Pre-slaughter handling and pork quality

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ABSTRACT

Environmental variables, as sound levels, were collected during the pre-slaughter process in 18 different Belgian commercial slaughterhouses. Four pre-slaughter phases were determined: firstly after arrival of the truck at the slaughterhouse and just before unloading, secondly during unloading, thirdly at lairage and finally while moving to the stunner. A total of 8508 pigs was examined during the pre-slaughter process, of which the pH_{LT} (*M. longissimus thoracis*), at 30 min post-mortem was measured. For each pre-slaughter phase, variables which might influence pork quality were determined. Moreover, this study made it possible to infer a checklist to represent and predict PSE traits of pork for all kind of pre-slaughter situations. The checklist shows also that the impact on pork quality is more decisive for the variables measured close to the stunning phase. Hence, this information is useful for the industry to optimize handling of pigs, reducing the risk for PSE traits.

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1. Introduction

Pork production is a still growing industry on the international market (AHDB, 2014), but subjected to great pressure, due to an enhanced competition between export countries. Moreover, consumers still attach a great importance to the trade-off between price and quality but also to the way food is produced, taking into account durability aspects, such as animal welfare (Payne, Mullan, Trezona, & Frey, 1999; USDA-FAS, 2014). Therefore, all stakeholders aim for an optimal qualitative pork production, but too many meat defects still occur, especially Pale Soft and Exudative meat (PSE meat) (Adzitey & Nurul, 2011; Van de Perre, Ceustermans, Leyten, & Geers, 2010; Van de Perre, Permentier, De Bie, Verbeke, & Geers, 2010). PSE meat is caused by acute stress just before slaughter. Pigs genetically sensitive to stress (Halothane gene), but also normal pigs are prone to the defect (Kerth, 2013, chap. 7). Stress results in an accelerated rate of glycolysis. Early post mortem, this metabolism is anaerobic and thus produces lactic acid. A lower pH, due to the lactic acid, while the carcass temperature is still high, results in an increased protein denaturation within the meat (Bendall & Swatland, 1988; Breteler, Wes, Huiskes, Kanis, & Walstra, 1995; Garrido, Pedauyk, Bacon, Lopez, & Laencina, 1995). Due to this process, PSE meat has the property to have a high light-scattering capacity and a low water holding capacity (WHC) (Adzitey & Nurul, 2011; Offer, 1991; Offer & Knight, 1988). Scheffler, Park, and Gerrard (2011) reported another explanation for the increased pH decline, instead of lactic acid production, namely the free protons and heat, originating from the ATP hydrolysis. To detect PSE meat, the pH of the meat has to be measured 30 min after slaughter. As Josell, Martinsson, Bogaard, Andersen, and Tornberg (2000) defined, the pH value 30 min after slaughter has to be below 6.1. But Van de Perre, Ceustermans, et al. (2010), Van de Perre, Permentier, et al. (2010) and Adzitey and Nurul (2011) reported that in countries where the incidence of PSE meat is high, a stricter pH value (≤ 5.9) can be used.

Thereby, handling at the farm, genetics, the season and pre-slaughter handling, namely during transport, unloading at the slaughterhouse and the handling of the pigs in the slaughterhouse, are very important aspects that influence the stress level of the animal and thus are responsible for the development of aberrant meat quality (Brown, Knowles, Wilkins, Chadd, & Warriss, 2005; Van de Perre, Ceustermans, et al., 2010; Van de Perre, Permentier, et al., 2010). Van de Perre, Ceustermans, et al. (2010) and Van de Perre, Permentier, et al. (2010) listed, described and investigated the combined effect of those parameters. As a follow-up, the significant aspects for the pork quality were selected for each pre-slaughter phase, after which the conditions to comply with good pork quality, were formulated for each pre-slaughter phase. The objective is to build a combination table or checklist for different cases over all pre-slaughter phases which might cause a risk for the pH of the pork and the percentage PSE meat. This table could be very useful for slaughterhouses to evaluate their handling procedures, and if needed to intervene during the pre-slaughter process to optimize the pork quality.

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2. Material and methods

2.1. Experimental design

In total, 8508 pigs were observed during the pre-slaughter phases, from March 2009 to March 2011 in 18 different slaughterhouses during 2 to 6 visits in each slaughterhouse. The pigs were heterozygous for the halothane or ryanodine receptor gene (Piétrain boar × homozygous negative sow). During each visit, it was attempted to survey two batches of pigs originating from two different farms, which were transported to the slaughterhouse by two different trucks. Pigs of one batch originated from the same farmer and thus had the same unique identification number. In general, pigs in one truck originated from one farm, due to sanitary measures. In total 181 groups of pigs were observed. Nevertheless, if there were pigs from a different batch on one truck, only pigs from one farm were observed.

2.2. Data collection

2.2.1. Pre-slaughter measurements

During different phases in the slaughtering process, several influential factors of the pre-slaughter environment were recorded, from transport of the pigs to the moment of slaughtering (Tables 2 and 3). The mean sound level (Testo 815, Testo NV, Ternat, Belgium) (dB(A)) was recorded just before unloading, when the truck arrived at the slaughterhouse, and during unloading. This measurements took place near the truck at the unloading ramp during the whole unloading procedure. The transport time (min), the time elapsing from arrival at the slaughterhouse till start of unloading (min), the mean live weight of the pigs (kg), the total number of panting pigs on the truck, the unique identification number and the stocking density (m^2/100 kg) were determined. Furthermore, the duration of unloading, the percentage vocalizing, falling and slipping pigs (%), pigs, having the tendency to turn back during unloading (%) and dead pigs (%) were counted. Unloading aspects, such as the use of a hydraulic lift (yes/no) and the angle of the ramp (°) were recorded. In the pens the number of pigs and the stocking density (m^2/100 kg) were quantified, also the presence of drinking nipples (yes/no), of sufficient air flow (yes/no) and of an operational showering system (yes/no) was noted. Also the water temperature of the shower (°C) and the lairage time (min) were registered. During lairage, movement to the stunner and at the stunner, the mean sound level (dB(A)) was recorded, each time at the same place, during 10 min and as close as possible to the group of pigs. The number of slipping or falling pigs (%) during movement to the stunner was counted. Thereby the use of an electrical prod (yes/no) was noted. Finally the stunning method (gas, manual electrical, head-only, head-to-chest), the properties of the used method (CO_2 concentration (%) or the voltage (V)) and the stunning efficiency (%), controlled by means of the corneal reflex test, were recorded (Tables 2 and 3) (Van de Perre, Ceustermans, et al., 2010; Van de Perre, Permentier, et al., 2010).

2.2.2. pH measurements

The pH (Hanna HI99163, Hanna Instruments, Temse, Belgium) of the *M. Longissimus thoracis* (pH_{LT}) was measured between the second last and the last rib, 30 min after slaughtering by using a pH electrode of glass (FC232D, Hanna Instruments) enclosed with an unbreakable stainless steel knife, to facilitate the measurements in a muscle. The apparatus was equipped with a built-in temperature sensor to compensate the pH for a change of temperature. At the start of the measurements and after every 20 measurements the pH electrode was treated with a cleaning solution for oils (HI 7077, Hanna Instruments, Temse, Belgium) and a cleaning solution for proteins (HI7073L, Hanna Instruments, Temse, Belgium). Further, the pH electrode was calibrated by using the standard solutions of pH 7 and pH 4. If the pH_{LT} had a deviation of more than 0.01 units, the electrode was recalibrated.

Due the high speed of the slaughter process, it was not possible to use the referential method of measuring pH_{LT} 45 min after sticking. Therefore the same method for accurate pH_{LT} measurements, recommended by Josell et al. (2000), Van de Perre, Ceustermans, et al. (2010), and Van de Perre, Permentier, et al. (2010) was used, as described in the introduction. pH_{LT} was measured 30 min after sticking. To make the measurements repeatable, the site along the slaughter line, which corresponds to 30 min after sticking, was determined for each slaughterhouse. Those measurements were performed by the same person, using the same type of pH electrode. PSE meat was defined when the pH_{LT} of the pork was less than 6.0, 30 min after sticking. Due to the fact that measurements took place on pigs heterozygous for the halothane gene, a risk to develop PSE meat was higher, as described in the introduction (Brown et al., 2005; Josell et al., 2000; Van de Perre, Ceustermans, et al., 2010; Van de Perre, Permentier, et al., 2010).

2.3. Statistical analysis

Statistical model building was conducted with SAS 9.3 software (SAS version 9.3, SAS Inst., Inc., USA). First, the data was checked for normality and univariate analysis was performed (means and standard deviations).

The whole pre-slaughter process was split into 4 stages, namely the transport phase, the unloading phase, the lairage phase and the phase at the stunner.

Next, the effect of every observed variable (Tables 2 and 3) on the pH_{LT} and the PSE prevalence was examined separately by using a mixed model, whereby slaughterhouse and sampled group of pigs (batch), nested within slaughterhouse, were used as random factors. Only variables classified as significantly ($p < 0.05$) influencing the pH_{LT} and the PSE prevalence were considered in the model. Correlations between variables were calculated to check for multicolinearity problems. If significant correlations were found between covariates ($|r| > 0.6$), the most adequate and representative variable was kept in the model. Insignificant variables and variables with less than 80% of the measurements were left out of the model used to build the checklist or combination table. Finally, for every significant variable, criteria were defined to classify from which value the significant variable has a positive or negative effect on the pH_{LT}. If every criteria, for each phase, was performed to ensure a pH_{LT} value, which is considered as indicating no risk for PSE ($pH_{LT} \geq 6$), the phase was qualified as 'Ok'; if not the phase was qualified as 'Not Ok' ($pH_{LT} < 6$). To conclude all this information was merged in one table, whereby combinations of different situations were put together and the remaining pH_{LT} and the potential risks to develop PSE meat (%), for the specific situations, were calculated.

3. Results and discussion

In total 181 batches of pigs, containing 8508 pigs, were observed from arrival at the slaughterhouse until stunning, and pH_{LT} was measured. This means an average number of 47 carcasses, randomly selected out of one batch, were examined. Table 1 presents the number of pigs and the number of batches, of which pre-slaughter parameters were observed and post-mortem pH_{LT} was measured per visit, season and slaughterhouse with their respective stunning methods.

The frequency distribution of pH_{LT} is shown in Fig. 1, with a minimum pH_{LT} of 5.33, a mean pH_{LT} of 6.19 and a maximum pH_{LT} of 6.95. At European level a prevalence of 8% PSE meat is reported (Kyriazakis & Whittemore, 2006, chap. 2), while this study shows a mean value of 15.10% of the measured carcasses with a high risk for PSE meat, based on pH_{LT}. This difference might be explained by the genotype of the pigs, i.e. 100% heterozygous for the ryanodine receptor gene, being more prone to develop PSE traits (De Smet et al., 1996). Table 2 shows the number of observed pigs and the mean level ($\pm$SD) for all observed continuous pre-slaughter variables, subdivided for each pre-slaughter