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Effect of unloading, lairage, pig handling, stunning and season on pH of pork

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ABSTRACT

A total of 12,725 pigs originating from 90 transports were followed up at 17 Belgian commercial slaughterhouses. The effects of several pre-slaughter parameters concerning transport, unloading, lairage, pig handling, stunning and season on fresh meat quality based on pH measurements 30 minutes (min) after slaughter were investigated. Meat quality was measured on 4285 pigs. Ten pre-slaughter parameters had a significant effect on meat pH after separate introduction of the variable as a fixed effect in the model. Simultaneous analysis of these variables in the global model revealed that the pH was influenced by four main risk factors, namely the mean noise level produced during unloading, the percentage of panting pigs, the use of an electric prod and season. Meat quality in terms of the percentage of potentially PSE carcasses was better in summer than spring or autumn and could be explained by a lower observed pre-stunning stress in summer.

1. Introduction

Appropriate pre-slaughter handling of pigs is very important, not only from a welfare point of view, but it also affects pork quality and is consequently linked to economic implications. When pigs are stressed, glycolysis rate increases (Fernandez, Levasseur, & Ecolan, 1995; Jensen, Aslesen, Jebens, & Skrondal, 1999) which can result in poor meat quality after slaughter i.e. pale soft and exudative (PSE) meat. DFD (dark, firm, and dry) meat might be associated with a long period of stress. Pigs suffering from chronic stress deplete body energy reserves before slaughter which results in a high final pH value 24 h after slaughter (Tarrant, 1989). PSE meat occurs when pigs suffer acute stress before slaughter and is a major problem in the pork industry. Sufficient energy reserves in the muscles cause a very fast drop of the initial pH post-mortem resulting in pale meat with a low water holding capacity (Offer & Knight, 1988). In the present study only PSE meat was considered as synonymous with poor pork quality.

Actions such as handling on farm, loading, transportation, unloading, lairage and driving to the stunning line are known to be responsible for the development of aberrant pork quality (Brown, Knowles, Wilkins, Chadd, & Warriss, 2005; Fraqueza et al., 1998; Geverinck et al., 1998; Hambrecht et al., 2004; Lambooy & van Putten, 1993; Pérez et al., 2002; Santos et al., 1997; Warriss & Brown, 1994). These handling procedures are associated with stress and therefore influence meat quality. The literature also describes genotype (De Smet et al., 1996; Gispert et al., 2000; Guàrdia et al., 2004), stunning method and season as being important risk factors influencing meat quality. Generally, the halothane gene (n) tends to increase the lean meat content in a carcass and involves the risk of development of PSE meat. In order to reduce the prevalence of PSE meat, heterozygous pigs (Nn) for the halothane gene are used, but this does not solve the problem completely. De Smet et al. (1996) reported that the PSE prevalence of Nn pigs is intermediate between nn and NN pigs. Electrical stunning can lead to a higher degree of petechial haemorrhages, bone fractures and PSE meat than carbon dioxide (CO_2) stunning (Channon, Payne, & Warner, 2002; Gregory, 1989; Larsen, 1983; Velarde, Gispert, Faucitano, Manteca, & Driestre, 2000). The higher frequency of PSE meat is caused by a greater increase in physical stress just before electrical stunning (Troeger & Woltersdorf, 1990, 1991). Guàrdia et al. (2004) reported that in summer the risk of PSE is almost twice the risk in winter because pigs are sensitive to high temperatures.

Previous research has tended to focus on the described meat quality influencing factors separately or combined. However, it remains unclear how meat quality is influenced by the complete sequence of events within the pre-slaughter process. Therefore, the aim of this survey was to investigate the combined effect of several pre-slaughter parameters measured during unloading, lairage and stunning on meat quality based on pH measurements on the slaughter line. The effect of season and parameters involving transport were also considered. As a consequence of this research, the critical control points can be inferred to improve meat quality in chain organized production systems.

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2. Materials and methods

2.1. Experimental design

Between March 2009 and February 2010, a total of 90 transports of slaughter pigs (with an average of 141 pigs per transport) were followed up in one to three visits at 17 Belgian commercial slaughterhouses (plants 1–17). During each visit, pigs originating from two different farms, i.e. two different transports were randomly surveyed. For the most part, all the pigs on one truck were from the same farm due to sanitary reasons. This was checked by the unique identification number. However, pigs from more than one farm were occasionally transported on one truck. In these cases, only one group of pigs on that truck was observed. In total, 12,725 pigs were included for measuring the pre-slaughter environment. An average number of 48 pigs were selected at random out of a transported group for pH measurements. Table 1 summarizes the number of observed pigs and pH measurements sampled per season, visit and slaughterhouse with their respective stunning method.

2.2. Pre-slaughter measurements

When a truck arrived at the slaughterhouse mean stocking density (m²/100 kg) was calculated before unloading. During unloading the following information was recorded: time elapsing from arrival at the slaughterhouse till start of unloading (min), mean weight of the pigs (kg), multiple farm identification numbers on truck (yes/no), percentage of panting pigs, unloading time (min), the use of a hydraulic lift/ramp (yes/no), angle of the ramp (°), percentage of falling/slipping/vocalizing/turning back pigs during unloading and the (mean, minimum and maximum) noise level (Testo 815, Testo NV, Ternat, Belgium) produced during unloading (dB(A)). Showering (yes/no), the temperature of showering water (°C), duration of lairage (min), number of pigs per pen, mean stocking density (m²/100 kg), produced (mean, minimum and maximum) noise level (dB (A)), presence of drinking nipples and sufficient air supply (personal perception; subjective measurement) were observed for each sampled group of pigs during lairage. The noise level was measured during 15 min next to the pen(s) of the observed pigs. During movement of the pigs to the stunner, the handling behavior of the slaughterhouse staff was observed (frequency of using an electric prod) together with the produced (mean, minimum and maximum) noise level (dB(A)) and the percentage of falling/slipping pigs. The noise level was measured next to the pathway of the pigs going to the stunner during 15 min. When an electric prod was used, the intensity of using it was recorded. Frequent use of the electric prod was defined as the prod being used on more than 60% of the pigs, intermediate use as it was used on 10 to 60% of the pigs and no frequent use as less than 10% experienced an electric prod. An electric prod was only used while driving pigs to the stunner. The stunning method, either electrical (head only/head-to-back/head-to-chest application of electrodes) or CO_2 and the stunning effectiveness, current (A), voltage or CO_2 concentration was noted. Stunning effectiveness was evaluated by corneal reflex and rhythmic breathing observations (Velarde et al., 2000). If more than 15% of the pigs of the same sampled group showed evidence of consciousness after stunning, the stunning was evaluated as not being effective. Table 2 summarizes the measurements made per slaughterhouse.

2.3. Meat quality measurements

The pH (Hanna HI99163, Hanna Instruments, Temse, Belgium) was measured in the *M. longissimus dorsi* (LD) at the last rib 30 min after slaughter (pH_i). To ensure that the pH was measured 30 min after slaughter, the site on the slaughter line to measure the pH was determined for each slaughterhouse by measuring the time post-mortem until 30 min were expired. The pH was measured by the same person with the same pH-electrode. To guarantee the measurements were correct, the electrode was cleaned by a solution for oils (HI 7077, Hanna Instruments, Temse, Belgium) and proteins (HI7073L, Hanna Instruments, Temse, Belgium) at the start of each visit, and after every 20 measurements as proposed by Hanna Instruments. After cleaning, the electrode reading was checked with standard solutions of pH 7 and 4. If the measured pH had a deviation of more than 0.01 the electrode was recalibrated.

Meat was defined to be PSE meat when pH_i was below 6.0. O'Neill, Lynch, Troy, Buckley, and Kerry (2003) also used this cut off value for PSE in the LD but the pH was measured 45 min post-mortem. In this

Table 1
Number of observed pigs and pH measurements sampled per visit, season and slaughterhouse (plant) with their resp. stunning methods.

	Number of observed pigs					Number of pH measurements					Number of visits					Stunning method
	Spring[a]	Summer[b]	Autumn[c]	Winter[d]	Total	Spring[a]	Summer[b]	Autumn[c]	Winter[d]	Total	Spring[a]	Summer[b]	Autumn[c]	Winter[d]	Total	
Plant 1	366	410	371	–	1147	62	100	100	–	262	1	1	1	0	3	CO_2
Plant 2	320	325	360	–	1005	61	100	101	–	262	1	1	1	0	3	Electrical
Plant 3	272	347	356	–	975	63	100	100	–	263	1	1	1	0	3	Electrical
Plant 4	318	237	165	–	720	82	135	100	–	317	1	1	1	0	3	CO_2
Plant 5	345	–	485	–	830	73	–	201	–	274	1	0	2	0	3	Electrical
Plant 6	227	–	673	–	900	71	–	191	–	262	1	0	2	0	3	Electrical
Plant 7	277	–	447	–	724	60	–	150	–	210	1	0	2	0	3	CO_2
Plant 8	–	260	251	–	511	–	63	100	–	163	0	1	1	0	2	Electrical
Plant 9	–	–	243	–	243	–	–	107	–	107	0	0	1	0	1	Electrical
Plant 10	331	–	639	–	970	100	–	187	–	287	1	0	2	0	3	Electrical
Plant 11	314	–	521	–	835	81	–	200	–	281	1	0	2	0	3	CO_2
Plant 12	322	–	669	–	991	102	–	201	–	303	1	0	2	0	3	CO_2
Plant 13	327	–	395	–	722	186	–	95	–	281	1	0	1	0	2	Electrical
Plant 14	–	135	79	197	411	–	100	50	100	250	0	1	1*	1	3	Electrical
Plant 15	298	–	538	–	836	90	–	201	–	291	1	0	2	0	3	CO_2
Plant 16	146	–	360	–	506	72	–	200	–	272	1*	0	2	0	3	Electrical
Plant 17	–	205	–	194	399	–	100	–	100	200	0	1	0	1	2	CO_2

*Only one transport was observed.
[a] Spring: 21 March–20 June.
[b] Summer: 21 June–20 September.
[c] Autumn: 21 September–20 December.
[d] Winter: 21 December–20 March.