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Effect of storage temperature at 7°C on the physical-chemical and microbiological quality of industrialized cooked chicken breast meat

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ABSTRACT. The effect of storage temperature at 7°C on the physical-chemical and microbiological quality of industrialized cooked chicken breast meat was analyzed. Frozen cooked breast meat supplied from a poultry-processing industry was used. Fillets were stored at a prescribed temperature (7°C) for 15-17 days and the sample's chemical composition and initial pH was determined. Color, texture and microbiology were analyzed to determine the shelf-life of the cooked chicken breast meat. *Salmonella spp.* and *Escherichia coli* were not detected. The highest values of Chroma a* were observed at 312 and 360 hours, exhibiting an intense red color resulting from meat deterioration. Chroma b* failed to show any significant difference between the first and last day of storage. Lightness (L*) was decreased with storage time and revealed a darker color caused by microbial spoilage. Texture decreased from 2.93 to 1.12 kgf. It may be concluded that shelf-life attended to expectations with regard to texture, color and microbiology of cooked chicken breast meat stored at 7°C during 13 days.

Keywords: shelf life, color, texture, microbiology.

Efeito da temperatura de armazenamento de 7°C na qualidade físico-química e microbiológica de peito de frango cozido industrializado

RESUMO. O objetivo deste estudo foi avaliar o efeito da temperatura de armazenamento de 7°C na qualidade físico-química e microbiológica de peito de frango cozido industrializado. Foi armazenado a 7°C o peito cozido de frango congelado, fornecido por uma indústria de processamento de aves, durante um período de 15-17 dias, para análise da composição química e pH inicial da amostra. Análises de cor, textura e microbiológicas foram executadas para determinar a vida útil da carne de peito de frango cozido. Não foi detectada a presença de *Salmonella spp.* e *Escherichia coli*. Os maiores valores de Chroma a* foram observados a 312 e 360h, exibindo cor vermelha intensa pela deterioração da carne. O Chroma b* não apresentou diferença significativa entre o primeiro e último dia de armazenamento. A luminosidade (L*) diminuiu ao longo do tempo de armazenamento, apresentando cor mais escura pela deterioração microbiana. A textura diminuiu de 2,93 para 1,12 kgf. Em conclusão, a vida útil atendeu as expectativas de legislação e controle de qualidade em relação às análises de cor, textura e microbiologia do peito de frango cozido armazenado a 7°C durante 13 dias.

Palavras-chave: vida útil, cor, textura, microbiologia.

Introduction

Poultry meat has a high contamination risk during processing (SHELDON, 2000). Chicken meat is highly perishable and the time that leads to deterioration varies from four to about twelve days after slaughter, even when maintained in a cooling environment (SMOLANDER et al., 2004). Deterioration depends on the microbiological conditions of poultry carcasses which are directly affected by slaughter and sanitization conditions (SHELDON, 2000).

Storage temperature, type of packaging, types and numbers of psychrotrophic bacteria are the major factors which determine the spoilage of poultry meat (TUNCER; SIRELI, 2008). The high consumption of poultry indicates that the marketed products must be thoroughly safe, have a low spoilage rate and show the right composition, packaging, color, taste and appearance (DEL RÍO et al., 2007).

Products excessively contaminated with microorganisms are undesirable from the standpoint of public health and storage quality.

Mesophilic aerobic counts, psychrotrophs, Enterobacteriaceae, coliforms, Micrococcaceae, enterococci, *Pseudomonas* spp., lactic acid bacteria, and yeasts and moulds are used in meat and poultry industries as general indicators of processing hygiene, storage quality and potential shelf-life both in oxygen atmosphere and in vacuum-packaged meat (DEL RÍO et al., 2007).

The development of multiple safety hurdles to control foodborne pathogens and spoilage microorganisms along the food chain remains a top research priority in food industries. One aspect of the food chain that needs greater attention is the control of bacterial pathogen proliferation and prevention of the product's cross-contamination as products move through the processing plant (SHELDON; LI, 2006). As the temperature is decreased below the optimum for growth, generation times and lag times are extended. However, many of the major relevant food spoilage and food poisoning microorganisms are cold-adapted psychotropic bacteria which are able to grow at low temperatures close to 0°C (RUSSELL, 2002; SMOLANDER et al., 2004).

Texture and color are highly relevant among the aspects of chicken meat that most attract the final consumer (VIEIRA, 2007). The integrated time-temperature is visualized as a color change. The indicator's color change proceeds as a function of time since the rate of visible color change is proportional to storage temperature (SMOLANDER et al., 2004). The texture is one of the most important quality criteria in any type of meat because it is ultimately associated with the satisfaction of the consumer. The texture of food is a sensory parameter with the main attributes featuring tenderness, cohesiveness and viscosity, and the secondary featuring chewiness, juiciness and adhesiveness (SOUZA, 2005).

Current analysis aims at studying the effect of temperature at 7°C on the physical-chemical and microbiological quality in industrialized cooked chicken breast meat.

Material and methods

Cooked chicken breast

Cooked chicken breast was obtained from a local poultry processing industry and transported to the laboratory in insulated polystyrene boxes with ice. According to the industry, the product had been boiled at a temperature of 78°C during 30 to 40 minutes, cooled to room temperature and then the cooked chicken breast meat was stored at -18°C.

pH

Product's pH was measured with a digital pH meter (Model PA 200, Marconi Instruments, Inc., Brazil), when 10 g of sample of cooked chicken breast were cut into small pieces to which 50 mL of distilled water were added. When a slurry was made by using a blender, pH was recorded.

Physical-chemical analysis

Moisture, ash, crude protein and crude fat contents of cooked chicken breast meat were determined according to methods described by AOAC (2000). Moisture was determined by the oven drying method at 110°C for 24 hours. Ash was determined by incineration in a muffle furnace at 550°C; total protein content was calculated by the Kjeldhal method; total lipids were evaluated by the Soxhlet method.

Microbiological analysis

A sample (25 g) was taken aseptically from the cooked fillet (chicken breast), and transferred aseptically to a stomacher bag (Seward Medical, London, United Kingdom) containing 225 mL of sterile 0.1% peptone water and homogenized with a stomacher (Lab Blender 400; Seward Medical) for 60 s at room temperature. Serial dilutions were prepared in sterile 0.1% peptone water and surface plated in duplicate on standard plate count agar (SPCA, Difco) for mesophilic, aerobic and psychrotrophic counts. Whereas plates for mesophile counts were stored at 35°C for 48 hours, plates for psychrotrophic counts were stored at 3.5°C for 10 days.

A ten-fold serial dilution was prepared using sterile 0.1 peptone solution (9 mL) and spread plated (0.1 mL) in duplicate onto broths and/or agars for detection of typical colonies, biochemical confirmation and identification, and plate counting (*Salmonella* spp., and *Staphylococcus*) or by the most probable number method (fecal coliform), according to classical methodology (USDA/FSIS, 1998). *Salmonella* was isolated according to standard methods Iso-6579 (ISO, 1986). Initially, 25 g of sample were aseptically added to 225 mL of pre-enriched medium, Buffered Peptone Water (Oxoid, Basingstoke, 0020UK) and incubated for 18h at 37°C. The pre-enriched culture, 0.1 and 1 mL respectively, was then transferred to Rappaport-Vassiliadis broth (Oxoid) and Selenite broth (Difco Laboratories Detroit, MI) and incubated at 42 and 37°C, respectively. After 24 and 48 hours of incubation, a loopful from each of the enriched broths was streaked onto plates of *Salmonella* Shigella agar (Difco) and XLD agar (Difco), and

incubated at 37°C for 24h. The plates were examined for typical colonies of *Salmonella*, i.e. transparent colonies with black centres on SS agar and red colonies with black centers on XLD agar (PUCCIARELLI; BENASSI, 2005). Suspected colonies (maximum five) were randomly selected from each plate and confirmed by biochemical tests, including fermentation of glucose, lactose and sucrose, hydrogen sulfide production, urease activity, phenylalanine deamination, lysine decarboxylation, citrate, methyl red and indole tests.

Texture evaluation

Texture evaluation of the cooked chicken breast meat was carried out with a texture analyzer Model TA-XT2 plus (Stable Micro Systems, Surrey, United Kingdom) calibrated for a cutting speed of 2 mm s⁻¹, return speed of 5 mm s⁻¹ and units kgf. Samples from the breast meat were removed in the form of 1 x 1 x 1 cm parallelepipeds following the orientation of the muscle fibers, according to Faria et al. (2008), with values expressed in kgf (kilograms force). Samples were submitted to a cutting shearing⁻¹ test using Warner-Bratzler shear work (kgf), which indicated the total energy (work) required for shearing (toughness).

Color measurement

The color of the samples was evaluated with a Minolta colorimeter, model 'Chroma Meter', CR400. Readings were done for the three samples of cooked chicken breast meat in each treatment and the samples were evaluated in the L*, a* and b* systems.

Statistical analysis

Color, texture and microbiological analyses were submitted to variance analysis and comparison of means was done by Tukey's Test at 5% of significance, using Statistica 7.0.

Results and discussion

Table 1 shows the approximate composition and the pH found in cooked chicken breast meat stored at 7°C.

It appears that the moisture content was low (64.6 ± 0.2%) when compared to rates provided by the industry supplier of the raw material (66-70%).

It should be noted that proteins were the most significant components with an inverse relationship to the moisture content. This fact perhaps occurred because they had higher percentages, excluding water. The levels found in cooked breast meat agreed with the data in the literature for chicken breast meat cooked by different methods, namely: 61.7-70.0% moisture, 27.9-35.7% protein, 1.1-3.2% fat and 0.7-1.3% ash (FLETCHER, 1999; VIEIRA, 2007). The pH in current study was clearly demonstrated since the range agreed with that indicated by the supplier (6.0-6.5) (MARFRIG GROUP, 2011) as well as with the data in the literature, with a pH ranging between 6.09 and 6.21 for different samples of cooked chicken breast meat (FLETCHER et al., 2000) and 6.11 found by Galarz et al. (2010) for cooked chicken breast meat. These rates indicated good quality meat with high durability. Ash and lipid rates in current study agreed with the range of values in literature.

When chicken cuts were compared, Oda et al. (2004) observed that the chemical composition was different, i.e. the chemical composition might vary and depended on different muscle groups that constituted the cuts. In general, Forrest et al. (1989), Souza et al. (2004) and Warriss (2003) described various aspects that contributed to variations in the parameters moisture, protein, lipid and ash, such as breed, genetic group, sex, age and diet.

The values found for ash in current study also agreed with those by Faria et al. (2008) who found a percentage of ash (1.69%) for chicken breast meat within the limits provided by the industry.

Danowska-Oziewicz et al. (2009) found a percentage of 22.44% when the researchers analyzed protein in *in natura* turkey meat. Rates exceeding these proteins were found in chicken breast fillets used in the preparation of nuggets (25.5 ± 0.4) (NUNES et al., 2006). However, the two rates were below those presented in current study for protein.

Table 2 presents the color and texture rates of cooked chicken breast meat stored at 7°C.

There was a decrease in texture rates during the storage days and the first day was statistically different from the last day of storage. However, during the first 9 days (216 hours) there was no significant difference in the sample with regard to texture.

Table 1. Physical-chemical analysis and pH of cooked chicken breast meat stored at 7°C.

Breast sample	Moisture (%)	Protein (%)	Crude fat (%)	Ash (%)	pH	References
Cooked	64.6 ± 0.2	30.6 ± 2.1	2.5 ± 0.1	1.1 ± 0.2	6.2 ± 0.1	Current research ^a
Cooked	64.6 ± 0.2	30.8 ± 3.3	2.6 ± 0.2	1.1 ± 0.1	6.11 ± 0.3	Galarz et al. (2010)
Cooked	61.7-70	27.9-35.7	1.1-3.2	0.7-1.3	6.1-6.2	Fletcher et al. (2000)
Cooked	66-70	27-31	Max 3	1.6-3.5	6.0-6.5	Marfrig Group (2011)

^aAverage and standard deviation calculated from a sample's analysis in triplicate.

Decrease in texture over storage time agreed with results found by Cortez-Vega et al. (2012) who observed a decrease between 3.23 and 0.94 kgf in raw chicken breast meat stored at 5°C for 9 days.

Table 2. Values of color and texture of cooked chicken breast stored at 7°C.

Time (hours)	Color			Texture (Kgf)
	L*	a*	b*	
0	82.42 ± 0.71 ^a	0.26 ± 0.17 ^c	14.72 ± 1.26 ^{abcd}	2.93 ± 0.13 ^a
24	82.39 ± 1.02 ^a	0.25 ± 0.38 ^c	14.02 ± 0.71 ^{bcd}	2.92 ± 0.16 ^a
72	81.6 ± 0.43 ^{ab}	0.22 ± 0.15 ^c	14.41 ± 1.32 ^{abcd}	2.85 ± 0.12 ^{ab}
120	81.24 ± 0.22 ^{abc}	-1.26 ± 0.29 ^d	17.15 ± 0.28 ^a	2.71 ± 0.10 ^{abc}
168	80.8 ± 0.33 ^{abc}	-1.12 ± 0.39 ^d	16.51 ± 0.52 ^{abc}	2.44 ± 0.11 ^{abcd}
216	80.04 ± 0.03 ^{abc}	0.53 ± 0.12 ^c	16.57 ± 0.04 ^{ab}	2.31 ± 0.13 ^{abcd}
264	79.4 ± 1.23 ^{bcd}	0.76 ± 0.24 ^{bc}	15.49 ± 0.56 ^{abc}	2.24 ± 0.37 ^{bcd}
312	78.88 ± 1.04 ^{cd}	1.71 ± 0.56 ^a	14.75 ± 2.10 ^{abcd}	2.04 ± 0.22 ^{cd}
360	77.63 ± 0.68 ^d	1.63 ± 0.36 ^{ab}	13.78 ± 1.16 ^d	1.84 ± 0.19 ^d
408	74.38 ± 1.41 ^e	1.50 ± 0.24 ^{ab}	12.56 ± 0.82 ^d	1.12 ± 0.25 ^e

Means followed by the same letter in the column did not differ by Tukey's Test ($p < 0.05$).

The decrease in cutting force is related to microbial deterioration during the storage period when nutrient uptake by bacteria occurs and the fibers break down more easily at a lower shear strength (DHANANJAYAN et al., 2006).

Texture rates in chicken were higher than those reported by Pavan et al. (2003) who reported values from 1.91 to 2.23 kgf and lower than those reported by Bressan and Beraquet (2004) from 2.92 to 3.50 kgf. Bickerstaffe et al. (1997) stated that meat was considered soft when it presented shear force rates of 8.00 kgf, with acceptable values ranging between 8 and 11 kgf. The above data showed that the chicken breast meat analyzed in this experiment was considered soft. Reduction of shear force (2.93-1.12) for industrialized cooked chicken breast meat agreed with data by Saláková et al. (2009) who found that chicken cuts had an initial and final shear force of 5.85 kgf and 3.34 kgf cm⁻² respectively.

The variable L* indicates lightness, differing light and dark colors (CORTEZ-VEGA et al., 2012). Its rates range between 100 for light colors (white) and zero for dark colors (black). In general, a reduction of approximately 9.75% in L* value of the cooked chicken breast meat during the first and the last day of storage at 7°C was observed. Saláková et al. (2009) argued that the positive value of L* for cooked chicken breast and the loss during cooking were correlated, showing a tendency that meat became darker over time due to the action of deteriorating microorganisms that caused color changes. Although L* values showed no significant difference in 216 hours (9 days), a significant difference was observed after 264 storage hours of cooked chicken breast meat. This fact revealed that starting from this time more marked deterioration of cooked chicken breast meat began to occur.

Young et al. (2005) showed that when cooked chicken breast meat was subjected to marination, an increased lightness (L*) occurred, or rather, meat became less red (reduced a*) and more yellow (higher b*). Lightness rates reported by the above author disagreed with those in current work since in storage at 7°C the brightness decreased and rates of Chroma a* increased with the passing of storage days. Lightness rates and Chroma b* agreed with values provided by Cortez-Vega et al. (2012) with a decrease in brightness of beef fillet and raw chicken breast meat packaged at different modified atmospheres after 9 days storage, which tended towards a darker color. There was also a decrease in Chroma b* rates tending towards yellow for the fillets of chicken breast meat, packaged in different modified atmospheres.

Chroma a* indicates the intensity of colors varying from green (-60) to red (+60) (CORTEZ-VEGA et al., 2012). Highest rates of Chroma a* from cooked chicken breast meat were observed at 312 and 360 hours. Young et al. (2005) obtained an average of 2.08 (a*), measured in breast meat of broiler bone after *rigor mortis*. This resulted in meat with less redness (a*), also observed in current research in which there was a decrease followed by an increase in Chroma a* tending towards a red color decrease.

The Chroma b* indicates the intensity of the colors varying from blue (-60) to yellow (+60) (CORTEZ-VEGA et al., 2012). Alterations of Chroma b* occurred throughout the storage time with a tendency towards an increase of intensity of yellow. Chroma b* rates did not show significant difference until the 13th day of storage for cooked chicken breast meat. Saláková et al. (2009) found a variation between 14.28 and 15.85 for Chroma b* for broiler cooked meat, which was within the range of values reported by the authors of current study. Chroma b* showed a tendency towards an increase of intensity or purity of color, but no significant difference between the first and last day of storage was shown in the product's saturation evaluation.

Table 3 presents the values of Log CFU g⁻¹ for aerobic mesophilic, *Staphylococcus* spp. and psychrotrophic aerobic for cooked industrialized chicken breast meat stored at 7°C.

Total mesophilic aerobic bacteria on chicken fillet should not exceed 10⁶ CFU g⁻¹ (AL-DUGHAYM; ALTABARI, 2010), which agrees with Morshedy and Sallan (2009), who in a zero-day storage found 4.62 log CFU g⁻¹ for chicken carcasses but obtained a higher score on the sixth and eighth days of storage. There was no significant difference in the growth of aerobic mesophilic microorganisms in 72 hours (3 days) of analysis, whereas the

tolerable limit for these microorganisms (10^6) was achieved in about 216 hours (9 days).

Table 3. Log₁₀ colony-forming units (CFU) g⁻¹ of microorganisms of cooked chicken breast meat stored at 7°C.

Time (hours)	Microorganisms Log(CFU g ⁻¹)		
	Mesophilic aerobic	<i>Staphylococcus</i> spp.	Psychrotrophic aerobic
0	1.56 ± 0.58 ^d	0.32 ± 0.08 ^c	1.18 ± 0.07 ^d
24	1.72 ± 0.7 ^d	0.94 ± 0.2 ^{dc}	1.32 ± 0.09 ^d
72	2.53 ± 1.03 ^d	1.18 ± 0.09 ^{dc}	1.75 ± 0.18 ^d
120	4.92 ± 1.32 ^c	1.95 ± 0.1 ^{cd}	4.03 ± 1.27 ^c
168	5.27 ± 0.59 ^{bc}	2.64 ± 0.15 ^{bc}	4.46 ± 0.65 ^{bc}
216	6.17 ± 0.32 ^{abc}	3.58 ± 0.12 ^b	5.32 ± 0.28 ^{bc}
264	6.34 ± 0.72 ^{abc}	3.76 ± 0.7 ^b	6.58 ± 0.32 ^{ab}
312	7.36 ± 0.32 ^{ab}	5.65 ± 1.18 ^a	8.47 ± 1.76 ^a
360	7.86 ± 0.41 ^a	2.95 ± 0.28 ^{bc}	8.43 ± 0.12 ^a

Means followed by the same letter in the column did not differ by Tukey's test ($p < 0.05$).

The growth of *Staphylococcus* was not significantly different in 72 hours (3 days) of analysis. Reports found by Barbut (2002) and by Franco and Landgraf (2008) showed that between 10^5 and 10^6 colony-forming units of *Staphylococcus* spp. per gram of food might produce the formation of toxins at levels that could cause intoxication. Analysis of *Staphylococcus* spp. showed that until the 13th day the chicken breast meat was fit for consumption. After this period, the product was already above the rates that would cause food intoxication if ingested.

The International Commission on Microbiological Specifications for Foods (ICMSF, 1986) established counts lower than 10^6 - 10^7 CFU g⁻¹ as safe standards for consumption in the case of psychrotrophic. Several studies found that the ideal sanitary conditions for chicken meat went beyond the count of 10^6 bacteria CFU g⁻¹ (RITTER; BERGMANN, 2003). Psychrotrophic aerobic bacteria are among the microorganisms that have developed well at refrigeration temperatures, 0 to 7°C (JAY, 2005). The sample of chicken breast meat analyzed showed no significant difference in 72 hours of storage and featured a 13-day shelf-life when stored at 7°C.

Cooked chicken breast meat had a bacteria count below 10^7 CFU g⁻¹, which was considered the maximum fit for human consumption. Presence of *Salmonella* spp. was not detected in cooked chicken breast meat stored at 7°C, which indicated good conditions of hygiene and product safety. The analysis of *Escherichia coli* showed counts lower than 0.3 MPN g⁻¹ of sample and revealed good manufacturing practice. Shelf-life of cooked chicken breast meat stored at temperature of 7°C was 13 days.

Conclusion

Highest values of Chroma a* from cooked chicken breast meat were observed in 312 and 360

hours. Lightness (L*) decreased with storage time, tending to a darker color. Texture was decreasing from 2.93 to 1.12 kgf due to degradation by microorganisms. The cooked chicken breast meat showed a shelf-life of 9 days for mesophilic micro-organisms and 13 days of shelf-life for psychrotrophic and *Staphylococcus* spp. microorganisms. This product was considered good, not presenting risks to public health for a period of 13 days when stored at 7°C.

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