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Pre-slaughter sound levels and pre-slaughter handling from loading at the farm till slaughter influence pork quality

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ABSTRACT

This study investigates the relationship between sound levels, pre-slaughter handling during loading and pork quality. Pre-slaughter variables were investigated from loading till slaughter. A total of 3213 pigs were measured 30 min post-mortem for pH_{30LT} (*M. Longissimus thoracis*). First, a sound level model for the risk to develop PSE meat was established. The difference in maximum and mean sound level during loading, mean sound level during lairage and mean sound level prior to stunning remained significant within the model. This indicated that sound levels during loading had a significant added value to former sound models. Moreover, this study completed the global classification checklist (Vermeulen et al., 2015a) by developing a linear mixed model for pH_{30LT} and PSE prevalence, with the difference in maximum and mean sound level measured during loading, the feed withdrawal period and the difference in temperature during loading and lairage. Hence, this study provided new insights over previous research where loading procedures were not included.

1. Introduction

The pork industry must continue to improve meat quality to remain one of the most important stakeholders in the food industry (USDA-FAS, 2014). Recent studies by Van de Perre, Permentier, De Bie, Verbeke, and Geers (2010) and Vermeulen et al. (2015a), detected high percentages of pork with Pale, Soft and Exudative characteristics (PSE meat) compared to the 8% PSE meat established at the European level, which can result in high economic losses for the pork industry (Breteler, Wes, Huiskes, Kanis, & Walstra, 1995; Garrido, Pedauyk, Bacon, Lopez, & Laencina, 1995; Kyriazakis & Whittemore, 2006, chap.2). Acute stress just before slaughter contributes to the development of pork with PSE characteristics. When pigs are acutely stressed prior to slaughter, muscles use more energy and glycolysis accelerates. This process continues early post-mortem and operates anaerobically. This causes more H^+ protons and heat to be produced from the ATP hydrolysis and results in an accelerated drop of the pork pH (Bendall & Swatland, 1988; Scheffler & Gerrard, 2007; Scheffler, Park, & Gerrard, 2011). A low muscle pH while the carcass temperature is still high increases protein denaturation and might result in PSE meat (Adzitey & Nurul, 2011; Van der Wal, Engel, & Reimert, 1999). Thus, an increased rate of decline in meat pH 30 min after slaughter is an indicator for pork with PSE characteristics (Van de Perre, Permentier, et al., 2010). Different pH ranges are used in literature to quantify the pork quality by measuring pH. According to Van de Perre, Permentier, et al. (2010), pork can be classified as PSE meat when the pH value 30 min after sticking is below 6.0. This is a lower pH value compared to other research where a level of 6.1 was specified. A stricter pH threshold 30 min after sticking can be applied if pigs genetically sensitive to stress (ryanodine receptor gene mutation) are investigated since those pigs are more susceptible to stress and thus might exhibit an accelerated pH drop (Channon et al., 2000; Josell, Martinsson, Bogaard, Andersen, & Tornberg, 2000; Van de Perre, Permentier, et al., 2010).

The sound level in the surrounding environment is one of the most important parameters influencing the pig stress level and PSE prevalence (Geverink et al., 1998; Grandin, 1996; Spensley, Wathes, Waron, & Lines, 1995; Vermeulen et al., 2015b). Vermeulen et al. (2015b) measured sound levels during unloading at the slaughterhouse, lairage and movement to the stunner. That work established that a sound level of 85 dB(A) was not only a critical threshold to reduce stress but also critical to minimize PSE incidence since significantly lower pH values of *M. Longissimus thoracis* were reported 30 min after slaughter when pigs were exposed to sound levels higher than 85 dB(A) during one of the previously mentioned slaughter phases (Geverink et al., 1998; Talling, Waran, Wathes, & Lines, 1996). Moreover, Vermeulen et al. (2015b) presented a sound level model for the risk of developing PSE meat where the mean sound level during lairage and prior to stunning remained significant within the proposed linear mixed model (Vermeulen et al., 2015b). However, sound levels during loading were

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not investigated in that work. Furthermore, Vermeulen et al. (2015a) determined all environmental parameters from transport till sticking, e.g. stocking density of pigs on the truck and sound level prior to stunning, had a significant influence on pH and % PSE meat of *M. Longissimus thoracis* 30 min after sticking (Brown et al., 2005; Channon et al., 2000; Kittawornrat and Zimmerman, 2010). Conditions for every significant parameter to favor good pork quality were established and formulated for each pre-slaughter phase. In addition, the pH of *M. Longissimus thoracis* 30 min after sticking and the % PSE meat were calculated and mapped out for all different combinations of handling the pigs from transport till sticking. Those different situations accompanied with the calculated pH-value and % PSE were summarized in one checklist. Environmental parameters of the loading phase just before transport to the slaughterhouse were not included in a checklist and were not investigated before, to the best of the authors' knowledge. This study re-evaluates the sound level model by recording sound levels during loading at the farm and completes the global classification checklist with all parameters of the loading phase which could potentially influence the prevalence of PSE meat.

2. Material and methods

2.1. Experimental design

From May 2012 to June 2014, pigs at six farms were observed during 134 days of measurements. In total, 22 different identification numbers were noted. Pigs having the same identification number were from the same farm but one farm could have pigs with multiple identification numbers, e.g. when pigs originated from different compartments of the farm. Pigs (quantity) were measured during the autumn (796), winter (686), spring (1014) and summer (717). All pigs were heterozygous for the ryanodine receptor gene (Piétrain boar × homozygous negative sow). During each day of measurement, one load of pigs, owned by the same farmer, was examined and a load of pigs could have different identification numbers. All pigs were transported to the same slaughterhouse and were unloaded in lairage. After arrival, pigs were kept in the lairage pen and were not mixed with unfamiliar pigs. Pigs were moved to the stunner by using automatic push gates and were CO_2 stunned.

2.2. Pre-slaughter measurements

2.2.1. Loading measurements

Before pigs were loaded, the mean sound levels (dB(A)) were recorded next to the ramp of the truck by using a Testo sound recording device (Testo NV, Testo 815, Ternat, Belgium) for 10 min maximum depending on how long it took to start loading the pigs. Pigs were loaded by using a hydraulic lift. The day when pigs were loaded was tracked since the season influences meat quality (Guàrdia et al., 2009; Van de Perre, Permentier, et al., 2010; Vermeulen et al., 2015a). Also, the outside temperature during loading (°C), the feed withdrawal period until slaughter (h), as well as the transporter and the farmer were listed (De Smet et al., 1996; Eikelenboom, Bolink, & Sybesma, 1991). Pigs were loaded in trucks with maximum three floors. The surface area was recorded and the animal weight was taken into account to calculate density of pigs on the truck (m^2/100 kg). The number of loaded pigs per floor, the duration of loading (min) and the minimum, maximum and mean sound levels (dB(A)) were measured. Sound level measurements took place during the entire loading procedure, next to the loading ramp of the truck near the pig passageway. Additionally, the percentage of slipping (slipping without touching the floor with their body), falling (slipping while touching the floor with their body), vocalizing, panting, lame pigs (difficult to move or unable to move forward) and pigs having the tendency to turn back by turning around towards the stable during loading (%), was counted. The minimum distance from farm to slaughterhouse was 3.1 km and the maximum distance was 58.1 km.

2.2.2. Transport, unloading, lairage and stunning measurements

Vermeulen et al. (2015a) described several pre-slaughter variables measured during unloading, lairage and stunning phase, that could affect meat quality. Hence, all those variables were monitored in this study (Table 1). After pigs were loaded, the time of departure and time of arrival at the slaughterhouse were recorded to calculate the transport time (min). The time elapsing from arrival of the truck till unloading (min) was also measured. This period varied depending on whether it was possible to unload the pigs immediately, which was mainly determined by the available space for the pigs in the lairage pen. If pigs could not be unloaded, the animals were kept on the truck. Next to the unloading ramp near the passageway of the pigs, the mean sound level (dB(A)) was recorded from the moment the truck arrived at the slaughterhouse until just before unloading. At the exact same location, during the entire unloading phase, the number of slipping, falling, vocalizing, panting, lame, dead pigs (%) and pigs having the tendency to turn back by turning around towards the truck during unloading (%), as well as the mean sound level (dB(A)) were measured. In addition, the unloading time (min) was recorded. Furthermore, it was noted that pigs were unloaded by using a hydraulic lift and an unloading bridge. The slope of the unloading ramp (°) was calculated (McGlone & Sapkota, 2014; Nanni Costa, Lo Fiego, Dall'Olio, Davoli, & Russo, 1999).

The pigs continued towards the lairage pen and mean sound levels (dB(A)) were recorded during the first 10 min, in the middle of the lairage pen, next to the observed group of pigs. The number of pigs

Table 1
Observed continuous, pre- and post-slaughter variables for each pre-slaughter phase, the number of observed pigs (N), the mean and the standard deviation (SD).

Phase	Variable	N	Mean ± SD
	Loading time per pig (min/pig)	3072	0.45 ± 0.14
	Amount of pigs per load	3193	169 ± 35
	Total loading time per load (min)	3072	77 ± 28
	Feed withdrawal period till slaughter (h)	3058	24 ± 5
	Mean outside temperature day before loading (°C)	3107	10.6 ± 6.3
	Temperature during loading (°C)	3107	9.5 ± 5.9
	Vocalizing (%)	3177	5.36 ± 3.43
	Panting pigs (%)	3193	0.12 ± 0.31
	Turning back (%)	3193	0.15 ± 0.34
	Lame pigs (%)	3193	0.27 ± 0.44
	Falling and slipping pigs (%)	3193	0.19 ± 0.58
	Mean sound level before loading (dB(A))	2573	63.1 ± 3.4
	Mean sound level during loading (dB(A))	2938	72.7 ± 2.9
	Maximum sound level during loading (dB(A))	2956	94.8 ± 5.1
Loading	Minimum sound level during loading (dB(A))	2982	59.4 ± 3.1
	Before unloading: mean sound level (dB(A))	2357	78.8 ± 3.4
	Transport time (min)	3152	34 ± 21
	Time elapsing arrival–unloading (min)	3084	9 ± 11
	Mean live weight pigs (kg)	872	110.4 ± 4.0
	Stocking density on the truck (m^2/100 kg)	872	0.46 ± 0.06
Transport	Dead pigs after transport (%)	3193	0.07 ± 0.25
	Mean sound level (dB(A))	3056	81.2 ± 2.8
	Duration unloading (min)	2930	14 ± 5
	Vocalizing (%)	3193	1.04 ± 1.21
	Panting pigs (%)	3193	0.51 ± 0.79
	Turning back (%)	3193	0.04 ± 0.15
	Lame pigs (%)	3193	0.26 ± 0.40
	Falling and slipping pigs (%)	3193	0.33 ± 0.73
Unloading	Slope of the ramp (°)	819	3.19 ± 1.63
	Mean sound level (dB(A))	2810	81.9 ± 3.8
	Water temperature of the shower (°C)	2431	15.8 ± 5.0
	Temperature during lairage (°C)	2736	13.6 ± 5.2
	Lairage time (min)	3039	84 ± 64
Lairage	Number pigs in pen	2565	16 ± 2
	Mean sound level (dB(A))	3081	86.8 ± 2.0
	Falling and slipping pigs (%)	3193	0.85 ± 1.92
Stunning	Emergency slaughtered pigs (%)	3193	0.52 ± 0.81
Post-slaughter	pH_{30LT}	3213	6.08 ± 0.09