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DETERMINATION OF LIVE BODY COMPOSITION OF SWINE USING BIOELECTRICAL IMPEDANCE TECHNOLOGY

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Background

Bioelectrical impedance (BIA) is an accurate, inexpensive, portable, and reliable method of determining body composition of livestock. BIA uses an alternating current of 800 μA at 50 kHz. The alternating current is transmitted from each of the two outer source electrodes to their respective opposite inner detector electrodes. Bioelectrical impedance measures the amount of resistance within a biological entity to the flow of a small amount of electric current. The more fat and bone within the biological entity, the more resistance to the current.

To date, bioelectrical impedance has been used to assess weight of muscle, fat-free muscle, and retail-ready cuts of live and abattoir-processed pigs (Marchello and Slanger, 1992; Swantek et al., 1992), sheep (Cosgrove et al., 1988; Jenkins et al., 1988; Berg and Marchello, 1994; Slanger et al., 1994), and beef (Marchello and Slanger, 1994; Slanger and Marchello, 1994).

Carcass data were the bases of the prediction equations of the above cited studies. This study was designed to develop prediction equations for the entire animal based on total-body grind.

Objective

The objective was to determine how well bioelectrical impedance technology can assess the fat-free mass of swine.

Materials and Methods

A four-terminal bioelectrical impedance analyzer was used to obtain resistance and reactance readings on 20 crossbred swine (10 barrows and 10 gilts) with various combinations of Hampshire, Yorkshire and Duroc breeding to assess leanness. The swine were selected from a group of pigs housed in a total-confinement facility and fed a standard corn-barley-soybean diet. They weighed 54 to 115 kg and were 107 to 190 days of age. Four 20 gauge vacutainer needles were used as electrodes. They were inserted along the dorsal midline 10 and 20 cm caudal from the base of the ear and at the base of the tail and 10 cm cranial from that point. The shorter ends (12.7 mm) of the vacutainer needles were inserted subcutaneously into the swine and the long ends served as attachment to the BIA. Distance (L, centimeters) was measured between the two detection needles. A full description of needle placement is provided by Swantek et al. (1992). All animals were handled with extreme care and guidance by USDA protocol and supervised by the vivarium officer. Each animal was anesthetized with ace promazine maleate (manufacturer: dose + concentration). After BIA measurements were made the swine were euthanatized by overdosing with pentobarbital and immediately placed into a container with dry ice to facilitate rapid freezing. The frozen animals were ground twice with a whole body grinder fitted with a .95 cm plate. Random sub-samples of approximately 2 kg were obtained for laboratory analysis. The sub-samples were lyophilized and further homogenized. Dry matter was determined by oven drying at 105°C (moisture meats (950.463), crude protein by the copper catalyst Micro-Kjeldahl Method (984.13), total fat by specific gravity - Foss-let (976.21), and ash (942.05). All procedures followed AOAC 1990 guidelines. Prediction equation development used the many statistical techniques of PROC REG from SAS (1988).

Results and Discussion

Fat percentages ranged from 17.8 to 33.5%. Similar results were obtained by Hall et al. (1989) with BIA when 64 rats were analyzed to compare fat-free mass (FFM) with whole body grind.

In theory (Lukaski et al., 1985), the FFM of any biological entity is directly proportional to the square of the length between the electrodes receiving the current divided by the resistance of the biological entity to the current applied to it. This value will be called VOL. The correlation between FFM and VOL for the 20 feeder pigs was .97. This correlation was .95 and .99 for barrows and gilts, respectively. The correlation between FFM and VOL for gilts adjusted to the same body weight was .94. This value was .48 for barrows.

Table 1 shows the multiple linear regression coefficients for predicting fat-free mass weight from measurements on swine. The prediction equation was FFM = -.29 + .362 x weight + 1.10 x reactance + .217 x vol. The adjusted R^2 of this equation was .99. The best within sex prediction equations had the same predictor variables and their adjusted R^2's and Mallows CP values were similar to those obtained from the combined data.

These very high correlations and adjusted R^2 are strong evidence of the potential of bioelectrical impedance to contribute to efficient livestock production.

Table 1. Coefficients for predicting amount of fat-free mass from bioelectrical impedance measurements taken on swine[a].

Item	Parameter Estimate	Standard Error	P-value
Intercept	.29	2.41	.9050
Weight, kg	.362	.04510	.0001
Reactance, ohms	1.10	.4260	.0200
Length^2/Resistance, (cm^2/ohms)[b]	.217	.03977	.0001

Mallows CP, Adj. R^2, RSD[c]: 3.50, .99, 1.50

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[a] N = 20, electrodes were 20-gauge needle inserted to a depth of 12.7 mm.

[b] Vol as described in the text.

[c] Mallows CP, adjusted R^2, and residual error standard deviation, respectively. Predictor variables allowed were weight, reactance, VOL, resistance, and length.

Conclusions

Bioelectrical impedance was very successful in determining the amount of fat-free mass of the market swine. Bioelectrical impedance can determine which among animals of the same live weight have high amounts of fat-free mass and which have low amount of fat-free mass. Bioelectrical impedance technology is a simple tool that can be applied economically to benefit the hog producer. It has the potential to be used for the genetic selection of superior animals and as a management tool in hog operations. Anyone involved in raising swine can use this technology to their benefit.

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