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Leptin as a predictor of carcass composition in beef cattle[1]

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ABSTRACT: Our objective was to determine if serum concentrations of leptin could be used to predict carcass composition and merit in feedlot finished cattle. Two different groups of crossbred *Bos taurus* steers and heifers were managed under feedlot conditions near Miles City, MT. The first group consisted of 88 ½ Red Angus, ¼ Charolais, and ¼ Tarentaise composite gene combination steers (CGC) harvested at the ConAgra processing facility in Greeley, CO. The second group (Lean Beef Project; LB) consisted of 91 F_2 steers and heifers born to Limousin, Hereford, or Piedmontese by CGC F_1 cows crossed to F_1 bulls of similar breed composition and harvested at a local processing facility in Miles City, MT. Blood samples were collected approximately 24 h before harvest (CGC) or approximately 3 d before and at harvest (LB). No differences in serum concentrations of leptin were detected ($P > 0.10$) between Hereford, Limousin, or Piedmontese F_2 calves nor between LB steers and heifers. Positive correlations ($P < 0.01$) existed between serum leptin and marbling score (r = 0.35 and 0.50), fat depth measured between the 12th and 13th rib (r = 0.34 and 0.46), kidney, pelvic, and heart fat (KPH) (r = 0.42 and 0.46), and quality grade (r = 0.36 and 0.49) in CGC and LB cattle, respectively. Serum leptin was also positively correlated with calculated yield grade for CGC steers (r = 0.19; $P = 0.10$) and LB cattle (r = 0.52; $P < 0.01$). Longissimus area was not correlated with serum leptin in CGC steers (r = 0.12; $P > 0.10$). However, a negative correlation existed between longissimus area and serum leptin in the LB cattle (r = –0.45; $P < 0.01$). Serum concentrations of leptin were significantly associated with carcass composition (marbling, back fat depth, and KPH fat) and quality grade in both groups of cattle studied and may provide an additional indicator of fat content in feedlot cattle.

Key Words: Carcass Composition, Cattle, Fat, Leptin, Lipid

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Introduction

The protein hormone leptin has been implicated in the control of food intake and body composition in mammals. The principal site of leptin production is adipocytes, and as adipocytes increase in mass, peripheral concentrations of leptin increase (Considine, 1997; Ahima and Flier, 2000). Once mammals reach their mature size, most subsequent growth occurs in the form of adipose tissue deposition; thus, it would seem reasonable that circulating concentrations of leptin would also increase.

Accrual of adipose tissue in the body first occurs as the result of hyperplastic adipocyte growth followed by hypertrophic changes (Owens et al., 1993). In the livestock industries, hypertrophy of adipose tissue is the major fat deposition involved in finishing animals to market weight (Hood, 1982); however, the rate of adipose tissue growth varies with location within the body. In growing cattle, sheep, and pigs, subcutaneous fat hypertrophy occurs faster than does intermuscular, intramuscular, or kidney, pelvic, and heart fat (**KPH**) hypertrophy (Kempster, 1980).

Adipocyte size may influence leptin synthesis and secretion because larger adipocytes contained more leptin mRNA (Auwerx and Staels, 1998). Adipocyte diameter varies according to tissue location, and in a study of 17-mo-old crossbred steers, diameter of adipocytes were classified in the following regions as containing the largest to smallest adipocytes: KPH, mes-

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Table 1. Content of diets (% DM basis) fed to CGC[a] steers and LB[b] steers and heifers during the growing and finishing phases

	CGC diet		LB diet	
Component	Growing	Finishing	Growing	Finishing
Corn silage	50.30	48.31	47.60	38.80
Alfalfa hay	19.60	0	14.30	0
Barley	25.80	6.14	32.30	57.30
Corn	0	41.45	0	0
Soybean meal	3.03	2.90	4.10	2.70
Urea	0.66	0.63	0.90	0.59
Calcium carbonate	0.34	0.33	0.45	0.30
Salt	0.15	0.14	0.21	0.13
Trace mineral mix[c]	0.09	0.08	0.12	0.08

[a]CGC represents composite gene combination cattle composed of ½ Red Angus, ¼ Tarentaise, and ¼ Charolais.
[b]LB represents steers and heifers born to Limousin, Hereford, or Piedmontese by CGC F_1 cows crossed to F_1 bulls of similar genetic makeup.
[c]Contains 20% Mg, 2.7% S, 6% Zn, 5% Fe, 4% Mn, 1.5% Cu, 0.11% I, 0.01% Co, and 0.01% Se with wheat mids and mineral oil as carriers.

enteric, subcutaneous, intermuscular, intramuscular, and brisket fat, respectively (Cianzio et al., 1985). Because quality and yield grades are both influenced by fat deposition and are used to determine carcass value, our objective was to determine if peripheral concentrations of leptin in feedlot cattle could be used to predict carcass merit.

Materials and Methods

Animal and Data Collection

Two different groups of *Bos taurus* steers and heifers, managed under feedlot conditions in Miles City, MT, were used in this study. The first group consisted of 88 composite gene combination steers (**CGC**; ½ Red Angus, ¼ Charolais, and ¼ Tarentaise) castrated at approximately 1 yr of age and approximately 112 d before harvest. The CGC steers were fed a growing diet (Table 1) and allowed ad libitum access to water. Three weeks before harvest, steers were fed a finishing diet (Table 1). The second group of cattle (Lean Beef Project; **LB**) consisted of 91 F_2 steers and heifers born to Limousin, Hereford, or Piedmontese by CGC F_1 cows crossed to F_1 bulls of similar genetic makeup. These steers were castrated at <60 d of age. The LB cattle were fed a growing diet from weaning until approximately 363 kg and were then fed a finishing diet (Table 1) for approximately 90 or 130 d. All diets were formulated on a DM basis, and neither group of cattle received ionophores or growth promotants. Heifers were not fed melengesterol acetate.

Blood samples were collected from CGC steers via coccygeal venipuncture approximately 24 h before harvest. Steers had access to fresh feed and water until the time of blood sampling. Blood samples were collected as steers were prepared for transport to the processing plant in Greeley, CO. Two blood samples were collected from LB steers and heifers. The first sample was obtained approximately 3 d before harvest, and the second sample was obtained at harvest. Samples collected 3 d before and at harvest did not differ in concentration of leptin; therefore, the mean of the two leptin values from each LB animal was used for analyses. All blood samples were allowed to clot for 6 to 18 h at 4°C, centrifuged at 2,500 × *g* for 30 min, and serum collected and stored at –20°C until assayed for leptin using the leptin RIA described by Delavaud et al. (2000). Intra- and interassay coefficients of variation for the leptin assay were less than 10%.

Animals in both groups were harvested according to humane cattle-processing procedures and carcass weight was measured immediately postharvest. Carcasses from both groups were chilled at 2°C for 24 h and ribbed between the 12th and 13th ribs to collect additional carcass data according to USDA (1989) guidelines. Traits measured for both groups of cattle were fat depth over the 12th rib, marbling score (scale of 1 = devoid to 28 = abundant +; with a small$^-$ [choice$^-$] = 11; Short et al., 1999), ribeye area, and KPH. Yield and quality grades were calculated from these data (USDA, 1989). Numerical quality grades were assigned to carcasses based on the ConAgra grading system in which 1 [practically devoid] = standard, 2 [traces] = standard, 3 [slight] = select, 4 [small] = choice-, 5 [modest] = choice, 6 [moderate] = choice$^+$, 7 [slightly abundant] = prime$^-$, and 8 [moderately abundant] = prime.

The LB cattle were processed at a local packing plant near Miles City, MT. Additional data collected from these animals included live weight, shear force, KPH weight, and finishing average daily gain. Warner-Bratzler shear force was determined from 2.54-cm-thick loin steaks vacuum packaged for 14 d at 2°C and then stored at –20°C until shear force analysis was performed (Wheeler et al., 1996).

Statistical Analysis

Data from CGC steers were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC), using carcass traits as dependent variables and serum concentration of leptin as the independent variable. For CGC steers, relationships between serum concentrations of leptin and carcass traits were quantified by Pearson correlation coefficients and linear regression. Data from LB cattle were analyzed using the GLM procedure of SAS (SAS Inst. Inc., Cary, NC), using serum concentration of leptin and carcass traits as dependent variables and breed, sex, time on finishing ration, and all possible interactions as independent variables for the initial model. The final model was based on deleting one nonsignificant term at a time from the full model until all terms remaining in the final model approached significance for one or more traits. Only main effects remained in the final model. Separate analyses were conducted for each group of cattle because the linear models that are appropriate for each data set differed. Partial correlations of leptin with carcass traits were determined from the error sums of squares and cross products. For each carcass trait, a partial regression on leptin was calculated with the main effects fit simultaneously. These traits, fat depth, marbling score, and KPH weight (LB) or percentage (CGC) were each indicative of a part of the overall variability in carcass fatness. In order to develop a consistent test of the effect of serum leptin concentration on carcass fatness, a multivariate analysis of variance was performed considering these three dependent variables simultaneously. Models used for the multivariate analysis of variance were identical to those described above. Significance of the serum leptin concentration effect was established using Wilks's criterion.

Results

Mean serum concentrations of leptin and carcass measurements for CGC and LB cattle are presented in Table 2. Among LB steers and heifers, mean serum concentrations of leptin in Hereford (26.8 ng/mL), Limousin (26.3 ng/mL), and Piedmontese (28.8 ng/mL) F_2 calves did not differ ($P > 0.10$). Adipose tissue measurements (fat depth, marbling score, and KPH) also did not differ ($P > 0.10$) between breeds (Table 3). Dressing percentage was different between breeds and was lower ($P < 0.01$) for Hereford than for Limousin or Piedmontese F_2 calves. There was no difference ($P > 0.10$) in mean concentration of leptin between steers (26.4 ng/mL) and heifers (27.7 ng/mL; Table 3). Fat depth and percent KPH ($P > 0.10$) did not differ by gender, but steers had greater marbling score ($P < 0.01$) and KPH weight ($P < 0.05$) than heifers (Table 3). Serum concentrations of leptin were greater ($P < 0.05$) among steers and heifers that spent a greater amount of time on the finishing diet (Table 3). The only adipose tissue measurement that increased ($P < 0.01$) with increased time on finishing diet was KPH weight (Table 3).

Serum concentrations of leptin were positively correlated ($P < 0.01$) with marbling score, fat depth, KPH, and quality grade in both CGC and LB cattle (Tables 4 and 5). Serum leptin was also positively correlated ($P < 0.01$) with the ConAgra muscling grid value in CGC steers and with calculated yield grade in LB

Table 2. Mean and standard deviation (SD) for leptin and carcass traits in CGC[a] steers and LB[b] steers and heifers

	CGC steers		LB steers and heifers	
Variable	Mean	SD	Mean	SD
Leptin, ng/mL[c]	18.71	7.40	27.03	8.24
Hot carcass weight, kg	293.91	31.66	277.66	11.94
Marbling score[d]	10.30	2.52	12.84	3.30
Fat depth, cm[e]	0.76	0.22	0.94	0.31
Kidney, pelvic, and heart fat weight, kg	—	—	4.97	1.17
Kidney, pelvic, and heart fat, %	1.83	0.24	1.83	0.45
Ribeye area, cm^2	79.66	7.66	79.18	11.55
Quality grade	3.22	1.06	4.26	1.07
Calculated yield grade	2.12	0.47	2.31	0.76
Dressing percent, %	56.97	0.02	58.24	1.96
Grid value[f]	99.11	6.70	—	—

[a]CGC represents composite gene combination cattle composed of ½ Red Angus, ¼ Tarentaise, and ¼ Charolais.
[b]LB represents steers and heifers born to Limousin, Hereford, or Piedmontese by CGC F_1 cows crossed to F_1 bulls of similar genetic makeup.
[c]Serum concentrations of leptin in blood samples collected from CGC steers approximately 24 h before harvest, and a mean concentration of leptin from blood samples collected from LB steers and heifers approximately 3 d before and at the time of harvest.
[d]Based on a scale of 1 = devoid to 28 = abundant +; with a small$^-$ [choice$^-$] = 11; (Short et al., 1999).
[e]Carcass fat depth measured over the 12th and 13th rib.
[f]Price based on sale of these cattle using 7/29/99 ConAgra muscling grid.

Table 3. Probability values for sources of variation affecting serum concentrations of leptin and carcass traits in LB cattle, and the associated mean square error[a]

Source	df	LEP	LW	HW	REA	FD	MS	KPHW	KPHC	CYG	SF	DP	QG
Breed	2	0.33	0.33	0.52	0.44	0.62	0.60	0.43	0.57	0.80	0.24	<0.01	0.56
Sex	1	0.79	<0.01	<0.01	0.14	0.61	<0.01	0.03	0.62	0.22	<0.01	0.01	<0.01
TOF	1	0.02	<0.01	<0.01	0.11	0.25	0.46	<0.01	0.42	0.30	0.27	0.19	0.39
TOF × breed	2	0.41	0.52	0.75	0.73	0.28	0.61	0.49	0.60	0.92	0.18	0.04	0.58
Error	84	8.24	20.58	11.94	11.55	0.31	3.30	1.17	0.45	0.76	0.98	1.96	1.07

[a]Abbreviations: LEP = mean leptin; LW = live weight; HW = hot carcass weight; REA = ribeye area; FD = fat depth over the 12th and 13th rib; MS = Fort Keogh marbling score; KPHW = kidney, pelvic, and heart fat weight; KPHC = calculated percent kidney, pelvic, and heart fat; CYG = calculated yield grade; SF = shear force; DP = dressing percent; QG = quality grade; TOF = time on finishing diet. Cattle referred to as LB represents steers and heifers born to Limousin, Hereford, or Piedmontese by composite gene combination (CGC) F_1 cows crossed to F_1 bulls of similar genetic makeup.

steers and heifers. Among CGC steers, there was only a tendency ($P < 0.10$) for serum concentrations of leptin and calculated yield grade to be correlated (Table 4). Dressing percentage and ribeye area were negatively correlated ($P < 0.01$) with serum leptin among LB steers and heifers (Table 5), while no relationship ($P > 0.10$) was detected between serum leptin and ribeye area among CGC steers, and only a tendency for a positive correlation ($P < 0.10$) existed between serum leptin and dressing percentage (Table 4).

Coefficients of linear regression equations predicting carcass traits from serum concentrations of leptin in CGC and LB cattle are presented in Tables 6 and 7, respectively. Serum leptin was a highly significant predictor of marbling score, fat depth, KPH fat, and quality grade in both groups of cattle. Among LB steers and heifers, serum leptin was also a highly significant predictor of ribeye area, calculated yield grade, and dressing percentage. Among CGC steers, serum leptin was a significant predictor of calculated yield grade and dressing percentage but was not indicative of ribeye area. The multivariate analysis of variance showed differences in serum concentrations of leptin predicted overall carcass fatness for both CGC and LB cattle ($P < 0.01$).

Discussion

Adipocytes store excess energy in the form of triglycerides when energy intake exceeds that which is needed for homeostasis and will subsequently release free fatty acids when dietary energy is inadequate (Kim and Moustaid-Moussa, 2000). Total adipose tissue mass increases via replication and differentiation of preadipocytes. Adipose tissue mass is influenced by volume and number of adipocytes (Prins and O'Rahilly, 1997). Adipocytes are also the principal site of leptin production in mice (Zhang et al., 1994), pigs (Mendiola et al., 1997), sheep (Dyer et al., 1997), cattle (Ji et al., 1998), and humans (Considine, 1997). In obese humans, the secretion of leptin per gram of adipose tissue is twice that of the leptin secreted per gram of adipose tissue in lean subjects (Fried et al., 2000). Among LB cattle, time on feed accounted for a significant amount of the variation in mean concentrations of leptin even though mean concentrations of leptin were similar between breeds. Diet and feeding times are variables known to influence serum concentrations of leptin in horses and sheep (Buff et al., 2001; Daniel et al., 2002). In humans, peripheral concentrations of leptin will peak at different times of the day,

Table 4. Pearson correlation coefficients for leptin and carcass traits of CGC steers[a]

LEP	HW	MS	FD	KPH	REA	QG	CYG	DP	GRID	Item
1.0	0.14	0.35**	0.34**	0.42**	0.12	0.36**	0.19†	0.21†	0.42**	LEP
	1.0	0.18†	0.31**	0.10	0.45**	0.28**	0.35**	0.49**	0.20†	HW
		1.0	0.40**	0.22*	–0.05	0.85**	0.35**	0.23*	0.81**	MS
			1.0	0.31**	–0.05	0.31**	0.71**	0.26*	0.33**	FD
				1.0	0.08	0.19†	0.24*	0.10	0.23*	KPH
					1.0	0.05	–0.56**	0.24*	–0.10	REA
						1.0	–0.29**	0.27**	0.88**	QG
							1.0	0.22*	0.36**	CYG
								1.0	0.30**	DP
									1.0	GRID

[a]Abbreviations: LEP = leptin; HW = hot carcass weight; MS = Fort Keogh marbling score; FD = fat depth over the 12th and 13th rib; KPH = percent kidney, pelvic, and heart fat; REA = ribeye area in centimeter; QG = quality grade; CYG = calculated yield grade; DP = dressing percent; GRID = ConAgra muscling grid pricing (7/29/99). The CGC steers were composite gene combination cattle composed of ½ Red Angus, ¼ Tarentaise, and ¼ Charolais.

†$P < 0.10$.

*$P < 0.05$.

**$P < 0.01$.

Table 5. Partial correlation coefficients with effects of breed, sex, and time on feed removed for LB steers and heifers[a]

LEP	LW	HW	REA	FD	MS	KPHW	KPHC	CYG	SF	DP	QG	Item
1.0	0.01	–0.23*	–0.45**	0.46**	0.50**	0.54**	0.56**	0.52**	0.03	–0.31**	0.49**	LEP
	1.0	0.71**	0.17	–0.16	–0.20†	0.12	0.01	–0.10	–0.12	–0.38**	–0.17	LW
		1.0	0.66**	–0.31**	–0.43**	–0.21†	–0.36**	–0.50**	–0.11	0.37**	–0.40**	HW
			1.0	–0.53**	–0.53**	–0.57**	–0.64**	–0.91**	–0.21†	0.62**	–0.52**	REA
				1.0	0.41**	0.43**	0.48**	0.80**	0.15	–0.17	0.42**	FD
					1.0	0.43**	0.47**	0.54**	0.02	–0.29**	0.98**	MS
						1.0	0.98**	0.63**	0.13	–0.44**	0.45**	KPHW
							1.0	0.69**	0.15	–0.48**	0.49**	KPHC
								1.0	0.21†	–0.51**	0.54**	CYG
									1.0	0.04	–0.04	SF
										1.0	–0.29**	DP
											1.0	QG

[a]Abbreviations: LEP = mean leptin; LW = live weight; HW = hot carcass weight; REA = ribeye area; FD = fat depth over the 12th and 13th rib; MS = Fort Keogh marbling score; KPHW = kidney, pelvic, and heart fat weight; KPHC = calculated percent kidney, pelvic, and heart fat; CYG = calculated yield grade; SF = shear force; DP = dressing percent; QG = quality grade. The LB steers and heifers were born to Limousin, Hereford, or Piedmontese by composite gene combination (CGC) F_1 cows crossed to F_1 bulls of similar genetic makeup.

†$P < 0.10$.

*$P < 0.05$.

**$P < 0.01$.

depending on the composition of the diet. A low-fat, high-carbohydrate diet will cause leptin levels to peak at night without affecting morning levels of leptin (Fried et al., 2000). In humans and sheep, fasting will decrease circulating levels of leptin, whereas overfeeding will increase circulating leptin without an appreciable change in fat mass (Considine, 1997; Daniel et al., 2002).

Mean serum concentrations of leptin were numerically lower in CGC steers (18.7 ng/mL) than LB steers (27.0 ng/mL). The fat depth and marbling scores were numerically lower in CGC carcasses (0.76 cm and 10.30, respectively) than LB carcasses (0.94 cm and 12.84, respectively) and likely contributed to the lower serum levels of leptin in CGC steers. The growing and finishing management, as well as variation in sample collection times, diets, and age at castration, may also have contributed to differences in leptin levels between the groups of cattle. Genetically, LB cattle were ½ CGC and either ½ Hereford, Limousin, or Piedmontese. The LB cattle used in this study were a subset of a population of animals used in a larger study to evaluate effects of sire breeds that differ in potential for lean tissue growth on traits measured from birth to slaughter (Short et al., 2002). The lack of difference in serum concentrations of leptin between breeds within the LB group was surprising because Short et al. (2002) reported large differences in fat depth and yield grade between these breeds in the larger population of LB cattle. While we observed differences in measures of fatness between breed of similar magnitude to those observed by Short et al. (2002), we were unable to detect differences in fat measurements between breeds. This lack of difference may be due to the smaller sample size in the current study. This lack of difference may also suggest that the leaner Piedmontese cattle express leptin from sites other than adipocytes or their expression per gram of adipose tissue is higher. The lower dressing percentage observed among the Hereford F_2 calves agrees with

Table 6. Summary of linear regressions to predict carcass traits from serum concentrations of leptin (ng/mL) in CGC steers[a]

Carcass trait	Intercept	Regression coefficient	Mean square error	*P*-value
Marbling score[b]	8.04	0.12	2.37	<0.01
Fat depth, cm[c]	0.57	0.01	0.21	<0.01
Kidney, pelvic, and heart fat, %	1.58	0.01	0.22	<0.01
Ribeye area, cm^2	77.4	0.12	7.65	>0.10
Calculated yield grade	1.89	0.01	0.46	<0.10
Quality grade	2.25	0.05	0.99	<0.01
Dressing percentage	55.5	0.06	2.18	<0.05

[a]CGC represents composite gene combination cattle composed of ½ Red Angus, ¼ Tarentaise, and ¼ Charolais.

[b]Based on a scale of 1 = devoid to 28 = abundant +; with a small$^-$ [choice$^-$] = 11 (Short et al., 1999).

[c]Carcass fat depth measured over the 12th and 13th rib.

Table 7. Summary of partial linear regressions to predict carcass traits from serum concentrations of leptin (nanograms per milliliter) in LB steers and heifers[a]

Carcass trait	Intercept	Regression coefficient	Mean square error	*P*-value
Live weight, kg	352.0	–0.12	20.9	>0.10
Hot carcass weight, kg	201.5	–0.34	11.9	<0.05
Ribeye area, cm^2	76.0	–0.52	10.53	<0.01
Fat depth, cm[b]	0.41	0.02	0.29	<0.01
Marbling score[c]	8.15	0.19	2.84	<0.01
Kidney, pelvic, and heart fat weight, kg	1.41	0.08	1.01	<0.01
Calculated kidney, pelvic, and heart fat, %	0.99	0.03	0.39	<0.01
Calculated yield grade	1.21	0.04	0.67	<0.01
Shear force, kg[d]	4.61	0.01	0.99	>0.10
Dressing percentage, %	58.6	–0.08	1.89	<0.01
Quality grade	2.65	0.06	0.92	<0.01

[a]The LB steers and heifers were born to Limousin, Hereford, or Piedmontese by composite gene combination (CGC) F_1 cows crossed to F_1 bulls of similar genetic makeup.
[b]Carcass fat depth measured over the 12th and 13th rib.
[c]Based on a scale of 1 = devoid to 28 = abundant +; with a small$^-$ [choice$^-$] = 11 (Short et al., 1999).
[d]Warner-Bratzler shear force of the longissimus muscle.

that of Short et al. (2002) and supports our observation that the Limousin and Piedmontese F_2 calves produced leaner carcasses without changes in serum concentrations of leptin.

While gender did not influence mean serum concentrations of leptin among LB cattle, the observation that steers had higher marbling scores and KPH weight without an increase in leptin suggests that leptin synthesis or degradation differs between steers and heifers. These results are consistent with those of Hellstrom et al. (2000) who reported that women typically have greater concentrations of circulating leptin than men. Our findings are inconsistent with results among horses and pigs in which serum leptin was greater in geldings or barrows than in mares or gilts (Berg et al., 2003; Buff et al., 2002). Others have also reported that peripheral concentrations of leptin may be influenced by testosterone and/or estrogen levels (Demerath et al., 1999; Horlick et al., 2000). Androgen effects on concentrations of leptin would have been minimal in the comparison of LB steers and heifers as the result of castration.

Significant correlations between subcutaneous fat thickness and circulating concentrations of leptin were observed among both groups of cattle in the present study, which agrees with previous research in cattle (Minton et al., 1998; Ehrhardt et al., 2000), sheep (Delavaud et al., 2000; Ehrhardt et al., 2000), pigs (Estienne et al., 2000), and horses (Buff et al., 2002). Percentage KPH and marbling scores were also significantly correlated with circulating concentrations of leptin in both groups of cattle. Minton et al. (1998) also reported positive correlations between serum concentrations of leptin and both KPH (r = 0.18) and marbling score (r = 0.28), but their correlations were considerably lower than the average correlations for these traits (r = 0.49 and r = 0.43 for KPH and marbling score, respectively) observed in the present study. A potential factor contributing to this difference in magnitude of correlations between these traits and leptin may be that serum was collected 30 d before slaughter in the study by Minton et al. (1998). Ehrhardt et al. (2000) reported strong linear relationships between peripheral concentrations of leptin and empty carcass fat content in Holstein calves but did not measure fat content from different sites. Others have reported no correlations between plasma concentrations of leptin and subcutaneous fat thickness, extracted longissimus muscle lipid content, or marbling score in Japanese Black steers (Kawakita et al., 2001). It was unclear from the study of Japanese Black steers when blood samples were collected relative to slaughter.

In humans, leptin mRNA and subsequent leptin production was greater in subcutaneous fat than in abdominal fat (Fried et al., 2000). Kidney and subcutaneous adipocytes are the largest and third largest adipose cells in steers (Cianzio et al., 1985), and adipocyte size influences leptin mRNA production and subsequent secretion of leptin in humans (Considine, 1997; Lonnqvist et al., 1997). In cattle, leptin mRNA expression was greatest from kidney fat followed by subcutaneous fat (Xie et al., 1999); thus, it is logical that such strong correlations exist between serum concentrations of leptin and these carcass traits.

Finished cattle can be sold by live weight, carcass weight, one of several muscling grids, or one of several marbling (quality) grids. The ability to predict an animal's dressing percentage or carcass composition and quality before harvest would allow sorting and sale of pens of cattle similar in carcass value. Intramuscular fat content may influence palatability in beef as it has been reported to increase perceived tenderness by replacing protein with lipid and to increase perceived juiciness by stimulating the salivary glands (Savell and Cross, 1988). Adipocyte number, rather than size, was the main factor influencing intramuscular fat con-

tent in cattle (Hood and Allen, 1973; Cianzio et al., 1985) and circulating concentrations of leptin (Shillabeer et al., 1998) in rats. The CGC steers in the present study were sold using the ConAgra muscle grid formula pricing, in which quality grade was the major price incentive, and serum concentrations of leptin was strongly correlated with carcass value ($r = 0.42$; $P < 0.01$).

Estimation of longissimus muscle marbling on the live animal is currently possible using ultrasound equipment and trained personnel. Because quality grade is assigned based on marbling score and maturity, we hypothesized that serum concentrations of leptin may have potential as an accurate preslaughter indicator of quality grade in feedlot cattle. In two different groups of cattle, we obtained similar results strengthening the previously reported relationship between circulating leptin and fat deposition in the body (Minton et al., 1998). It appears that greater concentrations of leptin are indicative of greater adiposity in fed cattle. Both quality grade and yield grade are used for price differentiation among beef carcasses.

Implications

The opportunity to modify body composition through selection or management can help cattle producers and feeders produce beef that more consistently meets expectations of consumers. Circulating concentrations of leptin may provide another indicator of fat content in live cattle and thus, facilitate more appropriate feeding and marketing management strategies. However, further research is needed to discern whether serum concentration of leptin coupled with other indicators may serve as a useful predictor of carcass value that can be applied before harvest.

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