REAL - TIME ULTRASONIC EVALUATION OF SWINE

¹E. B. SONAIYA, ²J. R. STOUFFER, ³H. R. CROSS

Department of Animal Science, Cornell University, Ithaca, NY, 14850, U.S.A.

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ABSTRACT

This study shows no difference in the backfat data collected on live and dead animals. In adjusted data, barrows had more backfat according to sonic and actual carcass measurement. There was a significantly ($P<0.05$) lower value in gilts in the first and last rib positions and in barrows in all positions but the tenth rib for sonic data as compared with carcass measurement. A high and significant ($P<0.01$) correlation existed between sonic and carcass measurements of fat thickness across sex. Within each sex, correlation was highest on the tenth rib followed by the last rib in gilts and the last lumbar in barrows. There were no significant differences in longissimus area measurement taken ultrasonically or in the carcass although correlations between them were high, being higher in gilts. 3MHz scanning produced greater accuracy in gilts than barrows for fat thickness and longissimus area determination, 5MHz, however, gave data that were closer correlated with carcass data. Except for the first rib position, there were no differences between scans taken on the hot carcass and actual carcass measures taken on the chilled right and left sides 48h later. The result suggests that hogs can be scanned a fortnight before slaughter and the data can be used in computing hog carcass yield at the point of sale. It also suggests the possibility of complete grading for hot carcasses and may further encourage hot processing if adopted. In cold processing situation, it may remove the necessity to enter the cooler for carcass measures.

Key words: Real-time ultrasound, pork, automatic grading.

INTRODUCTION

The value of ultrasonic techniques in live animal evaluation is well established. Ultrasound has the advantage of non-destructiveness and hence of being repeated several times on the same animal to measure fat deposition and muscle growth (Mersmann, 1982). Its value for carcass evaluation has remained doubtful because of the lag between scanning and data availability.

The time lag has been removed by the introduction of real-time scanning which was originally developed for medical diagnosis. The first use of real-time scanning of livestock was by Horst (1971) who used a single transducer mounted in a coupling medium at the focus of a parabolic reflector. The Danscanner, with an array of transducers, is designed specially for use on animals and is the real-time scanner currently in use for animal evaluation. It has the disadvantage of bulk and insufficient resolution for carcass quality evaluation (Kempster *et al.*, 1979). Within the last few years there has been great improvement in linear array scanning technology for medical application (Well, 1977).

The purpose of the present experiments was to evaluate real-time array scanning techniques in estimating fat depth and longissimus area in swine with a view to determine their applicability in carcass evaluation in the meat industry.

METHODS

Animals in experiment 1 were all barrows submitted for evaluation at the Houston Livestock Show by individual farmers.

Present Address:¹Department of Animal Science, Obafemi Awolowo University, Ile-Ife, Nigeria.

³USDA, ARS, Roman L. Hruska U.S. Meat Animal Research Center, P.O. BOX 166, Clay Center, NE 68933, USA

Animals in experiment 2 were all gilts used in an extension training program.

The animals were raised off the floor in a specially designed crate which restrained movement on all sides. Scanning was done with a Technicare 210DX Linear Array ultrasound system connected to a one-half inch video cassette recorder. Transducers can be quickly interchanged and both the 3MHz and 5MHz transducers were used in experiment 1 but only the 3 MHz was used in experiment 2. All ultrasonic measurements were made on the right side perpendicular to the backline. Mineral oil was used as a coupler between the skin and the transducer; hair was not removed. Scans for backfat were obtained at the first, tenth and last ribs and at the last lumbar while longissimus area scans were taken at the tenth rib only. Scan display on the cathode ray tube of the device was frozen with the freeze button. The date, animal number, sex and a code number for the measurement to be made were punched in. A cursor was introduced, moved to the skin line, the cursor was separated into two and one cursor moved down to the innermost fat layer to measure the fat depth. The frozen screen image was then recorded on video for the longissimus area. The recorded image was played back on a separate TV, traced from the screen onto acetate paper and the area measured by planimeter.

In experiment 1 these measurements were taken on the live animal before slaughter. In experiment 2, scans were taken 12 days before slaughter, again on the day of slaughter on the live animal and finally on the warm dressed carcass. Carcass backfats at the same locations as the ultrasonic scans and carcass longissimus area at the 10th rib were obtained on hanging right half carcasses after 48 h at 5C (NPPC, 1976). These carcass measurements were also taken on the left half carcass in experiment 2.

Data from both experiments were adjusted for live weight (sonic) and hot carcass weight (carcass) before analysis of variance, simple correlations and Duncan's test.

RESULTS AND DISCUSSION

The effect of live weight and hot carcass weight was similar on the ultrasound and carcass variables respectively. Without adjustments, the effect of sex was masked (Table 1). There seemed to be no sex effect on the ultrasonic measurement of backfat at the last lumbar. Fat depth at the ribs differed significantly with sex; barrows had more backfat according to sonic and actual carcass measurement (Table 2).

There was a consistently lower value for sonic data as compared with carcass measurement. This difference was significant in gilts in the first and last rib positions and in barrows in all positions but the tenth rib. Such a consistent difference between sonic and carcass values was apparent in the data of Mersmann (1982a, b) and Stouffer *et al.* (1961). It may also be due to errors associated with the actual measurement of the carcass by the ruler probe for fat thickness or to differences in orientation of the live body as compared with the carcass (Mersmann, 1982a).

Such a difference was not observed in the longissimus area measurement. The area measurement in both sonic and carcass methods was done by tracing and planimeter reading. This introduces tracing and interpretation errors which appear equalized for both methods.

The correlation between sonic and carcass measurements was high and significant (Table 2). Correlations for fat thickness across sex was highest at the tenth and last rib positions; higher than the mean of the four fat positions. Within each sex, correlation was also highest at the tenth rib followed by the last rib in gilts and the last lumbar in barrows. Hazel and Kline (1959) reported higher accuracy with ultrasound measurement at the loin and back than in the shoulder.

There were no significant differences in longissimus area measured ultrasonically or in the carcass and the correlation between these two measures were high, being higher in gilts. As predicted (Stouffer *et al.*, 1961),

TABLE 1. MEAN SQUARES FOR VARIABLES MEASURED BY ULTRASOUND ON LIVE ANIMALS AND DIRECTLY ON THEIR CARCASSES.

Source	Df	<u>Unadjusted</u>									
		<u>Ultrasound</u>				<u>Carcass</u>					
		1R	10R	LR	LL	LEA	1R	10R	LR	LL	LEA
Sex	1	.1412	.4251**	.0532	.0905	2.3521	.2807	.1825	.0831*	.2111*	3.2611*
Live Wt	1	.5990**	.6145**	.2571**	.1487*	10.0498**	-	-	-	-	-
HCW 11.8980**	1	-	-	-	-	-	-	.2127	.6004**	.5266**	.3414**
Error	57	.0587	.0384	.0208	.0262	.6751	.3308	.0488	.0171	.0389	.5516
Source	Df	<u>Adjusted</u>									
		<u>Ultrasound</u>					<u>Carcass</u>				
		1R	10R	LR	LL	LEA	1R	10R	LR	LL	LEA
Sex	1	.0470*	.4827**	.0788**	.0006	.7579*	.1909*	.3820**	.2155**	.2685**	1.1113*
Freq.	1	.0077	.0084	.0035	.0022	.1368	-	-	-	-	-
Error	58(57)	.0098	.0106	.0044	.0027	.1739	.0037	.0104	.0091	.0059	.2051

1R = First rib back fat thickness
 10R = Tenth rib back fat thickness
 LR = Last rib back fat thickness
 LL = Last lumbar back fat thickness
 LEA = Loin eye area

development in instrumentation has greatly reduced errors, improving correlations between ultrasound and carcass data from 0.5 in 1961 to 0.7-0.9 in 1984.

Comparison of gilts and barrows scanned at 3 MHz indicated greater accuracy in gilts than barrows for both fat thickness and longissimus area determination (Table 3). Comparison of 3 MHz and 5 MHz transducer frequency show that the higher frequency produced data that were closer correlated with carcass data. This

is consistent with the fact that higher frequencies improve resolution of sonar scans although there is a decrease in penetration (Wells, 1977). In this case the longissimus was not too large to be completely scanned at the higher frequency which resulted in greater accuracy. For hogs, 5 MHz and even frequencies as high as 7.5 and 10 MHz can be reliably used especially for fat thickness.

At present, there is growing interest in instrument grading. Real-time ultrasound

TABLE 2. MEANS AND STANDARD ERRORS OF ADJUSTED VARIABLES BY SEX.

Variable	Gilts		Barrows		Across Sex	
	Mean	SE	Mean	SE	Mean	SE
Number	18		42		60	
Live Wt., kg	106	2.87	112	2.20	110	2.42
Hot Carc. Wt., kg	78	2.43	82	1.50	81	1.81
Fat Thickness, cm						
First Rib (1R)						
Sonic	3.88 ^c	.039	3.74 ^d	.025	3.78 ^d	.032
Carcass	4.19 ^b	.024	4.50 ^a	.016	4.41 ^a	.020
r	.61		.53		.85	
Tenth Rib (10R)						
Sonic	2.35 ^b	.040	2.97 ^a	.028	2.78 ^a	.034
Carcass	2.46 ^b	.039	2.90 ^a	.027	2.77 ^a	.033
r	.94		.88		.97	
Last Rib (LR)						
Sonic	2.07 ^c	.026	2.33 ^b	.018	2.26 ^b	.022
Carcass	2.25 ^b	.036	2.58 ^a	.025	2.48 ^a	.031
r	.88		.53		.97	
Last Lumbat (LL)						
Sonic	2.46 ^b	.020	2.46 ^b	.014	2.46 ^b	.017
Carcass	2.44 ^b	.032	2.88 ^a	.019	2.57 ^a	.025
r	.59		.77		.67	
Avg. Fat						
Sonic	2.81 ^b	.035	2.83 ^b	.019	2.82 ^b	.027
Carcass	2.83 ^b	.022	3.21 ^a	.013	3.14 ^a	.018
r	.81		.70		.88	
Loin Eye (LEA), cm ²						
Sonic	33.94 ^{ab}	.392	32.49 ^b	.258	32.93 ^{ab}	.347
Carcass	34.57 ^a	.458	32.66 ^b	.287	33.23 ^{ab}	.377
r	.83		.73		.97	

^{abc}Variable means with different superscripts are significantly different at $P < .05$.

r = correlation coefficient between sonic and carcass data.

TABLE 3. MEANS AND STANDARD ERRORS OF ADJUSTED VARIABLES BY FREQUENCY AND SEX

TABLE 3. MEANS AND STANDARD ERRORS OF ADJUSTED VARIABLES BY FREQUENCY AND SEX

Variable	Mean	3 MHz				5 MHz			
		Gilts		Barrows		Across Sex		Barrows	
		Mean	SE	Mean	SE	Mean	SE	Mean	SE
Number		18		19		37		23	
Live Wt., kg	106		2.87	110	2.02	108	2.44	113	2.38
HCW, kg	78		2.43	82	1.34	80	1.89	83	1.66
Fat Thickness, cm									
First Rib (1R)									
Sonic	3.88 ^c		.039	3.70 ^d	.023	3.79 ^d	.031	3.77 ^d	.033
Carcass	4.19 ^b		.024	4.52 ^a	.025	4.36	.037	4.49 ^a	.035
r		.61		.69		.61		.67	
Tenth Rib (10R)									
Sonic	2.35 ^b		.040	2.93 ^a	.028	2.65	.034	3.00 ^a	.034
Carcass	2.45 ^b		.39	2.89 ^a	.042	2.68	.056	2.92 ^a	.058
r		.94		.70		.84		.80	
Last Rib (LR)									
Sonic	2.07 ^c		.026	2.31 ^b	.018	2.20	.022	2.35 ^b	.022
Carcass	2.25 ^b		.036	2.57 ^a	.040	2.41	.048	2.60 ^a	.055
r		.88		.21		.63		.64	
Last Lumbar (LL)									
Sonic	2.46 ^b		.020	2.44 ^b	.012	2.45	.016	2.48 ^b	.018
Carcass	2.44 ^b		.032	2.86 ^a	.032	2.66	.048	2.89 ^a	.044
r		.59		.78		.74		.84	
Avg. Fat									
Sonic	2.81 ^b		.032	2.79 ^b	.022	2.80 ^b	.022	2.85 ^b	.027
Carcass	2.83 ^b		.022	3.20 ^a	.039	3.08	.044	3.23 ^a	.053
r		.81		.63		.74		.88	
Loin Eye Area (LEA), cm ²									
Sonic	33.94 ^{ab}		.392	32.09 ^b	.554	32.99 ^b	.473	32.83 ^b	.221
Carcass	34.57 ^a		.458	32.46 ^b	.478	33.49 ^b	.516	32.82 ^b	.658
r		.83		.79		.81		.91	

^{abc}Variable means with different superscripts are significantly different at $P < .05$

r = correlation coefficient between sonic and carcass data.

techniques appear feasible for instrument grading during on-line processing of meat animals. To test this possibility, scans were taken in experiment 2 at three different times on the same animal (Table 4). The earliest scans done 12 days before slaughter did not differ in fat thickness measure from actual carcass measurements done on both left and right sides 14 days later. In essence, hogs can be scanned a fortnight before slaughter probably as they enter the marketing channels and the data can be used in computing hog

carcass yield at the point of sale. If this route is chosen there may be no need to take carcass measures beside weight and length in the slaughter house.

Similarly, except for the first rib position, there were no differences between scans taken on the hot carcass and actual carcass measures on the chilled right and left sides 48 h later (Table 4). This result suggests the possibility of complete grading for hot carcasses and may further encourage hot processing if adopted. In cold processing situations, it may remove

TABLE 4. MEANS AND STANDARD ERRORS OF ULTRASONIC AND ACTUAL CARCASS VARIABLES (EXP.2).

Variable	LS1*		LS2		CS		CAR		CAL	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
First Rib (1R)	4.35 ^a	.146	3.88 ^b	.150	3.69 ^b	.148	4.19 ^a	.151	4.30 ^a	.151
Tenth Rib (10R)	2.47 ^a	.123	2.35 ^a	.119	2.31 ^a	.122	2.46 ^a	.133	2.41 ^a	.130
Last Rib (LR)	2.24 ^a	.109	2.07 ^b	.080	2.27 ^a	.111	2.25 ^a	.097	2.31 ^a	.103
Last Lumbar (LL)	2.50 ^b	.083	2.47 ^b	.079	3.19 ^a	.111	2.44 ^b	.096	2.49 ^b	.123
Avg. Fat	3.03 ^a	.100	2.81 ^b	.092	3.05 ^a	.112	2.96 ^{ab}	.092	3.04 ^a	.100
Loin Eye Area (LEA)	32.60 ^b	1.185	33.94 ^{ab}	1.167	35.44 ^a	1.176	34.57 ^a	1.212	32.80 ^b	1.372

*LS1 = First live scan done 12 days before slaughter.

LS2 = Second live scan done just before slaughter.

CS = Carcass scan immediately after slaughter.

CAR = Actual measurements on the right side of the carcass.

CAL = Actual carcass measures on the left side.

^{ab}Variable means with same superscripts are not significantly different $P > .05$.

the necessity to enter the cooler for carcass measures.

The non-agreement in values of scan data taken at three time periods is most probably due to the effect of temperature on the velocity of ultrasound waves which in fat decreases with increasing temperature (Miles and Woods, 1979). This will reduce the resolution and hence precision of scan measurements. The repeatability of ultrasound measurements has been reported to range from 0.74 to 0.90 (Webb, 1975).

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