Using live estimates and ultrasound measurements to predict beef carcass cutability[1]

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ABSTRACT: Commercial slaughter steers (n = 329) and heifers (n = 335) were selected to vary in frame size, muscle score, and carcass fat thickness to study the effectiveness of live evaluation and ultrasound as predictors of carcass composition. Three trained personnel evaluated cattle for frame size, muscle score, fat thickness, longissimus muscle area, and USDA quality and yield grade. Live and carcass real-time ultrasound measures for 12th-rib fat thickness and longissimus muscle area were taken on a subset of the cattle. At the time of slaughter, carcass ultrasound measures were taken at "chain speed." After USDA grade data were collected, one side of each carcass was fabricated into boneless primals/subprimals and trimmed to .64 cm of external fat. Simple correlation coefficients showed a moderately high positive relationship between 12th rib fat thickness and fat thickness measures obtained from live estimates (r = .70), live ultrasound (r = .81), and carcass ultrasound (r = .73). The association between estimates of longissimus muscle area and carcass longissimus muscle area were significant (P < .001) and were higher for live evaluation (r = .71) than for the ultrasonic measures (live ultrasound, r = .61; carcass ultrasound, r = .55). Three-variable regression equations, developed from the live ultrasound measures, explained 57% of the variation in percentage yield of boneless subprimals, followed by live estimates (R^2 = .49) and carcass ultrasound (R^2 = .31). Four-variable equations using frame size, muscle score, and selected fat thickness and weight measures explained from 43% to 66% of the variation for the percentage yield of boneless subprimals trimmed to .64 cm. Live ultrasound and(or) live estimates are viable options for assessing carcass composition before slaughter.

Key Words: Beef, Carcass Composition, Live Estimation, Ultrasound

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Introduction

There is a desire within the beef cattle industry to initiate a value-based marketing system. Within a value-based system, it is vital for the feeder and packer to have a trusted system for assessing carcass merit before slaughter. Visual appraisal is a method commonly used to assess differences in feeder and slaughter cattle. Previous studies have indicated that visual appraisal is an effective method for estimating carcass fatness (Crouse and Dikeman, 1974; Daley et al., 1983). However, this system is often criticized for being too subjective. The Value Based Marketing Task Force (1990) called for the development of an instrument grading system and suggested that the most promising technology may be real-time ultrasound. Previous studies have shown that ultrasound provides accurate measures of live animal fat thickness and longissimus muscle area (Perry et al., 1989; Faulkner et al., 1990; Herring et al., 1994) and has some possibilities in predicting carcass composition (Hamlin et al., 1995; Griffin et al.,

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1999). With continued improvements in ultrasound technology, it may be possible to implement ultrasound evaluation at key points along the marketing chain. This study was conducted to examine the use of visual appraisal and ultrasound on the live animal and carcass for the prediction of carcass composition for cattle varying widely in phenotypic characteristics.

Materials and Methods

Animal Selection and Evaluation. Commercial slaughter steers (n = 329) and heifers (n = 335) differing in genotypic and phenotypic characteristics were selected to represent the possible variation within the slaughter cattle population. The cattle selection criteria for this study included sex class, slaughter frame size, and muscle score (USDA, 1976), as well as carcass adjusted 12th-rib fat thickness.

The cattle were weighed and evaluated by three trained evaluators (one USDA and two Texas A&M University personnel) the day before slaughter. The cattle were scored at the feedlot for frame size (large, medium, or small), muscle score (thick, average, or thin), 12th rib fat thickness, longissimus muscle area, yield grade, and quality grade. Ultrasound measures for 12th rib fat thickness and longissimus muscle area were taken on a subset of the cattle using an Aloka 210DX real-time ultrasound unit (Corometrics Medical Systems, Wallingford, CT) equipped with a 3.5-MHz linear array probe.

The cattle were transported to a commercial packing facility. At the time of slaughter, real-time ultrasound images were taken at the 12th rib for fat thickness and longissimus muscle area. These measures were taken at "chain speed" (~10 s/carcass) after exsanguination and before complete hide removal with the animal suspended vertically by both hindshanks. The ultrasound images were videotaped and subsequently translated. Because the transducer was not wide enough to measure the complete longissimus muscle area, a split-screen ultrasound machine was used and the images were merged for measurement. The USDA carcass grade traits were collected 24 h postmortem by USDA personnel (USDA, 1989).

Carcass Fabrication. One side of each carcass was fabricated into boneless primals/subprimals, minor cuts, lean trim, s.c. fat, seam fat, and bone. The cuts were trimmed to .64 cm of external fat, except for the knuckle and tenderloin, which were trimmed completely. Weights were recorded at all stages of fabrication for aggregate cut formulation.

The forequarter was fabricated following commercial procedures. The subprimals obtained along with their USDA (1996) Institutional Meat Purchase Specifications (**IMPS**) numbers were the rib (IMPS #103), shoulder clod (IMPS #114), chuck roll (IMPS #116A), chuck tender (IMPS #116B), arm section, brisket (IMPS #118), foreshank (IMPS #117), short plate (IMPS #121), skirt steaks (IMPS #121D and #121E), and short ribs (IMPS #123). The IMPS #103 rib was progressively fabricated into IMPS #107, #109, and #112A ribeye roll. The IMPS #118 was further fabricated to an IMPS #120 (brisket, boneless, deckle-off). The arm section, short ribs, short plate, and foreshank were separated into lean trim, fat, and bone.

For hindquarter fabrication, the fat in the cod, pelvic, and kidney regions was initially trimmed to not exceed 2.54 cm, and the hanging tender and kidney were removed. The flank was separated into lean, fat, bone, and IMPS #193 flank steak. The round was separated into the top round (IMPS #168), bottom round (IMPS #171), knuckle (IMPS #167), hindshank, and lean, fat, and bone components.

The loin was fabricated into a bone-in strip loin with a tail length of 7.5 cm on the rib end and 10.0 cm on the sirloin end, sirloin (IMPS #181), bottom sirloin butt (IMPS #185), and full tenderloin (IMPS #189). The strip loin, bone-in was further fabricated to a strip loin, short-cut, boneless (IMPS #180). The sirloin (IMPS #181) was separated into the IMPS #184 (top sirloin butt), IMPS #185A (bottom sirloin butt, flap), IMPS #185B (bottom sirloin butt, ball tip), and IMPS #185D (bottom sirloin butt, tri-tip). The IMPS #189 tenderloin had all fat removed and was trimmed to an IMPS #190 (full tenderloin, side muscle off, no fat).

Statistical Analyses. Means, standard deviations, and simple correlation coefficients were determined using SAS (1985). Accuracy between carcass grade traits and the evaluation methods were examined using absolute standard deviations and frequency distributions. Multiple regression equations were developed from ultrasonic measures, live estimates, and carcass traits to predict the percentage yield of boneless subprimals trimmed to .64 cm of external fat (Steel and Torrie, 1980). Three- and four-variable equations were selected to allow for the comparison of evaluation methods.

Results and Discussion

As per design, there was a wide variation in the carcass grade traits (actual and estimated; Table 1). Twelfth-rib fat thickness ranged from .10 to 3.56 cm and longissimus muscle area from 52.9 to 122.6 cm^2. This variation accounted for most of the variability exhibited in USDA yield grades (.2 to 6.2). USDA quality grade ranged from average Standard to average Prime. As expected with a wide range in carcass muscling and fatness, the percentage yield of boneless subprimal trimmed to .64 cm and percentage trimmable fat to .64 cm also exhibited considerable variation.

The simple correlation coefficients showed a moderately high positive relationship between adjusted 12th rib fat thickness and actual fat thickness (r = .70), ultrasound fat thickness (r = .81) and carcass ultrasound fat thickness (r = .73; Table 2). The association between live estimates and carcass longissimus muscle area were significant ($P < .001$) and were higher for actual longissimus muscle area (r = .71) than for the ultrasonic mea-

Table 1. Mean values for selected carcass traits, live estimates, real-time ultrasound measures, and carcass components[a]

Item	Mean	SD	Minimum	Maximum	CV
Carcass trait					
12th Rib fat thickness, cm	1.18	.60	.10	3.56	50.4
Adjusted fat thickness, cm	1.31	.57	.20	3.35	43.3
Kidney, heart, and pelvic fat, %	2.57	.66	1.00	5.00	25.7
Longissimus muscle area, cm^2	81.1	11.8	52.9	122.6	14.5
Hot carcass weight, kg	303.5	48.5	179.2	494.8	15.9
USDA yield grade	2.8	.90	.2	6.2	32.1
Maturity[b]	58.2	14.5	30	160	25.0
Marbling score[c]	413.8	86.5	180	880	20.9
Live weight, kg	486.8	71.7	310.7	719	14.7
Live estimates					
12th Rib fat thickness, cm	1.13	.37	.48	2.59	32.2
Longissimus muscle area, cm^2	77.7	11.6	50.0	110.5	14.9
USDA yield grade	2.8	.61	1.1	5.2	21.2
USDA quality grade[d]	6.0	1.04	2.0	8.5	17.2
Live ultrasound					
12th Rib fat thickness, cm	1.23	.45	.51	2.64	36.5
Longissimus muscle area, cm^2	80.3	11.2	54.1	107.1	13.9
Carcass ultrasound					
12th Rib fat thickness, cm	1.08	.40	.30	2.44	37.0
Longissimus muscle area, cm^2	74.4	9.3	51.0	102.6	12.6
Carcass yield					
Boneless subprimals trimmed to .64 cm, %	46.36	2.94	36.67	55.22	6.3
Trimmable fat to .64 cm, %	19.04	4.28	8.8	33.22	22.5
Lean trim, %	18.28	1.17	14.55	24.75	6.4
Bone, %	16.31	1.50	12.73	21.14	9.2

[a]Live estimates: mean values of the three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound: 12th rib measures were taken on the vertically suspended carcass before hide removal at "chain speed" (n = 542).
[b]Maturity score: A = 00–99; B = 100–199.
[c]Marbling score: Moderately Abundant = 800–899; Small = 400–499; Practically Devoid = 100–199.
[d]USDA quality grade: 9 = high Choice; 6 = high Select; 1 = low Standard.

sures of live animal longissimus muscle area (r = .61) or carcass longissimus muscle area (r = .55). Previous research examining the use of real-time ultrasound on the live animal has shown similar results for fat thickness (r = .85 to .86). However, those studies had slightly higher correlation coefficients for longissimus muscle area (r = .71 to .76) than the present study (Henderson-Perry et al., 1989; Stouffer et al., 1989). Crouse and Dikeman (1974) examined the use of visual appraisal for the estimation of carcass fat thickness and longissimus muscle area and showed significant ($P < .001$) moderate relationships for both traits.

Although simple correlation coefficients provide insight into the precision of each evaluation method to measure the selected carcass traits, correlation coefficients do not provide an indication of the accuracy of the method. Therefore, mean absolute deviations and frequency distributions were calculated (Table 3). Mean

Table 2. Simple correlation coefficients between carcass grade traits with ultrasonic measures and live estimates[a]

Trait	Live ultrasound	Carcass ultrasound	Live estimates
12th Rib fat thickness, cm	.81***	.73***	.70***
Adjusted fat thickness, cm	.85***	.74***	.74***
Longissimus muscle area, cm^2	.61***	.55***	.71***
USDA yield grade			.66***
USDA quality grade[b]			.30***

[a]Live estimates: mean values of three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound: 12th rib measures were taken on the vertically suspended carcass before hide removal at "chain speed" (n = 542).
[b]USDA quality grade: 10 = low Prime; 7 = low Choice; 1 = low Standard.
***$P < .001$.

Table 3. Accuracy (mean absolute deviation and standard deviation) of real-time ultrasound and visual appraisal for carcass traits[a]

Trait	Live ultrasound	Carcass ultrasound	Live estimates
12th Rib fat thickness, cm	.10 ± .10	.12 ± .11	.13 ± .11
Adjusted fat thickness, cm	.11 ± .09	.13 ± .11	.13 ± .11
Longissimus muscle area, cm^2	1.31 ± .95	1.30 ± 1.12	1.18 ± .94
USDA yield grade			.53 ± .42
USDA quality grade[b]			1.22 ± .96

[a]Live estimates: mean values of three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound; 12th rib measures were taken on the vertically suspended carcass before hide removal at “chain speed” (n = 542).
[b]USDA quality grade: 10 = low Prime; 7 = low Choice; 1 = low Standard.

absolute deviations for longissimus muscle area were lower for visual appraisal than for ultrasonic measures. The mean absolute deviations were similar for carcass 12th rib fat thickness regardless of evaluation method. Daley et al. (1983) examined the accuracy of visual appraisal for estimating fat thickness on steers of diverse breed-types and showed an overall mean absolute deviation for adjusted fat thickness of .20 cm; however, the mean absolute deviation ranged widely (.09 to .72 cm) with changes in fat thickness.

Frequency distributions for the difference between estimated and actual carcass measures are shown in Tables 4 to 7. The frequency distribution of the difference between 12th rib fat thickness and live ultrasound fat thickness was ± .25 cm 64.7% of the time, followed by carcass ultrasound fat thickness (58.2%) and live estimated fat thickness (47.8%; Table 4). Hough et al. (1991) showed a comparable difference between live ultrasound fat thickness and 12th rib fat thickness; 64% of the estimates were within .25 cm. The distribution of the differences tended to be balanced; similar percentages were overestimated and underestimated, regardless of evaluation method. This was not the case when the objective and subjective estimates were compared to adjusted fat thickness (Table 5). The majority of these observations were underestimated. According to the USDA grading standards (USDA, 1989), in the event the fat thickness measure at the 12th rib is not indicative of overall carcass fatness, the measure shall be adjusted. In this study, of the carcass fat thickness measures that were adjusted, the majority were adjusted upward (similar to the findings of Belk et al., 1998). This could partially explain the underestimations seen in these data, because there was not a means of adjustment for ultrasonic measures.

Frequency distribution for the difference between evaluation methods and carcass longissimus muscle area also possessed an unequal distribution, and the majority of the estimates were lower than the carcass measures (Table 6). This corresponds with work by

Table 4. Differences between actual 12th rib fat thickness and ultrasonic measures and live estimates of 12th rib fat thickness[a]

Item	Ultrasound: Live	Ultrasound: Carcass	Live estimates
	%		
Overestimated, cm			
> 1.0	0	.2	.5
1.0 to .51	3.9	2.6	5.6
.50 to .26	9.3	11.4	17.0
.25 to .01	25.0	21.9	19.2
No difference	14.7	14.4	14.9
Underestimated, cm			
.25 to .01	25.0	21.9	13.7
.50 to .26	14.7	15.5	15.5
1.0 to .51	5.9	10.5	11.3
> 1.0	1.5	1.6	2.3

[a]Live estimates: mean values of the three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound: 12th rib measures were taken at “chain speed” on the vertically suspended carcass before hide removal (n = 542).

Table 5. Differences between actual adjusted 12th rib fat thickness and ultrasonic measures and live estimates of 12th rib fat thickness[a]

Item	Ultrasound: Live	Ultrasound: Carcass	Live estimates
	%		
Overestimated, cm			
> 1.0	0	0	.2
1.0 to .51	1.5	1.8	2.6
.50 to .26	3.4	5.2	8.9
.25 to .01	11.3	12.9	16.4
No difference	10.8	10.5	10.3
Underestimated, cm			
.25 to .01	31.8	25.4	21.1
.50 to .26	29.9	26.5	22.6
1.0 to .51	10.3	15.5	15.4
> 1.0	1.0	2.2	2.6

[a]Live estimates: mean values of the three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound: 12th rib measures were taken at “chain speed” on the vertically suspended carcass before hide removal (n = 542).

Table 6. Differences between actual longissimus muscle area and ultrasonic measures and live estimates of longissimus muscle area[a]

Item	Ultrasound: Live	Ultrasound: Carcass	Live estimates
	%		
Overestimated, cm^2			
> 1.0	3.6	2.9	3.0
1.0 to .51	12.4	5.8	10.1
.50 to .26	9.8	8.6	10.6
.25 to .01	7.8	11.1	9.8
No difference	1.6	3.5	3.5
Underestimated, cm^2			
.25 to .01	13.5	15.7	12.2
.50 to .26	12.4	12.9	14.6
1.0 to .51	23.3	20.0	21.7
> 1.0	15.5	19.4	14.5

[a]Live estimates: mean values of the three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound: 12th rib measures were taken at "chain speed" on the vertically suspended carcass before hide removal (n = 542).

Henderson-Perry et al. (1989), which indicated that real-time ultrasonic measures underestimate longissimus muscle area. Regardless of evaluation method, accuracy of longissimus muscle area estimations was not as high as accuracy of evaluations for fat thickness. The evaluation method with the lowest number of observations with a difference greater than 12.9 cm^2 was live estimated longissimus muscle area (17.5%), whereas that with the highest was carcass ultrasound longissimus muscle area (22.3%). Live estimate of longissimus muscle area tended to be more accurate and precise (as indicated by simple correlation coefficients) than live or carcass ultrasound longissimus muscle areas.

The live-animal evaluators also estimated USDA yield grades and quality grades (to the nearest third) for each animal (Table 7). Whereas estimates of yield grade showed a moderate relationship with actual USDA yield grade (r = .66), the quality grade estimate was lowly correlated with actual quality grade (r = .30; Table 2). However, when evaluating the ability of the evaluators to predict the ultimate quality grade of the carcass, the correlation coefficients may be misleading. Differences between USDA quality grade and live estimates of quality grade indicate that the evaluators were within one quality grade for 96.8% of the cattle evaluated. More specifically, the evaluators were within one-third of a grade for 62.9% of the cattle.

Although estimating carcass traits is important, it is more important to accurately and precisely estimate carcass composition. Of the carcass measures, adjusted fat thickness had the highest association with boneless subprimal yield (Table 8). This corresponds with earlier studies that examined the relationship of selected carcass traits to carcass composition (Abraham et al., 1968;

Table 7. Difference between actual USDA quality and yield grades and the live estimates of quality and yield grades[a]

Quality grade	%	Yield grade	%
Overestimated			
> 1 grade	0	> 1.0	8.0
1	1.4	1.0 to .51	13.9
2/3	8.6	.50 to .26	15.1
1/3	21.0	.25 to .00	12.2
No difference	14.8		
Underestimated			
1/3	27.1	.25 to .00	11.7
2/3	17.3	.50 to .26	14.2
1	6.6	1.0 to .51	14.2
> 1 grade	3.3	> 1.0	6.7

[a]Live estimates: mean values of the three trained evaluators (n = 664).

Table 8. Simple correlation coefficients between carcass grade traits, ultrasonic measures, and live estimates with percentage yield of boneless subprimals trimmed to .64 cm of external fat and percentage trimmable fat to .63 cm[a]

Item	Boneless subprimal yield, %	Fat trim, %
Live trait		
Frame size[b]	–.26***	.31***
Muscle score[b]	–.35***	.16***
Live weight	.02	.06
Carcass trait		
12th Rib fat thickness, cm	–.53***	.77***
Adjusted fat thickness, cm	–.69***	.84***
Live estimated fat thickness, cm	–.62***	.72***
Live ultrasound fat thickness, cm	–.73***	.78***
Carcass ultrasound fat thickness, cm	–.49***	.65***
Kidney, heart, and pelvic fat, %	–.48***	.53***
Longissimus muscle area, cm^2	.48***	–.31***
Live estimated longissimus muscle area, cm^2	.28***	–.11**
Live ultrasound longissimus muscle area, cm^2	.07	.07
Carcass ultrasound longissimus muscle area, cm^2	.06	.06
Hot carcass weight, kg	–.04	.12**
USDA yield grade	–.82***	.85***
Live estimated yield grade	–.70***	.66***
Marbling score[c]	–.51***	.51***
Live estimated quality grade[d]	–.43***	.56***

[a]Live estimates: mean values of the three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound: 12th rib measures were taken at the time of slaughter on the vertically suspended carcass before hide removal at "chain speed" (n = 542).
[b]Frame size: 1 = large; 2 = average; 3 = small; muscle score: 1 = thick; 2 = average; 3 = thin.
[c]Marbling score: Moderately Abundant = 800–899; Small = 400–499; Practically Devoid = 100–199.
[d]Quality grade: 9 = high Choice; 6 = high Select; 1 = low Standard.
$^{**}P < .01$.
$^{***}P < .001$.

Table 9. Multiple regression equations for predicting the percentage yield of boneless subprimals trimmed to .64 cm using carcas measures/estimates[a]

Equation	Intercept	Fat thickness, cm	Longissimus muscle area, cm^2	Carcass weight, kg	Live weight, kg	Kidney pelvic, and heart	R^2	RSD
Carcass traits								
1	46.29	–2.689	.1214	–.0115	—	–1.068	.72	1.57
2	43.36	–3.088	.1280	–.0109	—	—	.67	1.71
Carcass ultrasound								
3	48.02	–3.898	.0576	—	–.0064	—	.31	2.40
Live ultrasound								
4	50.29	–4.964	.0599	–.0049	—	—	.57	2.06
Live estimates								
5	46.52	–4.649	.1407	—	–.0118	—	.49	2.08

[a]Carcass measures: adjusted 12th rib fat thickness measure was used in the regression equations; live estimates: mean values of the three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound: 12th rib measures were taken on the vertically suspended carcass before hide removal at "chain speed" (n = 542).

Powell and Huffman, 1973; Crouse et al., 1975). Of the fatness measures, carcass ultraasound fat thickness had the lowest simple correlation coefficient (r = .49) for the yield of boneless subprimals trimmed to .64 cm of external fat. Correlation coefficients for live and carcass ultrasound longissimus muscle area were low and not related ($P > .05$) to the yield of boneless subprimals trimmed to .64 cm. However, whereas the simple correlation coefficient for live estimated longissimus muscle area and boneless subprimal yield was only moderate (r = .28), it was markedly higher than the correlation coefficient for ultrasonic measures.

Multiple regression equations were developed to examine the ability of live estimates and ultrasonic measures to predict the percentage yield of boneless subprimals trimmed to .64 cm. The four-variable regression equation formulated from the traits in the USDA yield grade equation accounted for 72% of the variation in the percentage of boneless subprimal yield (Table 9). Three-variable regression equations, using appropriate fat thickness, longissimus muscle area, and weight measures, also are shown in Table 9. Equation 2, which was formulated from the actual carcass traits, explained 67% of the variation in percentage subprimal yield. Equations 3 through 5 used variables derived from the various evaluation methods. The equation using live ultrasound measures explained the highest amount of variation (R^2 = .57), probably due to the ability of live ultrasound to estimate carcass fat thickness, which was the individual trait that explained the most variation in subprimal yield trimmed to .64 cm. The three-variable equation using carcass ultrasound measures explained the least amount of variation in boneless subprimal yield (R^2 = .31). It is important to note that carcass ultrasound measures were taken at chain speed, and because of the split-screen nature of the ultrasound machine, the technician had to unite the images quickly. This may not have affected the fat thickness measure but could easily have played a role in measuring longissimus muscle area, which may explain

Table 10. Multiple regression equations for predicting the percentage yield of boneless subprimal trimmed to .64 cm using frame size and muscle score and a fat thickness and weight measure[a]

Equation	Intercept	Fat thickness, cm	Frame size			Muscle score			Weight, kg[b]	R^2	RSD
			Large	Medium	Small	Thick	Average	Thin			
Carcass traits											
6	49.83	–3.437	.4943	.3600		2.853	1.053		–.0011	.62	1.82
Carcass ultrasound											
7	49.93	–3.115	1.3251	.7882		3.234	1.074		–.0038	.43	2.20
Live ultrasound											
8	55.06	–4.103	1.3578	.0366		2.661	.911		–.0110	.66	1.84
Live evaluation											
9	50.20	–5.083	.1052	.1134		2.846	1.061		.0008	.50	2.06

[a]Carcass measures: adjusted 12th rib fat thickness measure was used in the regression equations; live estimates: mean values of the three trained evaluators (n = 664); live ultrasound: 12th rib measures were taken on the live animal at weighing (n = 202); carcass ultrasound: 12th rib measures were taken on the vertically suspended carcass before hide removal at "chain speed" (n = 542).

[b]Weight variable: equations using carcass traits and carcass ultrasound measures used hot carcass weight, and equations using live ultrasound and live evaluation used live weight.

the lower R^2 and larger error term for this estimate than for the other estimates.

If this technology is to be put into place within the beef cattle industry, the measures must be easily and quickly obtainable. Use of a slaughter frame and(or) muscle score may be useful in characterizing the cattle (Table 10). Equations 6 to 9 use frame size, muscle score, weight, and fat thickness. A fat thickness measure was used due to the importance of the measure in explaining the variation in carcass composition. The equations explained from 43 to 66% of the variation of percentage subprimal yield trimmed to .64 cm. The equation using live ultrasound fat thickness explained the most variation ($R^2 = .66$), followed by live estimates and carcass ultrasound. When the four-variable equation using live ultrasound fat thickness was compared to the four-variable equation developed from the yield grade factors (Table 9), there was only a small decrease in the R^2.

Implications

The use of live estimates and live ultrasound fat thickness, either singularly or in combination, is a viable option for assessing carcass composition before slaughter. These methods can be easily and quickly implemented to identify and select cattle with superior cutability. As measured in this study, ultrasonic longissimus muscle area measures were not adequate estimators of composition, but with improvements in ultrasound technology, muscling may be measured with greater accuracy and precision.

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