Interactions of the Factors Affecting Cattle Grade/Performance

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Introduction

Because economic value of carcasses is dependent primarily on carcass weight and carcass quality, feedlot managers have an interest in factors associated with maximizing these two variables. The NRC (1996) proposes that body composition (fat and protein) and carcass characteristics of beef cattle at a specified percentage of mature body weight (BW) are fixed, which indicates that maturity, rather than other factors such as energy or nutrient intake, drives body composition (Owens and Gardner, 1999). However, if body composition at a specified percentage of mature BW is fixed, carcass characteristics should not be altered by dietary or other factors except for those associated with differences in age and mature BW. In contrast, numerous studies involving implants, β-adrenergic agonists, and compensatory growth indicate that body composition at a specified BW can be altered and, therefore, is not fixed (Owens and Gardner, 1999). In addition, several factors have been shown to alter carcass quality, including genetics/breed of cattle, sex of calf, age at castration, creep feeding, age at weaning, plane of nutrition and health during backgrounding, internal parasites, implant strategy, nutritional factors during finishing (grain source/processing/level, roughage source/level, byproducts feed, etc.), and the USDA Grader (subjective measure).

During the past three years the beef cattle industry has seen extended periods where all segments of the industry (cow/calf; stocker/backgrounder; feedlot; packer) were profitable (Corah and McCully, 2006). In addition, consumer demand appears to be maintained at a new price threshold. Because consumer dollars ultimately drive the beef cattle industry, meeting consumer demand/desires will continue to determine profitability in the future (Corah and McCully, 2006). Since 1999, the percent of USDA Prime and Choice carcasses has declined, and the percent of USDA Yield Grade 4 and 5 carcasses has increased (VetLife Benchmark Performance Program). This decline in carcass quality has become a concern. The 1995 National Beef Quality Audit identified inadequate tenderness, low overall palatability, and inappropriate USDA Quality Grade mix (mix of Prime, Choice, and Select product that could be used by end-users) as three of the top ten aggregate concerns among purveyors, retailers, restaurateurs, and packers involved in the audit (Smith et al., 1996); economic losses were estimated at $28.41 for every steer and heifer harvested in the United States in 1995 as a result of inadequate marbling (Smith et al., 1996). It is likely that no one factor is solely contributing to the decline in marbling, but numerous factors are having an effect. This presentation will address the degree to which various management and nutrition factors might be associated with carcass quality.

Management Factors That Influence Carcass Quality

Retained ownership, alliances, and vertically coordinated supply chains are becoming an increasingly larger percentage of cattle on feed, resulting in an estimated 50% or greater of the cattle in the U.S. trading outside of the cash market (Ritchie, 2002). As segments of the industry become more coordinated, it becomes increasingly important to understand the effects that management and nutrition in each segment has on all subsequent phases of production and final carcass value. Age, weight, physiological maturity, breed type, and body composition upon entering the feedlot phase are all factors that have been taken into account when predicting potential feedlot performance and carcass merit of feeder cattle (Coleman and Evans, 1986; Coleman et al., 1993; Hersom et al., 2004). In addition, cow nutritional status and subsequent milk production, early or normal weaning, creep-feeding, physical form of the diet (forage vs. concentrate), diet energy density, and initiation of concentrate feeding are all interrelated nutritional factors that may influence performance in the finishing phase as well as final carcass value.

Depending on biological type and price of corn, calves are generally placed on a growing diet after weaning to achieve adequate frame size and carcass weight before entering the feedlot for finishing. Although growing programs in the U.S. have a wide range of variation, the most common growing programs consist of the following types (McCurdy, 2006). Across the southern plains and the southeastern U.S., grazing systems are commonly used for growing programs during the winter. Cool season forages, including wheat pasture, are utilized to grow cattle to desirable weights for feedlot entry (Byers, 1982). On the northern plains and across the Midwest, where weather often does not allow winter grazing, harvested and ensiled crops such as corn silage are fed to growing cattle. Some cattle may go directly on to a high-concentrate diet immediately following weaning. High-concentrate diets may be fed at restricted levels in the growing phase to provide a desired rate of gain while allowing for lean tissue growth (Sip and Pritchard, 1991). Because of the variability in growing programs among different regions of the country and in diets that may consist of grazed or harvested forage and/or grain-based diets, performance and weight gain of cattle before and after feedlot entry may be vastly different (McCurdy, 2006).

Calf Age and Nutritional Plane

Numerous investigations have sought to determine the effects of nutrition and management throughout the production chain on deposition of marbling and subsequent carcass quality (Berger and Faulkner, 2003). Increases in marbling have been shown by starting cattle on high-concentrate rations at younger ages (Myers et al., 1999a; 1999b; Wertz et al., 2001, 2002); however, these cases dealt with calves that were early weaned and started on feed at very early ages (70 to 100 days of age). Wertz et al. (2002) evaluated the effect of weaning calves and growing them on forage compared to early-weaning calves and immediately placing them on a high-concentrate diet. Early-weaned heifer calves were approximately 20% more efficient at any marbling endpoint compared with older heifers that had grazed and were placed on feed later in life. In addition, at any given 12th-rib fat thickness, early-weaned calves had higher quality grades. In a similar study, Angus × Simmental heifer calves that were fed high-energy diets at 208 days of age or earlier deposited more marbling relative to 12th-rib fat than heifers of the same genetics that were finished as long yearlings (Wertz et al., 2001).

In normal-weaned calves (approximately 200 days of age), Faulkner et al. (1994) showed that creep feed energy source could affect carcass quality even when gains were similar when calves were on the creep feed. In their experiment, calves which had been fed a corn-based creep had higher marbling scores than calves which had been creep-fed soy hulls. In contrast, no difference in marbling score was observed in normal-weaned calves creep-fed high corn, high fiber, or no creep (Berger and Faulkner, 2003). Reasons for discrepancies are unclear, although Bruns (2006) suggested that if calves can sustain their normal growth curve without additional supplementation then creep feeding won't increase quality grade. However, if the calves are growing below their growth potential, due to inadequate nutrition, then creep feeding or early weaning should help their ability to grade. Even though early weaned calves generally have lower average daily gains in the finishing phase than yearlings, they are consuming excess calories early in life above their requirement for normal growth. Therefore, marbling (intramuscular fat) deposition might be greater compared with normal-weaned calves (Bruns, 2006).

Nutritional plane prior to finishing appears to have a minimal effect on total amount of protein deposition and primarily affects body composition through differences in fat deposition (Fox et al., 1972; Owens et al., 1995; Hersom et al., 2004). Sainz et al. (1995) observed that steers on energy-restricted diets had less fat for all carcass measures compared with steers that had been fed concentrate diets ad libitum, and restricted steers had a greater percentage of empty BW as protein. When reviewing the literature, it is important to determine if cattle from different nutritional backgrounds were slaughtered at the same days on feed, age, BW, or body composition (12th-rib fat).

Several authors have observed that when steers were slaughtered at a common BW, previous nutritional restriction during the growing phase decreased total body fat and markedly decreased 12th-rib fat depth (Fox et al., 1972; Carstens et al., 1991; Sainz et al., 1995). However, when fed to the same compositional endpoint, decreases in marbling due to the previous nutritional restriction have not been observed and final carcass marbling scores do not seem to be affected by restriction in the growing phase (Sainz et al., 1995; Klopfenstein et al., 1999; Hersom et al., 2004).

Animal Health

Many of the existing beef alliances require verification of some type of prior health or preconditioning program for feeder calves before they begin the finishing phase of production. With the demand for higher quality products, the increase in value-based marketing, and the increase in vertical coordination systems, both cow-calf producers and feedlot operators have become more in-tune to health management practices that have the potential to increase overall profitability. The health status of calves upon arrival to the feedyard has been shown to impact the efficiency of cattle in the feedyard, and also to affect the quality attributes of the cattle at slaughter. McNeill (1994, 1995, 1996, 1997, 1998) and Montgomery et al. (1984) documented that morbid cattle during the finishing phase of production had carcasses with a lower degree of marbling and subsequently lower USDA Quality Grades. Therefore, although the medical costs attributable to the treatment of bovine respiratory disease (BRD) are substantial (Martin et al., 1982; Perino, 1992), the economic impact of BRD on animal performance, carcass merit, and meat quality are likely even more devastating.

Morbidity rates account for approximately eight percent of all production costs without consideration of losses due to decreased performance (Griffen et al., 1995). McNeill et al. (1996) reported that "healthy" steers had greater daily gains and 12% more U.S. Choice carcasses than cattle identified as "sick" at some point during the finishing period. Gardner et al. (1999) showed that steers with lung lesions plus active lymph nodes had $73.78 less net return, of which 21% was due to medicine costs and 79% due to lower carcass weight (8.4% less) and lower quality grade (24.7% more U.S. Standards). This negative impact on carcass traits 200 days after receiving the cattle illustrates the importance of preventing BRD. Roeber et al. (2001) documented that although cattle treated more than once in the feedyard had lower marbling scores and hot carcass weights than those not treated, within a quality grade class, no differences for tenderness or palatability traits existed in cattle stratified by number of hospital visits or preconditioning treatment program. Other research establishing relationships among health management programs and subsequent morbidity rates and their effect on beef palatability traits is limited.

Growth Promoting Implants

Timing and potency of implants relative to slaughter date is thought to impact carcass quality. Pritchard (2000) compared the use of a low potency or a high potency implant administered early in the finishing phase. Cattle receiving a low potency implant (Ralgro) on day 1 followed by a high potency implant (Revalor-S) on day 56 graded greater than 60% USDA Choice, whereas cattle receiving a high potency implant, Synovex Plus or Revalor-S, on day 1 graded 43% and 51% USDA Choice, respectively. These results suggest that marbling development may occur early in the finishing phase and therefore early management decisions could alter percent U.S. Choice carcasses.

Growth promoting implants stimulate lean growth and increase frame size causing a shift in the animals physiological maturity which delays fattening. Bruns et al. (2005) tested the effect of implanting on marbling development. Angus and Limousin × Angus steer calves were backgrounded to a weight of 650 lb before being allotted to one of three treatments: 1) Control, non-implanted; 2) Early Implant, implanted with an estradiol-trenbolone acetate implant on day 1 weighing 650 lb; 3) Delayed Implant, implanted at 750 lb with an estradiol-trenbolone acetate implant on day 56. Steers receiving an implant at 650 lb at the beginning of the trial had lower marbling scores than Control steers, whereas those receiving an implant at 750 lb had marbling scores that were not different from Controls. Bruns (2006) suggested that when the implant was administered too early, cattle were depositing more muscle tissue and the calories that would normally support muscle and fat growth were needed to support the added muscle growth demanded by the implant. In contrast, the later implanted cattle were able to consume enough calories to meet the demand of both tissues, due to increased feed intake at the time of implanting. A sample set of steers was harvested from each treatment at 650 and 750 lb to develop regression lines for marbling development. Steers which received an implant at the beginning of the trial would have required an estimated 123 lb of additional empty BW gain to reach the USDA low Choice grade (Bruns, 2006). Bruns (2006) also suggested that due to shifts in the growth curve, evaluating implant programs at a constant days on feed might be misleading, and cattle should be compared at the same 12th-rib fat endpoint for evaluating differences in quality grade.

Grain Source and Processing

The high price of corn and increasing availability of the byproducts of ethanol production continues to lead to the increased use of distiller's grains in beef cattle production. Distiller's grains are byproducts of corn and sorghum starch fermentation, and the production of distiller's grains is expected to increase greatly with the increased number of ethanol plants (Smith and Lunt, 2007). Distiller's grains are high in protein and fat (DM basis; Owens and Gardner, 1999), and generally have an energy value that is greater than dry rolled corn. In a study by Al-Suwaiegh et al. (2002), cattle fed distiller's grains had decreased marbling scores and a decreased number of steers grading U.S. Choice (Table 1). This and other results (mostly anecdotal) has led to the speculation that the increased use of distiller's grains in U.S. beef cattle production ultimately will reduce the number of cattle grading U.S. Choice. However, more data are needed before conclusions are drawn.

The effects of steam flaking corn appear to be similar to distiller's grains in terms of decreasing carcass quality (Owens and Gardner, 1999; Table 2). Owens and Gardner (1999) reported that cattle fed dry-rolled corn had smaller carcasses, but more favorable USDA Quality Grades. In finishing diets, ruminal digestion of distiller's grains fed with dry-rolled corn and steam-flaked corn fed as the sole grain source is efficient, and often results in greater average daily gains than when dry-rolled corn is fed. Greater ruminal digestion of energy when distiller's grains and steam-flaked corn are fed has been hypothesized to promote the production of carcass fat, but reduce the deposition of marbling (Smith and Lunt, 2007). However, in a summary of research trials, Owens and Gardner (2006) suggested that the decrease in quality grade is more likely associated with dilution of marbling (intramuscular fat) due to the greater ribeye size when steam-flaked corn diets or distiller's grains are fed, and not due to decreased marbling per se. More data are needed.

Genetics

Bertrand et al. (2001) reported heritability estimates for several carcass traits adjusted to an age constant or time-on-feed constant basis. The average heritability estimates for all traits were in the moderate-to-high range, although there was a higher frequency of low ($\leq$ 0.12) estimates observed for Warner-Bratzler shear force and tenderness score. Large genetic differences across breeds and small genetic differences within breeds have been reported for shear force and taste panel tenderness scores from reciprocal backcross and single-cross steers of several breeds (Van Vleck et al., 1992). Van Vleck et al. (1992) also reported that large across-breed and within-breed genetic variation existed for marbling score. Adequate within-breed genetic variation for shear force might warrant its inclusion in within-breed genetic evaluation programs for breeds of cattle (Bertrand et al., 2001). In the review by Bertrand et al. (2001), heritability estimates for carcass weight, ribeye area, shear force, marbling score, and calpastatin activity averaged across studies evaluating carcasses at a fat constant endpoint were also shown to be moderate to high. The authors concluded that average literature heritability estimates indicate that carcass traits will respond well to selection, and that it may be possible to select for increased growth within a breed without negatively impacting marbling score or percentage retail product.

Quantitative trait loci (QTLs) are stretches of DNA that are closely linked to the genes that underlie any given trait, such as characteristics of carcass quality and yield. Quantitative trait loci can be molecularly identified to help "map" regions of the bovine genome that contain genes involved in specifying a given quantitative trait. Bertrand et al. (2001) suggested that the QTL that are identified through searches of the bovine gene map are likely to be most beneficial for those traits that are difficult and/or expensive to measure, such as disease resistance and immunocompetence, carcass quality and palatability attributes, fertility and reproductive efficiency, maintenance requirements (i.e., energetic efficiency), carcass quantity and yield, milk production and maternal ability, and growth performance (ranked from greatest benefit to least benefit). Because immunocompetence affects carcass quality, and carcass quality influences consumer acceptance, DNA-based tools for carcass trait selection will become increasingly useful.

Conclusions

No one factor solely contributes to carcass quality, but numerous factors interact to have an effect. It is important to maintain the genetic potential of calves to express growth performance and carcass quality from conception to slaughter, especially when making management decisions that may alter the growth curve of the calf. Calf health, management (e.g., implant strategy) and nutrition prior to and during feedlot finishing can have an impact on carcass quality. Providing the animal with sufficient caloric intake at critical times to support both muscle growth and marbling development appears to improve the percentage of cattle that will grade USDA Choice. In addition, the potential exists for DNA-assisted selective breeding to maintain or increase muscle growth (ribeye area), while at the same time improving carcass quality (marbling score).

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Table 1. Carcass characteristics of feedlot beef cattle fed a standard corn-based finishing diet or a diet containing 30% (DM basis) corn distiller's grains.[1]

Item	Corn	Corn distiller's grains
n	19	20
Average daily gain, lb	3.64	3.97
Hot carcass weight, lb	791	815
Ribeye area, in^2	12.8	12.6
12^{th}-rib fat thickness, in	0.44	0.51
Marbling score	$Small^{58}$	$Small^{44}$
Yield grade	2.32	2.63
USDA Choice, %	95	70

[1]Adapted from Al-Suwaiegh et al. (2002).

Table 2. Carcass characteristics of feedlot beef cattle fed dry-rolled corn or steam-flaked corn.[1]

Item	Dry-rolled corn	Steam-flaked corn
n	60	60
Average daily gain, lb	3.13	3.48
Hot carcass weight, lb	710	738
Ribeye area, in^2	12.3	13.1
12^{th}-rib fat thickness, in	0.44	0.52
Marbling score	$Small^{24}$	$Slight^{82}$
Yield grade	2.69	2.85
USDA Quality grade	$Choice^{24}$	$Select8^{82}$

[1]Adapted from Owens and Gardner (1999).

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