INTERACTIONS OF MANAGEMENT AND DIET ON FINAL MEAT CHARACTERISTICS OF BEEF ANIMALS

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Why are some calves actually worth more than others to feedlots and packers even though the cattle are similar in breed, type, frame size, and muscle thickness? Today, the answer is likely to be differences in average daily gain, feed efficiency, yield grade, marbling score, or percent retail yield. As a seedstock or cow-calf producer, how do you select breeding animals and manage their offspring so that the calves actually achieve their optimum genetic potential? These are questions that you may need to be able to answer as the beef industry continues to move from a commodity market to a value-based, grid marketing industry where individual animals are identified and priced according to their consumer desirability. To answer these questions, you probably need to understand some basics of ruminant nutrient use as well as some windows of opportunity that exist where management can improve carcass characteristics so that your cattle achieve their genetic potential.

First, you need to understand that all nutrients (energy, protein, vitamins, minerals, and water) are used in a hierarchy that goes from maintenance > development > growth > lactation > reproduction > fattening. This means that an animal must have sufficient nutrients to maintain its body before bone or muscle growth can occur, and these must occur before fattening can occur. In breeding cattle, lactational anestrous occurs when an animal that is nutrient deficient, but milking heavily, can't rebreed. The second thing that you need to understand about ruminant nutrition is that feed is digested in the rumen by ruminal bacteria that attach to the surface of a feed particle to digest it. In ruminants, maintaining the digestive organs (rumen, reticulum, omasum, abomasum, small intestine, and large intestine) plus the liver and kidneys can take as much as 40-50% of the energy and 30-40% of the protein consumed in a day. Forage diets that are very bulky and only 40-60% digestible increase the weight of the digestive tract, because more undigested feed remains in each segment of the digestive tract. In contrast, grain-based diets result in decreased organ weights compared with forages, because grains are 80-100% digestible, and have a much smaller particle size, which allows them to have a faster rate of digestion and passage through the digestive tract. The result is that grain is more digestible than forage, plus it decreases an animal's maintenance requirement by resulting in less digestive organ mass, leaving more nutrients for muscle growth and fattening. Feedlots take advantage of the energy content and digestive characteristics of grains to finish cattle. However, if you have a grass-based system for your cows (like most of the world), you aren't going to switch to grain. One way to increase an animal's performance with forages is grinding the forage to increase its' digestibility by making more surface area available to ruminal bacteria and increasing the rate of passage of the forage through the digestive tract, decrease the bulk fill inherent with the forage, and decrease the animal's maintenance requirement by decreasing the digestive tract weight. However, increasing the surface area of a forage diet is not the only answer, because not all gain is the same, and what you feed an animal affects the carcass characteristics.

Producing consistently tender meat, and reducing excess external fat production while maintaining intramuscular fat deposition are still three of the major challenges in the beef industry, even though they were recognized in the 1992 National Beef Quality Audit sponsored by the National Cattlemen's Association. Nutrition and genetics are the two major factors contributing to these concerns. Excessive external back fat and internal seam and KPH fat production causes inefficiencies in both feedlots, due to the higher energy cost of depositing fat compared with protein, and the packing industry, due to the high cost of trimming and the low price received for the fat.. Developing management strategies to produce well-marbled, tender meat products are critical to the advancement of a high-quality beef industry.

Typically, cattle are finished on high concentrate diets for a period of time ranging from 80-280 days prior to slaughter. This finishing period allows for more rapid, efficient growth, and increased intramuscular fat (marbling) deposition so that the cattle carcasses grade choice compared with cattle grown on forage-based feeding systems. In general, tissues are deposited in the order of: 1. brain, 2. bone, 3. muscle, and 4. fat, however, some animals seem to totally skip the brain portion. Nevertheless, A young, rapidly growing animal that is in a linear phase of growth will naturally put on more bone and muscle. As an animal ages, and its' genetic potential for muscle growth begins to plateau, it will put on fat. Guenther et al. (1965) reported on the effects of feeding steers on a high or moderate level of nutrition. Steers fed the high level of nutrition deposited both lean and fat at a faster rate than steers fed at a moderate level of nutrition on both age- and weight-constant bases. Bone growth was not different among the two treatments and was more closely related to age than to nutrition. However, in both groups, the rate of fat deposition accelerated as the animals aged, whereas the rate of lean deposition decreased. The rate of fat accumulation was most rapid in the latter part of the feeding period, after lean deposition had begun to subside, which caused a decrease in the lean:fat ratio as the animals matured. As a result of much of this early work, the general idea has been developed that marbling is the last fat that is put on, and occurs only after an animal has already put on most of its' muscle. However, under conditions that are designed to maximize marbling, the age at which an animal is allowed to start expressing marbling is much younger than many people think.

The major volatile fatty acids (VFA) produced by rumen microorganisms are acetate, propionate, and butyrate. These VFA are the main products of the digestion of feed by bacteria in the rumen, and serve as the main precursors for both glucose and fat in ruminants. On a forage based diet, the proportion of VFA would be approximately 65-70% acetate, 15-25% propionate, and 5-10% butyrate. Feeding diets high in readily fermentable carbohydrate (starch) increases the proportion of propionate produced through ruminal fermentation, and results in VFA proportions of approximately 50-60% acetate, 35-45% propionate, and 5-10% butyrate. This shift toward more propionate is extremely important to carcass characteristics. Recent research by Johnson et al. (1982) and Bines and Hart (1984) found that increased peak insulin concentrations with increased propionate production will also lead to increased insulin secretion. Insulin increases fat and protein syntheses while inhibiting the breakdown of fat and protein at the tissue level. The increase in fat and protein synthesis due to insulin secretion is due to enhanced rates of nutrient uptake by tissues.

In order to understand how different management strategies can affect the ability of an animal to produce a choice carcass, and the yield grade of that carcass, some basic understanding of fat cell (adipocyte) growth is necessary. First, keep in mind that the marbling score is determined by the amount of intramuscular fat, and the preliminary yield grade is determined largely by the subcutaneous fat (backfat) measured at the 12 th rib. These two sites of adipocyte (fat cell) development may vary in synthesis rate with changes in age and nutrition. Adipose tissue mass increases by hyperplasia (cell proliferation), hypertrophy (cell enlargement), or a combination of both. Adipose tissue synthesis requires a source of fatty acid and glycerol 3-phosphate, almost all of which comes from glucose. In adult ruminant animals that are grazing forages, acetate is the major fatty acid precursor for adipocyte synthesis. When animals are fed a high concentrate diet, the amount of propionate produced increases relative to acetate. The importance of this is that propionate is the major glycogenic fatty acid. The reason that ionophores work on forage based diets is that more propionate is produced, and more glucose is produced in the liver, resulting in more net energy available to the animal.

The age at which cattle are thought to develop sufficient intramuscular fat to achieve the choice grade is debatable, because of the ability of ruminants to use different feedstuffs for growth and the fact that we have management systems for nearly every possible feedstuff. Smith (1995) stated that the age of an animal dictated the timing of the onset of lipogenesis (the formation of fat), but the diet modulated the amplitude of the rate of lipogenesis. In combining data from different studies, Smith (1995) concluded that cattle needed to be on feed 167 to 236 days and weigh between 835 to 945 pounds before ATP citrate lyase activity was in sufficient quantity to allow for lipogenesis. The steers used in this analysis were 265 days of age when they were started on the experiment (Smith et al., 1984), which made them 432 to 501 days of age when were predicted to be able to start lipogenesis. However, Smith et al. (1984) reported that backfat thickness and the activities of several enzymes involved in lipogenesis were greater in steers fed a high concentrate, corn based diet versus steers fed a forage based, alfalfa pellet diet, even though the metabolizable energy intake was higher with the pelleted forage diet. Therefore, the end products of ruminal fermentation as well as net energy intake are interrelated in terms of adipocyte formation. This is substantiated by Smith and Crouse (1984) in a study where they fed either a corn silage (low energy) or ground corn (high energy) diet to Angus steers from weaning, at 8 months of age, to a terminal age of 16 or 18 months of age. They reported that acetate provided 70 to 80% of the acetyl units for lipogenesis in subcutaneous adipose tissue, but only 10 to 25% of the acetyl units for lipogenesis in intramuscular adipose tissue. Conversely, glucose (from propionate) provided 1 to 10% of the acetyl units for lipogenesis in subcutaneous adipose tissue, but 50 to 75% of the acetyl units for lipogenesis in intramuscular adipose tissue. The authors concluded that different regulatory processes control fatty acid synthesis in intramuscular and subcutaneous adipose tissue. Therefore, the enzymes responsible for fatty acid synthesis, and therefore lipogenesis and adipocyte hypertrophy, are regulated by the end products of ruminal fermentation, which are determined by diet.

The age at which actual initiation of adipocyte growth begins is probably very early in life as reported by Vernon (1980) that hypertrophy of adipocytes begins after 100 to 200 days of age. Additionally, the age at which lipogenesis and adipocyte growth occurs is highly related to the age at which cattle are started on a high concentrate diet, due to days on a high concentrate diet, and a propionate fermentation being the major determining factor. This represents one window of opportunity for cow-calf producers. Fluharty et al. (2000) reported that 85% of steer calves weaned at 103 days of age, immediately started on a high concentrate diet, and harvested at 385 days of age (282 days on feed) graded choice, with 60% of the calves being in the upper 2/3 of the choice grade. Similarly, Myers et al. (1999) weaned steers at 117 days of age and either started them directly on a high concentrate or put them on pasture until 208 days of age at which time they were moved to the feedlot and fed the high concentrate diet. The calves started directly on a high concentrate diet were 394 days at slaughter (268 days on high concentrate diet), and the pasture calves were 431 days of age at slaughter (222 days on high concentrate diet). At harvest, 89% of the concentrate fed calves graded low choice or higher, with 56% average choice or higher, and 89% of the pasture fed calves also graded low choice or higher, with 38% average choice or higher. These kinds of results would not have been possible if the steers had been brought into the feedlot at a year of age. It would not have been genetics, but management that prevented the cattle from grading choice at a year of age.

In summary, much of the bias toward older cattle in the feedlot industry has nothing to do with there being a magical age at which cattle will grade choice, but rather is directly related to the length of time cattle have been fed a high concentrate diet that results in a propionate fermentation which results in more glucose production. In fact, Midwestern feedlots that predominantly feed calves often achieve 70-80% choice cattle. However, many southwestern feedlots that feed yearlings often achieve only 50% choice cattle. Although there are definitely differences due to sorting loads of cattle, the ability of young cattle to grade choice cannot be argued from a scientific or practical standpoint. Additionally, if cattle were all harvested between 12 to 16 months of age, there would be much less variation in carcass weight, because cattle would not be as close to approaching their mature weight, and the genetic variation that exists in the beef industry would have less of an effect on consistency of carcass weight.

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