Cyclic Heat Stress in Broilers and Their Effects on Quality of Chicken Breast Meat

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ABSTRACT

Background: The growing concern of the effects of high temperatures in the production of broilers, apart from the consistent increase of the consumption of chicken meat in Brazil and in the world and form the demands of consumers and industries increase the need for comprehensive studies on organoleptic characteristics of this meat, such as color and loss of water drip (drip loss). In this scenario, the objective of this research was to investigate the effects of cyclic heat stress on color and drip loss of chicken breast of broilers at different growth stages.

Materials, Methods & Results: A group of 840 1-day-old CobbAvian48® broiler male chicks was housed in a shed, in 24 boxes with 35 birds each according to a completely randomized design. The broilers were reared under thermal comfort for 15 days. On the 16th day the shed was divided in sections with the following thermal environments: Control - Broilers reared under natural temperature and humidity conditions between day 16 and 42 (C 16-42), and broilers submitted to cyclic heat stress between day 16 and 21 (CHS 16-21), day 22 and 42 (CHS 22-42), and between day 16 and 42 (CHS 16-42). Stress was imposed from 12:00 noon to 1:00 pm, with temperature above the maximum recommended for the lineage. On day 42, one broiler of each box weighing close to the mean weight on a box basis was slaughtered and the breast meat removed, totaling 24 breasts. Color was analyzed using the following visual standard: 1 = PSE meat (pale, soft, exudative), 2 = normal meat, and 3 = DFD meat (dark, firm, dry). Chicken breasts were visually compared to the standard. To determine drip loss, a meat fragment was removed, weighed, and placed in a nylon-poly plastic bag, which in turn was placed in polyethylene plastic packaging properly labeled. After, these were hung in a refrigerator for 48 h at controlled temperature of 4-8°C. Drip loss data were analyzed using ANOVA, and the means were compared using the Tukey test at 5%. Color data were evaluated using the Kruskal-Wallis test followed by the SNK test. Spearman analysis was used to assess the correlation between drip loss and color. Mean drip loss did not vary between thermal environments (P > 0.05). Regarding color, the broilers in the CHS 22-42 group differed from the C 1-42 group (P = 0.02). There were also significant differences between the CHS 22-42 group and the CHS 16-42 group (P = 0.03). The linear correlation between drip loss and color was significant, negative and of midrange intensity (r = - 0.41), which indicates that, when the drip loss increases, the score for color decreases, or vice-versa.

Discussion: One-hour cyclic heat stress accelerates rigor mortis in broilers, and may result in PSE meat. The alteration of chicken breast color is directly influenced by the time the broilers are submitted to the heat stress. The quality parameter drip loss may be influenced by environmental factors, such as cyclic heat stress; however, this study showed that there is no direct interference. In this sense, evidence of this interference in loss of water in chicken breast is important, because this factor influences the quality and yield of processed products, such as brine-preserved, skin-encased, and cook-in-bags food items. The use of heat stress for 1 h daily in different periods of life does not affect the loss of water in chicken breast, but it may alter the color.

Keywords: broiler, PSE meat, DFD meat, exudation.
INTRODUCTION

The consistent and growing expansion of chicken meat consumption in the Brazilian market reflects the success of the production chain, both in the domestic and international markets. In this sense, technological developments, standardization, and strict quality control measurements are essential tools for the country to hold its competitive edge in this sector [2].

Factors like lineage, environmental variables, field management practices, conditions prior to slaughtering, and routines adopted in processing units are among the production factors that directly affect the quality of chicken breast meat [3]. One of the environmental elements to which these birds are exposed during growth and development is heat stress, which may seriously affect maintenance of homothermy of these animals [12]. In addition, heat stress may affect muscle glycogen reserves, which govern the biochemical reactions post mortem [8]. As a result, the functional and sensory properties of foods may play a direct role in the industrial performance of chicken breast meat when it is used as an ingredient of industrialized foods [1].

Therefore, the loss of economic value of chicken breast is almost always associated with a set of industrial standards used to evaluate meat quality, called PSE (pale, soft, exudative) and DFD (dark, firm, dry) [2].

In this scenario, the present study investigated the effects of cyclic heat stress on color and loss of water by dripping in chicken breast meat during different management phases of broilers.

MATERIALS AND METHODS

Animals

In total, 840 1-day-old CobbAvian48® broiler male chicks were used, distributed in in 24 boxes according to a completely randomized block design, with 35 birds per box. Boxes were kept in a shed in the facilities of the School of Veterinary Medicine (FAMEV), Federal University of Uberlândia (UFU), MG, Brazil.

Experimental design

On the 16th day, the shed was divided in four sections, each with a different thermal configuration: Control (broilers reared under natural temperature and humidity between day 16 and day 42; C 16-42), and broilers exposed to heat stress from day 16 to day 21 (ECC16-21), from day 22 to day 42 (ECC 22-42), and from day 16 to day 42 (ECC 16-42). Heat stress was enforced between 12:00 noon and 1:00 pm, at a temperature above the maximum value recommended for the lineage. Heating was provided by infrared campanulas, and fans were turned on to ensure air circulation.

Color and drip loss

On day 42 broilers were weighed, and mean weight was calculated on box basis. Then, one chicken weighing close to mean weight in a box (± 5%) was retrieved from each container (n = 24), meaning that six animals represented each thermal condition used. All animals were identified using numbered rings and maintained in a box under fasting but with access to water, according to the Brazilian legislation. After the end of the fasting period broilers were slaughtered by cervical dislocation and bled. Next, the animals were scalded in hot water (55ºC) and manually plucked. After, viscera were removed. Carcasses were not chilled, but were cut to remove the breast, which was stored in transported to the laboratory for color evaluation and measurement of water drip loss.

Color analysis was carried out according to [21], which considers the following score system: 1 = PSE meat, 2 = normal meat, 3 DFD meat (Figure 1).

Figure 1. Visual standard used to evaluate color of broiler breasts. DFD: dark, firm, dry; PSE: pale, soft, exudative. Source: Olivo R. & Shimokomaki M.[15], adapted by Gotardo, 2015.
Following the methodology described previously [4], a fragment of chicken breast meat was weighed (93.19 to 99.71 g) and used in the drip loss assay. Next, the fragment was placed in a nylon-poly bag, which in turn was placed in a polythene plastic packaging labelled with the animal number. Samples were stored in a refrigerator for 48 h at 4°C to 8°C.

\[ \text{DL} = 100 - \left( \frac{\text{Initial weight}}{\text{Final weight}} \right) \times 100 \]

**Statistical analyses**

Since color is a qualitative variable, means were analyzed using the Kruskall-Wallis test and the SNK test as post-hoc. Drip loss values were evaluated with an analysis of variance (ANOVA), and means were compared using the Tukey test at 5% significance level in the software SISVAR. The correlation between color and drip loss was analyzed using the Spearman correlation coefficient in the tool Action.

**RESULTS**

**Color**

All chicken breasts removed from broilers from the group C 16-42 presented normal color. In turn, one ECC 16-21 sample was classified as DFD, three were normal, and two were ranked as PSE. Also, one ECC 22-42 sample was classified as normal, five as PSE, and none as DFD. In the ECC 16-42 regime, one, four and one broiler were classified as DFD, normal, and PSE, respectively.

Color of broiler breast meat under the ECC 22-42 regime differed significantly from the control group (P = 0.02). Comparable result was obtained for the groups ECC 22-42 and ECC 16-42 (P = 0.03). These dissimilarities indicate that, under heat stress for 1 h a day, broilers at different management stages will develop PSE or DFD breasts. However, there are no published data showing that consumers are able to tell this difference or name one or another characteristic as the object of their preference.

Contrasting with the consumption of these products at home, the processing units that use pale chicken breasts as raw material in the manufacture of mortadella, for instance, are required to resort to additives in order to recover the functional potential of PSE chicken meat [6].

**Drip Loss**

The exposure of broilers to 1-h cyclic heat stress a day did not affect percent drip loss in breasts (Table 1).

**Correlation between drip loss and color**

A significant, negative and midrange linear correlation was observed between the data of drip loss and color of broiler breasts (r = -0.41).

**Table 1.** Quality of the breast from broilers at different growth stage exposed to 1-h cyclic heat stress.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Initial weight (g)</th>
<th>Final weight 48 h (g)</th>
<th>Difference (g)</th>
<th>% Drip loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>C 16-42</td>
<td>96.92</td>
<td>94.45</td>
<td>2.47*</td>
<td>2.55 a</td>
</tr>
<tr>
<td>ECC 16-21</td>
<td>97.65</td>
<td>95.00</td>
<td>2.65*</td>
<td>2.70 a</td>
</tr>
<tr>
<td>ECC 22-42</td>
<td>96.94</td>
<td>94.43</td>
<td>2.51*</td>
<td>2.59 a</td>
</tr>
<tr>
<td>ECC 16-42</td>
<td>97.13</td>
<td>95.02</td>
<td>2.11*</td>
<td>2.17 a</td>
</tr>
<tr>
<td>CV (%)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>25.45</td>
</tr>
</tbody>
</table>

Means followed by the same letter did not differ in the Tukey test at 5% significance. C 16-42=Thermal comfort, ECC 16-21=cyclic heat stress from day 16 to day 21 into broiler development; ECC 22-42=cyclic heat stress from day 22 to day 42 into broiler development; ECC 16-42=cyclic heat stress from day 16 to day 42 into broiler development; CV=coefficient of variation.

**DISCUSSION**

Breasts removed from broilers reared according to the ECC 22-42 regime differed from the animals of the control group (C-16-42). The color classification system adopted in the present study showed that breast meat of broilers managed under cyclic heat stress were of a different color than the meat considered normal, and that it was mostly of the PSE class. A previous study showed that meat quality is influenced by exposure to heat stress, either shortly (before slaughtering), or for longer periods (during growth) [10]. Research has established that stress factors such as heat, for
example, may adversely affect meat quality, mainly the attributes appearance, texture, succulence, flavor, and functional properties (water retention capacity and exudation, or drip loss) [9].

It is known that water retention capacity is influenced when the animal is exposed to stress, which promotes muscle protein denaturation that, in turn, induces drip loss [5]. In the present study, no statistically significant differences were observed between drip loss values for broilers exposed to the different heat regimes used. The same finding was reported in another study, when no drip loss was observed after exposure to severe heat stress previously to slaughter (2 h at 35°C) [2]. Similarly, no difference in water retention capacity was observed between the control group and broilers exposed to 1-h heat stress at 40°C [13].

The classification of chicken breast as DFD indicates that the meat is subject to comparatively lower drip loss rates. In this sense, the present study confirms the results of previous studies: low drip loss values are typical of DFD meat, due to the low water content absorbed [11,14,16]. In turn, meat ranked as PSE looks pale, soft, and exudative, with high drip loss values, since during slaughter it absorbed large volumes of water that subsequently is released by dripping.

Due to the undesired functional properties, meat classified as PSE poses a problem for chicken meat products, resulting in skin-encased, brine-preserved, or cook-in-bags items that do not fit consumer standards. Therefore, quality meat has to be free of the negative effects caused by heat stress and present high water retention capacity [17], or lower drip loss, which is negatively influenced by the PSE condition [7].

The correlation between color and drip loss indicates that the breasts removed from broilers with greater drip loss values tended to present lower color scores. Therefore, according to the ranking system used (DFD = 3, normal = 2, PSE = 1), the higher the number of breast classified as 1, the higher will be the drip loss value. Although the end customers are free to decide what chicken breast meat is best according to their preference, the product sold in supermarkets should present normal color (score 2).

CONCLUSION

Exposure to 1-h heat stress does not affect drip loss of breasts of broilers at different growth stages, though color may be affected.

Ethical approval. This study was approved by the Ethics Commission for Experiments with Animals of the Federal University of Uberlândia (authorization number CEUA/ UFU 024/10).

Declaration of interest. The authors report no conflicts of interest and alone is responsible for the content and writing of the paper.

REFERENCES


