Stability of Poultry Meat During Refrigerated Storage, based on the Packaging Used

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Abstract

This study proposes a comprehensive investigation into identifying the spoilage threshold of refrigerated meat, focusing on skinless boneless chicken breast, packaged in two distinct methods: polyethylene bags with clips (Cryovac system) and trays wrapped in stretch film (Skin type). The analyses were initiated starting from the 7th day of storage, following the manufacturer's recommendations, and included parameters such as pH, easily hydrolyzable nitrogen, hydrogen sulfide, and formic aldehyde. Every day, we rigorously followed a protocol to examine five product units for each packaging method. The results indicate that, for 7 days, the freshness of the meat was maintained under both packaging conditions; however, subsequently, it was compromised. Nevertheless, it is noted that the chicken breast packaged in polyethylene bags with clips exhibited significantly longer freshness retention compared to the chicken breast packaged in trays with stretch film. These findings make significant contributions to understanding the process of refrigerated meat spoilage and can guide the development of improved packaging and storage strategies in the food industry.

Keywords: freshness, packaging, poultry meat, refrigeration.

1. Introduction

Ensuring a healthy and adequate diet is a priority of any state's policy, as food represents an issue with significant cultural, social, and economic implications. Therefore, animal husbandry has the obligation to provide food products in increasing quantities and of the highest quality for a continuously growing population.

An essential factor in the development and existence of individuals is represented by food consumption; therefore, it must be carried out in a balanced manner to ensure all the indispensable nutrients for the body. In dietary intake, animal-derived proteins should comprise a minimum of 35%. Thus, there is an increase in animal-derived food products compared to plant-derived ones.

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Meat is a significant food for humans, as it plays a well-defined role in both plasticity and energy provision for the body [1].

Meat constitutes an important source of protein in the human diet and is characterized by a high biological value [2].

Currently, the poultry sector stands out as the segment with the most accelerated expansion within the meat production industry [3].

In this context, poultry meat holds a particularly important place in human nutrition due to its qualities, among which we can enumerate the following: It has the advantage of providing continuously fresh meat due to its low body weight; concerning human nutrition, poultry meat is rich in protein and low in calories, containing all essential amino acids necessary for maintaining a healthy diet; it is easy to chew and digest due to its fine texture, which is why it is considered a suitable food for all ages (children, elderly, and convalescents).

In recent years, there has been an increasingly widespread growth in the commercialization of fresh refrigerated meat products, due to their characteristics such as the simplicity of culinary preparation, the appearance of "fresh meat," and "healthy meat" [4].

Refrigeration has become an essential element of the food chain, playing a crucial role in all its phases, starting from food processing, distribution, retail trade, and up to final consumption in households [5].

Refrigeration is considered one of the most widely used preservation methods, being applied both in meat processing technologies and as a preservation method, thus becoming preferred by consumers.

Refrigeration plays a role in preserving the initial characteristics of fresh meat, which are largely influenced by the genetics of the bird, diet and rearing conditions, age at slaughter, slaughter conditions, and last but not least, post-mortem treatment.

Meat refrigeration involves cooling meat or meat by-products to a temperature above 0°C (0... 4°C), with storage lasting from several days to several weeks, depending on the nature of the product, storage temperature, and the type of packaging used.

During storage, highly toxic substances such as ammonia, hydrogen sulphide, peroxidase, and biogenic amines such as cadaverine and putrescine can develop in meat and meat products, resulting from the decarboxylation of amino acids present in the meat [6].

For detecting the initial signs of meat spoilage, various relevant indicators have been proposed, with particular importance given to pH, easily hydrolysable nitrogen, the identification of hydrogen sulphide, and formic aldehyde identification [7].

Quality and freshness of products, especially in the case of meats, are the most important purchasing principles for consumers. It is critical to know when a food item is high quality and fresh, both in the store and in the kitchen.

In recent decades, the evolution and diversification of goods production have led to significant developments in packaging technologies, packaging materials, and packaging itself, resulting in the imposition of increasingly complex requirements.

With the advancement of nomadic culture, the development of containers for food storage became critical. The evolution of food packaging in its current form has required more than 300 years. Various types of packaging materials have played a distinct role in the packaging process throughout history [8].

Packaging has the capacity to ensure food protection and extend its storage life [9,10]. Furthermore, the purpose of food packaging is to efficiently package and present foods according to industry requirements and in line with consumer expectations, needs, and preferences. Simultaneously, food safety is maintained, and the environmental impact is minimized [11,12].

Thus, packaging, as the companion of goods throughout the producer-consumer flow, must fulfil a series of functions, including: the function of preserving and protecting the quality of food products; the function of transportation, handling, and storage; as well as the function of promoting food products [13].

This study aimed to investigate the impact of packaging materials on the long-term stability of quality indicators that define the characteristics of poultry meat, specifically boneless, skinless chicken breast, packaged both in polyethylene bags with clips and on trays with stretch film.

2. Materials and methods

Research Organization

The research was organized into two experiments, differentiated by the packaging method applied, on which specific determinations were carried out (determination of pH value, identification of easily hydrolysable nitrogen, identification of hydrogen sulphide, and identification of formic aldehyde).

Specifically, Experiment 1 (E_1) focused on the packaging method of boneless, skinless chicken breast in polyethylene bags with clips (Cryovac system), while Experiment 2 (E_2) focused on packaging boneless, skinless chicken breast on trays with stretch film (skin type). Each of the two experiments aimed to assess the stability of boneless, skinless chicken breast during refrigerated storage.

The chicken breast was sourced from the same producer and transported under appropriate conditions (in a refrigerated container) to the laboratories where specific analyses were conducted. In both packaging methods, the producer recommends storing the products at temperatures between 0 and 4°C for a maximum of 7 days (this period represents the shelf life).

We conducted the analyses starting from the 7th day of storage, which corresponds to the manufacturer's recommended shelf life, and examined 5 product units for each packaging method. We repeated these analyses daily until the 11th day of storage, adhering to the same working protocol.

Working methods applied

Determination of pH value

By measuring the pH, we can detect changes in the quality of poultry meat within a specific time interval. To perform this measurement accurately and quickly, we use pH meters, with a procedural error ranging between ±0.01 and ±0.03 pH units.

In this study, pH was determined using a specialized meat pH meter, the HANNA HI 99163. The HANNA HI 99163 automatically measures both acidity and temperature, enabling the application of corrections for accurate measurements. This procedure involved immersing the electrode into the meat after a preliminary calibration performed in buffer solutions with known pH (acidic solution, pH = 4.01; neutral solution, pH = 7.01).

After each calibration and between readings, the pH meter probe was cleaned with distilled water to avoid influencing the obtained results.

Identification of easily hydrolysable nitrogen

Easily hydrolysable nitrogen is represented by the amino groups that are about to detach from protein molecules; for quantitative determination, amino groups are removed from the food under the action of a weak base, in our case under the action of magnesium oxide. If a food product (chicken breast) is spoiled, the content of easily hydrolysable nitrogen increases [14]. Thus, with the help of this method, we can assess the freshness of poultry meat, specifically boneless, skinless chicken breast.

The determination of easily hydrolysable nitrogen was carried out according to standard STAS 9065/7-74 in a weakly alkaline and heated environment. The ammonia released in small quantities was conducted by steam and collected in a specific volume of acidic solution with a known titration. Any excess acid was subsequently titrated with a base of the same normality. Based on the volume of acid used to neutralize the ammonia, the amount of ammonia generated in the sample under study was calculated.

The freshness of poultry meat, including chicken breast, is evaluated based on the ammonia content according to the following criteria: fresh meat is defined by an ammonia content of up to 25 mg%; relatively fresh meat falls within the range of 25 to 35 mg% ammonia, while spoiled meat has an ammonia content greater than 35 mg%.

Identification of hydrogen sulphide

The method is applied to define the freshness status of meat because hydrogen sulphide should not be present in fresh meat. Microbial reactions with sulphur-containing amino acids lead to the formation of sulphide alcohols, hydrocarbons, and hydrogen sulphide. Upon combining hydrogen sulphide (H_2S) with lead acetate ($Pb(C_2H_3O_2)_2$), lead sulphide ($PbSO_4$) is formed, a compound of dark brown colour. The interpretation of the results was as follows: for fresh and well-preserved meat, no colour change was observed (negative reaction: “-”); for relatively fresh meat, a brown colour appeared on the edges of the filter paper (weak positive reaction: “±”); and for spoiled meat, the filter paper turned from brown to metallic glossy brown (positive reaction: “+”).

Identification of formic aldehyde

The Kreiss reaction is used to consistently detect formic aldehydes resulting from the oxidative breakdown of linoleic acid. Formic aldehyde is present in rancid fat in the form of acetate, which, when saponified with hydrochloric acid, helps release the aldehyde. To identify formic aldehydes in fatty tissue, an etheric solution of phloroglucinol (1%) and concentrated hydrochloric acid was used.

The process involved heating the fat to approximately 105 °C, after which a quantity (1-2 ml) was taken and mixed with hydrochloric acid and phloroglucinol. The colours obtained from the reaction were analysed to identify the presence of formic aldehydes. The colouring intensity is proportional to the volume of formic aldehyde, reflecting the oxidation process. The interpretation of the results was as follows: for a negative reaction (“-”), the liquid remains colourless; for a weak positive reaction (“±”), a pink colour appears (various intensities); and for a positive reaction ("+"), a purplish coloration appears [15].

3. Results and discussion

The pH dynamics

We observe a substantial change in the pH values of boneless, skinless chicken breast packaged in two distinct ways: polyethylene bags with clips and trays with stretch film, as the product undergoes modifications. After 7 days of refrigerated storage, the chicken breast packaged in polyethylene bags with clips recorded an average pH value of 5.82. In contrast, for the same period of time and storage conditions, the chicken breast packaged in trays with stretch film had an average pH value of 6.65. However, on the 11th day of the analysis period, i.e., the last day, both types of packaging showed a significant increase in pH value: for the chicken breast packaged in polyethylene bags with clips, the pH reached 7.03, and for the chicken breast packaged in trays with Stretch film, the pH reached 7.28 (according to Figure 1.). These observations indicate notable variations between the two packaging methods and distinct developments over time.

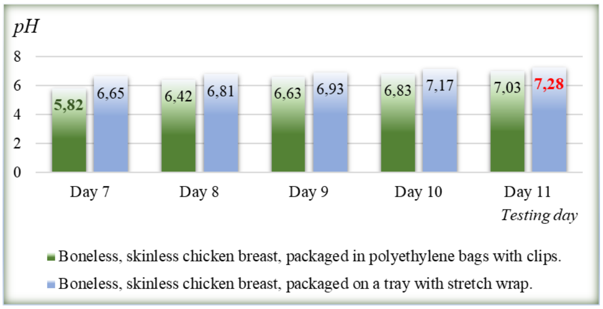

Figure 1. pH value dynamics for boneless, skinless chicken breast

The dynamics of easily hydrolysable nitrogen

The experimental data highlight a significant increase in easily hydrolysable nitrogen in boneless, skinless chicken breast packaged in two different ways: in polyethylene bags with clips (Cryovac system) and in trays with stretch film (Skin type) during refrigerated storage.

For the chicken breast packaged in polyethylene bags with clips, until the 9th day of storage, the content of easily hydrolysable nitrogen varied between 17.21 and 22.80 mg NH_3/100 g product. At the end of the storage period (the 11th day), this value increased to 26.85 mg NH_3/100 g product, indicating a relatively fresh state of the product (reference range: 25–35 mg NH_3/100 g product) (Figure 2). For the chicken breast packaged in trays with Stretch film, the content of easily hydrolysable nitrogen varied between 21.20 and 24.70 mg NH_3/100 g product until the 9th day of storage. On the 10th day, this value reached 26.00 mg NH_3/100 g product (Figure 2.). These findings support the premise that the packaging method can influence the evolution of the chemical composition of the product, with significant implications for evaluating its quality based on packaging conditions.

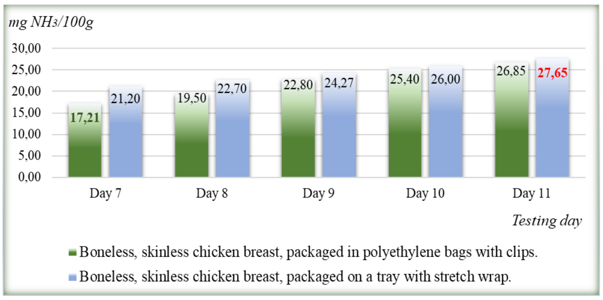

Figure 2. Dynamics of easily hydrolysable nitrogen for boneless, skinless chicken breast (mg NH_3/100g)

Identification of hydrogen sulphide presence

The obtained values regarding the presence of hydrogen sulphide (H_2S) indicate that boneless, skinless chicken breast packaged in polyethylene bags with clips (Cryovac system) maintained its freshness for 8 days of storage. The 9th day of storage (under refrigeration conditions) marks the beginning of the alteration processes (Table 1). The identification reaction of H_2S (hydrogen sulphide) was strongly positive ("+") on the 11th day of storage.

Similarly, we observed that the boneless, skinless chicken breast, packaged in trays with Stretch film, maintained its freshness for 7 days of storage, following the producer's recommended time period. The 8th day of storage (under refrigeration conditions) marks the beginning of alteration processes, as the filter paper soaked in lead acetate shows a brownish hue along the edges (Table 1). On the last day of storage, the identification reaction of H_2S (hydrogen sulphide) was strongly positive ("+").

These findings highlight not only the distinct periods of freshness of the investigated products, but also the use of the H_2S identification method as a sensitive indicator of ongoing alteration processes. Thus, these observations have significant implications for assessing the quality and durability of food products based on packaging and storage conditions.

Table 1. Identification of hydrogen sulphide presence for boneless, skinless chicken breast

Testing day	E_1	E_2
Day 7	-	-
Day 8	-	±
Day 9	±	±
Day 10	±	±
Day 11	+	+

E1: boneless, skinless chicken breast packaged in polyethylene bags with clips; E2: boneless, skinless chicken breast packaged in trays with stretch film; "-" = negative reaction; "±" = weakly positive reaction; "+" = positive reaction.

Identification of aldehydes presence

Analogous to the previous analyses, the investigation regarding the fat content in boneless, skinless chicken breast packaged in polyethylene bags with clips reveals that during the first 7 days of refrigerated storage (at a temperature ranging between 0 and 4 °C), the products maintained their freshness, complying with the manufacturer's recommended period. On the 8th and 9th days, slight signs of rancidity were observed, manifested by weakly positive reactions, indicated by a pale pink colour. By the 11th day, clear signs of rancidity became pronounced, as evidenced by a red-violet coloration, as detailed in Table 2.

In a similar context, fat analysis of boneless, skinless chicken breast packaged in trays with Stretch film demonstrated freshness maintenance during the initial 7 days of refrigerated storage (temperature between 0 and 4 °C), following the manufacturer's recommendations. However, during the last two days of storage, namely the 10th and 11th days, strong signs of rancidity were noted, manifested by a positive reaction visibly appearing as a red-violet coloration, according to the data presented in Table 2.

These observations underscore the importance of fat analyses in assessing the product's deterioration and reveal a potential indicator of product quality over successive storage periods. These aspects provide a detailed perspective on the product's behaviour over time and highlight the necessity of proper storage condition management to maintain its integrity.

Table 2. Identification of the presence of aldehydes for boneless, skinless chicken breast

Testing day	E_1	E_2
Day 7	-	-
Day 8	±	±
Day 9	±	±
Day 10	+	+
Day 11	+	+

E1: boneless, skinless chicken breast, packaged in polyethylene bags with clips; E2: boneless, skinless chicken breast, packaged in tray with stretch film; "-" = negative reaction; "±" = weak positive reaction; "+" = positive reaction.

4. Conclusions

The increasing demand from consumers and the continuous expansion of the meat market have stimulated producers to research and implement new packaging solutions.

In a comparative context of the two packaging methods, we observe that the polyethylene bag with clips provides superior resistance to meat deterioration processes compared to stretch film. However, after approximately seven days of storage, both methods have shown signs of alteration.

These conclusions emphasize the critical role of packaging in maintaining the integrity and freshness of poultry meat, as well as the need for improved packaging and storage strategies in the food industry. We anticipate that these results will inform future research and enhance food industry practices.

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