BIOELECTRICAL IMPEDANCE MEASUREMENTS ON BEEF CARCASSES FOR THE PREDICTION OF CARCASS LEAN CONTENT

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Background

Determining live body and carcass composition by non-invasive, accurate and simple methods has always received considerable interest in animal production. Bioelectrical impedance (BIA) has been shown to be able to predict skeletal muscle mass in live and slaughtered farm animals, e.g. in live cattle and in beef carcasses (Bohuslavek et al., 2000), in live pigs and in pork carcasses (Marchello and Slanger, 1992) and in sheep (Cosgrove et al., 1988). These initial findings indicated that BIA has potential as a means of predicting lean body mass in commercial situations, given its accuracy, simplicity and low cost.

Objectives

The objectives of this study were to investigate the potential of bioelectrical impedance measurements for the prediction of carcass lean content of Belgian Blue bulls, and to examine the effect of time of measuring post slaughter and the position of the electrodes.

Methods

Seventy six young bulls of the Belgian Blue breed, differing in body conformation and in myostatin genotype (mh/mh, 32 ; mh/+, 22 ; +/+, 22), were slaughtered in the abattoir of Ghent University. Animals originated from different farms and were fattened on high-concentrate diets. Feed was withheld overnight before slaughter. Live weight (LW), warm carcass weight (WCW) and cold carcass weight (CCW) after chilling for 24 hours were determined. Carcass classification was performed following the SEUROP scheme for conformation and fat grade. A four–terminal impedance plethysmograph (Model BIA-101, RJL Systems, Detroit, MI) was used to obtain resistance (Rs, Ω) and reactance (Xc, Ω) readings on the right carcass side at 1, 5 and 24 hours post mortem. The plethysmograph transmits a deep homogeneous, alternating current (800 µA, 50 kHz) between the outer two transmitter electrodes and measures the voltage drop between the inner two detector electrodes. The conductance or resistance depends on the geometric configuration, volume of the biological conductor, signal strength and frequency of the applied current (Lukaski et al., 1985). Assuming similar geometry for all bulls and using a constant electrical signal, impedance $\{Z = (Rs^2+Xc^2)^{0.5}\}$, resistance and reactance values depend on body composition. Measurements were made on the outer and inner right carcass side by inserting needles to specific postions and attaching the electrodes to the needles (Figure 1). For het outer side, the detector electrodes were positioned on the rear leg and the fore leg and the corresponding transmitter electrodes were placed 8 cm caudal and 8 cm cranial to the detector electrodes. For the inner side, the detector electrodes were positioned 10 cm above the *os pubis* and at the height of the first rib, and the corresponding transmitter electrodes were placed 8 cm caudal and 8 cm cranial to the detector electrodes. Distances (L, cm) between the two detector electrodes were also recorded. From the right carcass side, the 8th rib was separated in fat, lean and bone for the estimation of carcass lean content (%) using appropriate regression equations (Verbeke and Van de Voorde, 1978). The data were analyzed by correlation and multiple linear regression analysis (SPSS 9.0).

Results and discussion

The distribution of the carcasses according to the SEUROP classification for conformation (fat cover class 2, 3) was : S, 20 (20, 0) ; E, 11 (11, 0) ; U, 23 (12, 11) ; R, 22 (10, 12). Mean age at slaughter was 19.4 (sd 2.5) months. Carcass quality traits are given in Table 1.
Mean values for resistance, reactance and distance according to the three measuring times post mortem and the position of the electrodes at the outer or inner carcass side are given in Table 2. Impedance readings of Rs and Xc were significantly higher in the cold carcass than in the warm carcass. This was expected due to changes in the distribution of electrolytes between intracellular and extracellular compartments (Berg and Marchello, 1994). Higher values for Rs and Xc were found on the outer side in comparison with the measurements on the inner side, due to a longer distance between the detector electrodes.
Correlation analysis revealed that Xc was not or weakly related to carcass lean %, whereas Rs was strongly negatively related (Table 3). Correlation coefficients did vary to some extent between measuring sites and times. Carcass weight (data not given) and distance between electrodes, the latter related to carcass length and body conformation, were moderately related to carcass lean %; indicating that these variables are worthwhile taking into account when developing prediction equations. Using Rs, Xc and L or carcass weight as independent variables in a multiple linear regression model, R^2 values between 76 and 80% and standard error of the estimate (SEE) values between 2.72 and 2.96 were found (Table 4). These are reasonably accurate estimates. The measuring site and time had little effect on the accuracy. However, we previously showed on a large number of young bulls that the two SEUROP classification variables (conformation and fat cover score determined by an expert classifier, with three subclass scores per main class and converted to a numeric variable) yielded a higher accuracy (R^2 = 0.85 ; SEE = 1.86 ; De Smet et al., 2000). Adding dressing yield, another easily available variable in abattoirs, as an independent variable to the prediction equation further sligthly improved the accuracy. Also in the present study, when using the SEUROP classification variables and dressing yield in addition to the impedance variables in a stepwise multiple regression, the impedance variables were not withheld.

Conclusions

It can be concluded that bioelectrical impedance analysis has potential to be a relatively accurate and practical method for estimating carcass lean content. Although the time of measuring and the position of the electrodes have a large effect on the impedance values, the predictive accuracy is little affected by these parameters. Impedance measurements do, however, not yield the same accuracy for predicting carcass lean content as classification variables visually determined by a trained person.

Pertinent literature

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Table 1. Carcass quality traits

	Mean value	Standard deviation	Minimum - Maximum
Live weight (kg)	659	76	525 – 885
Warm carcass (kg)	436	63	315 – 615
Cold carcass (kg)	427	62	309 – 603
Lean (%)	70.3	6.1	56.2 – 80.5
Fat (%)	16.7	5.7	7.9 – 31.9
Bone (%)	13.0	1.7	7.9 – 17.5

n = 76

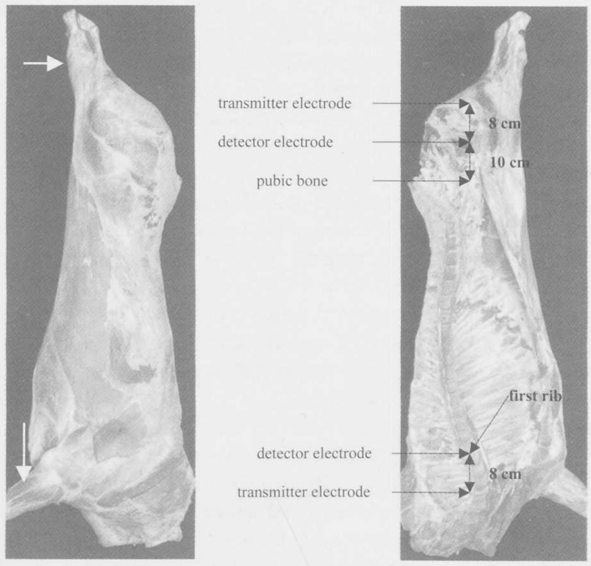

Figure 1. Position of the detector and transmitter electrodes on the outer and inner side of the carcasses

Table 2. Mean values (standard deviation) for resistance, reactance and distance according to measurement time and position of the electrodes

	outer carcass side		
	Rs	Xc	L
1 h pm	117 (16)	34 (4)	197 (9)
5 h pm	150 (24)	47 (8)	198 (10)
24 h pm	213 (36)	73 (10)	198 (10)
	inner carcass side		
	Rs	Xc	L
1 h pm	80 (10)	29 (3)	151 (7)
5 h pm	100 (15)	37 (5)	151 (6)
24 h pm	140 (23)	54 (8)	151 (6)

n = 72 at 1 hour pm, n = 76 at 5 and 24 hours pm
Xc = reactance (Ω), Rs = resistance (Ω), L = distance (cm)

Table 3. Correlation coefficients between carcass lean content (%) and impedance measurements

	outer carcass side			inner carcass side		
	Rs	Xc	L	Rs	Xc	L
1 h pm	-0.757	-0.040	-0.604	-0.739	0.000	-0.467
5 h pm	-0.519	0.019	-0.626	-0.568	-0.010	-0.453
24 h pm	-0.691	-0.267	-0.633	-0.678	-0.207	-0.456

n = 72 at 1 hour pm, n = 76 at 5 and 24 hours pm
Xc = reactance (Ω), Rs = resistance (Ω), L = distance (cm)

Table 4. Prediction equations for carcass lean content (%) using impedance measurements at 1 and 24 hours pm

	Independent variables	Model	R^2	SEE
1 h pm				
outer side	Rs, Xc, WCW	% lean = 113.4 – 0.484 Rs + 0.847 Xc – 0.0034 WCW	0.798	2.72
inner side	Rs, Xc, L	% lean = 135.2 – 0.522 Rs + 0.733 Xc – 0.289 L	0.780	2.84
24 h pm				
outer side	Rs, Xc, L	% lean = 110.9 – 0.197 Rs + 0.401 Xc – 0.140 L	0.762	2.96
inner side	Rs, Xc, L	% lean = 127.8 – 0.301 Rs + 0.453 Xc – 0.263 L	0.773	2.89

n = 72 at 1 hour pm, n = 76 at 5 and 24 hours pm
WCW = warm carcass weight (kg), Xc = reactance (Ω), Rs = resistance (Ω), L = distance between detector electrodes (cm), R^2 = adjusted R-square, SEE = standard error of the estimate, all coefficients in the equations are significant at $P<0.05$