Efficacy of Using Real-time Ultrasound to Predict Intramuscular Fat in the *Longissimus* Muscle of Live Swine

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Summary and Implications

Results of this study indicate that real-time ultrasound can be useful in predicting intramuscular fat (IMF) in the *longissimus*s muscle of live swine. The addition of tenth rib backfat measurements and sex as independent variables to IMF prediction equations increases prediction accuracy. Improvements in data collection and image analysis should further enhance prediction accuracy.

Introduction

Enhancements in muscle quality as well as quantity of muscle are essential for improved consumer acceptance of pork. Specific factors influencing pork quality, therefore, must be addressed.

The presence of marbling or lipids is said to be of importance to meat quality and sensory properties (7,9). Numerous studies have suggested that marbling influences the palatability of cooked meat (3,4,8,10,12).

The trend in modern pork production has been toward producing leaner pork. Increased selection for lean has caused considerable concern regarding the possibility of a reduction of intramuscular fat in pigs (14). Lower intramuscular fat levels would have detrimental effects on eating quality of pork (1).

Heritability estimates for intramuscular fat range from 0.49 to 0.81 (1,6,14). The genetic correlation between intramuscular fat and meat content is low ($r_g = -0.30$). A breeding program emphasizing simultaneous selection for higher levels of intramuscular fat and a higher meat content, therefore, should be possible (1).

At present, breeding programs for improving muscle quality require the collection of measurements on the carcass. Direct selection, therefore, cannot be performed, and breeding programs for these traits must be based on progeny tests.

Real-time ultrasound offers an alternative to traditional swine breeding programs for muscle quality, because it allows noninvasive measurement of a trait on the live animal at a reasonable cost.

Ultrasound has been used to predict 10th - 11th rib subcutaneous fat and loin muscle area of live swine with a correlation near .9 and .8, respectively (11). Few studies have been conducted to evaluate the accuracy of ultrasound in predicting intramuscular fat. Dion et al. (5) predicted marbling score with real-time ultrasonic cross-sectional and longitudinal scans. The accuracy of prediction was essentially zero.

The objective of this study, therefore, was to investigate the feasibility of predicting intramuscular fat in the longissimus muscle of live swine from a single real-time ultrasonic longitudinal image, and to assess the merit of using ultrasound predicted IMF values to classify animals into specific IMF groups.

Materials and Methods

Data used for this project (n=756) were collected as a part of the 1995 National Barrow Show® (NBS) Progeny Test (n=348) and the 1996 Livestock Producer Assistance Program (LPAP) test (n=408) conducted at the Northeast Iowa Swine Improvement Association Station located near New Hampton, Iowa. Animals represented in the NBS test were of the eight major breeds and crossbreds, whereas only crossbreds were included in the LPAP test.

Pigs were weighed and scanned off-test on an individual basis at weekly intervals upon reaching a weight = 240 lb.

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 by using a personal computer equipped with a frame-grabber board and controlling software. The images were stored as digitized files for later interpretation.

Two ultrasonic images were taken on each pig. A cross-sectional image of the loin muscle and subcutaneous fat overlying the loin muscle on the right-hand side of the pig at the 10th rib was acquired using a sound emitting transducer guide that fitted the natural contour of the pig's back. A longitudinal image was taken approximately 2.5 in. off the midline and parallel to the spine. The image included the 9th, 10th, and 11th ribs.

Digitized cross-sectional 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 these 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.

Longitudinal images were prerocessed to subjectively evaluate image quality. Images with less than ideal image quality were removed from this analysis. A 100*100 pixel region of interest (ROI) was then selected from the image above the 10th and 11th ribs. Image-processing parameters were then determined for the selected ROI.

Image-processing parameters were calculated using techniques of histogram analysis, texture analysis, and Fourier transformation. Histogram parameters are computed from the frequency distribution of the pixel intensities, texture parameters provide information about the image patterns generated in part by ultrasound scattering, and Fourier parameters were calculated from two-dimensional Fourier transformations.

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 were followed, as outlined in Procedures to Evaluate Market Hogs (NPPC, 1991, 3rd ed.). A sample was excised from the loin muscle at the 10th rib. The intramuscular lipids from the excised sample were measured according to the total lipid extraction method of Bligh and Dyer (2).

Of the 756 images collected, 350 images had ideal image quality and were used for this analysis. Image variables; live animal measures, including 10th rib backfat and sex of the animal; IMF values; and marbling score were statistically analyzed to select a set of parameters for regression model development. Stepwise regression procedures were used for selection of variables to determine the prediction models.

Multiple linear regressions (PROC REG [13]) were used to predict IMF and marbling score. Of the 350 images used, 200 were randomly chosen for model development and the remaining 150 were used for validation of the model.

Bias and mean absolute difference were calculated between predicted IMF and marbling score and actual IMF and marbling score. The regression equation containing all 12 of the ultrasound image variables, sex, and BF10 was utilized to obtain predicted IMF and marlbing score values. Bias was defined as:

$$= (\overline{X}_{chemical} - \overline{X}_{ultrasound})$$

The mean absolute difference was defined as:

$$= (|\text{Chemical - Ultrasound}|)$$

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

$$= \sqrt{\frac{(\sum Chemical - Ultrasound - Bias)^2}{N-1}}$$

Mean absolute differences were sorted into one of five groups: 0–.25%, .26–.50%, .51–.75%, .76–1.0%, and > 1.0%. The frequency of observations in each group was determined.

Actual IMF and predicted IMF values were grouped in one of three classes: 0–2%, 2–4%, and > 4%. The frequency of observations in each class was determined.

Results and Discussion

Variables used in regression equations, R^2 values and mean square error (MSE) are given in Table 1. The use of real-time ultrasound image analysis variables alone resulted in a R^2 of .33 whereas the addition of sex and BF10 to the prediction equations increased the R^2 to .34 and .38, respectively.

Table 1. Variables, R^2, and mean square error (MSE) from prediction equations.[1]

Variables	R^2	MSE
RTU variables	.33	1.12
RTU variables and sex	.34	1.09
RTU variables and BF10	.38	1.04
RTU variables, sex and BF10	.38	1.04

[1] RTU=real-time ultrasound, BF10=10th rib backfat.

The mean absolute differences between true and predicted IMF and true and predicted marbling score were .68 and .54, respectively. Bias for IMF prediction was 0.05, whereas bias for prediction of marbling score was .25. The SEP for IMF and marbling score was .96 and 1.01, respectively.

Figure 1 shows the classification of mean absolute differences by group. Over 77% of the mean absolute differences were less than 1%

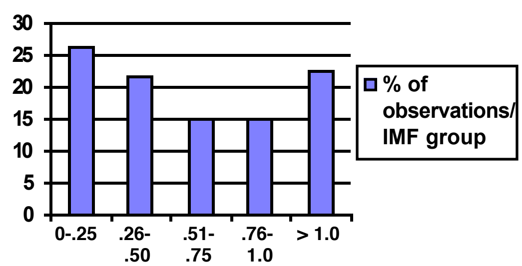

Figure 1. Classification of mean absolute differences between actual and predicted intramuscular fat.

Figure 2 illustrates the grouping of actual and predicted IMF values. Over 70% of the predicted values were correctly classified. All misclassifications fell into an adjacent class.

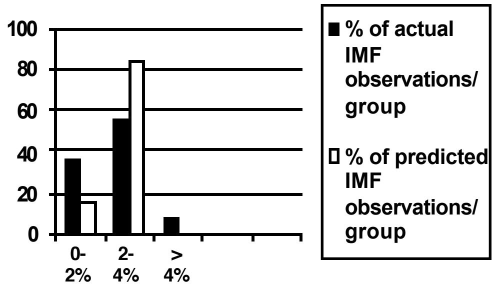

Figure 2. Classification of actual and predicted intramuscular fat values.

Conclusions

The results of this study indicate that objective measurement of IMF of the live animal with real-time ultrasound is feasible. This will allow the identification of breeding animals that are superior for IMF. Selection based on muscle quality measurements taken on the live animal will, therefore, be possible. The use of real-time technology to predict IMF also may be applicable for carcass evaluation. Image collection and procedures for image analysis must be further refined to enhance accuracy of IMF prediction.

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