COMPARISON OF ELECTRICAL AND MECHANICAL STUNNING METHODS ON CARCASS AND MEAT QUALITY OF PORK

P H G Jayamini De Silva [1], D. C. A. Kalubowila[2] and Missaka P.B. Wijayagunawardane [3]

[1] Post Graduate Institute Agriculture, Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400; [2] Keells Food Products PLC, 16, Minuwangoda Road, Ekala, Ja-ela, Sri Lanka; [3] Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400

Abstract – The objective of this study was to compare electrical (ES) and mechanical stunning (MS) methods on carcass and meat quality of pigs. A total of 150 Duroc × Landrace castrated boars were randomly allocated into two stunning methods: 1) ES (250 V, 1.25 A, 50 Hz, 8–12 sec.) 2) MS using a non-penetrative iron pole. ES method affected significantly higher (P<0.01) bleeding percentage and water holding capacity but resulted significantly lower (P<0.05) percentage of drip loss and dressing percentage. The use of ES method significantly (P <0.01) reduced the incidence of bruises in carcasses and hemorrhages in internal organs. *E coli*, *Staphylococcus*, and *Total plate count* were significantly (P<0.05) higher in carcasses from MS. However, *Salmonella* weren't observed in either method. A faster rate of muscle pH decline was found in MS and ultimate pH were found to be significantly (P<0.05) different between two methods. Meat of MS was significantly lighter in colour but a* and b* values, were not influenced (P>0.05) by stunning methods. These results indicate that ES of pigs reduced the percentage of drip loss, hemorrhages, bruises, microbial count, muscle lightness and the rate of muscle pH decline compared with pigs stunned mechanically.

Key Words – Microbial count, Pork quality, Stunning pigs

I. INTRODUCTION

Appropriate pre-slaughter stunning of pigs is very important not only from a welfare point of view, but also particularly important in determining quality of pork and is consequently linked to economic implications [1]. Prior to slaughter, the first step in the transformation of pig into edible pork involves stunning. However, stunning method is not a legal requirement in Sri Lanka. At present, both mechanical (MS) and electrical stunning (ES) methods are used for slaughtering pigs in Sri Lanka. The pre-slaughter stress depends on the stunning method used. Moreover as per the literature, stunning methods have significant effect on pork eating quality [2, 3, 4]. Therefore a comparison of these methods is desirable. Thus, the present study was conducted to evaluate the effect of stunning methods on physical, chemical and biological quality parameters of pork and to determine which method is more desirable to protect the quality of pork.

II. MATERIALS AND METHODS

Animals and slaughter procedures

One hundred and fifty crossbred castrates (live weight 95 -100 kg) of the same genotype (Duroc × Landrace) fed and handled using identical conditions were used for this investigation. Pigs were randomly allocated into two stunning methods: 75 pigs were electrically stunned (at 250 V, 1.25 A, 50 Hz, 8–12 s), whereas others underwent mechanical stunning, by iron pole. Immediately after stunning, pigs were bled and blood was collected and weighed.

Carcass and meat quality measurements

Hot and cold carcass weights were recorded and used to calculate dressing percentage. At 24 h postmortem, carcass length and back fat thickness were recorded using the procedures described by Cisneros et al., [5]. An overall grade was given to bruises of the carcasses and haemorrages of the internal organs. Carcass temperature was measured by digital thermometer (TESTO106) and pH was measured at intervals 0, 45 minutes, 2, 6, 24, 48 hours post-slaughter using a digital pH meter (Checkit Micro pH WP 01). The experimental meat samples were analyzed for *Staphylococcus aureus* on Baird-Parker medium spread plates incubated at 37 ^{0}C, *E coli* on Petrifilm^{TM} *E coli* count plate incubated at 35 ^{0}C, Total Plate Count

(TPC) on Petrifilm™ aerobic count plate incubated at 37 ^{0}C, and *Salmonella* were determined according to Gray and Patrick [6].
L*, a*, and b* values were assessed using a Minolta Chroma meter CV-300 [7]. Drip loss was determined as described by Channon et al., [2] and Water holding capacity (WHC) measured by centrifuging method [8].

Statistical Analysis
A difference between two treatments was analyzed using a one-way analysis of variance using the Statistical Package for Social Sciences version 13.0. Each carcass was considered as an experimental unit for data analyses.

III. RESULTS AND DISCUSSION

Both hot and chilled carcass weights, as well as dressing percentage, were significantly higher ($p<0.05$) in MS pigs and could be due to the incomplete bleeding in carcasses (Table 1). In ES pigs, bleeding percentage was significantly ($p<0.01$) higher (70.64 %) in 3 min than MS pigs (38.1%). This reduced bleeding percentage in MS pigs may be due to cardiac arrest resulted by excessive pre slaughter stresses caused by pre slaughter stunning.

Table 1. Effect of different stunning methods on carcass characteristics of pigs

Traits	MS	ES	Mean	SE	P value
Live weight (kg)	97.70[a*]	97.90[a]	97.8	0.5	0.47
Hot carcass weight (kg)	79.6 [a]	78.2 [b]	78.9	0.6	0.03
Chilled carcass weight (kg)	77.08 [a]	75.24[b]	76.16	0.36	0.04
Dressing percentage (hot)	81.47 [a]	79.87[b]	80.67	0.71	0.02
Carcass length (cm)	85.04 [a]	84.73[a]	84.88	0.67	0.22
Backfat thickness (cm)					
First rib[x]	4.32 [a]	4.30 [a]	4.31	0.05	0.54
10[th] rib[y]	3.02 [a]	3.25 [a]	3.14	0.06	0.09
Last rib[x]	2.50 [a]	2.66 [a]	2.58	0.02	0.58

[*]Means within rows showing different superscripts are significantly different ($p<0.05$)
[**] Hot carcass weight /slaughter weight
[x] On the midline
[y] Off the midline

The pH values at just after slaughtering and 45 minutes onwards illustrated significant differences ($p<0.05$) between two stunning methods (Figure 1). The faster rate of muscle pH decline in MS group could be due to increased glycolytic rate of muscle compared with ES pigs [9].

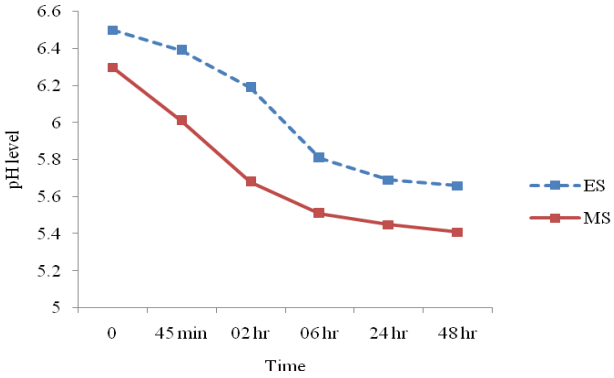

Figure 1 Effect of ES and MS on muscle pH at various times post-slaughter in pork

MS pigs had significantly higher ($p<0.05$) carcass temperature and drip loss and lower ($p<0.01$) WHC (Table 2). High temperature in muscle of MS pigs could be due to severe stress and impulsive behavior during stunning. Grandin, [10] implied that high "excitability" create pre-slaughter stress during stunning resulted in elevated glycolytic metabolism in pigs just prior to slaughter leads to production of heat which will elevate the pig's body temperature. Moreover Lawrie, [11] stated that the rate of biochemical reactions in the muscle was positively correlated with carcass temperature. This is supported in the literature [12, 13, 14, 15, 16] and in the present study where a faster pH fall in the early post mortem resulted in negative consequences in drip loss, WHC and pork color. Furthermore some proposed that combination of rapid pH drop and high temperature results in denaturation of muscle proteins that bind water which leads to the reduced WHC [17, 18, 19, 20, 21].

Meat colour is an important factor in purchase intent of consumers; therefore it requires protecting the preferable colour in meat. Meat

of the ES pigs, was significantly brighter (higher L* values) and also had numerically higher values for a* and lower value for b* than MS groups (Table 2) but that differences between the groups was insignificant ($p>0.05$). In MS pigs, redness of meat was higher, which could be due to that incomplete bleeding when compared to ES pigs. Joo et al., [22] and Van Laack et al., [23] proposed that L* value is correlated with WHC of pork.

Table 2 Effect of different stunning methods on meat quality of pork

Carcass characteristics	ES	MS	P value
Temperature (^{o}C)	34.48 ^{a}	37.86 ^{b}	0.02
Colour			
L*	46.12 ^{a}	48.06 ^{b}	0.03
a*	6.71 ^{a}	7.41 ^{a}	0.34
b*	1.2 ^{a}	0.9 ^{a}	0.21
Drip loss (%)	13.47 ^{a}	22.15 ^{b}	0.01
WHC (%)	47.82 ^{a}	40.34 ^{b}	0.007

*Means within rows showing different superscripts are significantly different ($p<0.05$)

It was observed that higher incidences of bruises, hemorrhages and skin blemishes in carcasses and hemorrhages in liver, lung, heart (Figure 2). These were significantly higher in MS pigs ($p<0.01$) due to physiological stress of stunning induced capillary rupture because of the increased blood pressure immediately after stunning resulting in high residual blood.

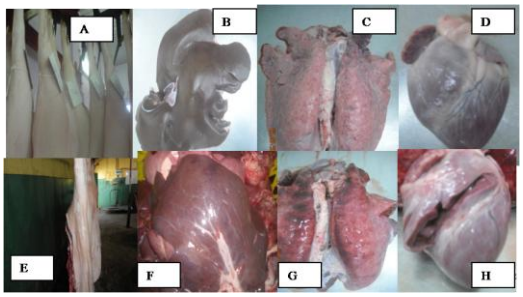

Figure 2 Macrophotography of the pig carcass and internal organs. A – ES carcass; B - View ES liver; C – View of ES lungs; D- View of ES heart; E- MS carcass; F - View MS liver; G - View of MS lungs; H - View of MS heart

There was a significant difference ($P< 0.05$) on *TPC*, *E coli* and *Staphylococcus* count due to the slaughter method (Table 3). These results may be attributed to the improper bleeding causing more blood to retain in the carcass. The bacterial count was positively affected by the amount of residual blood left in the carcass. In similar study related to broilers, Sayda et al., [24] found that bleeding percentage of animal depends on the stunning method used.

Table 3 Effect of different stunning methods on microbial count of pork

	ES	MS
TPC	2×10^{4} ^{a}	4×10^{5} ^{b}
E.coli	1×10^{2} ^{a}	4×10^{3} ^{b}
Staphylococcus	0 ^{a}	2×10 ^{b}
Salmonella	Negative	Negative

*Means within rows showing different superscripts are significantly different ($p<0.05$)

IV. CONCLUSION

The present study demonstrates that stunning methods can significantly affect the carcass and meat quality of pork. Although meat yield high, quality of pork obtained from ES pigs was better than in MS pigs. ES pigs had less bruises and hemorrhages hence, this method could reduce downgrading problems. ES method seems to be better than MS and therefore it is recommend to be used for stunning pigs.

ACKNOWLEDGEMENTS

The authors are appreciative of the funding provided by the Keells Food Products PLC and KEPRO farm to undertake this work and technical assistance provided by A. K. Baddegama and M. R. Tharangani were gratefully acknowledged.

REFERENCES

1. Van de Perre, V., Permentier, L., De Bie, S., Verbeke, G., and Geers, R. (2010). Effect of transport, unloading, lairage, pig handling and stunning on meat quality. In Proceedings 61 st Annual Meeting of the European Association for Animal Production (pp. 287), 23-27 August 2010, Heraklion, Greece.
2. Channon, H. A., Payne, A. M., and Warner, R. D., (2002). Comparison of CO_2 stunning with manual electrical stunning (50 Hz) of pigs on

carcass and meat quality. Meat Science, 60: 63–68
3. Franck, M., Svensson, M., VonSeth, G., Josell Figwer, P., and Poirel, M. T., (2003). Effect of stunning conditions on occurrence of PSE defects in hams of rn+/RN⁻ pigs. Meat Science, 64: 351–355.
4. Anil, M. H., McKinstry, J. L., and Wotton, S. B., (1997). Electrical stunning and slaughter of pigs. Fleischwirtschaft, 77: 473–476
5. Cisneros, F., Ellis, M., McKeith, F. K., McCaw, J., and Fernando, R. L., (1996). Influence of slaughter weight on growth and carcass characteristics, commercial cutting and curing yields, and meat quality of barrows and gilts from two genotypes. J. Anim. Sci, 74:925–933
6. Gray, L. D., and Patrick, R., (1995). Escherichia, salmonella, shigella and yersina in manual of clinical microbiology. American society for microbiology, Washington, D.C., 450- 456
7. Yang Xu, Ji-Chao H., Ming H., Bao-Cai X., and Guang-Hong Z., (2012). The effects of different chilling methods on meat quality and calpain activity of pork muscle longissimus dorsi. Journal of Food Science, 71: 27-32
8. Kristensen, L., and Purslow, P. P., (2001). The effect of ageing on the water-holding capacity of pork: role of cytoskeletal proteins. Meat Science, 58:17-23
9. Gregory, N. G., (2008). Animal welfare at markets and during transport and slaughter. Meat Science, 80: 2-11
10. Grandin, T., (1994). Methods to reduce PSE and blood splash. In Proceedings Allen D. Leman Swine Conference, University of MN. 21:206-209.
11. Lawrie, R. A., (1998). Lawrie's meat science. 6th ed. Cambridge, England: Woodhead Publishing Ltd. pp.442
12. Offer, G., (1991). Modeling the formation of pale, soft and exudative meat: Effects of chilling regime and rate and extent of glycolysis. Meat Sci. 30:157-184
13. D'Souza, D. N., Dunshea, F. R., Warner, F. R., and Leury, B. J., (1998[a]). The effects of handling pre-salughter and carcass processing rate post-slaughter on pork quality. Meat Sci. 50:429-437
14. D'Souza, D. N., Dunshea, F. R., Warner, F. R., and Leury, B. J., (1998[b]). Effects of on farm and pre-salughter handling of pigs on meat quality. Australian Journal of Agricultural research, 49:1021-1025.
15. Van der Wal, P. G., Engel, B., and Hulsegge, B., (1997). Causes for variation in pork quality. Meat Science, 46:319-327
16. Hambrecht E., Eissen, J. J., Nooijen, R. I. J., Ducro, B. J., Smits, C. H. M., Den Hartog, L. A. and Verstegen, M. W. A., (2004). Preslaughter stress and muscle energy largely determine pork quality at two commercial processing plants. Journal of Animal Science, 82:1401-1409
17. Penny, I. F., (1969). Protein denaturation and water holding capacity in pork muscle. J. Food Technol. 4:269-273
18. Wismer-Pedersen, J., (1987). Chemistry of animal tissue - Part 5. Water. In: The Science of Meat and Meat Products. (pp. 141-154). 3rd Ed. Edit. J. F. Price and B. S. Schweigert. Food and Nutrition Press, Inc. Westport, CN
19. Essen-Gustavsson, B., (1993). Muscle-fiber characteristics in pigs and relationships to meat-quality parameters - Review. In: Pork Quality: Genetic and Metabolic Factors. (pp. 140-159). Edit. E. Puolanne, D. I. Demeyer, M. Ruusunen, and S. Ellis., CAB International
20. Swatland, H. J. (1993). Growth physiology and post-mortem metabolism in porcine muscle. In: Pork Quality: Genetic and Metabolic Factors. (pp. 115-139). Edit. E. Puolanne, D. I. Demeyer, M. Ruusunen, and S. Ellis. CAB International
21. Van der Wal, P. G., Engel, B., Van Beek, G. and Veercamp, C. H., (1995). Chilling pig carcasses: Effects on temperature, weight loss and ultimate meat quality. Meat Sci. 40:193-202
22. Joo, S. T., Kauffman, R. G., Kim, B. C., and Kim, C. J., (1995). The relationship between colour and water - holding capacity in postrigor porcine longissimus muscle. J Muscle Foods, 6: 211–226
23. Van Laack R. L. J. M., Kauffman R. G., Sybesma W., Smulders F. J. M., Eikelenboom G., and Pinheiro J. C., (1994). Is colour brightness (L∗ value) a reliable indicator of water-holding capacity in porcine muscle? Meat Sci, 38:193–201
24. Sayda, A. M., Ali, Hyder Abdalla, O., and Ibrahim M. M., Effect of slaughtering method on the keeping quality of broiler chickens' meat, Egypt. Poult. Sci. 31:727-736