AN ON-LINE ELECTRICAL IMPEDANCE SPECTROSCOPY TO PREDICT PH45 AT 24 h POST-MORTEM IN THE SEMIMEMBRANOSUS MUSCLE

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Background

The meat with a low water holding capacity or high drip losses, caused by the incidence of PSE meat, is one of the major problems of the meat industry in Spain. 47.1 % of moderate PSE meat, (PQM at 24 h between 4 and 6 µs/cm) was reported by Gispert et al. 2000. Many researchers have investigated the use of electrical impedance in both the early and late post-mortem periods in order to identify abnormal pork quality. The electrical properties of meat provide an approach to the investigation of post-mortem cellular metabolism and water movement. The speed of these changes is related to the quality of the meat (Whitman et al., 1996; Forrest et al., 2000; Lee et al. 2000). Schöberlein et al. (1999) found important correlations between Py-value obtained at 24 h *p.m.* and pH_{45} and drip losses in *Longissimus dorsi* (LD) muscle. Oliver et al., (2001) evaluated an Electrical Impedance Spectroscopy (EIS) prototype, to select the hams on the basis of meat quality characteristics in commercial conditions. This study demonstrated that the EIS prototype applied in the *semimembranosus* region at 36 h *p.m.* may classify with 88.46 % accuracy the technologically normal meat ($pH_{45} > 6.10$) from the PSE meat. However, this prototype can not be used on the slaughter or production line.

The objective of this study was to evaluate a new on-line equipment, the EIS on-line, based on the electrical impedance measurements, to predict pH45 in the *Semimembranosus* muscle, at 24 h p.m.

Material and methods

This study was carried out under experimental conditions in a predetermined design that included 60 hams of PSE, normal and DFD quality. These hams were selected from commercial carcasses in order to obtain a sample that included all the range of quality. The carcasses were weighed (kg) and classified in a slaughterhouse with the Hennessy Grading Probe. DFD hams were selected as meat with a pH_{24} higher than 6.0 in the *Semimembranosus* muscle (SM)

Muscle pH in the SM was measured at 45 min. post-mortem (p.m.) (pH_{45}) in the slaughterhouse with a portable pHmeter (Crison 507, Crison Instruments S.A., Barcelona, Spain) and at 24 h p.m. in IRTA´s facilities, equipped with a xerolyt electrode (Ingold, Urdof, Switzerland. The conformation (H) was measured by a calliper (cm) and visual (VF) and external fatness (EF) were determined by two experts.

The EIS (Electrical Impedance Spectroscopy) is a new on-line equipment based on electrical impedance measurements. A temperature sensor was included in this on-line model and correction for changes in temperature have been performed (Foster & Schwan, 1996).

The device currently gives the value of R_o and R_∞, that correspond to the real part of the measured impedance at very low and very high frequencies. These values are expressed in ohms (Ω) and are not normalized to the particular electrode geometry used, so they may differ from values given by other devices. A third parameter, called K-value, is introduced corresponding to the ratio of R_∞, over R_o.

Results and discussion

The mean, S.D. , minimum and maximum values of the carcasses studied are shown in Table 1. The average carcass weight was 79.75 kg and it is representative of pig carcasses in Spain. P2 fat thickness, with a mean of 14.19 mm, includes a wide range of fat thickness representative also of the Spanish commercial pig carcasses. Ham weight was 12.11 kg with an average value of conformation score (H) measured by a calliper of 16.73 cm. The commercial hams studied have a mean of pH_{45} of 6.00 ± 0.29, with a minimum of 5.30 and a maximum of 6.50 and a pHu mean value of 5.69 ± 0.27, with a minimum of 5.33 and a maximum of 6.72. These data show the wide range of the sample, from pale, soft, exudative (PSE) at one extreme to dark, firm, dry (DFD) meat at the other. The PSE problem could lead to a high percentage of cooking losses principally in cooked ham production.

In the SM muscle, a range between 4.5 Ω and 34.0 Ω and from 4.0 Ω to 5.8 Ω was found for the electrical parameter Ro and Ri, respectively at 24 h *p.m.* The K-value (K) ranges from 0.20 to 0.90 with a mean of 0.47 at 24 h p.m.. This electrical variable depends on the extracellular water. The impedance values obtained by the EIS on-line equipment can not be compared with the electrical parameters obtained with the EIS prototype (Oliver *et al.*, 2001). This prototype scanned at different frequencies (from 8 kHz to 1 MHz) and was applied in two regions of the ham, defined as M and SM (for a more detailed description of these regions see Oliver *et al.*, 2001) and this new on line probe was used in muscles. Also, different absolute values were obtained by the different electrical impedance equipment developed by Whitman *et al.* (1996), Schöberlein *et al.* (1999), Forrest *et al.* (2000) and Lee *et al.* (2000).

Table 2 presents the coefficients of correlation between meat quality characteristics and electrical parameters obtained by the EIS on-line probe. Significant correlations were found between pH_{45} and the electrical variable Ro obtained at 24 h. p.m. in the SM muscle. These results agree with those presented by Swatland (1982) and Whitman *et al.* (1996) who demonstrated that low frequency electrical conductivity (Ro) is related to water holding capacity. However, the best correlations were found between pH measured at 45 min. *p.m.* and the electrical parameter K, obtained by the EIS on-line, when this equipment was applied in the SM muscle at 24 h *p.m.* (r= -0.78). These results could be of great interest in order to use this probe to avoid the PSE meat in ham factories. However a larger trial should be done to confirm these preliminary results and to ascertain the degree of accuracy of the probe.

References

Forrest, J.C., Morgan, M.T., Borggaard, C., Rasmussen, A.J., Jespersen, B.L., Andersen, J.R. (2000). Development of technology for the early post-mortem prediction of water holding capacity and drip loss in fresh pork. *Meat Science, 55*, 115 - 122.

Gispert, M., Faucitano, L., Oliver, M.A., Guardia, M.D., Coll, C., Siggens, K., Harvey, K., Diestre, A. (2000). A survey of pre-slaughter conditions, halothane gene frequency, and carcass and meat quality in five Spanish pig commercial abattoirs. *Meat Science, 55*, 97 – 106.

Lee, S., Norman, J.M., Gunasekaran, S., van Laack, R.L.J.M., Kim, B.C., Kauffman, R.G. (2000). Use of electrical conductivity to predict water-holding capacity in post rigor pork. *Meat Science, 55*, 385 - 389.

Foster K R, Schwan H P (1996). Dielectric properties of tissues, in C Polk, E Postow (Eds.) "Handbook of biological effects of electromagnetic fields", pp. 25-102, CRC Press, Boca Raton, FL, 1996.

Oliver, M.A., Gobantes, I., Arnau, J., Elvira, J., Riu, P., Grèbol, N., Monfort, J.M. (2001) .Evaluation of the Electrical Impedance Spectroscopy (EIS) equipment for ham meat quality selection. *Meat Science,* (in press).

Schöberlein, L., Scharner, E., Honikel, K.O., Altmann, M., Pliquett, F. (1999). Der Py-Wert als Fleischqualitätsmerkmal. *Fleischwirtschaft, 79 (1),* 116 - 120.

Swatland, H.J. (1982). Evaluation of pH related aspects of pork quality by capacitance measurements in an abattoir. *Can. J. Anim. Sci., 62*, 725 - 730.

Whitman, T.A., Forrest, J.C., Morgan, M.T., Okos, M.R. (1996). Electrical measurement for detecting early post-mortem changes in porcine muscle. *Journal of Animal Science, 74,* 80 - 90.

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Table 1: Descriptive statistical parameters of carcass and ham meat quality characteristics.

Characteristics	*n*	*Mean*	*S.D.*	*Minimum*	*Maximum*
Carcass weight (kg)	60	79.75	3.86	72.00	86.50
P2 Fat thickness (mm)	60	14.19	2.85	8.40	18.80
Ham weight (kg)	60	12.11	0.83	10.36	14.19
Conformation (cm) (H)	60	16.73	0.93	14.60	19.60
Visual fatness (VF)	60	2.48	0.96	1.00	5.00
External fatness in the ham (EF)	60	2.79	1.03	1.00	6.00
pH_{45} SM	60	6.00	0.29	5.30	6.50
pHu SM	60	5.69	0.27	5.33	6.72

Table 2: Coefficients* of correlation between electrical and carcass and ham characteristics at 24 h *p.m.*

	RoSM	RiSM	KSM
Carcass weight (Kg)	0.02	0.00	0.01
P2 (mm)	-0,25	-0.12	0,27
Ham weight (kg)	-0.17	-0.22	0.06
Conformation (cm) (H)	0.07	-0.11	-0.19
Visual fatness (VF)	0.08	0.14	-0.12
External fatness (EF)	-0.08	0.00	0.05
pH_{45} SM	0,72*	0,78*	-0.78*
pHu SM	0,27*	0,30*	-0.21