

# Effect of transport, rest period and temperature on pork quality from different countries

## Vplyv transportu, doby odpočinku a teploty na kvalitu bravčového mäsa z rôznych krajín

Juraj MLYNEK<sup>1</sup>, Ivan IMRICH<sup>2\*</sup>, Wojciech KAPELAŃSKI<sup>3</sup> and Eva MLYNEKOVÁ<sup>1</sup>

<sup>1</sup> Slovak University of Agriculture, Department of Animal Husbandry, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic

<sup>2</sup> Slovak University of Agriculture, Department of Veterinary Sciences, Tr. A. Hlinku 2, 949 76 Nitra, Slovak Republic, phone: +421-37-6414505, e-mail:ivan.imrich@gmail.com\* correspondence

<sup>3</sup> University of Technology and Life Science, Faculty of Animal Breeding and Biology, ul. Mazowiecka 28, 85-084 Bydgoszcz, Kujawsko-Pomorskie, Poland

### Abstract

The aim of the experiment was to assess the pig meat quality in relation to pre-slaughter conditions and import country. In the experiment, the meat quality of 1980 pigs was evaluated. The animals were divided into three groups according to country of import (Slovakia, Hungary and Netherlands). The following pre-slaughter indicators were evaluated: duration of transport, duration of housing, temperature during housing and transport. The meat quality was judged on the basis of the pH<sub>1</sub> value measured 45 minutes after the slaughter in the *musculus longissimus dorsi* – pH<sub>1</sub> MLD and in the *musculus semimembranosus* – pH<sub>1</sub> MSM. The highest frequency of PSE (pale, soft, exudative) meat in the MLD was in the group of pigs imported from Slovakia (24.13 %). These pigs had also statistically significant ( $P < 0.01$ ) the lowest average pH<sub>1</sub> MLD (6.05) in comparison with other imports. The incidence of PSE meat in the MSM was in all evaluated groups above 10 %. Group of pigs from Slovakia had the lowest value of pH<sub>1</sub> MSM (6.23) in comparison with other groups of pigs ( $P < 0.01$ ). Even though the average length of housing in a slaughterhouse was from 11.26 to 15.43 hours high incidence of PSE meat was recorded. However group of pigs with the longest rest period (15.43 hours - Netherlands) had significantly higher pH<sub>1</sub> MLD and pH<sub>1</sub> MSM compared to other imports ( $P < 0.01$ ). From these results can be concluded that the incidence of PSE meat in evaluated groups is relatively high. Prolonging rest period and lower temperatures had positively influence on the incidence of PSE meat and pH value.

**Keywords:** pork quality, rest period, temperature, transport

### Abstrakt

Cieľom experimentu bolo posúdiť kvalitu bravčového mäsa vo vzťahu k podmienkam pred porážkou a krajine dovozu. V experimente bolo hodnotených 1980 ošípaných. Zvieratá boli rozdelené do troch skupín podľa krajiny dovozu (Slovensko, Maďarsko,

Holandsko). Sledovali sme čas transportu, čas ustajnenia, teplotu počas transportu a ustajnenia. Kvalita mäsa bola posudzovaná na základe hodnôt  $pH_1$  meraných 45 minút po zabití v *musculus longissimus dorsi* –  $pH_1$  MLD a v *musculus semimembranosus* –  $pH_1$  MSM. Najväčší výskyt PSE (bledé, mäkké, vodnaté) mäsa v MLD bol v skupine ošípaných zo Slovenska (24,13 %). Tieto ošípané mali zároveň štatisticky preukazne najnižšiu ( $P < 0.01$ ) priemernú hodnotu  $pH_1$  MLD (6,05) v porovnaní s inými krajinami. Výskyt PSE mäsa v MSM bol vo všetkých skupinách nad 10 %. Skupina ošípaných zo Slovenska mala najnižšiu hodnotu  $pH_1$  MSM (6,23) v porovnaní s ostatnými skupinami ( $P < 0,01$ ). Aj keď priemerná dĺžka ustajnenia na bytúnku bola na úrovni 11,26 až 15,43 hodín, vysoký výskyt PSE mäsa bol zaznamenaný. Avšak skupina ošípaných s najdlhším odpočinkom (Holandsko – 15,43 hodín) mala preukazne vyššiu hodnotu  $pH_1$  MLD a  $pH_1$  MSM v porovnaní s ostatnými krajinami ( $P < 0,01$ ). Z uvedených výsledkov môžeme konštatovať že vo všetkých skupinách ošípaných bol zaznamenaný relatívne vysoký výskyt PSE mäsa a s predlžovaním doby odpočinku hodnota  $pH$  v mäse sa zvyšovala.

**Kľúčové slová:** kvalita mäsa, odpočinok, teplota, transport

## Detailný abstrakt

Pre konzumentov, ako aj pre mäsový priemysel je dôležité, aby bravčové mäso malo vyhovujúcu kvalitu. Stres počas transportu a ustajnenia na bytúnku má negatívny vplyv na welfare zvierat a kvalitu ich mäsa. V súvislosti s uvedenou problematikou, cieľom experimentu bolo posúdiť kvalitu bravčového mäsa vo vzťahu k podmienkam pred porážkou a krajine dovozu. V experimente bolo hodnotených 1980 ošípaných, mäsových hybridov s hmotnosťou od 100 do 130 kg. Zvieratá boli rozdelené do troch skupín podľa krajiny dovozu (Slovensko, Maďarsko, Holandsko). Sledovali sme čas transportu v hodinách, čas ustajnenia v hodinách, teplotu počas transportu a ustajnenia v °C. Kvalita mäsa bola posudzovaná na základe hodnôt  $pH_1$  meraných 45 minút po zabití v *musculus longissimus dorsi* –  $pH_1$  MLD a v *musculus semimembranosus* –  $pH_1$  MSM. Výsledky boli spracované v programe SPSS 11.0. Najväčší výskyt PSE (bledé, mäkké, vodnaté) mäsa v MLD bol v skupine ošípaných zo Slovenska (24,13 %). Tieto ošípané mali zároveň štatisticky preukazne najnižšiu ( $P < 0.01$ ) priemernú hodnotu  $pH_1$  MLD (6.05) v porovnaní s inými krajinami. Najnižší výskyt PSE mäsa v MLD (13,8 %) bola v skupine ošípaných dovezených z Holandska (tabuľka 1). Výskyt PSE mäsa v MSM bol vo všetkých skupinách nad 10 %. Skupina ošípaných zo Slovenska mala najnižšiu hodnotu  $pH_1$  MSM (6,23) v porovnaní s ostatnými skupinami, tento rozdiel bol štatisticky preukazný ( $P < 0,01$ ) (tabuľka 2). Aj keď priemerná dĺžka ustajnenia na bitúnku bola na úrovni 11,26 až 15,43 hodín (tabuľka 3), v jednotlivých skupinách bol zaznamenaný vysoký výskyt PSE mäsa. Avšak skupina ošípaných s najdlhším odpočinkom (Holandsko – 15,43 hodín) mala preukazne vyššiu hodnotu  $pH_1$  MLD a  $pH_1$  MSM ( $P < 0.01$ ) v porovnaní s ostatnými skupinami, ktoré mali kratšiu dobu ustajnené na bitúnku (tabuľka 1 a 2). Z uvedených výsledkov môžeme konštatovať že vo všetkých skupinách ošípaných bol zaznamenaný relatívne vysoký výskyt PSE mäsa a s predlžovaním doby odpočinku hodnota  $pH$  v mäse sa zvyšovala. U ošípaných dovezených zo Slovenska bola zaznamenaná maximálna vonkajšia teplota počas transportu a ustajnenia na úrovni 25,3 °C. To mohlo spôsobiť, že aj napriek krátkemu transportu, ošípané zo Slovenska mali najvyšší výskyt PSE mäsa.

Záverom môžeme konštatovať že vo všetkých skupinách ošípaných bol zaznamenaný relatívne vysoký výskyt PSE mäsa. V rámci všetkých hodnotených zvierat výskyt PSE v MLD bol na úrovni 19,44 % a v MSM na úrovni 12,68 %. Z výsledkov ďalej vyplýva, že dlhšia doba odpočinku na bitúnku a nižšie teploty počas transportu a ustajnenia majú pozitívny vplyv na výskyt PSE mäsa a hodnotu pH.

## Introduction

Primary importance for breeders is the economy of pig production (Šprysl, et al., 2010) but for the consumers as well as for the meat industry, it is very important that the pork will be in good quality. Pre-slaughter stress has a negative impact on animal welfare and meat quality (D'Eath, et al., 2010). The quality of pork is the result of a production system, as the combination of genetic, rearing condition (Hluchý and Eliáš 2006; Hluchý, et al., 2007), age and weight at slaughter, handling, stress (Majorano, et al., 2012), health (Rolinec, et al., 2010), as well as cooking method (Sinha, et al., 2009). Transportation conditions such as noise, loading and unloading, fighting due to the mixing of unfamiliar pigs and stocking too many animals in a truck mean severe stress for the animal resulting in an accelerated post-mortem glycolysis and impaired meat quality (Smulders and van Laack, 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. Demo (2002) states that meat quality indicators are the features of low heredity and then the final quality of raw material mostly depends on the conditions of the outside environment, especially on the conditions before, during and after slaughter. Pulkrábek, et al. (2003) claim that PSE meat detection is fairly complicated and that this is the reason why its coincidental occurrence is often deduced from the common practice based on the pH<sub>1</sub> values. The aim of the experiment was to assess the pig meat quality of fattening pigs in relation to pre-slaughter conditions and import country.

## Material and methods

In the experiment, the meat quality of 1980 pigs was evaluated. The meat hybrid pigs that were tested in the experiment were the crossbred of the White thoroughbred and Landrass pig breeds with the terminal, extremely heavy- muscled hogs. Their weight went from 100 to 130 kg. The animals were divided into three groups according to countries of import. The following pre-slaughter indicators were evaluated: transport time in hours, housing time in hours, temperature during housing in °C and temperature during transport in °C. The meat quality was judged on the basis of the pH<sub>1</sub> value measured 45 minutes after the slaughter of animals. Measuring the acidity rate in the carcass halves was observed in the thorax part of the longest back muscle between the next to last and the last breast vertebrae (*musculus longissimus dorsi, pars thoracis* – MLD) and from the geometric center of the semimembranous thigh muscle (*musculus semimembranosus* – MSM). The actual pH acidity in muscles was stated directly in the muscle tissue by means of the contact electrode, the TITANx apparatus. The method measuring the pH value 45 minutes after slaughter enable to identify the PSE meat (pale-, soft-, exudative), if the pH value falls down below 5.8 (Demo, 2002). The results were processed in the SPSS 11.0 program. Differences between groups were tested using analysis of variance with contrasts testing using Tukey HSD test.

## Results and discussion

In total 1980 pigs were analyzed in the experiment. The highest frequency of PSE meat in the MLD was in the group of pigs imported from Slovakia (24.13 %). These pigs had also statistically significant ( $P < 0.01$ ) the lowest average  $pH_1$  MLD (6.05) in comparison with other imports. The lowest incidence PSE meat in the MLD was in the group of pigs imported from the Netherlands (13.8 %). The average value  $pH_1$  MLD within all pigs was on the level 6.1 with variability 4.7 %. Statistically significant difference was also among pigs imported from Hungary and the Netherlands (table 1). In contrast to our results Lebret, et al. (2006) found out that pigs from conventional system of farming had pH value (30 minutes after slaughter) on the level 6.42 in longissimus muscle. The incidence of PSE meat in the MSM was in all evaluated groups above 10 %. Average value of the  $pH_1$  MSM within all pigs was recorded on the level 6.26 with variability 5.29 %. In this indicator group of pigs from Slovakia had lower value of  $pH_1$  MSM (6.23) in comparison with other groups of pigs, it was statistical significant ( $P < 0.01$ ) (table 2). Lebret, et al. (2006) found out pH value (30 minutes after slaughter) on the level 6.46 in semimembranosus muscle.

Table 1:  $pH_1$  and the incidence of PSE meat in the MLD

Indicator	Slovakia	Hungary	Netherlands	Together
n	837	565	578	1980
min	5.4	5.4	5.4	5.4
max	6.8	6.8	6.9	6.9
x	6.05 <sup>a</sup>	6.11 <sup>b</sup>	6.17 <sup>c</sup>	6.1
s	0.28	0.28	0.29	0.29
v%	4.65	4.54	4.71	4.7
% PSE	24.13	18.05	13.8	19.44

Legend: n-number of pigs, min-minimum, max-maximum, x-average, s-standard deviation, v%-variation coefficient in %, % PSE-incidence of PSE meat in %, <sup>a,b,c</sup>  $P < 0.01$

Table 2:  $pH_1$  and the incidence of PSE meat in the MSM

Indicator	Slovakia	Hungary	Netherlands	Together
n	837	565	578	1980
min	5.4	5.4	5.4	5.4
max	6.9	6.9	6.9	6.9
x	6.23 <sup>a</sup>	6.27 <sup>b</sup>	6.29 <sup>b</sup>	6.26
s	0.32	0.35	0.33	0.33
v%	5.08	5.59	5.25	5.3
% PSE	13.5	13,27	10,9	12.68

Legend: x-average, s-standard deviation, v%-variation coefficient in %, % PSE-incidence of PSE meat in %, <sup>a,b</sup>  $P < 0.01$

The longest average transit time (19.4 hours) was observed in pigs imported from the Netherlands. Animals imported from Slovakia were transported the shortest time (1.42 hours). The longest housing time in the slaughterhouse (15.43 hours) was provided to pigs imported from the Netherlands (table 3). Mota-Rojas, et al. (2009) find out that the animals without any rest before slaughter can show hemodynamic

and metabolic alterations that lead to hyperglycemia, lactic acidosis and to an abrupt descent of the pH value altering the carcass color. Young, et al. (2009) had investigated that the physical load increased the temperature of muscles, but decreased CP and ATP, the content of glycogen, and especially pro-glycogen in the slaughtered pigs, when they were slaughtered immediately after the load. They have found out that just one hour of rest after the physical load was enough to normalize these effects. Chai, et al. (2010) find out that high-density or long distance transport may markedly influence the blood constituents as well as meat quality. Pigs subjected to longer distance transport and higher-density would need longer lairage time to recovery. Smiecinska, et al. (2011) found out that pigs slaughtered immediately after transport and pigs slaughtered after a 24-hour rest period, were characterized similar incidence of normal-quality meat, partially PSE meat and PSE meat in both groups. Even though the average length of housing in a slaughterhouse was from 11.26 to 15.43 hours (table 3) high incidence of PSE meat was recorded in our experiment. However group of pigs with the longest rest period (15.43 hours - Netherlands) had significantly higher pH<sub>1</sub> MLD and pH<sub>1</sub> MSM (table 1 and 2) in comparison with pigs from other countries, which had shorter rest period. Similarly Nanni Costa, et al. (2002) state that prolonging holding time before slaughter from 2 to 22 h reduces the incidence of PSE meat. Sutherland, et al. (2009) reported that temperatures above 20 °C increase transportation deaths. In pigs imported from Slovakia, the maximum outdoor temperature during transportation and housing were recorded on the level 25.3 °C, while the average outdoor temperature during transportation was 11.94 °C and average temperature of the housing was 12.54 °C (table 3). This could cause that, despite the short transport, the pigs from Slovakia had the highest incidence of PSE meat and the lowest average values of pH<sub>1</sub> MLD and MSM.

Table 3: Outdoor temperature and time of transportation and housing

		Slovakia	Hungary	Netherlands
Transport time in hours	min	1	3	16
	max	2	7	21
	x	1.42	4,43	19.4
Housing time in hours	min	1	10	3
	max	41	21	25
	x	11,26	14.86	15,43
Temperature during transport in °C	min	-0.9	0.2	-0.8
	max	25.3	22.2	14.3
	x	11.94	12.36	5.33
Temperature during housing in °C	min	-0.9	-0.9	0.2
	max	25.3	24	13.8
	x	12.54	12.93	5.44

Legend: min-minimum, max-maximum, x-average

From these results can be concluded, that the incidence of PSE meat in the MLD (19.44%) is relatively high. The lower incidence of PSE meat (12.68%) was in the MSM. These values can be regarded as alarming, because the incidence of PSE meat we would like to have maximum to 5% (Demo and Hetényi 2002).

## Conclusions

Fattening pigs imported from the Slovakia, Hungary and Netherlands were used in the experiment. The average value pH<sub>1</sub> MLD within all pigs was on the level 6.1. The lowest incidence PSE meat in the MLD was in the group of pigs imported from the Netherlands (13.8 %). The highest frequency of PSE meat in the MLD was in the group of pigs imported from Slovakia (24.13 %). In pigs imported from Slovakia, the maximum outdoor temperature during transportation and housing were recorded on the level 25.3 °C. This could cause that, despite the short transport the pigs from Slovakia had the highest incidence of PSE meat. Average value of the pH<sub>1</sub> MSM within all pigs was recorded on the level 6.26 and the incidence of PSE meat in the MSM was in all evaluated groups above 10 %. From these results can be concluded that the incidence of PSE meat in evaluated groups is relatively high. Prolonging rest period and lower temperatures positively influence on the incidence of PSE meat and pH value.

## References

- Chai, J., Xiong, Q., Zhang, C.X., Miao, W., Li, F.E., Zheng, R., Peng, J., Jiang, S.W. (2010) Effect of pre-slaughter transport plant on blood constituents and meat quality in halotane genotype of NN Large White×Landrace pigs. *Livestock science*, 127(2-3), 211-217.
- D'Eath, R. B., Turner, S. P., Kurt, E., Evans, G., Thoelking, L., Looft, H., Wimmers, K., Murani, E., Klont, R., Foury, A., Ison, S. H., Lawrence, A. B., Mormede, P. (2010) Pigs' aggressive temperament affects pre-slaughter mixing aggression, stress and meat quality. *Animal*, 4(4), 604-616.
- Demo, P., Hetényi, L. (2002) Chov ošípaných. In: Brestenský, V., et al. (2002) *Sprievodca chovateľa hospodárskych zvierat*. Nitra:VÚŽV, p. 101.
- Demo, P. (2002) Produkty ošípaných a ich kvalita. In: Brestenský, V., et al. (2002) *Sprievodca chovateľa hospodárskych zvierat*. Nitra:VÚŽV, p. p. 130-134.
- Guàrdia, M. D., Estany, J., Balasch, S., Oliver, M. A., Gispert, M., Driestre, A. (2004) Risk assessment of PSE condition due to pre-slaughter conditions and RYR1 gene in pigs. *Meat Science*, 67(3), 471–478.
- Hluchý, S., Eliáš, Z. (2006) Differences in musculus semimembranosus structure between pure breed and hybrid pigs. *Scientific Papers Animal Sciences and Biotechnologies*, 39(1), 221-226.
- Hluchý, S., Eliáš, Z., Toman, R. (2007) Histological structure of *musculus longissimus dorsi* in pigs with the same ryanodine receptor genotype (CC) in relation to feeding indicators. *Scientific Papers Animal Sciences and Biotechnologies*, 40(1), 361-368.
- Lebret, B., Meunier-Salaün, M. C., Foury, A., Mormède, P., Dransfield, E., Dourmad, J. Y. (2006) Influence of rearing conditions on performance, behavioral, and

- physiological responses of pigs to preslaughter handling, carcass traits, and meat quality. *Journal of Animal Science*, 84(9), 2436-2447.
- Majorano, G., Kapelaňsky, W., Bocian, M., Pizzuto, R., Kapelaňska, J. (2012) Influence of rearing system, diet and gender on performance, carcass traits and meat quality of Polish Landrace pigs. *Animal*, 7(2), 341-347.
- Mota-Rojas, D., Herrera, M. B., Trujillo-Ortega, M. E., Alonso-Spilsbury, M., Flores-Peinado, S. C., Guerrero-Legarreta (2009) Effects of Pre-Slaughter Transport, Lairage and Sex on Pig Chemical Serologic Profiles. *Journal of Animal and Veterinary Advances*, 8(2), 246-250.
- Nanni Costa, L., Lo Fiego, D.P., Dall'olio, S., Davoli, R., Russo, V. (2002) Combined effects of pre-slaughter treatments and lairage time on carcass and meat quality in pigs of different halothane genotype. *Meat Science*, 61(1), 41-47.
- Pulkrábek, J., Pavlík, J., Vališ, L. (2003) Kvalita mäsa s ohľadom na mäsnatosť ošípaných. *Slovenský chov*, 8(6), 26.
- Rolinec, M., Bíro, D., Šťastný, P., Kanka, T. (2010) Analyzis of haematological profile of piglets in early postnatal period. *Acta fytotechnica et zootechnica*, 13(special), 40-43.
- Sinha, R., Park, Y., Graubard, B.I., Leitzmann, M.F., Hollenbeck, A., Schatzkin, A., Cross, A.J. (2009) Meat and meat-related compounds and risk of prostate cancer in a large prospective cohort study in the United States, *American Journal of Epidemiology*, 170(9), 165-1177.
- Smulders, F.J.M., van Laack, H.L.J.M. (1991) Pre-slaughter animal handling and fresh meat processing. *Proceedings 37th International Congress Meat Science Technology*. Kulmbach, Germany, September 1-6.
- Smiecinska, K., Denaburski, J., Sobotka, W. (2011) Slaughter value, meat quality, creatine kinase activity and cortisol levels in the blood serum of growing-finishing pigs slaughtered immediately after transport and after a rest period. *Polish Journal of Veterinary Sciences*, 14(1), 47-54.
- Sutherland, M. A., McDonald, A., McGlone, J. J. (2009) Effects of variations in the environment, length of journey and type of trailer on the mortality and morbidity of pigs being transported to slaughter. *Veterinary Record*, 165(1), 13-18.
- Šprysl, M., Čítek, J., Stupka, R. (2010) Interaction of selected production indicators of the economics of pork production. *Czech Journal of Animal Science*, 55(1), 1-10.
- Young, J.F., Bertram, H.C., Oksbjerg, N. (2009) Rest before slaughter ameliorates pre-slaughter stress-induced increased drip loss but not stress-induced increase in the toughness of pork. *Meat Science*, 83(4), 634-641.

## Acknowledgment

This article has been created with the support of VEGA 1/0493/12-Qualitative and production parameters of animal with regard to pre-slaughter factors, nutrition, technique and breeding technology.