Nutritional effects on carcass quality

Darryl Gibb, 1997

Introduction

As market trends move towards more grid pricing to account for differences in carcass quality, an understanding of factors that contribute to carcass quality is essential. These factors include variables dictated by nature such as genetics, gender, and natural growth patterns of cattle. But carcass quality can also be manipulated by how the cattle are fed.

Growth Patterns

Carcass growth is made up primarily of fat and protein. As cattle approach mature weight, carcass gain makes up a higher percentage of total gain. This is why dressing percentage increases with days on feed. Although performance is typically reduced for long fed cattle, adjusting performance for dressing percent can give us an indication of the performance of carcass growth.

Fat makes up a higher percentage of carcass gain with increasing maturity and days on feed. Energetically, fat is very expensive to produce and also helps explain the reduced performance with increasing days on feed. The correlation between dressing percent and carcass fat is high (R^2=.93). Dressing percentage increases more with concentrate than roughage diets. This is a reflection of the increased energy available for fat deposition.

Mature weight is that weight in which protein growth stops. Once mature weight is reached, excess available energy is retained as fat. Thus, animal maturity has a large impact on carcass composition - the more mature the animal, the greater the fat deposition. On average, carcasses contain about 36% fat when protein growth stops. Most choice or AAA carcasses contain about 28% fat. Although carcass composition can moderately be manipulated by nutrition, it is generally fixed at a given level of maturity. In other words, carcass composition will be very similar at the same percent of mature size for cattle of a given breed and frame size. Much of the induced changes in body composition (implants, limit feeding etc.) are actually a result of changes in mature size.

Heifers are typically about 80 - 85% the weight of steers at the same body composition - in other words they mature earlier and reach a given carcass composition at a lighter weight than steers. Although ribeye areas are slightly smaller for heifers than steers, ribeye area per 100 kg of carcass is greater for heifer which lead to a superior lean meat yield.

Anabolic implants increase mature size and alter carcass composition accordingly. Placing cattle on ad lib high concentrate diets early in life can reduce mature size. A VERY general thumb rule, is to assume an extra ½ to 2/3 lb mature weight for each day small framed cattle are backgrounded. In other words, if cattle are backgrounded for 100 days, mature weight will increase about 60 lbs.

Many people believe that fat accretion increases with increasing rates of gain. However, in a compilation of research it was found that rate of fat accretion increased with increasing gain

up to about 1.3 kg/d at which fat accretion reaches a plateau. This is a little more logical than the assumption that fat accretion continually increases with rate of gain. If this was true, feed efficiency would consistently be poorest on the fastest gaining cattle due to the energetic costs of fat deposition. In reality, cattle that are capable of faster rates of gain, like cattle with larger mature weight, deposit more protein per unit of fat deposited at high rates of gain.

Intramuscular fat (marbling) and subcutaneous fat (back fat) are metabolically different from each other - one is not dependant on the other nor can it give an indication of the other. Deposition of marbling fat is typically only 5% - 10% the rate seen for back fat. Marbling to backfat ratio declines as carcass weight increases. This is a reflection of the increasing backfat combined with the genetic limitation for marbling. Once the genetic limit is reached, most fat is deposited as back fat.

Nutritional Effects

Limit feeding

Limit feeding frequently reduces carcass fat deposition, thereby increasing the lean to fat ratio. Because carcass fat is affected more than carcass protein, and due to the light weight of fat, effects on rate of gain is frequently minimal.

Although both backfat and marbling can be reduced with limit feeding, back fat synthesis is more sensitive than is production of marbling fat.

Fat

Averaged across many trials, dressing percentage, marbling score and yield grade increase with supplemental fat.

Protein

High levels of dietary of protein, especially urea have increased external fat thickness in several trials. This may be attributed to buffering, improved acid base status or altered insulin:glucagon ratios. Although extra protein can increase quality grade, the backfat to marbling score ratio is generally increased with extra protein indicating protein has a greater effect on backfat than marbling. Economically, the positive effects on marbling can be offset by the negative effects of increased backfat and yield grades.

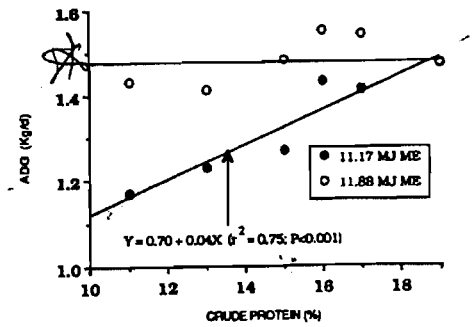

Fig. 1. The effect of protein and energy on the average daily gain (ADG) of large-frame steers fed from weaning to slaughter (Trial 1).

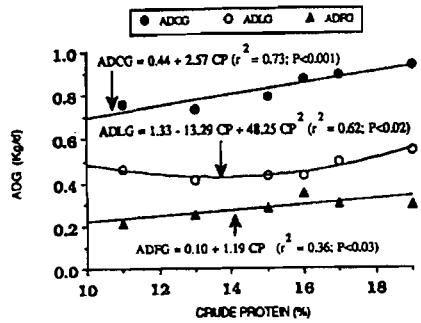

Fig. 2. The effect of protein on the average daily carcass gain (ADCG), average daily lean gain (ADLG) and average daily fat gain (ADFG) of large-frame steers fed a ration formulated to 11.17 MJ ME kg^{-1} DM from weaning to slaughter (Trial 1).

Protein effects on carcass quality are illustrated in a trial done at the University of Saskatchewan using 408 steers fed barley based diets. Canola meal was added to the diet to provide diets ranging from 11 to19% protein. On a low energy diet (51% barley), daily gain increased as protein level increased. However, there was no response to supplemental protein above 11% on the high energy diet (79% barley; Fig 1 at left). As the graph on the left (Fig.2) illustrates, there was a linear increase in carcass fat gain that coincided with the increasing carcass gain.

Another Canadian trial conducted by Feedlot Health Management Services at Okotoks Alberta demonstrates the effect excess protein can have on carcass fat. Twelve hundred yearling steers (40 pens) were implanted with Synovex Plus and fed an 80% barley finishing ration (~ 12.0% protein) supplemented with canola meal, urea or a canola meal/urea blend to bring the protein up to 13.5%. There were no positive responses to supplemental protein. In fact, extra protein from urea reduced performance compared to canola and the control diets. Supplementing with urea and canola/urea increased the number of A3 carcasses and reduced the number of A1 carcasses. Due to cost of protein supplement and differences in performance and carcass characteristics, there was an economic disadvantage of $5.28, $16.35, and $13.19 for canola, urea and canola/urea treatments respectively.

Grain processing

Averaged across grains (corn wheat milo), cattle fed steam flaked grains had larger ribeye areas, greater fat thickness, but surprisingly, less marbling than cattle fed dry rolled grains. Increased starch digestion appears to increase sub cutaneous fat deposition at the expense of marbling.

Vitamin D

Increasing post-mortem muscle calcium concentration, usually achieved through calcium chloride infusion following slaughter, has been shown to increase meat tenderness. This likely results from stimulation of calcium dependant protein degrading enzymes. Because blood calcium levels are regulated so closely, we cannot increase calcium concentration by feeding high calcium levels. Vitamin D is one of the compounds that helps regulates blood calcium levels. By feeding very high levels of vitamin D for about 1 week before slaughter, calcium levels can be increased and the meat is thereby tenderized.

Vitamin E

Exposure to oxygen (oxidation) is what causes pealed potatoes to go black and metal to rust. Vitamin E is an anti oxidant that can reduce the oxidation that also results in deterioration of the bright red color in meat and thereby increase shelf life. Up to 500 IU of vitamin E a day are required for the last 100 days of feeding.

MGA

MGA is commonly fed to heifers to suppress heat. Growth responses commonly reported for non-implanted heifers are due primarily to increased estrogen production and possibly from reduced activity. Feeding MGA frequently increases carcass fat. Although MGA has not been considered in the review articles quoted in previous sections, the trend towards increased marbling with MGA supplementation is more consistent than a growth response, especially when the heifers are implanted with an estrogen implant.

Even with the few animals (30) used in a trial at Kansas State, (Titgmeyer et al., 1996) there were significantly more heifers grading choice when heifers with or without a Revalor H implant were fed MGA. A Nebraska trial using 360 heifers also found that heifers fed MGA had a trend towards greater marbling.

In two of three Colorado trials in which MGA was a treatment, feeding MGA increased the number of heifers grading choice (all trials used over 200 heifers).

Conjugated Linoleic Acid (CLA)

Biohydrogenation of linoleic acid in the rumen can result in the formation of rumenic acid and compounds known as Conjugated Linoleic Acids (CLA). Positive health benefits of CLA's have been reported including cancer fighting properties, removal of plaque in heart arteries, and stimulation of the immune system. Forage finishing markedly increase CLA in beef fat compared grain finishing. Supplementation of finishing diets with specific vegetable oils (sunflower oil) may be able to enrich the CLA content of beef.

Summary

Cattle with greater initial weights, those fed more days, and those fed higher protein levels had higher dressing percentages. Dietary fat increases dressing percentage Up to a maximum of 4.4% (2.4% added fat).

Marbling is increased markedly with harvest age. Higher concentrate levels (except for Angus and Hereford heifers; Aalhus and Mandell, 1999), fat addition, and dietary protein levels result in slight increases in marbling score. The greatest effect was a result of added protein.

Yield grade increased (became less desirable) with greater harvest age, time on feed, and protein supplementation but decreased with initial weight and supplemental fat.

Increased harvest age, higher dietary crude protein, and longer feeding duration increased the ratio of subcutaneous fat:marbling. This explains why these factors increased yield grade.

Though nutritional effects on carcass quality can prove relevant, diet effects on performance should be of greater economic relevance.

Higher levels of either fat or protein in the diet consistently improved quality grade whereas source of grain or roughage and ionophore had little impact.

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