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Effect of the slaughterhouse on behaviour, blood parameters, meat quality and raw ham defects in heavy pigs

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Abstract. The effect of different pre-slaughter procedures on behaviour, blood parameters, meat quality traits and raw ham defects were evaluated on 120 pigs reared in one farm and delivered in groups of 40 subjects to three slaughterhouses. Due to the different attitude of the personnel involved, differences in handling were evident at loading and at unloading where the difficulties to drive the pigs increased the behavioural events. Blood analysis parameters showed that different resting time did not reduce the physical stress experienced by the pigs, which seems related "per se" to loading, journey condition and unloading and not to the different handling procedures applied in each slaughter plant. Among the meat quality traits measured, the rate and the extent of post mortem pH decline and L* and a* colour coordinates were affected by the slaughterhouse. The presence and the seriousness of the veining defect was significatively affected by the slaughter condition while the "red skin" defect did not varied accordingly to the plant. The results of the present study showed that the "slaughter plant" effect, namely how the animals are handled before death, has an unquestionable responsibility to the final quality traits of both meat and raw ham.

Keywords. Pig – Behaviour – Blood parameters – Meat quality – Raw ham quality.

Effet de l'abattoir sur le comportement, les paramètres sanguins, la qualité de la viande et les défauts du jambon de porcs lourds

Résumé. *L'effet des procédures de pré-abattage sur le comportement, les paramètres sanguins, la qualité de la viande et les défauts du jambon, a été évalué sur 120 porcs élevés dans une ferme et livrés en groupes de 40 sujets à trois abattoirs. En raison de l'attitude différente du personnel concerné, les différences de traitement étaient évidentes au chargement et au déchargement où les difficultés à conduire les porcs ont augmenté les événements de comportement. L'analyse des paramètres sanguins a montré que les différents temps de repos n'ont pas réduit le stress physique subi par les porcs, qui semble lié "en soi" aux conditions de chargement, voyage, et déchargement, et non aux différentes procédures de manipulation appliquées dans chaque abattoir. En ce qui concerne* les *caractéristiques de qualité de la viande, seules la vitesse et l'ampleur de l'abaissement du pH post mortem ont été influencées par l'abattoir. La présence et la gravité du défaut de la veine ont été significativement influencées par l'abattage, tandis que le défaut de la "peau (couenne) rouge" n'a pas varié en fonction des différents abattoirs. Les résultats de la présente étude ont montré que l'effet de l'abattoir, c'est-à-dire la façon dont les animaux sont traités avant l'abattage, a une responsabilité indiscutable pour la qualité finale de la viande et du jambon frais.*

Mots-clés. *Porc – Comportement – Paramètres sanguins – Qualité de la viande – Qualité du jambon cru.*

I – Introduction

Impaired pig carcass, meat and raw ham quality after slaughter are often attributed to differences in responses to pre-slaughter procedures related to the "farm of origin" effect, which accounts for genetic type, feeding and housing conditions. This generic attribution leads to a difficult assignment of responsibility for inadequate pre-slaughter handling, which usually flows from the slaughterhouse to the truck driver and finally reaches the farmer. In order to better define the role played by the pre-slaughter treatments related to "farm of origin", the present study was carried out on heavy pigs reared on one farm and slaughtered in three different plants.

II – Materials and methods

Behaviour, blood parameters and quality traits of meat and raw hams of 120 pigs (LW kg 160 ± 9) of the same farm and subjected to different pre-slaughter handling were examined. Pigs were delivered the same day in three groups of 40 subjects and slaughtered in three different plants (A, B and C). During each delivery, the time of loading, transport, unloading, and resting were recorded (Table 1).

Table 1. Number of pigs (castrated males, females) and time (min) of pre-slaughter procedures in the three plants

Plant	No. Pigs	Loading	Transport	Unloading	Resting	Total
A	40 (18,22)	32	50	7	81	170
B	40 (19,21)	17	101	5	15	138
C	40 (17,23)	15	68	9	60	152

The transport was carried out by three similar decks vehicles (space allowances 0.50 m^2 - 0.55 m^2 per 100 kg of LW). At the end of the journey, each group was unloaded and droved to the resting pens where watering nipples were available. Use of electric prods and mixing between subjects of different pens never occurred. During loading and unloading, the number of reversals, balks, falls, slips, bites, jumps, evacuations and vocalizations were recorded for each group. In the resting pens, one observation of 1 min each 15 min was carried out to record postures (standing, sitting, lying down), exploratory, olfactory and aggressive actions as well as drinking, mastication and evacuation. According to the resting time, the observations were 5 at the plant A, 1 at the B and 4 at the C.

In the slaughterhouse B the pigs were showered during resting with cold water for 6 min. The pigs were electrical stunned by manual tongs in the A and C plants (V 180-220) and by automatic system (V 300) in the B plant. At sticking, the blood was collected from each pig, centrifuged at 3500 g for 15 min and frozen at -20°C until analysis. Albumin, lactate, glucose, total protein, urea, osmolarity and creatin kinase contents were determined by an automatic analyzer (BM HITACHI 911 - Roche) and cortisol by enzyme-immunoassay with the automatic analyser DPC Immulite (Medical System) and the COR LKCO1 kit (Medical System). The weight of hot carcasses and left thighs after trimming were recorded. The pH_1 (1 h *post mortem*) and pH_u (24 h *post mortem*) measures as well as colour coordinates (L*,a*,b*) were recorded on *semimembranosus* and *bices femoris* muscles. On all left thighs, an expert assessor carried out the scoring of veining (Russo *et al*., 2003) and "red skin" (Lo Fiego *et al*., 2006) defects (Table 5). Based on these classifications, the average scores and percentage of thighs in each class were calculated.

The distribution of behavioural events and frequencies of postures were compared by χ^2 (Fischer's exact test). Creatin kinase, cortisol, lactate and osmolarity data were normalised by a log10 transformation and glucose by inverse transformation. Plasma parameters, carcass and meat characteristics, were processed by a model including the fixed effects of slaughterhouse, sex and their interaction, the latter excluded when P>0.05. Differences due to slaughterhouse and sex regarding the distributions of the thighs among the scoring classes were examined by non- parametric test of Wilcoxon for the scores and by χ^2 (Fisher exact test).

III – Results and discussion

A significant difference (P<0.05) in the distribution of behavioural events between pigs addressed to plants A and C was found (Table 2).

Table 2. Behavioural events observed at loading and at unloading in the three plants

Events	Loading			Unloading		
	Plant A	Plant B	Plant C	Plant A	Plant B	Plant C
	N	N	N	N	N	N
Reversal	4	9	21	1	2	7
Balk	3	16	20	-	2	-
Fall	1	1	1	-	2	2
Slip	4	5	5	-	6	-
Vocalization	-	10	15	-	10	18
Total	12	41	62	1	22	27
No. pipe/pig	1.6	4.1	4.8	0.2	0.7	4.8

A progressive raise of events was observed accordingly with the reduction of the loading time. They increased from 12 for the pigs destined to the plant A to 62 for those addressed to the plant C. The raise of behavioural events regarded mainly reversals and vocalizations. The difficulties to move the pigs towards the vehicle increased the use of the rubber pipe that, in turn, leads to more vocalizations. The observations recorded at loading highlight that differences in pre-slaughter handling raises very soon and confirms that fast driving increases the difficult to handle the pigs (Grandin, 2007). Despite very similar facilities and duration of unloading, there were significant differences (P<0.01) between the plants B and C in the distribution of the behavioural events. The higher number of events recorded in the latter plant, particularly the vocalization, could be related to a greater stimulation of movement, as showed by the higher use of the rubber pipe. In general, these results show that at loading and at unloading the differences in behaviour mainly reflected different personnel attitude to carry out such operations. The frequency of the postures (data not showed) was similar in all slaughter plants, even if there is a significant difference (P<0.05) in the first observation between B and C plants, the latter characterized by more sitting pigs. The behavioural events observed in the active subjects were limited to the exploration only. At the second observation, the frequencies of posture were not statistically different (P>0.05) between A and C plants, while, to respect to the previous one, an increase of subjects lied down was observed in both plants. Moreover, all the active subjects manifested exploratory activities only, confirming what was recorded in the first one. The subsequent observations found all pigs lied down until the stunning.

Least squares mean values of plasma variables are shown in Table 3. They were within the normal range (Boyd, 1984) in all groups excepted for the higher lactate and creatin kinase values. The levels of albumin, osmolality and total protein were higher (P<0.05) in the plasma of pigs slaughtered in plants A and C vs those slaughtered in plant B. This might indicate a week dehydration (Knowles and Warriss, 2007) in the former pigs, probably related to the longer resting time and to the absence of stimuli to drink, as the behavioural observation shown. In addition, the lower glucose and the higher lactate levels observed in pigs slaughtered in A and C plants (P<0.05) could be due to the longer lairage, even if their physical activity was limited to the exploration. CK activity was found very high in all groups. Irrespectively of the differences in pre-slaughter procedures, the means values did not differ significantly among the groups.

Table 3. Effect of slaughterhouse on plasma variables (untransformed least squared means ± SE)

Trait		Plant A	Plant B	Plant C
Albumin	g/l	42.90^{b} ± 0.54	39.93^{a} ± 0.54	45.33^{c} ± 0.54
Lactate	mmol/l	16.08^{a} ± 0.72	9.47^{b} ± 0.71	12.19^{c} ± 0.73
Glucose	mmol/l	6.22^{ab} ± 0.23	7.00^{b} ± 0.23	5.46^{a} ± 0.24
Total protein	g/l	79.51^{b} ± 0.76	69.50^{a} ± 0.76	76.70^{c} ± 0.79
Cortisol	nmol/l	231.29 ± 0.03	201.89 ± 0.03	233.70 ± 0.03
Urea	mmol/l	5.34 ± 0.16	5.26 ± 0.16	5.29 ± 0.17
Osmolarity	mOsm/K	309.18^{b} ± 1.19	300.48^{a} ± 1.17	310.35^{b} ± 1.22
Creatin kinase	U/l	1536.85 ± 140	1610.53 ± 138	1525.97 ± 144

a, b, c: P<0.05.

This result suggests that in terms of reaction to the physical stress experienced before lairage, the examined pigs showed a similar response. The prolonged resting time in A and C plants was not sufficient to recover from this stress.

The groups of pigs delivered to the three slaughterhouses were similar for carcass and trimmed thigh weight (Tables 4 and 5).

Table 4. Effect of slaughterhouse on carcass weight and meat quality traits (means ± SE)

	Plant A	Plant B	Plant C
Carcass weight (kg)	130.5 ± 1.14	132.2 ± 1.13	131.8 ± 1.15
M. semimembranosus:			
pH_1	6.12^{a} ± 0.04	6.53^{b} ± 0.04	6.09^{a} ± 0.04
pH_u	5.42^{a} ± 0.01	5.53^{b} ± 0.01	5.52^{b} ± 0.01
L*	47.99^{b} ± 0.45	47.83^{b} ± 0.46	45.36^{a} ± 0.47
a*	11.64^{c} ± 0.25	9.15^{a} ± 0.25	10.20^{ab} ± 0.25
b*	0.23 ± 0.31	0.22 ± 0.31	0.40 ± 0.31
M. biceps femoris			
pH_u	5.45^{a} ± 0.01	5.54^{b} ± 0.01	5.50^{ab} ± 0.01
L*	47.6^{b} 0 ± 0.34	46.92^{b} ± 0.35	43.46^{a} ± 0.35
a*	13.01^{b} ± 0.26	11.62^{a} ± 0.27	12.70^{ab} ± 0.27
b*	1.84	1.65	1.90

a, b, c: P<0.05.

Sex showed a significant effect on carcass weight, which was higher (P<0.01) in castrated males (data not shown), while there was no significant interaction between sex and slaughter. The slaughterhouse significatively affected the rate and the extent of *post mortem* acidification and the colour coordinates except for b* values. Nevertheless, the differences among plants were little and there were not defects or tendency toward PSE and DFD defects.

Regarding the veining defect (Table 5), the slaughterhouse showed a significant effect (P <0.01) on both average score and distribution of thighs among the scoring classes. The highest frequency and seriousness of the veining defect were found in plant B where, although with different intensity, 100 % of the trimmed thighs showed this defect. The score of the "red skin" defect was not significantly affected by the slaughter plant, nor was the distribution of thighs among the three scoring classes.

Table 5. Effect of slaughterhouse on distribution (%) of the left thighs among the classes of veining and "skin red" defects within slaughterhouses (means ± S.E.)

	Plant A	Plant B	Plant C	Signif.
Trimmed thigh weight (kg)	13.8 ± 0.14	13.9 ± 0.14	14.3 ± 0.15	ns
Veining score	2.15	2.77	2.54	**
"Red skin" score	2.27	2.40	2.10	ns
Veining score classes:				**
- 1 (no defect) (%)	20.0	0.0	2.5	
- 2 (light) (%)	47.5	30.0	40.0	
- 3 (evident) (%)	30.0	62.5	57.5	
- 4 (serious) (%)	2.5	7.5	0.0	
"Red skin" score classes:				ns
- 1 (absent) (%)	7.5	2.5	10.0	
- 2 (light) (%)	57.5	55.0	70.0	
- 3 (severe) (%)	35.0	42.5	20.0	

ns: not significant; **: P<0.01

However, the negative effect exerted by the slaughter conditions at plant B was confirmed, where the incidence of thighs with severe "red skin" reached 42.5 %, while in plants A and C this reached 35.0 % and 20.0 % respectively. Sex did not show any significant effect on the two defects. The results of the present study showed that the slaughter plant, namely how the animals are handled before and after death, plays an important role on the incidence and severity of the veining defect. This confirms previous findings on the role of some treatments *pre-* and *post mortem* such as the lairage duration, the method of stunning and the pre-chilling time of the thighs (Lo Fiego *et al*., 2003; Nanni Costa *et al*., 2005).

IV – Conclusions

The results achieved show that, irrespectively of the common origin of examined pigs, differences in pre-slaughter handling and, consequently, differences in pre-slaughter behaviour raise very soon, mainly related to the attitude to the personnel in animal driving. The most evident consequences concern the behaviour of animals and the metabolic responses to the resting, while the physical stress related to the pre-slaughter handling seems less affected by different pre-slaughter procedures. The experimental plan used for the present study did not allow identification of specific factors or treatments relating to the slaughter that could be responsible for the differences observed among plants. However, the results give an unquestionable responsibility to the slaughterhouse for the presence and seriousness of the veining defect. On the contrary, the incidence and severity of the "red skin" defect was not significantly related to the slaughter. This result suggests the need to investigate factors in the farm pens that may affect the condition of the thigh skin.

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