# ELECTRICAL AND $CO_2$ EXPOSURE METHODS TO STUN OR KILL BROILERS AT SLAUGHTER: WHAT'S THE INFLUENCE ON MEAT CHARACTERISTICS?

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**Abstract – In order to evaluate animal suffering and meat characteristics, the processes of stunning and killing broiler chickens in an electrical water-bath system and in a $CO_2$ chamber were studied. The volume of blood drained from carcasses was not different either stunning or killing the birds by each one of the investigated methods (P>0.05). However, the birds killed by electrical system retained more blood than the birds submitted to gas exposure (P<0.05) and, as a consequence, color analysis by CIELab color system revealed that breast and thigh meat from these birds showed a higher (P<0.05) redness score *(a*)*. However, meat quality variation reported in this study would not affect meat acceptance by consumers. On the other hand, the exposure to $CO_2$ caused strong reactions in 65% of the birds, with a wide variation in $CO_2$ concentration, gas exposure time required to stun or kill the birds, and also in time to regain consciousness after exiting the $CO_2$ atmosphere. Considering the Brazilian broilers slaughterhouse conditions, to reduce animal suffering, efforts should be concentrated in the standardization and monitoring of electrical stunning equipment parameters and in the operators' training.**

**Key Words – poultry welfare, meat quality, stunning**

## I. INTRODUCTION

Quality is a variable concept, which involves many factors and, in the meat consumer market, the concern with animal welfare is a quality aspect whose importance is growing every day. Thus, Brazilian law requires the stunning of animals at slaughter [1]. In Brazil, as well as in any country where slaughter is mechanized, electrical water-bath systems are the most common method of stunning birds prior to slaughter. Some research studies suggest the exposure to controlled atmosphere to replace the electrical system, either to stun or kill broiler chickens [2, 3, 4]. According to these authors, the use of air containing high levels of carbon dioxide causing anesthesia in birds has shown good results. However, carbon dioxide is acidic and irritates mucous membranes during inhalation, causing a rapid stop of respiration before loss of consciousness. Raj *et al*. [2] and Raj [5] proposed to kill broiler chickens by exposure to controlled atmospheres in order to minimize animal's suffering at slaughter. Although Brazilian legislation doesn't allow to kill the animals before bleeding [6], in this study the influence of stunning or killing poultry chickens at slaughter by both methods on the principal meat characteristics was evaluated.

## II. MATERIALS AND METHODS

A total of 80 Cobb 500 42-day-old broilers, raised under identical conditions and fed the same diet, with an average live weight of 3.42 ± 0.63 kg, were distributed in 4 treatments (electrical stunning, electrical killing, $CO_2$ stunning and $CO_2$ killing) in a completely randomized design and slaughtered according to the Brazilian laws [6, 7]. Electric stunning was performed by immersing the birds head in a water bath using 240V, 60 Hz and 120 mA for 3 sec. To kill the birds using the electrical equipment, the voltage was elevated to 300 V. In gas stunning procedure, it was used a 10% initial $CO_2$ concentration, gradually elevated to 30% after the birds' transportation cage was introduced into the gas chamber. During the exposure to $CO_2$ atmosphere, the behavior of the birds was evaluated and classified as "no reaction", "low reaction", corresponding to weak intermittent wings flapping, gasping and/or head shaking behavior, and "strong reaction", when the birds presented strong continuous wings flapping and/or convulsions. In the gas stunning method, birds were considered stunned when they fell over and did not have rhythmic breathing or nictitating membrane reflex. In both methods, the death of

the birds was determined by observation of complete breathing stopping. All birds were immediately bled after treatments. Birds were individually weighed before and after bleeding to determine the blood percentage drained from the carcasses. The color of breast and thigh meat was measured using a portable reflected-color spectrophotometer and expressed according to Commission Internationale de l'Éclairage Lab color system, as *L** (lightness), *a** (redness) and *b** (yellowness) [8]. Meat pH was determined 24 h after slaughter in breast and thigh muscles using a meat pHmeter with a spear-type probe. Results were analyzed by ANOVA and Duncan's Test at 5% significance level and Pearson linear correlation coefficients among the studied variables were determined [9]. The statistical analyses were carried out using the Statistical Analysis System software [10].

## III. RESULTS AND DISCUSSION

The blood volume loss during bleeding was not different when the birds were stunned or killed using any of the applied methods in this study (P>0.05). There was no difference in this variable between electrical or gas stunning method (P>0.05), but the amount of blood lost after electrical stunning or killing was significantly lower than after gas exposure (P<0.05). Final pH in breast did not vary among the different stunning methods (P>0.05). The pH in thigh meat of birds killed by electrical method was higher than those for thigh meat of birds killed by $CO_2$ exposure (P<0.05).

Table 1 Blood drained from birds and final pH in breast and thigh meat (mean ± standard deviation)

| | Blood loss (%) | Breast meat pH | Thigh meat pH |
|---|---|---|---|
| Electrical stunning | 2.97 $^{bc}$ ± 0.65 | 6.00 ± 0.17 | 6.31 $^{c}$ ± 0.19 |
| Electrical killing | 2.41 $^{c}$ ± 0.73 | 6.12 ± 0.13 | 6.66 $^{a}$ ± 0.11 |
| Gas stunning | 3.30 $^{ab}$ ± 0.50 | 6.07 ± 0.18 | 6.43 $^{bc}$ ± 0.19 |
| Gas killing | 3.89 $^{a}$ ± 0.76 | 6.10 ± 0.19 | 6.49 $^{b}$ ± 0.18 |

Means in a column followed by different letters differ significantly by Duncan's test (P < 0.05).

Tables 2 and 3 show the results of color attributes measured in breast and thigh meat, respectively. In CIELab color system, *L** value represents lightness. This varies from 0, which means no lightness (i.e. absolute black), to 100, which is maximum lightness (i.e. absolute white). The *a** value varies from green (negative values) to red (positive values) and *b** value varies from blue (negative values) to yellow (positive values) [11]. Breast meat from birds killed by gas exposure method presented significantly higher *L** value (P<0.05), indicating lighter meat, compared with other treatments, probably associated with the lower amount of residual blood in the carcasses. For the same reason, meat from birds killed by electrical system presented higher *a** value (P<0.05), indicating redder meat.

Table 2 Breast meat color parameters according to CIELab system (mean ± standard deviation)

| | L* | a* | b* |
|---|---|---|---|
| Electrical stunning | 62.24 $^{b}$ ± 2.28 | 4.81 $^{b}$ ± 1.47 | 15.02 ± 3.22 |
| Electrical killing | 61.50 $^{b}$ ± 4.88 | 6.12 $^{a}$ ± 1.00 | 14.61 ± 1.66 |
| Gas stunning | 62.69 $^{b}$ ± 4.62 | 5.21 $^{ab}$ ± 1.65 | 16.27 ± 4.30 |
| Gas killing | 66.81 $^{a}$ ± 1.41 | 3.57 $^{c}$ ± 0.59 | 13.90 ± 1.96 |

Means in a column followed by different letters differ significantly by Duncan's test (P < 0.05).

Table 3 Thigh meat color parameters according to CIELab system (mean ± standard deviation)

| | L* | a* | b* |
|---|---|---|---|
| Electrical stunning | 62.61± 4.90 | 6.20 $^{ab}$ ± 1.47 | 13.76 ± 2.38 |
| Electrical killing | 61.51 ± 4.49 | 7.46 $^{a}$ ± 1.70 | 12.41 ± 2.24 |
| Gas stunning | 62.43 ± 3.94 | 4.97 $^{bc}$ ± 1.40 | 12.88 ± 2.90 |
| Gas killing | 65.23 ± 5.27 | 4.37 $^{c}$ ± 1.55 | 13.11 ± 2.98 |

Means in a column followed by different letters differ significantly by Duncan's test (P < 0.05).

The influence of the blood volume loss at exsanguination on meat redness is confirmed by Pearson correlation results for breast and thigh meat, respectively (Tables 4 and 5). Pearson correlation analysis also revealed significant correlation between pH and breast and thigh meat *b** values. However, considering that pH values were not different among treatments in breast meat (Table 1), it is not possible to associate these results with the stunning or killing method.

Table 4 Pearson correlation coefficients among blood volume loss, pH and color, evaluated in breast meat

| | pH | L* | a* | b* |
|---|---|---|---|---|
| Drained blood | 0.2259 | 0.0872 | -0.4580 | -0.1622 |
| p-value | 0.3673 | 0.7307 | 0.0560 | 0.5201 |
| pH | | -0.1053 | -0.1986 | -0.4715 |
| p-value | | 0.6775 | 0.4294 | 0.0482 |
| L | | | -0.4086 | 0.0626 |
| p-value | | | 0.0923 | 0.8050 |
| a | | | | 0.2514 |
| p-value | | | | 0.3142 |

Table 5 Pearson correlation coefficients among blood drained from carcasses, pH and color, evaluated in thigh meat.

| | pH | L | a | B |
|---|---|---|---|---|
| Drained blood | -0.2767 | 0.1072 | -0.6809 | -0.0926 |
| p-value | 0.2662 | 0.6721 | 0.0019 | 0.7147 |
| pH | | -0.1226 | 0.4494 | -0.5230 |
| p-value | | 0.6280 | 0.0613 | 0.0259 |
| L | | | -0.2865 | 0.2414 |
| p-value | | | 0.2490 | 0.3346 |
| a | | | | 0.1037 |
| p-value | | | | 0.6823 |

According to the Brazilian law, $CO_2$ concentration to stun birds must be at least 30% [1]. In this experiment, when birds were exposed to $CO_2$ concentration upper than 10%, they showed evident discomfort symptoms that increased with the gas concentration elevation. So, it was adopted a 10% initial $CO_2$ concentration that was gradually elevated after the birds' transportation cage was introduced into the gas chamber. All birds exhibited headshaking and/or gasping and 65% presented strong reaction with continuous flapping and/or convulsions. Furthermore, the reaction of the birds to gas exposure varied greatly, with a wide variation in the time required to stun them, and also in time to regain consciousness after exiting the $CO_2$ atmosphere. The time required to kill the birds also presented great individual variation among birds.

## IV. CONCLUSION

Both stunning methods cause suffering to animals and there is not an efficient technological alternative to promote animal welfare at this slaughter stage. Birds suffering could be reduced by killing the animals instead of stunning before bleeding. Although this procedure can cause some effects on meat characteristics, there is not noticeable influence that might affect negatively the product acceptance by consumers. In Brazilian broiler slaughter plants, to reduce animal suffering, the electrical water bath stunning equipment must respect the legal specifications to provide an instantaneous and efficient insensibility.

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