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Use of geopropolis on quail egg quality

Uso de geoprópolis na qualidade de ovos de codornas

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RESUMO

O ovo é um alimento altamente nutritivo rico em proteínas e vitaminas, porém como todos os produtos de origem animal o ovo perde qualidade rapidamente na ausência de adequados métodos de conservação, nesse sentido foi conduzido um experimento com o objetivo de avaliar a qualidade de ovos de codorna não refrigerados, submetidos ao tratamento superficial da casca utilizando solução de geoprópolis da espécie *Melipona interrupta.* Os parâmetros de qualidade analisados foram: perda de peso; pH da gema e pH do albúmen. Foi realizada análise de variância usando um modelo incluindo os efeitos do tratamento superficial da casca, do tempo de estocagem, e da interação entre esses fatores. Como não houve interação entre os tratamentos e o tempo de estocagem, as médias do tratamento superficial da casca dos ovos foram comparadas pelo teste T a 5% de probabilidade e as médias dos efeitos do tempo de estocagem foram comparadas pelo teste SNK (Student Newman-Keuls) a 5% de probabilidade. Com o aumento do tempo de estocagem, os ovos apresentaram aumento na perda de peso, pH da gema e pH do albúmen, independente de terem recebido ou não o tratamento superficial na casca. O revestimento superficial da casca de ovos de codornas com solução de geoprópolis a 10% não é eficaz em manter a qualidade interna dos ovos ao longo de 55 dias de armazenamento.

PALAVRAS-CHAVE: tratamento superficial; *Melipona interrupta*; armazenamento.

ABSTRACT

The egg is a highly nutritious food rich in proteins and vitamins, however, like all products of animal origin, the egg loses quality quickly in the absence of adequate conservation methods. non-refrigerated quail, subjected to surface treatment of the shell using geoprópolis solution of the *Melipona interrupta* species. The quality parameters analyzed were weight loss: Yolk pH and albumen pH. Analysis of variance was performed using a model including the effects of surface treatment of the shell, storage time, and the interaction between these factors. As there was no interaction between treatments and storage time, the means of surface treatment of the egg shells were compared using the T test at 5% probability and the means of the effects of storage time were compared using the SNK test (Student Newman- Keuls) at 5% probability. With increasing storage time, the eggs showed an increase in weight loss, yolk pH and albumen pH, regardless of whether they had received surface treatment on the shell. The surface coating of quail eggshells with 10% geoprópolis solution is not effective in maintaining the internal quality of the eggs over 55 days of storage.

KEYWORDS: superficial treatment; *Melipona interrupta;* storage.

INTRODUCTION

Quail farming is a growing poultry sector, contributing to employment and income generation across its entire production chain. In addition, its main product, the egg, is a source of animal protein of high biological value (MOURA et al. 2010). Eggs are highly digestible and protein-rich, containing significant amounts of fat-soluble vitamins A, D, E, and K, as well as B-complex vitamins. They have a low cholesterol content (0.3%) and are rich in ascorbic acid, also known as vitamin C, which is present in fresh eggs but absent in chicken eggs (SANTOS 2008). However, egg quality deterioration is an inevitable and continuous process over time, which can be exacerbated by various factors, notably temperature and humidity conditions during storage

(SANTOS et al. 2016). In this way, quality parameters are predetermined in the most different aspects such as: physical-chemical, microbiological and nutritional parameters (BRASIL et al. 2019). Among the physicochemical parameters established for assessing quail egg quality, the most prominent are weight loss, yolk pH, and albumen pH.

In Brazil, quail egg production is predominantly carried out by small-scale farmers who typically do not employ sanitization methods or refrigerate eggs during pre-market storage (LACERDA et al. 2016). Furthermore, due to inadequate regulations and high costs, most commercial establishments store eggs at room temperature, compromising product quality before reaching the end consumer. Therefore, the implementation of cost-effective technologies is essential to maintain the internal quality of eggs. An alternative that has been extensively studied is the use of surface coatings (BRASIL et al. 2019). The primary purposes of egg coatings are to mitigate microbial contamination, minimize water and carbon dioxide loss, enhance shell permeability properties to reduce internal degradation, extend storage time without refrigeration, and increase shell impact resistance while preserving nutritional characteristics and properties (PEREIRA 2014).

According to SIMÃO (1985) and MENDONÇA et al. (2013) among the coatings used, mineral and vegetable oils are notable; however, the use of mineral oil as an egg protectant may lead to contamination by metals such as copper, zinc, and cadmium. This phenomenon is commercially significant, as consumers increasingly prioritize food safety, environmental sustainability, and residue-free products (PIRES et al. 2020). In this context, several ecological materials are being analyzed for use as a surface coating for eggs: Aloe vera (MAAN et al.) 2021, PIRES et al. 2022a), propolis (PIRES et al. 2019), whey (VALE et al. 2023), green banana flour (OLIVEIRA et al. 2023), essential oils such as thyme (SHARAF & TAHERGORABI 2019) and basil (ARAÚJO et al. 2023), among others. However, as PIRES et al. (2022b) argues, there remains substantial potential for developing coatings primarily derived from agroindustrial byproducts, regional resources, and indigenous materials.

An alternative to the aforementioned substances for maintaining egg quality is geopropolis, a mixture of clay and propolis produced by stingless bees. Unlike *Apis mellifera* propolis, geopropolis primarily consists of soil, along with plant resins and enzymatic secretions from bees, which serve as raw materials for the internal construction and external structures of the hive (LAVINAS et al. 2019, SILVA et al. 2023). This substance exhibits high levels of total phenols and flavonoids, demonstrating antioxidant and healing properties, as well as antibacterial activity against both Gram-positive and Gram-negative bacteria (SILVA et al. 2016). Beyond technical considerations, this technology appears to be viable in terms of economic, qualitative, and ecological aspects, as it ensures high quality, safety, and cost-effectiveness (GALVÃO et al. 2018).

Considering that most research on egg quality preservation through shell surface treatment has focused on propolis, this study aimed to evaluate the quality of quail eggs subjected to shell surface treatment using geopropolis solution from the *Melipona interrupta* species.

MATERIAL AND METHODS

The experiment was conducted at the Animal Morphophysiology Laboratory (LabMorfo) of the Federal University of Western Pará (UFOPA) in Santarém, Pará, Brazil, over a period of 55 days. For the experiment, 120 freshly laid eggs from 120-day-old Japanese quails (*Coturnix coturnix japonica*) were obtained from the quail farming sector of UFOPA. All birds were maintained on a uniform diet.

The experimental design was a completely randomized design (CRD) with a 2 x 6 factorial arrangement, comprising two treatments (untreated peel and surface treatment with geopropolis solution) evaluated over six storage periods (0, 7, 14, 28, 41, and 55 days). The experimental unit consisted of two eggs, with five replicates per treatment, totaling 10 eggs evaluated per treatment in each period.For the treatment of the shell with the geopropolis, 60 eggs were collected, selected, identified and immersed for one minute in 10% geopropolis tincture (90% cereal alcohol: 10% tincture of geopropolis from the native bee species *Melipona interrupta* sourced from the UFOPA Bee Forest, as described by MENDONÇA et al. (2013). Following surface treatment, the eggs were placed in a sieve for 30 minutes to drain excess product and air dry. The 60 eggs from the treatment without shell coating were selected, labeled, and transported from the farm to the laboratory, maintaining their original condition throughout the process. Throughout the experiment, eggs were stored in cardboard trays at room temperature, with average daily temperatures recorded using a Data Logger (Model RC-5 USB). The analyzed parameters included weight loss (%), yolk pH, and albumen pH.

On day zero of the experiment, 10 eggs from each treatment group were individually numbered and weighed using an analytical balance with 0.0001g precision. In subsequent storage periods, additional weight measurements were conducted to determine mass loss. The percentage weight loss was calculated by multiplying the weight loss in grams by 100 and dividing by the initial egg weight.

For pH analysis of yolk and albumen, eggs were cracked and mechanically separated into their components. The yolk and albumin were homogenized individually for a few seconds, then the pH was measured using a digital pH meter, previously calibrated with tampon solutions of pH 7 and 10 (BRASIL 1999).

Statistical analysis of the data was conducted using analysis of variance, incorporating a model that accounted for the effects of eggshell surface treatment, storage time, and their interaction. Como não houve interação entre os tratamentos e o tempo de estocagem, as médias do tratamento superficial da casca dos ovos foram comparadas pelo teste T a 5% de probabilidade e as médias dos efeitos do tempo de estocagem foram comparadas pelo teste SNK (Student Newman-Keuls) a 5% de probabilidade.

RESULTS AND DISCUSSION

None of the treatments significantly affected egg weight loss throughout the experimental period (Figure 1). Both geopropolis-coated and uncoated eggs experienced weight loss over time, potentially due to the loss of the shell membrane caused by handling damage. The exposure of shell pores facilitates the release of gases and moisture, contributing to the decrease in initial weight.

The breakdown of carbonic acid in egg white produces carbon dioxide (CO_2) and water (H_2O). Carbon dioxide escapes through the shell's pores, causing the egg white to thin and become watery, resulting in weight loss of the eggs (STADELMAN & COTTERILL 1994, EKE et al. 2013). This finding indicates that the geopropolis solution in the current study was unable to prevent water and CO_2 loss from the eggs to the environment, consistent with the results reported by ALMEIDA et al. (2015) examining the quality of chicken eggs coated with whey protein over a 42-day period, weight loss was observed regardless of the shell coating application.

SHARAF & TAHERGORABI (2019) reported contrasting findings to the present study when examining eggs from laying hens coated with sweet potato starch containing 2%, 4%, and 6% thyme essential oil, stored for 35 days at 25°C. Their results indicated that coated eggs exhibited reduced weight loss compared to uncoated eggs. AYGUN et al. (2012) also reported contrasting findings when assessing propolis effects on quail egg weight loss, using various shell surface treatments including 70% ethanol, benzalkonium chloride, and propolis solutions at different concentrations. 5%, 10% and 15%, finding that the eggs sprayed with the different propolis solutions presented less weight loss ($P<0.001$) compared to the eggs of the other treatments. The author attributed the reduced weight loss in propolis-treated eggs to the minimization of water loss through occlusion of egg pores following treatment.

During the storage period, significant differences in weight loss were observed between uncoated eggs and those coated with geopropolis. The greatest weight loss occurred on day 55, followed by days 41 and 28. The least weight loss was observed on day 7, which was not statistically different from day 14. MOURA et al. (2008) obtained similar results regarding weight loss in refrigerated and non-refrigerated eggs, with a linear increase in egg weight loss as storage time increased, when assessing the effect of temperature on the internal quality of quail eggs (2008).

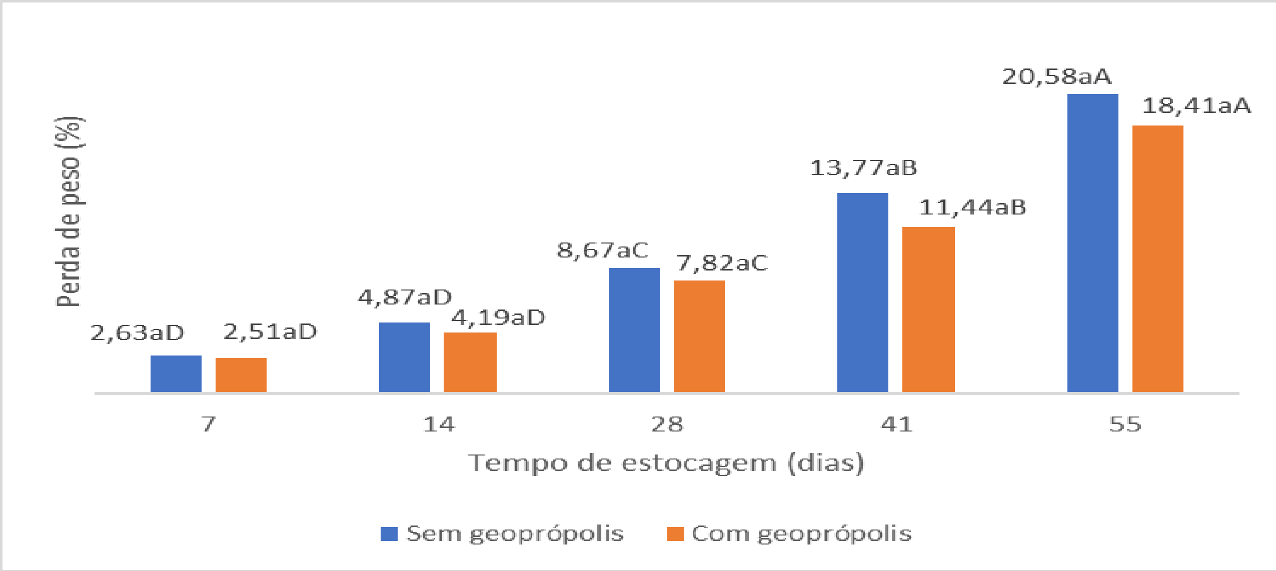

Figure 1. Weight loss of untreated quail eggs and those superficially treated with geoprópolis solution stored without refrigeration evaluated at different storage periods. Means followed by the same lowercase letter (treatment effect within each day of storage) do not differ from each other by the t test, at 5% probability. Means followed by the same capital letter (effect of storage day within each treatment) do not differ from each other by the SNK test, at 5% probability.

A 2-3% weight loss in eggs during storage is considered acceptable (FAO 2003). However, it can be seen that in this study, from 14 days onwards, the eggs lost more weight than recommended by the FAO (Food and Agriculture Organization of the United Nations), with 4.87% weight loss for uncoated eggs and 4.18% for eggs treated with geopropolis. This may have occurred because the conditions of the egg storage environment are a determining factor for the rate of deterioration of the internal quality of eggs (LIU et al. 2016).

As average ambient temperatures of 30.38°C were recorded, as shown in Figure 2, and the geopropolis solution treatment was potentially ineffective in sealing the shell pores, the influence of temperature may have accelerated the egg weight loss process. CANER & YUCEER (2015) observed contrasting results when evaluating chicken eggs coated with whey protein, zein, and shellac during 35 days of storage at 24°C. Both zein- and shellac-coated eggs maintained weight loss within the acceptable range of 2-3% by the end of the storage period.

For egg yolk pH, as shown in Figure 3, a significant difference between treatments was observed only on day 14, with geopropolis-coated eggs exhibiting higher yolk pH compared to untreated eggs. PIRES et al. (2020), obtained a similar result using protein concentrate of rice and propolis as a surface coating for the shell of chicken eggs, stored for six weeks at 20 °C. PIRES et al. (2019) observed contrasting results when coating chicken eggs with rice protein concentrate containing varying levels of propolis (0, 5, or 10%). They found that the yolk pH of coated eggs was lower than that of uncoated eggs from day 21 to day 35 of storage, indicating a change in yolk pH during this period.

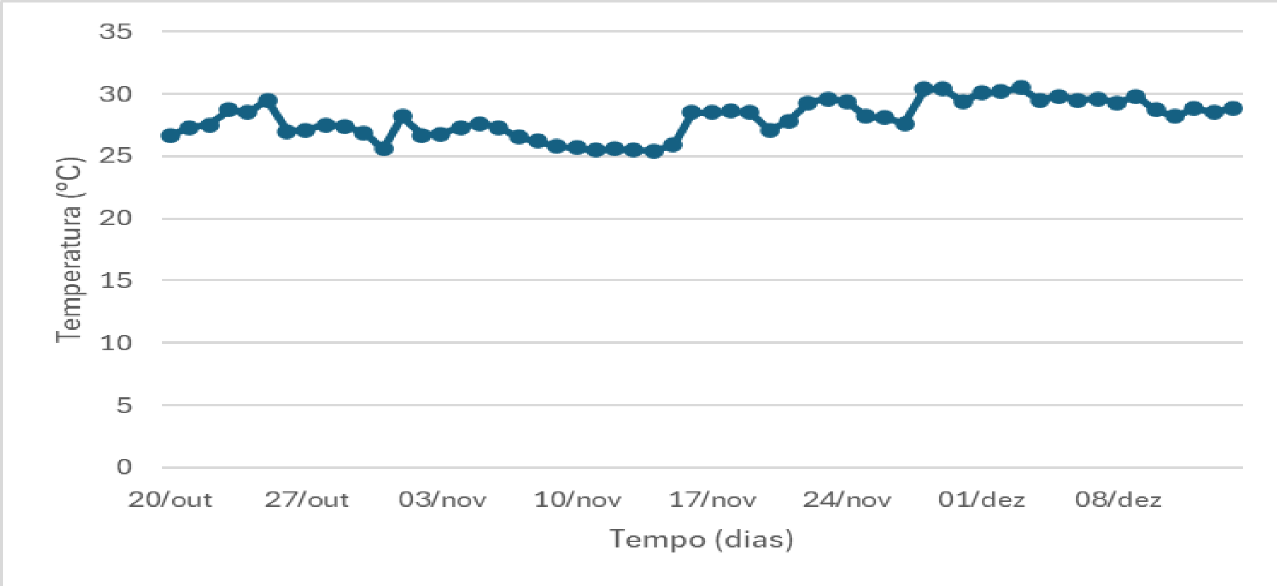

Figure 2. Average daily temperature recorded during the experimental period.

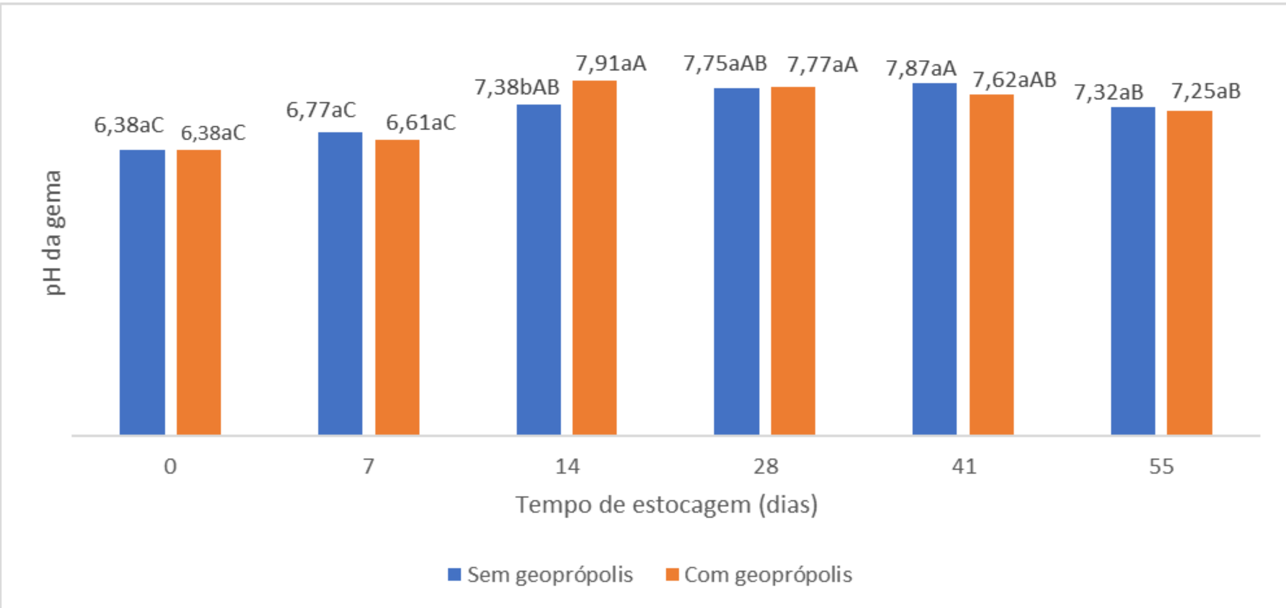

Figure 3. pH of quail egg yolk without treatment and superficially treated on the shell with 10% geoprópolis solution stored without refrigeration evaluated at different storage periods. Means followed by the same lowercase letter (treatment effect within each day of storage) do not differ from each other by the t test, at 5% probability. Means followed by the same capital letter (effect of storage day within each treatment) do not differ from each other by the SNK test, at 5% probability.

As storage time increased, significant differences were observed in yolk pH for both uncoated eggs and those with a surface coating of geopropolis. For uncoated egg yolks, lower pH values were observed on days 0 and 7 compared to day 41. Day 55 exhibited the lowest yolk pH value compared to day 41, but did not differ significantly from days 14 and 28. For geopropolis-coated eggs, lower yolk pH values were observed on days 0 and 7 compared to days 14 and 28. Day 55 showed a lower yolk pH than days 14 and 28, but was not statistically different from day 41.

Generally, the lowest yolk pH values were observed between days 0 and 7, with a gradual increase over time. This finding aligns with the results reported by CANER & YUCEER (2015), who observed an increase in yolk pH over time when examining chicken eggs coated with whey protein, zein, and shellac during a 35-day storage period at 24°C. This phenomenon occurs due to the exchange of alkaline ions from the albumen with H+ ions present in the yolk, resulting in an increase in the yolk's pH (SHANG et al. 2004). According to YANG et al. (2023) pH fluctuations can substantially affect protein structural characteristics, consequently influencing yolk properties and texture.

For albumen pH, as shown in Figure 4, significant differences between treatments were observed on days 14 and 55, with geopropolis-coated eggs exhibiting lower albumen pH values compared to uncoated eggs in both periods. PISSINATI et al. (2014) observed similar results, with uncoated eggs exhibiting the highest albumen pH (P<0.01), while mineral oil-coated eggs showed the lowest pH (P<0.01). This finding aligns with the results reported by AKPINAR et al. (2015), where initial albumen pH levels in each group increased with storage time, but this increase was more pronounced in the control group compared to eggs coated with varying propolis concentrations (5, 10, 15%). PIRES et al. (2019) reported contrasting findings in which eggs coated with rice protein concentrate containing varying levels of propolis (0, 5, or 10%) exhibited different albumen pH compared to uncoated eggs from the first week through 35 days of storage, with uncoated eggs showing higher albumen pH than coated eggs.

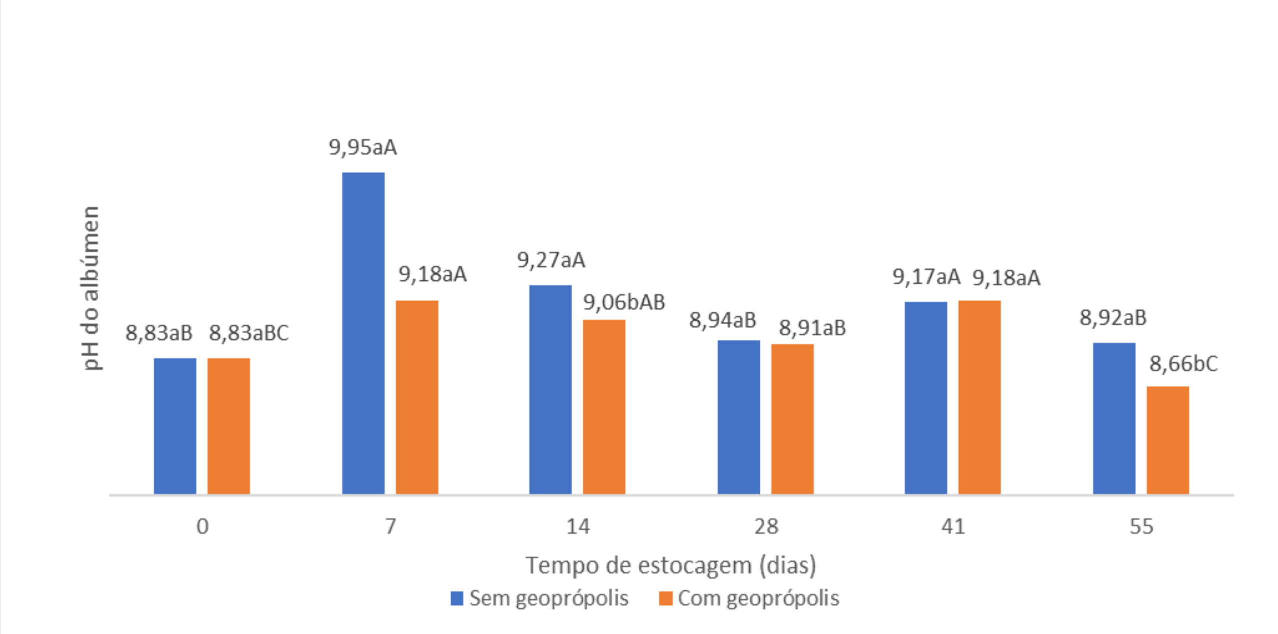

Figure 4. pH of the albumen of untreated quail eggs and those superficially treated on the shell with 10% geoprópolis solution stored without refrigeration evaluated at different storage periods. Means followed by the same lowercase letter (treatment effect within each day of storage) do not differ from each other by the t test, at 5% probability. Means followed by the same capital letter (effect of storage day within each treatment) do not differ from each other by the SNK test, at 5% probability.

Regarding the storage period, variations in albumen pH were observed for uncoated eggs. The lowest pH values were recorded on day 0, which did not differ significantly from days 28 and 55. Conversely, the highest albumen pH was observed on day 14, which was not statistically different from days 7 and 41. Variation in albumen pH of eggs coated with geopropolis solution was observed over storage time. The lowest albumen pH was recorded on day 55, followed by day 28, which did not differ significantly from day 0. The highest albumen pH values were observed on days 7 and 41, which were not statistically different from day 14.

The pH instability of the albumen likely resulted from chemical reactions within the egg due to fluctuations in ambient temperature throughout the analysis period. ALMEIDA et al. (2015) observed similar results when evaluating eggs coated with whey protein, where the pH of the egg albumen increased progressively across all applied methods, reaching its maximum value after 14 days of storage. Subsequently, pH values decreased, resulting in a quadratic behavior of the regression equations.

AKPINAR et al. (2015) observed an increase in the initial pH of the albumen over storage time in eggs, both treated and untreated with propolis solution. This is because according to FIGUEIREDO et al. (2013) as the egg ages, the thick albumen becomes more liquid due to various internal chemical reactions involving carbonic acid (H_2CO_3). This component of the albumen buffer system dissociates to form water and carbon dioxide (CO_2). According to STADELMAN & COTTERILL (1994), CO_2 loss through the shell pores leads to a decrease in albumen acidity, resulting in an increase in albumen pH. The loss of this substance during storage leads to increased alkalinity. This alkalinity can impact protein structure, decreasing albumen viscosity and altering the egg's sensory and functional properties (MONTEIRO et al. 2019).

CONCLUSION

The surface coating of quail eggshells with a 10% geopropolis solution is ineffective in maintaining the internal quality of eggs over 55 days of storage in a non-refrigerated environment, with an average ambient temperature of 30°C, as evidenced by increased weight loss and significant changes in yolk and albumen pH. This outcome may have been influenced by factors such as elevated temperatures and the concentration of geopropolis in the egg coating solution.

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