TRANSPORT AND OTHER POTENTIAL STRESS FACTORS AT SLAUGHTER: EFFECTS OF GENETIC AND REARING BACKGROUND.

Studies on pigs

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Introduction

The slaughter practice involves several potentially stressful procedures, such as mixing of pigs, transport, manipulation and food restriction. Stress reactions at slaughter may be due to physical (food restriction; fatigue; pain due to slaps, shocks or fights) and psychological discomfort (disruption of the social group; fear, due to novelty and human presence). Behavioural stress reactions involve running or on the contrary immobilisation of the animals, making moving them more difficult. Physiological reactions involve increase in heart rate and secretion of stress hormones such as cortisol and catecholamines (adrenaline and noradrenaline).

Meat quality is influenced by behavioural and physiological status of the animals before slaughter. Meat quality depends on speed and amplitude of post-mortem muscle pH decline. Amplitude depends mainly on muscle glycogen reserves, speed on muscle metabolic activity, mainly ATPase activity, at slaughter (4). Physical effort increases muscle metabolism, leading to net glycogen loss. Physical effort and psychological stress increase secretion of hormones that exacerbate effects of muscular activity on muscular glycogen depletion (1,2).

The way the pig responds to mixing, transport and slaughter stress in terms of physiology and behaviour, is influenced by its genetic background and earlier experience. Various experiments have been conducted to assess responses of pigs of different background to different stages of the slaughter procedure.

Material and Methods

Exp. 1. *Effect of loading, transport and unloading on adrenaline and/or heart rate of pigs of different genetic background.* Part I. Thirteen Large White and 12 Duroc crossbreeds (LW x LR dams, PIC sires) were reared indoors (6.3 m^2 pens with slatted floors) or outdoors (600 m^2 fields with huts) in a 2 x 2 factorial design. At 110 kg, pigs were slaughtered in an abattoir on the farm, after 24 h of food withdrawal and 10 min transport. Heart rate was measured for 10 min in the home pens and huts, and subsequently during loading (3 min), transport (5 min) and waiting (10 to 30 min) until slaughter (no unloading occurred during this experiment). Post-slaughter, technological meat quality measurements (pH, temperature, colour, glycogen and its metabolites contents) were taken (15, 45 min, 24 h post-mortem) on *Longissimus lumborum* (LL) and *Semimembranosus* (SM) muscles. Part II. Forty-eight pigs were reared individually in 1.5 x 1.5 m straw-bedded pens. Sixteen of them were Pietrain pigs, heterozygous for the halothane gene (Nn), the remaining 32 were homozygous non-carriers of the halothane gene: 16 of these were Large White and 16 Pietrain pigs. Urine was collected at spontaneous micturition, 1 wk before slaughter, in the morning while the pigs woke up. At 110 kg, half of each genetic type was mixed overnight, and the following morning transported for 3 h, then physically restrained for 1 min and immediately slaughtered (high stress). The other pigs remained in their home pens. The next morning they were individually transported for 7 min and immediately slaughtered upon arrival (low stress). For all pigs, duration of food withdrawal until slaughter was 20 h. Heart rate was measured over the 3 h (low stress group) or 30 min (high stress group) preceding slaughter. Post-slaughter, urine was collected for catecholamine assays, and various technological meat quality measurements (pH, temperature, colour, contents of glycogen and its metabolites) were taken (1, 45 min, 24 h post-mortem) on LL, *Adductor femoris* (AF) and SM muscles.

Exp. 2. Effect of handling training on reactivity at slaughter; consequences for meat quality. Forty-two Large White pigs were reared in groups of 7 pigs in straw-bedded pens. Pigs received different handling treatments for 40 d until slaughter age. Fourteen pigs were assigned to the Human Interaction group (HI), 14 pigs to the Refusal of Contact group (RC), 14 pigs to the control group. Pigs of the groups Human Interaction (HI) and Refusal of Contact (RC) were individually introduced into a pen each day where they remained for 3 min in presence of a squatted handler. The handler tried to increase progressively physical reciprocal interactions with the HI pigs. In contrast, RC pigs were pushed away when they touched the handler. Control pigs remained in their home pens. Pigs were slaughtered in a commercial abattoir, either in presence or absence of their handler, after 16 h of food withdrawal and overnight mixing. Behaviour during mixing was recorded. Technological meat quality measurements (pH, temperature, glycogen and lactate contents) were taken (1, 45 min, 24 h post-mortem) on LL, SM and *Semispinalis capitis.*

Exp. 3. Effect of breed on reactivity to stress and consequences for meat quality. Twenty-one pure-bred Durocs and 21 pure-bred Large White pigs were reared in groups of 7 pigs in straw-bedded pens. Over the 2-months-period preceding slaughter, pigs were subjected to two tests: exposure to a non-familiar object (traffic cone) and exposure to a non-familiar human, each lasting a total of 20 min, including 10 min habituation to the test situation. Behavioural reactions and heart rate were recorded. Order of testing was organised in a balanced design. At 110 kg, pigs were slaughtered, either after 34 h of food withdrawal, 5 h of mixing, 3 h of transport and 12 h of lairage (high stress) or after 14 h of food withdrawal and only 15 min of transport (no mixing: individual slaughter; low stress). Technological meat quality measurements (pH, temperature, colour, glycogen and lactate contents) were taken (1, 45 min, 24 h post-mortem) on LL, *Biceps femoris (*BF*)*, and AF.

Results

Exp. 1, Part I. Pre-loading heart rate was 109.9 ± 2.4 beats per minute (bpm). It rose to 153. 7 ± 3.6 during loading, then reduced to 133.0 ± 2.3 and 121.2 ± 2.6 during transport and waiting, respectively ($p<0.0001$). Duroc and Large White pigs showed similar tendencies ($p=0.15$) as did indoor and outdoor reared pigs ($p=0.45$). No correlations were found between heart rate responses and meat quality data. *Exp. 1, Part II*. Resting heart rate in the home pen was 89.1 ± 2.8 beats per min. Loading and unloading were associated with significant increases (e.g. unmixed pigs: 176.5 ± 3.2 and 175.6 ± 4.8, for loading and unloading, respectively) with an average peak value of 210.2 ± 4.0 bpm. Genotype did not have any effect. Heart rate was high during initial transport (unmixed pigs, 7 min of transport: 137.1 ± 3.4 bpm). At the end of 3 h transport heart rate was reduced to 121.8 ± 3.6, which is significantly lower than initial ($p<0.05$) but still much higher than resting values ($p<0.0001$). Urinary adrenaline was higher after slaughter compared to resting levels in the home pen ($p=0.06$). Only Pietrain Nn pigs showed a stronger increase after high stress than after low stress slaughter conditions ($p<0.05$). For pigs of the high stress group, heart rate during the 1-min physical restraint was negatively correlated with initial pH of the LL ($r=-0.46$; $p<0.05$). Post-mortem glycogen contents were negatively correlated with post-mortem urinary adrenaline content (e.g. glycogen immediately after slaughter, $r=-0.60$; $p<0.01$). *Exp. 2.* Prior handling experience did not in itself influence ultimate meat quality, but the presence of the negative handler (RC pigs) at slaughter caused lower pre-slaughter LL glycogen content. Fighting behaviour during mixing explained between 14 and 52 % of the variability of lightness of the LL, BF and SM ($p<0.05$). Multiple regression analyses including visual contact with the handler at the start of the handling training and number of fights initiated during mixing explained between 31 and 42 % of the variability of ultimate pH of the studied muscles ($p<0.05$). *Exp. 3.* Durocs touched the person significantly more often than Large Whites ($p<0.01$). Frequency of contact and heart rate were positively correlated for Durocs ($r=0.48$; $p<0.05$) and Large Whites ($r=0.61$; $p<0.01$), explaining higher heart rates of Durocs ($p<0.02$). No differences were found for frequency to touch the novel object and associated heart rate ($p=0.68$). Breed and slaughter effects were significant ($p<0.05$) for ultimate pH and meat colour for most muscles, and drip loss (LL). Breed x slaughter condition interactions showed that slaughter effects were mostly due to the larger sensitivity of muscles of the Large Whites to slaughter conditions. For Large Whites slaughtered in the industrial plant, ultimate pH of AF, BF and SM muscles were significantly higher compared to experimentally slaughtered Large Whites ($p<0.05$). Yellowness scores of AF, SM and LL of these same animals were lower ($p<0.05$). For Durocs, ultimate pH and colour of these same muscles were not influenced by slaughter conditions. For Large Whites of the high stress slaughter group, a negative correlation was found between frequency of touching the human during the test, and initial LL and BF temperature (e.g. LL: $r=-0.86$; $p<0.01$).

Discussion

Loading, transport and unloading caused significant increases in heart rate that are similar for pigs of different rearing and genetic background. The mere manipulation and 10 min transport of pigs caused increases in urinary adrenaline similar to overnight mixing and 3 h transport for non carriers of the halothane gene. Pietrains heterozygous for the gene showed an increased adrenaline response to these high stress slaughter conditions. Presence of the halothane gene appears thus to influence catecholamine secretion as earlier suggested (3). Adrenaline production and heart rate are both under the control of the autonomous nervous system. Their correlations with early post-mortem muscle metabolic activity illustrates that its activity during the hours or minutes preceding slaughter may have measurable consequences for meat quality.

Positive and mildly negative handling training modified behaviour towards the handler (5), but this had only a small effect on pre-slaughter glycogen meat metabolism and only if the negative handler was present during slaughter. In contrast, tendency to fight with other pigs and pre-training reactivity to humans determine part of the variability in ultimate pH and meat lightness.

Duroc and Large White pigs evaluated differently presence of man. The results show that Durocs were less fearful and/or were more motivated to touch the person. The meat quality results may indicate that in contrast to Large Whites, behavioural and physiological status of Durocs was little influenced by slaughter conditions. However, the stress reactivity tests had found a similar (non-familiar object) or increased reactivity (human exposure) of Durocs. It is therefore likely that Durocs did respond behaviourally and physiologically to slaughter conditions, but that these responses had little effect on post-mortem muscle metabolism. Increased approach to humans during the test was associated with higher pre-slaughter metabolism, but only for Large Whites. The results suggest therefore, that the impact of stress responses on meat quality is breed dependent.

Conclusion

At slaughter, loading and transport, fighting during mixing and reactivity to humans caused physiological and metabolic changes that explain part of the variability in pork. In the above studies, breeds did not influence heart rate and adrenaline responses to loading and transport, but did influence reactivity to humans, and its correlation with post-mortem metabolism. Although handling experience modified behaviour towards the handler, correlations between reactivity to humans and meat quality were not influenced by prior handling training.

References

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