Effects of Nutrition and Management during the Stocker Phase on Marbling Score and Quality Grade

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INTRODUCTION

The 2005 National Beef Quality Audit Survey reported that "Insufficient Marbling & Low Quality Grades" were the number one quality challenge facing the beef industry (Smith et al., 2006). This survey included responses from multiple phases of the beef production chain, including seedstock, cow/calf, stocker/backgrounding, finishing, and packer sectors. Retained ownership, alliances, and vertically coordinated supply chains are becoming a larger percentage of cattle on feed, resulting in an estimated 50% or greater of the cattle in the U.S. trading outside of the cash market (Ritchie, 2002). As segments of the industry become more coordinated, it becomes increasingly important to understand the effects that management and nutrition in each segment has on all subsequent phases of production and final carcass value. Improving nutritional and management strategies for growing beef cattle to enhance final carcass quality will not only benefit the beef industry as a whole, but will provide producers with more incentive to produce high-quality beef to meet consumer demand. Because consumer dollars ultimately drive the beef cattle industry, meeting consumer demand/desires will continue to determine profitability in the future.

Studies of nutrition and management practices that influence marbling (intramuscular fat) deposition have primarily focused on the feedlot phase of production (Owens and Gardner, 2000). However, pre-feedyard management strategies (health status, stocker/backgrounding, nutrient supplementation, etc.) can influence marbling development (Anderson and Gleghorn, 2007). Therefore, changes in management practices during early phases of the production cycle that increase intramuscular fat deposition and decrease fat deposition in other depots could enhance the efficiency of beef production and enhance carcass quality. Due to the current price of grains and harvested forages, cattle are entering the feedlot at heavier weights indicating that post-weaning management programs are being used to decrease the number of days cattle spend in the feedyard. Understanding how these post-weaning nutrition and management programs impact carcass growth and development is becoming increasingly important.

Depending on biological type of cattle, calves are often grazed or placed on a growing diet after weaning to achieve adequate frame size and carcass weight before entering the feedlot for finishing. Across the Southern Great Plains and the Southeastern U.S., grazing systems are commonly used for growing programs during the winter. Cool season forages, including wheat pasture, are utilized to grow cattle to desirable weights for feedlot entry (Byers, 1982). In addition, each year in the Southern Great Plains fall-weaned calves are wintered on dormant native range. Cattle that are wintered on dormant native range are typically fed a protein supplement to gain 0.25 to 050 kg/day through the winter months until spring forage growth occurs. These calves then graze summer pasture in either intensive-early stocking or season-long grazing programs prior to entering the finishing phase. In the Northern Great Plains, cattle are usually either grown on crop residues, dormant grass pastures, or placed in confinement and program fed for a moderate rate of gain on harvested and ensiled crops such as corn silage. Albeit stocker programs are increasing due to costs of gain in the feedyard, some larger-framed calves may go directly on to a high-concentrate diet immediately following weaning. High-concentrate diets may be fed at restricted levels in the growing phase to provide a desired rate of gain while allowing for lean tissue growth (Sip and Pritchard, 1991). Because of the variability in growing programs among different regions of the country and in diets that may consist of grazed or harvested forage and/or grain-based diets, performance and weight gain of cattle before and after feedlot entry may be vastly different (McCurdy

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et al., 2010). In addition, development of fat depots in relation to BW and maturity of the animal could be impacted to alter carcass quality. Because economic value of carcasses is dependent primarily on carcass weight and carcass quality, cattle producers have a strong interest in factors associated with maximizing these two variables.

MARBLING DEVELOPMENT DURING THE STOCKER PHASE

Adipose tissue development is of major importance to beef production because it influences production efficiency, product quality and consumer acceptance, and, therefore, product value (Smith et al., 1987). Growth of the intramuscular fat depot (i.e., marbling) is especially desirable due to consumer preference for well-marbled beef, whereas growth of other fat depots results in excess fat and production inefficiencies (Hausman et al., 2009). In addition, the amount of fat deposited in the intramuscular depot is the basis for carcass price premiums (marbling; USDA Quality Grade) and fat deposited in other depots can result in carcass discounts (subcutaneous fat; USDA Yield Grade). Anderson and Gleghorn (2007) suggested that marbling deposition is a lifetime event and that prefeedlot nutrition has a significant impact on marbling deposition. Peel (2003) estimated that 76% of the yearly calf crop enters a backgrounding or stocker program prior to finishing; therefore, there is tremendous opportunity to improve carcass quality attributes by influencing adipose tissue development during the stocker/backgrounding phase of production. During the stocker/backgrounding phase of production, significant muscle growth occurs and the primary structures of marbling deposits are developed. Although increasing intramuscular fat deposition relative to other fat depots would be beneficial, little is known about the association between muscle growth, metabolism and marbling development.

Numerous investigations have sought to determine the effects of nutrition and management throughout the production chain on deposition of marbling and subsequent carcass quality (Berger and Faulkner, 2003). Increases in marbling have been shown by starting cattle on high-concentrate rations at earlier ages (Myers et al., 1999a; 1999b; Wertz et al., 2001, 2002); however, these cases dealt with calves that were early weaned and started on feed at very early ages (70 to 100 days of age). Wertz et al. (2002) evaluated the effect of weaning calves and growing them on forage compared to early-weaning calves and immediately placing them on a high-concentrate diet. Early-weaned heifer calves were approximately 20% more efficient at any ultrasound marbling score compared with older heifers that had grazed and were placed on feed later in life. In addition, at any given 12th-rib fat thickness, early-weaned calves had higher ultrasound marbling scores. In a similar study, Angus × Simmental heifer calves that were fed high-energy diets at 208 days of age or earlier deposited more marbling relative to 12th-rib fat than heifers of the same genetics that were finished as long yearlings (Wertz et al., 2001).

In normal-weaned calves (approximately 200 days of age), Faulkner et al. (1994) showed that creep feed energy source could affect carcass quality even when weight gain was similar during the creep phase. In their experiment, calves which had been fed a corn-based creep had higher marbling scores than calves which had been creep fed soy hulls. In contrast, no difference in marbling score was observed in normal-weaned calves creep-fed high corn, high fiber, or no creep (Berger and Faulkner, 2003). Reasons for discrepancies are unclear, although Bruns (2006) suggested that if calves can sustain their normal growth curve without additional supplementation then creep feeding won't increase quality grade. However, if the calves are growing below their growth potential, due to inadequate nutrition, then creep feeding or early weaning should help their ability to grade. Even though early weaned calves generally have lower average daily gains in the finishing phase than yearlings, they are consuming excess calories early in life above their requirement for normal growth. Therefore, marbling (intramuscular fat) deposition might be greater compared with normal-weaned calves (Bruns, 2006).

LEVEL OF DIETARY STARCH DURING BACKGROUNDING

We conducted a meta-analysis to evaluate the level of dietary starch in growing diets during the stocker/backgrounding phase. A dataset with a total of 14 studies was compiled comparing growing diets fed to beef cattle in the drylot that differed in grain content of the diet (i.e., starch content) for 56 to 145 d prior to finishing. To be included in the dataset, feed intake of the different diets had to be adjusted to provide similar NE_g intake and achieve similar rates of gain during the growing phase. Treatments were categorized as either low (LS), medium (MS), or high (HS) starch diets based on grain and NE_g content of the diet. Corn was the predominate cereal grain used except in the study by Sainz et al. (1995), which used rolled wheat in the HS diet. Grain content of the diet was calculated from the reported ingredient composition of the experimental diets, where corn or sorghum silage was assumed to contain 50% grain. Seven studies had a comparison of HS versus MS, and 9 studies had a comparison of HS versus LS. Only 2 studies had a comparison of MS versus LS; therefore this comparison was not analyzed. The dataset was divided into two sub-datasets of either HS versus MS or HS versus LS. Grain content, NE_g concentration, and growing ADG for HS versus MS, and HS versus LS sub-datasets are presented in Table 1. Each sub-dataset was analyzed using a linear mixed model (Proc Mixed of SAS, SAS Instit., Cary, NC) that included diet as a fixed effect and intercept as a random effect with the unstructured option used for the var-(co)var matrix and trial as the subject. Least squares means were computed using the inverse of the squared standard error for the dependent variable as a weighting factor (St.-Pierre, 2001). Least squares means were compared using Tukey's W procedure and were considered different at $P < 0.10$.

Table 1. Mean (Range) for grain content, NEg concentration, and growing phase ADG for steers fed high versus medium starch, or high versus low starch diets during the growing phase

	Dataset 1		Dataset 2	
Variable	High Starch	Medium Starch	High Starch	Low Starch
Grain, %	79.4 (70.8 – 89.2)	45.2 (35.0 – 52.0)	72.8 (65.0 – 79.2)	16.4 (0.0 – 35.9)
NEg, Mcal/kg DM	1.42 (1.21 – 1.54)	1.02 (0.62 – 1.22)	1.42 (1.32 – 1.56)	1.03 (0.48 – 1.36)
Growing ADG, kg/d	1.07 (0.76 – 1.51)	1.12 (0.58 – 2.40)	1.30 (0.69 – 1.83)	1.26 (0.77 – 2.07)

Results of the HS versus MS comparison are presented in Table 2. Finishing performance was similar between diet types with no differences for ADG, DMI, or gain:feed. In addition, there were no differences in LM area, rib fat thickness, KPH, yield grade, or marbling score between steers previously fed HS or MS diets during the growing phase. Of the individual studies used in the meta-analysis, the results consistently show little to no difference in marbling score with regard to grain content of the growing diet. In three trials, Loerch (1990) fed Angus crossbred steers a corn silage-based growing diet ad libitum or high moisture corn-based diet at restricted intake for 85 d prior to finishing on a common diet. In all three trials, growing diet had no impact on final marbling score. Similarly, Sip and Pritchard (1991), Coleman et al. (1995) and McCurdy et al. (2010) showed that corn-grain based growing diets did not improve marbling score compared with corn/sorghum silage-based growing diets. Gunter et al. (1996) and Vasconcelos et al. (2009) reported that marbling scores were similar between steers fed 90% concentrate or 50 to 60% concentrate growing diets prior to finishing on a common diet.

When comparing finishing performance of steers fed HS or LS diets during the growing phase, there were no differences in final BW, DMI, or gain:feed; however, steers previously fed HS diets had greater ($P < 0.10$) ADG (1.76 vs. 1.67 kg/d, respectively) during the finishing phase (Table 3). Steers fed HS or LS diets during the growing phase had similar LM area, rib fat thickness, KPH, yield grade, and marbling score. Wagner (1988) fed growing steers a corn silage/alfalfa-grass hay diet ad libitum or high moisture corn diet limit-fed to provide similar ME intake as the corn silage/alfalfa-grass hay diet. Following the finishing phase, marbling score was similar between growing diets. Similarly, Sainz et al. (1995) observed that final marbling score was similar between steers fed an alfalfa hay/cottonseed hull-based growing diet or limit fed a grain-based diet. Vasconcelos et al. (2009) reported that steers limit fed a steam-flaked corn diet had no impact on final marbling score compared with steers fed a wheat midd/cottonseed hull growing diet ad libitum. McCurdy et al. (2010) compared carcass characteristics of steers limit fed a grain-based diet with steers that grazed winter wheat pasture managed such that rate of gain during the growing phase was similar (1.18 vs. 1.15 kg/d, respectively). After finishing on a common diet, marbling score was similar between steers that grazed wheat pasture and those that were fed the grain-based growing diet. Collectively, meta-analysis of these studies indicate that dietary starch content of growing diets has little impact on final marbling score.

Table 2. Meta-analysis of finishing performance and carcass traits from steers fed high- versus medium-starch growing diets prior to finishing from 9 published studies

Item[1]	High Starch	Medium Starch	SEM	*P*-value
Performance				
Initial BW, kg	362.5	359.2	8.1	0.21
Final BW, kg	527.7	525.5	16.4	0.59
ADG, kg/d	1.50	1.50	0.10	0.78
DMI, kg/d	8.72	8.80	0.32	0.62
Gain:Feed	0.172	0.171	0.008	0.62
Carcass characteristics				
HCW, kg	323.9	325.6	10.6	0.45
LM area, cm^2	82.10	82.28	2.39	0.78
Rib fat thickness, cm	1.27	1.28	0.09	0.63
KPH, %	2.70	2.69	0.25	0.59
Yield Grade	2.94	2.90	0.18	0.50
Marbling Score[2]	426.7	435.7	17.4	0.35

[1]HCW = hot carcass weight, KPH = kidney, pelvic and heart fat.
[2]Marbling grid: Slight00=300, Small00=400, Modest00=500.

Table 3. Meta-analysis of finishing performance and carcass traits from steers fed high- versus low-starch growing diets prior to finishing from 7 published studies

Item[1]	High Starch	Low Starch	SEM	*P*-value
Performance				
Initial BW, kg	361.5	356.5	13.1	0.38
Final BW, kg	532.8	535.1	11.4	0.61
ADG, kg/d	1.76	1.67	0.07	0.09
DMI, kg/d	10.19	10.29	0.36	0.58
Gain:Feed	0.174	0.162	0.010	0.12
Carcass characteristics				
HCW, kg	331.8	330.8	10.2	0.77
LM area, cm^2	77.53	77.95	3.27	0.68
Rib fat thickness, cm	1.22	1.21	0.10	0.88
KPH, %	2.42	2.44	0.27	0.75
Yield Grade	3.02	3.11	0.16	0.15
Marbling score[2]	443.1	433.6	19.1	0.40

[1]HCW = hot carcass weight, KPH = kidney, pelvic and heart fat.
[2]Marbling grid: Slight00=300, Small00=400, Modest00=500.

LEVEL OF STARCH SUPPLEMENTATION DURING GRAZING

Supplementation of starch to grazing cattle during the stocker phase has received less attention due to limited ability to dramatically change the starch content of the overall diet compared with growing diets fed in drylot. However, a few studies have evaluated starch-based supplements to grazing stocker cattle on final carcass quality. Horn et al. (1995) reported that high-starch corn-based supplements fed to steers grazing winter wheat pasture did not improve marbling score compared with steers fed a high-fiber soybean hull/wheat midd-based supplements. Similarly, Bumpus (2006) and Sharman et al. (2012) observed that high-starch supplements did not improve marbling score of steers grazing ryegrass and winter wheat pasture, respectively, compared with high-fiber supplements. Sharman et al. (2009) fed either corn, soybean hulls, or distillers grains at 1% of BW to steers grazing dormant winter native range. Similar to previous studies, these authors observed no difference in final marbling score between the different supplement types, even though glucose supply for steers grazing dormant native range would have been very low.

Interestingly, Lake et al. (1974) and Lomas et al. (2009) reported that supplementing steers grazing cool-season pasture with 1.82 or 1.64 kg/d of grain increased marbling score compared with no supplementation. However, in a second trial, Lake et al. (1974) observed no improvement in quality grade when steers were supplemented up to 2.72 kg/d of corn. The explanation for these differences could be that the starch-based supplement was not matched with a fiber-based supplement such that the supplement provided additional energy for fat deposition rather than a starch effect. Similarly, Bumpus (2006) observed that starch- and fiber-based supplements improved marbling score compared with non-supplemented steers, but rate of gain during the stocker phase was not increased for supplemented steers compared with non-supplemented steers. In contrast, Horn et al. (1995), Sharman et al. (2009), and Sharman et al. (2012) observed that starch- or fiber-based supplements did not improve marbling score compared with non-supplemented steers. Therefore, simply the additional energy does not appear to explain the improved marbling scores.

Another explanation could be the BW of cattle during the stocker phase relative to mature weight. Carter et al. (2002) evaluated the relationship between ultrasound intramuscular fat percentage and BW when steers were grown on pasture and placed on feed at three different weights (363, 408, or 454 kg initial finishing BW). These authors observed that regardless of placement weight there was breakpoint BW of 378 kg at which intramuscular fat began to increase. The breakpoint BW of 378 kg was calculated to be 64% of mature weight of the steers or 66% of final feedlot BW. When applying this concept to previous studies, feedlot placement BW of steers in Trial 1 of Lake et al. (1974), Bumpus (2006), and Lomas et al. (2009) were 73, 70, and 70% of final feedlot BW indicating that energy supplementation had increased energy intake after the point at which intramuscular fat deposition increased. In contrast, feedlot placement BW was only 66, 62, and 54% of final feedlot BW in the studies of Lake et al. (1974; Trial 2), Horn et al. (1995), and Sharman et al. (2009) where final marbling score was not influenced by energy supplementation during the stocker phase.

In conclusion, the starch content of growing diets or energy supplements fed to grazing cattle does not appear to influence final marbling scores. In addition, energy supplementation of lightweight stocker cattle may not improve final marbling score. However, energy supplementation of heavyweight yearling stocker cattle could be beneficial for enhancing final marbling score of cattle. Further research is necessary to validate the concept that providing an energy supplement to heavyweight yearling stocker cattle could improve marbling scores.

RATE OF GAIN DURING THE STOCKER PHASE AND PLACEMENT WEIGHT

A second dataset consisting of 29 trials was compiled to evaluate the relationships of rate of gain during the stocker/backgrounding phase and initial BW at start of finishing with carcass characteristics. To be included in the dataset, normal-weaned steers/heifers must have entered the stocker phase shortly after weaning, and stocker treatments must have differed in rate of gain by > 0.10 kg/d during the stocker phase. In this dataset, steers/heifers either grazed different forage types, were fed with different levels of supplement while grazing pasture, or were fed high-roughage growing diets in drylot to achieve different rates of gain during the stocker/backgrounding phase prior to being fed a common finishing diet. In some trials, treatments were fed for similar days on feed during the finishing phase, whereas in other trials treatments were fed to a common fat endpoint with different days on feed. Mixed model regression analysis following random coefficient methodology (St. Pierre, 2001) was used to evaluate the relationships of rate of gain during the stocker/backgrounding phase and initial finishing BW with carcass characteristics and rib fat-adjusted carcass characteristics. A general linear model (Proc GLM of SAS) that included the covariate (i.e., stocker ADG or initial BW), trial, and trial x covariate interaction terms was used to test the hypothesis that the slope between the covariate and carcass characteristics was similar among trials. Regression analyses were conducted using a mixed model (Proc Mixed of SAS) that included the covariate(s) as fixed effects, and intercept and covariate(s), when slopes differed among trials, as random effects with the unstructured option used for the var-(co)var matrix and trial as the subject. Regression coefficients were computed using the inverse of the squared standard error for the dependent variable as a weighting factor (St.-Pierre, 2001), and were considered different from zero at $P < 0.10$. Quadratic regression coef-

Table 4. Summary statistics of 29 trials used in meta-analysis to evaluate the relationship of stocker phase ADG and initial finishing BW with carcass characteristics

Variable	N	Mean	Minimum	Maximum
Trial initial BW, kg	79	240.4	186.0	278.0
Stocker ADG, kg/d	85	0.77	0.15	1.68
Initial finishing BW, kg	85	346.7	231.5	450.0
Hot carcass weight, kg	85	326.1	240.2	397.0
LM area, cm^2	78	78.80	64.50	96.57
Rib fat thickness, cm	82	1.30	0.51	2.40
Kidney, pelvic and heart fat, %	56	2.16	1.62	3.47
Yield Grade	73	2.99	2.37	4.02
Marbling score[1]	85	417	266	535

[1]Marbling grid: Slight00=300, Small00=400, Modest00=500.

Table 5. Regression coefficients (± SE) of carcass characteristics on stocker phase ADG (kg/d), initial finishing BW (kg), or hot carcass weight (kg) from a meta-analysis of 29 trials

Independent variable	R2	Intercept	Independent variables
HCW1, kg	0.788	310.80 ± 10.95	27.4394 ± 9.8434*ADG
	0.939	224.94 ± 23.39	0.2931 ± 0.0623*initial finishing BW
12th rib fat, cm	0.001	1.2719 ± 0.0741	0.0106 ± 0.0643*ADG
	0.062	1.1751 ± 0.2803	0.0002 ± 0.0007*initial finishing BW
	0.734	-0.0335 ± 0.2661	0.0040 ± 0.0001*HCW
LMA, cm2	0.419	75.7086 ± 1.5518	4.9965 ± 1.5243*ADG
	0.695	63.5700 ± 3.9409	0.0450 ± 0.0118*initial finishing BW
	0.864	34.5479 ± 5.1707	0.1367 ± 0.0158*HCW
KPH, %	0.341	1.9745 ± 0.1144	0.2705 ± 0.0977*ADG
	0.296	1.3788 ± 0.2402	0.0023 ± 0.0006*initial finishing BW
	0.143	1.4338 ± 0.4911	0.0023 ± 0.0015*HCW
Yield Grade	0.011	2.9268 ± 0.0971	0.0073 ± 0.0983*ADG
	0.075	2.6095 ± 0.3618	0.0009 ± 0.0010*initial finishing BW
	0.278	2.0057 ± 0.4756	0.0028 ± 0.0014*HCW

1HCW = hot carcass weight; LMA = longissimus muscle area; KPH = kidney, pelvic and heart fat.

ficients were tested and were not significant. Summary statistics for stocker performance and carcass characteristics of the 29 trials is presented in Table 4.

Stocker phase ADG and initial finishing BW were positively related with HCW, LM area, and KPH, but not rib fat thickness or yield grade (Table 5). Hot carcass weight was positively related to LM area, rib fat thickness, and yield grade, but not KPH. These results indicate that as cattle grew faster during the stocker phase and were heavier entering the feedyard they produced heavier carcasses with larger longissimus muscle area, but had no influence on carcass fat composition as evidenced by the lack of relationship with fat thickness and yield grade.

Marbling score was not related to stocker phase ADG (data not shown) or initial finishing BW (data not shown), but was positively related to HCW (Figure 1) suggesting that growth during the stocker phase has little influence on marbling score and it is the weight of the animal at slaughter that has the largest influence. Additionally, marbling score was positively related to rib fat thickness [y = 291.82 ± 29.2048 + 92.5465 ± 22.2935 * rib fat thickness (cm)].

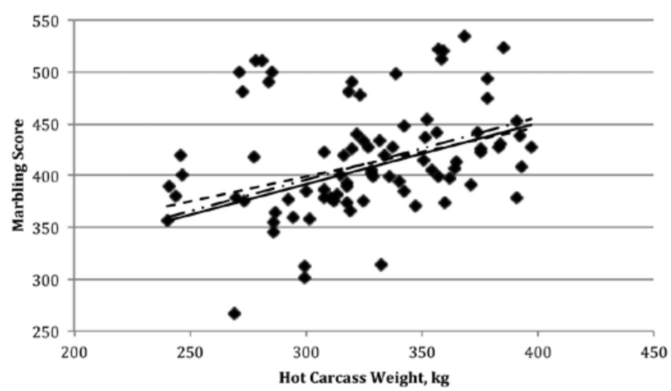

Figure 1. Mixed model regression of marbling score (◆) on hot carcass weight without and with inclusion of other independent variables in the model. Marbling grid: 300 = Slight00; 400 = Small00; 500 = Modest00. Marbling score (solid line) = 215 ± 93.05 + 0.596 ± 0.290*HCW (R2 = 0.76). Marbling score (dashed line) = 156 ± 51.28 + 0.478 ± 0.160*HCW + 76.29 ± 22.82*ribfat (R2 = 0.84). Marbling score (dash/dotted line) = 176.2 ± 55.78 + 29.36 ± 22.29*ADG – 0.216 ± 0.175*initial finishing BW + 0.604 ± 0.274*HCW + 69.80 ± 28.48*ribfat (R2 = 0.84).

Given the relationship between marbling score and rib fat thickness and to evaluate relationships with rib fat-adjusted carcass characteristics, rib fat thickness was included in the regression of stocker phase ADG, initial finishing BW, and HCW with marbling score. When adjusted for rib fat thickness, marbling score was positively related with stocker phase ADG, initial finishing BW, and HCW suggesting that all three factors may play a role in influencing marbling score when cattle are fed to a similar rib fat thickness. To determine the relative importance of stocker phase ADG, initial finishing BW, and HCW with rib fat-adjusted marbling score, these traits were included in the regression model to predict rib fat-adjusted marbling score. When stocker ADG, initial finishing BW, and HCW were included in the model along with rib fat thickness, HCW continued to be positively related to marbling score, but stocker phase ADG and initial finishing BW were no longer related to marbling score. Thus, it appears that increasing HCW will increase rib-fat adjusted marbling score regardless of previous management. Our regression analysis indicates that greater stocker phase ADG or initial finishing BW can increase HCW, which can be accomplished through the use of higher quality forage, energy supplements, or longer grazing periods. However, to increase rib fat-adjusted HCW, regression analysis indicates that lower rates of gain and longer grazing periods to achieve greater initial finishing BW are needed.

These results may explain the lack of differences in marbling score in cattle from different stocker and backgrounding studies (Coleman et al., 1995; Sainz et al., 1995; Hersom et al., 2004; McCurdy et al., 2010), because even though cattle in these studies underwent widely different growing programs the end result was similar HCW when fed to similar rib fat thickness. Our results are also contrary to the idea that cattle should be grown at moderate to high rates of gain and finished at young ages to achieve high quality grades. In agreement with our results, Klopfenstein et al. (2000) reported that long-yearling production systems resulted in greater initial finishing BW and HCW, and increased the percentage of cattle grading choice when adjusted to similar rib fat thickness compared with calf-fed production systems. Similarly, Sharman et al. (2012) observed that steers wintered on dormant native range followed by season-long grazing of native pasture prior to finishing increased initial finishing BW and tended to increase marbling scores but lower rib fat thickness compared with steers grazing winter wheat pasture prior to finishing.

CONCLUSIONS

In conclusion, marbling score and rib fat thickness-adjusted marbling score can be manipulated using nutrition and management during the stocker phase. Marbling scores can be improved by 'making cattle bigger' through increasing rate of gain during the stocker phase, initial finishing BW, and HCW. However, this will also increase rib fat thickness and yield grade resulting in little improvement in marbling to rib fat ratio. In contrast, rib fat-adjusted marbling score (i.e., improved ratio of marbling to rib fat) can be improved by using low to moderate rates of gain for longer grazing periods during the stocker phase to increase initial finishing BW and rib fat-adjusted HCW.

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