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The Effect of Vegetable Oil and Shea Butter Coating on the Physical Characteristics and Protein Content of Chicken Eggs Stored under Room Temperature at Different Storage Length

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Chicken eggs are rich in protein, vitamins, and minerals, containing all essential amino acids. They can complement other food proteins with lower biological values. This study explored the effectiveness of vegetable oil (olive oil) and shea butter in preserving the internal quality of eggs under room temperature. Ninety (90) White Leghorn eggs were sourced from the TANUVAS poultry farm and divided into three groups (T1- vegetable oil, T2- shea butter and T3- control) of 30 eggs

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each. The first two groups received treatments with olive oil and shea butter respectively, while the third served as the control group. The eggs in each treatment group were stored at room temperature for six weeks. Weekly assessment s of the physical and protein content was measured using the Haugh unit and the Biuret Method for protein concentration. The eggs showed less weight loss in the treated groups at T1 (vegetable oil) and T2 (shea butter) compared to the control group (T3). The-vegetable oil-coated-eggs maintained their quality more than 43 days compared to those coated with shea butter and the untreated ones. Internally, both albumen height and Haugh unit values decreased over the storage time, with the vegetable-oil-treated eggs retaining quality for the longest duration, followed by the shea butter treated group. Eggs in the control group showed decline in quality after 22 days. Protein levels in the albumen decreased in all groups with storage, but the vegetable oil and shea butter coated groups recorded led to less reduction in protein content than the control group. The study indicates that olive oil and shea butter can effectively preserve the physical and protein content of chicken eggs under different storage conditions, with olive oil demonstrating a greater efficacy upto 43 days. These findings support the use of these natural oils as alternative preservatives for prolong egg storage in regions where refrigeration is not feasible.

Keywords: Eggs; vegetable oil; shea butter; coating; egg storage; room temperature.

1. INTRODUCTION

It is impossible to overstate the significance of ensuring the quality of eggs in any nation. The small-scale poultry business provides over 50% of table eggs. Which are produced, processed, stored, and marketed without rigorous oversight or adherence to regulations (Frazier and Westerhif, 1998). On farms situated in rural areas, eggs are kept in a warm environments from the farm to the customer even though high temperatures may have a detrimental effects on their calibre. When there is an egg glut, table eggs may sit in the hot weather on the farm for a few days before they are purchased by middlemen and distributed to sales points or markets; where they might stay with the merchants for an additional week or two before reaching the customers. During these periods, eggs may get spoiled due to various reasons such as: alterations in pH, passage of water from thick albumen to other albumen layers and to the yolk, loss of carbon dioxide. These cause deterioration in the interior quality of eggs leading to economic loss to poultry industries (Frazier and Westerhif, 1998). During storage, the albumen loses its structural integrity due to destruction of the long mucin fibres that give it its gel structure under the alkaline conditions created; and the albumen simultaneously becomes a water-moving substance (Frazier and Westerhif, 1998). Movement of the albumen fluid into the yolk causes the yolk to expand and rupture the vitelline membrane, allowing the yolk to stretch out or combine with the albumen in "mixed rot" (Fromm, 1966). Another effect of long storage is alteration in egg protein; cause by proteolysis of the dense protein that is impacted by loss of water and CO_2 during storage (Derelioglu and Turgay, 2022).

Eggs that are refrigerated suffer very little quality loss yet, when these eggs are marketed, their quality rapidly deteriorates. Nonetheless, the practice of preservation eggs by refrigeration cannot be widely adopted in the tropics due to exorbitant energy costs due to, lack of electricity in the rural regions (Steward and Bose, 1948).

Chitosan coating prevents weight loss and maintains the albumin and yolk quality of eggs stored at 25°C (Haugh, 1937). Thus, the albumin quality of quail and chicken eggs can effectively preserved by all chitosan coating formulations (Haugh, 1937). Covering egg shell pores with stable sealants vegetable oil has been found to increase shelf life of eggs (Suppakul et al.,2010). However, according to some customers' perception, coating with a 25:75 emulsion of mineral oil and chitosan would have no effect on the overall surface look or purchase intent (Damir et al., 2010). Again, in order to preserve eggs, soybean, coconut, rice bran, and palm oils have been used (Nongtaodum, 2013). In his trials, all of the oils were successful in maintaining the interior characteristics of the table eggs. The albumin quality of quail and chicken eggs could be effectively preserved by all chitosan coating formulations (Haugh, 1937).

In the same way, numerous studies have found varying degrees of effectiveness of vegetable and mineral oils for egg preservation (Nongtaodum, 2013, Al-Hajo, 2012). Mineral oils have an equivalent sealing value but perform better than vegetable oils because they do not develop unpleasant smell easily and are less prone to alterations during storage (Almy et al, 1922). The effectiveness of oils in preserving eggs has been linked to their capacity to obstruct the egg shells' air holes, which stops air from entering and exiting the eggs and causing deterioration due to potential pollutants in the air (Al-Hajo, 2012). However, the application of olive oil and shea butter to preserve eggs has not received much attention by scientists.

The brick and salt method, the thin albumen just under the shell membrane, paraffin coating, soaking in lime, dipping in a beeswax and olive oil mixture, dipping in a boiling boric acid solution, and thermostabilization—which involves briefly immersing eggs in boiling water to coagulate them—as well as coating eggs with various mineral and vegetable oils are additional techniques in addition to chilling. Numerous studies have found varying degrees of effectiveness of vegetable and mineral oils for egg preservation (Nongtaodum, 2013, Al-Hajo, 2012, Almy et al., 1922).

2. MATERIALS AND METHODS

The eggs were obtained from a eighteen week-old White leghorn flock kept at the Tamil Nadu veterinary and animal sciences university (TANUVAS) poultry farm Madhavaram.

Eggs before treatment

Olive oil coated eggs

Shea butter coated eggs

Uncoated (control) eggs

Plate 1. The experimental period spanned from 03/1/2024 to 14/2/2024

Eggs collected from the farm were transferred to Ethiraj College Zoology lab on sanitised egg trays. Ninety whole eggs were sampled and split up into 3 treatment groups as: T1, T2 and T0, each containing 30 eggs. Eggs in the first and second groups were coated vegetable oil (olive oil) and shea butter while the third group acted as the control without any treatment. Each group of eggs was kept separately but under the same environment at 27±2 ^oC room temperature for six weeks. Ninety table eggs on day 1, weighing an average of 62 ±0.12. On the first day of every experimental week, 4 eggs were randomly chosen from each group and analysed for the physical characteristics and protein content accordingly.

2.1 Measurement of the Physical Characteristics of Eggs

The physical characteristics of eggs were assessed on days 1, 8, 15, 22, 29, 36, and 43 of storage. On weekly basis, 12 eggs in total were taken and broken for the physical and protein analysis. Each egg was examined by breaking it out onto a spotless levelled surface and weighed; the height of the albumen, or egg white that surrounds the yolk was measured by a spherometer. The Haugh Unit was determined by egg weight and height of the egg white as described by (Piotrowski, 1857). The Haugh unit was calculated by the equation below:

HU = 100*log (h – 1.7w0.37 + 7.6) is the Haugh Unit (Piotrowski, 1857).

2.2 Estimation of Protein Concentration of Eggs

Protein concentration of egg albumen in the 3 groups of eggs was determined, on storage days 1, 8, 15, 22, 29, 36 and 43 by the Biuret Method (Zak et al., 1984) at 3 replications per each albumen. 0.5 ml of each egg white per each storage group was analysed in separately in a test tube. 0.5 ml of distilled water and 3 ml of biuret, making 4 ml of solution. The solution was then incubated for 30 minutes at standard room temperature and use a spectrophotometer to measure absorbance at 540 nm. Protein concentration s of the egg albumen was determined by extrapolation from the Bovine serum albumin (BSA) standard graph.

2.3 Data Analysis

The data collected in all the above experiments of this study were subjected to analysis of variance (ANOVA) one-way ANOVA for completely randomized design (CRD)

3. RESULTS AND DISCUSSION

The effects of egg coating in preserving physical and protein content of egg weight, albumen height and Haugh's unit values of table eggs treated with vegetable oil, shea butter and control eggs with duration of storage in days.

3.1 Physical Characteristics of Eggs

Weight of the eggs in each treatment group gradually decreased up to the 43^{rd} day of storage. The vegetable oil coated eggs recorded was 51.77±0.57 shea butter was 47.72±0.48 and control eggs was found to be 40±0.81. Weight loss of eggs was found to be higher in the control eggs than the shea butter coated and vegetable oil coated eggs. Similar results were found when vegetable oil (groundnut oil, cottonseed oil, and coconut oil) coated eggs had a modest weight loss rate compared to non-treated eggs and glycerol-coated eggs (Mudannayaka et al., 2016). There was a steady increase in overall egg weight loss during the storage periods. During the course of five weeks of storage in an experiment, all eggs coated with MO and MO:CH emulsion significantly lost less weight than the control eggs (Muhammad et al., 2016). The lower egg weight loss recorded in the oil-treated eggs is because, similar to oils, beewax provides a barrier to prevent moisture escape through the egg shell, minimising weight loss (Muhammad et al., 2016). Egg weight loss of the control eggs in the current study increased more than that of pullulan eggs coated with nisin (Bhale et al., 2003). After five weeks of storage, no discernible decrease in egg weight was seen between the coated eggs and the control eggs (Bhale et al., 2003) but in the present study the weight loss of the control eggs was higher than the coated eggs of other two groups. Egg weight loss happens due to loss of CO_2 and H_2O leading to changes in albumen and yolk quality and thus egg deterioration (Dan et al.,2018, USDA, 2000).

3.2 Internal Egg Quality Characteristics

The albumen height and Haugh's Unit values decreased during the storage period for eggs in all three groups. Eggs treated with vegetable oil showed excellent results, maintaining high quality (AA grade) until the 43rd day of preservation. Shea butter treatment preserved the freshness of eggs until the 36th day, maintaining an AA grade. In contrast, untreated eggs kept an AA grade only until the 22nd day of storage, after which they gradually dropped to grades A and B. This comparison is based on the AA, A, B, and C grading system for eggs, as shown in Table 1 and Fig. 1. (Torrico et al., 2011). Therefore, eggs coated with olive oil exhibited a significantly better egg freshness than those coated with shea butter, according to Haugh's unit values while those treated with shea butter were also significantly fresher than the untreated eggs.

A study found that, compared to eggs soaked in oil and subsequently refrigerated, the albumen height was higher in both refrigerated eggs and those immersed in oil and stored at room temperature. Albumen height was less deteriorated in the vegetable oil and shea butter coated eggs than eggs in the control group. Similarly to a study Haugh's unit generally dropped as storage time increased (Bhale et al., 2003). In that work, compared to the control eggs, the measured HU dropped at a significantly slower rate in MO and MO:CH (25:75). This is mostly because the thick albumen gradually degrades into thin albumen in eggs covered with SO and SO:CH emulsion (Torrico et al., 2011). In the present work, Haugh unit dropped as the storage time s increased, but for eggs coated with oil, the decline was slower than for the control eggs. For five weeks, the oil-coated- eggs had a greater HU than the control eggs, suggesting that the oil was successful in maintaining albumen quality of the eggs (Omana et al., 2011).

In the present study, coated eggs maintained a higher Haugh unit compared to control eggs over a span of four weeks. Specifically, vegetable oil-coated eggs retained a high Haugh unit for up to six weeks, while shea butter-coated eggs maintained it for five weeks (Haugh, 1937). Reason for the gradual decline in Haugh unit with storage period was related to chemical alteration of albumen protein (ovomucin) (Ryu et al., 2011) and increases in clusterin and ovoinhibitin results in thinning of the albumen (Stevens, 1996).

Table 1. Egg weight, albumen height and haugh's unit values of table eggs coated with vegetable oil, shea butter and control eggs with duration of storage in days

DAY	EGG WEIGHT (g)	ALBUMEN HEIGHT (mm)	HAUGH'S UNIT	GRADE
VEGETABLE OIL				
1	59.5±1.29	7.17±0.12	85	AA
8	58±0.81	7.07±0.09	85	AA
15	53.25±0.95	6.95±0.1	85	AA
22	53.25±0.5	6.4±0.27	82	AA
29	53±0.81	6.2±0.14	81	AA
36	52.3±0.47	5.97±0.05	79	AA
43	51.77±0.57	5.35±0.23	75	AA
SHEA BUTTER				
1	59.5±1.29	7.17±0.12	85	AA
8	54.5±0.57	6.36±0.25	84	AA
15	52.75±1.25	6.2±0.14	81	AA
22	53±0.81	6.02±0.05	79	AA
29	51.62±0.47	5.72±0.18	78	AA
36	50.3±0.47	5.07±0.09	73	AA
43	47.72±0.48	4.75±0.1	71	A
CONTROL				
1	59.5±1.29	7.17±0.12	85	AA
8	51.5±0.57	6.17±0.12	81	AA
15	50±0.81	5.9±0.11	80	AA
22	45.75±0.5	5.07±0.09	75	AA
29	41.5±0.5	4.32±0.22	71	A
36	40.5±0.57	3.32±0.12	63	A
43	40±0.81	2.4±0.39	52	B

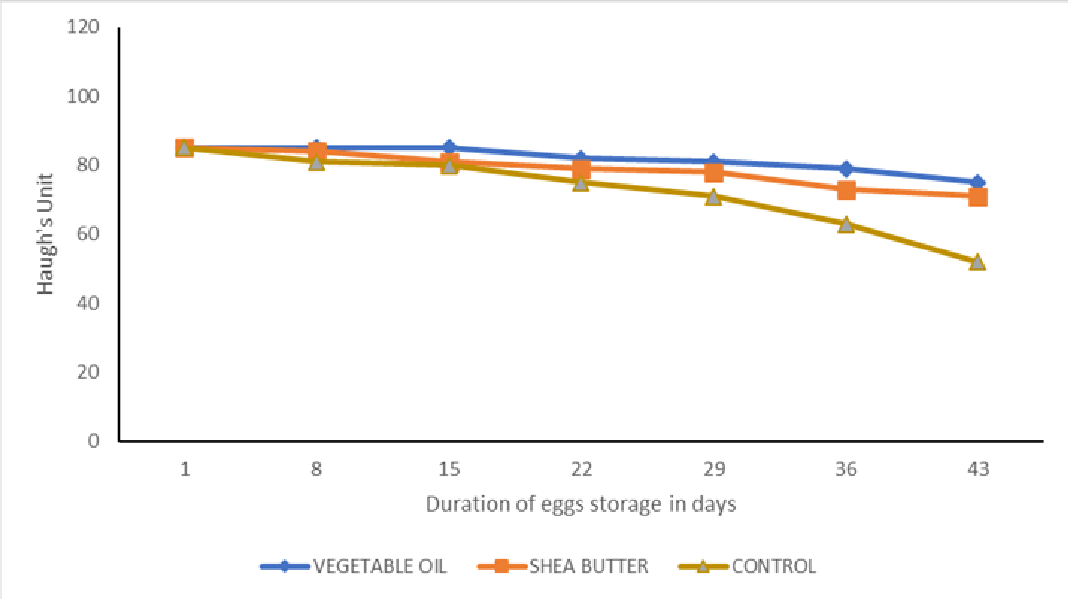

Fig. 1. Comparison of haugh's unit values of eggs treated with vegetable oil and shea butter different storage days

3.3 Protein Anaysis

In the three egg groups under investigation, the protein content decreased with prolonged storage time. The amount of albumen protein in the eggs covered with vegetable oil decreased from 104.2±0.18 mg/ml on day 1 to 85.4±0.42 mg/ml on day 43. The amount of protein in the shea butter-coated eggs dropped s from 104.2±0.18 mg/ml on day 1 to 83.4±0.40 mg/ml on day 43. Eggs in the control group show a drop in protein concentration from 104.2 ±0.18 mg/ml on day 1 to 54.4±0.43 mg/ml on day 43. Therefore, the Rate of reduction in the amount of protein was lesser in vegetable oil and shea butter coated eggs than control eggs (Table 2, Fig. 2).

Similar to studies on the excellent protein qualities of eggs treated with vegetable oil compared to shea butter-coated and control eggs, the rate of protein deterioration was analyzed and studies shows that vegetable oil coating might not prevent microbial multiplication within the eggs. In the present study, olive oil possesses linoleic acid, palmitic acid, alpha - linolenuc acid, palmitoleic acid and garlic acid while shea butter triglycerides (fat) derived from various fatty acids such as: oleic acid, stearic acid,linoleic acid, palmitic acid, linolenic acid and arachidonic acid may have contributed to positive outcome in terms of reducing the rate of protein degradation (Sheng et al., 2018, Pius and Olumide, 2017).

For eggs intended for prolonged storage at room temperature, SO (soyabean oil) coating's superior sealing qualities and hydrophobicity provide a strong moisture barrier (Davrieux, 2010). The capacity of oil to seal air pores in egg shells, preventing air flow in and out of eggs and deterioration by potential contaminants is credited to the oil's effectiveness in preserving the protein content of the eggs (Al-Hajo, 2012).

Tabel 2. Protein concentration (mg/ml) of eggs coated with vegetable oil and shea butter during storage under room temperature at different storage days

TREATMENTS	DURATION OF EGGS STORAGE (DAYS)						
	1	8	15	22	29	36	43
	PROTEIN CONCENTERATION IN (MG/ML)						
VEGETABLE OIL	104.2±0.18	102.4±0.35	99.5±0.31	96.8±0.21	94.2±0.18	90.4±0.40	85.4±0.42
SHEA BUTTER	104.2±0.18	100.2±0.18	98.6±0.08	95.2±1.02	92.4±0.64	87.2±0.90	83.4±0.40
CONTROL	104.2±0.18	97.2±0.14	90.4±0.35	83.2±0.18	72.7±0.18	63.8±0.99	54.4±0.43

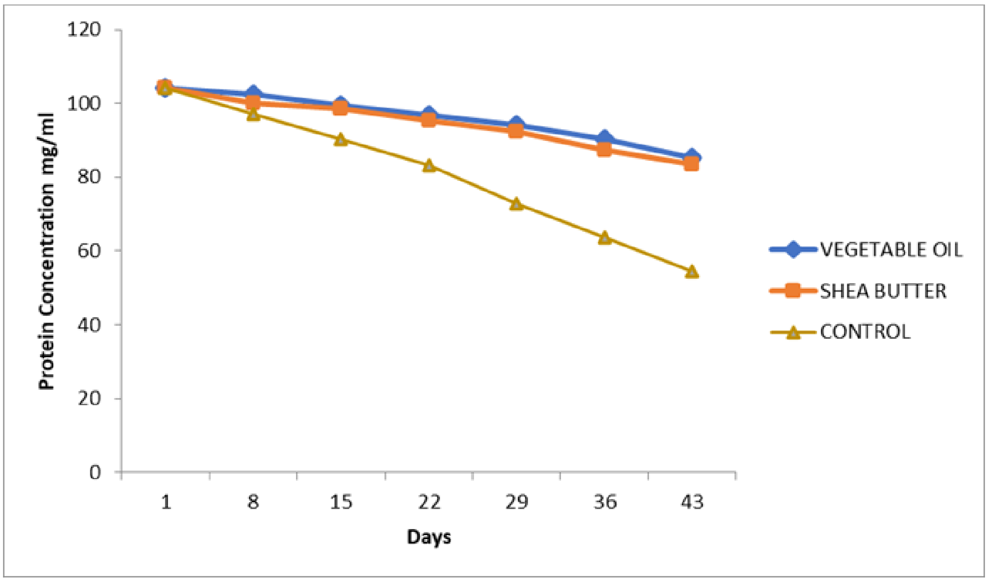

Fig. 2. Comparison of albumen protein concentration (mg/ml) of coated and uncoated eggs at different storage days

4. CONCLUSION

Eggs treated with olive oil exhibited the best physical quality and protein content. Eggs treated with shea butter also showed improved quality compared to the control group, but were not as effective as those treated with the olive oil. Both products are can be used to maintain the quality of eggs, particularly in areas where refrigeration is not feasible. The oil coating approach would not only benefit producers but would also ensure that consumers receive high-quality eggs to contribute to better health outcomes and market stability.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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