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Research Article

The Effect of Temperature and Storage Duration on Physical Quality of Japanese Quail Eggs Fed Containing Fermented *Turbinaria murayana*

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Abstract | This experiment examines the impact of temperature and storage duration on the physical quality of Japanese quail eggs (*Coturnix-coturnix japonica*) when fed a diet containing fermented *Turbinaria murayana*. The study employed a completely randomized design 2x3 factorial with four replications. Factor A represents the storage temperature, comprising room temperature and refrigerator temperature, while factor B represents the storage time, namely 1, 2, and 3 weeks. The observed variables included the physical characteristics of the eggs (egg weight, shell thickness, shell weight, yolk weight, albumen weight, yolk colour, and Haugh unit). The results revealed no significant interaction ($p>0.05$) between temperature and storage duration concerning the physical quality (egg weight, shell thickness, shell weight, yolk weight, albumen weight, yolk colour, and Haugh unit) of quail eggs fed with fermented *T. murayana* seaweed. The experiment concludes that quail eggs fed with fermented *T. murayana* can be stored for up to 3 weeks at room and refrigerator temperatures without adversely affecting their physical quality.

Keywords | Quail egg, Seaweed, Storage, Temperature, *Turbinaria murayana*

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INTRODUCTION

Increasing public awareness of the need for animal protein has led to an increase in egg consumption. Eggs are an inexpensive, readily available, easily digestible, and nutritionally complete source of animal protein suitable for everyone's consumption (Nova et al., 2014). Quail eggs are a less expensive protein source than chicken and duck eggs (Reski et al., 2023; Djulardi *et al*., 2022). Quail eggs contain complete nutrition, such as crude protein 13.30%, fat 11.99%, and crude fiber 0.63% (Thomas et al., 2016).

Besides adequate nutrition, quail eggs contain high cholesterol, reducing people's interest in consuming them. Efforts to reduce the cholesterol content of quail eggs have been made by Reski et al. (2023) by modifying the feed by including 20% *Turbinaria murayana* seaweed in the diet, resulting in a decrease in quail egg yolk cholesterol from 425.25 mg/100g to 213.31 mg/100g. *Turbinaria murayana* seaweed is one of the potential ingredients for poultry feed due to its nutrient content essential for livestock and its secondary metabolite, such as alginates, which can reduce meat and egg cholesterol while maintaining both external and internal egg quality (Reski et al., 2021, 2022, 2023).

Maintaining egg quality to remain excellent and durable from producers to consumers is a significant problem in egg marketing. Handling and storage are two methods that can be considered in the egg storage process so that the quality remains safe. According to Mutia et al. (2017),

temperature and storage duration impact the physical quality of eggs. Furthermore, the feed and storage methods impact egg quality (Ondrusikova et al., 2018). There have been no research reports on the storage of quail eggs supplemented with fermented *T. murayana* seaweed feed at different temperatures and durations and its effects on their physical quality. This experiment looks into the effect of temperature and duration of storage on the physical quality of Japanese quail eggs (*Coturnix coturnix japonica*) fed containing fermented *T. murayana* seaweed.

MATERIAL AND METHODS

Research implementation

The experiment was started by collecting quail eggs, which consumed a diet containing 20% fermented *T. murayana* seaweed. The diet was given for four weeks. The resulting eggs were taken randomly to serve as the research sample. The experiment was carried out for three weeks, namely by storing quail eggs at room temperature (28°C) and refrigerator temperature (4°C), and each treatment was stored for 1, 2 and 3 weeks. The Poultry Production Laboratory, Faculty of Animal Science, Universitas Andalas, measured each parameter.

Table 1: The composition of the treatment diet, content of nutrients (%), and metabolizable energy (Kcal/Kg).

Nutrition composition	The composition of diet ingredients
Corn	48.00
Fermented *Turbinaria murayana*	20.00
Soybean meal	7.00
Fish meal	7.00
Rice bran	2.00
Top mix	1.00
Corn gluten meal CGM	10.00
Stone meal	5.00
Total (%)	100.00
Crude protein	20.57
Crude fat	2.93
Crude fibre	2,76
Calsium	2.83
Phosfor	0.52
Metabolizable energy	2836.05

Material

The experiment utilized 72 quail eggs (36 at room temperature and 36 in the refrigerator) with an average egg weight of 9.8 grams. Two hundred laying quails were raised and fed a treatment diet of corn, soybean meal, fish meal, rice bran, corn gluten meal, top mix, stone meal, and fermented *T. murayana* seaweed meal prepared according to Djulardi (2022), ISO protein 20%, and energy metabolic 2800 Kcal/Kg. The composition of the treatment diet, content of nutrients (%), and metabolizable energy (Kcal/Kg) used can be seen in the following (Table 1).

Research procedure

At the end of the experiment, 72 eggs were collected as samples for egg quality assessment. These eggs were allocated to different treatments based on two factors: factor A, which included two levels (A1: storage at room temperature and A2: storage in the refrigerator), and factor B, which included three levels (B1: one week of storage, B2: two weeks of storage, and B3: three weeks of storage). The eggs were placed on an egg tray for further analysis. Every replication was comprised of three eggs, and each treatment included a total of 24 eggs. The placement of each treatment and the number of eggs placed in the random study can be seen in Table 2.

Table 2: Placement of quail egg storage treatments.

Factor A	Factor B			
	Replication	B1	B2	B3
A1	1	000	000	000
	2	000	000	000
	3	000	000	000
	4	000	000	000
A2	1	000	000	000
	2	000	000	000
	3	000	000	000
	4	000	000	000

Description: A1: Room temperature storage; A2: Refrigerator storage; B1: 1 week storage; B1: 2 weeks storage; B1: 3 weeks storage; 000: The number of eggs each replicate.

Measured parameters

In this experiment, the parameters assessed encompassed egg weight (g/egg), determined by weighing the eggs collectively using a digital scale (Osuka HWH, Japan) and multiplying by the total of eggs. The thickness of the eggshell (mm) was calculated utilizing a caliper (150 Digital Calliper, Nankai Japan). The weight of the eggshell (g) was calculated by weighing the eggshell using digital scales (Osuka HWH, Japan). Egg yolk and albumen weight are measured separately using a digital scale (Osuka HWH, Japan). The egg yolk colour is measured using yolk colour fun. The yolk colour is obtained by comparing the egg yolk colour with the standard egg yolk fan on a standard scale ranging from 1 to 15 (Nhan et al., 2018). Haugh Unit (HU) is calculated using the formula according to Nhan et al. (2018).

$$HU = 100 * Log (H + 7.57 - 1.7 * W^{0.37})$$

Where H = Egg white height (mm), W = Egg weight (g).

Table 3: Average physical quality of eggs stored at room temperature and in the refrigerator for 1, 2, and 3 weeks.

Parameter	A1 (Room temperature)			A2 (Refrigerator)			Interaction	SEM
	1 Week	2 Week	3 Week	1 Week	2 Week	3 Week		
Egg weight (g/egg)	9.13	8.90	8.70	9.25	9.17	8.90	NS	0.30
Eggshell weight (g/egg)	1.35	1.30	1.25	1.38	1.40	1.25	NS	0.10
Eggshell thickness (mm)	0.17	0.16	0.14	0.16	0.17	0.14	NS	0.01
Weight of the yolk (g)	3.45	3.57	3.53	3.30	3.30	3.30	NS	0.15
Albumen weight (g)	4.33	4.03	3.93	4.58	4.08	4.35	NS	0.28
Yolk colour	7.75	6.75	6.75	7.25	7.75	7.75	NS	0.38
Haugh unit	90.85	89.39	89.43	90.46	89.33	89.16	NS	0.73

NS: Non-Significant (p>0.05).

Statistical analysis

The data analysis of the experiment was performed utilizing SPSS version 25. If variations were observed among the treatments, additional analysis was carried out using the Duncan Multiple Range Test method outlined by Steel and Torrie (2002).

RESULTS AND DISCUSSION

The results of the experiment are presented in Table 3.

The experiment results indicate that there is no significant interaction (p>0.05) between temperature and storage time of quail eggs fed with fermented *T. murayana* seaweed meal in the diet on the physical quality of eggs (egg weight, shell weight, shell thickness, yolk weight, yolk colour, and haugh unit).

Egg weight

This experiment's mean quail egg weight spans 8.70 to 9.25 g/egg. The observed mean egg weight in this research remains consistent with the established norm, as Hilmi et al. (2015) indicated an average range of 8 to 11.91 g/egg. Quail egg weight varies based on protein intake and the quails' age (Santos et al., 2011; Nuraini et al., 2022). Analysis of variance results indicates no interaction (p>0.05) between storage temperature and storage time on the weight of quail eggs. This is because quail eggs in each treatment come from quail fed with consistent diets. The provided diet contains 20% fermented *T. murayana* seaweed in the ration. The *T. murayana* seaweed comprises bioactive compounds such as alginate, fucoidan, and fucoxanthin, which have the potential to support egg quality maintenance and lower the cholesterol level within the yolk. Reski et al. (2023) reported that alginate contained in *T. murayana* seaweed could assist in reducing the cholesterol content of quail egg yolks and preserving their quality. The mechanism for reducing egg yolk cholesterol by alginates contained in seaweed is through indigestible alginates binding bile salts in the digestive tract. Consequently, alginates are excreted through faeces, prompting the liver to actively synthesize bile salts by utilizing cholesterol and fats, ultimately reducing cholesterol content in the egg yolk. Therefore, quail eggs with a diet of 20% fermented *T. murayana* seaweed can be stored for up to 3 weeks at room temperature and in the refrigerator. According to Arizona and Ollong (2020), the optimal storage duration for quail eggs in the refrigerator is 21 days, while it is seven days at room temperature.

Shell weight

The average eggshell weight of quail in this experiment ranged from 1.25 to 1.40 g/egg. This average shell weight is consistent with the findings reported by Hilmi et al. (2015), which ranged from 1.03 to 1.18 g per egg and is higher than the results reported by Ondrusikova et al. (2018), which ranged from 0.89 to 0.99 g/egg. Analysis of variance results indicated no interaction between temperature and storage time on the eggshell weight of quail eggs fed a diet containing 20% *T. murayana* seaweed. This lack of interaction can be attributed to the fact that egg weights in each treatment did not differ, and the balance of calcium and phosphorus minerals in the diet was also the same, leading to no significant (p>0.05) on eggshell weight. Eggshell weight is influenced by the mineral balance in the diet, such as calcium, phosphorus, and magnesium (Nhan et al., 2018; King'ori 2011), as well as the resulting egg weight (Hilmi et al., 2015; Nhan et al., 2018).

Shell thickness

This experiment's measurements of eggshell thickness, which ranged from 0.14 to 0.17 mm, are consistent with those made public by Reski et al. (2023) and Kusumorini et al. (2021), who found that the thickness range was 0.14 to 0.18 mm. Analysis of variance results indicated no interaction (p>0.05) between temperature and storage time on the eggshell thickness of quail eggs fed a diet containing 20% fermented *T. murayana* seaweed. According to King'ori (2011), the thickness of eggshells is influenced by the balance of calcium, phosphorus, and magnesium in the provided animal diet. Additionally, the uniform eggshell thickness among treatments can be

attributed to the similarity in the resulting egg weights. In line with the viewpoint of Ondrusikova et al. (2018), the thickness of quail eggshells is directly proportional to the weight of the produced eggs.

Egg yolk weight

The average egg yolk weight produced ranged from 3.30 to 3.57 g, indicating no interaction ($p>0.05$) between temperature and storage time on the yolk weight of quail eggs fed a diet containing fermented *T. murayana* seaweed. These results are nearly consistent with the average yolk weight reported by Ondrusikova et al. (2018), which ranged from 3.68 to 3.91 g, also showing no differences among storage treatments. Mutia et al. (2017) stated that storage treatments for 21 days, whether at room temperature or in the refrigerator, do not affect the physical quality of the egg yolk.

Albumen weight

The average weight of egg albumen produced in this study ranged from 3.93 to 4.58, showing that temperature and storage period had no effect. However, there was a gradual decrease in weight with longer storage time. These results are consistent with the average egg white weight reported by Nhan et al. (2018), which ranged from 4.04 to 4.37 g. The decrease in egg white weight during storage is attributed to the evaporation of water and carbon dioxide during storage, leading to the thinning of the egg white (Mutia et al., 2017).

Egg yolk color

Average yolk colour produced in storage treatments at different temperatures and durations, consuming a diet containing fermented *T. murayana* seaweed, ranged from 6.75 to 7.75. These results are consistent with a study conducted by Agustantikaningsih et al. (2015), indicating that the yolk colour index of quail eggs ranged from 6.74 to 6.94 when fed a diet containing fermented *T. murayana* seaweed. Analysis of variance results indicated no significant difference in yolk colour among quail eggs stored at various temperatures and durations. However, these results are lower than the yolk colour index without storage, as Reski et al. (2023) reported, which ranged from 8.25 to 9. The decrease in yolk colour in eggs stored under different temperatures and durations is attributed to the rupture or damage of the vitelline membrane, allowing water to enter the yolk, resulting in a reduction in yolk colour intensity (Amalo et al., 2016).

Haugh unit eggs

The average Haugh unit of quail eggs fed a diet containing fermented *T. murayana* seaweed and stored at different temperatures and durations ranged from 89.16 to 90.85. These results are higher than those reported by Amalo et al. (2016), where the storage of quail eggs at varying temperatures and durations resulted in Haugh unit values ranging from 68.5 to 87.5. Furthermore, it is noted that the Haugh unit values of eggs stored in the refrigerator are higher than those stored at room temperature, attributed to the refrigeration's ability to inhibit water and carbon dioxide evaporation. Analysis of variance results indicated no significant treatment differences between temperature and storage duration on the haugh unit values of quail eggs fed a diet containing 20% fermented *T. murayana* seaweed. This lack of impact is due to the presence of secondary metabolite compounds in the fermented *T. murayana* seaweed, such as alginate, fucoidan, and fucoxanthin, which help maintain the quality of quail egg albumen and yolk, thus keeping the Haugh unit values unaffected (Reski et al., 2023).

CONCLUSIONS AND RECOMMENDATIONS

The quail eggs consuming a diet enriched with 20% fermented *T. murayana* seaweed can be stored for three weeks, either at ambient room temperature or within a refrigerated environment, without impacting their physical characteristics. These characteristics include an average egg weight of 8.70 g/egg, a shell weight of 1.25 g/egg, a shell thickness of 0.14 mm, a yolk weight of 3.53 g, an albumen weight of 3.93 g, yolk colour index of 6.75, and a haugh unit value of 89.43 at room temperature. Similarly, when stored in the refrigerator, the eggs exhibit an average egg weight of 8.90 g/egg, a shell weight of 1.25 g/egg, a shell thickness of 0.14 mm, a yolk weight of 3.30 g, an albumen weight of 4.35 g, yolk colour index of 7.75, and haugh unit values of 89.16.

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NOVELTY STATEMENT

The quails fed containing 20% fermented *T. murayana* seaweed can produce low-cholesterol eggs of good quality, which can be stored for up to 3 weeks, both at room temperature and refrigerator temperature, without compromising their physical quality.

AUTHOR'S CONTRIBUTION

All the authors mentioned in the paper have actively taken

part in the research activities and have made substantial contributions to the creation of this article. Collectively, Sepri Reski, Ridho Kurniawan Rusli, Montesqrit, and Maria Endo Mahata have been involved in shaping the research ideas collecting and analyzing data. Furthermore, all authors have agreed to submit this manuscript to the AAVS journal.

Conflict of interest

The authors have declared no conflict of interest.

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