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THE ON LINE MEASUREMENTS OF BEEF CARCASS QUALITY BY MEANS OF THE BIOELECTRICAL IMPEDANCE ANALYSIS

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Introduction

The method of bioelectric impedance analysis has so far been applied in research projects. Among the recent publications, there is the study presented by Balcaen et al.(2002) examining the ability of the BIA method to estimate carcass lean content of Belgian Blue bulls and to examine the impact of time after slaughter and the location of electrodes. The method was considered relatively precise and practically applicable. Allen et al. (2002) examined the accuracy of the BIA method in the estimation of lamb carcass composition. Hegarty et al. (1998) made use of the multifrequency method for the same purposes and found on the contrary that the BIA measurements taken in warm lamb carcasses explained 87% of the variation of saleable yield.

Objectives

The objective of the experiment was to ascertain the quality of the prediction of the commercial grading with the use of a measuring device with flat electrodes. Another objective was to check the reliability of new electrodes in the measurement carried out at an abattoir line with the capacity of 100 carcasses per hour.

Methodology

The experimental measurements were carried out in the company Südostfleisch , Altenburg, Germany, under normal operation. The impedance values were measured always on the left half of moving beef carcasses. Simultaneously, beef carcass classification was in progress on the line, with the use of the installed VBS2000, manufactured by E&V, based on the method of video image analysis.

a) Description of the carcass collection. In total, the evaluation reflected 441 beef carcasses, of this 198 young bulls, 7 bulls, 214 cows and 22 heifers. The physical and electrical characteristics for carcasses of the group of evaluated animals are summarized in TABLE 1.

b) Description of measuring method and device. The measurement of the bioelectric impedance was carried out with the use of an impedance analyzer described in Bohuslavek et al. (2002b). The functional properties are as follows:

Measurement of impedance and phase angle at the frequency of 1 kHz and 100 kHz; Maximum value of measurement current of 5 mA; Measurement with the use of 4-

electrode measuring method; Flat elastic electrodes with a Cu-foil, of the surface area about 30 sq.cm; Galvanic separation of impedance analyzer circuits from the mains; Automatic measurement of the beef carcass temperature; Connection and communication with PC and measurement process control and archiving of measured data.

c) Selection of measuring points. The positions of electrodes were selected in order to ensure simple anatomic definition, easy access and good contact of electrodes. Electrodes were situated at the outsides of the left half-carcasses. All electrodes were placed on the vertical lines going through heel tendon (tendo calcaneus). The upper measuring electrode was placed on the horizontal line going through the broadest part of the leg, i.e. on the musculus vastus lateralis, the lower measuring electrode was on the horizontal line going through tuber olecrani. The drive electrodes were placed 85 mm out of measuring electrodes.

d) Reference values. The carcasses of the examined animals were classified according to the SEUROP standard, according to two methods: "subjective" visual evaluation and "objective" classification with the use of technical facilities. The first method represents the usual subjective commercial grading (Conformation and Fatness) in the EU by the expert classifier, i.e. German Centre for Meat Research (BAFF) Kulmbach. The second method resulted in an objective classification carried out with the automatic classification device VBS2000, based on the method of video image analysis.

e) Output values of the analyzer. The measured impedance and phase angel were for statistical analysis calculated on real and imaginary part of impedance – resistance and reactance of parallel circuit (Rp, Xcp) along relationship, which is for example presented in Vrana (1989), Bohuslavek et al.(2002a).

Results & Discussion

A number of impedance values to the beef carcass conformation for all categories show correlation dependencies. For separate group of male animals (young bulls + bulls), the strongest correlations (r = 0.86) were identified between conformation and the value D^2/Xcp100k (relationship between the square of the distance between electrodes and the calculated parallel reactance at 100 kHz). Significant relations were also found for the fatness of all categories and particularly for the female categories (cows + heifers). The highest correlation has revealed in values derived from parallel reactance Xcp1k, measured at the frequency of 1 kHz. Also, the difference in reactance Xcp1k – Xcp100k shows considerable dependence to fatness; e.g. in the category of cows + heifers the correlation coefficient was r = 0.71 for the fatness determined by a BAFF expert. The dependence is significantly better than that in fatness determined according to E&V, which is why this value may serve for the improvement of the E&V estimate. Using the outcome of correlation analysis, a regression analysis was carried out in order to identify the best regression models – formulae for the estimation of conformation and fatness. The formulae were examined for the quality commercial grades determined by the BAFF expert, which may be considered to be more precise. TABLE 2 shows the best calculated model for the estimate of conformation.

Conclusions

The results of the experiment confirmed that the BIA method is suitable for practical use in the instrument evaluation of the commercial value of beef carcasses. With respect to the satisfactory results of the fatness estimate, it is also possible to expect that BIA may be applied as a complementary device with the VIA system (video image analysis).

References

Allen P.,McGeehin B., Hanrahan J.P. (2002): Estimating lamb carcass composition using BIA . Proceeding: 48th ICoMST , Rome, Italy, August 25–30, Vol II: 744–745.

Balcaen A.,Seynaeve M., Claeys E., De Smet S. (2002): Bioelectrical impedance measurements on beef carcasses for the prediction of carcass lean. Proceeding: 48th ICoMST , Rome, Italy, August 25–30, Vol II: 748–749.

Bohuslavek Z., Pipek, P., Malý J. (2002a)): Use of BIA method for the estimation of beef carcass composition – weight of longissimus lumborum muscle, ratio of muscle tissue and fat in loin cross-section Czech J. Anim. Sci., 47, 2002 (9): 387–394.

Bohuslavek Z., Pipek, P. (2002b): Prediction of beef carcasses composition from bioelectrical data. In.: Congress Proceedings Vol. II, 48th ICoMST , Rome 2002, p.754–755.

Hegarty R.S., McPhee m.J., Oddy V.H (1998): Prediction of the chemical composition of lamb carcasses from multi-frequency data., British Journal of Nutrition, 79, p. 169–176.

Vrana V., (1989): Modelování biologických objektů a dějů. (Modelling of biological objects and processes), VUT Brno, 1989, 168 s.

Tables and Figures

Table 1. Characteristics of the group of evaluated 441 animals

Category	198 Young bulls + 7 Bulls		214 Cows		22 Heifers	
	Mean	S. dev.	Mean	S. dev.	Mean	S. dev.
CW … warm carcass weight [kg]	366.20	63.70	281.18	58.13	247.25	53.17
D … distance of electrodes [cm]	159.24	6.57	160.21	6.38	149.67	8.7
Rp1k [ohm]	133.20	16.03	192.5	24.47	189.02	27.02
Rp100k [ohm]	82.08	11.59	121.39	16.94	117.56	18.69
D^2 / Xcp1k [cm^2 / ohm]	- 7.50	1.66	- 5.74	1.55	- 5.12	1.29
Conformation subclasses* [15]	9.63	2.6	13.13	1.72	12	1.87
Fatness subclasses* [15]	6.28	1.59	6.39	2.59	6.76	2.28

* Grading system EUROP (divided into 15 subclasses) for conformation and fatness respectively

Rp1k …parallel resistance by frequency 1 kHz , Rp100k … parallel resistance by frequency 100 kHz

Xcp1k … parallel reactance by frequency 1 kHz

Table 2. Regression models for beef carcasses

Model no.	Dependent variables	Independent variables	Equations	r^2 / r^{**}	SEE*
1.	Conforma-tion* [15]	CW D D^2 / Rp100k D^2/Xcp100k	Conformation = 6.726 - 2.427e^{-02} * CW + 8.487*10^{-02}*D + 2.034*10^{-02} * D^2/Rp100k + 9.652*10^{-02} * D^2/Xcp100k	0.85 /0.92	1.08

* [SEE]…stand. error of estimation r^2 / r^{**} … coefficient of correlation / determination;

all regression coefitients in the equations are significant at P<0.001