IMPEDANCE AND MEAT AGEING

Lepetit, J., Dalle, R., Favier, R., Salé, P.

Station de Recherches sur la viande, INRA, Theix -63122 Ceyrat, France.

BACKGROUND

Numerous studies on electrical properties of muscle have been developed to give quality indicators of meat. Slanger and Marchello, 1994, Jenkings *et al.* 1995 have shown that electrical impedance can be used to predict fat-free soft tissue in beef primal cuts or in carcasses. Cosgrove *et al.* 1988 showed that carcass lean content can be predicted (r=0.92) using carcass weight and a measure of electrical resistance. Kauffman *et al.* 1996 demonstrated a direct relationship between electrical conductivity and water holding capacity in *post-rigor* pork. Byrne *et al.* 1997 found conductivity or impedance were poorly correlated with Warner Bratzler shear force, drip loss, cooking loss, colour, juiciness, flavour and texture of the meat.

The impedance of muscle decreases rapidly during *pre-rigor* period as shown by Salé 1976 in beef and by Swatland 1980 in pork. Moreover impedance also decreases more slowly during *post-rigor* storage (Salé 1976, Pliquett *et al.* 1995). The *pre-rigor* variations of impedance have been linked to changes in membranes, whereas no clear understanding of *post-rigor* variations in impedance has been given.

OBJECTIVES : The purpose of this work is to analyse the variations in impedance of *post rigor* meat.

MATERIAL AND METHODS

The experiment was conducted on the *longissimus dorsi* and *triceps brachi caput longum* muscles from 5 bulls aged 19 to 24 months and 4 cull cows aged 6 to 8 years. Muscles were obtained 1h after slaughter and divided in 5 parts, vacuum packed and stored 24 h at 15°C and then at 4°C. The following measurements were performed at days 1, 2, 4, 7 and 14 days. From each part, 12 samples were cut (1x1x3cm, the longer dimension in the direction of muscle fibres) for electrical and mechanical measurements.

Electrical measurements:

The measuring system (figure 1) consisted of:

-a wave generator (Schlumberger 4431) giving a sinusoidal tension (5 volts peak amplitude) at 1Khz and 100Khz.
-a reference resistance of 150 ohms.
-a cell with 2 parallel mobile electrode plates (30x10 mm) made of stainless steel.
-a phase-meter (HP 3850) for the measurement of amplitude and phase.

From the measurements with the phase-meter, 3 variables were measured.
Z - the impedance modulus, R - the real part of the impedance and J - the imaginary part.
Also are calculated the following ratios.

$Rr = \frac{R_{1k}}{R_{100k}}$ $Rz = \frac{Z_{1k}}{Z_{100k}}$, when the capacitance effects disappear, these ratios tend to 1.

For the electrical measurements, the electrical field was perpendicular to the muscle fibre direction.

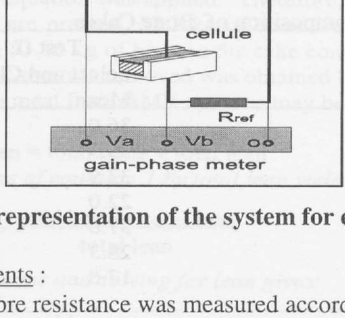

Figure 1 : Schematic representation of the system for electrical measurements.

Mechanical measurements :

The muscle fibre resistance was measured according to Lepetit and Buffiere, 1995. The compression cell was fitted onto an INSTRON 4302 allowing uni-axial compression of the sample. The resistance of muscle fibres was obtained at 20% compression.

RESULTS:

The different electrical variables show significant correlations, the higher correlations been obtained between variables measured at the same frequency (cf. Table 1).

	R_{1k}	J_{1k}	Z_{1k}	R_{100k}	J_{100k}	Z_{100k}	R_r	R_z
R_{1k}	1.00							
J_{1k}	-0.94	1.00						
Z_{1k}	1.00	-0.95	1.00					
R_{100k}	0.52	-0.32	0.51	1.00				
J_{100k}	-0.89	0.71	-0.88	-0.76	1.00			
Z_{100k}	0.72	-0.54	0.72	0.88	-0.89	1.00		
R_r	0.87	-0.90	0.88	0.11	-0.65	0.41	1.00	
R_z	0.91	-0.91	0.91	0.20	-0.71	0.43	0.97	1.00

Table 1 : Correlation coefficients between electrical variables obtained on 1080 samples.

There is a close relation between electrical measurements and muscle fibres resistance (Figure 2), but the slope of these relationships is different for different muscles and animals.

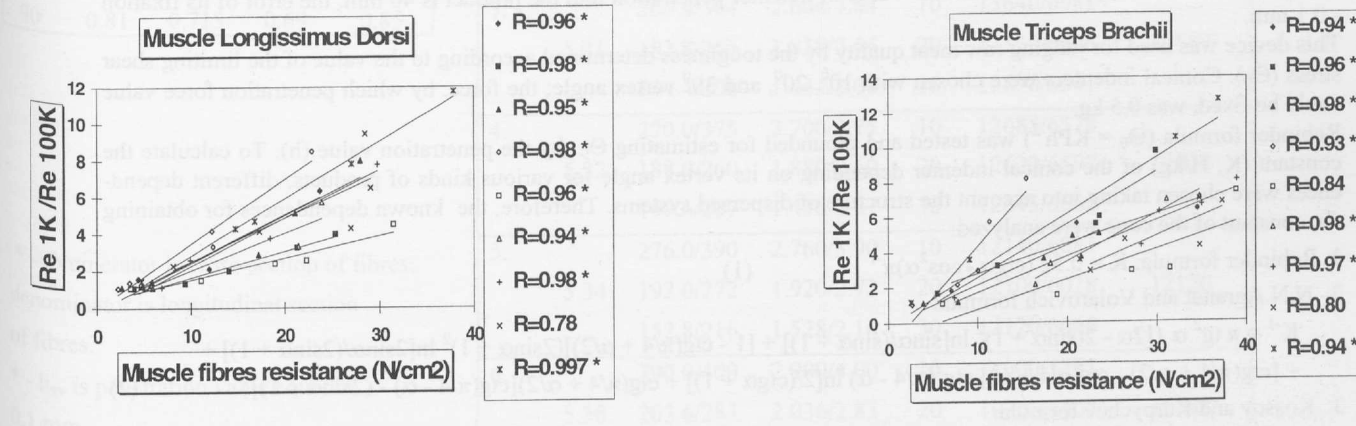

Figure 2 : Relationship between electrical measurements and muscle fibre resistance during ageing for the two muscles. Re 1K / Re 100 K is the ratio of the real part of impedance measured at 1 kHz and 100 kHz. The legend shows the correlation coefficients of the curves. An * indicates a significant correlation coefficient at the 5% level.

DISCUSSION - CONCLUSION :

It has been shown that impedance of *post-rigor* muscle varies with time of storage (Salé 1976, Pliquett *et al.* 1995). But, this work goes beyond as it shows a close relationship with the process of tenderisation, evaluated by the mechanical resistance of raw muscle fibres. The electrical impedance depends both on structure and composition of the tissue. The composition of meat slightly changes during ageing because of loss of drip and ions and peptides contained in it. But for the same composition, the electrical impedance also changes according to the mobility of ions, which depends on how the ions are linked to a structure and, when the ions are free, the viscosity of the fluid in which the ions move. During ageing little is known about the mobility of ions in meat. The modifications in proteins during ageing are likely to change the amount of free ions in the cytoplasm. During ageing there are major changes in the structures of meat. These changes affect myofibrillar structure, cytoskeleton and membranes. If the electric current is conducted mainly in the protein structures (myofibrils and cytoskeleton), the impedance would be expected to increase during ageing as those structures are progressively damaged. The opposite is observed. Therefore the electrical current seems to be propagated mainly in the fluids (extracellular, cytoplasmic and endoplasmic) and the proteins structures appear to act as electrical barriers. The more they are damaged during storage, the easier the current can propagate and so the lower is the impedance. Differences in slopes of the relation electric-mechanic could be due to varying amounts of ions in the muscles.

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