beef industry $4.03 for every fed animal marketed (NBQA, 1995), equating to $114 million per year, which represents an important economic loss both for the packer and the feedlot owner. Thus, the objective of this study was to investigate what relationship exists between the presence and

size of horns in beef cattle and the prevalence, anatomical location, and severity of bruising on beef carcasses.

Materials and Methods

Carcasses from 4,287 feedlot cattle from 27 lots of cattle, originating from 13 different feedlots in Texas and Kansas were observed at a commercial packing plant in southwest Kansas. Observations were made over 3 separate days. Cattle represented normal populations commonly received at the abattoir and included heifers and steers, as well as Holstein and beef breeds. Data collections took place during February, March and December of 2014. All measurements were taken at chain speed, and carcass ID tags applied by the abattoir were used to identify and track carcasses. All carcasses were evaluated for presence or absence of horns and were subsequently evaluated for presence and location of bruising after the hides had been completely removed.

The observation and recording of bruises was done by a single trained observer for all collection days. Carcasses were scored after the hide and head were removed and at a location in the slaughter plant where the moving carcasses made a 90° turn, which allowed the observer to have a multiple angle view of the carcass to fully evaluate all sides of the carcass. Bruise location and severity were scored using criteria developed by the Beef Cattle Institute as part of the Harvest Audit Program (HAP; Rezac et al., 2014). The location of the bruises on the carcass was determined by a 9 region diagram of the carcass (Figure 1). The severity of the bruises was recorded as: minor (-) = ≤5.1 cm", moderate (0) 5.1 to 15.2 cm", and severe (+) = >15.2 cm" (Rezac et al., 2014).

If a carcass had multiple bruises in multiple regions, each individual bruise location and severity was recorded. If multiple bruises were found a single one region, only the most severe bruise was recorded. If a bruise occurred along the dividing line of 2 regions, the region that contained the majority of the bruise, subjectively determined, was recorded.

All horn and bruising data were recorded and subsequently transferred from the paper data sheets to Excel, and were verified for accuracy by a second party. Prevalence of horns was determined by dividing the total number of horned cattle within each lot by the total number of all cattle in the same lot. Prevalence of bruising was determined by dividing the number of cattle in a lot with bruises by the total number of cattle in the lot. The relationship between the prevalence of horns and the prevalence of bruises within a lot was determined using a regression procedure in SAS version 9.3. Lot was the experimental unit. The relationship between the prevalence of bruising in and lot and the prevalence of horns in the same lot was considered significant for a $P \le 0.05$.

Results

Out of a total of 4,287 cattle, 291 animals had horns (6.8%); the average pen lot prevalence of cattle with horns was 6% across all 27 lots of cattle (range = 0 to 26%). The average length of a single horn was 11.2 cm (range = 3.0 to 28.0 cm). The average distance from tip-to-tip was 39.6 cm (range = 14.0 to 66.0 cm).

Of the total 4,287 carcasses evaluated 2,293 had one or more bruises (53.5%), with a range of 0 to 99% bruised carcasses in all pen lots. The distribution of bruises over the carcasses

showed the dorsal midline was the most frequently bruised portion (61.8% of total bruises).

Region 5 (Figure 1) was the most frequently bruised region, accounting for 33.6% of all bruises.

The remaining bruises were distributed throughout the left and right side of the carcasses (19.5

and 18.6%, respectively). Of the 4,094 individual bruises recorded, 38.8% were classified as

minor, 35.6% as moderate, and 25.6% were classified as severe. No relationship was found

between the prevalence of horns and prevalence of bruises within pen lots ($P = 0.90$; Figure 2).

Discussion

The mean prevalence of carcass bruises for all causes and severity reported in this study

was 53.5%. That is greater than the prevalence of bruising reported in the National Beef Quality

Audit conducted in 2011(23%, NBQA, 2011). However, similarities region of the carcass where

most bruising was observed was similar between the current study and the NBQA (2011)

surveillance study with the most bruises occurring on the dorsal midline. Prevalence of horns

found in this study (6%) was different from the prevalence found in the 2011 NBQA study

(23.8%). The difference in size and geographical locations of study populations, and of the

management of the feedlots supplying cattle to the slaughter plants could explain the differences

observed between the prevalence of bruising and of horns found in the 2 studies. However

according to the NBQA (2011) there has been a decrease in the prevalence of horns at the

packing plant from previous audits 1991, 1995, 2000, and 2005 (31.1. 32.2, 22.7, and 22.3%

respectively). Genetic selection toward cattle without horns could explain the continued

decrease in horn prevalence from the 2011 study to the current study.

Shaw et al. (1976) reported that trim loss due to bruising was almost double for groups of horned cattle verses lots of non-horned cattle (1.8 vs. 1.1 kg, respectively). Meischke et al. (1974) also recorded increased carcass bruising in horned cattle compared to non-horned cattle (1.6 verses 0.8 kg, respectively). In this study, no relationship was found between prevalence of horns and prevalence of bruises within lots of cattle.

Researchers have found other factors that contribute to carcass bruising. McCausland and Millar (1982) suggested that handling prior to slaughter has an effect on the prevalence of carcass bruising. Handling, loading, and travel prior to slaughter may all be sources of carcass bruising (Eldridge et al., 1984). During handling, cattle undergo changes to their social, physical, and emotional states. Conditions under which cattle are handled can be detrimental by causing stress or injury. Stressful or inappropriate handling leads to an increase in difficulty of handling (Eldridge et al., 1988). Confirmation that aggressive handling results in increased prevalence of carcass bruising was reported by Grandin (1981), in which cattle originating from feedlots which practice aggressive handling techniques had a greater prevalence of bruising than cattle from feedlots which practice low-stress handling techniques (15.5 vs. 8.4 %, respectively).

In light of the present study, and previous works on potential causative agents in carcass bruising, the industry practice of dehorning and tipping of calves or yearlings at feedyard processing needs to be reevaluated. There was an average of 6% of cattle with horns in all pen lots, but no relationship was observed between horned cattle prevalence within pen lot and the prevalence of carcass bruising. There is need to evaluate other causative agents in the production system. The potential animal welfare implications of dehorning and tipping at the feedyard may

not be justifiable when only considering the prevalence of carcass bruising at the time of transport to slaughter.

Benchmarking and reporting of carcass bruises by the NCBA has resulted in better management and a reduction in the prevalence of bruising. Carcass bruising has decreased in the United States beef industry as reported by the NCBA audits in 1991, 1995, 2000, and 2005 (39.2, 48.4, 46.7, and 35.2%, respectively). Carcass bruising causes both financial losses and an animal welfare concern for producers and packers alike. The financial losses are exacerbated because the most frequently bruised portion of the carcass is also the region of the carcass with the greatest economic value per unit of weight the rib and loin ($1.30 and $1.14/kg, respectively; USDA Daily Boxed Beef, 2015).
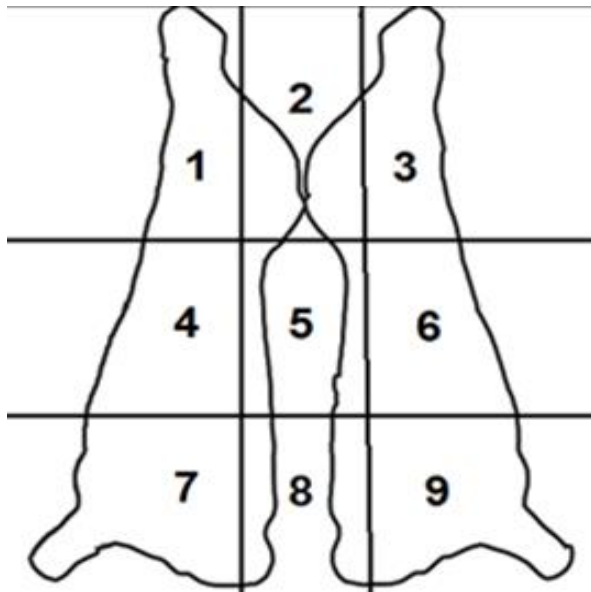
Conclusion

The current study did not find a relationship between the prevalence of horned cattle within a lot and subsequent prevalence of carcass bruising within those same lots. Further research is needed to ensure painful production practices such as dehorning, disbudding, and tipping are beneficial to the beef industry. However, in light of the data herein, areas that should be revisited by researchers include animal handling facility design, cattle trailer design, and animal handling practices.

References

AVMA. 2014. Literature Review on the Welfare Implications of the Dehorning and Disbudding of Cattle. https://www.avma.org/KB/Resources/LiteratureReviews/Documents/dehorning_cattle_bgnd.pdf

Bisschop, J. H. R. 1961. Transportation of animals by rail. I. the behaviour of cattle during transportation by rail. J. S. Afr. Vet. Med. Assoc. 32: 235-268.

Eldridge, G. A., J. L. Barnett, I. P. McCausland, H. W. C. Millar, and W. J. Vowles. 1984. Bruising and method of marketing cattle. Animal Production in Australia. 15: 675.

Eldridge, G. A., C. G. Winfield, and D. J. Cahill. 1988. Responses of cattle to different space allowances, pen sizes and road conditions during transport. Aust. J. Exp. Agric. 28(2): 155-159.

Jarvis, A. M., L. Selkirk, and M. S. Cockram. 1995. The influence of source, sex class and pre-slaughter handling on the bruising of cattle at two slaughterhouses. Livest. Prod. Sci. 43(3): 215-224.

Jarvis, A., C. Messer, and M. Cockram. 1996. Handling, bruising and dehydration of cattle at the time of slaughter. Anim. Welfare. 5(3): 259-270.

Kent, J. E., and R. Ewbank. 1986. The effect of road transportation on the blood constituents and behaviour of calves. II. one to three weeks old. Br. Vet. J. 142(2): 131-140.

Lyles, J. L., and M. S. Calvo-Lorenzo. 2014. Bill e. Kunkle interdisciplinary beef symposium: Practical developments in managing animal welfare in beef cattle: What does the future hold? J. Anim. Sci. 92(12): 5334-5344.

McCausland, I. P., and H. W. C. Millar. 1982. Time of occurrence of bruises in slaughtered cattle. Aust. Vet. J. 58(6): 253-255.

McKeith, R. O., G. D. Gray, D. S. Hale, C. R. Kerth, D. B. Griffin, J. W. Savell et al. 2012. National beef quality audit-2011: Harvest-floor assessments of targeted characteristics that affect quality and value of cattle, carcasses, and byproducts. J. Anim. Sci. 90(13): 5135-5142.

Mcmanus, D., and J. M. Grieve. 1964. Bruising of cattle stock for slaughter. Vet. Rec. 76: 84-85.

McNally, P. W., and P. D. Warriss. 1996. Recent bruising in cattle at abattoirs. Vet. Rec. 138(6): 126-128.

Meischke, H. R., W. R. Ramsay, and F. D. Shaw. 1974. The effect of horns on bruising in cattle. Aust. Vet. J. 50(10): 432-434.

Neely, C. D., D. U. Thomson, C. A. Kerr, and C. D. Reinhardt. 2014. Effects of three dehorning techniques on behavior and wound healing in feedlot cattle. J. Anim. Sci. 92(5): 2225-2229.

Nicholson, J. D. W., K. L. Nicholson, L. L. Frenzel, R. J. Maddock, R. J. Delmore Jr., T. E. Lawrence et al. 2013. Survey of transportation procedures, management practices, and health assessment related to quality, quantity, and value for market beef and dairy cows and bulls. J. Anim. Sci. 91(10): 5026-5036.

Ramsay, W. R., H. R. Meischke, and B. Anderson. 1976. The effect of tipping of horns and interruption of journey on bruising in cattle. Aust. Vet. J. 52(6): 285-286.

Rezac, D. J., D. U. Thomson, M. G. Siemens, F. L. Prouty, C. D. Reinhardt, and S. J. Bartle. 2014. A survey of gross pathologic conditions in cull cows at slaughter in the great lakes region of the united states. J. Dairy Sci. 97(7): 4227-4235.

Rickenbacker, J. E. 1959. Handling conditions and practices causing bruises in cattle. Marketing Research Report.United States Department of Agriculture. (346): 46.

Shaw, F. D., R. I. Baxter, and W. R. Ramsay. 1976. The contribution of horned cattle to carcase bruising. Vet. Rec. 98(13): 255-257.

Sutton, G. D., P. D. Fourie, and J. S. Retief. 1967. The behaviour of cattle in transit by rail. J. S. Afr. Vet. Med. Assoc. 38: 153-156.

Tarrant, P. V., F. J. Kenny, D. Harrington, and M. Murphy. 1992. Long distance transportation of steers to slaughter: Effect of stocking density on physiology, behaviour and carcass quality. Livest. Prod. Sci. 30(3): 223-238.

Wythes, J. R., J. C. Horder, J. W. Lapworth, and R. C. Cheffins. 1979. Effect of tipped horns on cattle bruising. Vet. Rec. 104(17): 390-392.

Wythes, J., R. Kaus, and G. Newman. 1985. Bruising in beef-cattle slaughtered at an abattoir in southern queensland. Aust. J. Exp. Agric. 25(4): 727-733.

USDA. 2013. Feedlot 2011, part I: Management practices on U.S. feedlots with a capacity of 1000 or more head. http://www.aphis.usda.gov/animal_health/nahms/feedlot/downloads/feedlot2011/Feed11_dr_PartI.pdf

USDA. 2015. Daily boxed beef report.http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3102138 http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELDEV3102138

Figure 3-1. The Harvest Audit Program Carcass Diagram

1 = right hind limb, 4 = right barrel, 7 = right forelimb. On the midline of the carcass, 2 = midline tailhead, 5 = midline thoracic cavity, 8 = midline shoulder and top of neck, and on the left side of the carcass, 3 = left hind limb, 6 = left barrel, and 9 = left forelimb.

Table 3-1. Lot (n=27) Bruising and horn descriptive statistics by lot for 4,287 beef cattle harvested at a single slaughter plant in southwest Kansas

Item	Average	Min	Max
Animals per Lot[a]	159	22	336
Bruised carcasses[b]	53.5	0	99.0
Horned Carcasses[c]	6.0	0	26.0

[a] Number of cattle observed per lot

[b] Percentages of bruised carcasses per lot

[c] Percentages of cattle with horns per lot

Table 3-2. Bruising prevalence by region for 4,287 beef cattle harvested at a single slaughter plant in southwest Kansas.

Region [a]	Percent of Total Bruises [b]
1	1.5
2	14.8
3	1.4
4	11.8
5	33.6
6	15.1
7	5.3
8	13.4
9	3.1

[a] Harvest Audit Program definitions

[b] Total bruises = 4,094

Table 3-3. Severity of bruises by region of the carcass for 4,287 beef cattle harvested at a single slaughter plant in southwest Kansas.

Region [a]	Percent of minor bruises [b]	Percent of moderate bruises [c]	Percent of severe bruises [d]
1	0.4	0.7	0.4
2	9.6	3.1	2.1
3	0.5	0.5	0.3
4	4.4	4.1	3.3
5	11.9	13.7	8.0
6	4.8	4.9	5.4
7	1.8	1.9	1.6
8	4.9	5.4	3.2
9	0.5	1.3	1.3
Total [e]	**38.8**	**35.6**	**25.6**

[a] Harvest Audit Program definitions

[b] Bruises defined as ≤ 5.1 cm

[c] Bruises defined as 5.1 to 15.2 cm

[d] Bruises defined as ≥ 15.2 cm

[e] Percentage of bruising by location of total bruises 4,094

Figure 3-2. Relationship between prevalence of bruising and prevalence of horns for 4,287 beef cattle harvested at a single slaughter plant in southwest Kansas.