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LEANNESS OF BEEF PRIMAL CUTS DETERMINED BY BIOELECTRICAL IMPEDANCE METHODOLOGY

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Please refer to Folio 30.

INTRODUCTION

Value-based marketing is dependent upon an objective measure to determine the leanness of animals, carcasses or cuts. Bioelectrical impedance has been shown to be a nondestructive method to successfully assess leanness and fat-free mass of pigs, pork carcasses (Swantek *et al.*, 1992) and Boston butts (Marchello and Slanger, 1992). Additional work in sheep by Berg and Marchello (1993), Cosgrove *et al.* (1988) and Jenkins *et al.* (1988) indicate that bioelectrical impedance can be used as a means of predicting leanness in commercial situations because of its precision, simplicity and portability. Therefore, it is an important step in developing a value-based marketing system. Preliminary investigations in beef animals showed that coefficients of determination (R^2) for predicting total lean and fat were 0.89 and 0.83, respectively, when several bioimpedance measurements were combined using stepwise regression procedures (Johns *et al.*, 1992). The objective of this research was to use bioelectrical impedance technology to develop prediction equations to assess the leanness and fat-free muscle of beef rounds, loins, ribs and chucks.

MATERIALS AND METHODS

A four-terminal bioelectrical impedance analyzer (BIA; Model BIA-101, RJL Systems, Detroit, MI) was used to obtain resistance (Rs) and reactance (Xc) readings. An alternating current of 800μA at 50KHz was introduced into the four lean cuts (round, loin, rib and chuck) via transmitter terminals and received by detector terminals. Voltage drops as the electric current passes through the cut. Needles were inserted about two cm from the edge of each primal cut and 5cm between transmitter and detector terminals (Figure 1). The primal cuts obtained from 33 beef cows with a wide range of weight (385-749kgt) age (three to 12 years) and fatness (0.13-2.54cm) were utilized to establish a database for the prediction equations. Each primal cut was obtained according to NAMP (1988) specifications. Weight, internal temperature, resistance (Rs), reactance (Xc) and length (L) between detector terminals were obtained for each cut.

Twenty-one gauge needles were inserted 2.54cm into the muscle tissue and 13 gauge needles 5.08 or 7.62cm depending on the wholesale cut. Loin, rib, and round were measured through the thickest part of the muscles along the sagittal plane of the carcass (Figure 1). The chuck was measured at the midpoint of the chuck over the clod area on the transverse plane. Each cut was physically separated into lean, fat and bone. Chemical composition (moisture, protein and fat) was determined on the lean portion. The fat percentages from the proximate analyses (AOAC, 1990) were used to determine the fat-free muscle (FFM). The FFM were determined by multiplying kilograms of lean by one minus percentage of fat.

Marbling measurements were obtained by inserting insulated 13 gauge needles into the centre of each loin at the rib end and 10cm apart for the detection terminals. Only 1.5cm of the needles was exposed in order to obtain resistance and reactance reading that would detect the amount of marbling in the loin eye muscle. A subsample of the loin eye muscle was obtained to determine the actual amount of fat (marbling) within the muscle.

Prediction equation development utilized the many statistical techniques of PROG REG (SAS Institute Inc., 1988). In summary, the strategy was to first examine the data for outlier observations and then study collinearity among independent variables, stability of estimated prediction equation coefficients, the independent variable subset equations with the higher R^2, and Mallows Cp. The number of independent variables was small enough that the R^2 of all possible models could be easily calculated.

The companion test to SAS regression capabilities (SAS Institute Inc., 1991) was used to guide the data analyses.

RESULTS AND DISCUSSION

Tables 1 and 2 show the coefficients for predicting kilograms of lean and fat-free muscle for primal cuts using large and small needles. Needle gauge had little effect on prediction equations. Only the round incorporated all five variables measured. Mallows Cp values were close to the number of dependent variables and intercept in the prediction equations. These results indicate that the prediction equations would be beneficial to industry to objectively assess leanness of cuts. These results are even better than our Boston butt work (Marchello and Slanger, 1992).

An equation for predicting marbling from bioelectrical impedance measurements was also developed (n=28): Marbling= -15.9+0.24(resistance)+0.25(temperature)+0.42(needle depth)-0.046(predicted fat-free muscle)+0.0119(volume).

The Mallows Cp for this equation was 5.48 with an R^2 of 0.79 and a residual error standard deviation of 0.90. This preliminary, positive result indicates that there is potential to assess quality objectively. It would be most useful if we could determine quality from hot carcass measurements. This may be possible with further research and modification of this equation.

CONCLUSION

Bioelectrical impedance is a rapid, nondestructive method for determining the amounts of lean and fat-free muscle of primal cuts and can be used as a value-based marketing tool. There is potential to determine quality aspects of marbling in beef carcasses using bioelectrical impedance measurements.

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Table 1. Coefficients for predicting kilograms of lean from bioelectrical impedance measurements using large and small needles of primal cuts of cull cows.[a]

Large Gauge needles	Chuck	Rib	Loin	Round
Intercept	13.7	2.3	3.6	1.7
Weight, kg	0.62	0.36	0.30	0.62
Length, cm	-0.024	0.18	0.089	-0.531
Temp, °C	-0.20	0.089	-0.14	-0.21
Resistance ohms	-0.16	-0.0531	-0.0708	-0.21
Reactance ohms	--	--	--	0.36
Adj. Cp	4.9	5.1	5.5	6.0
Adj. R^2	0.95	0.90	0.92	0.97
Adj. RSD[b]	1.19	0.445	0.917	0.879

Small Gauge needles	Chuck	Rib	Loin	Round
Intercept	10.7	1.3	-0.32	1.7
Weight, kg	0.62	0.32	0.30	0.17
Length, cm	--	0.13	0.27	0.18
Temp, °C	--	--	-0.18	-0.99
Resistance ohms	-0.117	-0.0293	-0.0454	-0.19
Reactance ohms	--	--	--	0.22
Adj. Cp	2.8	3.7	4.3	6.0
Adj. R^2	0.95	0.89	0.94	0.96
Adj. RSD[b]	1.20	0.460	0.797	0.918

[a] n = 30 except for round/large needles (n=29)

[b] Mallows Cp, adjusted R^2 and Residual standard deviation respectively.

Table 2. Coefficients for predicting kilograms of fat-free muscle from nioelectrical impedance measurements using large and small needles of primal cuts of cull cows.

Large Gauge needles	Chuck[b]	Rib[c]	Loin[d]	Round[c]
Intercept	18.1	2.1	6.9	1.8
Weight, kg	0.57	0.27	0.19	0.58
Length, cm	-0.52	0.21	0.31	0.21
Temp, °C	-0.27	--	-0.29	-0.11
Resistance ohms	-0.22	-0.0498	-0.857	-0.26
Reactance ohms	--	--	--	-0.43
Adj. Cp	4.2	4.0	4.0	6.0
Adj. R^2	0.93	0.91	0.88	0.94
Adj. RSD[b]	1.40	0.367	1.01	1.13
Small Gauge needles	Chuck[b]	Rib[b]	Loin[c]	Round[b]
Intercept	13.7	1.2	0.54	5.0
Weight, kg	0.549	0.32	0.32	0.54
Length, cm	--	0.16	0.30	0.24
Temp, °C	--	--	-0.25	-0.14
Resistance ohms	-0.157	-0.0287	-0.0552	-0.23
Reactance ohms	--	--	--	0.24
Adj. Cp	3.4	3.1	4.0	6.0
Adj. R^2	0.93	0.88	0.93	0.95
Adj. RSD[b]	1.39	0.413	0.786	1.05

[b] n=30
[c] n=29
[d] n=31