Acta Agraria Kaposváriensis (2014) Vol 18 Supplement 1, 109-114.
Kaposvári Egyetem, Agrár- és Környezettudományi Kar, Kaposvár
Kaposvár University, Faculty of Agricultural and Environmental Sciences, Kaposvár

Stress indicators and meat quality of pigs affected by different durations of lairage time

B. Lukić[1], I. Djurkin Kušec[1], D. Ovničević[2], S. Mandić[3], M. Đidara[1], M. Šperanda[1], G. Kušec[1]

[1]Josip Juraj Strossmayer University of Osijek, Faculty of Agriculture, Kralja Petra Svačića 1d, 31000 Osijek, Croatia
[2]Veterinarska stanica Valpovo d.o.o. Matije Gupca 36, 31550 Valpovo, Croatia
[3]University Hospital Centre Osijek, Department of Clinical Laboratory Diagnostics, Josipa Huttlera 4, 31000 Osijek, Croatia

ABSTRACT

Objective of this study was to investigate the effect of lairage time pigs on stress indicators and meat quality. The study was performed on 90 barrows and gilts divided into three groups according to lairage time: 0 h, 6 h and 24 hours. Blood samples were taken after exsanguination and glucose, lactate, cortisol, as well as activity of creatine kinase were determined. At the slaughter line and in laboratory pH values in ham and LD muscle 45 minutes and 24 h after slaughter, as well as meat colour coordinates (L, a*, b*), drip loss, cooking loss and instrumental tenderness were measured.. Concentrations of blood stress parameters were highest in the first group (0h lairage time). Statistical analysis showed a significant effect of resting before slaughter on final pH values measured 24 hours after slaughter in ham. Moreover, resting time had a significant effect on L* and a* values and showed tendency to decrease EZ drip (%) as lairage time increased. Pigs slaughtered without rest prior to slaughter showed higher levels of stress and tend to have less desirable meat quality traits.*
(Key words: pigs, lairage time, stress, blood parameters, meat quality traits)

INTRODUCTION

Pigs are very sensitive to various types of stress, especially at the end of production before slaughter. Length of transport, i.e. the distance from the farm to slaughterhouse and non-adequate loading and unloading induces stress on both behavioural and physiological levels.

Apart the negative effect of high stress on animal welfare, meat quality could also be significantly affected. Studies showed (*Perre et al.*, 2010; *Gispert et al.*, 2000) that transport could affect meat pH values or increase the proportion of DFD (dark, firm, dry) or PSE (pale, soft, exudative) conditions. Drip loss values could also be affected (*Murray and Jones*, 1994). These undesirable effects can be diminished by allowing pigs to recover with optimum lairage time which is, according to *Nanni et al.* (2002) considered as the most important factor prior to slaughter that affects meat quality. *Warris* (2003) reported that optimal lairage time should be 1-3 hours since shorter times were usually associated with the PSE meat. On the other side, longer lairage was associated with more aggressive behaviour, more skin damage and a lower carcass yield. In addition, recommendations for length of lairage time are different regarding the country's geographical location (*Warris*, 2003). In southern European countries where temperatures in certain part of the year are very high, shorter lairage is recommended.

By measuring some of the indicators of stress like glucose, lactate, creatine kinase and cortisol from the blood, level of stress arisen before slaughter with its possible effect on important meat quality traits can be determined. *Salajpal et al.* (2005) determined that a long period of rest reduces glucose levels in blood and produces the signs of muscle tissue deterioration. *Šmeiecinska et al.* (2011) found different levels of stress in pigs slaughtered immediately after transport than those with 24 h lairage time. Although there were no differences in the incidence of PSE meat, pigs with 24h lairage time had more favourable sensory attributes of meat.

Objective of this study was to investigate the effect of lairage time on stress indicators and meat quality traits of pigs.

MATERIAL AND METHODS

Animals and experimental design

The study was performed on 90 pigs divided into three equally sized groups. The pigs were commercial hybrids, fattened to 110–120 kg live weight on family farms in the eastern part of Croatia. All farms were located approximately 100 kilometres away from the slaughterhouse. Transport of animals to the slaughterhouse was carried out in trucks with 180, 150, and 160 pigs per each load. Loading of the pigs in each of the trucks lasted for approximately 100 minutes followed with approximately 100 minutes of transport. Unloading of the pigs at the slaughterhouse lasted approximately 30 minutes. Pigs from all three groups were unloaded to slaughterhouse in the morning hours. Animals from the first group were slaughtered immediately after loading, the second group had 6 h lairage time and the third rested for 24 h prior to slaughter.

Blood samples and stress indicators

After stunning the animals with CO_2 and before incision of blood vessels and exsanguination blood samples were collected by venepuncture into two tubes. Tube without anticoagulants served for glucose, creatin-kinase activity and cortisol concentrations, while sodium fluoride-potassium oxalate tubes served for lactate determination. The concentrations of glucose (mmol/L; GLU), lactic acid (mmol/L; LA) and creatin-kinase activity (U/L; CK) were determined by automatic biochemical analyser Beckman Coulter AU400 randomly with up to 400 photometric tests per hour. The concentration of cortisol (nmol/L; COR) in pigs was measured by electrochemiluminescence immunoassay "ECLIA" (Roche Elecsys 2010, Roche Diagnostics, Mannheim, Germany). Reproducibility was determined using an Elecsys reagents six times a day, 10 days in total (n=60). The intra- and inter- assay variation coefficient were <1.1% and <1.6% for the lowest detection limit.

Meat quality traits

Meat quality traits were measured in loin (*m. longissimus dorsi* - *LD*) and ham (*m. semimembranosus* – *MS*). At the slaughter line, pH values were measured 45 minutes (pH_{45}) and 24 hours (pH_{24}) *post mortem* using digital pH-meter "Mettler MP 120-B". Drip loss was measured by "bag method" according to *Honikel* (1987) and as EZ drip (*Christensen*, 2003). Meat colour coordinates were measured 24 h *post mortem* by "Minolta CR-300" device on *LD* muscle and expressed as L*, a* and b* values. Instrumental tenderness was analysed on a 2.54 cm thick chops of *LD* muscle that were frozen, defrosted for 24 h at 4 °C, sealed in vacuum bags, cooked in water bath to 73 °C internal temperature and cooled at 4°C overnight. Shear force was measured on at least

six 1.27 mm thick chops using a TA.XTplus Texture Analyser. Cooking loss was assessed from *LD* samples used for instrumental tenderness measurement. It was calculated from weights taken before and after cooking and expressed as a percentage.

Statistical analyses

GLM procedure of Statistica for Windows software (StatSoft 2007-2010) was used to examine the effect of lairage time on stress indicators and meat quality traits of investigated pigs. The groups were compared for all traits using Tukey's range test ($p<0.05$).

RESULTS AND DISCUSSION

Effect of lairage time on stress indicators

Table 1

Least square means and standard errors (in brackets) for biochemical stress indicators in relation to lairage times

Blood parameter	Lairage time			Significance
	0h	6h	24h	
Lactate (mmol/L)	5.10^{a} (0.39)	3.95^{b} (0.30)	3.91^{b} (0.30)	*
Glucose (mmol/L)	4.68^{a} (0.10)	4.07^{b} (0.18)	4.50^{ab} (0.08)	**
Creatin-kinase (U/L)	12049.36^{a} (1767.05)	5379.76^{b} (889.69)	3085.33^{c} (448.11)	***
Cortisol (nmol/L)	248.26^{a} (21.00)	124.71^{b} (13.29)	105.32^{b} (8.93)	***

*** = $p<0.001$; ** = $p<0.01$; *=$p<0.05$; † = $p<0.1$; n.s. = not significant

As expected, results show a significant increase in the concentration of LA and COR with an increase of the lairage time. This corresponds to studies of *Hambrecht et al.* (2004) and *Merlot et al.,* 2011). Variation in glucose concentrations tend to vary depending on the level of stress prior slaughter. In our study, concentrations in GLU were the highest in a group of pigs with no rest prior to slaughter. Opposite to these results, *Perez et al.* (2002), who compared the effect of transport time (15 min and 3 h), did not find differences in GLU concentrations in investigated groups. The study of *Merlot et al.* (2011) also showed that level of stress does not necessarily effect blood glucose concentrations. In *Table 1* it can be observed that lairage time significantly affected blood CK concentration, where the highest concentration of this blood parameter was measured in group of pigs without rest and the lowest in the group with 24h rest before slaughter. These results correspond with results from other studies (*Brown, et al.,* 1997) where highest values of creatine-kinase were measured in group of pigs with minimum level of stress before slaughter, or with shorter transport (*Perez et al.*, 2002). In later case, stress was primarily induced by the loading of pigs in the slaughterhouse, which clearly affected CK concentrations. Furthermore, *Yu et al.* (2009) found an increase ($P<0.01$) of CK activity after 1h or 2h of transportation indicating muscle damage and result from disruption in muscle cell membrane (sarcolemma) function and permeability.

Effect of lairage time on meat quality traits

Table 2

Least square means and standard errors (in brackets) for meat quality traits in relation to lairage time

Trait	Lairage time			Significance
	0h	6h	24h	
pH_{45} ham	6.44 (0.02)	6.46 (0.03)	6.42 (0.03)	n.s.
pH_{45} loin	6.33 (0.02)	6.38 (0.03)	6.31 (0.03)	n.s.
pH_{24} ham	5.50^{b} (0.01)	5.48^{b} (0.01)	5.59^{a} (0.03)	***
pH_{24} loin	5.49^{a} (0.01)	5.44^{b} (0.01)	5.53^{a} (0.02)	***
Drip loss (%)	5.54 (0.46)	5.04 (0.32)	4.61 (0.50)	n.s.
EZ drip (%)	5.77 (0.53)	4.89 (0.24)	4.35 (0.48)	†
L^{*}	54.91^{a} (0.41)	53.82^{ab} (0.60)	52.75^{b} (0.47)	***
a^{*}	5.60^{b} (0.16)	5.46^{b} (0.17)	6.36^{a} (0.19)	***
b^{*}	2.26 (0.13)	2.34 (0.19)	2.66 (0.13)	n.s.
Cooking loss (%)	33.45 (0.28)	33.25 (0.26)	33.29 (0.34)	n.s.
WBSF (N)	53.16^{ab} (1.13)	49.50^{b} (1.51)	53.89^{a} (1.47)	†

*** = $p<0.001$; ** = $p<0.01$; * = $p<0.05$; † = $p<0.1$; n.s. = no significance

From *Table 2* it can be observed that lairage time did not affect pH values measured 45 minutes *post mortem* in loin nor ham. Contrary to these results *Brown et al.* (1997) found significantly higher pH_{45} values in group of pigs with usual manipulation in slaughterhouses than the group of pigs specially manipulated before slaughter. In a similar study of *Hambrecht et al.* (2004), pH values measured 30 minutes after slaughter were lower in the group of pigs with higher level of stress before slaughter.

pH values measured in ham 24 hours after slaughter were strongly influenced by rest before slaughter. As it can be seen from Table 2, pigs which rested for 24 h before slaughter exhibited favourable final pH values. Contrary to results of this study *Brown et al.* (1997) and *Perez et al.* (2009) did not find significant differences between groups of pigs treated with various kinds of stress, e.g. manipulation of animals prior to slaughter or length of transport. Results from this study could therefore suggest longer lairage time as efficient way to prevent unfavourable lowering of pH_{24}.

No significant differences between investigated pig groups were found for drip loss and EZ drip. However, a tendency of decreasing the drip loss is observable as lairage period increases. Similar results were found by *Brown et al.* (1997) and *Perez et al.* (2002). From Table 2 it can be observed that meat from pigs with 24 h lairage time exhibited the lowest L* and the highest a* values suggesting a positive effect of long

lairage time on meat colour. Contrary to our results other studies did not find differences in paleness between studied groups of pigs in regard to other stress sources (*Brown et al.,* 1997; *Hambrecht et al.,* 2005). Instrumental tenderness (WBSF) was highest in the group with 24h lairage time. Probably this is the result of calpain proteolytic enzyme system status, which was not measured in this study. Furthermore, in the case of this trait, interpretation of results could be difficult since the relation of physical stress and tenderness is still unclear.

CONCLUSION

Pre-slaughter conditions, such as lairage time affects physic-chemical blood parameters, as well as overall meat quality in pigs. Animals slaughtered immediately after unloading exhibited the highest concentrations of glucose, lactate, cortisol and activity of creatin-kinase. With extend of lairage time blood parameters tend to decrease and meat quality traits improve.

REFERENCES

Becker, B.A., Mayers, H.F., Hahn, G.L., Nienabers, J.A., Jesse, G.W., Anderson, M.E., Heymann, H. and Hendrick, H.B. (1989). Effect of Fasting and Transportaation on Various Physiological Parameters and Meat Quality of Slaughter Hogs. J Anim Sci, 67. 334-341.

Brown S.N., Warriss, P.D. Nute, G.R. Edwards, J.E., Knowles, T.G. (1997). Meat Quality in Pigs Subjected to Minimal Preslaughter Stress. Meat Science. 49. 3. 257-265.

Christensen, L. B. (2003). Drip loss sampling in porcine m. longissimus dorsi. Meat Science, 63. 4. 469-477.

Gispert, M., L. Faucitano, M.A. Oliver, M.D. Guardia,C. Coll, K. Siggens, K. Harvey, A. Diestre (2000). A survey of pre-slaughter conditions, halothane gene frequency, and carcass and meat quality in five Spanish pig commercial abattoirs. Meat Sci. 55. 97-106.

Hambrecht E., J.J. Eissen, R.I.J. Nooijen, B.J. Ducro, C.H.M. Smits, L.A. den Hartog and M. W. A. Verstegen (2004). Preslaughter stress and muscle energy largely determine pork quality at two commercial processing plants. J Anim Sci., 82. 1401-1409.

Hambrecht E., J.J. Eissen, D.J. Newman, C. H. M. Smits M. W. A. Verstegen, L. A. den Hartog (2005). Preslaughter handling effects on pork quality and glycolytic potential in two muscles differing in fiber type composition. J. Anim. Sci., 83. 900-907.

Honikel, K.O.(1987). The water binding of meat. Fleischwirtschaft, 67. 1098-1102.

Murray, A.D., Jones, S.D.M., (1994.: The effect of mixing, feed restriction and genotype with respect to stress susceptibility on pork carcass and meat quality. Can. J. Anim. Sci., 74. 587-594.

Merlot E., A.M. Mounier, A. Prunier (2011). Endocrine response of gilts to various common stressors: A comparison of indicators and methods of analysis. Physiology & Behavior, 102. 259-265.

Nanni Costa, L., Lo Fiego, D. P., Dallolio, 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. 41-47.

Perre V. Van de, Permentier L., De Bie S., Verbeke G., Geers R. (2010). Effect of unloading, lairage, pig handling, stunning and season on pH of pork. Meat Science, 86. 931-937.

Perez, M.P., Palacio, J., Santolaria, M.P., Acena, M.C., Chacon, G., Gascon, M., Calvo, J.H., Zaragoza, P., Beltran, J.A., Garcia-Belenguer, S. (2002). Effect of transport time on welfare and meat quality in pigs. Meat Scientice, 61. 425-433.

Salajpal K., Dikic M., Karolyi D., Sinjeri Z., Liker B., Kostelic A., Juric I. (2005). Blood serum metabolites and meat quality in crossbred pigs experiencing different lairage time. Ital.J.Anim.Sci., 4. 3. 119-121.

Śmiecińska, 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.

Warriss, P.D., S.N. Brown (2000). Pig welfare and meat quality: A United Kingdom view. I Conferencia Virtual Internacional sobre Qualidade da Carne Suina, 16 de novembro a 16 de dezembro de 2000.

Young, JF, Jensen, JA & Oksbjerg, N. (2008). Stress up to at least 3 h before slaughter affects the meat texture. 54th International Congress of Meat Science and Technology, Cape Town, South Afrika. August 10-15.

Yu Jimian, Tang Shu, Bao Endong, Zhang Miao, Hao Qingqing, Yue Zhenghua (2009). The effect of transportation on the expression of heat shock proteins and meat quality of M. longissimus dorsi in pigs, Meat Science, 83. 474-478.

Corresponding author:

Goran Kušec
Josip Juraj Strossmayer University of Osijek, Faculty of Agriculture
Kralja Petra Svačića 1d, 31000 Osijek, Croatia
Phone: +385-31-554-866
E-mail: gkusec@pfos.hr