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THE IMPACT OF THE PH_1 VALUE AND THE LENGTH OF CARCASS ON THE QUALITY OF SLAUGHTERED PIGS OF THE HYBRID COMBINATION (CLW × CL) × D

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Abstract

The goal of this thesis was to establish the impact of the pH_1 value and the length of carcass on the quality of slaughtered pigs of the hybrid combination (CLW × CL) × D. The slaughtered pigs were divided into four groups depending on the measured pH_1. The first group of pigs (n = 18) had pH_1 value of less than 6.00, the second group included pigs (n = 53) with its value ranging from 6.00 to 6.20, the third group (n = 76) with pH_1 values ranging from 6.21 to 6.40 and the fourth group included the most pigs (n = 103), with an established pH_1 value higher than 6.40. The pigs were divided into the three following groups on the basis of carcass length: < 800 mm, 800–900 mm, > 900 mm.
An average pH_1 value of 6.36 was measured in the monitored group of slaughtered pigs in the present study. PSE defects were established in the meat of 4 dressed carcasses, which was 1.6% of all of the assessed slaughtered pigs. The average length of the dressed carcass in the pigs was determined on the level of 842 ± 4.05 mm. The average slaughter weight of the pigs fell along with increasing measured pH_1 value. The highest average price per 1 kg of dressed carcass (44.50 ± 2.29 CZK) was established in pigs, which had a measured pH_1 value ranging from 6.21 to 6.40. On the contrary, the lowest average price per 1 kg of dressed carcass (42.49 ± 4.30 CZK) was determined for pigs with the pH_1 value of < 6.00. The average slaughter weight of the pigs increased along with the increasing values of the length of the dressed carcass.

Keywords: Duroc, pH_1 value, length of the carcass

INTRODUCTION

At present, in order for a breeder to be successful on the pork market he must focus increasingly on the quality of the meat, as well as on other important factors. This is finally very important both in the competition for a position on the market and particularly in order to gain favour from the end customer. According to Bečková (1997), unilaterally targeted selection for a high proportion of lean meat in pigs to be slaughtered caused a partial decline in the quality of meat as a result of the occurrence of qualitative deviations of the nature of pale, soft and exudative meat (PSE) and dark, firm and dry meat (DFD).

PSE is a long-term problem in relation to pigs. This meat is pale due to a high level of light dispersion caused by low pH, it is soft due to free fluid between the muscle fibres and it is exudative due to low water binding capacity at this low pH, which leads to loss of weight caused by meat juices dripping (Lundström *et al*., 1989). Acute thermal stress immediately before slaughter stimulates muscle glycogenolysis and may lead to PSE, which is distinguished by a low capacity to retain water (Gonzales *et al*., 2020).

It has also been shown that PSE is very closely linked to so-called acute stress syndrome (PSS) or malign hyper-thermic syndrome (MHS) (Judge, 1972). If the pigs are stressed immediately before slaughter, the muscles use more energy reserves, the metabolism becomes exothermic and the muscle and body temperature rises. Muscle pH value falls, while the temperature of the dressed carcass remains high, protein is increasingly denatured and this could cause occurrence of PSE defects in the meat (Bertol *et al*., 2005; Adzitey and Nurul, 2011).

PSE usually occurs in pigs that are genetically sensitive to stress, when they are subject to acute stress immediately before slaughter (Oliver *et al*., 1988; Honkavaara, 1989; Küchenmeister *et al*., 2000). It is generally known that occurrence of PSE in meat is bound to the genotype for halothane sensitivity controlled by the *HAL* locus (Webb *et al*., 1985). This locus was identified by Fujii *et al*. (1991) on the level of DNA as gene *RYR 1*. Genetic sensitivity to halothane in the recessive genotype (*RYR 1*) causes increased occurrence of meat with PSE properties (Casteels *et al*., 1995). Šimek *et al*. (2002) states that PSE defects in meat may also occur as a result of slow cooling of the dressed carcass. If the dressed carcass is not rapidly cooled after slaughter, this may lead to PSE defects in the pork (Lesiów and Xiong, 2013).

Manipulation of the pigs and their genotype may have an impact on PSE defects in meat and may manifest as changes in muscle pH value or in electric conductivity 1–2 hours after slaughter (Guárdia *et al*., 2004).

Measurement of pH_1 value, measurement of colour paleness using remission and establishment of loss of meat juices through spontaneous dripping are the most frequently used methods, out of the many various methods and criteria, for objective evidence of the deviation in quality in PSE pork (Steinhauser *et al*., 1995). Channon *et al*. (2002) states that PSE defects in meat can be identified on the basis of low pH value, colour (L*value) and loss of meat juiceness through dripping. Measuring pH value 45 minutes post mortem is considered as the most reliable method of establishing PSE defects. The results of some studies indicate that measuring electric conductivity 1 hour post mortem or 24 hours post mortem, is also a suitable method (Van Oeckel *et al*., 1997). The PSE defect is most distinctively and most frequently apparent in the longest back muscle – *Musculus longissimus lumborum et thoracis* (*MLLT*), which is therefore most often used to detect PSE defects (Ingr *et al*., 1993).

PSE defects in meat can be prevented by taking genetic and breeding measures, and also by reducing and eliminating the stressors affecting pigs to be slaughtered during the period before actual slaughter.

The goal of this thesis was to establish the impact of the pH_1 value and the length of carcass on the quality of slaughtered pigs of the hybrid combination (CLW × CL) × D.

MATERIALS AND METHODS

A total of 250 slaughtered pigs of the hybrid combination (Czech Large White × Czech Landrace) × Duroc was included in the experiment. F_1 generation hybrids of Czech Large White × Czech Landrace (CLW × CL) were used as dams and were bred by insemination to boars of the Duroc (D) breed using insemination straws from the boar insemination station, concurrently with breeding to boars from the Duroc breed. The tested animals were slaughtered in selected slaughterhouses.

The pig carcasses were weighed after being slaughtered using an electronic scale on site before the refrigeration unit. The proportion of lean meat was also determined in the individualy tested animals using secondary indicators (thickness of back fat and depth of *MLLT*) using an IS-D-05 electromechanical device and the dressed carcass was classified in the relevant SEUROP sales class.

The IS-D-05 ultrasound device works non-invasively, i.e. the ultrasound sensor acts on a specific site on the dressed carcass and does not mechanically disrupt its integrity.

Data about muscle mass (%), muscle thickness (mm) and back fat thickness (mm) was obtained from each measurement of the carcass.

The regressive equation according to Pulkrábek *et al*. (2008) was used to find the proportion of muscle mass in the dressed carcass using an IS-D-05 device:

$$Y_{IS\text{-}D\text{-}05} = 60.69798 - 0.89211SIS\text{-}D\text{-}05 + 0.10560MIS\text{-}D\text{-}05, \quad (1)$$

whereas:

YIS-D-05 ..... estimated proportion of lean meat in the dressed carcass,

S IS-D-05 .... back fat thickness (including skin) in millimetres, measured 70 mm from the line of the halving cut between the second and third to last rib (measurement known as "P2"),

M IS-D-05... muscle depth in millimetres, measured at the same time and in the same place as SIS-D-05.

This formula is valid for carcasses weighing between 60 and 120 kilograms.

In order to establish PSE defects in the pork the pH_1 value was measured in the *MLLT* 45 minutes after slaughter. The pH value was determined by a 340/SET-1 (WTW) pH-meter Germany with insertable electrode.

The length of the dressed carcass was determined in the tested animals, measured from the cranial edge of the first rib to the cranial edge of the pelvic bone, within the terms of monitoring the traits of carcass value.

The established results of the carcass value of the tested pigs were evaluated according to the pH_1 value and dressed carcass length.

The slaughtered pigs were divided into four groups depending on measured pH_1. The first group of pigs (n = 18) had a measured value of less than 6.00, the second group included pigs (n = 53) with values ranging from 6.00 to 6.20, the third group (n = 76) with values ranging from 6.21 to 6.40 and the fourth contained the most pigs (n = 103), with an established value higher than 6.40.

The pigs were divided into the three following groups on the basis of carcass length: < 800 mm, 800–900 mm, > 900 mm.

Following statistical characteristics were established in relation to the monitored indicators – average (X), standard deviation (SD), minimum value (Min) and maximum value (Max). STATISTICA 12 software was used for statistical evaluation. An ANOVA, Tukey HSD test was used to determine the conclusiveness of differences between respective groups, and the probability of differences was determined at a level of $P < 0.05$ and $P < 0.01$.

RESULTS AND DISCUSSION

Tab. I gives the results of carcass value indicators for all tested slaughtered pigs of the hybrid combination (CLW × CL) × D. The slaughtered tested animals had an average slaughter weight of 120.79 kg, the average muscle mass of the dressed carcasses established during classification was 57.19 ± 2.79%, the average back fat thickness was 14.36 ± 3.89 mm. Lertpatarakomol (2019) *et al.* states that the Duroc breed in Thailand is extensively used for three-breed utility hybridisation in the following combination of breeds: (Large White × Landrace) × Duroc. The slaughtered tested animals of the cited study showed a slaughter weight of 101.67 kg and had a back fat thickness of 18.84 mm.

In the experiment with the hybrid combination (Large White × Landrace) × Large White, Conte *et al.* (2011) found that the slaughtered pigs had back fat thickness of 12.2 mm at a slaughter weight of 105 kg. Suzuki *et al.* (2003) recorded a greater back fat thickness (18 mm) in of hybrid combination (Landrace × Duroc) × Duroc, when slaughtered at 109 kg of weight.

An average pH_1 value of 6.36 was measured in the monitored group of slaughtered pigs in the present study. Vermeulen *et al.* (2015) carried out an experiment at selected slaughterhouses in Belgium, during which they measured pH_1 from February 2012 to May 2012 for a period of 25 days. They established the average pH_1 value (6.16 ± 0.24) in the tested slaughtered pigs, which complies with other European studies according to these authors.

If the measured pH_1 value, which is measured 45 minutes after the pigs are slaughtered, is less than 5.8, this concerns a PSE meat defect. PSE defects were established in the meat of 4 dressed carcasses, which was 1.6% pigs of all those slaughtered. In the study concluded by Jůzl *et al.* (2009) were determined PSE meat defects in two hybrid combinations (CLW × CL) × Pietrain and (CLW × CL) × D. They found PSE in 4.7% of the slaughtered pigs at the hybrid combination (CLW × CL) × Pn and in 2% of the slaughtered pigs of the hybrid combination (CLW × CL) × D. Aaslyng and Hviid (2020) evaluated the level of quality of pork in a random sample of the Danish population of pigs. The PSE meat defect in their study was established in just 2% of the monitored pigs.

In the study concluded by Garcia-Rey *et al.* (2005) give the average pH_1 value (6.45) for the hybrid combination (Landrace × Large White) × Duroc at a dressed carcass weight of 88.21 kg and an identical pH_1 value (6.45) for the hybrid combination (Landrace × Large White) × (Duroc × Large White) at a dressed carcass weight of 90.10 kg.

The average length of the dressed carcass in the pigs in the present study was determined on the level of 842 ± 4.05 mm. Sládek *et al.* (2006) established the effect of pig hybrid combinations on the length of the dressed carcass. In their study they state a lower values for carcass length than those determined in the present study in the monitored hybrid combination. The longest dressed carcass (825mm) in above cited study was registered in relation to the hybrid combination (CLW × CL) × CLW sire line and a statistically conclusive difference of $P < 0.05$ was established when compared to the shortest average dressed carcass in relation to the hybrid combination (CLW × CL) × (Pietrain × Hampshire) (814.1 mm). An average dressed carcass length of 820.1 mm was measured in relation to the three-breed combination of (CLW × CL) × D and an average dressed carcass length of 819.2 mm was measured in relation to the four-breed combination of (CLW × CL) × (Duroc × Hampshire).

As is clear from Tab. II, the average slaughter weight of the pigs fell along with increasing measured pH_1 value. The lowest slaughter weight (118.57 ± 14.68 kg) was found in pigs with a pH_1 value greater than 6.40. On the contrary, the highest average slaughter weight (126.79 ± 16.66 kg) was established in animals with a pH_1 value of less than 6.00. Zhen *et al.* (2013) measured a pH_1 value (6.32 ± 0.05) in pigs of the hybrid combination (Landrace × Large White) × D at a slaughter weight of 90 kg.

In the experiment performed by Moon *et al.* (2003) was found the effect of slaughter weight on the quality of meat in 240 slaughtered hybrids of the combination (Landrace × Yorkshire) × D, and were found that the quality of pork may improve with increasing slaughter weight from 95 kg to 125 kg. It was also concluded that increasing slaughter weight resulted in declining pH_1 value. Authors of this work also stated that no qualitative differences were observed in slaughtered pigs weighing over 125 kg. Kocwin-Podsiadla *et al.* (2002) came to a similar conclusion, when they found that the increasing slaughter weight of pigs had a positive

I: *Carcass value indicators in the tested animals of the pig hybrid combination (CLW × CL) × D (n = 250)*

Traits	X	SD	Min–Max
Slaughter weight (kg)	120.79	15.34	81.30–152.90
Carcass weight (kg)	94.00	11.94	63.30–119.00
Proportion of lean meat (%)	57.19	2.79	45.60–62.50
Depth of *MLLT* (mm)	61.77	9.15	30.20–85.50
Back fat thicknes (mm)	14.36	3.89	6.50–31.00
pH_1 value	6.36	0.26	5.67–7.04
Carcass length (mm)	842.00	4.05	750.00–990.00

x – Average, SD – Standard deviation, n – Number

II: *Indicators of the carcass value of pigs depending on the measured pH_1 value*

Traits	< 6.00 (n = 18)	6.00–6.20 (n = 53)	6.21–6.40 (n = 76)	> 6.40 (n = 103)
	X ± SD	X ± SD	X ± SD	X ± SD
pH_1 value	5.87 ± 0.09	6.12 ± 0.06	6.30 ± 0.06	6.62 ± 0.15
Slaughter weight (kg)	126.79 ± 16.66	124.17 ± 15.72	120.00 ± 15.17	118.57 ± 14.68
Back fat thicknes (mm)	15.02 ± 5.32	15.09 ± 4.24	13.55 ± 3.17	14.47 ± 3.85
Depth of *MLLT* (mm)	65.59 ± 8.51	62.32 ± 7.93	62.63 ± 9.74	60.18 ± 9.20
Proportion of lean meat (%)	56.87 ± 3.75	56.72 ± 2.99	57.68 ± 2.46	57.12 ± 2.70
Price per 1 kg dressed carcass (CZK)	42.49^a ± 4.30	43.34 ± 3.38	44.50^b ± 2.29	43.89 ± 2.84
Carcass length (mm)	846 ± 3.20	854 ± 3.46	837 ± 4.36	839 ± 4.16

x – Average, SD – Standard deviation, n - Number
a, b: means with different superscripts are significantly different at P < 0.01

impact on muscle acidity measured 45 minutes after the animal was slaughtered, which also led to increased water retaining capacity, to lower loss of water through dripping and lower loss of water during the culinary processing of the meat.

Egea *et al.* (2016) performed an analysis of dressed carcass quality in 90 pigs of the hybrid combination Iberian × Duroc. Within the terms of their experiment they recorded an average pH_1 value (6.30) in barrows at a slaughter weight of 155 kg and an average pH_1 value (6.13) in gilts at a slaughter weight of 146 kg.

Luo *et al.* (2018) measured pH 45 minutes after slaughter in 8,188 pigs. On the basis of their testing they found that purebred pigs had a lower average pH_1 value (6.53 ± 0.01) compared to hybrid pigs (6.59 ± 0.01).

In the present study the lowest average back fat thickness was found in pigs with a measured pH_1 value ranging from 6.21 to 6.40.

Higher average proportion of lean meat values were registered in pigs with a higher measured pH_1 value, i.e. in pigs with a pH_1 value ranging from 6.21 to 6.40 and in the group with the pH_1 value greater than 6.40.

Wojtysiak and Połtowicz (2014) monitored the slaughter weight in 20 pigs of the Puławska breed and in 30 pigs of the Polish Large White breed. In their study they give an average measured pH_1 value (6.78) in the Puławska breed, with average fat back thickness values (23.64 mm), with 45.30% lean meat. They give an average pH_1 value (6.45), with an average back fat thickness value (13.22 mm) and an average 55.48% lean meat, for the Polish White breed.

The highest average price per 1 kg of dressed carcass (44.50 ± 2.29 CZK) in the present study was established in pigs, which had a measured pH_1 value ranging from 6.21 to 6.40. On the contrary, the lowest average price per 1 kg dressed carcass (42.49 ± 4.30 CZK) was determined for pigs with a measured pH_1 value of < 6.00. There was a statistically conclusive difference (P < 0.01) between the average price per 1 kg of dressed carcass in slaughtered pigs in the group with a pH_1 value lower than 6.00, or more precisely ranging from 6.21 to 6.40.

The longest dressed carcass at the present study was measured in pigs with a pH_1 value ranging from 6.00 to 6.20, on the contrary, the shortest average dressed carcass was measured in hybrids with a pH_1 value ranging from 6.21 to 6.40.

Tab. III gives selected carcass value indicators according to the measured dressed carcass length. The slaughter weight of pigs increased along with increasing measured values of the length of the dressed carcass, i.e. the greatest average slaughter

III: *Indicators of the carcass value of pigs depending on the length of the dressed carcass*

Traits	< 800 mm (n = 29)	800–900 mm (n = 209)	> 900 mm (n = 12)
	X ± SD	X ± SD	× ± SD
Carcass length (mm)	778 ± 1.32	846 ± 2.99	929 ± 2.35
Slaughter weight (kg)	104.36^a ± 16.28	122.41^b ± 13.65	132.17^c ± 15.07
Back fat thicknes (kg)	12.97^a ± 4.38	14.42 ± 3.71	16.79^b ± 4.74
Depth of *MLLT* (mm)	56.27 ± 8.43	62.42 ± 9.08	63.75 ± 7.99
Proportion of lean meat (%)	58.09^a ± 3.02	57.16 ± 2.68	55.58^b ± 3.39
Price per 1 kg dressed carcass (CZK)	43.67^a ± 2.51	44.03^a ± 2.95	41.20^b ± 3.38
pH_1 value	6.37 ± 0.22	6.36 ± 0.27	6.45 ± 0.30

x – Average, SD – Standard deviation, n - Number
a, b, c: means with different superscripts are significantly different at P < 0.01

weight of 132.17 ± 15.07 kg was registered in the longest pigs with a dressed carcass length of over 900 mm. The lowest average slaughter weight was registered in pigs, which had a dressed carcass length of less than 800 mm.

According to expectations, the values of back fat thickness and muscle depth increased along with increasing dressed carcass length. The greatest average lean meat percentage of 58.09 ± 3.02 was registered in pigs with a dressed carcass length of less than 800 mm. On the contrary, the lowest average percentage of lean meat, of 55.58 ± 3.39, was found in dressed carcasses with a length of over 900 mm. Matoušek *et al.* (2001) measured the average dressed carcass length values at 210 days of age, in barrows at 822.0 mm and in gilts at 818.0 mm, in the hybrid combination (Large White × Landrace) × (Belgian Landrace × Duroc). In their study they state that the dressed carcass length, measured from the cranial edge of the first rib to the cranial edge of the pelvic bone, increases with increasing age. Wojtysiak and Połtowicz (2014) measured the average dressed carcass length (776 mm) in pigs from the Puławska breed with a lower slaughter weight (100 kg) than tested pigs of the present study and in pigs of the Polish Large White breed the dressed carcass length was 811 mm at 100 kg slaughter weight. Egea *et al.* (2016) performed an analysis of dressed carcass quality in 90 pigs of the hybrid combination Iberian × Duroc. Within the terms of their experiment they recorded an average dressed carcass length of 893 mm in barrows, at a slaughter weight of 155 kg, and an average dressed carcass length of 896 mm in gilts, at a slaughter weight of 146 kg.

Statistically conclusive differences on the level of significance of P < 0.01 were determined between the prices per 1 kg of dressed carcass in the present study. The greatest average price of 44.03 ± 2.95 CZK per 1 kg of dressed carcass was registered in the group of pigs with a dressed carcass length ranging from 800 to 900 mm. The lowest average price of 41.20 ± 3.38 CZK was found in pigs, where their dressed carcass length was measured at over 900 mm.

The greatest average pH_1 value (6.45 ± 0.30) was found in pigs with a dressed carcass length of over 900 mm.

CONCLUSION

On the basis of the results obtained from measuring of pH_1 value it can be stated that the slaughtered pigs of the monitored hybrid combination (CLW × CL) × D were of very high quality, because PSE meat defects were only found in 1.6% of all the slaughtered pigs.

The average slaughter weight fell along with increasing measured pH_1 value. Greater lean meat percentage values were registered in pigs with higher measured pH_1 value. The highest average price per 1 kg of dressed carcass was established in pigs, which had a measured pH_1 value ranging from 6.21 to 6.40. On the contrary, the lowest average price per 1 kg of dressed carcass was determined for pigs with a measured pH_1 value of < 6.00. The average slaughter weight of the pigs increased along with the increasing values of the length of the dressed carcass. The greatest average price of 44.03 CZK per 1 kg of dressed carcass was registered in the group of pigs with a dressed carcass length ranging from 800 to 900 mm. The lowest average price per 1 kg of dressed carcass was found in pigs, if the dressed carcass length was measured at over 900 mm.

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