Impedance and pH development in pork with different slaughter treatment and its relation to driploss

Annette Schäfer[1], Poul Henkel[2], Peter P. Purslow[1]

[1]Department of Dairy and Food Science, The Royal Veterinary and Agricultural University, Frederiksberg, Denmark
[2]Danish Institute of Agricultural Sciences, Research Centre Foulum, Tjele, Denmark

Background

Early post mortem pH decline is an important parameter influencing meat quality parameters such as driploss and colour. If a rapid pH decline occurs when the muscle temperature is still high, the muscle becomes pale, soft and exudative. A fast pH decline can be induced by pre-slaughter stress through exercising the pigs on a treadmill prior to slaughter (Karlsson et al. 1998).
The cell membrane is a natural barrier between intra- and extracellular space. Its breakdown post mortem changes the distribution of water between extra- and intracellular space thus contributing to the formation of drip. Impedance measurements give an indication of the amount of intact cells to extracellular space (Pliquett and Pliquett 1998). Impedance is an electrical parameter representing the complex conductivity, which is frequency dependent. Muscle can be characterised as a simple electrical model of cells surrounded by membranes and the extracellular space. At low frequencies the cell membrane reacts as a large resistance and therefore the impedance is determined primarily by the extracellular space (represented by κ_0). At high frequencies the capacitive resistance of the membrane is overcome and the impedance is determined by both the intra- and extracellular space (represented by κ_∞). As the membranes breakdown the extracellular space becomes larger and the κ_0 increases. The measuring instrument used in this experiment measured a Py-value which is defined as $(\kappa_\infty - \kappa_0)/\kappa_\infty$. As k_0 increases the Py-value decreases, which can be observed in muscle post mortem.

Objectives

The aim of this study was to investigate the extent to which pre-slaughter treatment influences the pH, temperature and impedance decline in meat post-mortem and to see how far a different pH, temperature and/or impedance decline is reflected in the driploss.

Methods

Animals and Treatments In this experiment 39 pigs Danish Duroc x Danish Landrace x Yorkshire were used. All pigs were reared at the experimental farm at Foulum and were given a standard diet at an ad libitum level. Females and castrated males were used. Two models were applied. Group A had no treatment and was stunned by 80 % CO_2 for 3 minutes. Group B was exercised immediately prior to stunning on a treadmill till exhaustion (breathing and tread frequency are becoming uncoordinated) and then electrically stunned (220V, 1.5 A, 15sec). Pigs were exsanguinated after stunning, scalded at 62 °C for 3 minutes, cleaned and eviscerated within 30 minutes. After 60min, the carcasses were stored at 4°C in a chilling room. All measurements were performed on the *longissimus dorsi* muscle.
pH: (at the last rib) duplicate measurements were performed with a pH-meter (Metrohm Model 704, Switzerland) equipped with an insertion glass electrode (Hamilton Tiptrode P/N:238'080, Switzerland) at fixed intervals post mortem: 1min, 15 min, 30 min, 1h, 2h, 24h.
L-value: measurements were performed with a Minolta chromameter CR 300. The means of 5 measurements were taken
Impedance: (at the 13th rib) Py-value measurements were performed with a Meatcheck 160 device (sigma electronic GmbH, Erfurt) post-mortem at 1 min followed by intervals of approx. 30 min up to 10h and at 24h. The obtained data were fitted as sigmoidal curves ($y = \frac{A_1 - A_2}{1 + e^{(x-x_0)/dx}} + A_2$, where x_0=center, dx=width, A_1=initial Y value, A_2=final Y value) using the curve fitting module of Origin 4.1 (Microcal Software, USA) with fixed maximum (A1) and minimum (A2) values.
Temperature: (at the last rib) measurement with an insertion thermo-element at the last rib at fixed intervals post mortem: 1min, 15 min, 30 min, 1h, 2h, 24h.
Drip loss: (at 10th/11th rib) on a 2cm thick slice suspended in a net in a plastic bag stored at 4°C over 48h.

Results and Discussion

Group B shows the same ultimate pH as group A (Table1) but the early post mortem pH decrease is significantly faster than in group A (results not shown). The temperature is significantly higher in the first hour post mortem for group B (results not shown). Thus the animals in group B undergo a fast pH drop at still high temperature which is prone to give PSE meat. The significantly higher L-value together with a higher drip loss in group B supports this. Using L-value and driploss as characterising parameters half of the animals in group B fall into this category (Fig.1). However group B also produces meat which has a normal colour but higher driploss which is characterised as RSE meat. With these two models a continuum and a broad range of driploss and L-value can be produced, indicating that this may be a valid model for investigating causes in driploss (Fig1).

After 24h group B shows a significantly lower Py-value (Tab.1). The driploss correlates with the Py-value at 24h ($r = -0.73$) (Fig.2) which is in accordance to the results of Schoeberlein et al. (1999). The time at which Py decrease drops post-mortem is also correlated with drip loss. The animals with a high driploss show an early and severe decrease of the Py-value while the animals with a low drip loss exhibit a slow and less pronounced decrease. This indicates that the extracellular space is increased either by membrane breakdown or by decrease of the cell volume and formation of dripchannels at a much earlier time post-mortem for the animals with high driploss. Histological observations (data not shown) indicate a strong correlation between drip channel formation, drip loss and high initial rates of Py fall. The Py-value shows a logarithmic correlation to the pH 1h p.m. (Fig.3). This indicates that only a low pH (below 6.2) at 1h p.m. has a significant influence on the Py-value.

Conclusions

Pre-mortem stress leads to an early post mortem pH drop at higher body temperature. It also results in higher driploss and an early and severe post mortem drop in Py-value. The Py-value shows a better correlation to driploss than to early post-mortem pH. Further studies will investigate the relation between Py-value and the opening up of drip channels in meat.

Pertinent literature

Karlsson A., Olsen E.V., Henckel P. (1998). Proc. ICOMST, Barcelona

Pliquett U., Pliquett F. (1998). Fleischwirtschaft 78, 1010

Schoeberlein H., Scharner E., Honikel K.O., Altmann M., Pliquett F. Fleischwirtschaft 79, 116

Tab.1 Meat quality parameters
$p<0.001$

	Group A	Group B
n	20	18
pH 24h	5.51±0.06	5.49±.0.04
L-value	56.09±1.94[a]	53.11±2.63[b]
drip [%]	4.93±1.75[a]	9.70±2.17[b]
Py 24h	41±11[a]	13±14[b]

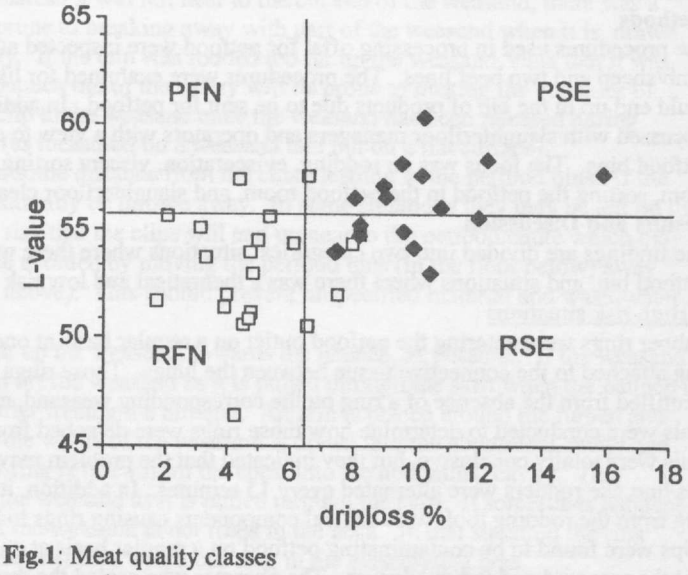

Fig.1: Meat quality classes
□ group A
◆ group B

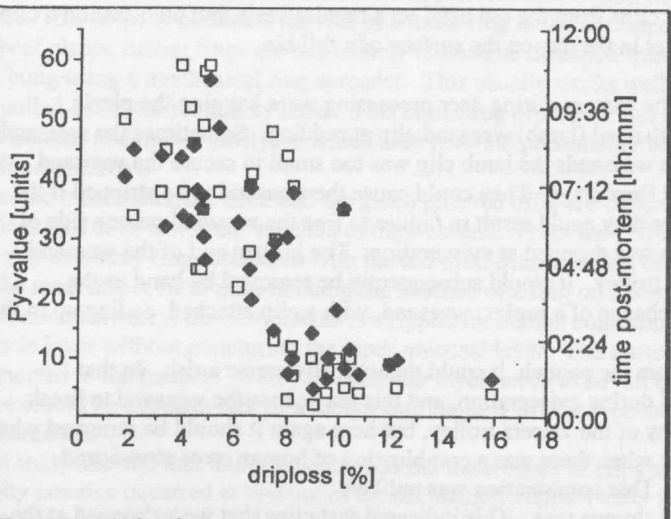

Fig2: Correlation between Py-measurements and driploss
◆ time at which Py-value has reached half maximum drop (r=-0.76898)
□ Py-value at 24h p.m. (r=-0.73448)

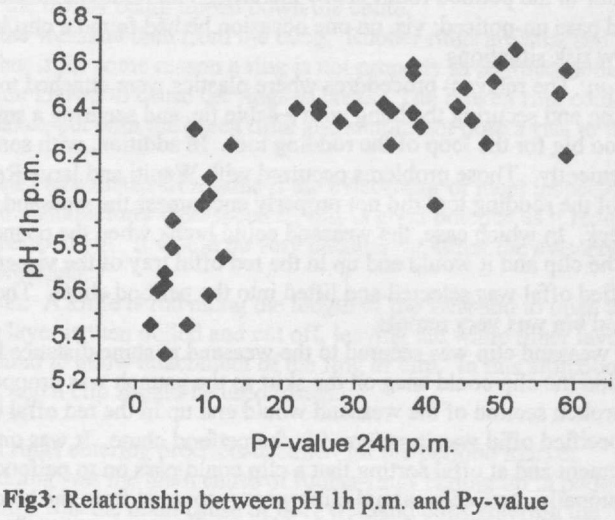

Fig3: Relationship between pH 1h p.m. and Py-value