METABOLIC CHARACTERISTICS OF SWISS LARGE WHITE M. LONGISSIMUS DORSI SAMPLES OF SPECIFIC pH24 VALUES*

Germaine J.F. Seewer[1*], Poul Henckel[1], Daniel Schwörer[2]

[1]Danish Institute of Animal Science, Product Quality, Research Center Foulum, DK-8830 Tjele, [2]Swiss Pig Performance Testing Station, CH-6204 Sempach, *Present Address: Swiss Federal Research Station for Animal Production, CH-1725 Posieux

Keywords: pig, longissimus dorsi, pH24, muscle metabolites

Background and Objectives

Different meat quality traits are influenced by the postmortal pH. The decrease will depend partly on genetic factors, but will also be determined by transportation, preslaughter handling and cooling. It is well-known, that transport as well as handling of the animals immediately before slaughtering leads to changes of energy stores of the muscle and therefore they have an influence on the pH decrease. Postmortem metabolism depends on the concentration of glycogen, high-energy phosphate compounds (like ATP, ADP and CP) and their metabolites. The breakdown of glycogen and of the phosphate compounds leads to lactate production, which causes a fall in pH. The rate of postmortem pH decline depends primarly on the levels of glycogen and energy rich phosphate compounds. When muscle fibres are completely depleted of ATP and CP, they develop a state of extreme rigidity, called rigor. The rigor process can be summarized by the following reactions: $MgATP + H_2O \rightarrow MgADP + P_i + H^+$; $MgADP + CP + H^+ \rightarrow MgATP$ + creatine; $3\ MgADP + 3\ H^+ + P_i + 1$ glucose $\rightarrow 3\ MgATP + 2$ lactate $+ 2\ H^+$. After the onset of rigor, an increase in free Mg^{2+} is associated with ATP disappearance. The major breakdown process of ATP postmortem is: AMP → IMP → inosine → HYP. When CP and glycogen are no longer availabel, the myokinase reaction ($2\ ADP \leftrightarrow AMP + ATP$) and ammonia production by AMP deaminase ($AMP \leftrightarrow IMP + NH_3$) become more important in energy production.These two reactions play an important role in ATP production, especially in glycogen depleted fibres. It seems very important to require more informations on the pH decrease, the energy metabolism and the influence on meat quality. Due to the fact, that Switzerland was including meat quality for around 20 years in the national breeding program, it seemed to be interesting to investigate samples out of Swiss pig breeding. Data shall provide some information about the state of energy metabolism in the selected muscles 24 hours post mortem.

* This study was funded by: Hermann Herzer Stiftung, CH-4010 Basel and Swiss Pig Performance Testing Station, CH-6204 Sempach

Material and Method

Animals. Swiss Large White pigs were chosen for the purpose. The specific pH values, measured 24 hours after slaughter, were determined on the mean value ± 1.5 standard deviation of nearby 1600 in six months at the Swiss Pig Performance Testing Station in Sempach investigated Large White animals: **≤5.36** and **≥5.56**. The collection period lastet four months and resulted in 38 samples with a pH24 ≤5.36 and only 16 samples with the pH24 ≥5.56; 36 samples with a pH24 ranging from 5.37 to 5.55 were also included. These totally 90 investigated pigs were performance tested animals in Sempach. Pigs were slaughtered in Luzern after reaching the slaughter weight of approximately 103 kg live weight.

Samples. Muscle longissimus dorsi samples were taken at the 10th rib, at time of carcass dissection 24 to 28 h post mortem in the slaughterhouse. After the pH measurement (pH24) on the carree a little piece of meat was cut out of those animals showing either low or high pH values; the samples were immediately frozen in liquid nitrogen. (Sampling was performed in a way not disturbing the dissection.) Collected samples were stored at -80°C and shipped on dry ice to Denmark for analysis. Before analysis, the samples were cut in different parts in a weighing chamber with a temperature of around -20°C. Intracellular pH measurements were done after homogenisation with a stomach electrode, lactic acid and glycogen (as glucose units) were measured using a spectrophotometrical method, whereas the phosphorous compounds CP, HYP, IMP and more were analyzed using the HPLC technique.

Statistical Analysis. A one factor analysis of variance containing eight groups (including sex and age at slaughter) showed no significant differences. Data were therefore put in the three pH 24 groups: ≤5.36, 5.37 to 5.55, ≥5.56 and were tested inside these groups for the normality by using standardized skewness and standardized kurtosis. The non-normality of a variable led to use the non parametric test of Kruskal-Wallis; in the other case a one factor analysis of variance with 3 groups was used.

Results and discussion

During planification we intended to collect only samples of low and high pH24 value respectively, 50 of each in the given time. After the project started we realized the difficulty to find animals with the pH24 ≥5.56. It was therefore decided to include these samples with a pH24 value laying in between the desired ones.

The mean values and standard deviations of the pH as well as the metabolite levels (lactic acid, glycogen, CP, ADP, HYP, IMP and INO) are presented in table 1.

pH24 values in the three groups are around 0.5 units lower than the appropriate intracellular pH. This is probably due to the different methods used: the pH24 values were measured with an insertion electrode whereas a stomach electrode in the muscle suspension is

used in the other case. Significant correlation between both pH measurement methods were found for the ph24 ≤ 5.36 (0.405*) and the pH24 ≥ 5.56 (0.595*).

24 hours post mortem the glycolysis is considered to be complete. The residuel glycogen (as glucose units) shows for the second group (pH24 5.37-5.55) a 3.64 units higher value than the animals of the ph24 ≤ 5.36 group; this difference is not significant. For the third group with the high pH the amount of residuel glycogen is around the half of the amount of the low pH group and shows a higher breakdown of the energy stores. The high glycogen value of the pH24 5.37-5.55 animals may be caused by the big variation in this group, as shown in graph 1.

The lactic acid measured in the selected muscle shows significant differences between the three pH24 groups; animals of the low pH24 group have the highest measured lactic acid content, whereas the animals of the high pH24 group have the lowest content in lactic acid. A significant correlation between the intracellular measured pH and the lactic acid content is only found in the group with pH24 ≥ 5.56 (-0.623**). The correlation between pH24 (insertion electrode) and lactic acid is for the same group -0.723**.

When looking to the high energy phosphate compounds data are showing a similiar behavior for the first two groups (ph24 ≤ 5.36 and pH24 5.37-5.55); the samples of the pH24 ≥ 5.56 animals show significant differences. They have significant lower contents of CP, IMP and INO and in consequence a significant higher content of HYP. Only the detected amount of ADP in the three investigated groups differed not from each other, but were showing a slightly decrease of ADP in direction from the low to high pH24 value. These results are according to the ATP postmortal breakdown, as it was mentioned before.

Conclusion

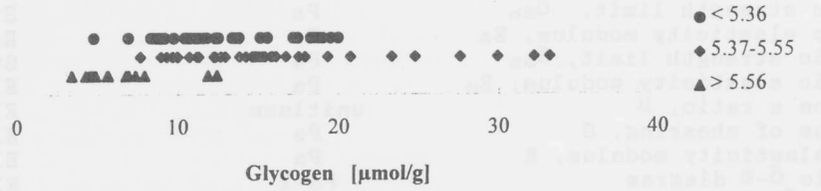
Conversion of muscle to meat comprises a number of chemical and structural processes. The conditioning period starts, by definition, at the moment of animal death and ends with the exhaustion of degradable energy rich compounds such as ATP, CP and glycogen; accompanied by pH falling. The 16 investigated muscle longissimus dorsi samples with a pH24 ≥ 5.56 seem still to be in the conditioning period, but having less energy stores and showing a greater breakdown of phosphate compounds than the animals of the two other groups at time of sampling.

These data give now first information on metabolic characteristics of muscle longissimus dorsi of Swiss Large White pigs 24 hours post mortem. In a next step results of these investigations will be brought in relation to different meat quality traits.

Table 1: Mean values and standard deviations of pH and metabolite levels
(Concentration of glycogen, lactic acid, CP, ADP, IMP, INO, HYP in µmol/g wet weight)

	≤ 5.36	5.37 - 5.55	≥ 5.56
	n=38	n=36	n=16
pH24	5.32^{a} ± 0.036	5.45^{b} ± 0.039	5.63^{c} ± 0.067
pH intracellular	5.87^{a} ± 0.092	5.99^{b} ± 0.086	6.13^{c} ± 0.083
Glycogen	12.52^{b} ± 4.022	16.16^{b} ± 6.481	6.38^{a} ± 2.580
Lactic Acid	121.49^{c} ± 11.034	110.59^{b} ± 10.114	103.58^{a} ± 8.940
CP	1.08^{b} ± 0.131	1.03^{b} ± 0.155	0.89^{a} ± 0.072
ADP	0.46 ± 0.120	0.42 ± 0.079	0.40 ± 0.090
IMP	3.73^{ab} ± 0.362	3.88^{b} ± 0.685	3.54^{a} ± 0.373
INO	1.06^{b} ± 0.158	0.92^{b} ± 0.259	0.85^{a} ± 0.155
HYP	0.27^{a} ± 0.039	0.28^{a} ± 0.075	0.32^{b} ± 0.076

^{a,b,c} Means with different subscripts differ at the $p < 0.05$ level



Graph 1: Variation in glycogen level