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Choux Pastry Made from Egg Groups based on the Hen Age and Shelf Life of the Eggs

Dany Iman Santoso [a,*], Ita Fatkhur Romadhoni [b], Rachmad Ramadhan Yogaswara [c]

[a] *Department of Mechanical Engineering, Universitas Negeri Surabaya, Surabaya, 60231, Indonesia*
[b] *Department of Home Economics, Universitas Negeri Surabaya, Surabaya, 60231, Indonesia*
[c] *Department of Chemical Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya, 60294, Indonesia*
Corresponding author: [*]danysantoso@unesa.ac.id

Abstract*— This study examines that hens' age and egg freshness affect water activity (a_w) and moisture content (MC). Both also impress the quality and shelf life of choux pastry. Eggs are purchased freshly hatched and stored at ambient temperature for a few days, as is customary. This study measured egg quality before the dough-making process. Then, this study made choux dough by the same recipe and time and grouped it by the hen's age. This study also measured the choux surface temperature simultaneously after the baking process finished. Egg quality indicated albumen freshness, as described by weight loss and Haugh Unit (HU) graphs. And the grade fell over the storage time, as the falling weight loss and HU charts showed. The surface temperature indicates the MC value because temperature affects the water content in the choux. The MC graphs decreased at ten days for eggs of 5- and 16-week hens, while for 22-week hens, it did not decrease. Meantime, the relative humidity of the baker explains the a_w of the choux. The a_w charts decreased at 20 days for eggs of 16- and 22-week hens, while for the 5-week hens, it dropped at 30 days. Egg freshness affects MC and a_w. The longer the egg storage time, the higher the MC and a_w. Low MC and a_w charts indicate high choux pastry quality and long choux shelf life. Young hens have a longer egg storage time.

***Keywords*— Hens age; egg freshness; water activity; moisture content; storage time.**

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I. Introduction

Eggs are one of the commercial foods that are widely consumed by the public because although they are simple, they contain many nutrients such as omega-6 polyunsaturated fatty acids (PUFAs) and omega-3 fatty acids (FAs) [1]. Apart from these advantages, eggs are easily damaged. At 72 hours after hatching, the solid layer becomes liquid, resulting in loss of albumen quality [2]. Many things affect decreasing egg quality, such as storage temperature, relative humidity, and hen age [3]. At room temperature, carbon dioxide across the shell, causing the deterioration of internal quality [4]. This movement is also influenced by environmental pH and causes weight loss of the egg [5]. It means a decrease in HU value.

During the storage period, the movement of carbon dioxide continues and causes dilution of the albumen. The change indicates it from ovalbumin to S-ovalbumin (SO) [6]. Ovalbumin is a beneficial protein contained in albumen, while SO decomposes ovalbumin. The SO content in the albumen increased from 18% to 86% after six months of refrigeration. Two ways to escalate the shelf life of eggs are refrigeration and shell coating. For example, century eggs are made by coating eggshells from a green tea mixture with 4-5% NaOH and 4-5% NaCl [7, 8]. Also, coatings can be made from a blend of calcium and nitric acid [9].

The effect of the age of laying hens is related to their ability to scavenge free radicals. Studies show that the buildup of reactive oxygen species (ROS) from the laying hen increases [10]. It results in oxidative stress, lipid peroxidation, and metabolic oxidative damage. It also triggers a decrease in product performance and even the disease onset. The effect on the egg is that the egg weight increases, but the HU score decreases with the increasing age of the laying hens [11]. The solution to prolong the productive life of laying hens is to raise them in an organic system. Studies show only 0.2% of layer hens are bred in organic designs, only 2% in free-range methods, and 88% still in cages [12].

Long shelf life is required in dry processing products, such as pastries, to maintain their quality. The oxygen and a_w contents in the product are precept factors in maintaining shelf life. Some studies suggest that probiotics can be blocked at a_w

values between 0.1 and 0.3, while at $a_w > 0.25$, their strain viability disappears rapidly [13]. a_w also can be used to assess microbial growth, enzymatic and non-enzymatic activities, lipid oxidation, and food texture [14]. Some studies mention probiotics isolated at warm temperatures, between 25 and 30°C, but are notorious at cold temperatures, below 5°C, and attack some cereal grains and forage [15-17]. Another study also mentioned that soy-based media has a substrate to promote probiotic growth [18].

Several methods are used to control a_w in products, including adding sweeteners closely related to water retention, starch gelatinization temperature, sweetness, browning reactions, and product shelf life [19]. The sugary or candy-like matrix resulting from the sweetener is in a glassy state, making the texture brittle [20]. Several studies suggest that the addition of sucrose can reduce MC and a_w because of the formation of an amorphous phase due to sugar crystallization which limits molecular mobility [21, 22]. MC will most affect the content, texture, and color of the product during storage due to a strong bond between food (adsorbent) and water (adsorbate) [23]. Another way to control a_w is to freeze the dough for longer shelf life, and consumers can taste fresh products at any time [24].

There are no studies that discuss the effect of egg freshness and age of laying hens on the age of egg dough products. This study-controlled egg freshness based on shelf life at room temperature, as was done in a grocery store. The eggs are grouped based on the age of laying hens from the first day of hatching. The shelf life of eggs ranges from day one to day forty. Every ten days, a choux pastry dough is made from these egg groups, and the temperature of the product is measured to calculate the moisture content and water activity. The calculation results can be used as a reference for how to regulate egg storage at pastry producers to obtain a longer product shelf life.

II. Materials and Methods

A. Preparation of Material Needed

This study used ISA Brown laying hens with a capacity of one egg a day. The egg-laying period is between 5 and 24 weeks. Eggs from laying hens aged 5, 16, and 22 weeks were used for ensuring the difference in its quality in the pastry. Table eggs of each age-laying hens took the eggs on their first hatch. Each period of laying hens provided five table eggs, which means 240 eggs were provided for this experiment. A total of 720 eggs are used for five dough-making periods. These periods are the first, tenth, twentieth, thirtieth, and fortieth days.

B. Research Procedures

HU measurements were carried out on egg samples to be made dough from each age group of laying hens. The sample taken is the largest and smallest size so that the average value of its quality can be found. After all the dough is finished making, they are baked in the same baker at 200 C for 40 minutes. It is done so that each dough gets the same temperature and humidity treatment so that their only differentiating factor is the age of the eggs used. After the baking process was completed, this study measured the temperature of each batch of pastry at the same time to avoid cooling at room temperature.

C. Data analysis

Data before the baking process, such as egg weight, yolk and albumen height, yolk and albumen diameter, and data after the baking process, such as pastry temperature pastry mass, were analyzed using ANOVA. The pastries were then tested for organoleptic and moisture content. The results of the water content test are presented in the form of a moisture content graph. Moreover, the results of the organoleptic test will be presented in another discussion. Both tests were analyzed using ANOVA. Fig. 1 describes the experiment process.

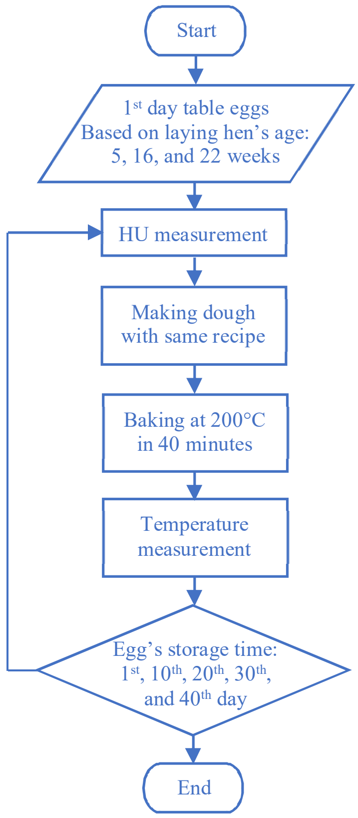

Fig. 1 Flowchart diagram of the experiment

D. Yolk index, albumen index, and Haugh unit

Yolk and albumen indexes are the ratios of the height to the diameter. While Haugh Unit (HU) is calculated using Equation (1) [6].

$$HU = 100\, log(H + 7.51 - 1.7W^{0.37}) \quad (1)$$

These are the albumen height H (mm), and the egg weight W (g).

E. MC and a_w

To calculate the MC in a substrate from the results of the baking test, Equation (2) is used [14] as follows:

$$MC = \frac{w_t - w_d}{w_t} \quad (2)$$

where w_t is the weight of the choux before baking and w_d is the weight of the choux after baking. While water activity is an indication of the amount of Free Water in food. Free Water is closely related to the temperature and relative humidity of the air surrounding the food. Based on Wang [18], the relationship between water activity and temperature and relative humidity is given by Equation (3) as follows:

$$a_w = \frac{p}{p_0} = \frac{ERH}{100} \quad (3)$$

where p is the water vapor pressure in the substrate, p_0 is the pressure of pure water at the same temperature, and ERH is the relative humidity of the food surrounding air where the product does not naturally lose moisture and is a state of equilibrium with the environment.

III. Results and Discussion

This study showed the mean egg and choux data with significant differences ($p \leq 0.05$) in Table 1 below. This study made weight loss, HU, MC, and aw charts from some of these data, as shown in Fig. 2, Fig. 3, Fig. 4, and Fig. 5 below.

TABLE I
THE MEAN EGG AND CHOUX DATA

Criteria	**Egg's age**	**Hen's age**		
		5 weeks	**16 weeks**	**22 weeks**
weight (g)	1	57 ± 4	64 ± 7	66 ± 10
$h_{albumen}$ (mm)	day	9.85 ± 1.35	10.6 ± 0	7.25 ± 0.25
$d_{albumen}$ (mm)		68.1 ± 3.4	70.6 ± 2.3	70.8 ± 1.1
h_{yolk} (mm)		18.3 ± 1.1	18.6 ± 1.4	17.3 ± 0.05
d_{yolk} (mm)		36.6 ± 0.05	39.3 ± 1.1	37.8 ± 1.4
t_{baking} (°C)		79 ± 1.5	80 ± 1.7	81 ± 1.9
m_{before} (g)		45 ± 2	47.5 ± 3	50 ± 4
m_{after} (g)		33.7 ± 1.8	35.4 ± 2.7	37 ± 3.8
weight (g)	10	52 ± 6	59 ± 4	62.5 ± 9.5
$h_{albumen}$ (mm)	days	8.3 ± 0.7	6.3 ± 0.6	4.3 ± 0.3
$d_{albumen}$ (mm)		70.5 ± 4.2	80.2 ± 0.1	84.3 ± 2.9
h_{yolk} (mm)		16.9 ± 1.55	16.1 ± 0.6	15.1 ± 0.5
d_{yolk} (mm)		39.1 ± 1.1	42.4 ± 1.1	43.4 ± 2.15
t_{baking} (°C)		86 ± 1.6	80 ± 1.8	75 ± 2
m_{before} (g)		44.5 ± 3	47 ± 4	49.2 ± 5
m_{after} (g)		34.7 ± 2.4	35.2 ± 3.6	35.7 ± 4.6
weight (g)	20	49 ± 6	56 ± 3	59 ± 9
$h_{albumen}$ (mm)	days	7.3 ± 0.6	4.05 ± 1.05	2.5 ± 0.5
$d_{albumen}$ (mm)		7.29 ± 5	85 ± 1	87.5 ± 3.85
h_{yolk} (mm)		16 ± 1.5	14.4 ± 0.65	11.9 ± 0.05
d_{yolk} (mm)		41.5 ± 2.15	45.8 ± 2.95	49.1 ± 5.7
t_{baking} (°C)		84.5 ± 1.7	78.2 ± 1.9	72.2 ± 2.1
m_{before} (g)		44 ± 4	46.6 ± 5	48.6 ± 6
m_{after} (g)		33.9 ± 3.2	34.5 ± 4.5	34.5 ± 5.2
weight (g)	30	46.5 ± 5.5	53.5 ± 2.5	56 ± 9
$h_{albumen}$ (mm)	days	6.3 ± 0.5	2.95 ± 1.15	1.6 ± 0.6
$d_{albumen}$ (mm)		75.3 ± 5.8	87.4 ± 1.6	89.2 ± 4.3
h_{yolk} (mm)		15.2 ± 1.25	13.2 ± 1.1	9.05 ± 0.65
d_{yolk} (mm)		44 ± 3.2	50.1 ± 4	53.5 ± 5.9
t_{baking} (°C)		82.3 ± 1.8	76.4 ± 2	70.5 ± 2.2
m_{before} (g)		43.4 ± 3	45.9 ± 4	48 ± 5
m_{after} (g)		32.8 ± 2.8	33.5 ± 3.7	33.1 ± 4.4
weight (g)	40	45.5 ± 5.5	52 ± 2	54 ± 8
$h_{albumen}$ (mm)	days	5.3 ± 0.4	2.3 ± 1.3	1 ± 0.5
$d_{albumen}$ (mm)		77.7 ± 6.6	88.6 ± 1.65	90 ± 4.5
h_{yolk} (mm)		14.6 ± 0.9	12.1 ± 1.7	5.9 ± 1.1
d_{yolk} (mm)		46.4 ± 4.25	55.9 ± 3.45	58.8 ± 2.85
t_{baking} (°C)		80.6 ± 1.9	74.3 ± 2.1	69.8 ± 2.3
m_{before} (g)		42.8 ± 4	45.3 ± 5	47.4 ± 6
m_{after} (g)		31.7 ± 3.4	32.6 ± 4.3	31.8 ± 5.1

Mean value and standard deviation ($p \leq 0.05$)

The heaviness for 1st-day egg age shows the distinction in weight of the three hen age groups. As the hen gets older, the eggs get heavier. The heaviness for the 10th-day eggs is lighter than the 1st day for all hen ages. It suggests the storage of eggs causes deterioration or thinning of the albumen [11]. The egg weight loss over egg storage time is shown in Fig. 2.

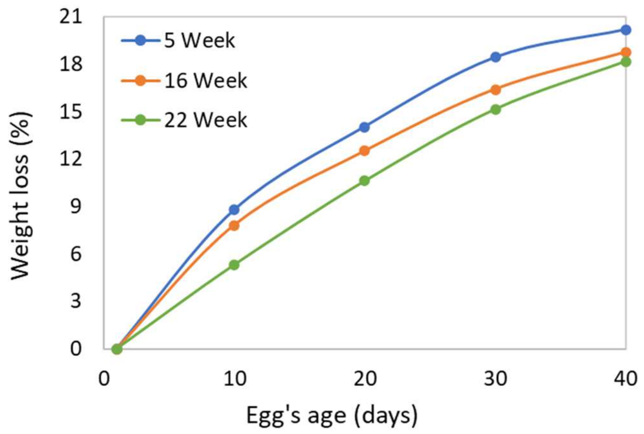

Fig. 2 Weight loss vs. egg's age

The egg weight loss in Fig. 2 shows that eggs from a younger hen age significantly decrease than eggs from an older hen age. It indicates more carbon dioxide has passed through the eggshell. Several factors can cause this movement, but the most dominant is the thin layer of the eggshell. Eggshell is a multifunctional biomineral complex consisting of high calcium carbonate, lipids, protein, and cuticle [25]. Another function of eggshells is to prevent fungal and microbial invasion. Younger hens have a thinner eggshell. The results of albumen quality measurements are shown in Fig. 3.

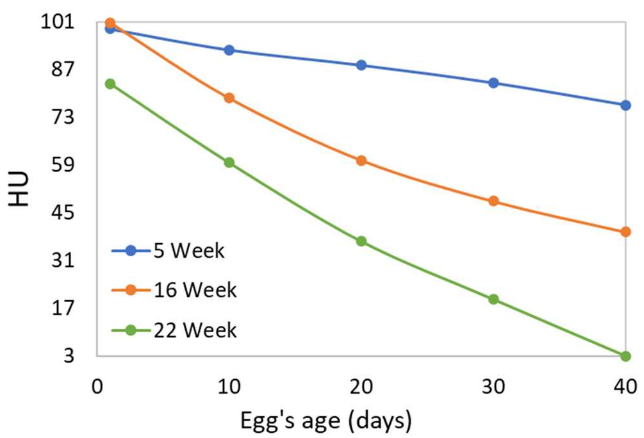

Fig. 3 HU vs egg's age

Fig. 3 shows the HU score of each egg group. The 22 weeks of hen-age eggs have the highest decrease in the HU score. The hen age group achieved the highest HU score of 16 weeks on the first day. Several studies stated that good-quality fresh eggs had HU scores above 80 [11]. Low-quality eggs have low-density lipoproteins, and they are thought to be destroyed in egg yolks containing the removed lipids [26]. It can affect both the dough and the cake. Some studies suggest that low selenium (Se) levels in eggs can result in untimely embryos [27].

The effect of egg freshness and hen age on MC is shown in Fig. 4. These graphs are obtained from the ratio of the mass difference to the beginning in Table 1. This difference is obtained from the baking process after the choux solely calculates the MC.

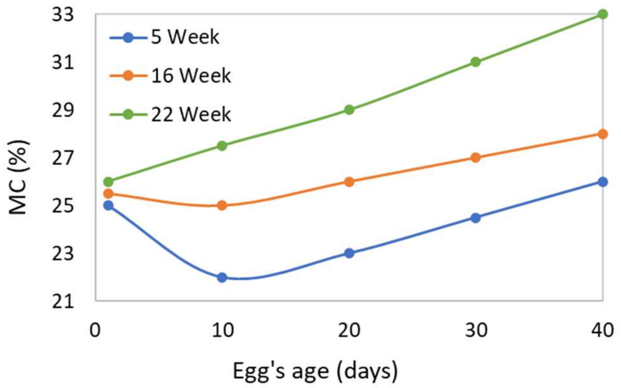

Fig. 4 MC vs. egg's age

Fig. 4 showed that eggs from the 22 weeks hen age group had the highest MC. It indicated a lot of water content in the albumen and meant low egg freshness in this group, as indicated by the HU score below 80 in Fig. 3. The shelf life of products for this group is also short due to high MC. The taste and aroma of the product can change due to the amount of water in the product, making it the riskiest thing. FAO (Food and Agriculture Organization) states that more than a third of food products for consumption are damaged and wasted before reaching consumers [28]. High MC can cause much food to be decayed.

The effect of egg freshness and hen age on water activity is shown in Fig. 5. The graphs in Fig. 5 are obtained from the calculation of Equation (3), where the vapor pressure (p) and pure water pressure (p_0) on the substrate are taken from the thermodynamic table based on the temperature of each choux. The water content of each dough group differs based on the freshness of the eggs. It gives the choux a different temperature when it comes out of the baker.

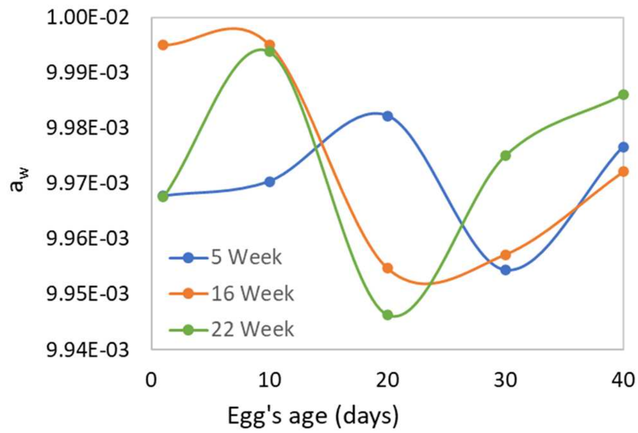

Fig. 5 a_w vs. egg's age

Fig. 5 shows the fluctuating a_w values of all egg groups. Eggs from the 16-week hen age group had the highest a_w value on the first day. However, eggs from the 22-week hen age group had the highest a_w values on the fortieth day. The fluctuation ranges of the two egg groups are almost the same. They have the same lowest a_w value on the twentieth day.

The 16 and 22-week egg groups had similar aw values, except that the 16-week egg group had a longer shelf life than the 22-week egg group. The 5-week egg group had a lower aw than the two previous egg groups and indicated that the egg shelf life was longer than the two preceding egg groups. Poor aw values indicate low microbial and fungal activity in the choux [16]. Pastry producers can select eggs from the young hen age group to have a longer shelf life. Besides, it is related to lipid oxidation and its low content of natural antioxidants [29].

Each egg group has a different size. Several studies measured eggs by hen age group to make handling easier [30]. This automation is not only intended for eggs but also other agricultural products, such as vegetables and fruit. The various forms of cultivation products require various tools to handle them automatically.

IV. Conclusion

Storage of eggs causes a decrease in egg quality, such as diluting the albumen and decreasing egg weight. The dilution of the albumen is due to the movement of carbon dioxide across the eggshell. Most carbon dioxide movements are experienced by eggs of the youngest hen age group. Coating the eggshell and refrigerating it are ways to block this movement.

Eggs in the 22-week hen age group had poor freshness because they had a HU score below 80. It indicated that the water content in eggs was high. Moreover, it caused the MC of the product to be also upper. The MC value for eggs of this age was the highest compared to other groups. The high MC value can affect the quality of the product, such as taste and aroma.

The a_w values for the 16 and 22-week egg group had a higher range of fluctuation than the 5-week egg group. However, the 16-week egg group had a longer shelf life than the 22-week egg group. It is indicated by the lower a_w value on the fortieth day. The high range of aw fluctuation values exhibit a shorter shelf life of the product.

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