EXTERNAL AND INTERNAL QUALITIES OF CHICKEN EGGS EARLY PRODUCTION AT VARIOUS STORAGE TIMES AT ROOM TEMPERATURE

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ABSTRACT

Eggs are one of the consumed foods that contain many essential amino acid nutrients such as lysine, tryptophan, and methionine. Egg quality can be seen from the storability of eggs after they are produced. This study aims to evaluate the effect of various storage lengths on the external and internal quality of chicken egg consumption of the Isa Brown strain at the beginning of production at room temperature. The research method is a Laboratories experiment using a Complete Randomized Design. The study treatment consisted of egg storage duration for 0 days (P0), 7 days (P1), 14 days (P2), and 21 days (P3) with 4 repeats and each test unit of 4 eggs. The research variables include external qualities: egg weight, egg index, shell weight, and eggshell thickness, then internal qualities: egg white index, yolk index, yolk color, and egg pH. The data obtained in this study were analyzed with ANOVA, if there are differences between treatments, then proceed with the the Least Significant Different test. The results showed that the duration of deviation had a very noticeable influence (P<0.01) on the external quality of the egg including: egg weight, weight and thickness of the eggshell, and no influence (P>0.01) on the egg index. The length of storage also has a very noticeable influence on the internal quality of eggs (P<0.01). Based on the results of the study, it can be concluded that the initial chicken eggs of production at a storage duration of up to 21 days at room temperature experience a decrease in external and internal qualities but still meet the Standards National Indonesia 3926:2008.

Keywords: Quality chicken eggs; duration of storage; egg production phase
INTRODUCTION

Eggs are one of the most perfect food sources of protein, a provider of nutrients with great biological value for the growth and development of body tissues (Feddern et al., 2017) at affordable prices (Wulandari et al., 2022) in all circles of society compared to large and small ruminant meat foodstuffs. One of the most important consumer criteria of egg quality is its freshness (Sati et al., 2020), but it is also important for its feasibility as a food ingredient to be consumed and needed especially by the egg processing industry. An important parameter of egg freshness is related to the quality of eggs, and their decrease depends mainly on the time and temperature of storage (Yimenu et al., 2017). However, over time storage after the eggs are produced by the hen in the laying hen farming business, the quality of eggs begins to decline (Oliveira et al., 2020).

External and internal qualities such as egg weight, albumen height, and egg pH are the main indicators for evaluating freshness, and are strongly influenced by storage time and temperature (Lee et al., 2016; Dong et al., 2017; Feddern et al., 2017) and are comprehensive indicators to reflect egg quality (Oliveira et al., 2020).

The results of the study by Padhi et al. (2013) showed that chickens from the Vanaraja male line breed at various ages of 28, 40, 52, 64, and 72 weeks also had a different influence on the quality of chicken eggs. The weight of the egg increases linearly until the age of 52 weeks and then remains stable, while the weight of the eggshell increases with age and the thickness of the shell is lower at the age of 28 and 40 weeks.

The novelty of this study was to evaluate the storability of chicken eggs from the Isa Brown strain at the initial age of production with various storage times of 0, 7, 14, and 21 days at room temperature and evaluate changes in egg quality due to egg storage. During storage, chicken eggs remain to carry out life activities, accompanied by various complex physical, chemical, and physiological changes (Al-Obaidi et al., 2015), which affect their quality. Egg weight, shell weight, albumen height, HU, and albumen viscosity decrease markedly with increasing storage time and temperature. However, the pH of eggs increases significantly with increasing storage periods and temperatures. Various factors such as chicken age, storage temperature, CO₂ presence, and storage time affect egg quality (Lee et al., 2016) resulting in albumen depletion, increased pH, weakening and stretching of the vitelline membrane, and increasing the moisture content in the yolk.

The quality of albumen is also an indicator of egg freshness which is influenced by genetics and environmental factors such as storage time, storage conditions, transportation, as well as the sales process can also affect the decline in egg quality (Altunatmaz et al., 2020.).

The time of distribution of eggs from chicken farmers to consumers is very varied, so the quality of eggs consumed by the community also varies, as well as consumer habits of storing eggs in open space before consumption. Therefore, the purpose of this study is to evaluate the effect of various storage durations at room temperature on the internal and external quality of early egg production originating from the chicken farming business.

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MATERIALS AND METHODS

Research materials
The research material was that Isa Brown's strain of chicken eggs came from the Diva Farm Wonokoyo livestock business, Kedung Kandang District, totaling 64 eggs with the age of the initial chicken production.

Research Methods
The research method is a Laboratories experiment using a Complete Randomized Design (CRD). The study treatment included egg storage duration during (P0: 0 days, P1: 7 days, P2: 14 days, and P3: 21 days) with 4 repeats and each repeat unit of 4 eggs. The temperature used at storage time averages 20-25°C.

Research Variables
The research variables observed, including the external and internal qualities of the eggs, include:
1) Egg weight (grams)
   Weighted using digital scales
2) Egg index (%)
   Measured using calipers, the ratio between the width of the egg and the length of the egg
3) Shell weight (grams)
   Weighted using digital scales
4) Shell thickness (mm)
   Measured using calipers
5) Egg white index
   Measuring the height and diameter of the egg white by breaking the egg on the glass plane, then measuring the height of the egg white using a calipers
   \[ IPT = \frac{\text{High Egg White}}{\text{Average Diameter of Egg White}} \]
6) Yolk color
   The color of the yolk is obtained by comparing using a Roche yolk color fan on a scale of 1-15
7) Yolk index
   Measurement of the height and diameter of the yolk by breaking the egg on the glass field of the data then measure the height using a toothpick and after that using a caliper
   \[ IKT = \frac{\text{Yolk Height}}{\text{Average Diameter of the Yolk}} \]
8) Egg pH
   Using a pH meter to measure the degree of acidity of eggs

Data Analysis
The data obtained in this study were analyzed with ANOVA, if there are differences between treatments, then proceed with the Least Significant Different test.

RESULTS AND DISCUSSION
Quality of Early Production Chicken Eggs
The quality of early chicken eggs in production can be judged from various storage lengths at room temperature including external qualities: Egg weight, eggshell weight and thickness, and egg index. The internal qualities of eggs: white index, yolk index, yolk color, and pH.

External qualities of eggs

Egg Weight
As per Table 1. The weight of chicken eggs in this study based on the National standardization Agency is classified as medium category (50-60 g), and large (> 60 g) (SNI 2008) with an average of 58.88 g to 65.75 g.

The results of the various analysis showed that various storage lengths had a very noticeable influence (P < 0.01) on the egg weight of the initial chicken production. The average weight of chicken eggs is indicated in Table 1.

The highest percentage of egg weight loss at 21 days of storage length was 10.45% and statistically no different from the percentage of egg weight loss at 14 days of storage length. The longer the storage results in a higher decrease in egg weight due to the...
accumulation of egg organic matter degradation results in the form of $H_2O$ evaporation and the release of $CO_2$, $NH_3$, $N_2$, and $H_2S$ gases. The synergy of the results of the research of Quan et al. (2021) Egg weight loss during storage will naturally occur due to the evaporation of water. Greater evaporation results in the loss of solvent in the egg through the cracks of the eggshell (Yeasmin et al., 2014; Lee et al., 2016). In addition, egg weight loss is associated with the porosity and thickness of the egg shell, egg white (albumen), and water conductivity (Brodacki et al., 2019).

Table 1. Average Egg Weight, Egg Index, Shell Weight, And Eggshell Thickness At Various Storage Durations

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Egg Weight (g)</th>
<th>Egg Index (%)</th>
<th>Shell Weight (G)</th>
<th>Eggshell Thickness (Mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>65.75± 3.46c</td>
<td>80.49± 1.49</td>
<td>8.83± 0.07b</td>
<td>0.51± 0.12c</td>
</tr>
<tr>
<td>P1</td>
<td>62.29± 1.85b</td>
<td>79.46± 3.10</td>
<td>8.13± 0.04a</td>
<td>0.39± 0.02b</td>
</tr>
<tr>
<td>P2</td>
<td>60.44± 1.77a</td>
<td>78.41± 4.03</td>
<td>8.09± 0.02a</td>
<td>0.37± 0.18b</td>
</tr>
<tr>
<td>P3</td>
<td>58.88± 1.33a</td>
<td>76.87± 2.57</td>
<td>7.85± 0.06a</td>
<td>0.19± 0.08a</td>
</tr>
</tbody>
</table>

Description: a,b,c different superscripts on the same column exert different influences (P<0.01)

Sufficiently high storage temperature conditions lead to drying of the cuticle and the shell membrane in the egg, resulting in an increase in the pore area and permeability of the egg (Kopacz and Dražbo, 2018), the breakdown of carbonic acid from the egg white produces carbon dioxide ($CO_2$) and water ($H_2O$), subsequently exiting through the pores of the shell resulting in a decrease in the thickness of the egg white and becoming watery, thus affecting the weight loss of the egg (Eke, Olaitan, and Ochefu, 2013).

**Egg Index**

As per Table 1. Various storage lengths do not affect (P > 0.05) the initial chicken egg index of production. The egg index of the study ranged from 76.87% - 80.49%, showing no difference in various storage durations. The egg index is classified by the criteria of oblong egg shape ($SI < 72$), normal eggs (standard) ($SI = 72–76$), and round eggs ($SI >76$). The egg index is related to the performance of the egg shape, the higher the egg index value, the more round the egg shape, while the lower the egg index value results in an increasingly oblong egg shape (Duman et al., 2016). The uterine diameter factor is more decisive and controls the presence of differences in the index of chicken eggs. The shape of the eggs produced tends to be around when the diameter of the uterus is wide, while the shape of the eggs produced tends to be oblong when the diameter of the uterus is narrow (Rahman, 2013; Liu et al., 2017).

It is stated by Altunatmaz et al. (2020) that the quality of eggs is significantly influenced by environmental conditions such as temperature, humidity, and also the length of storage while the temperature and duration of storage do not have a significant effect on the external quality characteristics of eggs (P>0.05) including egg length, egg width, egg index, and shell weight, as well as the results of the study of Okonkwo et al. (2021) storage methods and storage duration do not have different against egg indices.

The results of the study by Khatun et al., 2016, storage duration of 0 days (control) 3 and 7 days at room temperature (200–250°C) did not give a significant difference in egg length and egg width (P>0.05) with an average of 5.73±0.01 cm and 4.41±0.01 cm. Supported by the results of
the study of Sati et al. (2020) showed that the duration of egg storage of 0 days (control), 5 days, and 10 days did not give a difference (P>0.05) in the percentage of egg index of 78.77, 78.39 and 78.52, synergy with the results of the research of Şekeroğlu, Gok, and Duman (2016) that the duration of storage of 0, 7, 14, 21 and 28 days did not have a different influence on the percentage of egg index of 78.77, 78.39 and 78.52, synergy with the results of the research of Şekeroğlu, Gok, and Duman (2016) that the duration of storage of 0, 7, 14, 21 and 28 days did not have a different influence on the percentage of egg index of 77.29; 77.57; 77.88; 78.56 and 77.08. The storage method of temperature 4°C and temperature 28-31°C with storage duration of 0 days, 7 days and 14 days, 21 days, and 28 days also exerts the same influence on the egg index with a percentage of 75.71-76.59 (Yeasmin et al., 2014).

Eggshell Weight

As per Table 1. Various storage lengths exert a very noticeable influence (P<0.01) on the shell weight of early-production chicken eggs.

The eggshell is the outermost layer of protective egg contents containing about 95.1% inorganic matter and 3.3% protein with components in the form of calcium carbonate and the rest such as magnesium, phosphorus, sodium, potassium, zinc, iron, manganese, and copper with a structure including (a) the cuticle, has no pores, but is gas-passable; (b) the spongy/calcareous layer consists of protein fibers and a lime layer (c) mammary layer; and (d) membrane layers (Ketta and Tůmová, 2016; Ajala et al.,2018)

The percentage of eggshell weight from the study of chicken egg weight at various storage durations ranged from 11.92% -13.42%. The decrease in eggshell weight is thought to be due to the high level of moisture loss through the eggshell from the albumen during storage at room temperature. The eggshell is directly related to the surrounding atmospheric conditions, drying becomes very fast and the shell becomes drier as the storage time increases, thus making the eggshell lighter. The results of the research of Hagan, Adjei, and Baah, 2013 showed that storage time had a significant influence on reducing eggshell weight and egg weight (P<0.05). The weight of the shell is part of the total weight of the egg, the decrease in the weight of the egg will reflect in the decrease in the weight of the shell because moisture is lost from the shell before the effect is transferred to the contents of the egg.

The results of the study by Khatun et al. (2016) the length of storage did not have a different effect on the weight of the eggshell with an average of 0 days (6.18±0.10), 3 days (5.35±0.10) and 7 days (6.04±0.10), the results of this study were inversely proportional as reported by Ibrahim et al. (2020) there was a significant influence (P<0.001) of storage duration on the weight of the eggshell. The longer the storage, gives the increase in the weight of the eggshell, with the lowest average on the 0th day (5.53+0.18 g) and the highest weight on the 28th day (6.21+0.10 g). The varied weight of the eggshell can be caused by factors such as chicken strains, age, and storage environmental conditions.

Shell thickness

As per Table 1. Various storage lengths exert a very noticeable influence (P<0.01) on the thickness of the shell of early-production chicken eggs. The thickness or strength of the shell is the most commonly used parameter for measuring the external quality of eggs.

The percentage decrease in the thickness of chicken eggshells at various storage lengths statistically ranges from 37% to 76% with the highest decrease in eggshell thickness at a storage period of 21 days. The increase in storage time provides a decrease in the thickness of the eggshell, synergy with a decrease in the weight of the eggshell. It is suspected that the evaporation of the contents of the egg can degrade the thickness of the eggshell. The longer the storage causes more evaporation of gas, resulting in the degradation of the eggshell. The results of the research of Hagan, Adjei, and Baah (2013) and Grashorn (2016) showed a significant effect of storage time
(P<0.05) on the thickness of the eggshell and the weight of the shell. The increase in the length of storage leads to a decrease in the thickness of the eggshell. The results of the study of Khatun et al (2016) there was a decrease in the thickness of the eggshell at a storage period of 0 days (0.37a±0.008), 3 days (0.33b±0.01) and 7 days (0.34ab±0.01). Supported by Okonkwo et al., 2021 reported a significant decrease in shell thickness from a 3-day storage period of 0.80 to 0.70 at a storage time of 15 days as a result of the rate of CO2 loss from eggs.

**Internal qualities of eggs**

**Egg White Index**

As per Table 2. The results showed that various storage lengths had a very noticeable influence (P<0.01) on the egg white index of early-production chickens.

The value of the egg white index is related to the indicator of egg quality, the higher the value of the egg white index, the better the quality of the eggs, this is related to the level of freshness of the eggs. At storage lengths of 14 days and 21 days, the egg white index showed a very significant decrease compared to the storage lengths of 0 days and 7 days. This can be due to the increase in storage time affecting the viscosity of egg whites due to the evaporation of CO2 and H2O.

Santos et al. (2019) reported egg white index values were associated with an increase in albumen width and length along with an increase in storage length (p<0.05). In contrast, albumen height decreased due to the storage temperature increasing from 4 to 24°C (p<0.05). The results of the study by Okonkwo et al., 2021 showed that the length of storage influenced the quality properties of internal eggs (P<0.05).

Albumen height, Albumen index, Albumen ratio, Albumen weight, yolk height, yolk index, and HU decrease with an increase in storage time while increasing storage length results in an increase in Albumen length, Albumen width, and yolk diameter.

The increase in the length and width of albumen is due to the high CO2 loss that occurs at room temperature (Dada et al., 2018). The results of Khatun’s 2016 study, storage lengths of 3 days and 7 days resulted in a difference in Albumen height (P<0.05) of 5.06±0.56 and 3.95±0.56. The synergy of the results of the study of Sati et al., (2020) the length of storage provided a significant difference in the Albumen index (%) 0 days (11.37a), 5 days (8.53b) and 10 days (7.21c).

**Table 2.** Average egg white index, yolk index, yolk color, and egg pH at various storage durations

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Egg white index</th>
<th>Yolk index</th>
<th>Yolk color (g)</th>
<th>Egg pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>P0</td>
<td>0.15±0.01</td>
<td>0.5±0.01</td>
<td>9.56±0.47</td>
<td>7.53±0.08</td>
</tr>
<tr>
<td>P1</td>
<td>0.12±0.02</td>
<td>0.43±0.02</td>
<td>9.14±0.04</td>
<td>7.83±0.05</td>
</tr>
<tr>
<td>P2</td>
<td>0.05±0.005</td>
<td>0.37±0.01</td>
<td>8.50±0.20</td>
<td>7.94±0.03</td>
</tr>
<tr>
<td>P3</td>
<td>0.04±0.005</td>
<td>0.25±0.02</td>
<td>7.25±0.25</td>
<td>8.35±0.09</td>
</tr>
</tbody>
</table>

Description: a,b,c,d different superscripts on the same column exert different influences (P<0.05)

**Yolk Index**

As per Table 2. The results showed that various storage lengths had a very noticeable influence (P<0.01) on the yolk index of early-production chickens. The yolk index is an indication of the freshness of the egg, the higher the index, the more desirable the quality of the egg. Each length of storage contributes to a decrease in the value of the yolk index. The 14-day and 21-day storage periods gave the yolk index the largest drop of 0.12. This can be caused by an increase in the length of egg storage at room temperature resulting in the yolk getting bigger and mushy then the vitellin membrane will be damaged, so that the yolk breaks and results in a decrease in the value of the yolk index. Okonkwo et al., (2021)
conveyed that the yolk index has decreased with the increase in storage time due to the movement of CO$_2$ and moisture through the eggshell, causing changes in albumen, yolk, and egg weight (Dada et al., 2018). Supported by Ebegbulem and Asukwo (2018). The duration of storage of 7 days at room temperature lowers the value of the yolk index from 0.47 to 0.38, a decrease in the yolk index as a result of the decomposition of the ovomucin glycoprotein in the egg. The results of the study of Feddern et al. (2017) also gave a decrease in the egg index at 1-week, 2 weeks, 3 weeks, and 4 weeks storage lengths by 0.39; 0.32; 0.24, and 0.17. The fresh yolk is round and hard, as the storage time increases, the yolk degrades in quality by absorbing water and has an increasing size. The integrity of the yolk depends on the strength of the vitelline membrane which is inversely proportional to the length of storage, the decrease in the strength of the Vitelline membrane during storage makes the yolk more prone to rupture. An increase in the weight of the yolk as a result of the absorption of water by the yolk from the albumin layer results in a decrease in the yolk index with prolonged storage time.

**Yolk Color**

As per Table 2. The results showed that various storage lengths had a very noticeable influence (P<0.01) on the color of the yolk of early-production chickens.

The color density of the yolk at 14 days and 21 days of storage resulted in the largest decrease in the color density of the yolk by 1.25 compared to other storage hours. The color of the yolk is one of the factors in determining the internal quality of the egg. The color range of egg yolk in the color fan (Roche yolk color fan) is 1--15 from pale to dark orange (intense).

The highest concentration of yolk color is P0, which is an egg that has just been released by the hen because in this treatment the egg does not pass the storage period it making the yolk color value the highest compared to other treatments. The color of the yolk is influenced by the age of the chicken and the substances contained in the feed such as xanthofilbeta carotene, chlorophyll, and chitosan. At the time of egg storage, there will be a migration of H$_2$O from the egg white to the yolk. The color density of the yolk will be lower with the longer storage of the egg. The color of the yolk is directly related to the carotenoid pigment, of corn-like xanthophylls (Souza et al., 2021) Reduction of the color of the yolk with storage time, the possibility of dilution of the yolk pigment caused by damage to the vitelline membrane. The synergy of the research results of Hagan et al. (2013), Feddern et al. (2017), and Kruenti et al. (2022) there is a decrease in the color density of the yolk along with an increase in the length of egg storage.

**Egg pH**

As per Table 2. The results showed that various storage durations had a very noticeable influence (P<0.01) on the pH of chicken eggs at the beginning of production. The increase in egg pH at 14-day and 21-day storage lengths resulted in the highest increase of 0.41. This can be caused by the diffusion of several components, including CO$_2$ from the egg white through the eggshell, and the diffusion of H$_2$O from the egg white to the yolk. Egg whites mostly contain inorganic elements sodium and potassium bicarbonate, when CO$_2$ evaporation occurs during storage, the egg white becomes alkaline which results in an increased pH of the egg white, increasing the pH of the egg. Souza et al. (2021) report an increase in pH associated with solid albumen damage (decreased HU), causing the albumen to become increasingly liquid and dilute, due to changes in the ovomucin-lysozyme complex from increased pH over time to storage time (Feddern et al., 2017).

**CONCLUSION**

Based on the results of the study, it can be concluded that the initial chicken eggs of production at a storage duration of up to 21
days at room temperature experience a decrease in external and internal qualities but still meet the Standards National Indonesia 3926:2008.

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