BIOELECTRICAL IMPEDANCE AS A METHOD OF PREDICTING AMOUNT OF SALEABLE PRODUCT AND CARCASS QUALITY OF BEEF CATTLE AND THEIR CARCASSES

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SUMMARY

Fifty Charolais crossed calves were used to evaluate the use of bioelectrical impedance as a method of predicting amount of saleable product in live animal and carcasses of beef cattle. The amount of saleable product was then correlated to yield grade to be able to serve as a possible method of determining value of the live animal and also beef carcasses. Resistance (Rs) and Reactance (Xc) were measured from live animals and carcasses using the Bioelectrical Impedance Analyzer. Regression equations were then developed using Rs, Xc, length, and weight as independent variables for live animal and hot and cold carcasses. Correlations for weights of IMPS cuts of hot and cold carcasses to actual yield grade were (P=.0026, .0049), respectively. With the ability to determine amount of saleable product of carcasses and live cattle, this research indicates that the use of bioelectrical impedance technology may be an effective method of determining animal value.

INTRODUCTION

The cattle industry perpetually changes to increase product consumption and stay competitive in a marketing system that can fluctuate greatly from year to year. Consumer eating preferences, health concerns, and income have dictated the need to produce a leaner animal (Forrest et al. 1989). The meat processing industry itself has demanded leaner animals to reduce their own financial loss associated with excess fat trimmings (Wilson, 1992). Changes in the system are only made when an economic incentive can be realized. The importance of a value-based marketing system puts more emphasis on the predictability of carcass traits (Houghton and Turlington, 1992).

The most commonly used payment system is based on the weight of the animal. However, because of genetic and environmental variances, variation in the composition of carcasses occurs frequently. Therefore payment based on carcass merit is a possible marketing option in the cattle industry. Currently, livestock producers lack accurate methods to determine the value of animal carcasses before slaughter (Houghton and Turlington, 1992).

Ferrel and Cornelius (1984) stated that the ideal technique for measurement of body composition should be accurate, easily accomplished, inexpensive, applicable to a wide range of ages and compositions and capable of being applied to the live animal with minimal perturbation of subsequent performance. Bioelectrical impedance has shown promise as a nondestructive method to assess weight of muscle, fat-free muscle and retail-ready cuts of live and processed pigs, sheep, and beef. This method of measuring fat-free tissue requires the use of a Bioelectrical Impedance Analyzer (BIA). The BIA measures the components of impedance; resistance (Rs) and reactance (Xc). The four terminal impedance plethysmography introduces a constant current that provides a deep homogenous field in the variable conductor of the body. Differences in Rs measurements reflect differences in the transmitted field and should be due to differences in tissue mass. Four measurements such as; Rs, Xc, length between terminals and body weight have been used to predict fat-free skeletal muscle. In other words, the amount of lean tissue may be predicted in an individual carcass or live animal with the use of the bioelectrical impedance technology.

The objectives of this study were; 1) develop a predictive equation that would accurately estimate the amount of lean, saleable product in beef carcasses with the use of the BIA, 2) develop a predictive equation that would accurately estimate marbling in beef carcasses with the use of the BIA.

MATERIALS AND METHODS

Fifty crossbred calves (26 steers and 24 heifers) were used to investigate the use of the BIA as an accurate method of estimating lean, saleable product and carcass quality from live cattle and bled beef carcasses. Calves were measured for body weight (BW), length between terminals, Rs and Xc on August 15 and October 28, 1995 (creep feeding period). Following weaning calves were fed in four pens and subjected to a grower diet for 60 days then advanced to a finishing diet for approximately 180 days (range = 179-207). Calves were measured for BW, length between terminals, Rs and Xc every 28 days until slaughtered. Time of slaughter was based on calf sex and weight for one of four dates (June 6, 13 and July 11, 18, 1995).

Animals were processed after an overnight withholding of feed at Valley Meat, Valley City, North Dakota. Prior to exsanguination (bleeding at slaughter) each animal was again measured for BW, length between terminals, Rs and Xc. Rs and Xc were measured by fully inserting electrodes into the live animal along the spine 3.9 and 7.9 inches from the top of the shoulder and at the tail head and 3.9 inches cranial to it (figure 1). The electrodes were inserted from the external side of the hot and cold (from a 48 hour chill) carcass (figure 2). Hot and cold carcass temperatures at time of measurement were obtained with a standard meat probe thermometer inserted (5 inches) behind the midpoint of the shoulder into the muscle. Temperature was measured for use as a possible variable for the development of predictive equations. Hot carcass measurements were collected approximately 45 min after slaughter from either right or left carcass sides.

One carcass side per animal (side from which all measurements were collected) was processed into Institutional Meat Purchasers Specification (IMPS) cuts and weighed. This is representative of the processing currently practiced in the meat packing industry. Actual muscle weight was then correlated to % retail cuts from the formula and predicted IMPS cuts weights of the hot and cold carcass. Prediction equation development used the many statistical techniques of PROC REG from SAS (1988).

RESULTS

Equations developed to estimate saleable product are reported in (table 2).

Correlations and predictability of equations are reported in (Table 2). This table illustrates the probability of being able to predict the amount of saleable product from live cattle and hot and cold carcasses from equations listed in (Table 2).

IMPLICATIONS

Bioelectrical impedance technology can be a rapid, nondestructive, and accurate method for determining the amount of saleable product in live cattle and carcasses. Predictive equations developed for live, hot and cold carcasses proved to be to be highly correlated to actual weight of salable product (.0003, .0026, .0049 respectively). This agrees with results that of Swantek et al. (1992) and Johns et al. (1994) Predictive equations have not been developed to estimate carcass quality. However, Rs measurements collected on the exposed end of the ribeye muscle and the weight of the carcass half were predictive of the percentage fat at the exposed end of the ribeye muscle (P=.03). These positive results with such a narrow range of fat percentage indicates that we should be able to predict intramuscular fat as well as leanness. Further refinement and validation of predictive equations must be done before bioelectrical impedance can be used as a tool for value based marketing.

Table 1. Equations for predicting amount of saleable product.
[a]Live Prediction = 11.87 + (.409 * Live Weight) - (.335 * Live Length) + (.0158 * Vol 1[d]) R^2=.799[*]
[b]Hot Carcass Prediction = -58.84 + (.59 * Hot Weight) - (.85 * Rs) + (1.15 * Xc) + (.14 * Length) + (2.6 * Temperature) R^2=.948[*]
[c]Cold Carcass Prediction = 32.15 + (.63 * Cold Weight) + (.33 * Xc) + (.83 * Length) R^2=.931[*] + (.68 * Vol 1)
aPrediction based on live measurements taken prior to slaughter [b]Prediction based on measurements taken 45 min. after bled. [c]Prediction based on measurements taken at a 48 hour chill. [d]Length squared/Rs
[*]An R^2 value of "1" would indicate the variables used in the equation could fully predict the amount of saleable product.
Example: Predicting amount of saleable product from live animal measurements. Variables: Live weight = 1000 lb. (454.5 kg) Length = 90 cm Rs = 26

Xc = 3
Vol 1 = 312
Live Prediction = 11.87 + (409 * 454.5) - (.335 * 90) + (.0158 * 312)
= 172.2 kg or 378.8 lb.

Table 2. Correlations and probability between actual and predicted saleable product and yield grade.

Measurement	Yield Grade	Significance
Sum of actual IMPS	-.496	.0003
Predicted IMPS (hot)	-.418	.0026
Predicted IMPS (cold)	-.392	.0049

Back to 1996 Research Report Table of Contents
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