### **Short Communication**

# Physicochemical and microbiological parameters of frozen and chilled chicken meat

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**ABSTRACT** - With this study we aimed to evaluate and compare physicochemical and microbiological characteristics of frozen and chilled chicken meat. Only the prime cuts (breast, thighs, and drumsticks) were considered for the analysis of chemical composition, pH, color, water-holding capacity (WHC), thawing-cooking loss (TCL), and shear force (SF). For microbiological analysis, mesophilic bacteria, thermotolerant coliforms, and *Salmonella* spp. were considered. The frozen and chilled chicken meat showed no PSE (pale, soft, and exudative) or DFD (dark, firm, and dry) type of anomalies. The chromaticity showed higher redness in the breast (a\* = 0.23) and yellowness in the thigh (b\* = 5.64) for the frozen meat. The chilled meat showed better values for water-holding capacity in the thigh (69.19%) and thawing-cooking loss in the breast meat (18.84%). Samples of frozen and chilled chicken meat showed unconformities as to the percentage of occurrence of *Salmonella* spp., since the Brazilian legislation determines the absence of these pathogens. Both forms of preservation by freezing and chilling are recommended to maintain the physicochemical characteristics. In turn, we observed that the microbiological patterns can be maintained by the both forms of meat preservation by cold, mainly by freezing, provided there are satisfactory sanitary conditions in handling pre and post-slaughter of poultry.

Key Words: broiler, feed evaluation, meat quality, microbiology, pH

### Introduction

The poultry sector can be considered one of the most developed and modernized in the world agriculture. Advances in genetics, together with the development of nutrition, health and management techniques, resulted in the current poultry farming, with high efficiency and organization to produce animal protein of high biological value for human consumption, at a low cost (Bailone and Roça, 2016).

In the poultry sector, the quality and safety of the Brazilian product make the difference. Among the many cases of Avian Influenza in large world producers, Brazil remains free of this disease, which is a significant feature in a highly competitive market like the animal protein

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industry. It is not a coincidence that open markets kept buying poultry products from Brazil, and new doors opened, e.g., Pakistan for chicken meat (ABPA, 2015). However, meeting all specifications of meat quality is undoubtedly the major challenge of the current poultry industry, and it is important to know the physicochemical, microbiological, and sensory meat properties and if these attributes determine the quality of the end product (Le Bihan-Duval et al., 2008; Komiyama et al., 2010; Koblitz, 2011).

Thus, the preservation of meat by chilling and freezing is an alternative to keep the chemical, organoleptic, and nutritional characteristics of product as close as possible to the initial conditions and further prevent an unfavorable action of microorganisms and enzymes. Pradhan et al. (2012) researched the growth and survival of *Listeria innocua* and *Salmonella typhimurium* in chicken breasts during refrigerated and frozen storage and observed that the loads of both bacteria at frozen storage temperatures did not change significantly over time, while at a storage time of seven days, the increase in bacterial loads of *L. innocua* at 4 and 8 °C was 2.1 log cfu/g and 3.7 log cfu/g, respectively, and that of *S. typhimurium* at 8 °C was 1.2 log cfu/g.

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In this context, the objective of this study was to evaluate and compare the physicochemical and microbiological parameters of frozen and chilled chicken meat.

### **Material and Methods**

Sixty whole chicken carcasses (Bailey et al., 2000; Pradhan et al., 2012) of two leading brands in the Brazilian market were purchased in three supermarket chains (twenty carcasses in each), all on the same day, in the state of Rio Grande do Norte, thirty of which were frozen (-12 °C) and thirty were chilled (between 0 and 4 °C). On the days of poultry collection, samples of breast, thighs and drumsticks of carcasses had the bones, skin, and fat removed. For microbiological analyses, we used the poultry breast (Olivo, 2006; Pradhan et al., 2012), while breast, thigh, and drumstick were used for physicochemical analyses.

The homogenized muscle tissue of each prime cut was analyzed in triplicate for chemical composition (moisture, lipids, protein, and ash) following the laboratory techniques described by Silva and Queiroz (2005). The potential hydrogen (pH) was quantified in triplicate, using a digital pH meter (Hanna<sup>©</sup>) coupled to a penetration electrode, after the acquisition of samples. The meat color was checked in triplicate for breast, thighs, and drumsticks, using a portable spectrophotometer (Minolta<sup>©</sup> CM-700d) programmed with the CIELab system considering the coordinates L\* (black/white), corresponding to lightness; a\* (red/green), redness; and b\* (blue/yellow), yellowness (Olivo, 2006).

To determine the water-holding capacity (WHC), 0.5 g of meat cubes were placed in circular filter papers, and these between two glass plates, on which a 5 kg weight was placed for 5 min. This variable was then calculated as the weight difference (initial – final), according to Hamm (1960), adapted by Osório et al. (1998). For the thawing-cooking loss (TCL), samples were kept at a temperature of 4 °C for 24 h, weighed, individually wrapped in aluminum foil, and placed on a cooking in plate (grill) preheated to 170 °C, until reaching 80 °C at the geometric center, which was checked using a digital thermometer (Delta OHM HD

9218). Samples were then dried on blotting paper, cooled to room temperature, and subsequently the difference in weight (initial – final) was measured to obtain the result (Warriss, 2003).

The shear force (SF) was measured using a Warner-Bratzler Texture Analyzer instrument (TA-XT-125) coupled to the device with pre-test speed of 2.0 mm/s, test speed if 2.0 mm/s, and velocity after test of 10.0 mm/s. The distance traveled by the blade after having reached the top of the sample was 20.0 mm (Monte et al., 2007). The same samples for determination of TCL were used, with the setting of  $1.0 \times 1.0 \times 3.0$  cm. Shear force was expressed in kgf/cm<sup>2</sup>.

To evaluate the microbiological quality of the meat, we used the methodology described in the official analytical methods for microbiological analyses for control of animal products and water established by Normative Instruction 62 (Brasil, 2003).

Data were examined for homoscedasticity and normality, in which outliers were not identified, and then subjected to analysis of variance and the Tukey test at 5% probability, using the statistical software R - Development Core Team (2011).

### **Results and Discussion**

The chemical compositions of chilled and frozen chicken prime cuts (Table 1) did not differ (P>0.05).

Data available in the literature show that the chemical composition of the muscle tissue of poultry varies with factors such as sex, age, breed, or line, pre-slaughter and post-slaughter handling, temperature of the muscle tissue, and the carcass chilling speed (Olivo et al., 2001). However, little variation is related to the method of preservation, refrigeration, or freezing, although some pre-chilling techniques that make use of water and ice can increase the moisture of the carcass and cause loss of nutrients through leaching (Bailone and Roca, 2016).

As for color, there were no differences (P>0.05) between frozen and chilled chicken meat for lightness,

Table 1 - Chemical composition of frozen and chilled chicken prime cuts

|                   | Bre         | Breast       |             | Thigh        |             | Drumstick    |        |
|-------------------|-------------|--------------|-------------|--------------|-------------|--------------|--------|
| Chemical analysis | Frozen meat | Chilled meat | Frozen meat | Chilled meat | Frozen meat | Chilled meat | CV (%) |
| Moisture          | 75.80a      | 73.20a       | 74.50c      | 74.10c       | 76.80e      | 77.30e       | 1.05   |
| Protein           | 18.70a      | 19.50a       | 16.40c      | 15.80c       | 17.30e      | 17.10e       | 5.40   |
| Lipids            | 1.10a       | 0.90a        | 4.00c       | 3.70c        | 5.80e       | 6.10e        | 1.24   |
| Ash               | 0.95a       | 0.96a        | 0.88c       | 0.86c        | 0.87e       | 0.89e        | 1.12   |

a,b - means followed by different letters in the row differ by Tukey's test (P<0.05) for breast.

c,d - means followed by different letters in the row differ by Tukey's test (P<0.05) for thigh.

e,f - means followed by different letters in the line differ by Tukey's test (P<0.05) for drumstick.

CV - coefficient of variation.

L\*, in the breast, thigh, and drumstick (Table 2). Thus, the samples may be considered normal and free of PSE (pale, soft, and exudative) or DFD (dark, firm, and dry) anomalies (Olivo, 2006).

Redness, a\*, however differed between the preservation forms only for breast meat (P<0.05). According to Zeola et al. (2002), the commercial lines of broilers show pale pink breast meat, making them less reddish, which can certainly explain the lower values observed in this parameter. For yellowness, b\*, they differed only in the drumstick (P<0.05), which may be related to the fact that the temperature used to freeze allows more lipid and pigment oxidation, making the meat more yellowish (Franco and Landgraf, 2006).

There were no differences (P>0.05) for pH in prime cuts between the two forms of chicken meat preservation (Table 3). The poultry behavior at slaughter, particularly the movement of opening and closing wings, influences the pH decline. This is a decisive criterion for the quality of the meat, since color, water-holding capacity, and softness are correlated (Le Bihan-Duval et al., 2008).

The pH of chicken meat decreases due to acid formation, in which the breast meat should present final pH between 5.7 and 5.9. Olivo and Shimokomaki (2002) reported that pH values below 5.7 indicate meats with PSE characteristics, and above 5.9, development of DFD characteristics in chicken meat. Thus, the values observed for the frozen and chilled chicken meat may be considered normal, those samples being free of PSE and DFD anomalies.

For water-holding capacity (WHC), only the thigh differed (P<0.05) between the two forms of preservation, while thawing-cooking loss differed only for breast meat

(P<0.05), and the chilled chicken meat showed the best result in both parameters (Table 3), which is due to the freezing allowing the formation of ice crystals and the disruption of cellular structures by perforations; thus, the subsequent thawing or variations in storage temperature promote denaturation of proteins and the water retention capacity (Olivo and Shimokomaki, 2002).

The water-holding capacity is defined as the capacity of the meat to retain its moisture, or water, during the application of external forces, such as cuts, heat, grinding, pressing, and/or centrifuging (Sá, 2004). This property affects appearance and palatability and is directly related to loss of water before and during cooking (Baracho et al., 2006; Mendes et al., 2003). The values for the prime cuts of frozen and chilled chicken meat for this parameter were higher than the 56.38 to 58.80% reported by Castro et al. (2008).

As for shear force, there were no differences (P>0.05) between frozen and chilled chicken meat for breast, thigh, and drumstick (Table 3). The literature reports discrepant values regarding the limits of shear force for the chicken breast meat to be considered soft. Simpson and Goodwin (1974) used as the reference value 8.0 kgf/g, while Lyon et al. (1995) reported 7.5 kgf/g as a limit, above which the meat can be considered tough. Castro et al. (2008), in turn, reported values for this parameter ranging from 4.07 to 5.27, higher than the values observed in this study for both forms of preservation for breast. The samples used in this study can be considered soft according to Bressan and Beraquet (2004), who, after evaluating pre-chilling and chilling treatments on poultry breast meat quality, found

Table 2 - Mean values for color (L\*, a\*, b\*) of frozen and chilled chicken prime cuts

|              | Color  |        |       |        |       |       |           |       |       |      |
|--------------|--------|--------|-------|--------|-------|-------|-----------|-------|-------|------|
| Poultry      | Breast |        |       | Thigh  |       |       | Drumstick |       |       |      |
|              | L*     | a*     | b*    | L*     | a*    | b*    | L*        | a*    | b*    | _    |
| Frozen meat  | 47.77a | 0.23a  | 4.81a | 45.47c | 2.06c | 5.05c | 47.79e    | 1.63e | 5.64e | 1.15 |
| Chilled meat | 47.74a | -0.03b | 4.57a | 46.46c | 2.11c | 5.39c | 46.43e    | 1.70e | 4.33f | 1.27 |

a,b - means followed by different letters in the column differ by Tukey's test (P<0.05) for breast.

Table 3 - Mean values for pH, water-holding capacity, thawing-cooking loss, and shear force of frozen and chilled chicken prime cuts

| Physical analysis                  | Breast      |              | Thigh       |              | Drumstick   |              |        |
|------------------------------------|-------------|--------------|-------------|--------------|-------------|--------------|--------|
|                                    | Frozen meat | Chilled meat | Frozen meat | Chilled meat | Frozen meat | Chilled meat | CV (%) |
| рН                                 | 5.90a       | 5.96a        | 6.42c       | 6.49c        | 6.38e       | 6.56e        | 1.10   |
| Water holding capacity (%)         | 70.12a      | 70.91a       | 65.54d      | 69.19c       | 65.89e      | 68.62e       | 1.80   |
| Thawing-cooking loss (%)           | 25.48a      | 18.84b       | 32.55c      | 29.26c       | 32.54e      | 29.25e       | 2.24   |
| Shear force (Kgf/cm <sup>2</sup> ) | 3.51a       | 3.41a        | 3.72c       | 3.73c        | 3.92e       | 3.89e        | 1.74   |

a,b - means followed by different letters in the row differ by Tukey's test (P<0.05) for breast.

c,d - means followed by different letters in the column differ by Tukey's test (P<0.05) for thigh.

e,f - means followed by different letters in the column differ by Tukey's test (P<0.05) for drumstick.

CV - coefficient of variation.

c,d - means followed by different letters in the row differ by Tukey's test (P<0.05) for thigh

e,f - means followed by different letters in the row differ by Tukey's test (P<0.05) for drumstick.

CV - coefficient of variation.

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Table 4 - Thermotolerant coliforms counts, most probable number of mesophilic organisms, and percentage of *Salmonella* spp. in frozen and chilled chicken meat

| Poultry      | Thermotolerant coliforms counts (log MPN g <sup>-1</sup> ) | Mesophilic (log cfu g <sup>-1</sup> ) | Salmonella spp. | CV (%) |
|--------------|--|---------------------------------------|-----------------|--------|
| Frozen meat  | 1.89a  | 4.15a                                 | 18b             | 3.24   |
| Chilled meat | 1.92a  | 4.26a                                 | 26a             | 2.75   |

a,b - means followed by different letters in the column differ by Tukey's test (P<0.05).

MPN - most probable number; cfu - colony-forming unit; CV - coefficient of variation

mean values ranging from 2.92 to 3.50 kgf/g and classified the samples as highly soft.

According to microbiological analysis (Table 4), all samples were within the standard for thermotolerant coliforms presented by the Brazilian legislation (RDC n. 12 January 2001), which sets the upper limit of fecal coliforms at  $10^4/g$  of food (Brasil, 2001).

The presence of coliform bacteria in food is considered a useful indication of contamination, which may be related to poor hygiene during food processing and storage (Silva et al., 2002). Regarding the number of mesophilic aerobic organisms, the values observed in this study (Table 4) did not differ (P>0.05), and although there is not a standard in the current legislation, the high value in this group of bacteria in perishable foods, such as chicken, can be related to the bad healthy conditions during the production chain, since most of the foods show detectable changes when values are greater than  $10^6$  cfu/g of food (Franco and Landgraf, 2002).

There was a higher incidence of *Salmonella* spp. in chilled chicken meat (P<0.05) compared with frozen meat (Table 4), indicating that the chilling process is less efficient in controlling microorganism growth. According to Franco and Landgraf (2006), preservation by cold has the advantage of preserving much of the nutritional and sensory value of foods, but it has the downside of not eliminating the harmful action of microorganisms or toxins, because as soon as the temperature becomes favorable, their activity is resumed.

Frozen and chilled chicken meat samples showed unconformities regarding the percentage of occurrence of *Salmonella* spp., since the current Brazilian legislation determines absence of these pathogens.

#### **Conclusions**

Cold preservation of chicken meat, by freezing or chilling, is recommended to maintain the meat

physicochemical characteristics. Provided there are satisfactory sanitary conditions in handling pre and post-slaughter of poultry, the microbiological patterns can also be maintained by cold preservation techniques, mainly by freezing.

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