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EFFICACY OF WHITE TURMERIC SOLUTION AS A NATURAL PRESERVATIVE FOR EGGS: A 12-HOUR SOAKING EVALUATION ON INTERNAL QUALITY

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Abstract. The present study investigated the influence of a 12-hour soak in white turmeric solutions at varying concentrations on the internal quality characteristics of eggs laid by purebred chickens, assessing its potential as a natural preservation method. This study utilized 64 one-day-old eggs from Isa Brown hens. This study used a complete randomized design in a lab setting with four treatments and four replications. Each replicate consisted of 4 eggs. The eggs were soaked in one of the following solutions of white turmeric for the study: P0: 0%, P1: 15%, P2: 30%, and P3: 45%. The variables observed consisted of egg yolk color, egg white index, egg yolk index, and egg pH. The recorded data were subjected analysis of variance. Least significance difference test was applied to identify which mean populations are statistically different. The results showed that soaking eggs using turmeric white solution had a highly significant effect (P<0.01) on egg yolk color, egg white index, egg yolk index, and egg pH. The average yolk color was highest at P2 (7.69±0.13), egg white index at P2 (0.08±0.01), egg yolk index at P2 (0.44±0.01), lowest pH value at P2 at 7.73 and highest at 9.14 at P0. It can be concluded that the internal quality of purebred chicken eggs can be enhanced by soaking them for 12 hours in a solution of 30% white turmeric, which can be used as a natural preservative.

Keywords: Egg quality, chicken eggs, turmeric, natural antioxidants, storage time

Abstrak. Penelitian ini bertujuan untuk mengevaluasi pengaruh perendaman telur selama 12 jam dengan menggunakan berbagai konsentrasi larutan kunyit putih sebagai pengawet alami terhadap kualitas internal telur ayam ras. Materi penelitian ini adalah telur ayam ras strain *Isa Brown* yang berjumlah 64 butir dengan umur telur 1 hari. Metode penelitian ini adalah eksperimen laboratorium dengan menggunakan Rancangan Acak Lengkap dengan 4 perlakuan dan 4 ulangan. Setiap ulangan terdiri dari 4 butir telur. Perlakuan penelitian adalah merendam telur dalam larutan kunyit putih: P0: 0%, P1: 15%, P2: 30%, P3: 45%. Variabel penelitian terdiri dari warna kuning telur, indeks putih telur, indeks kuning telur, dan pH telur. Data dianalisis menggunakan Analisis Varians. Apabila hasil analisis menunjukkan adanya perbedaan yang nyata, dilanjutkan dengan uji BNT. Hasil penelitian menunjukkan bahwa perendaman telur menggunakan larutan kunyit putih memberikan pengaruh yang sangat nyata (P<0,01) terhadap warna kuning telur, indeks putih telur, indeks kuning telur, dan pH telur. Rata-rata warna kuning telur tertinggi pada P2 (7,69±0,13), indeks putih telur pada P2 (0,08±0,01), indeks kuning telur pada P2 (0,44±0,01), nilai pH terendah pada P2 sebesar 7,73 dan tertinggi pada 9,14 pada P0. Berdasarkan hasil penelitian, dapat disimpulkan bahwa perendaman telur selama 12 jam menggunakan larutan kunyit putih 30% sebagai pengawet alami dapat meningkatkan kualitas internal telur ayam ras.

Kata kunci: Kualitas telur, telur ayam, kunyit, antioksidan alami, waktu penyimpanan

Introduction

With their great nutritional content, eggs are one of the animal products that come from poultry (Antova et al., 2019). This may encourage the community to eat more eggs. The easily available of eggs and affordable prices make them a good choice for all levels of society (Zaheer, 2015), making them an economical choice to meet the body's needs for protein and nutrients in sufficient quantities (Réhault-Godbert et al., 2019). Chicken eggs are considered to be nature's perfect food, the egg white is an excellent natural source of high-quality protein, which is rich in essential amino acids (Lesnierowski & Stangierski, 2018). Chicken egg is one of the best sources of high-quality protein that is useful for supporting growth, repairing body tissues, and fulfilling various important functions in the body (Miranda et al., 2015). Even while eggs are a great source of nutrients that the human body needs, it should be recognized that eggs also have vulnerabilities. If not handled properly, they can easily become destroyed, much like perishable food. Eggs stored at room temperature cannot last long (Yimenu et al., 2017), because higher temperatures can change the chemical and physical structure of eggs (Ketta, 2015), and warmer room temperatures can facilitate the development of bacteria such as salmonella in eggs. Purebred chicken eggs exhibit a restricted shelf life, typically not exceeding two weeks (Rahmawati et al., 2014).

Damage to the egg typically occurs when microorganisms penetrate through its pores or cracks after the protective protein layer covering it has been compromised (Akter et al., 2014; Luo et al., 2020). The evaporation of water and gas can also harm the contents of eggs, leading to both physical and chemical alterations, ultimately resulting in a decline in egg quality due to the depletion of water and carbon dioxide (CO2), as well as alterations in chemical composition (Lee et al., 2016). This factor reduces the duration for which eggs remain fresh, requiring diligent effort to preserve their internal qualities like yolk color, egg white and yolk index, Haugh units, and egg pH.

To mitigate the post-harvest decline in egg quality, effective and practical preservation methods are warranted. These technologies aim to seal the eggshell pores, minimizing excessive moisture loss and safeguarding the egg against microbial contamination (bacteria, fungi, and germs) This can significantly increase the shelf life of eggs. This preservation technology uses natural preservatives that contain bioactive compounds with antimicrobial and antioxidant properties that play a role in maintaining egg quality (Triawan et al., 2021; Umela &; Nurhafnita (2021); Herijanto et al., 2023).

White turmeric (Curcuma zedoaria Rosc.) is one type of plant from the Zingiberaceae family that has an important role in traditional medicine and the drug industry. This plant is often used in traditional medicine for various purposes such as anti-inflammatory, antidiabetic, and to relieve indigestion. In addition, white turmeric is also used in the pharmaceutical industry for the manufacture of various medicinal products (Saefudin et al., 2014).

White turmeric contains a variety of chemical compounds, including monoterpenes in essential oils, zedoarone, epicurminol, curcuminol, and curcumin. Curcumin is one of the best-known compounds for having strong antioxidant activity. Antioxidants in food have an important role in maintaining product quality by preventing oxidation that can cause rancidity, changes in nutritional value, changes in color and aroma, and other physical damage. Therefore, the use of white turmeric or curcumin compounds as a source of natural antioxidants can be beneficial in the food industry to improve product durability and quality (Teshome et al., 2022). The antimicrobial activity of white turmeric is caused by the presence of bioactive compounds such as phenols, flavonoids, and tannins contained in it (Tran et al., 2022). The findings from the study conducted by Ivanović et al. (2021) indicate that the total phenolic content in turmeric rhizomes, at 13.93 mg GA g^{-1} DW, surpasses that of ginger (9.63 ± 0.05 mg GA g^{-1} DW). Additionally, the antioxidant activity of essential oils in turmeric was found to be higher compared to both ginger and cardamom, as noted by Ibáñez and Blázquez (2020).

Flavonoid compounds such as curcuminealoin can result in bacterial protein inactivation and loss of function, while saponins can dissolve lipids on bacterial cell membranes that change lipid voltage, cell permeability, and cell function to be abnormal, which ultimately leads to bacterial cell lysis and death (Muflihah, 2015). The findings from Sedya and Rinawidiastuti's study in 2022 indicates that soaking eggs in citronella leaf extract at a concentration of 30% for 12 hours resulted in the highest egg white index value, surpassing those from soak times of 6 and 24 hours. Immersing eggs in Moringa leaf solution at concentrations of 10%, 20%, and 30% has been shown to impact the elevation of the egg white index, as demonstrated by Riawan et al. (2017). The aim of this research was to assess how immersing eggs in a white turmeric solution of different concentrations for 12 hours, as a natural preservative, impacts the internal quality of chicken eggs.

Materials and Methods

A total of 64 Isa Brown strain chicken eggs was used. All the eggs were the same age and weigh approximately 61-62 grams each. Eggs that met the requirements of being unbroken and clean brown in color were chosen. The farm of Mr. Syahroni in Mendalanwangi Village was the source of the eggs.

This study employed a complete randomized design (CRD) in a laboratory setting with four treatments and four repetitions. Each test consisted of 4 purebred chicken eggs as an experimental unit in conducting the study. The treatments carried out were:

P0 : Purebred chicken eggs without soaking (control).
P1 : Soaked purebred chicken eggs in a solution of white turmeric with a concentration of 15% for 12 hours at room temperature.
P2 : Soaked purebred chicken eggs in a solution of white turmeric with a concentration of 30% for 12 hours at room temperature.
P3 : Soaked purebred chicken eggs in a solution of white turmeric with a concentration of 45% for 12 hours at room temperature.

This research was conducted through several stages as follows:

1. **The stage of making white turmeric solution**. Commercial instant white turmeric powder using a spatula was adjusted to the needs of the treatment carried out in each study using white turmeric weighing 150 grams (15%), 300 grams (30%), and 450 grams (45%), then the commercial instant white turmeric powder was mixed in a beaker glass with 1000 ml of water and stirred until homogeneous using a stirrer so that the white turmeric solution was ready to be used as research material.
2. **Egg preparation stage**. A total of 64 purebred chicken eggs were obtained and their initial weights were **measured** using digital scales to ensure a representative sample for the subsequent analyses in this study. The shells of purebred chicken eggs are sanitized using wipes or cloths to eliminate contaminants and microorganisms present on the eggshell surface.
3. **Egg soaking stage**. Four eggs were placed in each container previously labeled with white turmeric (curcuma zedoaria) at three concentrations, namely 150% (15%), 300% (30%), and 450% (45%). Following the preparation, aliquots of the white turmeric solution were added to each soaking container, which housed four eggs for a 12-hour incubation period (Sedya & Rinawidiastuti, 2022).
4. **Egg storage stage**. Following a 12-hour soaking period, eggs were drained, meticulously dried, and positioned on the incubation tray with the blunt end oriented upwards. Each egg was then labeled and maintained at room temperature for 21 days (Feddern et al., 2017).
5. **Internal quality test stage of eggs.** After 21 days of storage, the eggs were weighed using a digital balance and the weight recorded. The eggs were then cracked using a knife and their contents transferred to a petri dish. Following this, several parameters were measured: yolk color using a Yolk Colour Fan, egg white height and yolk height using calipers, and egg white pH using pH paper.

Research Variables

The variables of the study observed were:

1. **Egg Yolk Color.** The yolk color is compared to the standard color on the Roche Egg Yolk Colour Fan tool. The yolk color is

scored with the lowest value of 1 and the highest value of 15 from pale to dark orange/orange. The color of the yolk that is close to one of the colors on the tool is the number of the yolk color score (Bovšková et al., 2014).

2. **Egg White Index.** Egg white index (IPT) is a comparison between the height of egg whites and the average diameter of egg whites. The tool used to measure the egg white index is a caliper. Calculated by the following formula (Datukramat et al., 2021):

   Egg White Index = $\frac{h}{(d1 + d2)/2}$

   Information:
   h = Egg white height
   d1 = Diameter of egg white length
   d2 = Short diameter of egg whiteIndeks Kuning Telur

3. **Egg Yolk Index (EYI).** In this study, Egg Yolk Index (EYI) is defined as the ratio between the height of egg whites to the average diameter of egg yolks measured using a caliper. The EYI is calculated according to the following formula (Datukramat et al., 2021):

   EYI = $\frac{\boldsymbol{h}}{(\boldsymbol{d1} + \boldsymbol{d2})/2}$

   Description:
   h = High yolk.
   d1 = Diameter of the length of the yolk.
   d2 = Short diameter of the yolk.

4. **Egg pH.** The egg is broken then beaten until homogeneous then take 1 strip of litmus paper and dip it into the sample for about 5 seconds, then remove and immediately match the color change on the strip paper on the color table in the packaging box.

Data analysis

To assess treatment effects, data were subjected to analysis of variance (ANOVA). In the event of a significant ANOVA outcome, a post-hoc Least Significant Difference (LSD) test was employed to identify specific treatment group differences.

Results and Discussion

Internal qualities of eggs

In this study, it was investigated the effects of soaking eggs in varying concentrations of turmeric white solution for 12 hours on internal quality parameters during storage for 21 days at ambient temperature. The evaluated quality parameters included egg yolk color, egg white index, egg yolk index, and egg pH.

Egg Yolk Color

Yolk color intensity, measured using a standardized yolk color fan (e.g., Roche Yolk Color Fan) with a scale ranging from 1 (palest yellow) to 15 (darkest orange). Yolk color intensity is investigated as a potential indicator of internal egg quality for consumer consumption.

Analysis of variance revealed a statistically significant ($p < 0.01$) effect of white turmeric solution concentration on chicken egg yolk color. The means of egg yolk colour are presented on Table 1

Table 1. The Average Egg Yolk Color

Treatment	**Egg Yolk Color**
P0	6.94 ± 0.13[a]
P1	7.14 ± 0.34 [a]
P2	7.69 ± 0.13 [b]
P3	7. 63± 0.25 [b]

[a,b] : different superscripts in the same column are significantly different at P<0.01

Chicken egg yolks immersed in a white turmeric solution for 12 hours and subsequently stored for 21 days exhibited a shift in their average color value. Yolk coloration intensity within the 30% treatment group suggests a positive correlation between treatment concentration and final yolk color intensity. This may be due to the content of tannin compounds in the white turmeric solution, which serves to coat the eggshell to inhibit the release of CO_2 and prevent microorganisms from entering through the pores of the eggshell. Thus, the process of mixing the white with the yolk which can cause the color of the yolk to fade can be inhibited. In addition, flavonoid compounds in white turmeric solution have an effective antimicrobial role by denaturing proteins in bacterial cells. This causes damage to the structure and mechanism of bacterial cells, so that bacterial growth can be inhibited and the risk of egg damage due to bacterial contamination can be reduced. Meanwhile, the color of the yolk is also influenced by the content of carotenoid compounds. Carotenoid compounds are abundant in plants and are directly related to carotenoid pigments. For example, xanthophylls found in maize (Souza et al., 2021). This principle illustrates how the compound content in white turmeric solution can play a role in affecting the color of egg yolks. Storage duration is another factor influencing yolk color. The concentration of yolk color tends to be highest in eggs that have just been released by the mother because at this time the eggs have not passed the storage period. During egg storage, water migration (H_2O) occurs from egg white to yolk. As a result, the color density of the yolk tends to decrease with the increase in egg storage time. Another possibility that causes a decrease in the color density of the yolk is the dilution of the yolk pigment caused by damage to the vitelline membrane. The results of research from Hagan et al. (2013), Feddern et al. (2017), and Kruenti et al. (2022) showed a decrease in the concentration of egg yolk color along with an increase in egg storage duration. This finding is in line with the opinion of Fadillah (2022), which states that eggs with a yellow color density that reaches a score of more than 8 can be considered to have high quality. Eggs with an intense yellow color, orange or dark yolk, tend to have better quality. While eggs with a yellow color density between a score of 6 to 8 can be classified as eggs with medium quality. The synergy between these findings reinforces the view that egg storage duration can affect the color density of the yolk, which in turn can be an indicator of egg quality.

Egg White Index

A positive correlation exists between the egg white index and egg quality. Eggs with higher egg white index values exhibit superior quality characteristics. The results of analysis of variance showed that various concentrations of white turmeric solution had a very real effect ($P < 0.01$) on the egg white index. The average white index of chicken eggs is listed in Table 2.

The standard index of fresh egg whites ranges between 0.050-0.174 with normal numbers between 0.090-0.120 (SNI 3926:2008). As can be seen in the table above, the numbers produced in each treatment show numbers that are included in the standard egg white index. Tannin compounds contained in white turmeric solution have the potential to cover the pores in eggshell.

Table 2 Average Egg White Index

Treatment	Egg White Index
P0	0.05 ± 0.00 [a]
P1	0.07 ± 0.01 [b]
P2	0.08 ± 0.01 [b]
P3	0.07 ± 0.00 [b]

[a,b]: different superscripts in the same column denote significantly different effects (P<0.01)

Thus, CO_2 gas produced during egg storage can be blocked from exiting, meanwhile, the barrier can also prevent the entry of microorganisms into the egg. Therefore, almost equal egg white indices between various immersion concentrations may indicate that the tannin compounds have provided similar protection against eggs from CO_2 gas and microbes, although different solution concentrations have been used (Nugraha et al., 2017; Hidjrawan, 2020). Tannins can react with proteins present on the surface of the eggshell and form a layer that is impermeable to gases, including CO_2 gas produced during egg storage. Additionally, tannin compounds possess antibacterial properties against eggshell-associated bacteria through various mechanisms. One is by denaturing proteins, which cause damage to the protein structure of bacteria and disrupt their cellular function. In addition, tannin compounds can also damage bacterial cell membranes, resulting in inhibition of activity and biosynthesis of specific enzymes needed in bacterial metabolic reactions. Consequently, bacteria are inhibited from carrying out their essential cellular processes normally, resulting in cell death. Findings of the study suggest that tannin compounds warrant further investigation as potential antimicrobial agents for application in egg preservation, owing to their reported inhibitory effects on bacterial growth (Sigar et al., 2020; Riawan et al., 2017).

Santos et al. (2019) reported a positive correlation between egg white index and albumen dimensions (width and length). This increase in albumen dimensions can be caused by the high loss of CO_2 that occurs at room temperature, according to findings by Dada et al. (2018). In addition, it is known that the egg white index will decrease with the length of storage, since ovomucin in egg white undergoes a breakdown accelerated by an increase in pH. White turmeric solution can maintain the egg white index by slowing down the evaporation of water and CO_2 through the pores of the eggshell, so that the pH of the egg can be maintained. The increase in egg pH is caused by the evaporation of CO_2, which occurs due to the decomposition of $NaHCO_3$ compounds in purebred chicken eggs into NaOH and CO_2. The NaOH formed will decompose into Na+ and OH-, while CO_2 will evaporate. This process can cause a decrease in the quality of egg whites, as explained by Luo et al., (2020). Immersion in white turmeric solution may contribute to preserving egg white quality by mitigating CO2 efflux and stabilizing egg pH.

This study investigated the antibacterial effects of curcumin, isolated from white turmeric rhizome extract. The results indicate that curcumin disrupts or lyses bacterial cell membranes, leading to inhibition of colony growth. In addition, according to Suprihatin et al. (2020), white turmeric rhizome extract with water solvent contains various chemical compounds such as alkaloids, tannins, flavonoids, glycosides, and carbohydrates. Each of these bioactive compounds has a role in inhibiting microbial activity in chicken eggs soaked for 12 hours. Flavonoid compounds, have the ability to damage microbial cell walls, ultimately leading to cell death. Flavonoids can also form complexes with extracellular proteins and dissolve so that they can damage bacterial cell membranes, which then causes the release of intracellular compounds. This finding is in line with research by Obianwuna et al., (2022), which showed that flavonoid compounds have significant antimicrobial potential by damaging bacterial cell membranes. Based on these findings, white turmeric rhizome extract appears to be a promising source of bioactive compounds with antibacterial properties against bacterial growth in chicken eggs.

Abdeldaiem (2014) reported that flavonoid compounds possess the ability to induce protein aggregation. Furthermore, flavonoids exhibit lipophilic characteristics, enabling them to disrupt the bacterial cell membrane's lipid bilayer. This process disrupts cell wall formation by inhibiting the activity of the enzyme peptidoglycan transpeptidase, which is responsible for the formation of bacterial cell walls. As a result, the bacterial cell wall becomes weak and susceptible to damage.

Furthermore, flavonoids directly compromise bacterial cell membranes, inducing leakage and structural damage. This disrupts membrane integrity, leading to the efflux of vital cellular components like proteins and nucleic acids. Flavonoid compounds in plants have the potential to damage bacterial cell membranes and interfere with the activity of enzymes involved in the formation of bacterial cell walls of bacteria. Therefore, flavonoids have potential as effective antimicrobial agents in fighting bacterial growth.

Egg yolk index

Analysis of variance revealed a statistically significant effect ($p < 0.01$) of white turmeric solution concentration on the egg yolk index. White turmeric solution concentration exhibits a positive correlation with yolk index value. Egg yolk indices averaging between 0.39 and .44 fall under quality grade II. This is following SNI 3926:2008 that the index of fresh egg yolks ranges from 0.33 to 0.52 with an average of 0.42. The egg yolk index value can be grouped into several qualities, namely: a. quality I of 0.458 - 0.52, b. quality II of 0.394-0.457, and quality III of 0.330-0.393. Eggs soaked for 12 hours with a solution of white turmeric that had been stored for 21 days still had better yolk index values compared to those that had not been soaked. Tannin compounds present in white turmeric solution have the ability to maintain the quality of egg yolks during the storage period. Tannin compounds exhibit tanning properties, potentially occluding pores within the eggshell of purebred chickens. By covering these pores, tannin compounds can inhibit the evaporation of CO_2 gas from the egg and also prevent a rise in the pH of albumen. Thus, the effect of tannin compounds is to maintain egg quality by preventing changes that occur during storage, such as an increase in albumen pH that can occur due to CO_2 evaporation. This finding is consistent with research conducted by Lestari, Malacca, & Garantjang (2013), which showed that tannin compounds in white turmeric solution can play a role in maintaining egg yolk quality during the storage period. The means of egg yolk index of chickens are listed in Table 3.

A decrease in the quality of egg whites characterized by dilution of egg whites can have an impact on decreasing the yolk index. This process occurs due to the migration of water from egg white to yolk. When the egg white is diluted, the water content increases and some of the water can transfer to the yolk. As a result, the quality of the yolk can be affected, and the yolk index can decrease. Research conducted by Wulandari et al. (2013) supports this concept by showing that a decrease in the quality of diluted egg whites can have an impact on decreasing the yolk index. Therefore, maintaining the quality of egg whites is an important factor in maintaining the overall quality of eggs, including the quality of egg yolks. Research by Ebegbulem and Asukwo (2018) shows that storage time affects the quality and freshness of eggs, with the longer the eggs are stored, the quality will decrease. The length of storage also contributes to the decrease in the value of the yolk index. Increased egg storage time at room temperature can cause physical changes in the yolk, such as larger size and softer texture. In addition, the vitelin membrane that protects the yolk can be damaged along with the increase in storage time. As a result, the yolk can become brittle and tend to break, which then has an impact on decreasing the value of the yolk index. Thus, it is important to pay attention to the length of storage of eggs in order to maintain their quality.

Table 3. Means of Egg Yolk Index

Treatment	Egg Yolk Index
P0	0.39 ± 0.01 [a]
P1	0.41 ± 0.01 [ab]
P2	0.44 ± 0.01 [c]
P3	0.42 ± 0.01 [b]

[a,b,c]: different superscripts in the same column show statistically significant effects (P<0.01)

Storage of eggs at the right temperature and for a not too long period of time can help minimize deterioration in quality, including a decrease in the value of the yolk index. A study conducted by Okonkwo et al. (2021) states that the decrease in egg yolk index is caused by the movement of CO2 and moisture through the eggshell, which causes changes in albumen, yolk, and egg weight. This finding is supported by research conducted by Dada et al. (2018) and Ebegbulem and Asukwo (2018), which showed that environmental changes such as CO_2 movement and humidity can affect egg quality, including egg yolk index. In addition, the study conducted by Feddern et al., (2017) also highlighted the decrease in egg yolk index as a result of the breakdown of glycoprotein ovomusin in eggs. The process of decomposition of glycoprotein ovomusin can cause depletion of the yolk, which then has an impact on decreasing the value of the yolk index. Thus, various factors such as environmental changes and internal processes in the egg can contribute to a decrease in the value of the yolk index. This emphasizes the importance of maintaining storage conditions and managing eggs due to maintain their quality, including the quality of the yolk.

The tannin content in the solution of white turmeric plays an important role in maintaining the stability of the yolk index. Tannins serve as protective agents that protect the pores in the eggshell from external attacks. With protected pores, eggs are better protected from the entry of microorganisms from the outside environment. This condition creates a stable internal environment of the egg, where CO_2 levels are maintained and not reduced. Thus, the activity of microbes entering the egg can be inhibited, because the environment in the egg is maintained. Studies by Abdeldaiem (2014) and Putra & Tiring (2021) substantiate this notion, demonstrating that the tannin content in white turmeric solution contributes to egg protection against microbial spoilage. Consequently, white turmeric solution application may aid in preserving yolk index stability and upholding overall egg quality.

Tannin-protein interactions on the eggshell surface can generate a gas-impermeable layer. This process creates an effective barrier against the entry of gases such as CO_2 into the egg and the exit of those gases from the egg. As a consequence, the internal environment of the egg can be maintained with good stability. Our observations on the interaction between tannins and proteins in the impermeable layer corroborate the findings of Nimalaratne & Wu (2015). This suggests that these layers may be crucial for maintaining egg quality by limiting detrimental changes within the internal environment, thereby protecting both yolk and overall egg quality.

Egg pH

The results of variance analysis showed that various concentrations of white turmeric solution had a highly significant effect (P < 0.01) on the pH of eggs. The unsoaked control group (P_0) exhibited a higher pH compared to the group soaked in white turmeric solution. Soaking chicken eggs in a white turmeric solution demonstrated the ability to impede the rise in egg pH. This process occurs due to the presence of significant evaporation of CO_2 during the storage period of eggs. CO2 efflux can alter the rheological properties of egg white and yolk, resulting in a decrease in viscosity. These changes can cause a rise in the pH of the egg. In addition, egg whites naturally contain inorganic elements such as sodium and potassium bicarbonate. When CO_2 evaporation occurs during storage, egg whites tend to become more alkaline, which has an impact on increasing the pH of egg whites. Our observations corroborate the findings of Putra & Tiring (2021), who demonstrated that a white turmeric soak impedes the rise in egg pH. This suggests that white turmeric solution could be a viable strategy to preserve egg quality during storage.

By maintaining equivalent temperatures across all treatment groups, this study effectively isolated the influence of white turmeric solution on egg pH, eliminating the confounding effects of temperature variation. Corroborating previous research by Indratiningsih (1984) and Sihombing et al. (2014), the present study demonstrates the influence of temperature on the pH of egg whites and yolks. As the temperature increases, the amount of CO_2 lost from the egg will be more, which eventually leads to an increase in pH in the egg white and yolk. In addition, research conducted by Sihombing et al., (2014) also showed that with increasing shelf life of eggs, the height of the viscous layer of egg white will decrease due to changes in the structure of the gel. This phenomenon may lead to the dilution of the egg white, consequently inducing an expansion of its surface area and an elevation of its pH. Building on prior research demonstrating the influence of temperature and storage duration on egg white and yolk pH via various mechanisms, this study employed strict temperature control. This approach aimed to isolate and precisely evaluate the impact of the turmeric white solution on egg pH. According to Nuro et al., (2021), eggs that have just come out of the mother have a pH of around 7, but during egg storage, the pH can increase to around 9.0-9.7. This increase in pH value is influenced by temperature factors and the length of egg storage. Research conducted by Okonkwo et al., (2012) added that the pH of eggs increases due to the release of CO_2 through the pores of the eggshell. Within the application of white turmeric solution as a food preservative, its tannin constituents might contribute to the suppression of egg albumin degradation. This results in reduced evaporation or loss of CO_2 gas. Since CO_2 evaporation is an influential factor in increasing pH during storage, the use of white turmeric solution can help maintain the pH of eggs at a lower level, thus inhibiting excessive pH elevation. Average pH of eggs shown in Table 4.

Jazil et al. (2013) reported that elevated pH levels in egg albumin disrupt the structural integrity of ovomucin fibers, responsible for the viscous character of albumin. This disruption leads to decreased albumin viscosity. Consequently, significant pH alterations in eggs can negatively impact albumin structure and quality, ultimately affecting overall egg texture and consistency. The results showed that the higher the percentage of white turmeric solution caused a decrease in pH value. This may be due to the closure of the pores on the eggshell by tannins, which reduce gas evaporation and consequently lower the pH of the egg. However, along with the length of storage time, there is an increase in the pH value.

Table 4. Average pH of Eggs

Treatment	pH of Eggs
P0	9.14 ± 0.46 [a]
P1	8.55 ± 0.42 [a]
P2	7.73 ± 0.22 [b]
P3	7.80 ± 0.47 [b]

[a,b]: different superscripts in the same column indicate statically significant effects (P<0.01)

This phenomenon is likely attributed to the combined effects of diffusion: CO2 effluxes from the albumen (egg white) through the eggshell, while water migrates from the albumen towards the yolk. Notably, egg whites inherently contain inorganic elements like sodium and potassium bicarbonate, which can also contribute to these processes. When CO_2 evaporation occurs during storage, egg whites tend to become more alkaline, which has an impact on increasing the pH of egg whites, and consequently, the overall pH of eggs also increases.

Findings of this study corroborate previous work by Souza et al. (2021) demonstrating a link between elevated pH and solid albumen degradation. This translates to a decrease in Haugh Units (HU) and a concomitant increase in albumen fluidity and dilution. As reported by Feddern et al. (2017), these changes can be attributed to alterations in the ovomusin-lysozyme complex due to rising pH during storage. Turmeric-induced acidification (pH decrease) may influence the antimicrobial activity of curcumin compounds. According to Syaifuddin (2019), a decrease in pH can affect the structure of curcumin compounds, which in turn can reduce the effectiveness of antimicrobial properties. The reduced antimicrobial properties in curcumin compounds can then lead to increased microbial growth, which also has an impact on increasing microbial activity in breaking down proteins into amino acids and simple acids.

Turmeric addition may alter egg quality through pH-mediated effects on curcumin's antimicrobial properties and subsequent changes in microbial growth and protein degradation. This necessitates evaluation of turmeric solution as an egg preservative, considering its potential impact on both microbiological safety and nutritional value. The decrease in pH value is also influenced by the acidity possessed by turmeric itself. Turmeric contains H+ ions, which can contribute to acidity in a product. The greater the number of H+ ions released by turmeric, the lower the pH produced. Turmeric additionally contains ascorbic acid, contributing to its acidic character.

Corroborating findings of this study, Nopandi et al. (2019) reported a decrease in pH of products containing turmeric compared to control products without turmeric. This shows that the pH content of products with the addition of turmeric is able to withstand lower acidity levels. Therefore, the addition of turmeric can affect the overall pH of the product, which in turn can affect the quality and stability of that product.

The observed decrease in yield between P2 and P3 may be attributed to a shift in white turmeric solution viscosity. As the concentration of white turmeric increases, solution viscosity is known to correspondingly rise. Solution viscosity can influence the penetration of turmeric into the egg, potentially leading to more complex interactions between turmeric's active components and egg constituents, such as proteins and lipids. Hille et al., (2015) indicated that the viscosity of the solution can affect the penetration process and the interaction of the active substance in the solution with the substrate hit. In the context of this study, the change in viscosity of the white turmeric solution from P2 to P3 may have influenced the process of turmeric penetration into eggs and the interaction between the active compounds in turmeric and the egg components. These variations may influence egg preservation efficacy, potentially leading to disparaties in yield observed between the two treatment groups.

Conclusions

The present study demonstrates that a 12-hour soaking process in a 30% white turmeric solution, employed as a natural preservative, enhances the internal quality of eggs laid by purebred chickens.

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