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EFFECT OF OIL PRE-TREATMENTS ON THE STORAGE QUALITY OF CHICKEN FRESH SHELL-EGGS

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Abstract
Shell eggs undergo significant quality deterioration during storage. Inexpensive, yet effective methods for their preservation are needed. The effect of oil pre-treatments on the quality of stored fresh shell-eggs was studied. These involved coating with cold vegetable oil (COTE), antibiotics in oil (AOTE), and hot oil treatment (HOTE), while untreated eggs served as control (UNTE). The stored eggs were analyzed for their physical, nutrient, functional, microbial and sensory properties. The results showed a significant ($p< 0.05$) reduction of egg weight in UNTE (59.13-50.63g), with increased airspace (1.10-3.80mm) compared to untreated eggs. Among the treated eggs, COTE had the highest reduction in haugh units (85.10-65.28) and UNTE had lowest moisture content (43.25%).The protein content of UNTE (21.43-16.31%), and pretreated eggs (22.04-19.10%) decreased at the end of storage. The decline in foam (101.10-9.33%) and emulsifying (45.00-24.52%) properties were more severe in the control (UNTE). Coliforms were detected in UNTE and COTE ($< 10^1$Cfu/ml)) at the end of egg storage. The overall sensory acceptability showed preference for COTE (5.75) and AOTE (5.25) egg samples. Treatment with cold vegetable oil gave the best protective effect in most parameters evaluated.

Keywords: Egg qualities, emulsifying, haugh, oil, and sensory acceptability

Introduction

Eggs have been a human food source since the beginning of its existence on earth (Dudusola, 2009). It provides means in the diet through which the animal protein requirement of the population can be met. It has various uses and contains many essential nutrients as it supports life during embryonic growth (Scott and Silversides, 2001). Egg is one of the most nutrient rich and complete foods known to man (Shittu and Ogunjinmi, (2011); Onyenweaku *et al.*, 2018).Freshness is a major contribution to the egg quality. Shell eggs undergo significant physical, chemical, structural and physiological changes during storage. Easily observable physical changes include an increase in the air cell, thinning of the albumen (the part surrounding the yolk), and flattening of the yolk. The air cell increases as a result of loss of water and CO_2 through the shell and due to physiochemical changes in the albumen and yolk (Okiki and Ahmed, 2017). The internal quality of eggs begins to deteriorate after they have been laid due to loss of moisture and carbon dioxide via the eggshell pores (Nongtaodum, 2013). Egg spoilage during storage has been attributed to gaseous (CO_2) 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 fertilized eggs), and absorption of foreign odors (Okiki and Ahmed, 2017).The shell of the egg is porous to admit the passage of air in and out, but is coated with a mucilaginous matter, which prevents the entrance of bacteria unless it is very old, wet, softened by moisture, rubbed off or otherwise the keeping quality of the egg is much reduced (Shittu and Ogunjinmi, 2011). Therefore, eggs should not be washed, held in damp musty places, or handled more than necessary, and should be marketed or preserved as soon after laying as possible (Barbosa, 2004; Okiki and Ahmed, 2017).Many methods employed in shell-eggs preservation have not been entirely successful, which suggest that these methods are not effective in protecting the natural structure of the shell, so that air bearing germs that are responsible for the deterioration of shell-eggs may be completely eliminated (Shittu and Ogunjimni, 2011; Nahed *et al.,* 2014). Storage of shell

eggs in refrigerators is most effective way of preserving egg quality. The problems associated with refrigeration storage is the high cost, and erratic electricity supply in Nigeria, and other developing countries, with the situation worst in rural communities. Therefore, need to exploit other egg preservation options that do not involve electricity. An alternative method that is inexpensive yet effective, to preserve the internal quality of eggs, and to prevent microbial contamination is needed (Ryu *et al*., 2011). Surface coating of shell-eggs is increasingly becoming a cost effective viable alternative to extend the shelf-life (Nongtaodum *et al*., 2013; Morsy *et al*., 2015). This requires some innovations in use of coating as a method of shell-egg preservation. Therefore, this research investigated the effects of coating shell-eggs in cold, hot and antibiotic-treated oils on some quality indices of stored shell-eggs.

Materials and Methods

Source of Samples

Freshly laid eggs were collected from Umudike Poultry farm, Michael Okpara University of Agriculture. The vegetable oil (Tesco pure vegetable oil) was sourced from Orie Ugba market, while the oil soluble antibiotics (streptomycin) was sourced from Oyems Pharmaceuticals, both in Umuahia North Local Government Area, Abia State, Nigeria.

Treatment of samples

The eggs were candled to ensure there were no crack or blood spots. One hundred and sixty-eight (168) eggs were collected and divided into four (4) groups, comprising of forty-two (42) eggs per batch. The first batch served was untreated and served as control (UNTE). The second batch was treated with cold vegetable oil by immersion for 5 minutes (COTE). The third batch was also treated with cold vegetable oil with antibiotics (2000mg of streptomycin in 1000ml of vegetable oil) by immersion for 5 minutes (AOTE). The fourth batch was treated with hot vegetable oil (80°C)by immersion for 2 minutes (HOTE). All the eggs were stored at room temperature (30.0±5°C) for 70 days. Sampling for the internal and external qualities of the raw shell-eggs was done at the beginning (day 1) and end of 70 days of storage.

Methods of Analyses

Evaluation of physical qualities: Weight (gram) of shell-egg was measured in triplicates using electronic balance. Egg weight loss was determined as the difference between successive weights of eggs at different weighing days (Torrico *et al*., 2011). The internal qualities of the eggs were determined by methods described by Ryu *et al*., (2011). Yolk height and width (cm) was measured using a caliper. Yolk index was estimated from ratio of yolk height to yolk width. The airspace was measured using a caliper by placing the flattered side of the egg upward, and flashing light through the pointed end. The method described by Morsy *et al.* (2015), was used in determining the Haugh unit, as function of height and width of the albumen and yolk in each egg.

Chemical analysis: The method described by AOAC (2006) was used in determining proximate composition of the samples which includes moisture, ash, fat, proteins and total carbohydrate was calculated by difference.

Functional analysis: Functional properties (foam and emulsion capacities, and gelatinization temperature) of the liquid whole egg (internal contents of yolk and white mixture) were determined by the method described by Onwuka (2018).

Microbial analysis: This was determined using the method described by Okaka and Ene (2005). 1ml of each sample was homogenized in 10ml of sterile peptone water. A 10-fold serial dilution of the sample was prepared and inoculated into sterile molten plate count agar (PCA) for total viable count, MacConkey agar for coliforms and Malt extract agar for fungi counts. The plates were allowed to solidify, incubated at 37°C and growths were enumerated after 48hours for bacteria and coliform counts, and 7 days for fungi counts. The results were expressed as colony forming unit per ml of sample (Cfu/ml).

Sensory evaluation: After storage period of 10 weeks, the shell-egg samples were boiled in tap water for 10 minutes and allowed to cool to ambient temperature. The boiled egg samples were presented to 15 semi-trained panelists, comprising of staff and students of Food Science and Technology Department of Michael Okpara University of Agriculture, Umudike, for sensory evaluation of ease of peeling, surface smoothness, taste, aroma, texture and general acceptability, using a 9-point Hedonic scale that ranged from 1(dislike extremely) to 9(like extremely) as described by Iwe (2007).

Experimental Design and Data Analysis: The experimental design was Complete Randomized Design (CRD). Data were expressed as mean of triplicate determination presented as mean ± standard deviation. The results obtained were subjected to Analysis of Variance (ANOVA) using statistical package for social sciences (SPSS version 20). Means were separated using Duncan's multiple Range Test (DMRT). Significant difference was determined at $P < 0.05$.

Results and Discussion

Physical properties of stored shell-eggs

The results of the physical properties of shell-eggs at the beginning and end of 70 days of storage are presented in Table 1. The results showed changes in weight of the stored shell-eggs. There was reduction in weight across the samples at the end of storage. However, the weight of the untreated egg sample (UNTE) had more significant ($p<0.05$) reduction from 59.13g to 50.63g. Among the treated samples, HOTE had least reduction in weight (7.13%), followed by AOTE (10.27%). The treated samples had more percentage weight loss (7.13-11.52%) than 2% reported by Okiki and Ahmed (2017) for fresh eggs coated with vegetable oil, and stored for 50 days. These results also corroborate report by

Barbosa (2004) who observed egg weight loss with increased storage period. Torrico *et al.* (2011) stated that mineral oil coatings minimized weight loss (0.5%) for at least 3 weeks longer than those observed for non-coated eggs at 25°C. Scott and Silversides (2001) attributed egg weight loss to be principally from loss in albumen weight. The slow reduction in weight of HOTE could be attributed to the pre-treatment with hot vegetable oil, which provided a more protective coating resulting from the coagulation of shell membrane, thus preventing porous passage of air in and out of the shell (Shittu and Ogunjimni, 2011). Weight loss in eggs occur through evaporation and varies depending on the storage time, room temperature, relative humidity and shell porosity(Ryu *et al.,* 2011; Naheed *et al.,* 2014; Almeida *et al*., 2016). There was increase in airspace in all the egg samples at end of storage (Table 1). The increase in airspace was more pronounced in the control sample UNTE (1.20 – 3.80 mm) followed by COTE (1.25 – 3.05 mm). The hot oil treated sample HOTE had the least increase in air-space (1.05 – 2.00 mm). An air space forms when the contents of the egg cool and contract after the egg is laid. The air cell grows larger as the egg ages. Airspace measures the freshness of the egg without having to break the egg (Nahed *et al*., 2014). The airspace of the samples showed significant ($p<0.05$) difference at the end of storage. Temperature, humidity, air movement and storage time have adverse effects on interior quality. These factors cause loss of moisture in shell-eggs through the pores (Shittu and Ogunjinmi, 2011; Okiki and Ahmed (2017). As egg ages, moisture and carbon dioxide leave through the pores of the shell, air enters to replace them and the air cell becomes larger (Shittu and Ogunjinmi, 2011). The small airspace in HOTE implied that the samples are fresher, and had better protection among the treated samples. There was no significant ($p>0.05$) difference in the Haugh units of both untreated and treated shell-eggs at the start of storage. There was decrease in Haugh unit (HU) values at the end of storage period in all the samples. The control sample (UNTE) had the lowest HU (50.70) after the storage period compared to the treated ones. Among the treated shell-eggs, COTE had the highest reduction in HU (85.10-65.28) compared to AOTE (86.20-67.43) and HOTE (85.04-78.49).The HU showed significant ($p<0.05$) variations in the samples with respect to the treatment given. Almeida *et al*. (2016) reported a decrease of HU for uncoated (86.60-37.80) and coated (85.80-56.50) shell eggs after 42 days of storage. HU reduction during storage is due to thinning of the albumen as it loses CO_2(Morsy *et al*., 2015). HU values decrease is associated with a reduction in internal egg quality (Almeida *et al*., 2016). The efficacy of oil coating in egg preservation as shown by treated samples has been attributed to the ability of the oil to block the pores of the shell-eggs, thereby preventing the flow of air in and out of eggs and degradation by microbes such air may carry (Scott and Silversides, 2001). Thus, at the end of the storage period, HOTE had better protection. Variations between COTE and AOTE could also be attributed to the inclusion of antibiotics, which further facilitated the blockage of the air pores resulting in improved protection in AOTE during storage. In hot oil treatment (HOTE), the pores were not only blocked by the oil, heating further coagulated the shell membrane between the egg shell and albumen, thereby preventing the rapid loss of carbon dioxide (Shittu and Ogunjinmi, 2011; Okiki and Ahmed, 2017). Nongtaodum (2013) also reported decrease in HU with increase in storage time and significant difference between vegetable oil coated eggs and uncoated eggs. According to USDA (2011), eggs with HU of 97.00-60.00 represent high internal quality, while those with HU of 59.00-0.00 represent low quality. It could therefore be inferred that, the untreated shell-eggs (UNTE) had poorer internal qualities than oil treated shell-eggs at end of storage period.

Yolk index

At the beginning of storage, the yolk index (YI) of untreated egg samples UNTE (0.96) were not significantly ($p> 0.05$) different from YI of treated shell-eggs (0.97-0.99). The YI is an indication of the freshness of egg. And the value of 1 is considered the peak of fresh quality (Morsy *et al*., 2015). However, similar to the Haugh unit, YI of untreated eggs (UNTE) was significantly ($p<0.05$) lower (0.56) than that of treated egg samples (0.62-091) at the end of storage. Similar trend was reported by Almeida *et al*. (2016) for coated (0.44-0.34) and uncoated (0.44-0.32) shell eggs after 42 days of storage. Morsy *et al.* (2015) also reported that the yolk index of uncoated eggs stored at room temperature reduced to 0.22 after 5 weeks and 0.36 and 0.38 for pullulan and pullulan-nisin coated eggs respectively. The hot oil treated eggs (HOTE) had the highest YI of 0.91. The reduction in yolk index was basically due to the decrease in yolk height. This suggests that the use of cold vegetable oil alone provided less protection than vegetable oil that contains antibiotics and hot vegetable oils. Yolk Index (YI) as a measure of egg freshness indicates the progression of deterioration of vitelline membranes, and liquefaction of the yolk caused by diffusion of water from the albumen (Scott and Silversides, 2001). The high YI value of HOTE (0.91) suggests better preservation in egg quality than other treated samples.

Chemical composition of stored shell-eggs

The result of proximate composition of the eggs at the beginning and end of storage are presented in Table 2. The moisture content of the studied samples were not significantly ($p>0.05$) different at the beginning of storage. The moisture content ranged from 64.10 (HOTE) to 65.24% (UNTE), and 43.25% (UNTE) to50.40% (HOTE) for start and end of storage respectively. This reduction implied significant ($p<0.05$) moisture losses during storage. Notably, the untreated eggs (UNTE) had lowest moisture content (43.25%), while HOTE had the highest (50.40%) at the end of storage. COTE (47.15%) and AOTE (47.55%) showed no significant ($p<0.05$) difference in their moisture loss. These findings suggest that hot vegetable oil provided better barrier to moisture loss than other treatments. The loss of moisture in untreated samples is

an indication of reduction in quality with storage period, and it's undesirable in keeping egg quality. The moisture content refers to the amount of water present in a food material, and amount of water varies from low amount in dry food to high amount in high moisture foods (Ndife *et al*., 2015; Fatai *et al.,* 2015).Protein was the highest nutrient in the egg samples. However, the protein decreased significantly ($p<0.05$) with storage period in all the egg samples. The control sample (UNTE) had the highest reduction among the shell-eggs with values of 21.43% (before storage) and 16.31% (end of storage).HOTE had the lowest reduction at the end of storage (25.10%), while AOTE and COTE showed no significant ($p>0.05$) difference at the end of storage with values of18.83% and 18.70% respectively. Okiki and Ahmed, (2017) demonstrated the superiority of the protein qualities of eggs treated with vegetable eggs (71.43%) over those treated with shea butter (54.29),and the untreated eggs (40%), after ambient storage for 50 days. The reduction of protein in HOTE implied better protective effect of hot vegetable oil. Reduction in protein content is also an indication of quality loss. The results show that the egg samples will be rich sources of protein when consumed will help in reducing the incidence of protein energy malnutrition (PEM). Eggs have been found to contain all the essential amino acids required for growth (Fatai and Oginni, 2015; Onyenweaku *et al*., 2018).The fat content of the egg samples at the beginning of storage (11.63-12.54%) was significantly ($p<0.05$) higher than the values recorded at the end of storage (9.33-11.89%). Reduction of about 2% was observed in the fat content of the control (UNTE),while in the treated samples, the fat reduction was approximately about 12% with values of 11.63 to 10.99% for COTE, 12.54-11.89% for AOTE and 12.25-11.85% for HOTE. These findings signified that the fat content was less affected by the compositional changes in coated eggs during storage. Barbosa, (2004), reported that the storage period of uncoated eggs had significant effect on lipid oxidation of their yolks, resulting in decrease of nutritive value and sensory characteristics. Generally, fat are reservoir of some vitamins, and provide energy when consumed (Gordon, 2002).The ash content of the egg samples was higher at the beginning of storage (1.50-1.55%), but experienced slight reduction at the end of storage (1.05-1.45%), with no significant ($p>0.05$) difference among the samples at the beginning and end of storage. However, the control sample (UNTE) showed more reduction (1.55%-1.05%) than in the treated samples. Among the treated samples, more reduction was observed in COTE (from 1.50%-1.15%), followed by AOTE (from 1.51%-1.35%), while HOTE (from 1.55%-1.45%) had the lowest reduction in ash content. The values obtained in this study are in close range with those recorded by Fatai and Oginni (2015).Ash content represents the presence of appreciable amount of mineral in a given sample. Samples with high ash content are expected to have high concentration of various mineral elements, which help to speed up metabolic processes, improve growth and development. Onyenweaku *et al.* (2018) stated that carbohydrate contents of eggs are in trace amounts. The chemical composition of the shell-eggs especially the coated samples will no doubt enhance nutritional status when consumed

Functional properties of stored shell-eggs

The results of functional properties of the studied egg samples are presented in Table 3. The foam capacity of shell eggs were not significantly ($p<0.05$) different from each other at the start of storage. However, the foam capacity of both the untreated and treated egg samples declined at the end of storage. The decline was more severe in the control UNTE (100.10-51.20%) than in the treated eggs. There were significant ($p<0.05$) differences in foam capacity of the egg samples at the end of storage. The foam capacity at the end of storage was highest in HOTE (72.30%), followed by AOTE (65.05%). The poor foaming capacity of uncoated eggs implied that the protein degradation in control (UNTE) was more pronounced, as shown in the proximate composition (Table 5).Proteins form and stabilize foam due to their amphilic behavior (Onimawo and Akubor, 2005).The reduction in foam capacity after storage could be due to reduction in the surface tension, from the inhibition of flexible protein molecules of the eggs (Akinyede and Amoo, 2009).Foam contributes to the texture of bread, cakes, cookies, meringues, ice creams, and several bakery products, all of which require the incorporation of air to maintain texture, and structure during and after processing (Ndife *et al*., 2010). Emulsifying ability and emulsion stability are important quality parameters in egg products. The emulsion capacities (EC) of the egg samples at the start of storage ranged from 44.50 to 45.00% and were not significantly ($p>0.01$) different. However, at the end of storage, the EC showed significant ($p<0.05$) difference in the egg samples. COTE had the highest emulsion capacity (32.00%) at the end of storage, followed by AOTE (30.10%). The untreated samples (UNTE)had the lowest emulsion capacity (24.52%). Emulsification is one of the primary functional properties of proteins in foods, and the most important functionality of phospholipids (lecithin) in the yolk is the emulsion formation. Proteins in dispersion may cause a lowering in the surface tension at the water air interface, thus, forming a continuous cohesive film which prevent separation in food components (Onimawo and Akubor, 2005; Kaushal *et al*., 2012).The gelatinization temperature (GT) of the egg samples at the beginning of storage ranged from 86.90-88.0^{o}C and 112.50-117.00°C at the end of storage. Among the treated samples, HOTE had the highest GT at the start and end of storage. The GT was not significantly ($p>0.05$) different at the start of storage between the coated and uncoated eggs. Control (UNTE) had the lowest GT at end of storage. The increased GT at the end of storage indicated that the temperature at which the samples may form gel may be high. Also, the high GT in the samples at end of storage suggested a low gelling power of the egg components, which would affect food formulations. The primary function of gel depends on protein coagulation, which acts as a structural bond with other ingredients in foods (Onimawo and Akubor, 2005).Functional properties

affect food sensory characteristics and play important roles in the physical behavior of food and its ingredients during preparation, processing and storage

Microbial quality of stored shell-eggs

Table (4) showed the microbial content of shell-egg samples. There was no significant ($p<0.05$) growth in total microbes ($4.7\text{-}5.0\times10^{1}$Cfu/ml) of the coated and uncoated eggs at the beginning of storage. Some authors have reported that freshly laid egg are usually free of bacteria on the inside as it is well protected by the shell, membranes, and several chemical substances like ovotransferrin, avidin, and lysozyme in the egg white (El-Kholy *et al.,* 2014).However, if the eggs are subjected to warm temperatures or moisture, or both, microbes are then able to penetrate the egg, and overcome the egg's defense. (Nahed *et al*., 2014). There was significant ($p>0.05$) increase in bacteria growth in the stored eggs at the end of storage. HOTE (1.2×10^{2}Cfu/ml) and AOTE (1.8×10^{2}Cfu/ml) showed the least bacteria growth, while control (UNTE)(1.0×10^{5}) had the highest. The same trend was repeated in the Fungi counts. This phenomenon could be attributed to the bactericidal effect of antibiotics used in AOTE, and the sterilizing effect of hot oil on microbial growth (HOTE). The microbial contents of all the egg samples were within the acceptable limit of microbial load (10×10^{5}) for fresh eggs(ICMSF, 1996).Coliform bacteria were detected in only UNTE and COTE (< 10^{1}Cfu/ml) at the end of egg storage. El-Kholy *et al*. (2014) reported values of 1.1×10^{3}, 2.6×10^{2} and <10Cfu/ml for total viable bacteria, fungi and coliform counts respectively in newly laid eggs. (Nahed *et al.* (2014), reported that, as eggs stay longer in storage, their resistance reduced enabling yeast and molds to penetrate into the eggs. By blocking the pores through coating the eggs with oil, the cuticle helps to preserve freshness and prevent microbial contamination of the contents(Okaka and Ene, 2005).The most common microbial contaminants of shell eggs and egg products are the genera *Alcaligenes, Acinetobacter, Pseudomonas, Serratia, Cloacae, Hafnia, Citrobacter, Proteus,* and *Aeromonas*. However from the microbial quality evaluation, the eggs are still healthy for consumption.

Sensory characteristics of stored shell-eggs

The results of sensory evaluation of the studied shell egg samples are presented in Table 5. Ease of peeling is an important aesthetic quality of boiled egg. In this study, ease of peeling is judged based on the effort needed to remove about 50% of the shell. The ease of peeling the uncoated eggs (8.25-5.50) was significantly ($p<0.05$) better than coated samples at the start and end of storage. The coated eggs did not show uniform trend in the ease of peeling, and were generally poor(6.72-3.51).UNTE (5.50) was not significantly different from COTE (5.30) at the end of storage. This result is in agreement with the findings of Shittu and Ogunjinmi (2011),that the ease of peeling of uncoated eggs, irrespective of storage condition, was preferred compared to the coated samples. Practically, boiled shell egg that peels easily give smoother surface visual appeal to consumers especially at eateries, while peeled eggs with rough surface give the impression of poor quality. There was significant difference ($p<0.05$) in the taste and aroma of the uncoated and coated and samples, with reduction in preference at the end of storage period. The taste (7.25) and aroma (8.00) of the control sample (UNTE) were preferred by the panelists at the start of storage, followed by cold oil treated eggs (COTE), with 6.10and 6.72 scores. However, the taste of the uncoated UNTE (7.25-4.75) and coated (6.10-4.50) egg samples deteriorated with time as shown by their low scores. The same trend was observed for the aroma scores of all the egg samples. Shittu and Ogunjimni (2011) reported that coated eggs gave unacceptable odor which later disappeared in few seconds after peeling. They attributed this characteristic aroma to H_2S and CO_2 within the shell egg which was trapped due to impermeability of shell coating. The texture scores of uncoated UNTE (6.25) compared with coated COTE (6.13) and AOTE (6.00)egg samples were relatively the same at the inception of storage. The texture of hot oil treated sample HOTE (5.70) was significantly ($p<0.05$) different. The texture scores of all the egg samples however decreased at the end of storage. The reduction was more prominent in UNTE (4.00) and HOTE (4.41). Some authors have reported gummy texture to be associated with eggs that have been stored for more than a month (Barbosa, 2004; Morsy *et al*., 2015; Almeida *et al*., 2016). Deterioration of the structure of the thick albumen and yolk results in liquefaction and thinning, primarily due to migration of water from the albumen through the vitelline membrane into the yolk(Almeida *et al*., 2016).Generally, the control sample (UNTE) had higher acceptability (8.10) at the beginning of storage, which significantly ($p<0.05$) deteriorated at the end (4.00), when compared to the coated shell-eggs (6.95-5.15). The overall acceptability of the coated eggs were not significantly ($p>0.05$) different at the start and end of storage. The cold oil (COTE) and antibiotics oil coated (AOTE) egg samples were the most preferred at the end of storage period. General acceptability is an overall assessment of the sensory characteristics of samples (Iwe, 2007). Overall acceptability is the combination of all the other sensory parameters, and if a product records acceptable quality levels in most of the other parameters, it is expected that such product will have a good overall acceptability (Iwe *et al*., 2017).

Conclusion

The data from this study on the evaluated quality indicators of shell-eggs revealed the oil pre-treatment methods provided better protection against deterioration for fresh shell eggs than the untreated eggs. However, among the different oil treatments, cold vegetable oil coating of fresh shell eggs (COTE) gave a better protective effect against deterioration of most quality parameters and thus, extended the shelf life of the studied egg samples. The addition of antibiotics to cold vegetable oil (AOTE) provided better protection against bacterial growth in shell eggs. The hot oil coating of HOTE was poorly accepted in the sensory

evaluation. Oil pre-treatments could provide viable protection against spoilage of fresh shell eggs compared to other preservation techniques.It could therefore, be inferred that the oil treated shell-eggs had better internal qualities than non-coated eggs (UNTE) at end of storage period.The findings of this study showed that vegetable oil coating could be used as cheap preservative methods for extending the shelf life of fresh shell-eggs.

Table 1: Physical properties of shell-eggs at the beginning and end of storage

Sample	Egg-weight (g)		Air space (mm)		Haugh unit		Yolk index	
	1 day	70 days	1 day	70 days	1 day	70 days	1 day	70 days
UNTE	59.13^{a}±2.8*	50.63^{a}±2.81	1.10^{a}±0.10*	3.80^{a}±0.14	85.58^{a}±1.21*	50.70^{c}±7.21	0.97^{a}±0.05*	0.56^{d}±0.06
COTE	60.93^{a}± 2.72	53.91^{b}±3.42	1.25^{a}±0.15*	3.05^{b}±0.07	85.10^{a}±3.05*	65.28^{b}±4.30	0.96^{a}±0.04*	0.62^{c}±0.08
AOTE	53.53^{b}± 3.55	48.03^{a}±3.40	1.20^{a}±0.10*	2.61^{bc}±0.07	86.20^{a}±1.58*	67.43^{b}±4.30	0.99^{a}±0.04*	0.75^{b}±0.05
HOTE	55.80^{b}±1.90	51.82^{b}±1.75	1.05^{a}±0.12*	2.00^{c}±0.14	85.04^{a}±0.76*	78.49^{a}±2.45	0.97^{a}±0.03*	0.91^{a}±0.04

***Data are mean values of triplicate determination ± standard deviation; Means within column with different letters are significantly different (p<0.05). T-test of comparison between initial and end of storage for each parameter with asterix as significantly different (p<0.05). UNTE - Untreated eggs (Control), COTE - Cold oil treated eggs, AOTE - Antibiotic oil treated eggs, HOTE - Hot oil treated eggs**

Table 2: Chemical composition (%) of shell-eggs at the beginning and end of storage

Sample	Moisture		Protein		Fat		Ash	
	1 day	70 days	1 day	70 days	1 day	70 days	1 day	70 days
UNTE	65.24d±2.04	43.25c±1.35	21.43^{d}±1.63	16.31^{c}±1.80	11.64^{b}±1.21	9.33^{a}±1.17	1.55a±0.17	1.05^{c}±0.15
COTE	64.21c±1.91	47.25b±1.64	22.20^{c}±1.74	18.70^{b}±1.73	11.63^{b}±1.86	10.99^{ab}±1.14	1.50^{a}±0 .14	1.15^{b}±0.11
AOTE	64.31b±1.86	47.55b±1.03	21.25^{b}±1.81	18.83^{b}±1.56	12.54^{a}±1.60	11.89^{a}±1.16	1.51^{a}±0.14	1.35^{a}±0.14
HOTE	64.10b±1.95	50.40a±1.50	22.04^{a}±1.28	19.10^{a}±1.62	12.25^{a}±1.50	12.85^{a}±1.12	1.55^{a}±0.13	1.45^{a}±0.17

***Data are mean values of triplicate determination ± standard deviation; Means within column with different letters are significantly different (p<0.05). T-test of comparison between initial and end of storage for each parameter with asterix as significantly different (p<0.05). UNTE - Untreated eggs (Control), COTE - Cold oil treated eggs, AOTE - Antibiotic oil treated eggs, HOTE - Hot oil treated eggs**

Table 3: Functional properties of shell-eggs at the beginning and end of storage

Sample	Foam capacity (%)		Emulsion Capacity (%)		Gelatinization Temperature (^{o}C)	
	1 day	70 days	1 day	70 days	1 day	70 days
UNTE	101.10^{a}±1.00	51.20^{c}±1.11	45.00^{a}±1.70	24.52^{a}±1.00	87.50^{ab}±1.71	112.50^{b}±0.00
COTE	102.30^{a}±1.20	60.15^{b}±1.31	45.20^{a}±1.20	32.00^{c}±1.20	87.10^{ab}±2.20	115.00^{a}±0.00
AOTE	101.10^{a}±1.51	65.05^{b}±1.20	44.50^{a}±1.41	30.10^{b}±1.10	86.90^{b}±2.01	116.00^{a}±2.83
HOTE	102.20^{a}±1.10	72.30^{a}±1.26	44.80^{a}±.60	27.50^{b}±1.50	88.00^{a}±1.90	117.00^{a}±1.41

***Data are mean values of triplicate determination ± standard deviation; Means within column with different letters are significantly different (p<0.05). T-test of comparison between initial and end of storage for each parameter with asterix as significantly different (p<0.05). UNTE - Untreated eggs (Control), COTE - Cold oil treated eggs, AOTE - Antibiotic oil treated eggs, HOTE - Hot oil treated eggs**

Table 4: Microbial content of shell-eggs at the beginning and end of storage (Cfu/ml)

Sample	Total bacteria count		Total Fungi count		Totalcoliform count	
	1 day	70 days	1 day	70 days	1 day	70 days
UNTE	$5.2^{a}\times10^{1}$	$1.0^{a}\times0^{5}$	ND	3.2×10^{3}	ND	$<1\times10^{1}$
COTE	$4.8^{a}\times10^{1}$	$2.2^{b}\times10^{4}$	ND	1.5×0^{2}	ND	$<1\times10^{1}$
AOTE	$4.7^{a}\times10^{1}$	$1.8^{a}\times10^{2}$	ND	1.4×10^{1}	ND	ND
HOTE	$5.0^{a}\times10^{1}$	$1.2^{a}\times10^{2}$	NN	$<1\times10^{1}$	ND	ND

***Data are mean values of triplicate determination ± standard deviation; Means within column with different letters are significantly different (p<0.05). T-test of comparison between initial and end of storage for each parameter with asterix as significantly different (p<0.05). UNTE - Untreated eggs (Control), COTE - Cold oil treated eggs, AOTE - Antibiotic oil treated eggs, HOTE - Hot oil treated eggs; ND - Non Detectable**

Table 5: Sensory scores of shell-eggsat the beginning and end of storage

Sample	Ease of shell peeling		Texture		Aroma		Taste		Overall Acceptability	
	1 day	70 days	1 day	70 days	1 day	70 days	1 day	70 days	1 day	70 days
UNTE	$8.25^{a}\pm1.00$	$5.50^{a}\pm0.58$	$6.25^{a}\pm0.96$	$4.00^{a}\pm1.41$	$8.00^{a}\pm1.41$	$4.75^{a}\pm0.00$	7.25 ± 1.26	$4.75^{a}\pm1.41$	$8.10^{a}\pm0.50$	$4.00^{a}\pm0.82$
COTE	$6.72^{b}\pm1.71$	$5.30^{ab}\pm1.29$	$6.13^{a}\pm0.82$	$5.50^{b}\pm2.06$	$6.72^{b}\pm1.91$	$6.80^{c}\pm0.58$	6.10 ± 2.45	$5.50^{b}\pm1.00$	$6.95^{b}\pm2.06$	$5.75^{b}\pm0.96$
AOTE	$6.10^{b}\pm1.71$	$4.83^{b}\pm1.29$	$6.00^{a}\pm0.82$	$5.00^{b}\pm2.08$	$5.80^{c}\pm3.00$	$5.75^{b}\pm0.50$	5.95 ± 2.50	$4.50^{a}\pm2.28$	$6.80^{b}\pm2.45$	$5.25^{b}\pm1.71$
HOTE	$5.75^{c}\pm1.26$	$3.51^{c}\pm0.82$	$5.70^{b}\pm1.71$	$4.41^{b}\pm1.41$	$5.11^{c}\pm2.65$	$5.34^{b}\pm1.29$	5.83 ± 2.50	$5.00^{b}\pm1.71$	$6.25^{b}\pm2.75$	$5.15^{bc}\pm0.96$

***Data are mean values of triplicate determination ± standard deviation; Means within column with different letters are significantly different (p<0.05). T-test of comparison between initial and end of storage for each parameter with asterix as significantly different (p<0.05). UNTE - Untreated eggs (Control), COTE - Cold oil treated eggs, AOTE - Antibiotic oil treated eggs, HOTE - Hot oil treated eggs**

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