Evaluation of Real-time Ultrasound and Carcass Characteristics for Assessing Carcass Composition in Swine

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Summary and Implications

Results of this study indicate that correlations between real-time ultrasound loin depth and carcass loin muscle area and between carcass loin depth and carcass loin muscle area are high. However, using carcass loin muscle area as the true value, the standard error of prediction for real-time ultrasound loin muscle area was lower than those for loin muscle areas predicted from either real-time ultrasound loin depth or carcass loin depth. Real-time ultrasound and carcass depth or length or a combination thereof is a less accurate predictor of carcass loin muscle area than simply real-time ultrasound loin muscle area alone.

Introduction

Ultrasound has been used to predict carcass traits of live animals for many years (Hazel and Kline, 1959; Mersmann, 1984; Moeller, 1994). Due to improvements in ultrasound technology, real-time ultrasound (RTU) use has increased dramatically in recent years. Real-time images have currently been interpreted optically by humans and measured manually with the assistance of a computer (Liu and Stouffer, 1995). Because of this, trained interpreters are required to accurately assess the images to determine traits of significant merit such as loin muscle area and backfat depth. This is a time and labor consuming process. Due to such disadvantages, methods have been sought to estimate loin muscle area from parameters such as loin muscle depth which are more quickly obtained and result in less interpreter error.

The objective of this study was to investigate the relationship between ultrasonic and carcass measures of the loin muscle and to assess the possibility of utilizing other measures from a single cross-sectional RTU image to predict actual loin muscle area.

Materials and Methods

Data utilized for this project were collected as a part of the 1995 National Barrow Show® Progeny Test (N=352) conducted at the Northeast Iowa Swine Improvement Association station located near New Hampton, Iowa. Animals represented in the study were Berkshire, Chester White, Duroc, Hampshire, Landrace, Poland China, Spotted, Yorkshire, and some crossbreds. Pigs were weighed and scanned off-test on an individual basis at weekly intervals upon reaching a weight ≥ 240 lbs.

Scanning was 24 hours prior to slaughter and accomplished with an ALOKA 500V (Corometrics Medical Systems, Wallingford, Connecticut) real-time ultrasonic machine fitted with a 12.5 cm, 3.5 Mhz linear array transducer. Ultrasonic images were digitized on-site using a personal computer equipped with a frame-grabber board and controlling software. The images were stored as digitized files for later interpretation.

Ultrasonic images were taken along the dorsal midline at the tenth rib. The transducer was aligned perpendicular to the spine at the tenth rib. A cross-sectional image of the loin muscle (RTULMA) and subcutaneous fat overlying the loin muscle (RTUBF10) on the right hand side of the pig at the tenth rib was acquired using a sound emitting transducer guide which fitted the natural contour of the pig's back.

Digitized images were interpreted using Quality Evaluation and Prediction (Iowa State University, Ames, Iowa), a computer software package developed specifically to measure linear distance and area of digitized images and matriculate to a data file. BF10 was measured as the distance from the outer edge of the skin to the start of the fascia layer in the center of the *longissimus* muscle at a point approximately 2.5 in. lateral to the spine. Additionally, loin muscle depth (RTULMD) and loin muscle length (RTULML) were measured on real-time ultrasonic images. Figure 1 details the measurements utilized for depth and length in this study. Depth was measured as the distance between the dorsal and ventral boundary of the loin muscle at a point perpendicular to the long axis of the muscle. Length was taken as the linear distance between the lateral boundaries of the loin muscle at the approximate vertical center of the muscle. BF10 was measured to the nearest .01 in. and LMA was measured to the nearest .01 in^2. LMD and LML were measured to the nearest .01 in.

Upon completion of the test, pigs were transported to Hormel Co. in Austin, Minnesota, for carcass evaluation. Carcass measurements were taken by Iowa State University personnel following a 2-hour rapid chill. Standard carcass collection procedures, as outlined in Procedures to Evaluate Market Hogs (NPPC, 1991, 3rd ed.). Carcass BF10 backfat depth was measured on the ribbed section of the hanging carcass (CBF10) to the nearest .05 in. Carcass loin muscle (CLMA) area was measured from acetate tracings using a standard pork grid (ISU Extension, AS-235) and measured to the nearest .05 in^2 . Carcass loin muscle depth (CLMD) and length (CLML) were also measured from acetate tracings using a standard ruler probe and measured to the nearest .05 in.

A least squares analysis of variance procedure using a general linear model (SAS, 1985) was used to evaluate dependent ultrasound and carcass measures for sources of variation. The model included the effects of sex and breed and the linear covariate of live weight. Sire(breed) was used to test breed effects. Pearson product-moment correlation coefficients were used to analyze relationships between RTU and carcass measures on a total and residual basis.

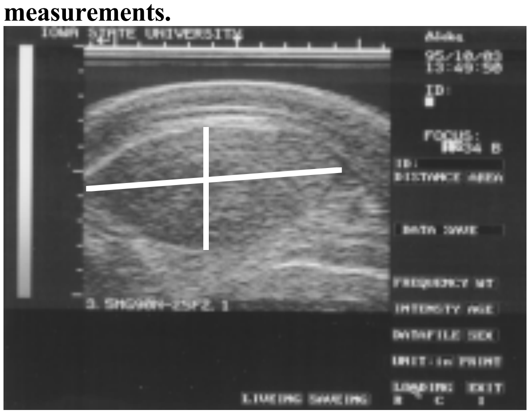
Multiple linear regressions (PROC REG; SAS, 1985) predicting CLMA and RTULMA were performed.

Standard errors of prediction (SEP), widely considered as the standard measure of the ability of RTU to precisely evaluate compositional differences between animals, were computed using the formula:

SEP = tenth rib loin muscle area

$$\frac{\sqrt{\left(\sum_i \text{Carcass}_i - \text{Ultrasound} - \text{Bias}\right)^2}}{N - 1}$$

Figure 1. Real-time ultrasonic cross-sectional image at the 10th rib illustrating the RTULMD and RTULML measurements.



Results and Discussion

Means, standard deviations, and ranges for ultrasound and carcass traits are presented in Table 1. Ultrasound measurements were less variable than their corresponding carcass measurements and also displayed a smaller range. Ultrasound measurements slightly underestimated LMA and BF10 carcass measurements in this study. Mean carcass loin depth exceeded the mean RTU loin depth by .32 in., and mean RTU loin length was 55 in. greater than the mean carcass loin length.

Residual correlations are given in Table 2. Residual correlations after accounting for the effects of sex and breed and the linear effect of live weight at slaughter were .74 ($p < .01$) between RTU and carcass measures of LMA and .84 ($p < .01$) between RTU and carcass measures of BF10. The correlation between RTULMA and RTULMD was .90, and that of RTULMA with RTULML was .63. Correlations for carcass measurements comparing CLMA with CLMD and CLMA with CLML were large and of similar size (.84 and .75, respectively). The correlations of RTULMD with CLMA and RTULML with CLMA were .69 and .41, respectively.

Means and significance determined by Bonferroni T tests for ultrasound and carcass traits within breed are shown in Table 3. Significant breed effects were observed for RTULMD, CLMA, CLMD, and CLML. Real-time ultrasound estimates of LMA underestimated carcass measures of all breeds except Berkshire and Chester White. Carcass measures of loin muscle depth were consistently greater than estimates for RTULMD, while RTULML estimates consistently exceeded the corresponding estimates for CLML.

Least squares means and standard errors for ultrasound and carcass measures across sex are given in Table 4. Significant ($P<.05$) sex effects were observed for all traits, with lower values for barrows than gilts for all traits.

Multiple linear regressions predicting CLMA and RTULMA are shown in Table 5 with their respective SEP. When using RTULMA as the independent variable and CLMA as the dependent variable, the SEP was .54. The RTULMA SEP, when compared to all other ultrasound independent variables utilized to predict CLMA, had the lowest SEP. Real-time ultrasound depth measurements and a combination of RTULMD and RTULML were good predictors of RTULMA with SEP values of .35 and .23, respectively. However, the same variables were not as predictive of CLMA with SEP of .79 and .76, respectively.

Conclusions

The results of this study indicate that RTULMA is the most accurate non-invasive predictor of CLMA. Although RTULMD is highly correlated with CLMA, the SEP of the regression equation using RTULMD to predict CLMA is larger that that of RTULMA and therefore not as accurate. This finding also suggests that correlation coefficients alone are not good estimates of accuracy in predicting carcass measures from live measures, because they fail to enumerate the actual differences between the ultrasound and carcass values. SEP, however, does accomplish this task. This is consistent with previous studies (Moeller, 1994; Robinson et al., 1992).

Use of CLMA as the dependent variable may also be somewhat misleading, because it is readily recognized that carcasses are not measured without error (Robinson et al. 1992; Rouse et al., 1992). Carcass measurements may be influenced by changes occurring during the chilling process (Houghton and Turlington, 1992). The presence or absence of pale, soft, and exudative (PSE) pork may have some effect on carcass trait measurements. Both the subcutaneous fat and the loin muscle of PSE carcasses fail to preserve their shape due to the yielding nature of the product. Therefore, the loin muscle has a tendency to expand when pressure is placed on the surface to obtain meaurements. Furthermore, muscles and subcutaneous fat take on a different position from that observed in a normal live standing animal due to shackling and subsequent hanging of the carcass. The differences in muscle extension and/or flexing may have some effect on the differences that are observed between ultrasound and carcass, especially between depth and length of the loin muscle (Turlington, 1990). This effect is a likely cause of the rather large differences between live and carcass loin muscle depths and lengths found in this study.

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Table 1. Means, standard deviations (SD), and ranges of ultrasound and carcass traits.[1]

RTULMA, in.^{2}	5.87	0.86	4.11 - 9.32
RTULMD, in.	1.78	0.19	1.38 - 2.49
RTULML, in.	4.24	0.24	3.38 - 5.04
RTUBF10, in.	1.03	0.26	0.52 - 2.01
CLMA, in.^{2}	6.10	1.10	3.60 - 9.95
CLMD, in.	2.10	0.25	1.25 - 2.75
CLML, in.	3.69	0.32	3.00 - 4.65
CBF10, in.	1.07	0.29	0.50 - 1.90

[1] RTU=real-time ultrasound, C=carcass, LMA=loin muscle area, LMD=loin muscle depth, LML=loin muscle length, BF10=10th rib backfat

Table 2. Residual correlations between carcass and ultrasonic measurements.[1]

Variable	2	3	4	5	6	7	8
1 RTULMA	0.90*	0.63*	-0.37*	0.74*	0.67*	0.54*	-0.33*
2 RTULMD		0.38*	-0.34*	0.69*	0.69*	0.44*	-0.31*
3 RTULML			-0.35*	0.41*	0.33*	0.38*	-0.24*
4 RTUBF10				-0.43*	-0.39*	-0.38*	0.84*
5 CLMA					0.84*	0.75*	-0.46*
6 CLMD						0.41*	-0.41*
7 CLML							-0.44*
8 CBF10							

[1] RTU=real-time ultrasound, C=carcass, LMA=loin muscle area, LMD=loin muscle depth, LML=loin muscle length, BF10=10th rib backfat

* P<0.01

Table 3. Breed means and tests of significance* for carcass and real-time ultrasound loin muscle traits.[1]

	RTULMA	RTULMD	RTULML	CLMA	CLMD	CLML
Berkshire	5.589[a]	1.709[abc]	4.195[a]	5.02[d]	1.963[b]	3.300[c]
Chester White	5.385[a]	1.638[c]	4.318[a]	5.11[cd]	1.925[b]	3.438[bc]
Duroc	6.038[a]	1.830[ab]	4.274[a]	6.32[ab]	2.130[ab]	3.769[a]
Hampshire	6.058[a]	1.840[a]	4.270[a]	6.61[a]	2.219[a]	3.825[a]
Landrace	5.962[a]	1.817[abc]	4.270[a]	6.14[abc]	2.127[ab]	3.712[ab]
Poland China	5.597[a]	1.704[abc]	4.142[a]	5.89[abcd]	2.025[ab]	3.721[ab]
Spotted	5.331[a]	1.649[bc]	4.115[a]	5.47[bcd]	1.953[b]	3.572[abc]
Yorkshire	5.621[a]	1.758[abc]	4.161[a]	5.82[abcd]	2.049[ab]	3.597[abc]
Crossbred	5.949[a]	1.844[a]	4.210[a]	6.23[ab]	2.137[ab]	3.732[ab]

[1] RTU=real-time ultrasound, C=carcass, LMA=loin muscle area, LMD=loin muscle depth, LML=loin muscle length

Means with the same letter are not significantly different. (P<0.05)

*[a, b, c] Bonferroni T tests used for significance testing

Table 4. Least squares means and standard errors by sex for carcass and ultrasound measurements.[1]

	Variable					
	RTULMA	RTULMD	RTULML	CLMA	CLMD	CLML
Sex						
Barrow	5.537[b]	1.732[b]	4.153[b]	5.543[b]	2.004[b]	3.546[b]
Gilt	6.036[a]	1.900[a]	4.323[a]	6.638[a]	2.152[a]	3.772[a]

[1] RTU=real-time ultrasound, C=carcass, LMA=loin muscle area, LMD=loin muscle depth, LML=loin muscle length

Means with the same letter are not significantly different. (P<0.05)

Table 5. Intercepts, coefficients, and standard errors for CLMA and RTULMA.[1]

		ß-value					
Equation	Dependent Variable	Intercept	RTULMD	RTULML	CLMD	CLML	SEP
1	CLMA	-4.70*	3.72*	0.98*	- - - -	- - - -	.76
2	CLMA	-1.45*	4.23*	- - - -	- - - -	- - - -	.79
3	CLMA	-3.94*	- - - -	2.37*	- - - -	- - - -	.98
4	CLMA	-5.59*	- - - -	- - - -	2.70*	1.62*	.31
5	CLMA	-1.78*	- - - -	- - - -	3.75*	- - - -	.57
6	CLMA	-3.90*	- - - -	- - - -	- - - -	2.70*	.68
7	RTULMA	-5.20*	3.24*	1.23*	- - - -	- - - -	.23
8	RTULMA	-1.10*	3.88*	- - - -	- - - -	- - - -	.35
9	RTULMA	-4.50*	- - - -	2.44*	- - - -	- - - -	.61

[1] RTU=real-time ultrasound, C=carcass, LMA=loin muscle area, LMD=loin muscle depth, LML=loin muscle length

* P<0.01