Windows of Opportunity

Management and genetics interact to determine carcass characteristics of feedlot steers.

BY FRANCIS FLUHARTY

The calves look alike — similar in breed, type, frame and muscle thickness. Why are some of them, usually an unknown subset, worth significantly more to feedlots and packers? There will be differences in average daily gain (ADG), feed efficiency (FE), yield grade (YG), marbling score and percent retail product.

To minimize those differences, the beef industry has relied largely on pedigrees, expected progeny differences (EPDs) and ultrasound data to make breeding decisions. DNA technology may allow us to select animals for even more performance and carcass traits than are currently available. Imagine being able to select for a combination of marbling and tenderness or for feed efficiency.

Even considering all of the current and future selection tools, one thing comes to the forefront as being vitally important: management. Having an animal with the genetic potential to reach a certain marbling score or tenderness level does not guarantee that the animal will achieve it.

How do you select breeding animals and manage their offspring so the calves actually achieve their optimum genetic potential? These are questions you must 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.

Many of the answers lie in the basics of ruminant nutrition. There are windows of opportunity where management can improve carcass characteristics so your cattle achieve their genetic potential.

The hierarchy

Remember that all nutrients (energy, protein, vitamins, minerals and water) are used in a hierarchy that goes from maintenance to development to growth to lactation to reproduction to 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.

Just maintaining the digestive organs, plus the liver and kidneys, can take as much as 40%-50% of the energy and 30%-40% of the protein a ruminant consumes in a day.

A bulky forage diet that is

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only 40%-60% digestible increases the weight of the digestive tract because more undigested feed remains in each organ. In contrast, grain-based diets result in relatively lighter organ weights because grains are 80%-100% digestible.

Ruminal bacteria must attach to the surface of each feed particle to digest it. Therefore, when ruminants "chew their cud" on forage diets, they are creating more surface area to which bacteria can attach so digestion can occur — pieces longer than about ½ inch can't pass from the rumen. The smaller particle size of grains allows a faster rate of digestion and passage through the digestive tract.

That means, besides being more digestible than forage, grain diets decrease ruminant maintenance requirements. The lighter digestive-organ mass leaves more nutrients for muscle growth and fattening. Feedlots take advantage of the energy content and digestive characteristics of grains to finish cattle.

But you have a grass-based system for your cows (like most of the world), and 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. That makes more surface area available to ruminal bacteria, increasing the rate of passage of the forage through the digestive tract. It decreases the bulk fill inherent with forage and decreases the animal's maintenance requirement by decreasing the digestive-tract weight.

Increasing the surface area of a forage diet is not the whole answer because not all gain is the same. And what you feed an animal affects the carcass characteristics.

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The challenge

Producing consistently tender meat and reducing excess external fat while maintaining intramuscular (IM) fat deposition are still the major challenges in the beef industry, even though they were recognized in the 1992 National Beef Quality Audit (NBQA).

Nutrition and genetics are the two major factors contributing to these concerns. Putting on excessive external and internal [seam and kidney, pelvic and heart (KPH)] fat is inefficient at the feedlot due to the higher energy cost of depositing fat compared with protein. It's also inefficient at the packing plant due to the high cost of trimming and the low price received for fat.

Developing management strategies to produce well-marbled, tender meat is critical to the advancement of a high-quality beef industry. As genetic technology progresses to allow identification of potentially well-marbled, tender animals, the focus will sharpen on management strategies that allow genetic expression of an animal's potential.

Conventional wisdom

Most cattle in this country are finished on high-concentrate diets, though the finishing period may range from 80 to 280 days prior to slaughter. Finishing on grain concentrates allows for more rapid, efficient growth and increased IM fat (marbling) deposition so more of the carcasses grade Choice compared with cattle grown on forage-based feeding systems.

In general, tissues are

deposited in this order: brain, bone, muscle, then fat. A young, rapidly growing animal that is in a linear phase of growth naturally will put on more bone and muscle than fat. As an animal ages and its genetic potential for muscle growth begins to plateau, it will put on fat. However, this doesn't mean that an animal that is managed properly can't deposit intramuscular fat until it is a yearling.

Much of the beef industry's conventional feeding wisdom is based on older research, and it needs to be revised. In the 1965 *Journal of Animal Science*, J.J. Guenther reported on the effects of feeding steers on a high or moderate level of nutrition. Steers fed the high level 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.

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-to-fat ratio as the animals matured.

As a result of much of this early work, the consensus has developed that marbling is the last fat deposited and occurs only after an animal already has put on most of its muscle. 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.

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The propionate shift

The main products of feed digestion by ruminal bacteria are the volatile fatty acids (VFAs) acetate, propionate and butyrate, the chief 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. On a concentrate diet high in readily fermentable carbohydrate (starch), propionate gains at the expense of acetate, resulting in production of roughly 50%-60% acetate, 35%-45% propionate and 5%-10% butyrate.

This shift toward more propionate is important to carcass characteristics. Research by Johnson *et al.* (1982) and Bines and Hart (1984) found that increased peak-insulin concentrations with the increased propionate production also leads to increased insulin secretion and enhanced nutrient uptake. That's important because insulin increases fat and protein syntheses while inhibiting their breakdown at the tissue level.

To understand how management strategies affect an animal's ability to grade and to yield, some basic understanding of fat-cell (adipocyte) growth is necessary. Adipose-tissue (fat) mass increases by cell division, enlargement or a combination of both. Fat synthesis requires a fatty acid from acetyl units (CH_3CO) and glycerol 3-phosphate, almost all of which come from glucose. Keep in mind that the marbling score is determined by the amount of IM fat, and the preliminary yield grade is determined largely by the subcutaneous (sub-Q) fat measured at the 12th rib.

These two sites of fat development vary in synthesis rate with changes in age and nutrition. Acetate, which cannot be converted to glucose in mammals, dominates as the fatty acid in adult ruminant animals grazing forages. But animals on a high-concentrate diet produce more propionate, the major glycogenic fatty acid. (Ionophores can get more from forage-based diets by facilitating more propionate production, so more glucose is produced in the liver, resulting in more net energy available to the animal.)

It's an age thing

The age at which cattle are thought to develop sufficient IM fat to achieve the Choice grade is debatable because ruminants can use different feedstuffs for growth, and we have management systems for nearly every possible feedstuff. That's why some calves go on a concentrate diet as young as 100 days of age, while others aren't fed grain until they are more than a year old. Stephen Smith (1995) stated the age of an animal dictates the timing of the onset of lipogenesis (the formation of fat), but the diet modulates the amplitude of that rate.

In combining data from different studies, Smith concluded cattle needed to be on feed 167-236 days and weigh between 835 and 945 pounds (lb.) before enzyme activity was sufficient to allow

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for lipogenesis. Since the steers used in this analysis were 265 days of age when they were started on the experiment, they were 432-501 days of age when they were predicted to be able to start putting on fat.

However, Smith earlier (1984) reported that fat thickness and the activities of several enzymes involved in lipogenesis were greater in steers fed a high-concentrate, corn-based diet vs. steers fed a forage-based, alfalfa-pellet diet, even though the energy intake was higher for steers eating the pelleted forage diet.

Therefore, the end products of ruminal fermentation, as well as net energy intake, are interrelated in terms of adipocyte formation. Smith and John Crouse (1984) 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. They reported that acetate provided 70%-80% of the acetyl units for fat synthesis in fat thickness, but only 10%-25% of the acetyl units for fat synthesis in marbling.

On the other hand, glucose (from propionate) provided 1%-10% of the acetyl units for fat synthesis in fat thickness but 50%-75% of the acetyl units for fat synthesis in marbling. They concluded the enzymes responsible for fatty-acid synthesis, and therefore fat synthesis and fat cell enlargement, are regulated by the end products of ruminal fermentation, which are determined by diet.

A matter of timing

The age at which actual initiation of fat-cell growth begins is probably early in life. R.G. Vernon (1980) reported that fat-cell enlargement begins after 100-200 days of age. Additionally, the age at which fat synthesis and fat-cell growth occur is highly related to the age at which cattle are started on a high-concentrate diet because days on feed and propionate fermentation are the major determining factors.

This represents one window of opportunity for cow-calf producers. In research at Ohio State University, steer calves weaned at 103 days of age, immediately started on a high-concentrate diet and harvested at 385 days of age, graded 85% Choice — 60% in the upper two-thirds of Choice.

Similarly, in 1999, S.E. Myers and co-workers at the University of Illinois weaned steers at 117 days and either started them directly on a high-concentrate diet 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.

Those started directly on a high-concentrate diet were 394 days old at slaughter, and the pasture calves were 431 days of age. At harvest, 89% of the concentrate-fed calves graded Choice or higher, with 56% in the upper two-thirds of Choice or higher. Of the pasture-fed calves, 89% also graded low-Choice or higher, but 38% achieved the upper two-thirds of 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 and fed a high-concentrate diet for only 140 days. It would not have been genetics, but management, that prevented the cattle from grading Choice at a year of age.

The bottom line

Much of the bias toward older cattle in the feedlot industry has nothing to do with a magical age at which cattle will grade Choice. It is simply and directly related to management decisions and the length of time cattle have been fed a high-concentrate diet, which results in a propionate fermentation and more glucose production.

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In fact, Midwestern feedlots that predominantly feed calves often achieve 70%-80% Choice across all sources. Many feedlots that feed yearlings often achieve only 50% Choice cattle.

When managed for optimized marbling, young cattle have the ability to grade Choice if they are fed a diet that results in a propionate fermentation. As recent research has shown, these calves often convert feed to gain at a ratio of 5-to-1 or better from approximately 100 days of age until harvest. When young calves have good feed conversions, it's because they are gaining weight rapidly while they are still in a linear phase of growth, and maintenance requirements are lower than with older, heavier cattle.

If all cattle were harvested between 12 and 17 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. As a result, fewer cattle would be discounted for heavyweight carcasses, and consistency of portion size would be improved. That's a window of opportunity for the whole beef industry.

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