

Preservation of Quality of Table Eggs Using Vegetable Oil and Shea Butter

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Abstract. The poultry industry in Nigeria keeps expanding on a daily basis and it is faced with the problem of egg glut almost yearly. Most of the poultry are raised in rural environments where there is no available and avoidable power supply for egg preservation. The study was aimed at using locally available and cheap materials for preservation of eggs quality under the hot ambient temperature. The eggs were divided into three groups of 80 eggs each. The first and second groups were treated with vegetable oil (soybean oil) and shea butter, respectively, while the third group served as control. The eggs were stored under the ambient conditions and assessed for their physical and nutritional qualities on days 1, 8, 15, 22, 29, 36, 43 and 50. The physical quality was assessed by determining the albumen height and the Haugh's unit, while the nutritional quality was appraised through the protein concentration of the albumen. Based on the values of Haugh's unit, eggs treated with vegetable oil produced excellent results; good quality eggs were obtained up to 50th day of storage. Treatment with shea butter maintained quality eggs up to the 29th day, while with untreated eggs good physical quality was maintained up to 22nd day of storage. Protein concentrations of eggs in the three groups studied decline with duration of storage, however the protein concentrations of eggs treated with vegetable oil were significantly higher than the other groups ($p < 0.001$). The eggs treated with shea butter recorded a comparative higher protein concentrations than the untreated eggs ($p = 0.002$).

1. Introduction

The table egg is an important source of protein, essential vitamins and minerals [1]. Egg protein is of high biological value as it contains all the amino acids needed by human body. Eggs can therefore complement other food protein of lower biological value by providing the amino acids that are in short supply in those foods [1].

The avian eggs have three main parts, namely shell, albumen (egg white) and yolk. The shell is separated from the albumen by the shell membrane, while the yolk is separated from albumen by the vitelline membrane. An intact and strong vitelline membrane prevents the content of the albumen and yolk from mixing thereby preventing egg molting. Storing eggs at room temperature can increase the incidence of molting, the vitelline membrane weakens and both the yolk and albumen becomes thinner and watery as the egg ages [2]. The yolk in a newly laid egg is round and firm, but as the egg ages it absorbs water from the albumen, which increases its size and causes it to stretch and weaken the vitelline membrane. The resulting effect is a flattened and enlarged yolk shape [3].

The poultry industry in Nigeria keeps expanding on a daily basis and it is faced with the problem of egg glut almost yearly. During the period of egg glut, table eggs could remain on farm for several days under the hot ambient temperature before they are bought over by the middle men for distribution to retailers. They could remain with the retailer for another one to two weeks before getting to the consumers. Even with the consumers, due to poor electricity supply, the eggs could be left unrefrigerated for days before they are consumed. According to Frazier and Westerhoff [4] such eggs could experience loss in internal physical qualities and increase in bacterial load.

It has been recommended that shell eggs destined for the retail market should be transported under refrigerated conditions and shell eggs packed for the consumer are labeled “Keep Refrigerated” and stored and transported under refrigeration or at an ambient temperature that is not greater than 45 °F [5]. Most of the African countries cannot meet this condition, because that will increase the cost of production (that is when electricity supply is available) and table eggs will not be within the reach of the people because of the poverty level. It is therefore necessary to look for cheap approaches to keeping egg quality high especially during egg glut.

Egg spoilage during storage has been attributed to gaseous (CO₂) loss, change in pH, movement of water from thick albumen to other albumen layers and to yolk, entry of microorganisms through the pores, embryonic development (in case of fertile eggs), as well as absorption of foreign odours [6]. The methods employed in egg preservation are aimed at minimizing these changes during storage. These methods are based on the principle of retarding microbial growth and sealing of the pores to reduce the evaporation of moisture and escape of gases [6,7].

The problem of preservation of eggs has been the focus of the scientists for a long time and methods that have been employed in eggs preservation, aside refrigeration, include: coating with paraffin, soaking in lime, dipping in a mixture of beeswax and olive oil, dipping in boiling boric acid solution, thermostabilization (immersion of eggs for a short time in boiling water to coagulate a thin albumen immediately beneath the shell membrane), brick and salt method, egg washing, as well as egg coating using various forms of vegetable and mineral oils [7-11].

Vegetable and mineral oils have been widely used, and various degrees of efficiencies on egg preservation have been reported [10,11]. The coating method of the eggshell with oil was first used by Dutch farmers as early as 1807, and it was reported that coating the egg with mineral oil greatly improved the shelf-life of the eggs [11, 12].

The present study was aimed at using locally available and cheap materials in Nigeria, such as vegetable oil (soybean oil) and shea butter, to preserve eggs quality under the hot ambient temperature. Soybean oil is a vegetable oil extracted from the seeds of the soybean (*Glycine max*). It is one of the most widely consumed cooking oils. Shea butter is an off-white or ivory-colored fat extracted from the nut of the African shea tree (*Vitellaria paradoxa*), commonly used in cosmetics as a moisturizer, salve or lotion because it has been claimed to possess anti-inflammatory, emollient and humectants properties [13]

2. Material and Methods

2.1. Eggs collection and treatment

Freshly laid eggs were purchased from a commercial poultry farm in Owo, Nigeria. The eggs were transported in clean egg trays to the Biology laboratory of Achievers University, Owo, Nigeria. The eggs were candled to ensure there was no crack. Two hundred and forty table eggs were divided into 3 groups of 80 eggs each. The first and second groups were respectively treated with vegetable oil (soybean oil) and shea butter, while the third group served as control. Treatment of eggs with vegetable oil was by dipping, while treatment with shea butter was by rubbing. All the eggs were stored under the ambient temperature of 28±2 °C for seven weeks. Ten eggs per group were randomly selected each week, starting from the first day, weighed and broken for analysis of physical and nutritional qualities.

2.2. Determination of the physical qualities

The evaluation of the physical qualities of eggs, on days 1, 8, 15, 22, 29, 36, 43 and 50 of storage, was by determining the Haugh Unit, as described by Haugh [14]. This is an important method by which contemporary industries determine egg quality. In this method, the egg was weighed, broken onto a flat clean plate and a micrometer used to determine the height of the albumen (egg white) that immediately surround the yolk. The height of the albumen and the egg weight were used to determine the Haugh Unit. The Haugh Unit, $HU = 100 * \log (h - 1.7w^{0.37} + 7.6)$.

Eggs are further graded based on their HU values: AA: 72 or more, A: 71 – 60, B: 59 – 31, C: 30 or less. AA and A values are considered to be eggs of high qualities while those with B and C values are eggs of low quality. Eggs with 70 HU value are considered acceptable [15].

2.3. Assay of protein concentration of eggs

Protein concentrations of the albumen in the 3 groups of eggs were determined, on days 1, 8, 15, 22, 29, 36, 43 and 50 of storage under the ambient temperature, by the biuret method as described by Association of Analytical Chemists [16]. One milliliter of each egg albumen was added to 3ml of distilled water, thoroughly mixed, followed by addition of 2 mL of biuret and with the aid of a spectrophotometer protein absorbance was taken at 540nm. Casein was used as standard protein at concentration of 2 mg/mL. Into each tube were added 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4.0 mL of the standard protein solution, and the content of each tube made up to 4ml by adding distilled water. Then 2 mL of biuret added and absorbance of colour change was taken at 540 nm. Protein concentrations of the egg albumen were determined by extrapolation from the casein's standard protein graph.

2.4. Statistical analysis

Rate of deterioration of eggs ($1 - r$) in each treatment group was determined from the formula $l = ar^{n-1}$; where 'l' and 'a' are egg concentrations on the first and the last day of storage respectively; and 'n' is the number assays from the first to the last day in the treatment group.

Comparisons of groups for significant difference were determined with One-Way ANOVA when more than two groups and paired *t* test for a group of two. SPSS 16.0 was used for the analysis and a value of $p \leq 0.05$ was considered significant.

3. Results

Two hundred and forty table eggs, average weight 63.83 ± 3.61 g, were divided into three groups of treatments using vegetable oil (soybean oil) and shea butter while the third group served as control. There was no significant difference in the weight of eggs distributed to the three groups ($F = 0.039$, $p = 0.738$)

There was decline in albumen height and values of Haugh's unit with duration of storage of all eggs in the 3 groups. Eggs treated with vegetable oil produced very excellent results; good quality eggs were obtained up to 50th day of storage. Treatment with shea butter maintained quality eggs up to the 29th day, while for untreated eggs, good physical quality was maintained up to 22nd day of storage, based on AA, A, B and C grading of eggs (Table 1). Based on 70 HU acceptable quality, soybean oil, shea butter treated and control eggs maintain physical qualities up to days 43, 29 and 18 respectively, by extrapolation from Fig. 1. Based on Haugh's unit values, eggs coated with soybean oil showed significantly superior quality over those coated with shea butter ($p=0.044$) and control ($p=0.007$), also the eggs treated with shea butter gave a significantly higher quality than the untreated eggs ($p=0.007$).

The protein concentrations of eggs, in the three studied groups, decline significantly with duration of storage ($p < 0.001$). The eggs coated with the vegetable oil decline in albumen protein concentration from $14.0 \pm 0.41\%$ on day 1 to $10.0 \pm 0.93\%$ on day 50, with a rate of deterioration of 0.0460; eggs coated with shea butter decline from $14.0 \pm 0.41\%$ on day 1 to $7.6 \pm 0.76\%$ on day 50, with a rate of deterioration 0.0836; while the control eggs decline from $14.0 \pm 0.41\%$ on day 1 to $5.6 \pm 0.56\%$ on day 50, with a rate of deterioration 0.1227 (Table 2).

The protein concentrations, during the period storage, of eggs treated with vegetable oil were significantly higher than the other two groups ($p < 0.001$), however the eggs treated with shea butter recorded a comparative higher protein concentrations than the untreated eggs ($p = 0.002$), Fig. 2.

Table 1. Variation of albumen height and Haugh's unit values of table eggs treated with vegetable oil and shea butter as well as control eggs with duration of storage.

DAY	EGG WEIGHT (g)	ALBUMEN HEIGHT (mm)	HAUGH'S UNIT	GRADE
VEGETABLE OIL				
1	65.42±2.84	9.72±1.26	97	AA
8	62.15±2.84	8.75±1.26	93	AA
15	63.20±5.57	7.75±0.82	87	AA
22	66.70±1.15	7.25±0.58	83	AA
29	62.35±5.50	6.75±0.48	81	AA
36	62.40±5.54	5.75±1.26	74	AA
43	63.80±5.57	5.52±0.87	71	A
50	64.00±3.50	4.35±0.98	60	A
SHEA BUTTER				
1	65.42±2.84	9.72±1.26	97	AA
8	62.40±4.60	6.80±0.96	91	AA
15	65.50±4.42	5.80±0.58	85	AA
22	63.20±4.47	5.00±0.96	77	AA
29	62.60±1.87	4.30±1.26	71	A
36	65.63±1.26	3.30±1.83	59	B
43	65.10±1.83	2.00±1.86	49	B
50	63.00±1.56	1.50±1.90	17	C
CONTROL				
1	65.42±2.84	9.72±1.26	97	AA
8	66.60±8.78	7.50±0.96	84	AA
15	59.75±2.73	6.50±0.58	80	AA
22	70.53±5.38	4.75±0.96	61	A
29	59.13±3.14	3.00±1.15	46	B
36	57.60±5.17	2.00±0.82	29	C
43	57.80±4.17	1.75±0.50	21	C
50	64.10±1.14	1.50±0.82	7	C

AA and A = High quality

B and C = Low quality

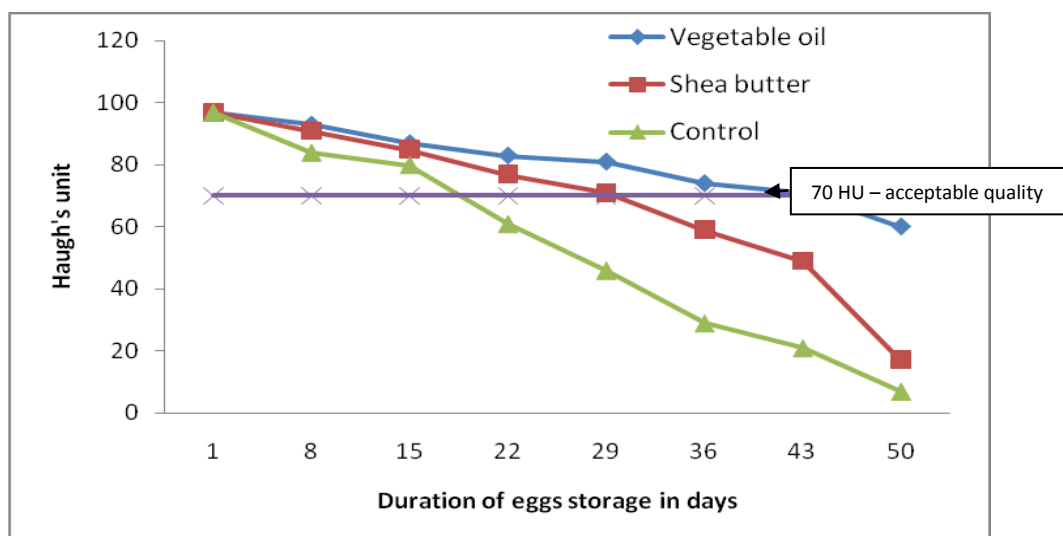


Figure 1. Comparisons of Haugh's unit values of treated with vegetable oil and shea butter and untreated table eggs (Vegetable oil/Control, $p=0.007$; Vegetable oil/Shea butter $p=0.044$; Shea butter/Control, $p=0.007$).

Table 2. Deterioration of protein concentrations (%) of eggs treated with vegetable oil and shea butter during storage under ambient tropical temperature.

Treatments	Duration of eggs storage (days)								Rate of deterioration
	1	8	15	22	29	36	43	50	
Vegetable Oil	14.0± 0.41	12.7± 1.27	12.2± 1.22	12.2± 1.18	11.3± 1.13	10.6± 1.06	10.6± 0.5	10.0± 0.93	0.0469
Shea Butter	14.0± 0.41	10.6± 1.06	10.2± 1.02	10.2± 0.97	9.5± 0.95	8.4± 0.84	8.4± 0.81	7.6± 0.76	0.0836
Control	14.0± 0.41	10.2± 1.02	9.0± 0.91	9.0± 0.84	7.9± 0.79	7.1± 0.71	7.1± 0.63	5.6± 0.56	0.1227

Values are expressed as mean±SD.

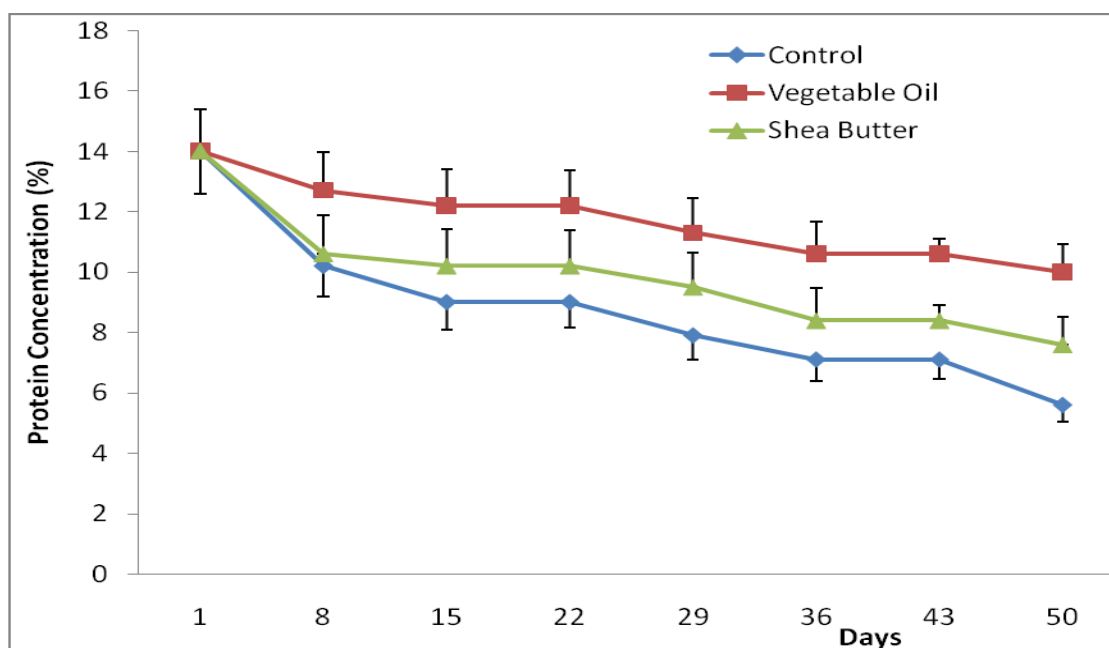


Figure 2. Comparisons of albumen protein concentrations of treated and untreated table eggs (Vegetable oil/Control, $p < 0.001$; Vegetable oil/Shea butter $p < 0.001$; Shea butter/Control, $p = 0.002$).

4. Discussion

The importance of egg quality assurance in any country cannot be over emphasized. In Nigeria, table eggs are produced, processed, stored and marketed without strict monitoring and compliance to guidelines, because more than 50% of eggs are produced by small scale poultry farms in rural environments. From farm to the consumers, eggs are stored under the hot ambient temperature which is can negatively affect their quality [17,18].

Eggs are highly perishable and can rapidly lose their internal quality (physical structure and chemical compositions) due to the loss of moisture and carbon dioxide through pores of the eggshell as a result of improper storage methods [6,18]. During storage, loss of moisture and carbon dioxide via the shell pores causes negative quality changes in albumen and yolk as well as weight loss of eggs. Temperature, humidity, air movement and storage times can all have adverse effects on interior quality. These factors, if not controlled, can cause loss of moisture in eggs [19,20].

Earlier studies showed that eggs stored at high ambient temperature experienced sharp loss in physical and nutritional qualities with duration of storage, under the ambient temperature, compared to refrigerated eggs [17,19]. Significantly lower qualities of yolk, albumen and protein, and higher microbial loads have been reported in eggs stored in the tropical Nigerian ambient temperature compared to refrigerated eggs [17].

Vegetable and mineral oils have been widely used in egg preservation, and various degrees of efficiencies have been reported [10,11]. The efficacy of oils in eggs preservation has been attributed

to ability of oil in blocking the air pores of the egg shells, thereby preventing the flow of air in and out of the eggs and degradation by the contaminants such air may carry [10,11].

In the present study, eggs treated with vegetable oil and stored under the ambient temperature produced excellent physical and protein qualities. Eggs treated with shea butter also produced better qualities than the untreated eggs, but not as well as those treated with vegetable oil. The findings in the present study compared favourably with the work of Obanu and Mpieri [21], as well as with that of Nongtaodum et al [7]. Obanu and Mpieri [21] used ground nut, cotton seed and coconut oils, while Nongtaodum et al [7] used soybean, coconut, rice bran and palm oil in eggs preservation. All the oils in both studies were effective in preserving internal qualities of table eggs with all the parameters they considered. In the present study, AA grade was maintained for 36, 22, and 15 days for soybean oil coated, shea butter coated and control eggs respectively. The oil coated eggs in the work of Nongtaodum and co-workers [7] maintained AA grade for 3 weeks and at week 5 the oil coated eggs have changed to A grade, while the control in the experiment went below B grade. In the present study, the control eggs fell below B grade at the 5th week, while the soya oil treated eggs maintained A grade up to the 7th week and the shea butter treated eggs maintained A grade up to the 4th week and B grade at 6th week.

Eke et al [18] reported that the internal quality of oiled eggs stored under the tropical Nigerian ambient temperature over a period of 4 weeks compared favourably with that of refrigerated eggs. The protein qualities of vegetable oil treated eggs in this study compared favourably with those obtained for refrigerated eggs in the earlier work of Okiki et al [17]. This study however demonstrated the superiority of the protein qualities of eggs treated with vegetable eggs over those treated with shea butter and the untreated eggs; with rate of protein deterioration: vegetable oil treated < shea butter treated < untreated eggs. Owolabi and coworkers [22] experimental studies showed that coating of eggs with vegetable oils did not stop microbial multiplication within the eggs, but was effective in preventing deterioration, maintaining interior quality, the yolk height and physical appearance of the eggs compared to the uncoated eggs.

Nongtaodum et al [7] established experimental evidence that the fatty acids contents of vegetable oils play a significant role in egg preservation, aside the oil covering the egg pores. Soybean oil possesses alpha-linolenic acid, linoleic acid, oleic acid, stearic acid and palmitic acid [23], while shea butter is a triglyceride (fat) derived mainly from oleic acid, stearic acid, linoleic acid, palmitic acid, linolenic acid and arachidic acid [24]. The fatty acids present in the soybean oil and shea butter could have contributed to the positive result obtained in this study, in their effectiveness in egg preservation.

In conclusion, coating table eggs with vegetable oil and shea butter could be effectively used to preserve eggs quality thereby reducing wastage, especially during glut in environment where there are no refrigeration opportunities for eggs.

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