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Effects of Backgrounding and Growing Programs on Beef Carcass Quality and Yield

Terry J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

R. Cooper
University of Nebraska-Lincoln

D. J. Jordon
University of Nebraska-Lincoln

D. Shain
University of Nebraska-Lincoln

T. Milton
University of Nebraska-Lincoln

See next page for additional authors

Authors

Terry J. Klopfenstein, R. Cooper, D. J. Jordon, D. Shain, T. Milton, Chris R. Calkins, and C. Rossi

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T. Klopfenstein[2], R. Cooper, D. J. Jordon, D. Shain, T. Milton, C. Calkins, and C. Rossi

Animal Science Department, University of Nebraska, Lincoln 68583-0908

Abstract

Clearly, the future of the beef cattle industry in the United States depends on the quality of the product. The majority of calves are born in the spring; therefore, to have a consistent supply of feeders entering feedlots and to take advantage of forages, a variety of stocker programs exist. Cattle enter the feedlot at varying weights and ages and from different nutritional backgrounds, and this variation could produce differences in carcass quality. The economically important measures of carcass quality are yield grade and quality grade. They are directly related: as cattle fatten in the feedlot, both quality grade and yield grade increase. Because cattle are commercially fed to fat-constant end points, it is logical to make comparisons at equal fat end points. Then, marbling (percentage Choice) becomes the primary quality criterion. We analyzed data from 534 cattle serially slaughtered and found that the percentage grading Choice increased 12 ± 1 percentage units for each 1-mm increase in rib fat. Marbling score increased 30 units (200 = slight 00) for each 1-mm increase in fat. To determine the effect of rate of winter gain on carcass quality, 372 calves over 5 yr were wintered at .23 or .61 kg/d gain. When adjusted to equal rib fat after summer grazing and finishing, there was no difference in quality grade. To test the effect of summer gain on carcass quality, 418 calves over 7 yr were followed through the feedlot after gaining .57 or .84 kg/d on grass. When compared at equal rib fat, there was no difference in quality grade. Shear force values and consumer taste panels were used to evaluate steaks from 90 cattle from calf-fed and yearling production systems. Calf-feds were 14 mo of age at slaughter and yearlings were 19 or 21 mo. Each group was serially slaughtered. There was no effect of an additional .39 cm of rib fat on shear force, juiciness, tenderness, flavor, or overall palatability. Calf-feds were significantly more tender than yearlings, but the risk of an undesirable steak from yearlings was < .2% based on shear force and < 2.8% based on the consumer taste panel. If cattle are fed to a common rib fat end point, and within the range of rates of winter and summer gains reported herein, we conclude that the backgrounding program has little or no effect on marbling or carcass quality grade.

Key Words: Beef Cattle, Carcass Quality, Systems, Tenderness, Palatability

Introduction

The future of the beef cattle industry in the United States is dependent on the quality of the product. The majority of calves are born in the spring. Therefore, to have a consistent supply of feeders entering feedlots, a variety of stocker programs are used. About 30% of calves produced in the United States enter the feedlot as calf-feds. Some of these calf-feds are weaned and enter the feedlot 30 to 40 d later. It is also common for calves to be backgrounded 2 to 6 mo before entering the feedlot.

Many calves enter yearling programs. These cattle are nutritionally restricted to varying degrees and for various times. They make compensatory gain on grass and then make additional compensatory gain when they enter the feedlot (Klopfenstein et al., 1999).

Because of the great variety of cattle production systems, cattle enter the feedlot at varying weights and ages and from various nutritional backgrounds. This variation could produce differences in carcass quality.

Discussion

End Point Comparisons

There are two basic measures of carcass quality that can be made at the present time in commercial beef production. The first is yield grade or degree of fattening, and the second is quality grade, which is primarily dependent on degree of marbling. Because both are measures of lipid content, they are related: the greater the amount of fat (higher yield grade), the greater the amount of marbling (higher quality grade). This is the single most important point in this discussion. Geneticists contend that the correlation of fat cover (rib fat) to marbling is very low.

Dodehoff and Wilson (1999) reported a genetic correlation between fat depth and marbling of .02 for the Angus sire summary. The phenotypic correlation was .16. These cattle were adjusted to equal slaughter age and represent a fairly narrow range of genetics (Angus). Gregory et al. (1995) found a .44 genetic correlation between fat depth and marbling score and a phenotypic correlation of .25. These cattle represented 12 breed groups and were serially slaughtered over a 63-d period. The genetic relationships discussed above cannot be extrapolated to our discussion herein. Genetic comparisons are only logical if the cattle are treated similarly (in this case, fed the same number of days). Conversely, we want to consider the consequences of time on feed. As cattle are fed (high-grain diets) for longer periods, they become fatter and quality grade (marbling) increases. That is why we feed grain to cattle. If days-on-feed were not important, we would slaughter cattle off grass.

Time-on-feed is well illustrated in a study using progeny of Angus bulls with low and high EPD for marbling (Gwartney et al., 1996; Vieselmeyer et al., 1996). Over a 2-yr period, 245 calves (both steers and heifers) were produced. The steers were fed as calves and the heifers were backgrounded (.56 kg/d gain) before being put on feed at 14 mo of age. The cattle were fed high-energy finishing diets and were serially slaughtered to determine rates of change in rib fat and quality grade with time on feed. The steers were slaughtered after 124 and 190 d on feed and the heifers after 84 and 147 d on feed.

The cattle fattened with time on feed (.064-mm/d increase in rib fat for the steers and .077-mm/d increase for the heifers). The cattle were gaining about 1.38 kg/d during the finishing period. Marbling increased by 1.48 units/d (200 = slight^{oo}; 300 = small^{oo}). This clearly shows that as cattle are fed for more days they achieve an increase in 12th rib fat (and yield grade) and in marbling. The second slaughter date for the high-marbling steers and heifers was at the average fat thickness for commercial cattle (approximately 1.4 cm). At that slaughter time, the phenotypic correlation between fat thickness and marbling score was .48 (Figure 1). When both slaughter dates were analyzed as a continuum of time on feed, the phenotypic correlation was .64 for the relationship of fat thickness to marbling score for the high-marbling cattle (Figure 2).

Steers and heifers sired by high-marbling bulls had significantly higher marbling scores than the calves sired by low-marbling bulls (Figure 2). Interestingly, the phenotypic relationship of fat thickness to marbling score was stronger for the high-marbling cattle than for the low-marbling cattle (r = .64 vs .48). Further, the slope of the relationship was greater for the high-marbling cattle than that for the low-marbling cattle.

The percentage of calves grading Choice or higher increased with fattening, similar to the change in marbling score. However, the rate of change was less with the high EPD calves because they were approaching 100% Choice.

Cattle in commercial feedlots are usually fed to a slaughter end point based on rib fat depth. Producers are actually trying to achieve Choice quality grade, and they use rib fat depth as an indicator of marbling (ability to grade Choice). The average fat depth is 1.3 cm (Boleman et al., 1998). Because marbling and fat depth both increase with time-on-feed, it seems logical then that cattle fed in different feeding (backgrounding or stocker) programs should be compared at equal fat depths. Often this is not done, primarily because it requires serial slaughter (Wheeler et al. 1986) or careful estimation of fat depth (Brethour, 1992), such as with ultrasound.

In order to be able to adjust cattle of unequal fat depths to a common end point, we analyzed data from several serial slaughter experiments. There were 534 cattle including calf-feds and yearlings covering the range of cattle production systems. Fat depth at the first slaughter averaged .83 cm and 1.26 cm at the second slaughter and percentage grading Choice averaged 36 and 88 at the respective slaughter dates. Cattle grading Choice increased 12 ± 1 percentage units for each 1-mm increase in fat depth. Marbling scores were available on 276 of the cattle. Marbling score increased 30 units (200 = slight^{oo}) for each 1-mm increase in fat depth. For cattle in different pens or treatment groups, percentage Choice or marbling score was adjusted using these values.

We can illustrate the adjustment with a comparison of yearlings to calf-feds. Calves (Sindt et al., 1991) were randomly allotted at weaning to calf-fed or yearling systems. The calf-feds were placed on high-grain diets within 60 d of weaning. The yearlings were backgrounded on cornstalks in the winter and grazed grass in the summer. The yearlings were finished on high-grain diets similar to those fed to the calf-feds. The yearlings consumed more feed and gained more rapidly in the feedlot than the calves (Table 1). The calves were more efficient than the yearlings. More importantly for this discussion, the yearlings had less fat, and a lower percentage graded Choice. This is somewhat contrary to the common perception that calf-feds are leaner than yearlings. It all depends on how long the cattle are fed. In this case the yearlings were not fed to a similar degree of fatness as the calves. We used the adjustments mentioned above and when the yearlings were adjusted to a fat thickness equal to the calves, the percentage grading Choice was greater for yearlings than for calves (95 vs 76%). This demonstrates just how important it is to compare cattle at equal fat end points. Further, these data suggest that calf-feds and yearlings have similar carcass quality when slaughtered at an equal fat end point. (Because of the degree of adjustment, we are reluctant to conclude that yearlings grade better.) This also represents the extremes in backgrounding systems from none to quite extensive.

These data make another important point. The final weight of the yearlings was 91 kg higher than that of the calves. More recent observations (Jordon et al., 1999) suggest the difference may be as much as 130 kg. This extra weight can be positive or negative, depending on the situation. Increased weight increases gross income and reduces the break-even price at market (Shain et al., 1998). If the cattle are smaller-framed, such as British breeding heifers, then the increased weight reduces the risk of lightweight carcasses. Conversely, if the cattle are steers of Continental breeding, the extra weight in a yearling system may produce overweight carcasses and resulting discounts. The key is to match cattle type to the production system and to market cattle before overweight carcasses are produced.

Effect of Winter Gain on Carcass Quality

Several experiments have been conducted to study the effect of winter gains on subsequent compensatory gain on pasture and feedlot performance. This research allows us to evaluate the effect of rate of winter gain on subsequent carcass quality. Lewis et al. (1990) wintered calves over 2 yr at .28, .38, or .50 kg/d gain. The cattle grazed cool- and warm-season grasses and were then finished in the feedlot for 112 d. Fat thickness ranged from 1.10 to 1.25 cm and quality grades were similar (Table 2).

Downs et al. (1998) and Klopfenstein et al. (1999) wintered calves at .19 kg/d or .72 kg/d. Calves fed cornstalks were supplemented with corn gluten feed to achieve the added gain. The cattle grazed smooth brome or native range pastures and were finished for 71 to 124 d in the feedlot. Feedlot diets contained 35% wet corn gluten feed to minimize acidosis. Compensating yearlings are aggressive eaters, and acidosis may limit their ability to make the compensatory gain. The cattle finished with nearly similar fat; the slower-gaining winter cattle had .06 cm less fat (Table 3). Quality grades were slightly less for the slow cattle, as were the percentage grading Choice. There was no difference in quality grade after adjusting to equal fatness.

Jordon et al. (1999) and Wilson et al. (1999) wintered calves at .21 and .62 kg/d. Corn gluten feed was supplemented to the calves while they grazed stalks to produce the difference. The cattle grazed native range and cool-season grass until they entered the feedlot. They were fed for 92 to 96 d on a 35% wet corn gluten feed diet. Feedlot gains were similar and the low-winter-gaining cattle were slightly less fat than the high-winter-gaining cattle, and they had correspondingly lower marbling scores. However, when adjusted to equal fat thickness, the cattle had similar marbling scores and percentage grading Choice (Table 4).

The three previous studies had a total of 372 cattle over 5 yr. Winter gains ranged from .19 to .72 kg/d over the four studies. There were no differences in quality grades due to rate of winter gains when cattle were adjusted to equal fat thickness at slaughter. We conclude that winter gain does not influence carcass quality.

Effect of Summer Gain on Carcass Quality

Three studies were summarized to study the effect of summer gain on carcass quality. Summer gains were influenced by the quality of forage available. There was no supplementation during summer grazing. Shain et al. (1998) summarized data over 5 yr in which yearlings grazed smooth brome pasture or were rotated from smooth brome to mixed, seeded warm-season grasses. The cattle were finished primarily on diets containing gluten feed. The cattle gained .31 kg/d over the winter on cornstalks. Summer gains were .72 and .82 kg/d, respectively, for cattle grazing brome and brome rotated to warm-season grass (Table 5). Feedlot gains were similar but the higher summer grass gains slightly reduced intakes and increased feed efficiency. Fat depths and quality grades were similar.

Downs et al. (1998) grazed yearlings on native Sandhills range and smooth brome following wintering on cornstalks (.54 kg/d). The cattle were finished on 35% corn gluten feed diets following summer grazing for 85 to 112 d. Summer gains on the brome were quite poor because of precipitation distribution during the summer. The low summer gains on brome apparently produced some compensatory gain in the feedlot, including improved feed efficiency. The slow-summer-gaining cattle (fed brome) were slightly fatter at slaughter with slightly higher quality grades (Table 6). When adjusted to equal fat depths, quality differences essentially disappeared.

Jordon et al. (1999) and Wilson et al. (1999) had yearlings on two different summer native range pastures following wintering on cornstalks at .42 kg/d. The cattle were finished on 35% corn gluten feed diets for 92 to 115 d. One summer range had approximately one-half the forage supplied as wet meadows containing cool-season species. With abundant rainfall, forage production was high and cattle gains were low (.51 kg/d), probably due to overly mature forage. Rates of gain in the feedlot were similar, as were feed efficiencies. The faster-summer-gaining cattle were slightly fatter at slaughter but marbling scores and quality grades were similar (Table 7). Adjusted to equal fat depths, the cattle gaining slower during the summer had somewhat higher quality grades. They were fed 23 d longer in the feedlot.

The three reports reviewed provide a summary of 418 cattle over a 7-yr period. When summer pasture gains varied by only .1 kg/d., there was no effect on carcass quality. In the two latter studies, the summer gain differed by .46 kg/d. The slower-summer-gaining cattle were fed for an average of 25 d longer than the cattle gaining faster in the summer. When adjusted to an equal fat depth, the slower-summer-gaining cattle had higher marbling scores and higher percentage grading Choice (16.2 percentage units). Because of the increased cost of gain with low pasture gains, it would likely not be feasible to attempt to enhance economics through increasing quality by having low summer pasture gains. Of course, that depends on the cost of the pasture.

Carcass Palatability and Tenderness

We have previously discussed the effects of backgrounding on carcass quality grade adjusted to equal fat depth. One of the major concerns facing the industry is the issue of tenderness and variation of tenderness. The marketplace will reflect differences in tenderness when we have an inexpensive and rapid measure of tenderness that can be applied to carcasses. We have conducted one study to investigate the influence of backgrounding and production system on carcass palatability and tenderness.

Ninety cattle were used in three production systems. Thirty cattle were fed as calf-feds and slaughtered at an average of 14 mo of age. The other 60 cattle were in two yearling systems. The yearlings grazed crop residues during the winter months and were placed on grass May 1. Thirty cattle were placed on feed September 2 and the other 30 on November 19. The two groups averaged 19 and 21 mo of age at slaughter.

Heifers were used for the yearling system because they are smaller-framed (Fox et al., 1992) and have carcass characteristics similar to those of steers when slaughtered at the same fatness end point (Adams and Arthaud, 1963; Suess et al., 1966; Zinn et al., 1970; Prost et al., 1975). The calf-feds were Continental × British steers from five different Nebraska ranches. The yearling heifers were British breeding, mostly crossbreds from four ranches. None of the cattle had any Brahman influence.

All three groups of cattle were serially slaughtered (at one of two times). Yield and quality grades were obtained in a commercial packing plant and the whole ribs from the right side were cut into steaks and cooked at 70°C for determination of shear force and evaluation of palatability using a consumer taste panel.

Fat depth was .7 to .8 cm for the first slaughter group and 1.1 to 1.2 cm for the second slaughter group. When data were statistically adjusted to equal marbling scores, no differences were observed for flavor or juiciness of steaks from cattle produced in the three systems (Table 8). However, the yearling cattle were significantly less tender than the calf-feds. Although the cattle were genetically different, the lower tenderness scores of the yearlings is likely due to the greater age (Cross et al., 1984). The 2-mo difference in age between cattle in the two yearling systems had no effect on tenderness (Table 8).

In order to better understand the importance of the differences between the calf-feds and the yearlings, the uniformity of quality attributes was compared within systems and the risk of having an unacceptable steak was estimated. The statistically estimated probability for an animal to belong in one of the different groups of acceptability and shear force rating was made based on the variation measured in this study. The estimated probability of being in the "undesirable" or "tough" category for a calf-fed was .08 and .004%, respectively (Table 9). Based on shear force, the probability of "very tender" loin steaks was 99.2% for the calf-feds and 90.3 to 93.2% for the yearlings. The probability of a "tough" yearling steak was only .10 to .18%.

Clearly, age reduces tenderness, but that does not mean yearlings are tough. The ribs in this study were aged 14 d and the steaks were not overcooked. In fact, a subsequent study with these steaks showed that the tenderness differences disappeared when steaks were cooked to 75°C rather than 65 or 70°C (Calkins et al., 1995). Even though some would argue that calf-feds ensure tenderness, subsequent aging and cooking can mitigate the differences. We conclude that backgrounding system has little, if any, effect on tenderness and has little risk of producing "tough" steaks if they are handled appropriately.

Implications

There are many systems used to produce cattle. These systems allow producers to use local resources integrated into production systems and provide a rather constant flow of cattle into feedlots and subsequently into slaughter facilities. It is critically important to compare slaughter data at equal rib fat end points. When that is done, it seems that backgrounding system has little apparent effect on marbling (quality grade). Systems that increase age of cattle at slaughter may reduce tenderness; however, if the meat is handled and cooked appropriately, the risk of tough steaks is very small.

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Notes

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2. Correspondence: phone: 402-472-6443; fax: 402-472-6362; E-mail: ansc825@unlvm.unl.edu.

Table 1. Finishing performance and carcass characteristics for calves vs yearlings[a]

Item	Calf-fed	Yearling
Initial weight, kg	244	373
Final weight, kg	501	544 (592)[b]
Days on feed	207	108 (139)[b]
Feed intake, kg/d	7.9	11.3
Percentage of weight	2.1	2.5
Daily gain, kg	1.26	1.54
Gain/feed	.162	.136
Fat depth, cm	1.22	.97 (1.22)
Choice, %	76.0	64.9 (95.3)

[a]5 years, 489 cattle, 48 pens. Sindt et al. (1991).

[b]Adjusted to 1.22 cm rib fat (12 percentage units increase in Choice grade per 1 mm increase in fat depth).

Table 2. Effect of winter rate of gain on finishing performance and carcass characteristics[a]

	Winter gain			
Item	Low	Medium	High	SE
No. of steers	40	40	40	
Winter ADG, kg	.28	.38	.50	.02
Pasture ADG, kg	.64	.56	.47	.06
Finishing				
Daily gain, kg	1.64	1.70	1.74	.11
Daily feed, kg	11.96	11.99	12.35	.50
Gain/feed	.137	.141	.141	.005
Carcass data				
Hot carcass wt, kg	326.1	327.2	335.7	5.42
Fat thickness, cm	1.25	1.14	1.10	.08
Quality grade[b]	7.24	7.27	7.24	.07
Yield grade	2.71	2.78	2.80	.07

[a]Lewis et al. (1990).

[b]Low Choice = 7.17, average Choice = 7.5.

Table 3. Effect of winter gain on carcass quality[a]

Item	Low	High
Winter gain, kg/d	.19	.72
Summer gain, kg/d	.73	.52
Feedlot gain, kg/d	1.94	2.10
Gain/feed	.151	.152
Fat depth, cm	1.24 (1.30)[b]	1.30
Quality grade	19.1 (19.3)[b]	19.4
Choice, %	84.6 (91.8)[b]	87.0

[a]Downs et al. (1998); Klopfenstein et al. (1999).
[b]Adjusted to 1.30 cm fat depth (12 percentage units increase in Choice grade per 1 mm increase in fat depth).

Table 4. Effect of winter gain on carcass quality[a]

Item	Low	High
Winter gain, kg/d	.21	.62
Summer gain, kg/d	.64	.56
Feedlot gain, kg/d	2.14	2.16
Gain/feed	.153	.151
Fat depth, cm	1.01 (1.16)[b]	1.16
Marbling score	490 (534)[b]	532
Choice, %	50.3 (68.3)[b]	66.9

[a]Jordon et al. (1999); Wilson et al. (1999).
[b]Adjusted to 1.16 cm fat depth (12 percentage units increase in Choice grade per 1 mm increase in fat depth).

Table 5. Performance data pooled across years (five) for cattle grazing continuous brome or warm-season grasses[a]

Item	Continuous brome	Brome, warm-season	SE
Winter gain, kg	.31	.31	.01
Summer gain, kg	.72	.82	.01
DMI, kg/d	12.1	11.7	.11
ADG, kg	1.63	1.63	.03
Gain/feed	.134	.138	.001
Fat depth, cm	1.07	1.07	.01
Quality grade[b]	18.7	18.7	.05
Yield grade	2.39	2.34	.02

[a]Shain et al. (1998).
[b]20 = average Choice, 19 = low Choice, 18 = high Select.

Table 6. Effect of summer gain on carcass quality[a]

Item	Slow	Fast
Winter gain, kg/d	.54	.54
Summer gain, kg/d	.28	.81
Feedlot gain, kg/d	2.16	1.98
Gain/feed	.157	.145
Fat, cm	1.28	1.21 (1.28)[b]
Quality grade	19.5	19.1 (19.30)[b]
Choice, %	90	74 (82.4)[b]

[a]Downs et al. (1998).
[b]Adjusted to 1.28 cm fat (12 percentage units increase in Choice grade per 1-mm increase in fat depth).

Table 7. Effect of rate of summer gain on carcass quality

Item	Slow[a]	Fast[b]
Winter gain, kg/d	.42	.42
Summer gain, kg/d	.51	.90
Feedlot gain, kg/d	2.15	2.15
Gain/feed	.151	.151
Fat, cm	1.10 (1.23)[c]	1.23
Marbling score	529 (567)[c]	517
Choice, %	70 (85.2)[c]	68

[a]Jordon et al. (1999).
[b]Wilson et al. (1999).
[c]Adjusted to 1.23 cm fat (12 percentage units increase in Choice quality grade or 30 units increase in marbling per 1-mm increase in fat depth).

Table 8. Adjusted values for palatability traits and shear force of loin (longissimus muscle) steaks from cattle of different production systems[ab]

	System			
Item	Calf	Yearling	High-forage yearling	SE
No. of observations	29	30	30	—
Juiciness[c]	5.7	5.6	5.4	.08
Tenderness[c]	6.0[d]	5.6[e]	5.4[e]	.08
Flavor[c]	5.6	5.4	5.4	.06
Overall acceptability[c]	5.7[d]	5.5[e]	5.4[e]	.07
Shear force, kg	2.84[d]	3.30[e]	3.22[e]	.08

[a]Adjusted for marbling score.

[b]Rossi et al. (1994).

[c]Means based on a eight-point scale (8 = extremely desirable, 7 = very desirable, 6 = moderately desirable, 5 = slightly desirable, 4 = slightly undesirable, 3 = moderately undesirable, 2 = very undesirable, 1 = extremely undesirable).

[d,e]Means within a row lacking a common superscript letter differ ($P < .01$).

Table 9. Probability of taste panel ratings and shear force values of loin (longissimus muscle) steaks from cattle of different systems (percentage)

	System								
	Calf			Yearling			High-forage yearling		
Item	Undesirable[b], tough[c]	Slightly desirable, tender	Desirable, very tender	Undesirable, tough	Slightly desirable, tender	Desirable, very tender	Undesirable, tough	Slightly desirable tender	Desirable, very tender
Juiciness	.17	31.04	68.79	.37	40.15	59.48	1.43	58.05	40.52
Tenderness	.03	12.27	87.70	.52	40.38	59.10	2.83	56.27	40.90
Flavor	.08	38.89	61.03	.51	60.52	38.97	.51	60.52	38.97
Overall acceptability	.05	29.12	70.83	.28	49.72	50.00	1.36	69.52	29.12
Shear force	.004	.836	99.16	.18	9.52	90.30	.10	6.70	93.20

[a]Rossi et al. (1994).

[b]Acceptability rate: Undesirable = consumer taste panel rating less than 4.5; slightly desirable = consumer taste panel rating between 4.5 and 5.5; desirable = consumer taste pane rating greater than 5.5.

[c]Shear force rate: <3.86 kg = very tender; > 3.85 < 4.55 kg = tender; > 4.5 kg = tough.

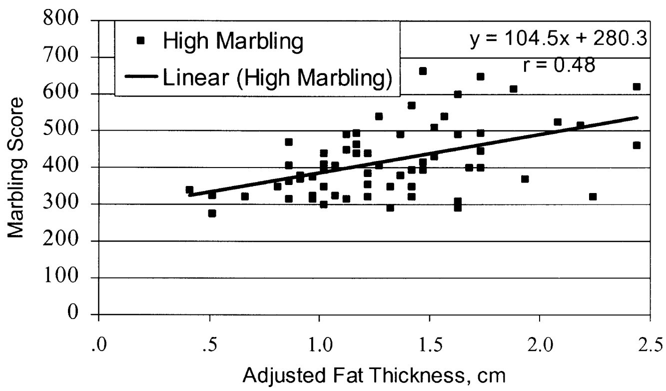

Figure 1. Relationship of adjusted fat thickness to marbling score of high marbling steers and heifers at the second slaughter date. Marbling score: 200 = slight^{00}; 300 = small^{00} (Gwartney et al., 1996).

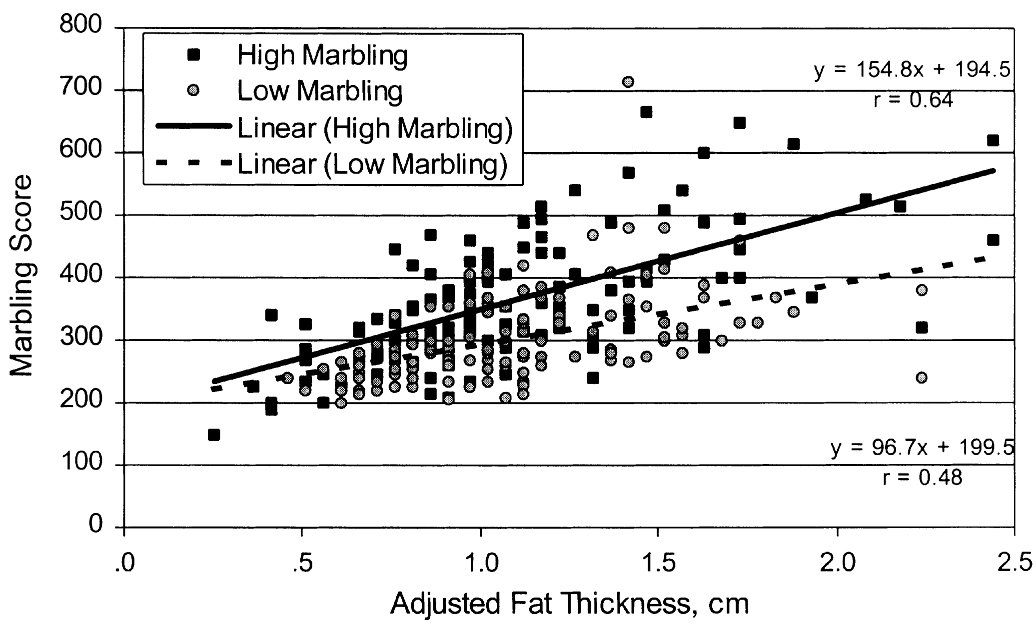

Figure 2. Relationship of adjusted fat thickness to marbling score of high and low marbling steers and heifers at the first and second slaughter dates. Marbling score: 200 = slight^{00}; 300 = small^{00} (Gwartney et al., 1996).

