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The Effect of Storage Duration and Soaking of Eggs Using Basil Leaf Solution (Ocimum basilicum L.) on Maintaining the Internal Quality of Duck Eggs (Anas platyrhynchos domesticus)

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ABSTRACT

Duck eggs are highly nutritious animal based food products but are prone to quality deterioration during storage. One natural preservation method is immersion using basil leaf solution, which has antibacterial properties. This study aimed to determine the effect of storage duration and basil leaf solution concentration on the internal quality of duck eggs and to identify the most effective treatment combination. The research was conducted at the Livestock Production Laboratory, Faculty of Agriculture, Universitas Sumatera Utara, using a factorial Completely Randomized Design (CRD) with two factors: basil solution concentration (0%, 15%, 30%, and 45%) and storage duration (0, 10, 20, and 30 days). Observed parameters included albumen index, yolk index, weight loss percentage, and pH value. The results showed a highly significant interaction ($P<0.01$) between the treatments on albumen index, yolk index, and pH. Immersion in 45% basil solution was effective in maintaining albumen and yolk indices as well as pH, while the 30% concentration was most effective in reducing weight loss. Day 10 was identified as the optimal storage period, during which all internal quality parameters remained stable. After this period, egg quality significantly declined.

Keyword: Basil leaf, Duck egg, Immersion, Internal quality, Storage

1. Introduction

Eggs are one of the poultry farm products that have a delicious taste, are easy to digest, and contain high nutritional value. However, eggs are also among the livestock products that are highly perishable because they are easily contaminated by microorganisms. Eggs have several weaknesses, such as their shells being easily cracked or broken and unable to withstand strong pressure. Therefore, eggs cannot be handled roughly in any container. Air humidity and storage temperature are also factors that can affect the quality of eggs and cause chemical and microbiological changes. Thus, preservation efforts are essential to maintain the quality of eggs [1]. The shelf life of commercial chicken eggs is very short—only up to about two weeks [2]. The internal quality of eggs, such as weight loss, thinning of the egg white, deterioration of the yolk, and enlargement of the air cell, can result from prolonged storage. According to [3], the longer the storage period, the more evaporation of liquid and gas occurs inside the egg, causing the air cell to become larger. Food products like eggs are highly perishable and can spoil within 14 days when stored at room temperature.

According to [4], efforts to maintain the quality of eggs and extend their shelf life include soaking them in natural tanning agents derived from plants, such as tannins. While tannins can act as anti-nutrients in animal feed, they can be utilized for tanning in this context. Many parts of plants contain tannins, including basil leaves (Ocimum basilicum L.). Basil (Ocimum basilicum L.) has many benefits as a traditional medicinal plant. Existing research shows that basil leaves contain compounds with insecticidal, larvicidal, nematicidal, antipyretic, fungicidal, antimicrobial, and antioxidant properties [5]. [6] has proven that basil (Ocimum basilicum L.) has antibacterial and antioxidant activity, especially when consumed as a vegetable or raw herb.

2. Method

This research was conducted over the course of one month, from February to March 2024, at the Livestock Production Laboratory, Faculty of Agriculture, Universitas Sumatera Utara, Medan.

2.1. Tools

Ballpoint pen, paper, plastic egg tray, digital scale, caliper, knife, glass table, thermohygrometer, digital pH meter, large jar, strainer, paper labels, large bowl, cleaning sponge, spoon, and plastic bags.

2.2. *Population and Sample*

The materials used in this study were fresh basil leaves, clean water, and 128 duck eggs from Mojosari ducks aged 58 weeks, all laid on the same day. The eggs were obtained from Mrs. Ningsih's farm in Hamlet VIII, Aman Damai Village, Serapit District, Langkat Regency, North Sumatra. The eggs were selected based on the following criteria: clean, intact shells without cracks, smooth shell texture, and oval shape. In this study, the eggs were chosen based on external appearance, regardless of uniformity in shell color.

2.3. *Data Analysis Methods*

The method used in this study was an experimental approach using a Completely Randomized Design (CRD) with a factorial pattern consisting of 4x4x4 experimental units. Each replication consisted of 2 eggs as a single experimental unit. Two factors were examined in this study, which are as follows:

Factor 1: Concentration of basil leaf solution with 4 levels:

D0: Egg immersion without basil leaf solution 0% (control);
D1: Egg immersion in 15% (b/v) basil leaf solution;
D2: Egg immersion in 30% (b/v) basil leaf solution;
D3: Egg immersion in 45% (b/v) basil leaf solution.

Factor 2: Egg storage duration with 4 levels:

H0: Storage for 0 days (control);
H1: Storage for 10 days;
H2: Storage for 20 days;
H3: Storage for 30 days.

The data analysis method for factorial RAL is as follows:

$$\mathbf{Yijk : \mu + \alpha i + Qj + (\alpha\beta)ij + \varepsilon ijk}$$

Description:

- $\mathbf{Y_{(ijk)}}$: Observation result for factor A at level *i* and factor B at level *j* in replication *k*
- $\boldsymbol{\mu}$: General mean
- $\mathbf{a_i}$: Effect of factor A at level *i*
- $\boldsymbol{\beta_j}$: Effect of factor B at level *j*
- $\mathbf{(a\beta)_{ij}}$: Interaction between factor A at level *i* and factor B at level *j*
- $\boldsymbol{\varepsilon_{ijk}}$: Experimental error for factor A at level *i*, factor B at level *j*, in replication *k*

3. Result and discussion

3.1 Egg White Index

Egg white is the part with the highest percentage in a single egg, consisting of thick and thin (liquid) portions. The egg white index is obtained by dividing the height of the egg white by the average diameter of the egg white. The average diameter is calculated by adding the diameter of the thick egg white and the diameter of the thin egg white, then dividing by two. The data on the duck egg white index from eggs soaked in basil leaf solution with varying concentrations and storage durations are presented in Table 1.

Table 1. Average values of duck egg white index after soaking in various concentrations of basil leaf solution and different storage durations (mm).

Solution Concentration	Storage Duration H0 (0 Day)	H1 (10 Days)	H2 (20 Days)	H3 (30 Days)	Mean ± SD (Standard Deviation)
D0 (0%)	$0,061^{Aa}$	$0,066^{Aa}$	$0,066^{Aa}$	$0,088^{Ba}$	0,070 ± 0,011
D1 (15%)	$0,074^{Aab}$	$0,073^{ABa}$	$0,057^{Bab}$	$0,075^{Aab}$	0,069 ± 0,008
D2 (30%)	$0,079^{ABb}$	$0,072^{ABa}$	$0,067^{Aab}$	$0,088^{Ba}$	0,306 ± 0,009
D3 (45%)	$0,084^{Ab}$	$0,071^{Aa}$	$0,076^{Ab}$	$0,068^{Ab}$	0,074 ± 0,006
Mean ± SD	0,074 ± 0,009	0,070 ± 0,002	0,066 ± 0,007	0,079 ± 0,009	

Note: Superscripts with different capital letters across rows and different lowercase letters down columns indicate significant differences (P < 0.05).

ANOVA analysis showed that the effect of various concentrations of basil leaf solution (0%, 15%, 30%, and 45%) on the duck egg white index did not have a significant effect (P > 0.05). However, treatment with different storage durations (0 days, 10 days, 20 days, 30 days) had a significant effect (P < 0.05) on the duck egg white index, and there was an interaction between the basil leaf concentration and storage time. Table 1 presents the egg white index values that remained stable under treatments with concentrations of 15%, 30%, and 45% and storage durations of 0, 10, 20, and 30 days.

Increasing the concentration of the basil leaf solution proved capable of preventing the decline in the egg white index. This is attributed to the bioactive compounds in basil leaves, such as flavonoids, tannins, and essential oils, which possess antibacterial and antioxidant properties. Tannins are known to form a protective layer on the eggshell surface, reducing the evaporation of water and gases from inside the egg. This aligns with research [7] on egg preservation through soaking in melinjo leaf extract. That study showed that tannin content of 4.55% in melinjo leaf extract affects both the internal and external quality of eggs, where higher concentrations of melinjo extract improve egg quality, and the soaking duration also contributes to maintaining egg quality and shelf life.

Furthermore, storage duration also had a significant effect, as eggs soaked in basil leaf solution were able to maintain the stability of the egg white index even when stored for longer periods. This effect relates to the antibacterial and antioxidant content in basil leaves, which helps inhibit the deterioration of the egg's internal quality. This finding is consistent with research [8], which demonstrated that soaking eggs in melinjo leaf extract for 24–36 hours helped maintain egg quality and shelf life. On the other hand, an increase in pH within the range of 7 to 9.7 can accelerate the deterioration of the egg white index, so pH stability is also an important factor in preserving egg quality.

The average egg white index values obtained in this study are still considered good. This is in accordance with the standards from [9], which state that the fresh egg white index ranges from 0.050 to 0.174. These results also align with findings from [10], who soaked duck eggs in guava leaf extract. That study showed that the longer the storage time, the more the egg white index decreased. This decline is suspected to be caused by a suboptimal soaking duration and low tannin content in the guava leaf extract, so the protective layer formed on the eggshell surface was not able to function optimally in maintaining egg quality.

3.2 Yolk Indeks

The yolk index value is obtained by dividing the height of the yolk by the diameter of the yolk. The longer the egg is stored, the yolk tends to become thinner and more fragile, causing its diameter to increase and the yolk index value to decrease. The data from testing the yolk index of duck eggs soaked in basil leaf solution with various concentrations and different storage durations are presented in Table 2.

Table 2. Average values of duck egg yolk index after soaking in various concentrations of basil leaf solution and different storage durations (mm).

Solution Concentration	Storage Duration H0 (0 Day)	H1 (10 Days)	H0 (0 Day)	H3 (30 Days)	Mean ± SD (Standard Deviation)
D0 (0%)	$0,414^{Aa}$	$0,341^{Ba}$	$0,357^{Ba}$	$0,223^{Ca}$	0,333 ± 0,080
D1 (15%)	$0,427^{Aa}$	$0,393^{ABa}$	$0,340^{Bab}$	$0,279^{Cb}$	0,359 ± 0,064
D2 (30%)	$0,379^{Aa}$	$0,385^{Aa}$	$0,257^{Bc}$	$0,280^{Bb}$	0,325 ± 0,071
D3 (45%)	$0,424^{Aa}$	$0,351^{Ba}$	$0,299^{Bbc}$	$0,216^{Ca}$	0,322 ± 0,087

Mean ± SD	0,411 ± 0,013	0,367 ± 0,025	0,313 ± 0,044	0,249 ± 0,034	

Note: Superscripts with different capital letters across rows and different lowercase letters down columns indicate highly significant differences ($P < 0.01$).

ANOVA analysis showed that the effect of various concentrations of basil leaf solution (0%, 15%, 30%, and 45%) on the duck egg yolk index had a significant effect ($P < 0.05$). Treatment with different storage durations (0 days, 10 days, 20 days, 30 days) also had a highly significant effect ($P < 0.01$) on the duck egg yolk index, and there was an interaction between the basil leaf concentration and storage time. Table 2 shows the yolk index values that remained stable with treatments at concentrations of 15%, 30%, and 45% over storage durations of 0, 10, 20, and 30 days.

The highest yolk index value was obtained from the treatment with a 15% concentration of basil leaf solution. This is suspected because the tannin content in basil leaves can inhibit the transfer of water from the egg white to the yolk. Tannins are impermeable, meaning they can reduce the rate of water movement and affect CO_2 gas transfer through their ability to bind to particle surfaces. CO_2 bound to tannin particles also reduces the rate of gas diffusion into the egg. This finding aligns with \[11], which states that tannins in jackfruit leaves can interact with the proteins in the eggshell through a tanning process. During this process, tannins precipitate and form a layer on the eggshell pores, making it impermeable to gases and water evaporation. However, at a 45% concentration, it is suspected that the high content of active compounds such as flavonoids, tannins, and essential oils may penetrate into the egg and affect the stability of the yolk structure. Although microbial activity is suppressed, excessively high concentrations of these active compounds potentially reduce the yolk index value [12].

The yolk index value in this study tended to be maintained only until the 10th day of storage. The decrease in the index is suspected to be related to the deterioration of egg quality as storage time increases. According to \[13], egg age affects the strength and elasticity of the vitelline membrane, causing yolk quality to weaken. The decrease in vitelline membrane elasticity and the thinning consistency of the yolk occurs due to the diffusion of most of the water from the egg white into the yolk. This ongoing water transfer causes the yolk to shrink, become flattened, and easily break [14]. This decline is caused by the continuous osmotic pressure difference between the egg white and yolk, resulting in loss of elasticity of the vitelline membrane [15]. Consequently, the yolk becomes wider and the yolk index decreases. Thus, the longer the storage time, the lower the yolk index.

These results are consistent with the findings of [16], who reported that soaking chicken eggs in basil leaf solution showed a decline in yolk index starting on day 14. Meanwhile, in this study, yolk index quality remained good up to day 10 of storage but began to decline thereafter. This decline was caused by increased storage time affecting the strength and elasticity of the vitelline membrane, resulting in decreased yolk quality. According to [17], fresh eggs generally have a yolk index in the range of 0.30–0.50. As another reference, a yolk index value of 0.22 is considered low (poor), 0.39 is moderate (average), and 0.45 or higher is considered high (good).

3.3 Percentage of Egg Weight Loss

Weight loss in eggs is a natural occurrence in eggs that have been stored for a long time. The longer the eggs are stored or remain unconsumed, the more they will continue to lose weight. This weight loss can be determined by calculating the difference between the egg weight after storage and the initial egg weight. Excessive weight loss can also be an indicator of declining egg quality. Data on the weight loss of duck eggs soaked in basil leaf solution with various concentrations and different storage durations are presented in Table 3.

Table 3. Mean percentage values of weight loss in duck eggs soaked in various concentrations of basil leaf solution and stored for different durations (%).

Solution Concentration	Storage Duration				Mean ± SD (Standard Deviation)
	H0 (0 Day)	H1 (10 Days)	H0 (0 Day)	H3 (30 Days)	
D0 (0%)	0,009	0,022	0,045	0,057	0,033 ± 0,021
D1 (15%)	0,034	0,016	0,036	0,050	0,034 ± 0,013
D2 (30%)	0,012	0,020	0,045	0,035	0,028 ± 0,014
D3 (45%)	0,007	0,027	0,057	0,064	0,038 ± 0,026
Mean ± SD	$0,015^{a} \pm 0,012$	$0,021^{a} \pm 0,004$	$0,045^{b} \pm 0,008$	$0,051^{b} \pm 0,012$	

Note: Superscripts in the same column indicate no significant difference (P>0.05), while superscripts in the same row indicate a highly significant difference (P<0.01).

ANOVA analysis showed that the effect of various concentrations of basil leaf solution (0%, 15%, 30%, and 45%) on the percentage of weight loss in duck eggs had no significant effect (P>0.05). Furthermore, treatments with different storage durations (0 days, 10 days, 20 days, 30 days) had a highly significant effect (P<0.01) on the percentage of weight loss in duck eggs. Duncan's multiple range test indicated that the storage duration at day H0 was significantly different from H2 and H3, but not significantly different from H1. The highest average percentage of weight loss was observed at storage duration H3 (30 days), and the lowest average percentage was at H0 (0 days).

The factor affecting the percentage of egg weight loss in this study was storage duration. This aligns with [18], who stated that the longer eggs are stored, the greater the weight loss. This weight loss is caused by water evaporation and the release of CO_2 gas from inside the egg through the eggshell pores. The evaporation and gas release processes continue throughout storage, so the longer the storage period, the more the egg's weight decreases.

According to [19], since eggs are stored, water evaporation and the release of gases such as CO_2, NH_3, N_2, and small amounts of H_2S occur through the eggshell pores as a result of organic material degradation. This process continuously reduces the quality of the egg white, creates an air pocket, and decreases egg weight. This is supported by [20], who stated that the average CO_2 production from eggs per day reaches 3.5 mg. Additionally, water evaporation through the shell and diffusion of water from the egg white to the yolk increase pH and damage the gel structure of the egg white. These processes continue during storage, making the egg contents increasingly watery as storage time increases.

Besides storage duration, environmental temperature and humidity also contribute to egg weight loss. This is consistent with [21], who stated that egg weight loss during storage is influenced by storage temperature, relative humidity, and eggshell porosity. Higher temperature and humidity accelerate water evaporation from inside the egg, causing faster weight loss. For example, storage at 25°C with 70% relative humidity can cause a weight loss of 0.8 g per egg per week, while at 30°C, weight loss increases to about 2 g per egg per week. If relative humidity rises to 80%, water loss in eggs can increase by approximately 20 mg per egg per day [22].

This study's results do not align with findings by [23], who reported that the lowest egg weight loss occurred during the second week with eggs soaked in 45% basil leaf solution. The difference is suspected to be due to different methods of preparing the basil leaf solution. In [24], the solution was made by heating basil leaves at 55°C until they turned brownish to optimally release tannin content. Nevertheless, these results align with [25], who showed weight loss after soaking eggs in bay leaf solution, likely due to the low tannin content used, so the protective layer formed on the eggshell surface was not optimal. [26] stated that the higher the tannin content used, the better its ability to maintain egg quality and shelf life. Additionally, according to [27], a tannin content of 6.73% can maintain egg quality up to 30 days of storage.

3.4 Degree of Acidity (pH)

Degree of acidity (pH) is an important parameter in assessing the internal quality of eggs. The pH value can reflect the freshness level and protein stability in the egg, particularly in the egg white (albumen). In fresh eggs, the normal pH ranges from 7.0 to 8.5 and will gradually increase during storage due to the release of CO_2 over time and microbial activity. Increasing pH changes can affect the viscosity of the egg white and lead to a decline in egg quality. Data from the pH testing of duck eggs soaked in basil leaf solution with various concentrations and different storage durations are presented in Table 4.

Table 4. Mean pH values of duck eggs soaked in basil leaf solution with various concentrations and different storage durations.

Solution Concentration	Storage Duration				Mean ± SD (Standard Deviation)
	H0 (0 Day)	H1 (10 Days)	H0 (0 Day)	H3 (30 Days)	
D0 (0%)	$7{,}60^{Ca}$	$5{,}79^{Aa}$	$6{,}73^{Bab}$	$6{,}93^{Ba}$	6,76 ± 0,747
D1 (15%)	$6{,}71^{Ab}$	$6{,}76^{Ab}$	$6{,}90^{ABab}$	$7{,}37^{Ba}$	6,93 ± 0,300
D2 (30%)	$6{,}79^{Ab}$	$7{,}10^{Ab}$	$6{,}55^{Aa}$	$7{,}05^{Aa}$	6,87 ± 0,254
D3 (45%)	$6{,}56^{Ab}$	$6{,}83^{ABb}$	$7{,}28^{Bb}$	$6{,}86^{ABa}$	6,88 ± 0,297

Mean ± SD	6,91 ± 0,466	6,62 ± 0,572	6,86 ± 0,311	7,05 ± 0,225

Note: Different superscripts with capital letters across rows and lowercase letters down columns indicate a highly significant difference ($P<0.01$).

ANOVA analysis showed that the effect of various concentrations of basil leaf solution (0%, 15%, 30%, and 45%) on the pH of duck eggs had no significant effect ($P > 0.05$). Additionally, treatments with different storage durations (0 days, 10 days, 20 days, 30 days) had a significant effect ($P < 0.05$) on the pH of duck eggs, and there was an interaction between basil leaf concentration and storage duration. Table 4 shows the pH values of eggs maintained under treatments with concentrations (15%, 30%, and 45%) over storage durations of (0 days, 10 days, 20 days, 30 days).

The results of this study showed that the treatment without soaking (D0) experienced significant pH fluctuations, from 7.60 on day 0 (H0) to 5.79 after 10 days of storage (H1). This pH decrease is suspected to be caused by increased microbial activity and the release of CO_2 gas that dissolves in the egg white and reacts with water to form carbonic acid (H_2CO_3), thereby lowering the pH of the solution. This aligns with statement [28] which explains that carbon dioxide (CO_2) molecules and water (H_2O) in a solution react to form carbonic acid, which subsequently ionizes into H^+ ions and affects the acidity of the solution. However, over time, CO_2 evaporates through the eggshell pores, causing the pH to rise again.

In contrast, treatments soaking in basil leaf solution (D1, D2, and D3) showed more stable pH changes compared to the treatment without soaking (D0), which experienced greater pH fluctuations. This stability is suspected to be due to the bioactive compounds in basil leaves, such as flavonoids and tannins, which have antimicrobial properties and can suppress spoilage bacteria activity, thereby helping maintain pH balance during storage. This is consistent with [29], which states that flavonoids work by inhibiting microbial respiratory enzymes and damaging cytoplasmic structures, thus slowing down the spoilage process. Meanwhile, \[30] states that egg pH tends to increase during storage due to the loss of carbon dioxide (CO_2) through eggshell pores. This is reinforced by [31], which mentions that preventing water and CO_2 evaporation can slow pH increases and maintain the viscosity of egg white.

Furthermore, these findings align with [32], which showed that broiler chicken eggs soaked in jackfruit leaf solution could maintain pH stability up to a 60% concentration. This stability is attributed to active compounds such as tannins and flavonoids forming a protective layer on the eggshell pores, reducing evaporation and oxygen infiltration [33]. The pH values obtained in this study are also not much different from those reported by [34], which reported a pH range of 6.10–6.26 in eggs soaked using dragon fruit peel extract, and the study by [35] which reported a pH range of 6.33–6.47 using lemongrass and scallion soak. However, the pH in this study is higher than the results reported by [36], which showed pH values of 5.33–5.47 in treatments with guava leaf extract.

4. Conclusion and Suggestions

4.1 Conclusion

Based on the results of the discussion, it can be concluded that soaking duck eggs in a 45% basil leaf solution is effective in slowing the decrease of albumen and yolk indices, as well as maintaining pH stability during storage. Meanwhile, to minimize egg weight loss, the best results were obtained with a 30% concentration. In addition, the 10th day of storage is considered the optimal point, as all internal egg quality parameters (albumen index, yolk index, pH, and weight loss) remained in good and stable condition. After the 10th day, egg quality tends to decline significantly.

4.2 Suggestion

It is recommended for future research to explore the preparation of the basil leaf solution by heating it first in order to optimize the release of tannin content. Furthermore, microbiological tests such as total plate count (TPC) should be conducted to determine the effectiveness of the solution in inhibiting microbial growth during storage.

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