# INFLUENCE OF WET AND DRY AGING ON COLOUR PARAMETERS OF CHICKEN MEAT

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RESEARCH ARTICLE

**Abstract**
*Among all the attributes related to quality, appearance holds the greatest importance in the selection of most foods, especially chicken meat. Consumers often decide to choose or reject a product based solely on its appearance. One of the key factors contributing to the appearance of meat is its color, designated as a significant criterion for the selection of fresh meat. The objective of this scientific article was to monitor the evolution of the color of matured chicken meat through two methods—dry and wet—depending on the pH modification. The chicken meat used in this study consisted of thigh meat and came from chickens raised extensively. The maturation of chicken meat lasted for 20 days, with pH and colorimetric analyses conducted on the surface of the meat every four days as follows: the first analysis was performed on day 0 (the day of poultry slaughter), and the rest on days 4, 8, 12, 16, and 20 of maturation. Statistical tests on pH values revealed very significant differences ($p < 0.001$) between the two aging types for this analyzed parameter. Additionally, other characteristics studied within the pH of chicken meat, such as days of aging and type of aging*days of aging interaction, also showed very significant differences ($p < 0.001$). Regarding the color of chicken meat, the type of maturation presented very significant differences ($p < 0.001$) for all analyzed colorimetric parameters (CIE L, CIE a*, and CIE b*), with similar results observed in the days of aging characteristic. The interaction between type of aging*days of aging on the color of chicken thigh meat showed very significant differences ($p < 0.001$) only for the CIE L* colorimetric parameter, with significant differences ($p < 0.05$) and non-significant differences ($p > 0.05$) identified for the CIE a* and CIE b* parameters, respectively.*

**Keywords**: chicken thigh (*biceps femoris*), mean colour, wet and dry aging, aging time
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## INTRODUCTION

The concept of meat quality is used to define the general characteristics of meat, including its physical, chemical, morphological, biochemical, microbial, sensory, technological, hygienic, nutritional, and culinary properties (Tougan et al, 2013).

In general, the appearance, and implicitly color, represent the primary quality attribute of raw or cooked poultry meat, associated with the freshness and attractiveness of the product, influencing consumers' purchasing decisions. Poultry meat is sold with or without skin, and various factors influence the color and pigmentation level of poultry meat, ranging from growth and feeding conditions to the availability of lipid-soluble pigments in feed, food sources, xanthophyll concentrates, exotic sources (e.g., broccoli, pepper, and tomatoes), additives for animal feed (e.g., fish oils, antioxidants, vitamins, and trace elements), and processing parameters: breed and species, diseases and health, environment, conditions before slaughter, processing variables, and gender. The color of raw poultry meat is crucial in determining consumer purchasing decisions, while the color of cooked meat provides a final product evaluation. Poultry meat color is determined by myoglobin content, its chemical state, reactions, and meat pH (Wattanachant, 2008).

Chicken meat can be processed in various forms and is primarily available fresh, refrigerated, or frozen. Continuous evolution in poultry processing is necessary to meet modern consumer requirements. The poultry meat market has undergone considerable changes in recent decades, with a current preference for anatomically cut regions or even processed products (Wattanachant, 2008; Le Bihan-Duval et al, 2008; Barbut et al, 2021).

The quality of chicken meat and poultry products can be influenced by processing methods and temperature. Moreover, the temperature at which poultry meat is maintained after processing and during cold storage significantly determines its shelf life (Wattanachant, 2008).

In the poultry industry, a significant concern is the time interval between bird slaughter and the deboning process to achieve the primary goal of providing tender, juicy meat with quality taste and color, as well as ensuring stable shelf life. Meat maturation is a crucial element in achieving the desired quality, although it involves significant costs. If not carried out under optimal conditions of time, temperature, humidity, and ventilation, maturation can lead to undesirable qualitative changes (physical, sensory, microbiological) (Santos et al, 2004; Thielke et al, 2005).

Depending on the type of maturation and temperature, the maturation time varies for chicken meat. Optimal dry aging for chicken meat is reported to be around 21 days (Cho & Kim, 2023), although studies on maturation for this species are limited. Therefore, this study monitored the color changes and the pH changes in chicken meat from extensively raised birds subjected to wet and dry maturation over a period of 20 days, with qualitative assessments conducted every four days. This study aims to contribute to the existing body of specialized literature on chicken meat, considering the limited number of scientific articles addressing the meat color of this species compared to the abundance of articles available for pork and, especially, beef.

## MATERIAL AND METHOD

The biological material used in the study consisted of skinless chicken thighs (*biceps femoris*) obtained from 6 hens (females) raised in an extensive system in Iași County, Romania. The preparation of the biological material involved skin removal and deboning of the thighs, followed by equal division of the meat. A portion was subjected to wet maturation (maintained at refrigeration temperature in a vacuum atmosphere), while the remaining portion underwent dry maturation (conducted under the influence of humidity, air currents, and temperature conditions in the refrigerated space – temperature = 0 - 2ºC; relative air humidity = 70%; and air current velocity = 0.2 – 0.3 m/s).

Throughout the aging period, pH and colorimetric analyses were conducted on the meat on the day of poultry slaughter (day 0) and on days 4, 8, 12, 16, and 20 of aging. A total of 6 colorimetric analyses were performed for each aging type. The meat maturation process was conducted in the meat processing section, and colorimetric analyses were performed in the Meat Technology and Quality Control laboratory.

The analyses regarding meat color were conducted using a portable colorimeter, the Konica Minolta CR-410, with a measurement diameter of 50 mm. For measuring the color of the samples, the colorimeter was pre-calibrated on a standard white plate for calibration, and D65 illuminant with a 10° observation angle was used. The analysis was carried out within the CIELAB color space objective system, a globally recognized standard system, which is a 3-dimensional color space built from three axes perpendicular to one another. In the CIELAB color space:

- The L*-axis represents lightness, with a white object having an L* value of 100 and a black object having an L* value of 0.

- Chromatic colors are described using two axes in the horizontal plane. The a*-axis denotes the green (-a*) to red (+a*) spectrum, while the b*-axis spans from blue (-b*) to yellow (+b*). The asterisk (*) appended to L, a, and b signifies that this is the updated color system, succeeding the older CIELAB system.

Measurements with the colorimeter were performed on the meat surface, involving 10 readings for each aging method on the six days during the aging period when these analyses were conducted.

The pH measurements were conducted using a Meat pH meter from Hanna Instruments, model HI98163, equipped with a stainless steel blade for easier penetration into the interior of meat pieces. The electrode of this pH meter features an internal reference made of Ag/AgCl and a conical tip that is ideal for pH measurements of solid and semi-solid foods. Ten pH measurements were performed for each of the analyzed samples on the specified maturation days outlined in this scientific article.

The data derived from pH and colorimeter assessments underwent statistical analysis through the ANOVA (Analysis of Variance) test within the XLSTAT software, which is an integrated statistical tool in Microsoft Excel.

## RESULTS AND DISCUSSIONS

The initial findings in this scientific article pertain to the pH values of dry- and wet-aged chicken meat (Table 1) over the entire maturation period (20 days). The purpose of this analysis was to identify the influence of aging type, aging progression, and the interaction between these two characteristics on the pH value of chicken meat.

According to the statistical analysis applied to the pH results of chicken meat subjected to two different maturation types (dry and wet), as shown in Table 1, it can be observed that the aging type, aging day, and the interaction between maturation type and day exhibited highly significant differences ($p < 0.001$).

Table 1

**The average pH values during the aging period and the influences produced by the type of aging, its evolution, and the interaction between these two characteristics on the pH values of chicken thigh**

| Aging time | Type of aging | |
|---|---|---|
| | Dry | Wet |
| 0 | 5.620±0.007[a] | 5.604±0.005[a] |
| 4 | 5.900±0.014[c] | 5.798±0.013[b] |
| 8 | 5.894±0.016[c] | 5.952±0.017[d] |
| 12 | 5.716±0.006[b] | 5.898±0.007[c] |
| 16 | 6.168±0.007[d] | 6.190±0.008[e] |
| 20 | 6.258±0.004[e] | 6.284±0.007[f] |
| p-value | | |
| Type of aging | **< 0.001 (***)** | |
| Days of aging | **< 0.001 (***)** | |
| Type of Aging*Days of aging interaction | **< 0.001 (***)** | |

*a, b, c, d, e, f - Superscripts on different means within the same column differ significantly, p ≤ 0.05*

Both wet-aged and dry-aged meat exhibited very similar pH values at the beginning of the aging process (day 0), measuring 5.604±0.007 for wet-aged meat (Table 1 and Figure 1) and 5.620±0.007 for dry-aged meat (Table 1 and Figure 1), resulting in a difference of only 0.016. On all subsequent days when analyses were conducted on chicken thigh meat, pH values were higher than those identified on day 0.

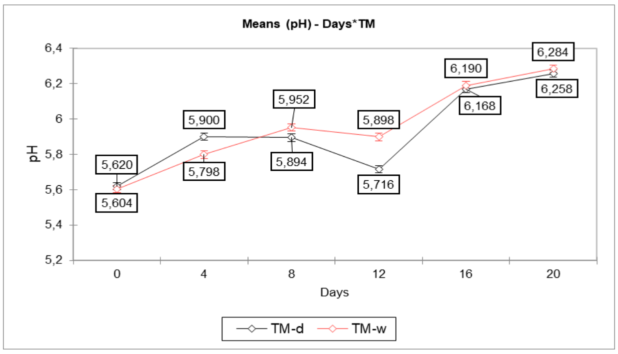


Figure 1 **The mean values of pH during wet and dry aging of chicken thigh**

*TM – type of maturation/aging; d – dry aging; w – wet aging*

Dry aging recorded relatively lower pH values compared to wet aging, especially from the 8th day of maturation, as observed in Table 1 and Figure 1. This difference may be attributed to a more pronounced breakdown of myofibrillar proteins in the case of dry aging (Jeong C.H. et al., 2023). The most significant difference between the pH of wet-aged and dry-aged meat samples was observed on the 12th day (Table 1 and Figure 1), with a difference of 0.182. The pH values on the 12th day were 5.898±0.007 for wet aging and 5.716±0.006 for dry aging. The 12th day of maturation was the only day when the pH value showed a slight decrease (Figure 1) compared to the gradual increase from day 0.

In the case of dry aging, a slight decrease in pH values was observed compared to the initial increase from 5.620 on the day of poultry slaughter to 5.900±0.014 on day 4 of maturation. Starting from the 8th day of maturation, an average pH value of 5.894±0.016 was obtained (Table 1). This downward trend in pH values within dry aging continued on the 12th day of maturation (Table 1 and Figure 1), where a value of 5.716±0.006 was identified, lower than that on the 8th day of maturation. The highest pH value for dry-aged meat was obtained on the last day of maturation (day 20), measuring 6.258±0.004 (Table 1).

Wet-aged chicken thighs exhibited lower pH values in the first two days of pH analysis during maturation (day 0 and day 4) compared to dry aging (Table 1 and Figure 1), measuring 5.604±0.005 and 5.798±0.013, respectively.

Starting from the 8th day of maturation, the average pH values for wet aging were higher than those for dry aging (Figure 1). From day 0 of wet aging until the 8th day, a gradual increase in the pH values of the analyzed chicken thighs was observed (Figure 1 and Table 1), followed by a slight decrease in pH on the 12th day of maturation to a value of 5.898±0.007. After the mentioned day, a return to the gradual increase in pH values was observed until the last day of maturation, similar to the early days of maturation (Table 1 and Figure 1). The maximum pH value identified in wet aging was obtained on the 20th day of maturation, as observed in dry aging, measuring 6.284±0.007 (Table 1).

Lower pH values were associated with paler-colored meat, while higher values, exceeding 6, were associated with darker (reddish) meat, consistent with findings by Barbut et al (2005) and Fletcher (1999).

The results of the objective color measurements of dry-aged and wet-aged chicken thighs are presented in Table 2.

Statistical analysis of the variation in chicken meat samples through the analyzed color parameters in the CIELab* system identified highly significant differences ($p < 0.001$) for all colorimetric parameters between dry aging and wet aging (Table 2). Highly significant differences ($p < 0.001$) were also identified for the Days of aging characteristic (the period during maturation when the color analysis was performed) for the three parameters of the CIE system (L*, a*, and b*) (Table 2). The interaction type of aging*days of aging did not show significant differences ($p > 0.05$) for the CIE b parameter, but significant differences ($p < 0.05$) were identified for the CIE a* parameter, and highly significant differences ($p < 0.001$) were found for the CIE L* parameter (Table 2).

Results with highly significant differences ($p < 0.001$) for the three studied characteristics (type of aging, days of aging, and the interaction type of aging*days of aging) for the CIE L parameter indicate a pronounced modification of meat brightness with a significant decrease as the maturation period progresses, particularly in dry aging, as observed in the results presented in Table 2.

Table 2

**The effects of aging type, evolution of aging, and the interaction between aging type and evolution of aging on color parameters (L*, a*, and b*) on the chicken thigh**

| Type of aging | Aging time | Parameters | | |
|---|---|---|---|---|
| | | L* | a* | b* |
| Dry | 0 | 57.164±0.886[de] | 15.590±0.726[b] | 7.086±0.379[a] |
| | 4 | 50.488±1.145[c] | 14.634±0.741[b] | 13.138±0.818[bc] |
| | 8 | 50.412±0.494[c] | 16.306±0.517[bc] | 12.610±0.611[bc] |
| | 12 | 50.370±1.492[c] | 17.836±0.694[c] | 12.850±0.428[bc] |
| | 16 | 41.162±0.893[ab] | 17.832±0.693[c] | 14.292±0.620[c] |
| | 20 | 39.206±0.853[a] | 18.986±0.599[d] | 15.266±0.565[d] |
| Wet | 0 | 61.676±0.952[e] | 10.014±0.793[a] | 7.262±0.433[a] |
| | 4 | 54.248±0.556[d] | 11.810±0.593[a] | 11.150±0.575[b] |
| | 8 | 50.354±1.098[c] | 13.178±0.442[ab] | 11.632±0.374[b] |
| | 12 | 51.218±1.217[c] | 16.714±0.291[bc] | 12.042±0.494[b] |
| | 16 | 52.262±1.432[cd] | 15.102±0.487[b] | 13.684±0.391[c] |
| | 20 | 53.310±1.369[d] | 15.734±0.453[b] | 13.078±0.360[bc] |
| p-value | | | | |
| Type of aging | | **<0.001 (***)** | **<0.001 (***)** | **0.001 (***)** |
| Days of aging | | **<0.001 (***)** | **<0.001 (***)** | **<0.001 (***)** |
| Type of aging*Days of aging interaction | | **<0.001 (***)** | **0.026 (*)** | 0.224 (ns) |

*a, b, c, d, e - Superscripts on different means within the same column differ significantly, $p \leq 0.05$*

The colorimetric parameter CIE L* recorded higher values during wet aging compared to dry aging over the maturation period (Table 2 and Figure 2). Wet aging achieved the maximum average value of the L* color parameter (61.676±0.952) throughout the maturation period on day 0 (Table 2 and Figure 2), when the lowest pH value of 5.604±0.005 was obtained (Table 1). The average value of the CIE L* parameter during wet aging showed decreases (54.248±0.556 on day 4 and 50.354±1.098 on day 8) until day 12 when a slight increase was identified, reaching 51.218 ± 1.217 (Table 2 and Figure 2).

It can be observed that the average value of the colorimetric parameter L* (Table 2 and Figure 2), which refers to meat brightness, decreased as the average pH value increased

(Table 1 and Figure 1), similar to the study conducted by Florowski et al (2002) on chicken breast. The decreasing trend of the CIE L* parameter values was interrupted on the 12th day of maturation (Table 2 and Figure 2) when a sudden decrease in pH value occurred (Table 1 and Figure 1). Wet aging showed a gradual increase in the average value of the CIE L* parameter from the 12th day of maturation until the last day of maturation, reaching a final value of 53.310±1.369 (Table 2 and Figure 2). These results for the second half of the wet maturation period, in correlation with pH results (Table 1 and Figure 1) for the same period, indicate an increase in the average value of the CIE L* parameter (Table 2 and Figure 2) concurrently with the rise in pH value. These results contradict those obtained for the first half of maturation (up to day 8, including day 8), when the average CIE L* value decreased as the meat pH increased. However, the CIE L* parameter showed, during wet aging, average values with very low fluctuations, especially starting from the fourth day of maturation, suggesting that wet aging does not have a significant influence on the brightness of chicken meat from the beginning to the end of maturation, remaining relatively constant.

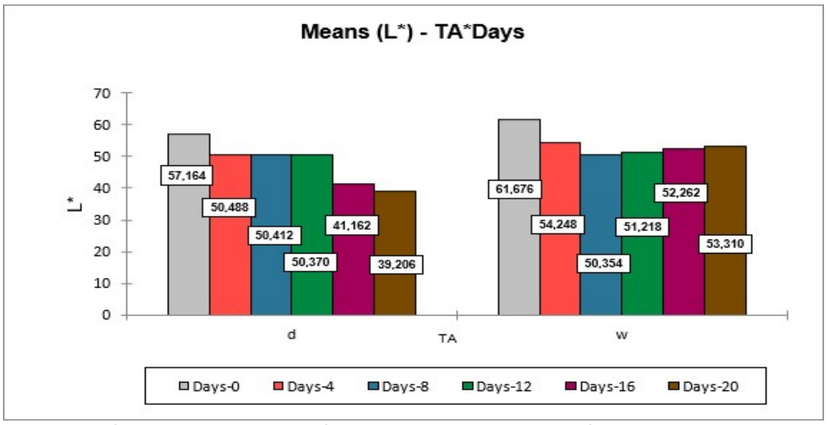


Figure 2 **Mean values of the L* parameter for wet and dry aging of the meat on each day when color measurements were taken**
*L* - lightness from 0 to 100; TA- type of aging; d – dry aging; w – wet aging*

The influence of dry aging on the colorimetric parameter CIE L* was more significant than that of wet aging on chicken thighs. This can be observed through much larger differences in the average value of this parameter over the maturation period, indicating a decrease in the brightness of the samples (Table 2 and Figure 2) caused by the reduction in meat moisture. Similar to wet aging, the maximum average value of the CIE L* parameter in dry aging was 57.164±0.886 (Table 2 and Figure 2). In this type of aging, a gradual decrease in the average value of CIE L* was observed until the last day of maturation when the lowest average value of 39.206±0.853 was identified (Table 2 and Figure 2). On days 4, 8, and 12 of dry aging, very close values for the L* colorimetric parameter were obtained: 50.488±1.145, 50.412±0.494, and 50.370 ± 1.492, respectively (Table 2 and Figure 2). It can be observed that the sudden decrease in pH values from the 12th day of dry aging (Table 1 and Figure 1) does not affect the brightness (L*) of chicken thighs. Large differences in the CIE L* value in dry aging are noticeable from the 16th day of maturation when an average value of 41.162±0.893 was obtained for this parameter (Table 2 and Figure 2). Also, on this day of maturation (day 16), a more significant increase in pH value occurred (Table 1 and Figure 1), suggesting that the increase in this parameter (pH) leads to a decrease in the brightness of the studied chicken meat samples, as observed in the first half of the wet aging period.

The colorimetric parameter a* showed relatively higher average values in dry aging compared to wet aging (Table 2 and Figure 2). Wet aging of chicken thighs recorded the lowest average value of the red-green parameter (a*) on the first day of maturation, which was 10.014±0.793 (Table 2 and Figure 3), and the highest on the 12th day of maturation (16.714±0.291). This maximum value of CIE a* coincides with the sudden decrease in pH observed on the 12th day of maturation (Table 1 and Figure 1). The CIE a* parameter recorded gradual increases in the average value from day 0 to day 12 of maturation (Table 2 and Figure 3), obtaining average values of 11.810±0.593, 13.178±0.442, and 16.714±0.291 on days 4, 8, and 12, respectively. On the 16th day of wet aging, a decrease in the color parameter a* to an average value of 15.102±0.487 was identified (Table 2 and Figure 3), followed by a slight increase to 15.734±0.453. By analyzing the average values obtained during wet aging for CIE a* (Table 2 and Figure 3) and pH (Table 1 and Figure 1), it can be said that CIE a* shows a concurrent increase with the increase in meat pH, with the only contradiction found on the 12th day of this aging period. In this period of wet aging, the slight decrease in pH values (Table 1 and Figure 1) resulted in a significant increase in the CIE a* value (Table 2 and Figure 3).

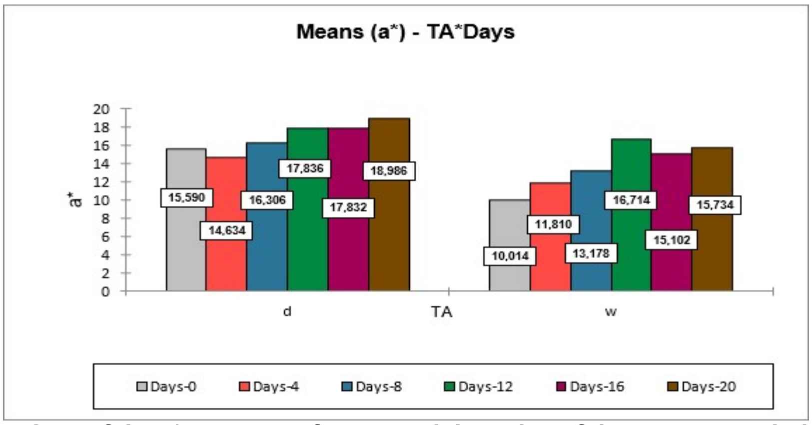


Figure 3 **Mean values of the a* parameter for wet and dry aging of the meat on each day when color measurements were taken**

*a* - redness (-a* - greenness); TA- type of aging; d – dry aging; w – wet aging*

Dry aging resulted in chicken meat with a redder color (+a*) compared to wet aging (Table 2 and Figure 3). The minimum value of CIE a* was obtained on the 4th day of maturation, being 14.634±0.741 (Table 2 and Figure 3), and the maximum value was 18.986±0.599 on the last day of maturation (day 20). Similar to wet aging, dry aging also showed a gradual increase in the a* parameter, with exceptions on days 4 and 16 of maturation when there were slight decreases in the average value for this parameter. After the fourth day of maturation, there was an increase in the CIE a* value on day 8 (16.306±0.517) and on day 12 (17.836±0.694), followed by a very subtle decrease on the 16th day of maturation (17.832±0.693), which is only 0.004 lower than the previous day when colorimetric analyses were performed, as observed in Table 2 and Figure 3. By analyzing the results obtained for pH (Table 1 and Figure 1) and those for the CIE a* parameter (Table 2 and Figure 3), it can be observed that in the first half of maturation, specifically on the 4th day, the increase in pH value resulted in a decrease in the color parameter a*. However, in the second half of maturation, specifically on the 20th day, the increase in pH value led to an increase in the average value of the red-green color parameter (CIE a*). The same phenomenon was observed in wet aging for the CIE L* parameter (Table 2 and Figure 2).

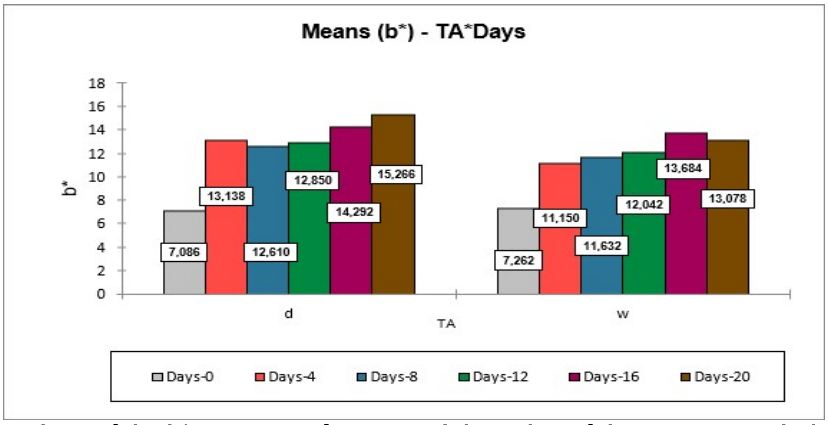


Figure 4 **Mean values of the b* parameter for wet and dry aging of the meat on each day when color measurements were taken**

*b* - yellowness (-b* - blueness); TA- type of aging; d – dry aging; w – wet aging*

The CIE b* parameter, like the CIE a* parameter, shows a gradual increase in average values from the beginning to the end of maturation for both types of aging (Table 2 and Figure 4), with a few exceptions. Higher values of CIE b*, similar to CIE a*, were obtained in dry aging (Table 2 and Figure 4); however, the differences were not significant ($p > 0.05$). Both wet and dry aging recorded the lowest average value of the b* parameter on the day of chicken slaughter (day 0), which was 7.262±0.433 for the first type of aging and 7.086±0.379 for the second type (Table 2 and Figure 4).

Wet aging of poultry thighs showed an upward trend in the CIE b* value until the 16th day of maturation when the maximum value of this colorimetric parameter was obtained, reaching 13.684±0.391 (Table 2 and Figure 4). After this point in wet aging, there was a decrease in the CIE b* value on the last day of maturation (day 20) to 13.078±0.360. The increase in pH value (Table 1 and Figure 1) led to an increase in the CIE b* value (Table 2 and Figure 4) for all days of wet aging, except for day 20, when a slight decrease in the b* parameter value occurred, even though the highest pH value was obtained on this day.

The changes induced by dry aging on the CIE b* colorimetric parameter are similar to those produced by wet aging, with the exception of a decrease on the 8th day of dry aging compared to the decrease observed on the 20th day of wet aging. On the 4th day of dry aging, the CIE b* parameter showed an initial increase in the average value to 13.138±0.818, compared to the value obtained on day 0 of 7.086±0.379 (Table 2 and Figure 4). This initial increase was followed by a decrease in the average value to 12.610±0.611 on day 8, after which the average value of the b* parameter continued to increase in the remaining days of aging, reaching 12.850±0.428 on day 12, 14.292±0.620 on day 16, and 15.266±0.565 on day 20.

The evolution of pH values had a similar influence on CIE b* as it did on CIE a*, in the sense that, in most cases, an increase in pH value led to an increase in the yellow color of the meat (+b*). The sudden decrease in pH value on the 12th day of aging did not have a noticeable impact on the CIE b* parameter but only resulted in a lower increase in its average value compared to the differences observed in the other days of aging for the same colorimetric parameter.

## CONCLUSIONS

The study of chicken meat aging through two different methods (dry and wet), conducted within this work, aimed to investigate the differences induced by this process (aging) on the objective color parameters CIE L*, CIE a*, and CIE b*, as well as on the pH value over a period of 20 days.

The average pH values of chicken meat exhibited highly significant differences ($p < 0.001$) between the two aging methods, as well as across different aging days, and also in the interaction between these studied characteristics (type of aging * days of aging). Nevertheless, the pH evolution was similar for both studied aging methods (wet and dry aging).

The most notable fluctuations in colorimetric values between the two aging methods (wet and dry) were identified within the CIE L* parameter, as evidenced by statistical data processing revealing highly significant differences ($p < 0.001$) for all studied characteristics (type of aging, days of aging, and their interaction).

The CIELAB system parameters were more affected by dry aging than wet aging of meat, as indicated by significantly larger differences in the mean values (in the case of the CIE L* parameter) and higher average values observed for the CIE a* and CIE b* parameters. These results can be attributed to the decrease in moisture and the concentration of meat pigments in dry aging, leading to meat with a darker color (lower CIE L* value) and a redder color (increased CIE a* value).

## REFERENCES

Barbut, S. & Leishman, E.M., 2021. Quality and Processability of Modern Poultry Meat. Animals, 12(20), 2766.

Barbut, S., Zhang, L., & Marcone, M., 2005. Effects of pale, normal, and dark chicken breast meat on microstructure, extractable proteins, and cooking of marinated fillets. Poultry science, 84(5), 797-802.

Cho, H.G. & Kim, H.-Y., 2023. Changes in physicochemical characteristics of pork loin, beef loin and chicken breast with various wet aging periods. Food and Life, 2023(1) 19-27.

Fletcher, D.L., 1999. Broiler breast meat color variation, pH, and texture. Poultry science, 78(9), 1323-1327.

Florowski, T., Slowinski, M., & Dasiewicz, K., 2002. Colour measurements as a method for the estimation of certain chicken meat quality indicators. Electronic Journal of Polish Agricultural Universities. Series Food Science and Technology, 2(05).

Jeong C.H., Lee S.H., Kim H.Y., 2023. Optimization of dry-aging conditions for chicken meat using the electric field supercooling system. Journal of Animal Science and Technology, 12, 13.

Le Bihan-Duval, E., Debut, M., Berri, C.M., Sellier, N., Santé-Lhoutellier, V., Jégo, Y. & Beaumont, C., 2008. Chicken meat quality: genetic variability and relationship with growth and muscle characteristics. BMC genetics, 9, 1-6.

Mir, N.A., Rafiq, A., Kumar, F., Singh, V. & Shukla, V., 2017. Determinants of broiler chicken meat quality and factors affecting them: a review. Journal of food science and technology, 54, 2997-3009.

Santos, H.C., Brandelli, A. & Ayub, M.A.Z., 2004. Influence of post-mortem aging in tenderness of chicken breast fillets. Ciência Rural, 34(3), 905-910.

Thielke, S., Lhafi, S. & Kühne, M., 2005. Effects of aging prior to freezing on poultry meat tenderness. Poultry Science, 84(4), 607-612.

Tougan, P.U., Dahouda, M., Salifou, C.F.A., Ahounou, S.G.A., Kpodekon, M.T., Mensah, G.A. & Karim, I.Y.A., 2013. Conversion of chicken muscle to meat and factors affecting chicken meat quality: a review. International Journal of Agronomy and Agricultural Research, 3(8), 1-20.

Wattanachant, S., 2008. Factors affecting the quality characteristics of Thai indigenous chicken meat. Suranaree journal of science and technology, 15(4), 317-32.