

# Predicting Carcass Composition of Beef Cattle Using Ultrasound Technology<sup>1</sup>

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**ABSTRACT:** We evaluated 20 slaughtered cattle with ultrasound before hide removal to predict fat thickness and ribeye area at the 12th rib for possible use in carcass composition prediction. Carcasses were fabricated into boneless subprimals that were trimmed progressively from 2.54 to 1.27 to .64 cm maximum fat trim levels. Stepwise regression was used to indicate the relative importance of variables in a model designed to estimate the percentage of boneless subprimals from the carcass at different external fat trim levels. Variables included those obtained on the slaughter floor (ultrasound fat thickness and ribeye area; estimated percentage of kidney, pelvic, and heart [KPH] fat; and warm carcass weight) and those obtained from carcasses following 24 h in the chill cooler (actual fat thickness, actual ribeye area, estimated percentage of KPH fat, warm carcass weight, and marbling score). At all different

subprimal trim levels, percentage KPH was the first variable to enter the model. In the models using measures taken on the slaughter floor, ultrasound fat thickness was the only other variable to enter the model. Ultrasound fat thickness increased  $R^2$  and decreased residual standard deviation (RSD) in models predicting subprimals at 2.54-cm maximum fat trim; however, at 1.27- and .64-cm trim levels,  $R^2$  and RSD increased. Models using the same two variables (except actual fat instead of ultrasound) in the cooler were similar to those using data from the slaughter floor. However, as more cooler measurement variables entered the models,  $R^2$  increased and RSD decreased, explaining a greater amount of the variation in the equation. Ultrasonic evaluation on the slaughter floor may be of limited application compared with the greater accuracy found in chilled carcass assessment.

Key Words: Beef, Carcass Composition, Carcass Yield, Measurement, Ultrasound

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J. Anim. Sci. 1999. 77:889-892

## Introduction

The use of ultrasound to aid in livestock selection and in ultimate prediction of carcass cutability continues to be one of the current areas of interest to the beef industry (Cross and Whittaker, 1992; Houghton and Turlington, 1992; Whittaker et al., 1992; Herring et al., 1994; Hamlin et al., 1995a,b; Shepard et al., 1996). Cross and Whittaker (1992) stated that a

functional value-based marketing system must have a means of identifying the value of animals or carcasses. Determining the value of cattle, especially with the hide still on them, gives greater comfort to producers than if value is only determined on chilled carcasses. Ultrasound technology may be the answer to this need.

This study compared ultrasound measurements obtained on the slaughter floor before the hide was removed with those obtained from chilled carcasses for their accuracy and precision of predicting the composition of beef carcasses when fabricated to three different fat trim end points.

## Materials and Methods

Twenty beef carcasses were selected from a group of 30 steers that had been evaluated with ultrasound immediately following exsanguination and before hide removal. The cattle were slaughtered at a commercial beef packing facility and were a subset of the carcasses used by Griffin et al. (1992). The 20

<sup>1</sup>Technical Article from Texas Agric. Exp. Sta. This study was supported in part by the National Live Stock and Meat Board (now the National Cattlemen's Beef Association), Chicago, IL.

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Received June 2, 1997.

Accepted September 28, 1998.

Table 1. Carcass characteristic means and standard deviations of beef cattle evaluated by ultrasound<sup>a</sup> before cutability evaluations

Characteristic	Mean	Standard deviation	Minimum value	Maximum value
Actual carcass fat thickness, cm	1.23	.34	.51	1.78
Ultrasound fat thickness, cm <sup>a</sup>	1.17	.25	.76	1.78
Carcass ribeye area, cm <sup>2</sup>	80.45	7.86	70.32	98.06
Ultrasound ribeye area, cm <sup>2</sup>	79.45	10.37	56.13	95.43
Kidney, pelvic, and heart fat, %	2.00	.64	1.25	3.50
Warm carcass weight, kg	313.07	36.15	229.97	374.21
Marbling score <sup>b</sup>	417.00	48.35	320.00	560.00
USDA quality grade <sup>c</sup>	299.65	26.16	220.00	353.00
USDA yield grade	2.87	.51	2.10	3.83

<sup>a</sup>Ultrasound measures were taken immediately following exsanguination with the cattle hanging on the rail.

<sup>b</sup>Marbling score: 300 to 399 = Slight; 400 to 499 = Small; 500 to 599 = Modest.

<sup>c</sup>Quality grade: 200 to 299 = Select; 300 to 399 = Choice.

carcasses were selected to fill specific USDA quality grade, USDA yield grade, and carcass weight combinations for the composition study of 100 beef carcasses reported by Griffin et al. (1992). An Aloka model 210 DX linear array ultrasound instrument with a 3.5-MHz transducer was used to obtain measurements of fat thickness over the longissimus muscle as well as longissimus muscle size between the 12th and 13th ribs. A coat of mineral oil was applied to the hide at the 12th-13th rib region to ensure adequate acoustical contact. Following selection, all carcasses were shipped via refrigerated truck from the beef plant to the Rosenthal Meat Science and Technology Center, Texas A&M University, for evaluation and fabrication.

Carcasses were fabricated into boneless subprimals according to the procedures of Griffin et al. (1992) and were trimmed to three maximum external fat trim levels: 2.54, 1.27, and .64 cm maximum fat remaining. These subprimals along with their USDA (1996) Institutional Meat Purchase Specifications (IMPS) numbers were IMPS #112A ribeye roll; IMPS #114 shoulder clod; IMPS #115 chuck, square cut, boneless; IMPS #120 brisket, boneless, deckle-off; IMPS #167 knuckle; IMPS #168 top (inside) round; IMPS #170 bottom (gooseneck) round; IMPS #180 strip loin, short-cut, boneless; IMPS #184 top sirloin butt; IMPS #185A bottom sirloin butt, flap; IMPS

Table 2. Correlation coefficients comparing actual carcass and ultrasound<sup>a</sup> measures for fat thickness and ribeye area

Ultrasound <sup>a</sup> measure	Actual carcass measure	
	Fat thickness, cm	Ribeye area, cm <sup>2</sup>
Fat thickness, cm	.81*	-.40 <sup>†</sup>
Ribeye area, cm <sup>2</sup>	-.32	.52*

<sup>a</sup>Ultrasound measures were taken immediately following exsanguination with the cattle hanging on the rail.

<sup>†</sup> $P < .10$ .

\* $P < .05$ .

#185B bottom sirloin butt, ball tip; IMPS #185C bottom sirloin butt, tri-tip; and IMPS #189A full tenderloin, side muscle on, defatted. Data were

Table 3. Correlation coefficients of ultrasound<sup>a</sup> and carcass characteristics with yield of major boneless subprimals at different trim levels

Characteristics	Subcutaneous fat trim level, cm		
	2.54	1.27	.64
Actual carcass fat thickness, cm	-.20	-.36	-.43
Ultrasound fat thickness, cm	-.21	-.36	-.40
Ribeye area, cm <sup>2</sup>	.14	.26	.26
Ultrasound ribeye area, cm <sup>2</sup>	.002	.06	.07
Kidney, pelvic, and heart fat, %	-.47*	-.42 <sup>†</sup>	-.37
Hot carcass weight, kg	-.11	-.07	-.07
Marbling score <sup>b</sup>	-.16	-.22	-.21
USDA quality grade <sup>c</sup>	-.07	-.09	-.08
USDA yield grade	-.37	-.53*	-.58**

<sup>a</sup>Measures taken immediately after exsanguination with cattle hanging on the rail.

<sup>b</sup>Marbling score: 300 to 399 = Slight; 400 to 499 = Small; 500 to 599 = Modest; 600 to 699 = Moderate.

<sup>c</sup>Quality grade: 200 to 299 = Select; 300 to 399 = Choice; 400 to 499 = Prime.

<sup>†</sup> $P < .10$ .

\* $P < .05$ .

\*\* $P < .01$ .

Table 4. Multiple regression equations using ultrasound<sup>a</sup> and actual carcass measures for predicting the yield (%) of major boneless subprimals with a maximum trim level of 2.54 cm

Intercept	Equation variables <sup>b</sup>							R <sup>2</sup>	Residual SD	Mallow's statistic (C <sub>(p)</sub> )
	Ultrasound fat thickness, cm	Ultrasound ribeye area, cm <sup>2</sup>	Kidney, pelvic, and heart fat, %	Warm carcass weight, kg	Actual fat thickness, cm	Ribeye area, cm <sup>2</sup>	Marbling score			
Measures easily obtained on the kill floor										
51.2105			-1.0441*					.22	2.89	1.56
53.5999	-1.7946		-1.1925*					.33	2.47	1.25
Actual carcass measures										
51.2105			-1.0441*					.22	2.89	2.64
52.8407			-1.1461*		-1.1588			.30	2.38	2.76
49.6884			-1.2381*		-.9189	.0378		.34	2.06	3.82
50.7128			-1.2177*	-.0090	-.9109	.0595		.38	1.88	4.88
48.2373			-1.4664	-.0103	-1.0621	.0699	.0065	.42	1.76	6.00

<sup>a</sup>Ultrasound measures taken immediately after exsanguination while hanging on the rail.

<sup>b</sup>Variables in the models included only those that were significant at  $P < .50$ .

\* $P < .05$ .

values for actual carcass characteristics and ultrasound measurements. Simple correlation coefficients (Table 2) between actual and ultrasound measures indicate that actual and ultrasound fat thickness were highly correlated, and ribeye measured by ultrasound was not as correlated (although still significant,  $P < .05$ ).

The yield of major subprimals from the round, loin, rib, and chuck at 2.54, 1.27, and .64 cm trim levels were correlated with actual and ultrasound measurements in Table 3. As would be expected, the actual and ultrasound fat thickness measures were negatively correlated with cutability of the carcass, and both ribeye area measures were positively correlated.

No correlations were significant, except the estimated percentage of KPH fat when the subprimals were trimmed to 2.54 cm ( $P < .05$ ) and to 1.27 cm ( $P < .10$ ), and actual yield grade at the 1.27-cm trim level ( $P < .05$ ) and the .64-cm trim level ( $P < .01$ ). These correlations indicated that as the percentage of KPH fat or yield grade increased, the percentage of boneless subprimals decreased.

Stepwise regression was used to indicate the importance of variables to a model designed to estimate the percentage of boneless subprimals from the carcass at different subcutaneous fat trim levels (Tables 4 to 6). Variables included along with ultrasound fat thickness and ribeye area as measure-

Table 5. Multiple regression equations using ultrasound<sup>a</sup> and actual carcass measures for predicting the yield (%) of major boneless subprimals with a maximum trim level of 1.27 cm

Intercept	Equation variables <sup>b</sup>							R <sup>2</sup>	Residual SD	Mallow's statistic (C <sub>(p)</sub> )
	Ultrasound fat thickness, cm	Ultrasound ribeye area, cm <sup>2</sup>	Kidney, pelvic, and heart fat, %	Warm carcass weight, kg	Actual fat thickness, cm	Ribeye area, cm <sup>2</sup>	Marbling score			
Measures easily obtained on the kill floor										
50.1130			-.9623 <sup>†</sup>					.17	2.67	4.10
53.6774	-2.6771*		-1.1836*					.38	2.79	1.07
Actual carcass measures										
50.1130			-.9623 <sup>†</sup>					.17	2.67	7.15
52.7623			-1.1280*		-1.8832*			.36	2.72	3.87
48.4467			-1.2540*		-1.5549 <sup>†</sup>	.0517		.43	2.42	4.00
49.6525			-1.2300*	-.0106	-1.5454 <sup>†</sup>	.0773 <sup>†</sup>		.48	2.02	4.63
47.6259			-1.4336*	-.0117	-1.6692 <sup>†</sup>	.0858 <sup>†</sup>	.0054	.50	2.02	6.00

<sup>a</sup>Ultrasound measures taken immediately after exsanguination while hanging on the rail.

<sup>b</sup>Variables in the models included only those that were significant at  $P < .50$ .

<sup>†</sup> $P < .10$ .

\* $P < .05$ .

Table 6. Multiple regression equations using ultrasound<sup>a</sup> and actual carcass measures for predicting the yield (%) of major boneless subprimals with a maximum trim level of .64 cm

Intercept	Equation variables <sup>b</sup>							R <sup>2</sup>	Residual SD	Mallow's statistic (C <sub>(p)</sub> )
	Ultrasound fat thickness, cm	Ultrasound ribeye area, cm <sup>2</sup>	Kidney, pelvic, and heart fat, %	Warm carcass weight, kg	Actual fat thickness, cm	Ribeye area, cm <sup>2</sup>	Marbling score			
Measures easily obtained on the kill floor										
49.7262	-2.3232 <sup>†</sup>							.16	2.58	4.41
52.5601	-2.8877*		-1.0944*					.38	2.78	1.18
Actual carcass measures										
49.3151								.19	2.79	7.51
51.7895			-1.0479*					.39	2.83	3.70
47.9169			-1.1610*			.0464		.44	2.46	4.15
49.1587			-1.1363*	-.0109		-1.8808*	.0727	.49	2.25	4.64
47.1472			-1.3384*	-.0120		-2.0038*	.0812 <sup>†</sup>	.52	2.06	6.00

<sup>a</sup>Ultrasound measures taken immediately after exsanguination while hanging on the rail.

<sup>b</sup>Variables in the models included only those that were significant at  $P < .50$ .

<sup>†</sup> $P < .10$ .

\* $P < .05$ .

ments obtainable on the slaughter floor, during slaughter, included estimated percentage of KPH fat and warm carcass weight. The variables included as those regularly obtained from carcasses following 24 h in the chill cooler included actual fat thickness, actual ribeye area, estimated percentage of KPH fat, warm carcass weight, and marbling score. At all three trim levels, KPH fat percentage was the first variable to enter the model. This agrees with the findings of Herring et al. (1994), who showed that estimated KPH was the first factor to enter equations for predicting retail cut-out at different cutability end points. In the models using measures taken on the slaughter floor, ultrasound fat thickness was the only other variable to enter the model to the  $P < .50$  level. Ultrasound fat thickness increased  $R^2$  and decreased residual standard deviation (RSD) in models predicting subprimals at 2.54-cm maximum fat trim; however, at 1.27- and .64-cm trim levels,  $R^2$  and RSD increased. Models using the same two variables, except actual fat instead of ultrasound, in the cooler were similar to those using data that could be obtained on the slaughter floor. This finding disagrees with Hamlin et al. (1995a), who found that ultrasonic predictors explained approximately 10% less variation in retail product percentage than did carcass measures. As more variables entered the models developed from data obtained in the cooler,  $R^2$  increased and RSD decreased, explaining a greater amount of the variation in the equation.

### Implications

There is potential for the use of ultrasound as a predictor of carcass cutability at different fat trim levels. However, application of ultrasound in high-

speed slaughter operations as a method of stratifying or sorting carcasses before chilling will depend on automated ultrasonic measuring equipment. Advancements in ultrasound measuring equipment may allow for more accurate carcass merit assessment in the future.

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