EFFECTS OF PRESLAUGHTER MUSCLE EXERCISE AND BODY TEMPERATURE ON MEAT QUALITY CHARACTERISTICS STUDIED IN ANAESTHETIZED PIGS OF DIFFERENT HALOTHANE GENOTYPES

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SUMMARY

Anaesthetized pigs were used to study the effect of preslaughter muscle exercise and elevated body temperatures on porcine meat quality, while minimizing other stressors normally present under commercial slaughter conditions. Three lines of pigs of different halothane genotype (nn, Nn and NN) were anaesthetized for 45 min. In experiment 1 muscle exercise was stimulated by electrical pulses in a part of the longissimus muscle for 15 min. Pigs used in experiment 2 were either warmed up or cooled down during the period of anaesthesia. After this period all pigs were exsanguinated and slaughtered. Muscle pH, water-holding capacity, and colour were determined.

Both preslaughter exercise and raised body temperatures negatively influenced the measured meat quality characteristics of all halothane genotypes compared to control samples. Exhaustive exercise had a greater influence on the meat quality of NN- and Nn-pigs and even reduced the differences that existed between the control samples of the three genotypes. An elevated body temperature had a larger impact on Nn- and nn-pigs. The meat quality of Nn-pigs was closer to NN-pigs at low preslaughter body temperatures and closer to nn-pigs at higher temperatures. It was concluded that physical stress factors already have a large effect on porcine meat quality independent of mental stressors. Especially NN- and Nn-pigs will benefit from low preslaughter stress levels, because the control samples of nn-pigs already showed a reduced meat quality.

Introduction

Meat quality of pigs is determined by the perimortem muscle metabolism and depends on the genetic constitution of the pig and environmental conditions (Briskey, 1964; Tarrant, 1989). Denaturation of muscle proteins and a decrease in the electrostatic repulsion between myofilaments are assumed to be caused by a combination of low pH and high muscle temperature after slaughter. Colour and water-holding capacity of meat are related to the extent of lateral shrinkage of the myofibrils and the subsequent increase in light scattering properties (Bendall and Wismer-Pedersen, 1962; Offer and Knight, 1988; Offer, 1991).

The halothane gene (n) is a major gene that determines pork quality. Pigs that are homozygous for this recessive gene are more likely to give rise to pale, soft, and exudative (PSE) meat than NN-pigs. Heterozygous pigs (Nn) were shown to have intermediate values after normal slaughter conditions (Lundström et al., 1989). Stress due to preslaughter handling is the most important environmental factor that influences muscle metabolism and meat quality (Tarrant, 1989). The events that take place in the period before slaughter will cause both physical and mental stress factors, which will stimulate ante- and postmortem muscle metabolism. This may lead to relatively high postmortem muscle temperatures and a low pH that might cause PSE meat (Briskey, 1964; Offer, 1991). Beside being a result of an increased preslaughter muscle metabolism, a rise of temperature might also be a causative factor in enhancing both ante- and postmortem muscle energy metabolism.

The purpose of this study was to examine the effects of the physical stress factors exercise and elevated body temperatures in the period just before slaughter on meat quality of pigs of different halothane genotypes, while minimizing other stress factors.

Materials and Methods

In experiment 1 three groups of pigs with different halothane genotype (8 NN-, 8 Nn- and 8 nn-pigs) were obtained from a commercial breeding company (Seghers Hybrid, Buggenhout, Belgium). The NN-pigs were offspring from a homozygous halothane-negative sow line (Landrace). Pigs homozygous for the recessive halothane gene came from a halothane-positive boar line (nn, Belgian Landrace). Crossbred pigs from the sow and the boar line were used for the intermediate genotypes (Nn). Halothane genotype of the pigs was confirmed by a DNA-test using a polymerase chain reaction technique (PCR) as described by Fujii et al. (1991). At each day of the experiments three pigs were anaesthetized for 45 min one after another by using a combination of azaperone (Stresnil®, Janssen Pharmaceutica, Tilburg, Netherlands, 4 mg/kg BW) and metomidate (Hypnodil®, Janssen Pharmaceutica, 5 mg/kg BW) as earlier described (Klont et al., 1993). An i.v. metomidate infusion was applied via the ear vein during the period of anaesthesia. Pigs received endotracheal intubation and were ventilated with a mixture of two parts nitrous oxide (N_2O) and one part oxygen (O_2).

Stimulation needle electrodes with a length of 5 cm were inserted at one side of the longissimus muscle (LD) at 30 min after the start of anaesthesia. After insertion the LD was stimulated between an electrode at the height of the last rib and another electrode approximately 20 cm caudal at the height of the fifth lumbar vertebra. Supramaximal 5 V square waved pulses, with a pulse width of 1 ms and at a frequency of 10 Hz, were given for 15 min by a pulse generator. The contra lateral muscle of each pig was taken as a non-exercised control. Directly after stopping the muscle stimulation, at 45 min after the onset of anaesthesia, the pigs were exsanguinated.

Fifty-seven pigs of different halothane genotype (16 NN-, 13 Nn- and 18 nn-pigs) were used in experiment 2. All pigs were anaesthetized for 45 min similar to those in experiment 1. Directly after the onset of anaesthesia each pig was covered by a blanket containing water filled tubes that were connected to a thermostatic circulator and a waterbath. Water with a temperature of 70 °C was continuously pumped through the blanket of 9 NN-, 7 Nn-, and 9 nn-pigs. The other pigs were connected to a waterbath with a temperature of 10 °C. Rectal temperature and muscle temperature of the LD of all pigs were measured at the start of anaesthesia and just before slaughter with thermocouples connected to a digital thermometer. After 45 min of anaesthesia the pigs were exsanguinated and slaughtered. Carcasses were air chilled overnight at 4 °C (air velocity 1.5 m/sec).

Temperature (T) and pH of the LD were measured at 45 min and 18 h postmortem. Muscle pH was measured with a pH-meter connected to an Ingold electrode. At 18 h postmortem a LM sample was taken at the 1st-4th lumbar vertebra, and water-holding capacity was measured according to the filter paper absorption method (Kauffman et al., 1986). After a 30-min oxygenation period the colour was determined in triplicate by measuring Hunter L*-values. The percentage drip loss was measured on a LD sample which was packaged and stored at 4 °C for 48 h. PSE meat was defined according to the criteria of Kauffman et al. (1993) with Hunter L* values > 58 and a drip loss > 5%.

The variables of interest in experiment 1 were analysed with a split-plot analysis of variance model. Fixed effects in the model were main effects and interactions for factors: day of experiment, sequence of usage during the day of experiment (first, second, last), genotype (NN, Nn, nn), and treatment (stimulated muscle contraction, non-exercised control muscle). Animals were introduced as random effects. The meat quality parameters of experiment 2 were analysed with an analysis of variance model. Factors in the model were sequence of usage during the day of experiment, genotype, and treatment (low temperature, high temperature). Genotypes within treatments were compared pairwise with Fisher's method (t-test with pooled error variance).

Results and Discussion

Results of the meat quality measurements of experiment 1 are shown in Table 1. Muscle exercise lowered muscle pH at 45 min postmortem to the same extent in all genotypes, resulting in a .1 to .2 decrease in the LD of all genotypes. It could be argued that the non-stimulated control side, due to the position of the electrodes in the contracting LD, was also stimulated to a lesser extent. However, no actual contractions were seen at the control side. The use of glycogen as an energy source for the preslaughter muscle exercise raised muscle pH measured at 18 h postmortem in all genotypes. The water-holding capacity of the LD samples from NN- and Nn-pigs were more affected by preslaughter muscle contractions than those of nn-pigs, which led to a significant genotype x treatment interaction for the results of the filter paper method ($P < .05$). LD samples from NN-pigs had a higher increase in Hunter L*-values than those of the other genotypes after muscle stimulation. From the meat quality measurements in experiment 1 it could be argued that, as stated by Barton

Gade (1984), nn-pigs may yield meat of inferior quality almost irrespective of preslaughter management and that in practice especially NN- and Nn-pigs will benefit from low preslaughter stress levels.

Table 2 shows the results of experiment 2. The rectal temperatures of all pigs in this experiment are in the normal range for conscious pigs, which ranges from 37.0 to 39.6°C (Hannon et al., 1990). The cold and heat treatment effectively shifted all measured temperatures to lower or higher values, respectively, within this range. The postmortem influence of temperature on the measured meat quality characteristics did not show a clear difference between NN-pigs and the other halothane genotypes. Water-holding capacity, as measured by the filter paper method and drip loss after 48 h storage, was decreased in all halothane genotypes by a raised preslaughter temperature. This decrease was only significant in Nn- and nn-pigs. The influence of preslaughter temperature on meat colour was less evident, although meat colour tended to become lighter with higher preslaughter temperatures, especially in NN- and Nn-pigs. The main reason why the meat quality of all halothane genotypes was influenced by temperature in this experiment, is that temperature is an important factor in determining postmortem protein denaturation, and thereby colour and water-holding capacity of meat (Bendall and Wismer-Pedersen, 1962; Offer and Knight, 1988; Offer, 1991).

The changes in body temperatures in our experiment did not exceed the normal range, but an increase to the upper level of the normal range already caused an increased incidence in PSE meat, especially in nn-pigs. Preslaughter stress factors like exercise and high ambient temperatures, might easily elevate body temperatures in conscious pigs to values between 39.0 and 41.0°C, with the highest increases for "stress-susceptible" pigs compared to "stress-resistant" pigs (Aberle et al., 1974; Lundström, 1976; D'Allaire and DeRoth, 1986; Geers et al., 1992). Muscle temperatures after normal slaughter conditions will further increase and range from 39.0 to 43.0°C at 40 min postmortem (Sybesma and Van Logtestijn, 1966).

Conclusion

It may be concluded that physical stress factors already have a large effect on porcine meat quality independent of mental stressors. Especially the meat quality of NN- and Nn-pigs will benefit by lowering preslaughter stress levels. Pigs of the nn-genotypes already showed a reduced meat quality in their control samples.

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