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# Effects of handling procedure during unloading on welfare and meat quality of market-weight pigs

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**Abstract.** This study aimed to examine the effects of handling procedure during unloading on blood glucose level, carcass lesions and meat quality of market-weight pigs. Rough handling during unloading was related to higher blood glucose level and frequency of slipping and falling. In contrast, gentle handling during unloading was related to the lower blood glucose level and frequency of slipping and falling, but the higher frequency of reluctance to move and turning back. Rough handling during unloading resulted in a higher carcass lesion score, and the higher tendency towards lesions on the middle part of the carcass and handling-type carcass lesions. Pigs subjected to rough handling during unloading had a higher meat temperature 45 minutes after slaughter, lower meat pH value 45 minutes and 24 hours postmortem, higher drip and cooking loss, higher L\* and b\* values and lower sensory colour score, and consequently, produced a higher prevalence of pale, soft and exudative meat. In contrast, pigs exposed to gentle handling during unloading produced a lower percentage of pale, soft and exudative meat, but a higher percentage of pale, firm, and nonexudative. In conclusion, gentle handling during unloading resulted in improved animal welfare, decreased stress intensity, and increased pork quality.

## 1. Introduction

Unloading at the abattoir is one of the most stressful moments on the day of slaughter, since pigs are exposed to an unknown environment and contact with unfamiliar people, which can cause stress and negatively affect animal welfare and pork quality [1]. Pig welfare at this pre-slaughter stage can be assessed according to animal-based (slipping/falling, reluctance to move, turning back, vocalization and lameness) and resource-based (unloading ramp angle, corridor appearance, type of handling tools, etc.) measurements [1]. In addition, physiological stress indicators and pork quality traits could be useful indicators of welfare conditions at unloading [2]. Rough handling in the unloading area, which includes the use of electric prods and sticks, compromises pig welfare and results in lower pork quality [2-3]. Several studies reported that alternative handling tools (sorting boards, rattle paddles and flags) to the electric prods and sticks, used to move pigs from the lorry to the lairage pens, were more effective devices because they induced fewer behavioural problems and reduced stress intensity and pork quality defects [1-3]. Therefore, the aim of this study was to examine the effects of handling procedure during unloading on blood glucose level, carcass lesions and meat quality of market-weight pigs. The research hypothesis was that gentle handling during unloading would improve pig welfare and pork quality.



## 2. Materials and Methods

### 2.1. Experimental animals and management procedures

The study was conducted in April 2021 on 69 market-weight pigs (29 barrows and 40 gilts) with average live weight of approximately 105 kg and 6 months old. All pigs were of the same genetics ([Yorkshire × Landrace] sows sired with Pietrain boars) and originated from the same farm and, thus, were reared under identical conditions. At the farm, the pigs were loaded in groups of 4-5 pigs by the same lorry driver. Lorry departed from the farm immediately after loading. Transportation of pigs was conducted in two groups (group 1 = 35 pigs; group 2 = 34 pigs) in an interval of two weeks by the same driver and the same lorry. Both groups of pigs were transported to the abattoir for about two hours at the loading density of ~0.43 m<sup>2</sup>/100 kg. Both groups of pigs were unloaded as soon as possible (~5 min of waiting time for both groups) after the arrival at the abattoir using a 5-m long metal ramp with a slope of 20°. Pigs from the first group were unloaded by abattoir personnel using electric prods and sticks (in groups of 10–15 pigs) in compliance with standard abattoir practices (unloading time: 5 minutes). Pigs from the second group were unloaded by the first and second author in a slow and calm manner with a PVC sorting board and rattle paddle (in groups of 4-5 pigs), and without the use of electric prods and sticks (unloading time: 15 minutes). After the pigs were unloaded, they were moved to a lairage pens for 30 minutes at a lairage density of 1 m<sup>2</sup> per pig. Pig slaughter and carcass processing were identical for both groups and were performed at the same commercial abattoir in compliance with the standard industry-accepted practices.

### 2.2. Behavioural and physiological stress indicators

Pig behaviour (slipping, falling, turning back, reluctance to move) was monitored at unloading by direct observation of two trained observers based on the Welfare Quality® protocol [4], as outlined in Table 1. For the measurement of blood glucose levels, blood samples were collected from 15 slaughtered pigs per group (n = 30). Samples were collected in a plastic cup from the bleeding wound at sticking and results were immediately determined (within 15 s) using a handheld device analyser (Gluko Sure Auto Code, ApexBio, Taiwan).

**Table 1.** Indicators of pig behaviour and health recorded during unloading at the abattoir

Item	Description [4]	Thresholds [5]
Slipping	Loss of balance without the body touching the floor.	Excellent: 3%; Advanced: 6%; Acceptable: 8%; Unacceptable: >8%
Falling	Loss of balance in which a part of the body other than the legs is in contact with the floor.	Excellent: 0%; Advanced: 0.4%; Acceptable: 0.8%; Unacceptable: >0.8%
Turning back	Pig facing towards the unloading zone makes a 180° turn in the direction of the lorry area.	Excellent: 0%; Advanced: 1.5%; Acceptable: 4%; Unacceptable: >4%
Reluctance to move	Pig showing reluctance to move when it stopped walking, without moving its head and body and failed to explore for at least 2 s.	Excellent: 0%; Advanced: 0.5%; Acceptable: 1.5%; Unacceptable: >1.5%

### 2.3. Carcass lesion evaluation

Carcass lesions were visually assessed on the left carcass side (n = 30; 15 slaughtered pigs/group) by two trained observers in the cold chamber 45 minutes after slaughter using a visual scoring system based on Welfare Quality® protocol [4]. Also, carcass lesions were classified as handling type-carcass lesions, fighting-type carcass lesions and mounting-type carcass lesions by visual assessment of shape and size to recognize their origin [6].

### 2.4. Pork quality measurements

Pork quality measurements were carried out 45 minutes, 24 hours and 72 hours postmortem on the *Musculus longissimus dorsi* at the level of the 10th and 11th ribs on the left carcass side. Meat samples

were collected from 15 slaughtered pigs per group ( $n = 30$ ). Both pH ( $\text{pH}_{45\text{min}}$  and  $\text{pH}_{24\text{h}}$ ) and temperature ( $T_{45\text{min}}$  and  $T_{24\text{h}}$ ) were measured 45 minutes and 24 hours postmortem using a pH meter (Testo 205, Testo AG, Lenzkirch, Germany). For determination of pork colour and water holding capacity, two boneless loin samples ( $2.54\text{ cm}$  thick,  $100 \pm 4.5\text{ g}$ ) were cut 24 hours postmortem by trained abattoir personnel from each selected carcass. Instrumental colour was determined using a portable colorimeter (Konica-Minolta, Chroma Meter CR 410, Osaka, Japan). Subjective colour of meat samples were evaluated 24 hours postmortem by three trained sensorists by using the scaling method according to the National Pork Producer Council colour standard [7]. To evaluate water holding capacity, drip loss, thawing loss and cooking loss were determined, as described in Čobanović et al. [8]. Pork quality classes were determined using pH values measured 24 hours postmortem, drip loss variations, and lightness ( $L^*$  value) based on Čobanović et al. [8] (Table 2).

**Table 2.** Determination of pork quality classes based on Čobanović et al. [8]

Pork quality class	$\text{pH}_{24\text{h}}$	Drip loss (%)	$L^*$ value
PSE pork	$<6.0$	$\geq 5$	$\geq 50$
RSE pork	$<6.0$	$\geq 5$	42-50
RFN pork	$<6.0$	2-5	42-50
PFN pork	$<6.0$	2-5	$\geq 50$
DFD pork	$\geq 6.0$	$\leq 2$	$<42$

Abbreviations:  $\text{pH}_{24\text{h}}$  – pH value measured 24 hours after slaughter; Drip loss – meat juice loss at  $4^\circ\text{C}$  for a period of 24 to 72 h after slaughter;  $L^*$  value – lightness; PSE – pale, soft, and exudative; PFN – pale, firm, and nonexudative; RSE – red, soft, and exudative; RFN – red, firm, and nonexudative; DFD – dark, firm, and dry.

### 2.5. Statistical analysis

Statistical analysis of the results was conducted with SPSS software (version 23.00, IBM Corporation, Armonk, NY, USA). According to handling procedure during unloading, the pigs were allocated to two groups: gentle handling = the group of pigs handled in a slow and calm manner with a PVC sorting board and rattle paddle, and without the use of electric prods and sticks ( $n=35$ ) and rough handling = the group of pigs handled by using the electric prods and sticks ( $n=34$ ). Student's t-test was used to examine the effects of unloading practice on the blood glucose level, carcass lesion score and meat quality traits of market-weight pigs. Data were described by descriptive statistical parameters as the mean value and standard error of the mean (SE). The effects of unloading practice on behavioural indicators, carcass lesion type, lesion distribution on carcass regions and pork quality classes were determined by Fisher's exact test. Since none of the slaughtered pigs had lesions on the ears and legs nor produced DFD pork, these carcass regions and quality class were not considered for this statistical test. Each pig was considered an experimental unit. In all tests, statistical significance was accepted at  $P < 0.05$ , while tendencies were accepted at  $0.05 < P < 0.10$ .

## 3. Results and Discussion

Effects of handling procedure during unloading on behavioural and physiological stress indicators of market-weight pigs are shown in Table 3. A higher occurrence of slipping ( $P=0.0356$ ) and falling ( $P=0.0416$ ) was recorded in pigs subjected to rough handling in the unloading area. The same group of pigs had a percentage of slipping and falling above the threshold level for unacceptable welfare conditions at the abattoir (Table 1) [5]. High frequency of slipping and falling of pigs during rough handling in the unloading area could be attributed to the use of electric prods and sticks, but also to the too steep unloading ramp (slope of  $20^\circ$ ) [3]. An unfamiliar environment and a too steep unloading ramp ( $>15^\circ$ ) lead to agitation and stress in pigs, which make them rush (as shown by the shorter unloading time), and resulting in much more difficult handling during unloading [1]. This results in nervousness and frustration in abattoir personnel, leading to rougher handling of pigs and more frequent use of electric prods and/or sticks during unloading [1]. Considering that unloading ramp was identical for both

groups of pigs, it can be argued that rough handling by unqualified abattoir personnel had the greatest impact on the frequency of slipping and falling of pigs in the unloading area.

**Table 3.** Effects of handling procedure during unloading on behavioural and physiological stress indicators of market-weight pigs (n=69)

Handling procedure during unloading	Rough	Gentle	<i>P</i> -value	Significance
Number of pigs	34	35		
<i>Behavioural stress indicators</i>				
Slipping (%)	23.53 <sup>a</sup>	5.71 <sup>b</sup>	0.0356	*
Falling (%)	17.65 <sup>a</sup>	2.86 <sup>b</sup>	0.0416	*
Turning back (%)	2.94 <sup>a</sup>	31.43 <sup>b</sup>	0.0029	*
Reluctance to move (%)	0.00 <sup>a</sup>	14.29 <sup>b</sup>	0.0221	*
<i>Physiological stress indicator</i>				
Blood glucose (mmol/L)	6.89±0.57 <sup>a</sup>	5.51±0.33 <sup>b</sup>	0.0445	*

Rough handling = pigs handled using the electric prods and sticks; Gentle handling = pigs handled in a slow and calm manner with a PVC sorting board and rattle paddle.

\* Statistical significance at ( $P < 0.05$ ); T: tendency ( $0.05 < P < 0.10$ ); NS: not significant ( $P > 0.05$ )

<sup>a, b</sup> Different letters in the same row indicate a significant difference at  $P < 0.05$ .

In contrast, pigs exposed to gentle handling during unloading had higher frequencies of turning back ( $P=0.0029$ ) and reluctance to move ( $P=0.0221$ ) (Table 3). The same group of pigs had percentages of turning back and reluctance to move above the threshold level for unacceptable welfare conditions at the abattoir (Table 1) [5]. Scientific and professional attitudes about the cause of the aforementioned forms of pig behaviour are not consistent. Some authors [3] suggest that the use of electric prods and/or sticks during unloading leads to the higher frequencies of turning back and reluctance to move in pigs. On the other hand, other authors [1-2] reported more turning backs and reluctance to move in pigs handled during unloading without electric prods and sticks, indicating that gentle handling is connected with these forms of behaviour. Thus, great care is needed when interpreting the causes of turning back and reluctance to move during unloading, since there are indications that these forms of pig behaviour are not reliable indicators of animal welfare at the abattoir [1].

In the present study, pigs that underwent rough handling during unloading had a higher blood glucose level at exsanguination ( $P=0.0445$ ), indicating the higher degree of stress after inadequate handling procedures. It has been observed that the use of electric prods and/or sticks immediately before slaughter leads to the activation of behavioural and physiological responses to stress, so such pigs have higher blood cortisol, lactate and glucose levels at exsanguination [2-3]. Stress stimuli just prior to slaughter provoke activation of the sympathetic-adrenal-medullary axis, causing the release of catecholamines (noradrenaline and adrenaline), which accelerate metabolism and lead to the breakdown of glycogen reservoirs in skeletal muscle and in the liver, and consequently resulting in increased blood lactate and glucose levels [1-2].

Effects of handling procedure during unloading on carcass lesions of market-weight pigs are displayed in Table 4. Pigs subjected to rough handling during unloading had a higher ( $P=0.0463$ ) carcass lesion score. Also, there was a higher tendency ( $P=0.0656$ ) for the occurrence of lesions on the middle region of the carcass and handling type-carcass lesions in pigs subjected to rough handling (Table 4). Rough handling, although it shortens the unloading time, causes fear and panic in pigs, which makes them rush, and leading to a higher occurrence of slipping, falling, mounting and hitting the floor or walls of the unloading ramp and corridors, consequently resulting in a higher prevalence of carcass lesions [2]. As a consequence of the use of electric prods and sticks during unloading of a large number of pigs at the same time, they jump on each other's backs in an attempt to escape from a source of stress, resulting in the higher occurrence of carcass lesions [1]. To reduce the prevalence of carcass lesions and

to facilitate unloading procedure, it is strongly recommended to unload pigs in small groups of 4-5 individuals, with at least two animals moving side by side [1].

**Table 4.** Effects of handling procedure during unloading on carcass lesions of market-weight pigs (n=30)

Handling procedure during unloading	Rough	Gentle	P-value	Significance
Number of pigs	15	15		
Carcass lesion score	1.20±0.20	0.67±0.16	0.0463	*
<i>Carcass lesion type (%)</i>				
Handling type-carcass bruises	80.00	40.00	0.0604	T
Fighting-type bruises	6.67	13.33	>0.9999	NS
Mounting-type bruises	13.33	6.67	>0.9999	NS
<i>Carcass regions (%)</i>				
Anterior part	80.00	60.00	0.4270	NS
Middle part	66.67	26.67	0.0656	T
Posterior part	40.00	13.33	0.2148	NS

Rough handling = pigs handled using the electric prods and sticks; Gentle handling = pigs handled in a slow and calm manner with a PVC sorting board and rattle paddle.

\* Statistical significance at ( $P < 0.05$ ); T: tendency ( $0.05 < P < 0.10$ ); NS: not significant ( $P > 0.05$ )

<sup>a, b</sup> Different letters in the same row indicate a significant difference at  $P < 0.05$ .

Effects of handling procedure during unloading on meat quality of market-weight pigs are depicted in Table 5. Meat obtained from pigs subjected to rough handling had higher temperature 45 minutes postmortem ( $P < 0.0001$ ), lower pH value 45 minutes ( $P = 0.0100$ ) and 24 hours ( $P < 0.0001$ ) after slaughter, increased drip ( $P = 0.0013$ ) and cooking loss ( $P = 0.0167$ ), higher L\* ( $P = 0.0104$ ) and b\* ( $P < 0.0001$ ) values and lower sensory colour score ( $P = 0.0005$ ). Consequently, pigs exposed to rough handling produced a higher percentage of PSE pork ( $P = 0.0656$ ).

**Table 5.** Effects of handling procedure during unloading on meat quality of market-weight pigs (n=30)

Handling procedure during unloading	Rough	Gentle	P-value	Significance
Number of pigs	15	15		
<i>Pork quality parameters</i>				
pH <sub>45min</sub>	6.10±0.05 <sup>a</sup>	6.28±0.04 <sup>b</sup>	0.0100	*
T <sub>45min</sub> (°C)	38.58±0.08 <sup>a</sup>	37.25±0.22 <sup>b</sup>	<0.0001	*
pH <sub>24h</sub>	5.61±0.07 <sup>a</sup>	5.99±0.03 <sup>b</sup>	<0.0001	*
T <sub>24h</sub> (°C)	1.87±0.03	1.84±0.02	0.4785	NS
Drip loss (%)	8.39±0.39 <sup>a</sup>	6.35±0.41 <sup>b</sup>	0.0013	*
Thawing loss (%)	4.65±0.47	4.61±0.40	0.9485	NS
Cooking loss (%)	24.94±1.02 <sup>a</sup>	20.87±1.23 <sup>b</sup>	0.0167	*
L* value	55.41±0.81 <sup>a</sup>	51.95±0.96 <sup>b</sup>	0.0104	*
a* value	11.12±0.31	11.17±0.41	0.9229	NS
b* value	9.63±0.20 <sup>a</sup>	7.91±0.31 <sup>b</sup>	<0.0001	*
Sensory colour score	1.76±0.11 <sup>a</sup>	2.71±0.22 <sup>b</sup>	0.0005	*
<i>Pork quality classes (%)</i>				
PSE meat	86.67 <sup>a</sup>	40.00 <sup>b</sup>	0.0209	*
RSE meat	13.33	26.67	0.6513	NS

RFN meat	0.00	6.67	>0.9999	NS
PFN meat	0.00	26.67	0.0996	T

Rough handling = pigs handled using the electric prods and sticks; Gentle handling = pigs handled in a slow and calm manner with a PVC sorting board and rattle paddle.

\* Statistical significance at ( $P < 0.05$ ); T: tendency ( $0.05 < P < 0.10$ ); NS: not significant ( $P > 0.05$ )

<sup>a, b</sup> Different letters in the same row indicate a significant difference at  $P < 0.05$ .

These results can be explained by the fact that rough handling during unloading leads to intensified metabolism in skeletal muscles ante and postmortem, resulting in increased meat acidification and temperature [8]. High meat acidification combined with high meat temperature induces denaturation of sarcoplasmic and myofibrillar proteins and reduction in their water holding capacity, thus causing the occurrence of PSE pork [8]. As rough handling during unloading compromises pig welfare and adversely affects the pork quality, most authors [6,9] agree that the use of electric prods should be strictly limited, while hitting, kicking and sticks must be strictly prohibited. Previous findings [6,9] reported that avoiding the use of the electric prods and sticks reduced the prevalence of carcass lesions and PSE pork by as much as 50%. This is confirmed in the present study, where the use of sorting boards and rattle paddles to move pigs during unloading instead of electric prods and sticks halved the prevalence of handling type-carcass lesions (rough handling: 80.00% vs. gentle handling: 40.00%) and PSE pork (rough handling: 86.67% vs. gentle handling: 40.00%) (Table 5). Also, gentle handling in pigs led to a slowdown of metabolic processes in skeletal muscles postmortem and only partial denaturation of meat proteins, so those individuals produced better pork quality, in terms of the lower prevalence of PSE pork and increased tendency towards pale, firm and non-exudative (PFN) pork ( $P = 0.0656$ , Table 5).

#### 4. Conclusion

The results showed that gentle handling of pigs during unloading resulted in improved animal welfare (lower frequency of slipping and falling and carcass lesion scores), decreased stress intensity (lower blood glucose level), as well as increased pork quality (lower prevalence of PSE meat). Education of abattoir personnel to better understand human-animal relationships, such as animal behaviour, practical aspects of animal handling and the influence of handling practice on the animal welfare and on the meat quality, as well as the use of alternative handling tools (sorting boards, rattle paddles and flags) would reduce the deleterious effects of rough handling during unloading. Education programs for abattoir personnel, which include training, evaluation of achieved knowledge and skills certification, should be repeated regularly so that acquired knowledge can be renewed and upgraded.

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