

A review of the impact of feedlot management and nutrition on carcass measurements of feedlot cattle

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Abstract

Carcass quality and yield information from 552 published research trials together with data on cattle weights, age, and diet composition were assembled. These data were examined for relationships among carcass measurements and for relationships between carcass measurements and cattle and diet factors. Although most carcass measurements varied with carcass weight, this relationship generally was not proportional. For example, as carcass weight increased, longissimus muscle area increased ($P < .01$) at a decreasing rate (quadratic; $P < .02$), whereas longissimus muscle area relative to carcass weight decreased linearly ($P < .01$). Hence, those carcass variables detected as significantly altered by carcass weight were adjusted for carcass weight based on linear, quadratic, and curvilinear regression coefficients. Relationships of these adjusted carcass values to animal and diet measurements were assessed by regression analysis, and plots of relationships were prepared. As initial weight increased, dressing percentage, longissimus muscle area, and quality grade increased, whereas s.c. fat, kidney, pelvic, and heart fat, and marbling score decreased. A longer feeding period before slaughter and an increased slaughter age were associated with increased longissimus muscle area, marbling score, external fat thickness, and yield grade. As concentrate in the diet increased, dressing percentage, longissimus muscle area, marbling score, and skeletal maturity all increased at a decreasing rate. Low levels of fat addition to the diet were associated with an increased dressing percentage, longissimus muscle area, quality grade, marbling score, and yield grade; higher amounts of added fat tended to decrease the latter two measurements. Higher dietary crude protein levels and added dietary fat were associated with greater dressing percentages and marbling scores.

Key Words: Steers, Feedlots, Carcass Quality, Diet Treatment, Age

Introduction

Growth and development have been reviewed in classic texts cited in articles by Preston (1971), Lindsay et al (1993), and Owens et al. (1993, 1995). The "equivalent weight" concept advanced by the NRC (1996) for beef cattle proposes that body composition and carcass measurements at a specified percentage of mature weight are fixed, which indicates that maturity, rather than energy or nutrient intake, drives body composition. If body composition at a specified fraction of maturity is fixed, carcass measurements should not be altered by dietary or feeding conditions except those that may be associated with differences in age and mature weight. However, numerous studies involving growth stimulants and compensatory growth indicate that body composition at a specified weight can be altered and, therefore, is not fixed. Whether this means that carcass characteristics at a fixed physiological age are altered or simply that physiological age is altered is not clear. However, because economic value of carcasses is dependent primarily on carcass weight and, to some degree, carcass quality, cattle producers have a strong interest in using diet and feeding procedures to maximize carcass weight and quality. The objective of this review was to ascertain the degree to which various animal factors (initial weight, days fed, slaughter age) and feedlot diet composition (concentrate level, crude protein concentration, and

fat supplementation) as well as crude protein source and ionophore presence and type might be associated statistically with carcass measurements.

Materials and Methods

The published literature was screened, and data from feeding trials including diet type and composition, animal factors (initial and final weight, sex, and number of cattle per treatment), and carcass measurements were extracted and compiled. Individual trial information is available upon request.

For statistical purposes, each treatment mean within each trial was considered to be an observation. Because some of the information that was assembled was related to non-feedlot diets and cattle, observations reported to be from cows and from cattle slaughtered at an age greater than 900 d, for cattle fed less than 80 d, and for cattle fed diets containing less than 70% concentrate were deleted. To examine effects of grain source, grain processing, roughage source, ionophore addition, and protein source, contrasts were drawn within specific experiments by including experiment as a class variable ignoring differences in carcass weight and sex. However, to examine overall relationships of continuous variables (i.e., initial weight, days fed, slaughter age, concentrate level, fat supplementation, and protein concentration),

statistics were calculated across all experiments but data from heifers were excluded.

Unfortunately, data sets providing carcass information (Table 1) often were incomplete with regard to diet information, and vice versa. Although stepwise regression might be ideal to detect important relationships, certain measurements were lacking in many of the trials. To avoid this loss of data, individual rather than stepwise regressions were used.

In most cattle feeding experiments, cattle are fed several different diets for a specified number of days and all cattle are slaughtered at a specific date. If cattle fed different diets gain weight at different rates, then carcass weights will differ. If carcass weight is increased, certain carcass measurements will be altered. For example, an increased carcass weight usually results in an increased longissimus muscle area. If not adjusted for the difference in carcass weight, a researcher might conclude that a specific treatment will increase longissimus muscle area whereas, in fact, the increase in carcass weight can fully explain this difference in the carcass measurement. In contrast to research trials, feedlots generally feed only one finishing diet to a pen of cattle and, in most cases, all cattle in that pen are slaughtered on a single date when marbling scores presumably have reached some economic optimum. For research results to fit the feedlot situation, adjustments for carcass weight are necessary. Alternatively, carcass measurements from research cattle could be adjusted to a specific external (rib) fat thickness on the presumption that this measurement will reduce extraneous variation among treatments.

Because most measurements were significantly altered by carcass weight, and possibly by sex, data from heifers were eliminated from the database. Predicted carcass measurements at the mean carcass weight were calculated based on a regression equation weighted by the number of steers per observation for the highest (i.e., linear, quadratic, or cubic) polynomial that was detected as being significant ($P < .05$). The fractional change in various carcass measurements across a range in carcass weights (mean \pm 1 SD) was plotted. These regression equations then were used to standardize carcass measurement for carcass weight differences. The relationships between these standardized carcass measurements and animal age or diet factors then were examined. In addition, certain ratios (s.c. fat area:longissimus muscle area; marbling score to s.c. fat area) were calculated in an attempt to determine whether either animal or dietary conditions altered ratios of lean to fat or of intramuscular to s.c. fat. We used s.c. fat area rather than fat thickness when calculating ratios in order to equalize measurement units; longissimus muscle area and marbling are both areas, not linear measurements. Subcutaneous fat area was calculated based on the assumption that the longissimus muscle area represented a quarter-circle beginning 1 cm from the center of the circle and that s.c. fat area was equal to the area of a quarter-donut outside this circle with a thickness equal to the measured fat thickness. By such calculations, s.c. fat area was equal to a mean of 30% of the area of the longissimus muscle (range from 10 to 92%) and marbling score to s.c. fat area averaged 36 units (range of absolute values of 12 to 130).

To detect the linear, quadratic, and cubic relationships of standardized carcass measurements to input factors, regressions weighted by number of animals in an observation were calculated. When the cubic response proved significant ($P < .05$) it was used; otherwise, the quadratic response was examined and used when significant ($P < .05$). When the quadratic relationship was not significant, the linear relationship was examined and used if significant ($P < .05$). If the linear relationship was not significant, this served as an indication that the input factor did not influence the carcass trait being examined.

The reader is cautioned that relationships presented are a result of summarization of the available literature. If literature values are erroneous, not fully representative of all trials, or incomplete, then analyses may yield invalid information. Further, relationships of individual carcass and animal or diet measurements were estimated. In some cases, these relationships may be indirect; for example, cattle that graze before entering a feedlot usually have greater initial weight and, therefore, often are fed for fewer days but will be older at slaughter. With the large number of relationships detected, it is impossible to judge which ones may be direct or indirect and which may be casual rather than causal. When relationships have some logical explanation or might be due to some inherent interaction, explanations are provided. However, even inexplicable relationships are presented in the hope that it may alert researchers to analyze or to design experiments to test relationships that they deem important using their own data. In some cases, as with fat, protein, or ionophore supplementation, cattle within the individual trials serve as control cattle for comparison with others. For examining the continuous input variables, the magnitude of change in output values for a specified change in the input variable was calculated and graphed.

Regression equations describing the response in each carcass measurement to a change in the input variable from 1 SD below to 1 SD above the mean of the input variable were plotted to illustrate the response. The shape of the response, rather than the absolute value, should be of primary interest. Nevertheless, mean carcass measurements with standard deviations for steers and heifers are presented in Table 2; these can be used to calculate the range of input variables used for generating the response curves.

Effects of Animal and Diet Factors on Carcass Measurements: Discrete Input Variables

For statistical comparisons of effects of sex, grain source, grain processing, ionophore addition, and protein and roughage sources, no adjustments for sex or carcass weight (except in the case of sex) were employed, and statistical contrasts were drawn within rather than across trials.

Sex Differences

Mean, minimum, and maximum values for performance as well as live, carcass, and longissimus characteristics for heifers and steers are presented in Table 2. Considerably

fewer data were available from trials with heifers than from trials with steers. The amount of information available for certain traits is very limited. Significant differences between means for most carcass measurements between steers and heifers, both with and without adjustment for carcass weight, were detected. Uncorrected for differences in carcass weight, steers gained 9% faster and 1.3% more efficiently than heifers. In some cases, significance of the sex effect was eliminated, adjusting all cattle to a standard carcass weight. Nevertheless, these differences would suggest that carcass composition, even when standardized through linear, quadratic, and cubic factors for differences in carcass weight, differs with sex. Heifers had lower dressing percentage despite greater s.c. fat thickness. On an unadjusted basis, longissimus muscle area was slightly smaller for heifers than for steers, but longissimus muscle area per 100 kg was greater for heifers than for steers. This led to a yield grade that was superior or lower ($P < .05$) for heifers than for steers when carcass weight differences were ignored but not when carcass weight differences were considered. This may reflect excessive adjustment in the yield grade equation that favors cattle with lighter carcass weights.

Grain Source Effects

Performance and carcass means for steers and heifers fed concentrate diets based on corn, milo, and wheat grains are presented in Table 3. Gains were lower for cattle fed milo-based diets than for cattle fed corn- or wheat-based diets. A higher incidence of subclinical acidosis decreases feed intake and gain (Fulton et al., 1979). Diets low in fat content, as are milo-based diets, might increase acidosis that in turn will reduce gains of cattle. Feed efficiency was poorest for cattle fed milo-based diets; lower starch availability from diets in which the milo was not steam-flaked might explain this poorer efficiency. Yield grade was slightly greater for cattle fed milo- than for cattle fed corn-based diets. Further, the ratio of marbling:s.c. fat area was lower for cattle fed wheat-based than for those fed corn- or milo-based diets. This may reflect level of fat or bypassed starch from these grains; dressing percentage and marbling score often increase when fat is supplemented to a high-concentrate diet (Zinn, 1992). No other significant differences between grain sources were detected.

Grain Processing Effects

Cattle fed steam-flaked grains gained more efficiently and had heavier carcass weights than those fed dry-rolled, high-moisture, or whole-grain diets. These efficiency improvements can be attributed to increased starch availability of steam-flaked grains (Owens et al., 1997). Compared with cattle fed dry-rolled grains (averaged across corn, milo, and wheat diets), cattle fed steam-flaked grain had larger longissimus muscle areas and greater s.c. fat thickness but lower marbling and quality grades (Table 4). Fat thickness per unit of longissimus muscle area was greater

and the marbling:s.c. fat area ratio was lower for cattle fed steam-flaked than for cattle fed dry-rolled grain. This may reflect a shift in site of digestion, with increased fat deposition being related to less ruminal escape of dietary starch. High-moisture diets (ensiled or reconstituted grains) generally produced carcass measurements intermediate to those of cattle fed dry-rolled or steam-flaked grains. Cattle fed whole grain (usually corn) had lower dressing percentages than cattle fed steam-flaked corn, perhaps due to greater digestive tract fill. Cattle fed whole grain had the lowest marbling scores and grades, except for cattle fed steam-flaked grains.

Roughage Source Effects

Few differences in performance and carcass measurements were detected between cattle fed alfalfa and those fed corn silage as a source of roughage with high-concentrate diets (Table 5).

Ionophore Effects

When values across all ionophores in the diet were averaged and compared with the mean for cattle fed no supplemental ionophore, gain, feed efficiency, and carcass weight all were increased, but, surprisingly, longissimus muscle area per 100 kg carcass weight was decreased by ionophores (Table 6). When least squares means are contrasted with values for cattle not fed ionophores, cattle fed ionophores were more efficient, but rate of gain was not significantly altered by feeding monensin and salinomycin. Other ionophores increased rate of weight gain, but only laidlomycin increased marbling score. The tendency for an increase in s.c. fat thickness and the decrease in longissimus muscle area per 100 kg may reflect a slight increase in energy balance (increased energy intake or reduced energy expenditures) for cattle receiving ionophores.

Protein Source Effects

In some past trials, supplemental soybean meal has been associated with greater longissimus muscle area (attributed to an increased amino acid supply), whereas high levels of dietary urea have increased s.c. fat thickness, perhaps due to increased energy intake either from ruminal buffering (from ammonia) or an improved acid:base status and a reduced incidence of subclinical acidosis. Averaged across trials in this summary, no significant differences in cattle performance or carcass weight were detected between steers fed soybean meal and those fed urea supplements (Table 7). Lack of difference would suggest that when ruminal ammonia supply was adequate from either urea or soybean meal, postruminal amino acid supply must have been sufficient for carcass protein deposition. With a mean hot carcass weight of 318 kg and a feeding period mean of 139 d, cattle deficient in dietary protein early in the feeding period probably would have had adequate time for compensatory growth.

Effects of Animal and Diet Factors on Performance and Carcass weights: Continuous Input Variables

Effects of various animal and diet factors on ADG are presented in Figure 1. Extending the days fed, an increased age at slaughter, and high levels of supplemental fat were associated with decreased rates of live weight gain. In contrast, higher concentrate levels increased ADG to a plateau, whereas higher-protein diets and cattle with heavier initial weights made faster gains. However, cattle with greater initial weight were less efficient in converting feed to live weight gain (Figure 2). Added protein, fat, and concentrate improved feed efficiency. Cattle fed for a longer time tended to have a greater gain:feed ratio, probably a reflection of lighter placement (initial) weights for those pens of cattle. Carcass weight (representing the combination of initial weight, ADG, and days fed) responses were similar to those for ADG except for the response to days fed (Figure 3); hot carcass weight was greater for cattle fed longer.

Effects of Animal and Diet Factors on Carcass Quality Measurements: Continuous Input Variables

Impact of Carcass Weight on Other Carcass Measurements. Figures 4 through 6 illustrate the fractional changes in various carcass measurements across the 2-SD range in carcass weight. Longissimus muscle area increased as carcass weight increased; however, the increase in longissimus muscle area was only 10% for the 19% (from 293 to 351 kg) increase in carcass weight (Figure 4). This means that longissimus muscle area as a percentage of carcass weight decreased by about 7% as carcass weight increased across this range. This indicates that covariance adjustment of longissimus muscle area for carcass weight alone is erroneous. The decrease in longissimus muscle area in relation to carcass weight may be caused by several factors. First, longissimus muscle area is a surface measurement, whereas carcass weight is volumetric, and longissimus muscle length may increase without a change in surface area. Second, muscle size may reach a plateau (maturity) before body weight, reflecting the natural progression from lean to fat deposition with maturity. Note that s.c. fat thickness in these experiments increased slightly with carcass weight, whereas yield grade and dressing percentage responses seemed curvilinear for no apparent reason.

Kidney, pelvic, and heart fat, estimated and expressed as a percentage of carcass weight, decreased as carcass weight increased, again perhaps reflecting earlier maturity of this tissue (Figure 5). Quality grade and marbling scores both increased with carcass weight, although the response for quality grade was more dramatic than for marbling. Skeletal maturity generally decreased as carcass weight increased, opposite the direction one might expect if cattle heavier initially are more likely to be yearlings and fed to heavier weights than cattle slaughtered at lighter weights. However, chronological age often is not closely related to lean maturity score (Owens and Gardner, 1999).

The ratio of s.c. fat:longissimus muscle area increased markedly with carcass weight (Figure 6). Longissimus muscle shear force tended to decline as carcass weight increased, as noted previously by Duckett et al. (1997), perhaps associated with greater stretch of the longissimus muscle with greater carcass weight. Hanging carcasses in different configurations in the cooler, through stretching certain muscles and relaxing others, has been suggested to increase tenderness of stretched muscles and decrease tenderness of relaxed muscles. Surprisingly, the marbling:s.c. fat ratio tended to decline as carcass weight increased. This again is opposite the effect one would expect if carcass weight is used as an index of maturation with intramuscular fat being the final site of lipid deposition.

Because of the significant relationships of numerous carcass measurements to carcass weight, subsequent carcass measurements were standardized to the mean carcass weight of all trials based on whatever significant relationships (linear, quadratic, and cubic) to carcass weight were detected. Consequently, subsequent discussion relates to measurements at a standardized carcass weight. Changes for each carcass variable were calculated across a range of 2 SD in each input variable; means and standard deviations for input values are presented in Table 1.

Dressing Percentage

Among all the carcass measurements, dressing percentage probably has the greatest perceived economic importance because it serves to relate live weight to carcass weight and, thereby, carcass value. Those cattle with greater initial weights, those fed more days, and those fed higher-protein diets had higher dressing percentages (Figure 7). Dressing percentage increased to a maximum when cattle were fed a 90% concentrate diet. Curvilinear responses to added and total dietary fat were detected; a maximum dressing percentage was observed when about 2.4% fat was added or 4.4% fat was present in dietary dry matter. Dressing percentage typically has been associated with increased carcass weight and fat deposition; however, the correlation of dressing percentage to longissimus muscle area often is higher than with s.c. fat. Thus, muscle and fat mass seem important for determining dressing percentage. A greater weight of the digestive tract and its contents decreases dressing percentage. Consequently, displacement of the digestive tract and its contents by either fat or lean tissue will increase dressing percentage.

Longissimus Muscle Area

Fat supplementation to a level of about 2% of the diet or 4% total dietary fat seemed to maximize longissimus muscle area (Figure 8). In contrast, longissimus muscle area increased linearly with three interrelated variables: initial weight, days fed, and slaughter age. This suggests that longissimus muscle area, like muscle mass, has not reached a maximum at typical slaughter age but continues to increase with time on feed.

Carcass Maturity

Significant relationships to maturity were detected with only two of the input variables (Figure 9), perhaps because only 22 of the treatment means had carcass maturity estimates (Table 1). As time on feed increased, lean maturity decreased, whereas skeletal maturity increased as percentage of concentrate in the diet was increased. Tenderness seems inversely related to lean maturity, whereas greater skeletal maturity has been associated with more desirable beef flavor (Owens and Gardner, 1999).

Marbling Score

Marbling score increased markedly with slaughter age and slightly with days fed, but it decreased as initial weight increased (Figure 10). Higher concentrate levels, fat addition, and particularly higher dietary protein levels were associated with slight increases in marbling score. The maturity response in marbling score may be related to a greater prevalence of larger, more discrete fat depots within the longissimus muscle of older than of youthful animals.

Quality Grade

Although most responses in quality grade paralleled those in marbling score, as would be expected, some differences were detected. Levels above 2% added fat were associated with lower quality grades (Figure 11). Increases in quality grade were most evident with added protein and heavier initial weights.

Subcutaneous Fat Thickness

Longer feeding times and advanced slaughter age were associated with greater s.c. fat thickness (Figure 12). In contrast, fat supplementation and heavier initial weights were associated with less external fat. This would suggest that steers with greater initial weight fed for a short time should have the least fat cover and highest yield grades.

Kidney, Pelvic, and Heart Fat

Responses in kidney, pelvic, and heart fat percentage to input factors were quite similar to those for s.c. fat thickness (Figure 13), although no response to supplemental dietary fat was detected. Heavier initial weight, which generally leads to shorter feedlot time, was associated with less kidney, pelvic, and heart fat expressed as a percentage of carcass weight. However, slaughter age had a curvilinear effect on this measurement. No explanation for this response is apparent.

Yield Grade

Generally responding like s.c. fat thickness, one of its primary driving factors, yield grade increased (became less desirable) with greater slaughter age, time on feed, and pro-

tein supplementation but decreased with initial weight and supplemental dietary fat (Figure 14).

Marbling:Subcutaneous Fat Ratio

Increased slaughter age, higher dietary crude protein, and longer feeding duration decreased the marbling:s.c. fat ratio, whereas higher amounts of added fat tended to increase it (Figure 15). Whether an increase in dietary fat together with a decrease in dietary protein would enhance marbling over the short term near the end of a feeding period is not clear. Longer-term feeding of low-protein diets to swine increases intramuscular lipid content, although performance often must be depressed to realize this increase in intramuscular lipid (Ellis and McKeith, 1999).

Subcutaneous Fat:Longissimus Muscle Ratio

A decrease in the s.c. fat:longissimus muscle ratio may reflect increased carcass muscularity (Figure 16). Heavier initial weights and an older age at slaughter tended to decrease (improve) this ratio, whereas the ideal dietary fat level to reduce this ratio was about 4.5% dietary fat.

Overview

The value of altering a diet or management practice is the difference between the input cost and the output value. Input costs need to be calculated on an individual case basis. However, rate and efficiency of gain can be altered and thereby cost of production may be altered by a specific practice. Value for cattle produced will depend on marketing practices. Cattle sold on a live weight basis will not realize an immediate benefit from a practice that alters dressing percentage, carcass quality, or value for retailers or consumers. In contrast, cattle sold on a carcass weight basis will realize a benefit from increased carcass weight, whereas cattle sold on a grade-and-yield or formula basis can benefit from increased carcass quality and predicted lean meat yield. In the future, effects on meat tenderness and taste will also need to be considered. Effects of specific dietary or management factors on economic return must take into account effects on production costs, carcass yield, and carcass quality. Table 8 illustrates the magnitude of some of the changes that must be considered to estimate the total financial impact a specific diet or management change can have. These factors must be considered together in a systems approach because in some cases factors that are favorable to performance and carcass weight adversely influence carcass merit (e.g., growth-enhancing implants).

In general, the percentage responses in performance and carcass weight were greater than the carcass measurement responses (adjusted for carcass weight) to the various animal and dietary factors. Also, animal background, sex, and carcass weight often had greater impacts on carcass measurements than dietary factors. Feeding cattle for a longer time, and thus increasing carcass weight, is the more direct method to alter carcass measurements, but altering concentrate level

of the diet and dietary protein and fat levels and ionophore source can influence yield grades and marbling scores. Even though these carcass quality changes can be relevant, diet effects on performance (ADG, efficiency, and carcass weight) and proper market timing to avoid price discounts should be of greater immediate economic concern to cattle producers than formulating diets for ideal carcass quality. Integration of cattle feeding with the packing and retail industry will increase the importance of formulating diets to optimize carcass quality, yield, and consistency.

Summary

Animal background (weight and age at feedlot entry), feeding conditions (concentrate, fat, and protein content of the diet), and feeding duration were associated with differences in carcass measurements. Most carcass traits varied markedly with carcass weight and sex. Yield grades were better for cattle fed corn-based diets than for cattle fed milo-based diets. Yield grades were higher (less desirable) for cattle fed steam-flaked than for those fed dry-rolled or whole-grain diets. When carcass traits were adjusted to a standard carcass weight, adding up to 2% fat to the diet increased dressing percentage, longissimus muscle area, and quality grade. However, higher amounts of added fat reversed these effects. Higher dietary protein concentrations were associated with increases in dressing percentage, marbling score, and percentage kidney, heart, and pelvic fat. Because these relationships are based on summarization across a series of trials and not tested within specific trials, their validity remains open to question. Further verification of specific relationships awaits trials designed specifically to alter input factors within a trial and analyze carcass measurements when fully adjusted for carcass weight differences. Because protein source, protein level, and fat level seem to be the primary factors altering marbling scores summarized across trials, these three factors would be prime candidates for closer scrutiny.

Implications

When averaged across numerous feeding trials, most carcass traits differed with sex and usually varied curvilinearly with carcass weight. Summarization of available literature suggests that animal background (weight and age at feedlot entry), dietary concentrate, fat, and protein as well as days on feed all can alter carcass measurements, including marbling score and yield grade. Higher levels of either fat or protein in the diet consistently improved quality grade, whereas source of grain or roughage and ionophore choice had little impact on carcass measurements. Adjustment of carcass traits for carcass weight and sex should increase the precision of detecting carcass responses.

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Notes

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Table 1. Sources and means of literature information

Data set	Trials	Contrasts	Cattle
Source			
Fat supplementation	21	70	2,016
Grain sources and processing	176	159	6,818
Implants – Heifers	48	124	5,084
Implants – Steers	96	325	12,615
Ionophores	159	283	9,107
Meat quality	27	58	2,098
Protein levels and sources	25	54	1,156
Total	552	1,073	38,904
Item			
	Mean	SD	
Initial weight, kg	323	50.8	
Days fed	139	42.3	
Concentrate level, % of DM	85.9	7.17	
Slaughter age, d	498	103	
Added dietary fat, % of DM	2.41	2.23	
Total dietary fat, % of DM	4.19	2.34	
Crude protein, % of DM	12.3	1.52	

Table 2. Animal, diet, and carcass measurement means

Measurement	Sex						Difference, Unadj. ^a	P <, Adj. ^b
	n	Steers	SD	n	Heifers	SD		
Carcass weight, kg	864	327	29.1	209	296	27.7	.001	—
ADG, kg	832	1.44	.24	202	1.32	.22	.001	.001
DMI, kg	745	9.22	1.14	195	8.53	1.01	.001	.001
Gain/feed	740	.156	.025	195	.154	.022	.431	.001
Dressing, %	764	61.9	1.88	199	61.4	1.57	.002	.001
Longissimus muscle area, cm ²	715	80.7	6.01	191	79.7	6.54	.052	.001
Longissimus muscle area, cm ² /100 kg	715	.25	.016	191	.27	.017	.001	.001
Fat thickness, mm	770	12.5	3.57	194	12.8	2.83	.139	.001
Yield grade	684	2.85	.42	183	2.73	.48	.001	.136
Marbling score	607	517	58.1	123	532	58.7	.004	.001
Quality grade	734	511	48.0	141	524	54.2	.002	.001
Percentage choice carcasses	214	69.1	18.0	90	74.4	12.1	.003	.001
Kidney, pelvic, heart fat, %	586	2.40	.54	155	2.57	.46	.002	.001
Lean maturity	12	153	14.5					
Skeletal maturity	12	149	12.4					
S.c. fat /longissimus muscle area	700	29.2	9.0	191	30.2	8.1	.139	.001
Marbling/external fat	582	44.5	12.54	118	41.8	6.81	.045	.335
Longissimus shear force, kg	97	4.46	1.21	19	3.67	1.32	.001	.038

^a Unadjusted for carcass weight.^b Adjusted for differences in carcass weight.

Table 3. Influence of grain source on carcass measurements of slaughtered feedlot cattle

Measurement	Corn	Milo	Wheat	n	Error mean square
ADG	1.48	1.43	1.48	389	.272
Gain/feed	.165 ^a	.154 ^b	.177 ^a	389	.004
Carcass weight, kg	326	322	325	116	2,498
Dressing percentage	62.4	62.8	62.1	142	4.246
Longissimus muscle area, cm ²	82.6 ^a	79.3 ^b	79.3 ^b	105	482.4
Longissimus muscle area, cm ² /100 kg	.249 ^a	.240 ^b	.243 ^{ab}	105	.00207
Fat thickness, mm	11.86	11.57	12.18	131	.808
Yield grade	2.72 ^b	2.92 ^a	2.86 ^{ab}	123	.0553
Marbling score	512	499	498	138	196.2
Kidney, pelvic, and heart fat, %	2.20	2.26	2.17	99	.487
Sc. fat/longissimus muscle area	27.7	29.1	29.5	105	27.17
Marbling/s.c. fat	44.9 ^a	45.3 ^a	40.6 ^b	125	6.52

^{a,b} Within a row, means lacking a common superscript letter differ ($P < .05$).

Table 4. Influence of grain processing on carcass measurements of slaughtered feedlot cattle

Measurement					n	Error mean square
	Dry-rolled	High-moisture	Steam-flaked	Whole		
ADG	1.42 ^b	1.46 ^b	1.58 ^a	1.43 ^b	390	.289
Gain/feed	.157 ^b	.155 ^b	.184 ^a	.157 ^b	390	.0040
Carcass weight, kg	322 ^b	324 ^b	335 ^a	322 ^b	116	2,154
Dress, %	62.4 ^b	62.4 ^b	62.9 ^a	61.9 ^b	141	3.972
Longissimus muscle area, cm ²	79.4 ^c	81.5 ^b	84.3 ^a	79.5 ^{bc}	104	421.25
Longissimus muscle area, cm ² /100 kg	.245	.249	.248	.245	104	.001796
Fat thickness, mm	11.3 ^b	12.3 ^a	13.1 ^a	10.7 ^b	130	.7938
Yield grade	2.69 ^b	2.84 ^a	2.85 ^a	2.75 ^{ab}	122	.0482
Marbling score	524 ^a	519 ^a	482 ^b	512 ^{ab}	137	181.9
Quality grade	524 ^a	519 ^a	482 ^b	512 ^{ab}	137	897
Kidney, pelvic, heart fat, %	2.24	2.27	2.16	2.22	99	.1444
S.c. fat/longissimus muscle area	26.7 ^c	29.1 ^{ab}	30.7 ^a	26.0 ^{bc}	104	25.494
Marbling/s.c. fat	45.8 ^a	44.2 ^{ab}	41.1 ^b	48.3 ^a	124	23.94

^{a,b,c} Within a row, means lacking a common superscript letter differ ($P < .05$).

Table 5. Influence of roughage source on carcass measurements of feedlot cattle

Measurement					n	Error mean square
	Alfalfa	Corn silage	$P <$			
ADG	1.50	1.49	.89	391	.290	
Gain/feed	.1657	.170	.63	391	.0045	
Carcass weight, kg	328	330	.85	117	2,359	
Yield grade	.80	2.73	.61	93	.0561	
Marbling score	504	512	.75	109	206.64	
Kidney, pelvic, and heart fat, %	2.39	2.36	.11	70	.127	

Table 6. Influence of ionophore presence and source on carcass measurements of feedlot cattle

Measurement	None	Laidlo- mycin	Lasal- ocid	Lyso- cellin	Monensin	Salino- mycin	Tetro- nasin	Iono- phore		Error mean square
								<i>P</i> <	n	
ADG	1.32 ^c	1.41 ^a	1.38 ^{ab}	1.43 ^{ab}	1.32 ^c	1.36 ^{bc}	1.37 ^{ab}	.01	170	.016
Gain/feed	.144 ^c	.152 ^b	.152 ^b	.165 ^a	.152 ^b	.153 ^b	.155 ^b	.01	170	.000052
Carcass weight, kg	303 ^b	310 ^a	307 ^a	310 ^{ab}	303 ^b	307 ^{ab}	308 ^{ab}	.01	170	565
Dressing, %	62.0	62.2	62.1	62.1	62.0	62.0	62.1	.74	218	5.46
Longissimus muscle area, cm ²	78.0	78.7	78.7	77.2	78.0	78.4	77.9	.70	174	352.52
Longissimus muscle area, cm ² /100 kg	.260	.256	.259	.252	.260	.259	.256	.02	174	.001326
Fat thickness, mm	13.7 ^b	13.7 ^b	13.5 ^b	15.3 ^a	13.6 ^b	14.1 ^{ab}	13.6 ^{ab}	.10	186	1.254
Yield grade	2.85	2.88	2.88	3.00	2.85	2.89	2.91	.13	186	.0752
Marbling score	524 ^b	549 ^a	530 ^{ab}	—	521 ^{ab}	514 ^{ab}	533 ^{ab}	.27	98	770.3
Quality grade	501	509	506	—	500	500	510	.12	215	737.3
Kidney, pelvic, and heart fat, %	2.61	2.62	2.77	2.66	2.61	2.70	2.58	.25	144	.276
S.c. fat/longissimus muscle area	32.8 ^b	32.7 ^b	31.7 ^b	37.4 ^a	32.8 ^b	33.9 ^{ab}	32.5 ^{ab}	.07	174	40.11
Marbling/s.c. fat	40.4 ^b	44.1 ^a	41.3 ^{ab}	—	39.9 ^b	39.9 ^{ab}	41.1 ^{ab}	.27	98	8.205

^{a,b,c} Within a row, means lacking a common superscript letter differ ($P < .05$).

Table 7. Influence of protein source on carcass measurements of feedlot cattle

Measurement	Soybean		<i>P</i> <	n	Error mean square
	meal	Urea			
ADG	1.25	1.23	.83	55	.323
Gain/feed	.153	.142	.22	48	.0031
Carcass weight, kg	302	307	.73	41	3568
Dressing, %	61.5	62.0	.63	46	6.346
Longissimus muscle area, cm ²	77.8	80.3	.52	49	436
Longissimus muscle area, cm ² /100 kg	.257	.263	.59	49	.0017
Fat thickness, mm	13.1	13.9	.76	48	1.634
Yield grade	3.16	3.04	.74	42	.157
Marbling score	566	604	.39	38	778.4
Quality grade	510	520	.58	49	906.6
S.c. fat/longissimus muscle area	31.1	32.7	.84	49	44.37
Marbling/s.c. fat	53.2	53.7	.94	38	15.91

Table 8. Percentage change in various performance and carcass measurements in response to a 1 SD change in individual management or dietary input factors

Management/diet factor and range (mean \pm .5 SD)	ADG	Gain/feed	Carcass weight	Dressing percentage, HCW adjusted	Yield grade, HCW adj.	Marbling score, HCW adjusted
Initial weight 359 vs 292 kg	6.78	-4.82	4.68	.27	-.88	-.13
Days fed 171 vs 112 d	-3.15	4.73	3.32	.08	1.40	.28
Carcass weight 322 vs 307 kg				.945	.83	.34
Concentrate level 90.9 vs 81.2%	3.34	4.96	.39	.075	-.01	.37
Protein level 13.4 vs 11.3%	9.10	11.60	4.67	.25	1.04	.61
Fat addition 3.91 vs .92%	.34	4.06	-3.80	-.03	-2.00	.03
Monensin addition All vs none	0	6.25	1.32	0	.35	-.20
Sex Steers vs heifers	6.77	2.56	10.96	.92	-.38	-.85

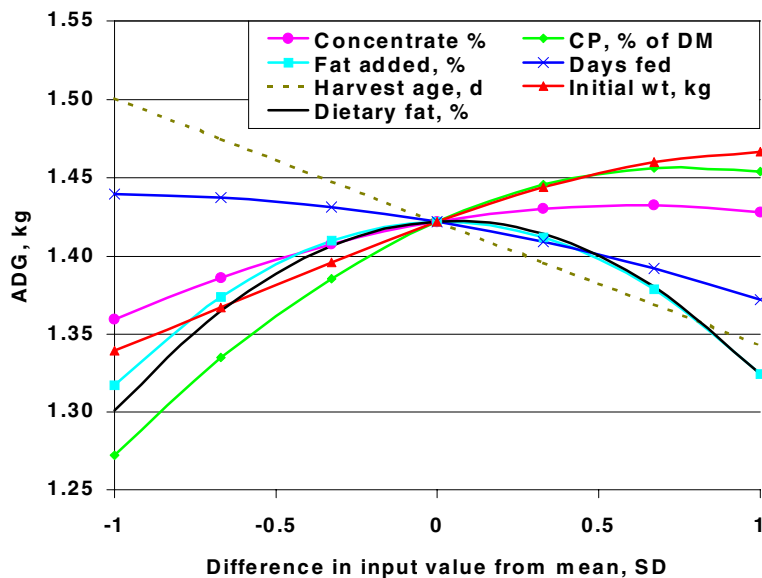


Figure 1. Influence of increases or decreases in various management and dietary factors on ADG by feedlot cattle.

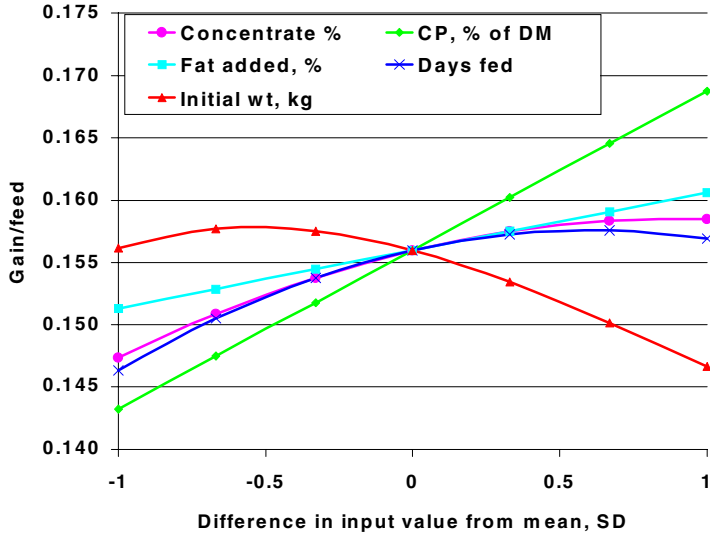


Figure 2. Impact of changes in various management and dietary factors on gain:feed ratio of finishing feedlot cattle.

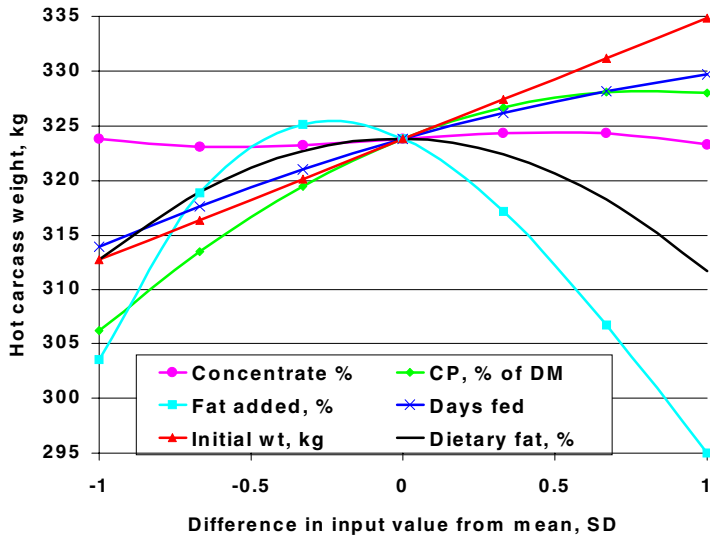


Figure 3. Effect of altering various management and dietary factors on carcass weight of feedlot cattle.

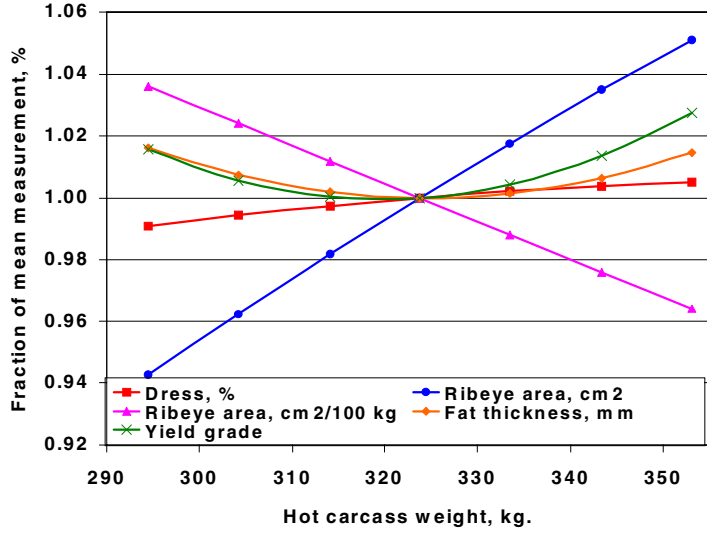


Figure 4. Response in various carcass measurements to carcass weight of slaughtered feedlot cattle.

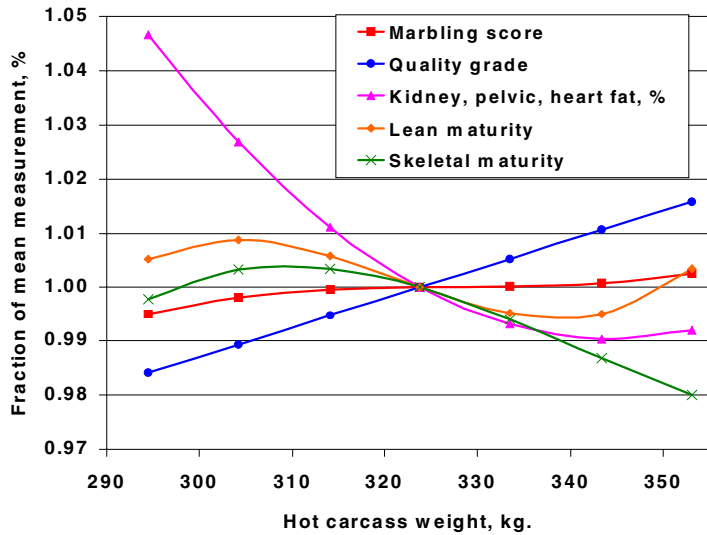


Figure 5. Response in additional carcass measurements to carcass weight of slaughtered feedlot cattle.

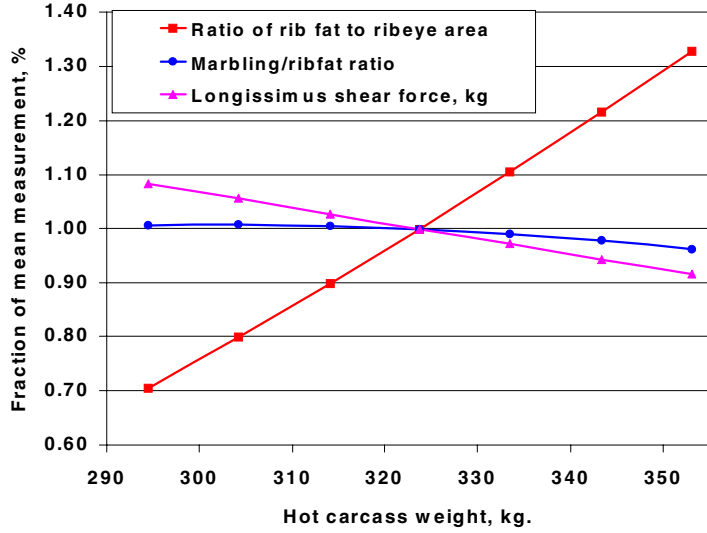


Figure 6. Response in more carcass measurements to carcass weight of slaughtered feedlot cattle.

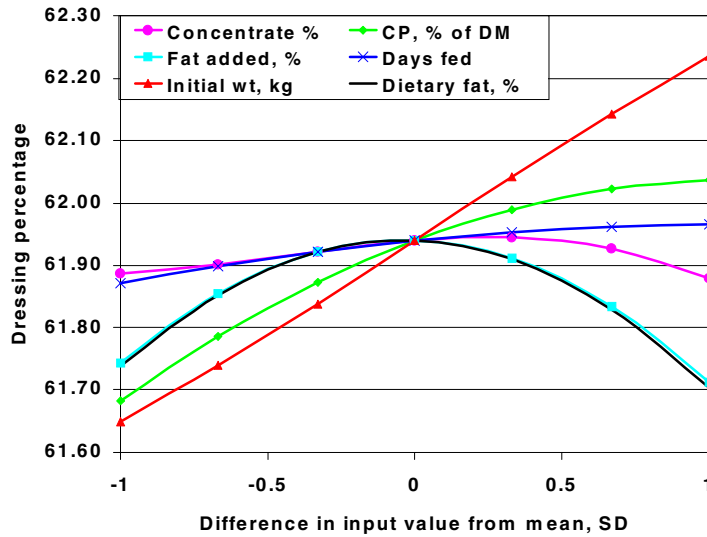


Figure 7. Dressing percentage responses to alterations in various management and dietary factors adjusted for carcass weight effects on dressing percentage.

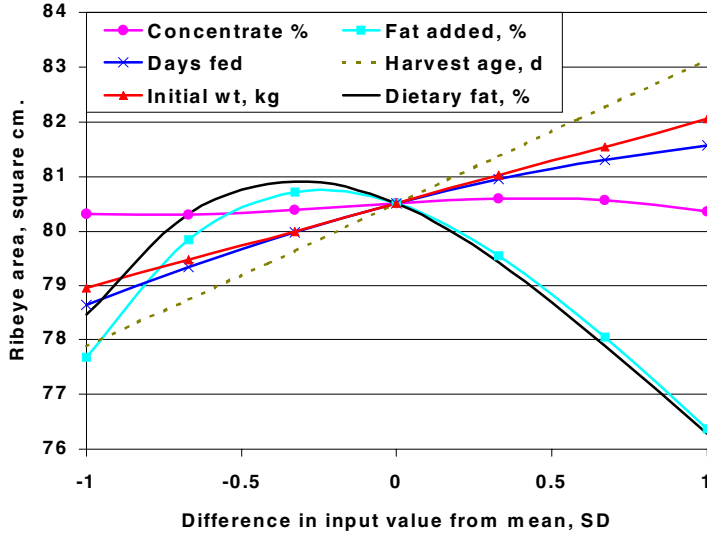


Figure 8. Longissimus muscle (ribeye) area responses to alterations in various management and dietary factors adjusted for carcass weight effects on longissimus muscle area.

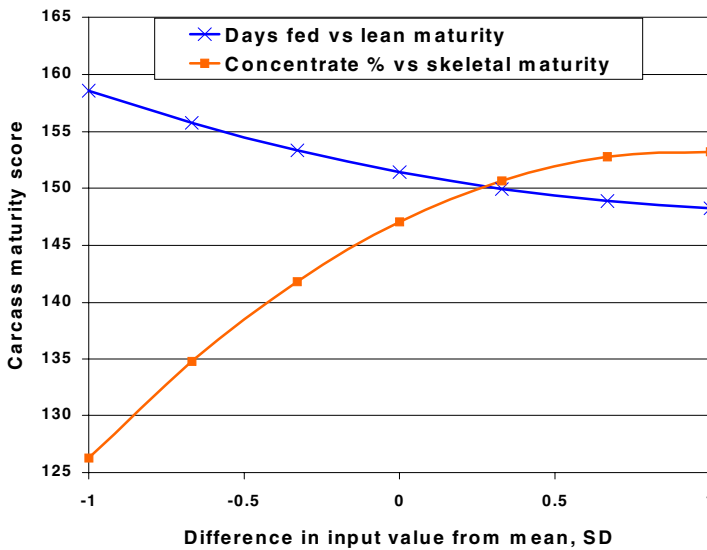


Figure 9. Carcass maturity responses to alterations in various management and dietary factors adjusted for carcass weight effects on maturity.

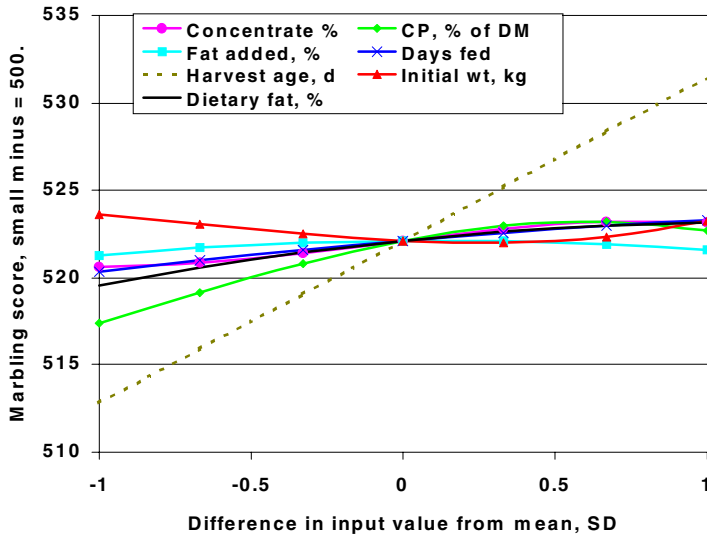


Figure 10. Marbling score responses to alterations in various management and dietary factors adjusted for carcass weight effects on marbling score.

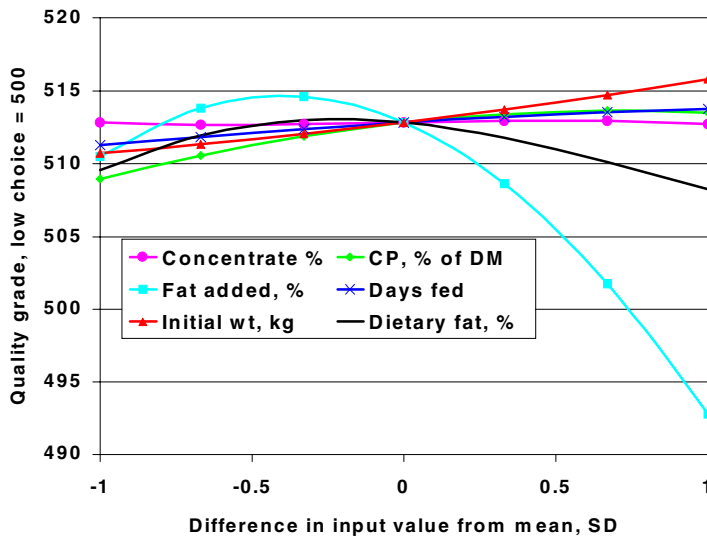


Figure 11. Quality grade responses to alterations in various management and dietary factors adjusted for carcass weight effects on quality grade.

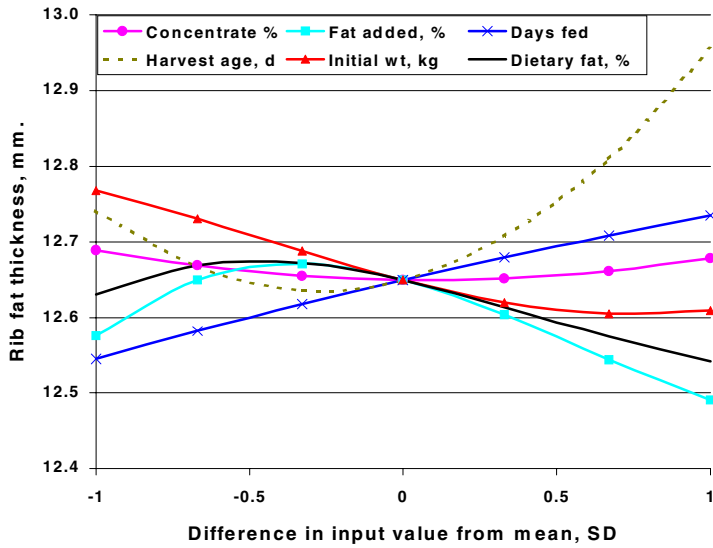


Figure 12. Subcutaneous fat thickness responses to alterations in various management and dietary factors adjusted for carcass weight effects on fat thickness.

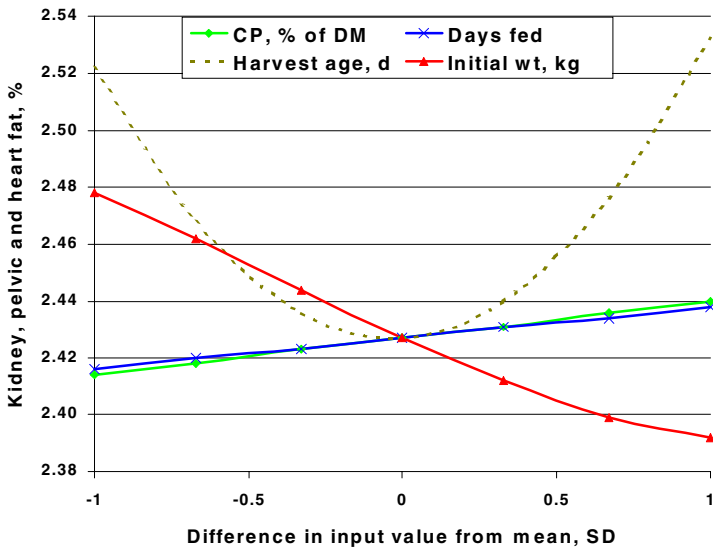


Figure 13. Kidney, pelvic, and heart fat percentage responses to alterations in various management and dietary factors adjusted for carcass weight effects on kidney, pelvic, and heart fat.

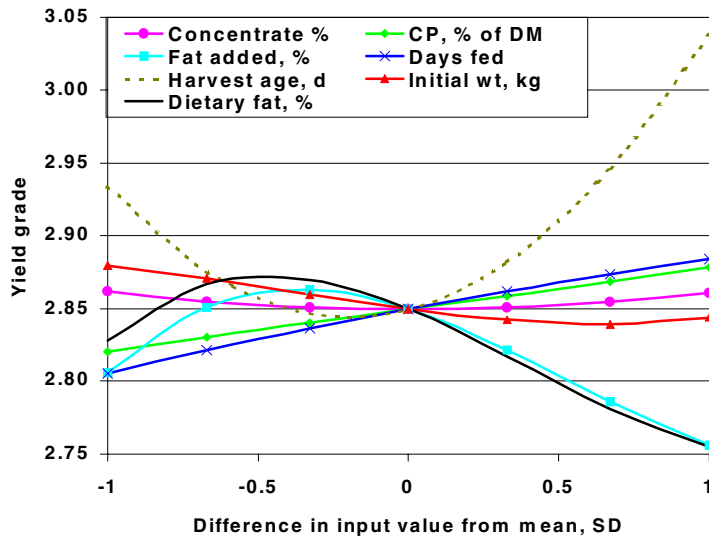


Figure 14. Yield grade responses to alterations in various management and dietary factors adjusted for carcass weight effects on yield grade.

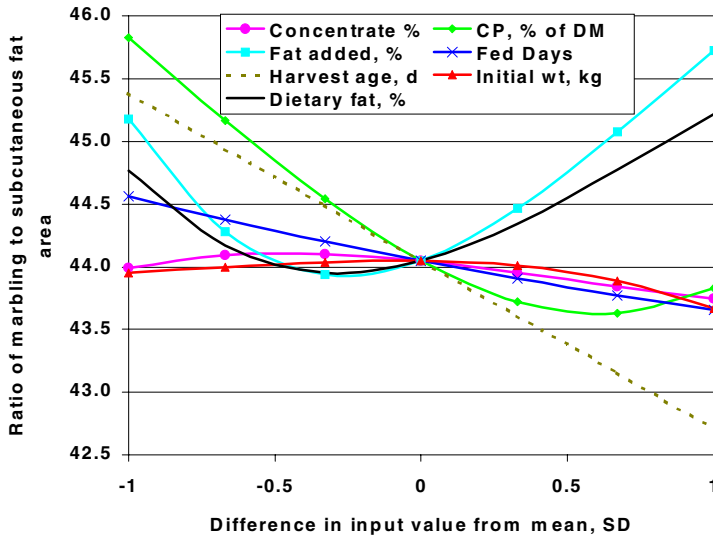


Figure 15. Response in the ratio of marbling score to s.c. fat area associated with alterations in various management and dietary factors adjusted for carcass weight effects on this ratio.

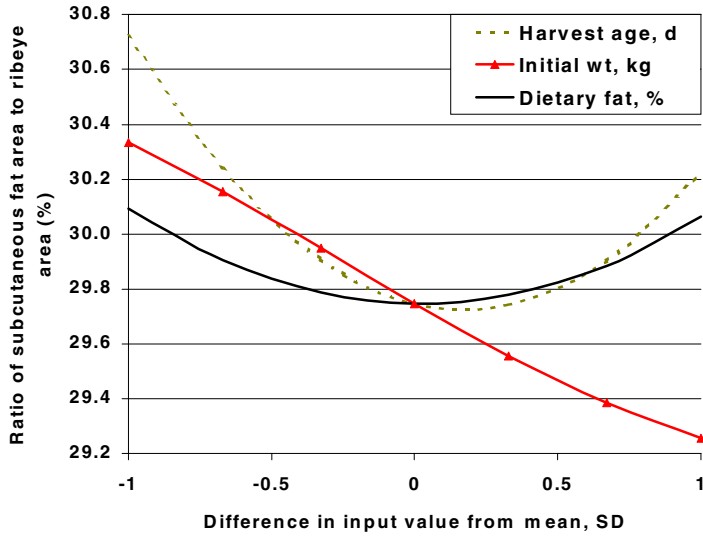


Figure 16. Response in the ratio of s.c. fat area to longissimus muscle area to alterations in various management and dietary factors adjusted for carcass weight effects on this ratio.