Influence of different electrical stunning conditions on the meat quality of broilers

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Abstract – The aim of this study was to evaluate the effect of different electrical variables used in broiler stunning on the final quality of the meat. Two hundred Cobb broilers (48 days-old) were randomly assigned in 4 treatments with 2 waveforms (WF) (pulsed direct current - DC and rectangular alternating current – AC) and 2 frequencies (FREQ) (650 Hz and 300 Hz) in a 2^2 factorial design. Broilers were electrically stunned in water bath of a commercial slaughterhouse. *Pectoralis major* (PM) samples were analyzed for pH, cooking loss, water holding capacity, shear force and instrumental color. Results were analyzed by GLM and Tukey´s test ($P<0.05$). The interaction between WF x FREQ was significant only for lightness (L*). The effects of WF or FREQ were not significant for pH, CL, SF and a* ($P>0.05$). FREQ had a significant effect on WHC and b* ($P<0.05$), which were higher in PM of poultry stunned at 650 Hz. The higher frequency also resulted in lower L*. This study indicated that the stunning frequency exerts greater influence than the waveform on the meat quality of broilers. The use of higher frequency (650Hz) improved meat quality when compared to the lower frequency (350 Hz).

Key Words – electronarcosis, waveform, frequency.

I. INTRODUCTION

The poultry industry employs more than 3.6 million people in Brazil and accounts for over 1.5% of the Gross Domestic Product (GDP). Additionally, Brazil is the world´s largest exporter of chicken meat [1]. The growing demand for chicken exports has led to the continous improvement of meat quality and safety. More recently, animal welfare has gained importance among consumers, producers and retailers of animal foods, mainly in European Union [2]. According to the Brazilian legislation [3], animals must be rendered unconscious before slaughter. Electrical water bath stunning of broiler chickens is the most commonly used method in commercial chicken slaughterhouses in Brazil. Stunning methods have to be efficient on rendering animals unconscious, but should not interfere with the meat quality. Thus, combinations of different electrical waveforms, frequencies, voltages, and amount of current are used [4]. High stunning frequencies (>500Hz) remarkably improve carcass quality and decrease breast muscle hemorrhage in broilers [5] and turkeys [6]. However, frequency levels >800 Hz may not render birds unconscious until the beginning of the bleeding stage [7]. On the other hand, low frequencies (<200Hz) may cause death and have been associated with meat quality defects such as hemorrhage and broken bones [8]. The waveform of the current also influences the effectiveness of the stunning. A pulsed direct current (DC) is often used for electrical water bath stunning of chicken. Alternating current (AC) has also been used, and the sinusoidal waveform is the most prevalent in the industry [7]. However, rectangular alternating waveform has been adopted in modern commercial slaughterhouses. Alternating currents may induce ventricular fibrillation during stunning [9], which is associated with animal welfare, since the recovery of consciousness during bleeding is prevented [10, 11]. The scientific literature shows that most studies on electrical stunning in chickens were carried out in laboratories and not in real industrial conditions. In addition, there is a lack of studies on the effects of different

waveforms at intermediate frequency levels for the electrical stunning of broiler chickens. Thus, the objective of this study was to evaluate the effect of pulsed direct current (DC) and rectangular alternating current (AC) at 300 Hz and 650 Hz on the meat quality of chickens slaughtered in an industrial process.

II. MATERIALS AND METHODS

Birds: Two hundred (200) Cobb broilers (male and female) were used. Birds were 48 days-old and weighed from 2.9 to 3.0 kg.

Experimental design: A 2×2 factorial design was applied, containing 4 treatments with 2 waveforms (WF) (pulsed direct current - DC and rectangular alternating current – AC) and 2 frequency (FREQ) levels (300 Hz and 650 Hz). Electrical stunning was carried out in an industrial electrical water bath HF 6000 (Fluxo®, Chapecó, Brasil) for 8.0 ± 1.0 s. Current (Amperage, Voltage) was the same in all treatments (80 to 100 mA and 70 V).

Bleeding was performed within 10 s after stunning by severing the jugular vein and carotid artery by a neck cut of 0.78 inch. Bleeding was maintained for 180 s. Then, broilers were slaughtered according to the conventional procedure used by the slaughterhouse. Carcasses were cooled down in a water chiller until reaching 4 °C. *Pectoralis major* (PM) samples were manually cut from the carcasses within 40 min from slaughter. Samples were frozen in a tunnel freezer at -30 ºC and stored at -18 ºC. Meat samples were thawed at 4 ºC for 24h prior to the analyses.

Meat quality parameters: pH was measured using a digital pHmeter (Quimis, São Paulo, Brazil) with a penetrating electrode [12]; water holding capacity (WHC) was determined according to Hamm [13], with samples subjected to pressure (10 kg) for 5 minutes at room temperature; samples were cooked in a water bath until reaching 82 °C in their core and cooking loss (CL) was determined [14]; shear force (SF) was determined in 1.27 cm^3 samples (cube-shaped) of the cooked meat using a TAXT2i texturometer (Stable Micro Systems, Surrey, England) equipped with a Warner-Bratzler blade. SF was taken perpendicularly to the muscle fibers direction, with 2 mm/s test speed and 30 mm distance from the base; instrumental color was determined using colorimeter (Konica Minolta CR 410, Tokyo, Japan), illuminant D_{65}, opening diameter 50-53 mm, observation angle 2° and CIE color coordinates L*, a* and b*.

Statistical analysis: Results were analyzed using the General Linear Models (Statgraphics Anturion XV program version 15.2.05). The individual effect of waveform and frequency and their interaction were determined according to the statistical model: $Y_{ijk}=\mu+I_i+A_j+I_i*A_j+e_{ijk,}$ where: Y_{ijk} = variable, μ = mean; I_i = frequency (i = 1, 2), A_j = waveform (j = 1, 2); I_i*A_j = interaction between frequency and waveform; e_{ijk} = residual error. When the interaction was not significant (P>0.05), the main effects were analyzed without interaction and means were compared by Tukey´s test (P<0.05).

All experimental procedures were approved by the Ethics Committee on Animal Use (CEUA) of PUCPR (process nº. 709).

III. RESULTS AND DISCUSSION

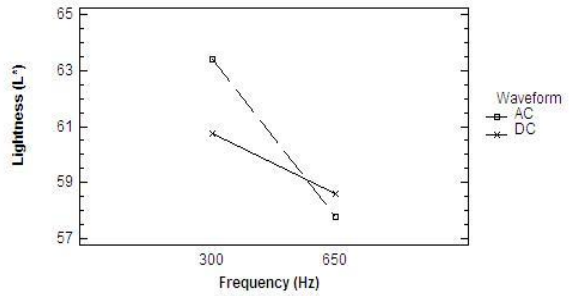
The interaction between WF x FREQ was significant only for lightness (L*). The main effects of WF or FREQ were also not significant for pH, CL, SF and redness (a*) of broiler meat (P>0.05). Electrical frequency had a significant effect on WHC (P<0.05), which was higher in PM of poultry stunned at 650 Hz (P<0.05) (Table 1). The significant interaction between WF x FREQ indicated that the combination of AC and 650 Hz result in lower L* values (Figure 1). Lightness were higher in PM of broiler stunned at 300 Hz, which also showed lower WHC and lower yellowness (b*) compared to PM of broilers stunned at higher frequency (650Hz) (Table 1). This indicates that electrical stunning at lower frequency (300Hz) resulted in paler meat color and higher water loss. WHC in PM of all treatments performed in this study were higher than those reported by Takahashi [15] for PM of broilers stunned at 800Hz/ 90V (25.51%). Higher WHC indicates higher ability of the meat to retain its moisture during application of external forces, such as cutting, grinding or heating, which commonly applied during meat processing [16].

Table 1. Effects of waveform and frequency on meat quality parameters of broilers (Mean ± standard error).

Item	Electrical variables			
	Waveform		Frequency	
	DC	AC	300	650
pH	5,76±0,017[a]	5,78±0,017[a]	5,78±0,017[A]	5,76±0,017[A]
CL	30,21±0,64[a]	31,88±0,63[a]	30,50±0,64[A]	31,59±0,63[A]
WHC	31,57±0,57[a]	33,29±0,56[a]	30,77±0,57[B]	34,08±0,56[A]
SF	3,60±0,22[a]	3,42±0,22[a]	3,51±0,22[A]	3,51±0,22[A]
L*	59,67±0,34[a]	60,58±0,34[a]	62,08±0,34[A]	58,17±0,34[B]
a*	11,45±0,19[a]	10,99±0,19[a]	11,13±0,19[A]	11,31±0,19[A]
b*	15,74±0,36[a]	15,94±0,36[a]	14,76±0,36[B]	16,92±0,36[A]

DC = direct current; AC = alternating current. CL = cooking loss (%),WHC = water holding capacity (%), SF = shear force (kgf), L* = lightness, a* = redness and b* = yellowness. Different lowercase superscripts in the same row indicate significant difference between waveform treatments (P<0.05). Different uppercase superscripts in the same row indicate significant difference between frequency treatments (P<0.05).

Figure 1. Interaction between waveform (DC = pulsed direct current, AC = rectangular alternating current) and frequency (300 and 650 Hz) on L* values in the breast meat of electrically stunned broilers



Similarly to the results found in the present study, Xu et al. [17] did not found differences in pH, CL and a* values of PM from broilers stunned at different electrical frequencies (160Hz, . However, the authors found lower SF broilers stunned at 400Hz and 1,000Hz. In the present study, frequency did not affect the SF of PM. Xu et al. [17] indicated that the high stunning frequencies used may improve meat quality. The results presented on Figure 1 also showed that use of 650Hz for the electrical stunning improved L* values of PM cuts.

IV. CONCLUSION

This study indicated that among the electrical stunning parameters, frequency exerts greater influence than waveform on the broiler´s meat quality. The use of electrical stunning at 650Hz resulted in better meat quality than 300 Hz.

REFERENCES

1. UBA (União Brasileira de Avicultura). (2014). Relatório Anual 2014. 7-10. Available at: http://www.ubabef.com.br/publicacoes?m=75&date=2014-03.
2. Lambooij, E., Reimert, H.G.M., Verhoeven, M.T.W. & Hindle, V.A. (2014). Cone restraining and head-only electrical stunning in broilers: effects on physiological responses and meat quality. Poultry Science 93: 512-518.
3. BRASIL. Ministério da Agricultura, Pecuária e Abastecimento. (2000). Instrução Normativa nº 3, 17/01/2000. Regulamento técnico de métodos de insensibilização para o abate humanitário de animais de açougue. Diário Oficial da União, Brasília, DF.
4. Prinz, S., Van Oijen, G., Ehimger, F., Bessei, W. & Coenen, A. (2012). Electrical waterbath stunning: influence of different waveform and voltage settings on the induction of unconsciousness and death in male and female broiler chickens. Poultry Science 91: 998-1008.
5. Wilkins, L. J., Gregory, N. G., Wotton, S. B. & Parkman, I. D. (1998). Effectiveness of electrical stunning applied using a variety of waveform-frequency combinations and consequences for carcass quality in broiler chickens. British Poultry Science 39:511–518.
6. Wilkins, L. J. & Wotton, S. B. (2002). Effect of frequency of the stunning current waveform on carcass and meat quality of turkeys processed in a commercial plant in the UK. British Poultry Science 43:231–237.
7. Prinz, S., Van Oijen, G., Ehinger, F., Coenen, A. & Bessei, W. (2010). Electroencephalograms and physical reflexes of broilers after electrical waterbath stunning using an alternating current Poultry Science 89:1265–1274.
8. Gregory, N. G. (1989). Stunning and slaughter. In: Processing of Poultry. G. C. Mead, ed. Elsevier Applied Science, London, UK. 31–63
9. Ludtke, C. B., Ciocca, J. R. P., Dandin, T., Barbalho, P. C. & Vilela, J. A. (2010). Abate humanitário de aves. Rio de Janeiro: WSPA. 119 p.
10. Gregory, N. G. (1998). Stunning and slaughter. In: Animal Welfare and Meat Science. CABI Publishing, Oxon, UK. 223–240.
11. Prinz, S., Van Oijen, G., Ehinger, F., Bessei, W. & Coenen, A. (2010). Effects of waterbath stunning on the electroencephalograms and physical reflexes of broilers using a pulsed direct current. Poultry Science 89:1275–1284.

12. AOAC. (2000). Official methods of analysis of the Association of Official Analytical Chemists. 17. ed. Gaithersburg, v. 1.
13. Hamm R. (1960). Biochemistry of meat hydratation. Advances in Food Research 10:335-443.
14. Froning, G. W. & Uijttenboogaart, T. G. (1988). Effect of post mortem electrical stimulation on color, texture, pH, and cooking loses of hot and cold deboned chicken broiler breast meat. Poultry Science 67: 1536-1544.
15. Takahashi, S. E, Mendes, A. A., Komiyama, C. M., Souza, H. B. A., Paz, I. C. L. A., Garcia, R. G., Moreira, J., Neto, A. B. & Boiago, M. M. (2009). Efeito do atordoamento elétrico e tipo de desossa sobre a ocorrência de carne pálida em frangos de corte. Veterinaria e Zootecnia 3: 61-69.
16. Roque-Specht V. F., Simoni, V., Parise, N. & Cardoso, P. G. (2009). Avaliação da capacidade de retenção de água em peitos de frango em função do pH final. Revista Brasileira Agrociência 15: 77-81.
17. Xu, L., Zhang, L., Yue, H. Y., Wu, S. G., Zhang, H. J., Ji, F. & Qi, G. H. (2011). Effect of electrical stunning current and frequency on meat quality, plasma parameters, and glycolytic potential in broilers. Poultry Science 90: 1823–1830.