Development of a Model to Predict Intramuscular Fat in Live Pigs Using Real-Time Ultrasound

A.S. Leaflet 2050

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Summary

Recent developments in real-time ultrasound technology offer producers an opportunity to estimate intramuscular fat in live pigs. Genetic improvement of intramuscular fat will continue as an emphasis in swine breeding programs and genetic progress in this important trait will be possible through implementation of this technology.

Introduction

Prediction of intramuscular fat (IMF) in live pigs has been shown to be feasible. The ability to measure IMF in live pigs will enable producers to identify superior breeding animals and enhance genetic progress through the use of this technology in multiple-trait selection programs. There are currently several brands of ultrasound equipment capable of evaluating compositional differences. However, many of these systems do not have the necessary software algorithms for the prediction of IMF. Swine researchers at ISU have developed a prediction model for possible use in research programs and in breeding programs with an emphasis on improvement of intramuscular fat percentage. The purpose of this paper is to present the IMF prediction model developed by ISU swine researchers.

Materials and Methods

Records from ultrasonic scans of 770 purebred Duroc barrows and gilts from two extensive research projects at Iowa State University were utilized for model development. Pigs utilized in this study were scanned 5 d prior to harvest with an Aloka 500V SSD ultrasound machine fitted with a 3.5 MHz, 12.5-cm linear-array transducer (Corometrics Medical Systems, Inc., Wallingford, CT). Gain settings for the ultrasound machine were: Overall, 90; Near, -25; and Far, 2.1. Focal lengths were set at 1 and 2. A minimum of four longitudinal images were collected 7 cm off-midline across the 10^{th} to 13^{th} ribs by a National Swine Improvement Federation certified technician. The probe was used without a guide and vegetable oil was used as a couplant. Images were stored on a ZIP™ diskette and taken to the ultrasound imaging laboratory in the ISU Animal Science Department for interpretation.

A trained technician made a visual assessment of each image to ensure proper location, absence of echoes due to external fat, consistent depth penetration, and clarity. A 100- x 100-pixel defined region of interest was placed on the 10^{th} to 11^{th} rib interface of each digital image. The technician used texture analysis software (Amin et al., 1997) to define Fourier transformation, gradient, histogram, and co-occurrence matrix parameters (Hassen et al., 2001).

After harvest, a slice of the longissimus muscle from the 10^{th} to 11^{th} rib interface was analyzed for carcass intramuscular fat percentage by the method outlined in Bligh and Dyer (1959). Regression analysis procedures were used to develop a prediction model for intramuscular fat percentage by using carcass intramuscular fat percentage as the dependent variable and image processing parameters from the ultrasound images as the independent variables. Independent variables with the highest P-value were removed individually until all variables remaining were significant ($P < 0.05$).

Results and Discussion

The prediction model developed in this project is as follows:

$$y = 12.6535 - 0.5638*P_1 + 0.0617*P_1^2 - 0.0018*P_1^3 - 0.0088*P_3 + 0.0092*P_4 - 0.0870*P_5 - 0.3876*P_6 + 0.1892*P_7 - 0.0100*P_8 - 0.0051*P_9 - 16.8555*P_{10} + 7.7912*P_{10}^2$$

$$\text{Intramuscular fat \%} = e^y.$$

where,

P_1 = Fourier, coefficient of variation
P_3 = Fourier, ratio of low to high average power at (1-30)/(30-100) percentile
P_4 = Fourier, ratio of low to high average power at (1-10)/(10-20) percentile
P_5 = Gradient, mean
P_6 = Gradient, skewness
P_7 = Histogram, skewness
P_8 = Histogram, 10^{th} percentile of cumulative histogram pixel frequency
P_9 = Co-occurrence, difference variance at angle 90º
P_{10} = Co-occurrence, difference entropy at angle 135º

The corresponding R^2 and root mean square error for the prediction model were 0.36 and 1.31%, respectively. This prediction model is only applicable to the Aloka 500V SSD/12.5-cm system and is not applicable to any variation of this ultrasound system. Swine researchers at Iowa State University have taken all practical research measures to establish the accuracy and applicability of the information in the current report. Ultrasonic images may be heavily influenced by system settings and calibration, technician

experience, and various other conditions such as temperature, animal preparation, and electrical interference. As a result, Iowa State University assumes no responsibility for certain aspects of the applicability of the prediction model included in this report when applied by other persons.

Implications

With evolution of value-added markets that focus on meat quality, genetic improvement of intramuscular fat will continue as an emphasis in swine breeding programs. At the present state of technology, intramuscular fat percentage can be evaluated in live pigs with the use of real-time ultrasound. This technology will enable swine producers to identify superior animals in breeding schemes aimed at improvement of this important trait.