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Physical Quality of Chicken Egg Coating with Herbal Materials During Storage

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ABSTRACT

Chicken eggs will experience a decrease in quality during storage. Egg preservation methods are needed to maintain egg quality and extend shelf life. This research evaluated the effect of coating egg shells using herbal solutions during storage on egg white index, egg yolk index, egg white pH, egg yolk pH and air sac depth. The research method used a completely randomised design with 2 treatment factors and 4 replications. The first treatment factor was eggshell coating consisting of 4 levels, namely control, lemongrass solution, kaffir lime leaf solution and pandan leaf solution. The second treatment factor is storage time, which consists of 5 levels, namely 0, 5, 10, 15, and 20 days. Data were analysed using ANOVA with Tukey's advanced test at a significance level 0.05. The research showed that the eggshell coating method using herbal ingredients and cold storage maintained the physical quality of purebred chicken eggs during 20 days of storage compared to the control treatment at room temperature. Coating herbal ingredients using lemongrass solution is the best herbal ingredient with the lowest egg white index, egg yolk index, egg white pH, egg yolk pH and air sac depth.

Keywords: Chicken egg, herbal, quality, storage

INTRODUCTION

Eggs are a source of animal protein with high nutrition and water content, so they are classified as a perishable food ingredient. Egg white contains 10.82% protein, 87.72% moisture, 0.85% carbohydrates, 0.19% fat and 0.42% ash. Egg yolk contains 55.02% moisture, 15.50% protein, 1.09% carbohydrates, 26.71% fat and 1.68% ash (Rehault-Godbert, 2019). Egg damage occurs due to evaporation of CO_2 gas and water and contamination by microorganisms, resulting in decreased egg quality during storage. The quality of eggs can last for 14 days in room temperature storage (BSN, 2008). The long process of transporting and distributing eggs causes the quality of eggs sold in the market to decline. This can cause cost losses to sellers and breeders due to damaged eggs that must be thrown away.

Eggs have complex protection, consisting of the shell, shell membrane, and antibacterial content. The eggshell consists of the mammillary layer and the palisade layer. The eggshell layer forms pores as a place for gas exchange. Some of the functions of the eggshell are as a place for oxygen exchange, evaporation, and bacterial exchange (Solomon, 2010). Eggs also contain antibacterial properties, namely lysozyme, ovotransferrin, protease inhibitors and avidin (Guyot et al., 2013). Egg antibacterial is a defence mechanism for eggs from contamination by pathogenic and spoilage microorganisms. However, these antibacterial properties decrease during storage. Evaporation of CO_2 and water causes changes in the physical quality of eggs. Long storage changes the binding of ovomucin and lysozyme so that the egg pH rises. This increase in pH causes the viscosity of the egg white to decrease from thick to runny. Water moves from the runny egg white to the egg yolk due to osmotic pressure so that, over time, the egg yolk becomes flat. The physical quality of eggs can be seen from the egg white index, egg yolk index, pH value and air sac depth. Decreasing the physical quality of eggs can also reduce the functional properties of eggs, such as emulsification and foaming, which are widely used, especially in the food industry.

Egg preservation aims to extend shelf life and maintain egg quality. Preserving fresh whole eggs consists of eggshell coating, pasteurisation and cold storage. Eggshell coating is a simple method that can be done by closing the pores of the eggshell using an antimicrobial agent. This aims to protect the eggshell from contamination by pathogenic and spoilage bacteria and inhibit gas and water vapour exchange. Saputri's research (2011) used coating the shells with coconut oil, which could maintain egg quality for 35 days. Coating eggshells with edible protein using rice protein concentrate (RPC) and

Brazilian green propolis (GP) can extend shelf life for 6 weeks at 20 C (Pires et al., 2021). The eggshell coating material is natural, harmless, non-toxic, and antibacterial (Davalos-Saucedo et al., 2018).

Lemongrass (*Cymbopogon citratus*), kaffir lime leaves (*Cytrus hystrix*) and pandan leaves (*Pandanus amaryllifolius*) are generally used as spices and fragrances in cooking. Herbal ingredients such as antioxidants are found in lemongrass (Muala et al., 2021), kaffir lime leaves (Anuchapreeda et al., 2020) and pandan leaves (Suryani et al., 2017). Herbal ingredients that act as antibacterials are found in lemongrass (Muala et al., 2021) and kaffir lime leaves (Ulhaq et al., 2020). The antioxidants and antibacterials contained in these herbal ingredients have the potential to be used as eggshell coating materials that can maintain the quality of chicken eggs. Coating eggshells with herbal ingredients combined with cold storage. Cold storage can prevent food spoilage and inhibit the growth of microorganisms (Dada et al., 2018). Combining cold storage and adding natural preservatives can extend the shelf life and maintain egg quality (Saputri, 2023). Information regarding preservation methods using a combination of eggshell coating and cold storage is still limited. This research aims to determine the physical quality of chicken eggs coated with herbal ingredients during 20 days of storage.

MATERIALS AND METHODS

Tools and Materials

The tools used in the research were callipers, analytical scales, refrigerators, egg racks, pH meters, blenders, knives and stationery. The ingredients used in the research were chicken eggs, water, pandan leaves, kaffir lime leaves and lemongrass.

Research Methods

This research used a completely randomized design (CRD) consisting of 2 treatments and 4 replications. The first treatment is eggshell coating, and the second is storage time. The eggshell coating consists of 4 levels, namely control (room temperature), pandan leaf solution, lemongrass leaf solution and kaffir lime leaf solution. The storage time consists of 5 levels, namely 0, 5, 10, 15, and 20 days. The parameters for observing the physical quality of eggs were egg white index, egg yolk index, egg white pH, egg yolk pH and air sac depth.

Preparation of Herbal Solutions

Wash pandan leaves, kaffir lime leaves and lemongrass first. Each herbal ingredient is weighed as much as 700 g and then chopped or cut into small pieces. After chopping ingredients, add 1 litre of water and blend until smooth. The blender results are filtered to obtain a solution. Next, the herbal solution is boiled until it boils for 2 minutes and cooled. The cold herbal solution is placed in a bottle and then closed tightly.

Preparation of Chicken Eggs

Chicken eggs that are 0 days old are cleaned of dirt, washed using warm water and dried. The eggs are sprayed using an herbal solution and aired. Day-old chicken eggs are cleaned from dirt, washed using warm water and dried. Eggs are placed in an egg rack in a modified refrigerator with a solution container underneath. The herbal solution is sprayed automatically on the eggs for 45 minutes daily using a mini pump. Eggs are stored for 20 days.

Egg White and Yolk Index

The egg is cracked and placed on a flat glass base. The height and diameter of the thick egg white were measured using a calliper. The egg white index value is obtained by dividing the height and diameter of the thick egg white (BSN, 2008). The height and diameter of the egg yolk were measured using a calliper. The egg yolk index value is obtained by dividing the height and diameter of the egg yolk (BSN, 2008).

pH Value

The pH value is measured using a pH meter. Calibrate the pH meter with buffer pH 7 and pH 4. The pH meter is placed in the egg white and egg yolk, then the pH value is displayed on the instrument (Pires et al., 2021).

Air Sac Depth

Break the eggshell and then separate the egg and shell contents. Air sacs were observed in the blunt part of the eggshell. The depth of the air sac is measured with a caliper (BSN, 2008).

Data Analysis

The research data, namely egg white index, egg yolk index, egg white pH, egg yolk pH and air sac depth, were tested using ANOVA. If the treatments are significantly different, proceed with the Tukey test with a significance level of 0.05% (Steel and Torrie, 1993).

RESULTS AND DISCUSSION

Egg White Index

The egg white index before storage or 0 days has an average value of 0.1439, indicating the quality of I eggs based on SNI 01-3926-2008. Herbal coating and storage time had a significant effect ($P<0.05$) on the egg white index (Table 1). The egg white index decreased during storage, but the quality decrease occurred more quickly in the combination without shell coating and room temperature storage compared to the combination of shell coating and cold storage at 4 °C. The egg white index of the control treatment decreased from 0.1439 (0 days) to 0.0460 (20 days). The egg white index with lemongrass solution coating decreased from 0.1445 (0 days) to 0.1305 (20 days). The egg white index coated with kaffir lime leaf solution decreased from 0.1436 (0 days) to 0.1171 (20 days). The egg white index with pandan leaf solution coating decreased from 0.1437 (0 days) to 0.1141 (20 days). Egg quality based on the egg white index decreased from quality I to quality III with eggshell coating, while eggs in the control treatment decreased from quality I to loss during 20 days of storage.

Table 1. Egg white index with herbal coating during storage

Treatment	Storage Time (Days)				
	0	5	10	15	20
Control	0.1439±0.00	0.1086±0.00[a]	0.0683±0.00[a]	0.0504±0.00[a]	0.0460±0.00[a]
Lemongrass solution	0.1445±0.00	0.1440±0.00[c]	0.1366±0.00[d]	0.1344±0.00[c]	0.1305±0.00[c]
Kaffir lime leaf solution	0.1436±0.00	0.1397±0.00[b]	0.1258±0.00[c]	0.1244±0.00[b]	0.1171±0.00[b]
Pandan leaf solution	0.1437±0.01	0.1356±0.01[b]	0.1145±0.01[b]	0.1205±0.00[b]	0.1141±0.00[b]

Note: Different superscripts on the same column indicate significant differences ($P<0.05$)

The egg white index is related to the height and diameter of the thick egg white. The lysozyme-ovomucin bond affects the viscosity of egg whites (Gharbi & Labbafi, 2019). The decrease in egg white index is due to the loss of CO_2 through the pores of the eggshell, so the concentration of bicarbonate ions decreases. This causes the egg white buffer balance to decrease and the pH of the egg to increase. The ability of ovomucin to maintain egg white viscosity will decrease during storage (Chen et al., 2019). The ovomucin lysozyme bond is damaged, so the egg white changes from thick to runny. Cold storage can maintain the physical quality of chicken eggs because it reduces the evaporation of water and CO2 and inhibits the growth of microorganisms, which can accelerate egg deterioration.

Eggshell coating using herbal ingredients effectively maintains the physical quality of purebred chicken eggs during cold storage for 20 days. The antibacterial and antioxidant content of herbal ingredients can protect eggshells from egg damage. Kaffir lime leaves have antioxidants in the form of phenolics, agrostophyllinol and citronellal (Anuchapreeda et al., 2020) and ethanol as an antibacterial (Ulhaq et al., 2021). Pandan leaves have antioxidant content consisting of alkaloids, flavonoids, phenols, and saponins (Suryani et al., 2017). According to Sefriyanti et al. (2020), the antibacterial content of lemongrass consists of the compounds trans-geraniol (19.88%), citronella (16.27%), beta-citronellol (13.55%), alphaamorphene (8.85%), and cyclohexene (5.84%). Organic acids are used as food preservatives because they have antimicrobial content and acidic properties. The propionic acid content in lemongrass is the highest and can act as an antibacterial and antifungal (Muala et al., 2021). Essential oil from lemongrass can control the growth of bacteria and fungi and has antioxidant activity. Each herbal solution's antibacterial and antioxidant components can inhibit bacteria from entering the egg and bacterial growth on the eggshell. The index of egg white with shell coating using lemongrass solution was the highest compared to the index of egg white with kaffir lime leaf solution and pandan leaf solution. The lemongrass solution's antioxidant and antibacterial components occupy the eggshell's pores. They can survive for 24 hours before the lemongrass solution is resprayed, thus inhibiting the evaporation of water and gas from inside the egg.

Egg Yolk Index

The egg yolk index is related to the height and diameter of the egg yolk. The height of the egg yolk will decrease, and the diameter will become wider during storage. The egg yolk index before storage or 0 days has an average value of 0.4734, which indicates the quality of the I eggs based on SNI 01-3926-2008. Herbal coating and storage time had a significant effect

(P<0.05) on the egg yolk index (Table 2). The egg yolk index decreased during storage, but the quality decline occurred more quickly in the combination of shell coating and room temperature storage compared to the combination of shell coating and cold storage at 4 °C. Egg quality based on the egg yolk index decreased from quality I to quality III with shell coating eggs. In contrast, eggs in the control treatment decreased from quality I to loss during 20 days of storage. The egg yolk index for the control treatment decreased from 0.4760 (0 days) to 0.2117 (20 days). The egg yolk index with lemongrass solution coating decreased from 0.4749 (0 days) to 0.4231 (20 days). The egg yolk index by coating with kaffir lime leaf solution decreased from 0.4785 (0 days) to 0.4126 (20 days). The egg white index with pandan leaf solution coating decreased from 0.4643 (0 days) to 0.3880 (20 days).

Table 2. Egg yolk index with herbal coating during storage

Treatment	Storage Time (Days)				
	0	5	10	15	20
Control	0.4760±0.01	0.3809±0.01^{a}	0.2763±0.01^{a}	0.2522±0.02^{a}	0.2117±0.01^{a}
Lemongrass solution	0.4749±0.01	0.4666±0.01^{c}	0.4568±0.00^{c}	0.4396±0.01^{c}	0.4231±0.01^{c}
Kaffir lime leaf solution	0.4785±0.00	0.4450±0.00^{b}	0.4251±0.00^{b}	0.4110±0.00^{bc}	0.4126±0.01^{bc}
Pandan leaf solution	0.4643±0.01	0.4370±0.01^{b}	0.4145±0.01^{b}	0.3948±0.01^{c}	0.3880±0.02^{b}

Note: Different superscripts on the same column indicate significant differences (P<0.05)

The change from thick egg white to thin during storage causes the water content to increase. The egg yolk is round and protected by the yolk membrane. The osmotic pressure of egg yolk is higher than egg white. This is because the water content of the egg yolk is 55.02% lower than the water content of the egg white, which is 87.72% (Rehault-Godbert, 2019). The low water content increases the viscosity, making the egg yolk thicker. Due to osmotic pressure, water moves from the egg white to the egg yolk. Continuous water movement reduces the viscosity of the egg yolk; over time, it will become flat and then break (Romanof & Romanof, 1963).

Cold storage and coating of egg shells using herbal ingredients maintained the egg yolk index compared to room temperature storage for 20 days. The index of egg white with shell coating using lemongrass was the highest compared to the index of egg white with a solution of kaffir lime leaves and pandan leaves. The main content of lemongrass is essential oil as an antibacterial, which can inhibit the growth of *Escherichia coli* and *Staphylococcus aureus* (Nurcholis et al., 2019). Coating egg shells with lemongrass solution can maintain thick egg whites so that the egg white index value is the highest among the egg yolk index values. This prevents water movement in the egg yolk. The shape of the egg yolk remains round or does not break during 20 days of storage, whereas when stored at room temperature, the shape becomes flat. The antibacterial and antioxidant content of herbal ingredients can help reduce contamination by pathogenic bacteria and damage eggs quickly.

Egg White pH Value

The pH value of 0-day-old egg whites has an average of 7.34. This pH value approaches the buffer system as pH 7. Changes in the buffer system occur during storage due to damage to the ovomucin and lysozyme bonds. This causes the pH value of egg whites to become increasingly alkaline. The pH value of egg whites increased during 20 days of storage, but the control treatment had the highest pH value (Table 3). The pH of egg whites in the control treatment increased from 7.38 (0 days) to 9.54 (20 days). The pH value of egg whites with shell coating using lemongrass solution increased from 7.30 (0 days) to 8.64 (20 days).

Table 3. pH value of egg whites coated with herbal ingredients during storage

Treatment	Storage Time (Days)				
	0	5	10	15	20
Control	7.38±0.08	8.02±0.14	9.29±0.06^{c}	9.43±0.02^{a}	9.54±0.02^{c}
Lemongrass solution	7.30±0.04	7.69±0.18	8.21±0.07^{a}	8.56±0.09^{b}	8.64±0.08^{a}
Kaffir lime leaf solution	7.34±0.08	7.84±0.09	8.24±0.01^{ab}	8.73±0.02^{b}	8.86±0.08^{b}
Pandan leaf solution	7.34±0.04	7.81±0.07	8.45±0.01^{b}	8.83±0.04^{c}	8.86±0.04^{b}

Note: Different superscripts on the same column indicate significant differences (P<0.05)

The pH value of egg whites by coating the shells using kaffir lime leaf solution increased from 7.34 (0 days) to 8.86 (20 days). The pH value of egg whites by coating the shells using pandan leaf solution increased from 7.34 (0 days) to 8.86 (20 days). The pH of egg whites without treatment at room temperature increased after 5 days of storage, while the pH of egg whites coated with herbal ingredients increased after 10 days of storage at cold temperatures. Cold storage can inhibit the increase in egg white pH. Research by Dada et al. (2018) showed that the pH of eggs increased from 7.28 to 8.97 during 6 weeks of storage at cold temperatures. The pH values of egg whites with shell coating using lemongrass solution, kaffir lime leaf solution and pandan leaf solution after 10 days of storage at 4 °C respectively reached 8.21, 8.24 and 8.45. This pH value is close to the research of Feddern et al. (2017), which showed that the pH value of egg white after 21 days of storage under refrigeration reached 8.61. Coating with herbal ingredients and cold storage maintained the pH value of egg whites compared to without treatment (control). Herbal coatings have antibacterial and antioxidant properties that protect eggshells from gas and water evaporation. The increase in pH is slower compared to the control treatment at room temperature. The main components of lemongrass solution, namely flavonoids and propionic acid, are highly effective as antibacterials and antioxidants and can prevent water and gas evaporation in eggs. This can be seen from the egg white index, with the lemongrass solution being higher than the egg white index value of lime leaf and pandan leaf solutions. The change from thick egg white to thin is lower, so the pH value is also lower. The pH value of egg whites with the eggshell coating method and cold storage for 20 days is still close to the pH of fresh egg whites, according to research by Ding et al. (2022), which is 8.45.

pH Value of Egg Yolk

The pH value of 0-day-old egg yolk is an average of 6.18. The pH value of egg yolk is lower than the pH value of egg white. The pH value of egg yolk increased during 20 days of storage, but the control treatment had the highest pH value (Table 4). The pH value of egg yolk in the control treatment increased from 6.18 (0 days) to 6.73 (20 days). The pH value of egg yolk by coating the shells using lemongrass solution increased from 6.18 (0 days) to 6.64 (20 days). The pH value of egg yolk by coating the shells using kaffir lime leaf solution increased from 6.18 (0 days) to 6.66 (20 days). The pH value of egg yolk by coating the shells using pandan leaf solution increased from 6.17 (0 days) to 6.64 (20 days).

Table 4. pH value of egg yolk with herbal ingredients coating during storage

Treatment	Storage Time (Days)				
	0	5	10	15	20
Control	6.18±0.08	6.49±0.09^{b}	6.52±0.04^{c}	6.68±0.01^{b}	6.73±0.04^{a}
Lemongrass solution	6.18±0.02	6.25±0.02^{a}	6.35±0.03^{a}	6.51±0.04^{a}	6.64±0.02^{a}
Kaffir lime leaf solution	6.18±0.03	6.27±0.03^{a}	6.40±0.05^{b}	6.43±0.04^{a}	6.66±0.04^{a}
Pandan leaf solution	6.17±0.01	6.27±0.03^{a}	6.40±0.02^{b}	6.47±0.03^{a}	6.64±0.09^{b}

Note: Different superscripts on the same column indicate significant differences (P<0.05)

The increase in the pH value of egg yolk during 20 days of storage in the control treatment and herbal coating occurred slowly. Research by Gherardi et al. (2015) showed changes in egg yolk pH from 6.19 to 6.37 after 28 days of storage at four °C. The decrease in egg yolk quality occurs due to the water movement from the egg white to the yolk, so the vitelline membrane breaks over time, and the egg yolk becomes runny (Hiroko et al., 2014). In this study, the water movement from egg white to egg yolk took longer, which can be seen from the condition of the egg yolk not breaking. Eggshell coating and cold storage methods reduce evaporation and gas loss. The slow increase in the pH of egg whites also causes the process of increasing the pH of egg yolks to take place slowly.

Air Sac Depth

The air sac depth in 0-day-old eggs has an average of 0.09, which is included in quality I. The air sac depth increased during 20 days of storage, but the control treatment had the highest air sac depth. The air sac depth of the control treatment increased from 0.12 (0 days) to 0.52 (20 days). The depth of the air pockets by coating the shells using lemongrass solution increased from 0.08 (0 days) to 0.22 (20 days). The depth of the air pockets by coating the shells using kaffir lime leaf solution increased from 0.10 (0

days) to 0.33 (20 days). The depth of the air pockets by coating the shells using pandan leaf solution increased from 0.08 (0 days) to 0.32 (20 days).

Table 5. Depth of air sac with herbal material coating during storage

Treatment	Storage Time (Days)				
	0	5	10	15	20
	----------cm----------				
Control	0.12±0.02	0.30±0.04^{c}	0.37±0.08^{a}	0.45±0.08^{b}	0.52±0.05^{c}
Lemongrass solution	0.08±0.02	0.13±0.02^{a}	0.17±0.02^{b}	0.18±0.05^{a}	0.22±0.05^{a}
Kaffir lime leaf solution	0.10±0.04	0.22±0.05^{b}	0.23±0.05^{a}	0.30±0.04^{a}	0.33±0.06^{b}
Pandan leaf solution	0.08±0.02	0.23±0.02^{bc}	0.28±0.02^{ab}	0.28±0.02^{a}	0.32±0.02^{ab}

Note: Different superscripts on the same column indicate significant differences (P<0.05)

Water evaporation occurs during storage, causing the water content to decrease. The contents of the egg shrink, causing the space to be replaced with air and the air sac to become more prominent. The pores of the eggshell will become more open and more extensive during storage so that gas will quickly enter and exit through the pores (Saraswati, 2015). Evaporation of water and gas takes place through the pores of the eggshell. The herbal coating can protect and close the eggshell's pores so that the egg quality declines slowly. Herbal ingredients fill the space in the pores of the eggshell so that water and gas cannot escape freely. According to SNI 01-3926-2008, the quality of eggs in the control treatment decreased from quality I to quality II. In contrast, the quality of eggs coated with herbal ingredients remained at quality I.

CONCLUSION

The method of coating egg shells using the herbal ingredients of lemongrass, kaffir lime leaves and pandan leaves, as well as cold storage, can maintain the quality of chicken eggs. Coating eggshells with lemongrass solution is the best coating material to maintain egg quality for 20 days. This can be seen from the values of the egg white index, egg yolk index, egg white pH, egg yolk pH, and the lowest air depth.

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