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Impacts of Calf Nutritional Management on Quality Grade

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Why is quality important?

An enormous amount of research and money have been invested in determining the impacts of just about every management practice on the effects of marbling. Marketing and management practices have been developed around the choice/select spread. But the question begs to be asked, "Is marbling important?" Regardless of the choice/select spread or any other premiums received due to carcass quality, the answer to that question should be a resounding "YES", for no other reason than the importance of a quality eating experience from consumers. The 2005 National Quality Beef Audit reports that the #1 concern of both beef packers and merchandisers is insufficient marbling. Moreover, as the trend for reduced per capita consumption of beef continues, quality and consistency is extremely important to retain consumer satisfaction. There are three major influences that affect the eating experience of beef: flavor, juiciness, and tenderness. To some degree, either directly or indirectly, marbling affects all three.

Although managerial decisions, such as implants and growth promotants certainly may affect quality grade, this talk and proceedings is going to focus on timely nutritional factors that may influence quality grade.

Changing Industry

Bio-fuel production is driving an unprecedented change in animal agriculture throughout the United States. The growing corn ethanol and soy-diesel industries provide significant economic benefits to grain producers, however, the resulting increases in feed prices and lack of suitable alternative energy-dense feedstuffs presents serious challenges for traditional livestock production systems. In fact, corn price fluctuations led to an increase over 100% in the last 24 months. Although grain prices have currently dropped back to "normal" ranges, the mandate to produce greater volumes of ethanol remains, and prices will almost assuredly remain unstable in future years. To offset higher feed costs, alternative production strategies are needed for beef producers to remain viable and competitive in the beef industry. One means of achieving this lofty goal is to use more expensive feeds during critical stages in the life cycle of beef cattle when a high plane of nutrition is necessary for optimal economic and performance while utilizing less expensive feedstuffs during less critical periods. Furthermore, adapting a new production system to include grazing crop residues will act to not only decrease high priced feed costs, but also to utilize inexpensive resources available. Adopting such an alternative production systems could result in reduced feed cost without sacrificing animal performance and improve the financial stability of beef enterprises across the region and nation. Our long term research goal is to provide research-based information that allows beef producers to adapt to a new production paradigm in feeding cattle that is less reliant on continuous feeding of corn and other high value feed stuffs.

Feeder Calf Development

Developing a means to improve the efficiency of production and profitability of high quality carcasses is essential to increase beef quality and the economic viability of producers (Wertz et al., 2002). Typical beef cattle production systems in the United States wean calves at approximately 205 d of age. However, peak milk production occurs between 45-60 days of lactation in most British and Continental breeds (NRC, 1996), therefore, declining milk production beyond 60 days coupled with accelerated calf growth, limits energy intake and calf growth (Robinson et al., 1978). Historically, weaned calves were fed mostly forage diets and as a result, were forced to grow at slower rates until they reached 800-900 lbs, when they were fed high grain-based diets until slaughter (1200-1400 lbs). This production system maximized skeletal growth and allowed cattle to reach heavier carcass weights while minimizing time in the feed yard. In more recent years, inexpensive grain prices and the demand for higher quality carcasses has caused a paradigm shift towards placing calves into a feed yard immediately after weaning. This production system reduced cattle age at harvest and increased carcass quality while maintaining acceptable carcass weights, though not as heavy as yearling cattle.

Extensive research over the last decade suggests that early weaning steers (between 100-150 days old) is a viable option to improve carcass quality. In fact, early weaned steers have higher quality carcasses, are harvested at a younger age, and have a greater gain to feed efficiency than traditionally weaned steers (Harvey and Burns, 1988a, b; Myers et al., 1999; Wertz et al., 2002). Recent data suggest marbling development begins early in a calf's life and can be influenced by management and nutritional inputs (Berger and Faulkner, 2005; Bruns et al., 2005). Given that adipocyte development is largely a function of nutrient intake, stimulating intramuscular fat formation may be possible during periods where nutrient intake is greater than maximal muscle growth. This is likely the scenario of greater ultimate marbling scores in those cattle subjected to early weaning protocols.

However, early weaning calves often results in lighter carcass, greater number of days on a concentrate diet, and increased feed costs. Although premiums are paid on quality carcasses, hot carcass weight is still the major economic driver behind beef carcass values. Tatum et al. (2006) concluded that even in today's value added pricing system, total pounds of carcass weight accounts for approximately 70% of the total revenue from a feedlot calf. Recently the dramatic increase in feed costs has caused the industry to revert to traditional means of feeding cattle. In particular, cattle are placed in management scenarios that utilize slower growth rates and decreased inputs. Cattle feeders want to minimize the length of time cattle are fed and therefore, have begun sourcing yearling cattle rather than feeder calves, which historically has decreased carcass quality.

Given our understanding of muscle growth and fat accretion, it is possible to feed high energy diets to beef cattle during strategic periods of time that produce carcasses with comparable quality to those of early weaning systems as well as take advantage of lower input feeding periods allowing for similar skeletal growth seen in yearling cattle, thus producing heavier final carcasses. *Our preliminary data suggests that feeding calves a high concentrate diet early in life (120 days of age) until they reach 205 days of age followed by a slow plane of nutrition prior to returning them to a high concentrate finishing diet will result in carcasses with higher quality grades and similar weights to traditionally fed cattle.*

Although adipose tissue deposition and proliferation tend to be topics that are a little more scientifically involved than what the normal producer is concerned, below is a brief overview of the metabolic signals responsible for adipose tissue deposition and some further evidence to how we might impact marbling early in life.

Adipose Tissue Deposition: Greater marbling scores reported in early weaned calves fed high concentrate, starch-based diets are likely attributed to elevated ruminal propionate and serum insulin concentrations (Schoonmaker et al., 2004). Of the VFAs absorbed for energy, propionate is the primary gluconeogenic precursor. Although, acetate supplies 70-80% of the acetyl units for lipogenesis in subcutaneous adipose tissue depots, acetate only accounts for between 10-20% of the acetyl units used for lipogenesis in intramuscular (marbling) fat. Glucose, on the other hand, is the predominant provider of acetyl units in intramuscular adipose depots providing between 50-75% of the acetyl units for lipogenesis in the intramuscular adipose depot (Smith and Crouse, 1984). Serum insulin concentrations increase 50-60% with propionate production in grain fed steers (Trenkle, 1970). Early weaned calves fed high concentrate diets ad libitum had greater glucose uptake at the tissue level due to greater serum insulin levels (Schoonmaker et al., 2003). Thus, it is likely that the increase in gluconeogenic substrates from rumen fermentation and the increased insulin concentration in response to circulating glucose allowed for greater cellular uptake and utilization of glucose for marbling deposition during the growing phase. Additionally, the methylmalonyl-CoA produced as an intermediate during the conversion of propionate to succinate may replace malonyl-CoA as a primer for lipogenesis (Okine et al., 1997). Therefore, increased marbling scores observed in early weaned calves are likely due to increased gluconeogenic (i.e. propionate) and lipogenic precursors (i.e. methylmalonyl-CoA) leading to greater glucose and insulin concentrations in grain fed cattle which lends itself to greater intramuscular fat deposition in relation to subcutaneous fat deposition.

Adipocyte differentiation/development: Fat deposition in cattle initially is a function of adipocyte hypertrophy, even though a new wave of adipocyte development only occurs once the mean diameter of the adipocyte reaches 80 to 90 μm (Allen, 1976). Robelin (1981) reported a 100 fold increase in subcutaneous adipose tissue from 15 to 65% of mature BW, which coincided with an approximate 6-fold increase in cell number and a 13-fold increase in cell size. Thus, adipose cell proliferation appears to occur between 15 and 25% of mature BW; lipid filling occurs between 25 to 45% of mature BW and a second increase in cell numbers occur from 45 to 65% of mature BW. This biphasic distribution of adipocytes found in concentrate-fed steers indicates that the time of additional dietary energy may play a vital role in marbling development (Hood and Allen, 1973). Although some scientists suggest marbling is influenced in-utero, or during the neonatal periods (Teboul et al., 1997), the ultimate localization of marbling adipocytes to the perimysium supports the argument that marbling arises primarily from fibroblasts associated with connective tissue (Smith et al., 2009). This further suggests that marbling is a late-maturing fat depot that is not fully developed until the latter phases of finishing (Hood and Allen, 1973; Cianzio et al., 1985; May et al., 1994). In contrast, however, evidence indicates that pre-weaning dietary influences may affect intramuscular adipocyte formation and these effects may be maintained throughout the finishing phase (Meyers et al., 1999; Shike et al., 2003). Furthermore, marbling score has a quadratic relationship with days on feed, indicating that intramuscular fat depots can be developed early and again prior to reaching their growth plateau (May et al., 1992; Van Koevering et al., 1995). It has been suggested that additional adipocytes developed early in life may undergo hypertrophy during the finishing phase and have a have a tremendous impact on final carcass quality (Albrecht et al., 2006). To that end, data out of our lab (Lake et al., 2008, unpublished) has demonstrated that early weaned calves (~100 days of age) fed a high concentrate diet had greater ultrasound marbling scores after 100 days on feed (~200 days of age) compared to their non-weaned contemporaries of a similar age. Although accretion of marbling decreased in the early weaned calves after they were placed on a low plane of nutrition for 150 days, their marbling scores were still greater than their contemporaries which had that had been placed on a high concentrate diet immediately after weaning.

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