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# Effect of Edible Oil Coating on Physico-Functional Properties and Shelf Life of Chicken Eggs Stored at Room Temperature

T.M.C. PERERA and H.K.J.P. WICKRAMASINGHE

*Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 60170, Sri Lanka*

## ABSTRACT

**Physico-functional properties weight loss (%), Haugh Unit, Yolk Index, yolk pH, albumen pH, air cell depth, foaming capacity (%), foaming stability (%) and gelling strength) of edible oil coated (coconut oil, palm oil and sunflower oil) and uncoated (control) chicken eggs stored at room temperature (32 °C) were evaluated. There was a significant effect ($p<0.05$) of edible oil coating on weight loss (%), Haugh unit, yolk index, albumen pH and air cell depth regardless of the oil type treated at 32 °C. All oil coated eggs showed a significantly low weight loss (%) than those of uncoated eggs. Meantime, Haugh units indicated that coconut oil coated eggs remained in grade "A" up to three weeks of storage whereas uncoated eggs changed from grade "A" to grade "B" after one week of storage and the thick albumen was absent in uncoated eggs after four weeks of storage. Yolk index values of all coated eggs were significantly higher than those of uncoated eggs. Regardless of the oil type all the coated eggs maintained albumen pH value above 8.0 and significantly lower values than coated eggs. There was no significant effect ($p>0.05$) observed in storage time on functional properties regardless of the treatment at 32 °C. Results indicate that edible oil coatings act as a protective barrier for quality deterioration and can be used as a method of preserving eggs in room temperature in Sri Lanka.**

**KEYWORDS:** Edible oil, Eggshell coatings, Egg quality, Functional properties

## INTRODUCTION

Chicken eggs are called incredible edible eggs (Stadelman, 1999) and are the most popular eggs in human consumption (Al-Nasser *et al.*, 2007). They are an inexpensive source of high-quality protein and other nutrients. However, immediately after shell eggs are laid, the aging process of eggs begins by altering the internal qualities and functional properties. This happened due to the loss of moisture and Carbon dioxide *via* the egg shell pores. Therefore preservation of eggs are needed to extend the shelf life of eggs. When egg preservation is considered, it is done mainly on time and temperature management and by the use of coatings on the shell (Yuceer and Caner, 2014). There are many methods to preserve shelled eggs such as dry packing, immersing in liquids, oil coating and refrigeration *etc.* Out of them refrigeration is very effective in preserving egg quality (Nongtaodum *et al.*, 2013) and the temperature management is used in this method. However refrigeration of eggs may be seldomly practiced in some developing regions of the world (Ryu *et al.*, 2011). Thus this situation can be seen in many rural areas of Sri Lanka too. Most of small scale retailers store their shell eggs in room temperature. Therefore, an alternative method, that is inexpensive yet effective, to preserve the internal quality of eggs is needed. Surface coating is another method to preserve egg quality (Nongtaodum *et al.*, 2013). Past studies have revealed numerous surface coating materials such as chitosan, shellac, mineral oil, and waxes to be efficient in reducing accumulations transfer by sealing pores and aid in preservation egg quality (Mayer and Spencer, 1973; Wong, *et al.*, 1996; Caner, 2005). However the information on physico-functional properties of eggs after applying edible oil coatings is scarce in Sri Lanka.

Therefore the main objective of the present study was to evaluate the effect of edible oil coatings (coconut oil, palm oil and sunflower oil) on physico-functional properties of chicken eggs during storage at room temperature of Sri Lanka. Meanwhile, the specific objective of this study was to find out the most effective edible oil that can be used as a coating for chicken eggs with minimum changes of its physico-functional properties during storage at room temperature in Sri Lanka.

## MATERIALS AND METHODS

### *Experimental Site*

The study was carried out in the laboratory of the Department of Plantation Management and in the laboratory of the Department of Livestock Fisheries and Nutrition, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), situated in the Low Country Intermediate Zone ($IL_{1a}$) at an elevation of 300 m above mean sea level. The mean temperature and the mean relative humidity at Makandura during the experimental period were 32 °C and 68%, respectively. The experiment was conducted during the period from January to February 2016.

### *Collection of Materials*

Five hundreds of freshly laid (1-day-old), unwashed, faeces-free, brown shell (from 38-weeks old Hyline breed hens), large size eggs(55 g-65 g) supplied from Switz Lanka Layer Farm (Mahakumbukkadawala, Puttalam, Sri Lanka) were used in the present study. All three types of oil were obtained from the local market.

### *Treatment of Eggs*

Four hundreds and eighty eggs were randomly divided into four treatments; coconut oil coated eggs ($T_1$), palm oil coated eggs ($T_2$), sunflower oil coated eggs ($T_3$) and uncoated eggs ($T_4$) with three replicate per treatment. The eggs were immersed individually by hand in the coating solutions for 1 min (first layer of coating), then immersed again for 1 min (second layer of coating) and finally dried at ambient temperature for 24 hours. Uncoated eggs served as control. The eggs were subsequently placed in open moulded plastic egg trays and stored under ambient laboratory conditions (32 °C with 68% relative humidity) for four weeks.

### *Measurement of the Internal Quality Characteristics of Eggs*

In each week, eggs were weighed and weight loss (%), Haugh Unit (HU), Yolk Index (YI), albumen pH, yolk pH and air cell depth were determined. Weight loss (%) was calculated and the albumen pH and the yolk pH were measured as described by Caner (2005). Haugh Unit was measured as described by Haugh (1937) and yolk index (%) was calculated as described by Funk (1948) while the air cell was measured as described by Wickramasinghe *et al.* (2013).

### *Measurement of Functional Properties of Eggs*

*Measurement of Foaming Properties*

Foaming properties, foaming capacity (%) and foaming stability (%) were measured as described by Ferreira *et al.* (1995).

*Measurement of Gelling Strength*

Whole eggs were broken in to 50 mL plastic containers and homogenized at 1500 rpm for one min with the analog magnetic stirrer (Scilogex, CT, USA). Then they were kept in a preheated water bathe at 85 °C for 30 min. After gel had been formed, the gelling strength was measured with a penetrometer (FT 011, David Bishop Instruments, London). The measurements were taken in $kgfcm^{-2}$ and converted to Pascal.

### *Statistical Analysis*

The data were analyzed using Complete Randomized Design by making use of Statistical Analysis System (SAS 9.4) and the Least Significant Difference (LSD) test was used to detect significant differences between the means.

## RESULTS AND DISCUSSION

### *Effect of Edible Oil Coating on Quality Characteristics of Eggs*

*Weight Loss (%)*

Weight loss of eggs during storage is caused mainly by evaporation of water and loss of carbon dioxide through the porous shell (Caner, 2005). In present study, regardless of the treatment, weight loss (%) of eggs has increased with the storage period (Table 1) at 32 °C. Treatment four showed significantly higher weight loss (%) during the storage period ($p \leq 0.05$) with compared to $T_1$, $T_2$ and $T_3$. These results are in agreement with Wong *et al.* (1996), who found that corn, wheat gluten, soy protein isolate, mineral oil and egg albumen exhibited less weight loss than uncoated eggs. Caner (2005) also reported that the lowest weight loss (0.526%) was observed in shellac-coated eggs.

The differences in weight loss among studies can be due to the storage period, temperature, egg size or shell porosity (Bahale, *et al.,* 2003). Different coating materials can enhance protective barrier properties of shell eggs and minimize the weight loss, thus helping to extend shelf life.

*Haugh Unit*

The Haugh unit is an expression relating egg weight and height of thick albumen. The higher the Haugh value, the better the albumen quality of the egg (Stadelman, 1995). In overall assessment, the Haugh unit significantly decreased with increasing storage period ($p<0.05$) and the Haugh unit of $T_4$ decreased more rapidly than did in coated eggs (Table 2). Treatment one did not show a significant difference ($p>0.05$) of mean Haugh value until the 3rd week. Treatment two and $T_3$ showed a significant difference after two weeks of storage and $T_4$ showed a significant difference ($p<0.05$) after one week of storage. These results of the present study were in agreement with Bhale *et al.* (2003) and also Wong *et al.* (1996). All coated eggs maintained better grades than $T_4$ (Table 2).

**Table 1. Mean values of weight loss (%) of coated and uncoated eggs during storage time at 32 °C**

| Treatment | Storage time (weeks) | | | |
|---|---|---|---|---|
| | Week 1 | Week 2 | Week 3 | Week 4 |
| $T_1$ (Coconut oil) | $0.28917 \pm 0.0817^{b,y}$ | $0.4708 \pm 0.1689^{b,y}$ | $0.4958 \pm 0.1146^{b,y}$ | $0.8842 \pm 0.6377^{b,x}$ |
| $T_2$ (Palm oil) | $0.28667 \pm 0.1021^{b,y}$ | $0.3408 \pm 0.1184^{b,y}$ | $0.3933 \pm 0.1130^{b,y}$ | $0.5792 \pm 0.3126^{b,x}$ |
| $T_3$ (Sunflower oil) | $0.27583 \pm 0.0847^{b,z}$ | $0.4283 \pm 0.1280^{b,yz}$ | $0.7050 \pm 0.3360^{b,xy}$ | $0.8100 \pm 0.8304^{b,x}$ |
| $T_4$ (Control) | $0.94833 \pm 0.2354^{a,z}$ | $2.7833 \pm 0.5062^{a,y}$ | $4.5492 \pm 1.0971^{a,x}$ | $4.9508 \pm 1.1281^{a,x}$ |

*Means with different superscripts (a,b) within a column indicate significant differences ($p \leq 0.05$). Means with different superscripts (x,y,z) within a row indicate significant differences ($p \leq 0.05$).*

**Table 2. Mean values of Haugh Unit and grades* of coated and uncoated eggs during the storage time at 32 °C**

| Treatment | Storage time (weeks) | | | | |
|---|---|---|---|---|---|
| | Week 0 | Week 1 | Week 2 | Week 3 | Week 4 |
| $T_1$ | $68.56 \pm 0.7257^{a,x}$ | $65.753 \pm 3.1684^{a,x}$ | $63.04 \pm 3.3793^{a,xy}$ | $62.74 \pm 3.6232^{a,xy}$ | $57.48 \pm 5.1201^{a,y}$ |
| | A | A | A | A | B |
| $T_2$ | $68.56 \pm 0.7257^{a,x}$ | $63.350 \pm 4.4036^{a,x}$ | $44.34 \pm 9.7456^{ab,y}$ | $43.61 \pm 4.5382^{ab,y}$ | $38.09 \pm 6.5762^{b,y}$ |
| | A | A | B | B | B |
| $T_3$ | $68.56 \pm 0.7257^{a,x}$ | $58.130 \pm 6.9722^{ab,x}$ | $46.81 \pm 6.3996^{ab,xy}$ | $41.11 \pm 2.3367^{ab,y}$ | $41.04 \pm 10.6207^{b,y}$ |
| | A | B | B | B | B |
| $T_4$ | $68.56 \pm 0.7257^{a,x}$ | $51.560 \pm 3.8399^{b,xy}$ | $36.50 \pm 22.2340^{b,xy}$ | $28.52 \pm 28.9649^{b,y}$ | - |
| | A | B | B | C | - |

*Means with different superscripts (x,y) within a row indicate significant differences ($p \leq 0.05$). *A-Haugh unit value from 71 to 60, B-from 59 to 31, C-below 30, $T_1$-Coconut oil coated eggs, $T_2$-Palm oil coated eggs, $T_3$-Sunflower oil coated eggs, $T_4$-Control*

*Yolk Index (YI)*

The spherical nature of egg yolk can be expressed as Yolk Index (Stadelman, 1995). Yolk Index is an indication of freshness of the egg. It indicates a progressive weakening of the vitelline membranes and liquefaction of the yolk caused mainly by the diffusion of water from the alumen (Obanu and Mpieri, 1984)A fresh good quality egg has a Yolk Index (%) of around 45% and older yolk would have a lower index (%) (Senkoylu, 2001). In the present study, $T_1$, $T_2$ and $T_3$ maintained a significantly higher yolk Index (%) than $T_4$ during the storage time at 32 °C. The Yolk Index (%) value of uncoated eggs (23.020 %) in the 1st week was less than the Yolk Index (%) of all three types of coated eggs ($T_1$ = 24.383%, $T_2$= 24.650% and $T_3$ = 27.677%) in the 4th week. These results are in agreement with those of Obanu and Mpieri (1984) and Caner (2005).

*Albumen pH and Yolk pH*

The albumen pH of a newly laid egg is about 7.6-8.0 and an egg initially contains about 30 mL of dissolved carbon dioxide existing in the carbonate form, all in the albumen (Caner, 2005). After egg is laid, with the time moisture and carbon dioxide in the albumen evaporate through the pores. Due to this, the egg pH becomes more basic and pH eventually increases to 8.9-9.4 and structural changes happen in the albumen (Akyurek and Okur, 2009).

In this study, the albumen pH of all four treatments was increased with the time ($p>0.05$). During all four weeks, the albumen pH of $T_4$ was significantly different with the albumen pH of coated eggs ($p<0.05$). According to these results, egg shell coating decreases the carbon dioxide permeation through the egg shell pores because these coating materials act as a barrier to the carbon dioxide and moisture movement through the egg shell. The results are in agreement with those of Caner (2005), Nongtaodum *et al.* (2013) and of Ryu *et al.* (2011).

Meantime, in the present study, all four treatments showed a slight increase of the yolk pH with the time. There was no any significant difference ($p>0.05$) for treatments in any week except in the 2nd week. In the 2nd week the yolk pH values of $T_1$ and $T_2$ were significantly less than the yolk pH values of $T_3$ and $T_4$. The present results of the study were in agreement with Mudau (2007) and he reported that there was no any significant difference for the treatment × storage time interaction effect for yolk pH values of mineral oil coated and uncoated eggs at 32 °C.

*Air Cell Depth*

As the egg ages, the egg air cell size increases due to the loss of carbon dioxide and moisture through the shell pores (Bradley and King, 2004). In the present study, regardless of the treatment; all the four treatments showed an increase of the air cell with the time. Treatment one and $T_4$ showed a significant increase ($p<0.05$) of the air cell depth with the storage time while $T_2$ and $T_3$ did not show a significant increase ($p>0.05$) of air cell depth.

The air cell depth values of all coated eggs in the 4th week were less than the value of $T_4$ in 2nd week. These results are in agreement with those of Senadheera *et al.* (2014).

### *Effect of Edible Oil Coating on Functional Properties of Eggs*

Functional properties of eggs refer to the attributes of eggs that make them a useful ingredient in food products. Foaming and gelling are two most important functions of eggs (Yang and Baldwin, 1995). The functional properties of chicken eggs are affected by temperature and storage. When eggs are stored the conversion of ovalbumin in to S-ovalbumin and the dissociation of the ovomucin-lysozyme complex result in decreasing gelling and foaming properties and liquefaction of albumen. These reactions are due to the rise in the pH (Mudau, 2007).

#### *Foaming properties*

Foam is a colloidal dispersion in which a gaseous phase is dispersed in a liquid or solid phase (Yang and Baldwin, 1995). Globulins, ovomucin and ovalbumin are proteins in albumin that are responsible for the foaming properties of albumin and the foam of these egg proteins provides lightning and a volume to the food products such as angel food cakes, sponge and chiffon (Mudau, 2007). Foaming Capacity (FC) and Foaming Stability (FS) are important criteria of foaming properties (Mine, 1995). In the present study, regardless of the treatment there was no significant different of FC and FS within time and also within treatments during the experiment period at 32 °C (Table 3).

#### *Gelling Strength*

Gelation is an orderly aggregation of proteins, which may or may not be denatured, forming a three-dimensional network. Egg proteins coagulate or thicken when heated. They have the ability to attract and hold large quantities of liquid thus forming a gel or coagulum (Yang and Baldwin, 1995). This quality makes eggs useful as a thickening agent in food products such as cakes, custards, sauces, scrambled, hard cooked and fried eggs (Mine, 1995). Ovalbumin and conalbumin are important to gelling properties (Mudau, 2007). In the present study, there were no any significant differences observed for Gelling Strength of coated and uncoated eggs during the storage time at 32 °C. The gelling strength values have decreased with the time in all 4 treatments (Table 3). These results are in agreement with Senadheera *et al.* (2014) who reported that regardless of the treatment there was no significant difference in functional properties of eggs stored at room temperature.

## CONCLUSIONS

Results revealed that the effectiveness of edible oil coats (coconut oil, palm oil and sunflower oil) for maintaining the quality of eggs during storage was significant in several indices namely weight loss (%), HU, YI, albumen pH and air cell depth at 32 °C. All three types of oil coated eggs maintained a significantly low HU, YI and weight loss decrement and significant less increment of albumen pH than the uncoated eggs. These results also indicated that use of these oils as coatings does not affect the functional properties of eggs. Based on overall results coconut oil can be considered as the most effective edible oil for surface coating of eggs at 32 °C.

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**Table 3. Mean values of functional properties of coated and uncoated eggs during the storage time at 32 °C**

| Functional property | Treatment | Storage time (weeks) | | | | |
|---|---|---|---|---|---|---|
| | | Week 0 | Week 1 | Week 2 | Week 3 | Week 4 |
| Foaming Capacity (FC) | $T_1$ | 75.56±5.09$^{a,x}$ | 68.89±20.37$^{a,xy}$ | 45.55±13.47$^{a,z}$ | 50.00±10.00$^{a,yz}$ | 50.00±3.33$^{a,yz}$ |
| | $T_2$ | 75.56±5.09$^{a,x}$ | 64.44±7.70$^{a,x}$ | 45.56±11.71$^{a,y}$ | 43.33±3.34$^{a,y}$ | 48.89±10.18$^{a,y}$ |
| | $T_3$ | 75.56±5.09$^{a,x}$ | 53.33±6.67$^{a,y}$ | 32.22±15.75$^{a,z}$ | 53.33±10.00$^{a,y}$ | 45.56±12.62$^{a,yz}$ |
| | $T_4$ | 75.56±5.09$^{a,x}$ | 77.78±10.18$^{a,x}$ | 38.89±17.10$^{a,y}$ | 35.55±3.85$^{a,y}$ | 45.56±1.93$^{a,y}$ |
| Foaming Stability (FS) | $T_1$ | 96.67±3.34$^{a,x}$ | 96.67±3.34$^{a,x}$ | 95.56±1.93$^{a,x}$ | 93.33±0.00$^{a,x}$ | 96.11±2.55$^{a,x}$ |
| | $T_2$ | 96.67±3.34$^{a,x}$ | 95.56±1.93$^{a,x}$ | 95.55±3.85$^{a,x}$ | 95.56±1.93$^{a,x}$ | 96.67±3.34$^{a,x}$ |
| | $T_3$ | 96.67±3.34$^{a,x}$ | 94.44±1.93$^{a,x}$ | 96.67±0.00$^{a,x}$ | 94.44±1.93$^{a,x}$ | 95.56±1.93$^{a,x}$ |
| | $T_4$ | 96.67±3.34$^{a,x}$ | 93.33±0.00$^{a,x}$ | 96.67±3.34$^{a,x}$ | 96.67±3.34$^{a,x}$ | 96.67±0.00$^{a,x}$ |
| Gelling Strength (GS) | $T_1$ | 81722±7489$^{a,x}$ | 67012±14154$^{a,xy}$ | 52302±10207$^{a,yz}$ | 45764±2830$^{a,z}$ | 50668±11323$^{a,yz}$ |
| | $T_2$ | 81722±7489$^{a,x}$ | 73550±12972$^{a,x}$ | 60474±14154$^{a,x}$ | 49033±8492$^{a,x}$ | 62109±18563$^{a,x}$ |
| | $T_3$ | 81722±7489$^{a,x}$ | 80088±7489$^{a,x}$ | 55571±7489$^{a,yz}$ | 44130±0.00$^{a,z}$ | 68647±9806$^{a,xy}$ |
| | $T_4$ | 81722±7489$^{a,x}$ | 75184±2830$^{a,x}$ | 76819±10207$^{a,x}$ | 58840±8492$^{a,y}$ | 49033±4903$^{a,y}$ |

*Means with different superscripts (x,y,z) within a row indicate significant differences ($p \leq 0.05$). $T_1$- Coconut oil coated eggs, $T_2$- Palm oil coated eggs, $T_3$- Sunflower oil coated eggs, $T_4$- Control*

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