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Effect of Storage Conditions on the Quality Attributes of Shell (Table) Eggs

* Eke, M.O.[1], Olaitan, N.I.[2] and Ochefu, J.H.[1]

ABSTRACT

In tropical countries like Nigeria, egg preservation is a serious problem. The common practice is to store under ambient condition due to lack of refrigeration facilities and erratic power supply. Four crates of fresh table eggs were bought from the University of Agriculture, Makurdi farm and preliminary investigations of egg weights, Haugh unit, pH and yolk index were carried out before storage and found to be within standard. Thirty eggs were stored under ambient condition with and without application of oil respectively. The other group of thirty eggs was refrigerated. The initial weights were in the range of 60 – 69 g which reduced drastically. All other quality indices like the Haugh unit, the yolk index and pH declined drastically within the four weeks of the storage especially those that were stored under the ambient conditions. Those stored under refrigeration and those that were oiled and stored under ambient conditions (32 + 2°C) maintained high quality standards in all the quality indices evaluated. The microbiological result also showed higher bacteria, yeast and mould count on those stored under ambient condition with the initial count of 5.0 x 10^3 at first week and 2.8 x 10^7 at the fourth week while the oiled and refrigerated eggs had values of 5.0 x 10^3 at week zero and 7.2 x 10^4 at week four of storage respectively. It is suggested that application of oil on eggs before storage can be practised to ensure retention of good quality eggs especially in the tropics and most developing nations of the world.

Keywords: Ambient, oiled, refrigerated, eggs, yolk index and Haugh units.

Introduction

Eggs are laid by females of many different species, including birds, reptiles, amphibians and fish but the most often consumed by humans is the chicken (Table) egg (Wikipedia, 2012). Chicken eggs provide a well balanced source of nutrients for man of all ages. Chicken egg, whole and hard-boiled, contains 12.6 g/100 g protein, 10.6 g/100 g fat, 1.12 g/100 g carbohydrate and 647KJ (155Kcal)/100 g energy. Due to the protein content, the United States Department of Agriculture (USDA) categorised eggs as meats within the Food Guide Pyramid (Howe *et al.*, 2004). Eggs are declared as A (Jumbo) quality must have at least 72 Haugh Units, eggs of B (Extra large) quality must have more than 60 Haugh Units and eggs with Haugh Units lower than 30 are not for consumption as a shell egg (Faris *et al.* , 2011). Chicken eggs consist of a protective egg shell, albumen (egg white) and vitellus (egg yolk) contained within various thin membranes. Egg shells act as hermetic seals that guard against bacteria invasion (Wikipedia, 2012) and the shell membranes function to retain the fluid of the albumen and also to resist bacterial invasion (Hassan and Aylin, 2009). A young hen produces eggs with thicker shells and longer pores than older hens. The egg shell colour is caused by pigment deposition during egg formation in the oviduct and can vary according to species and breed (USDA, 2011).

[1] Department of Food Science and Technology, University of Agriculture, P.M.B 2373, Makurdi, Benue State, Nigeria.
[2] Department of Home Science and Management, University of Agriculture, P.M.B. 2373, Makurdi, Benue State, Nigeria.
* corresponding author: ekemouam@yahoo.com

All foods have a limited shelf life which will vary depending on the food and storage conditions. Eggs are very perishable food products. Careful preservation of edible eggs is extremely important as improperly handled eggs may contain elevated levels of Salmonella bacteria that can cause severe food poisoning, hence the USDA recommends refrigerating eggs in order to prevent the growth of Salmonella (Wikipedia, 2012). The application of coatings on eggs, on the other hand, can be justified since they maintain the functional properties of food by decreasing moisture loss and gas transport (oxygen and carbon dioxide), hence the application of coating on eggs reduces weight loss and maintains internal measurement such as albumen and yolk (Nadia *et al.*, 2012). Though oiling of eggs is very effective in slowing down reduction in albumen and yolk quality, it does not replace the need for cool storage (Faris *et al.*, 2011). The internal quality of eggs starts to decline as soon as laid by hens (Roxana and Usturoi, 2012). The major difference between freshly laid eggs and stored eggs are albumen pH and albumen quality (Albumen height) (Nadia *et al.*, 2012). Albumen quality, a standard measure of egg quality, is influenced by genetic and environmental factors such as temperature, time and humidity of storage (Roxana and Usturol, 2012).

Egg handling and storage practices have a significant impact on the quality of eggs reaching consumers. Eggs produced in farms could have good quality (more than 75 Haugh units) but because of poor handling and storage conditions in farms and in markets it could lead to losses in quality (Faris *et al.*, 2011). Handling concerns the increase in the volume of the air cell, the liquefaction of the thick albumen portion, and the weakening of the vitelline membrane separating the yolk and albumen (Berardinelli *et al.*, 2008). During egg storage, the quality of the vitelline membrane declines, making the yolk more susceptible to breaking (Nadia *et al.*, 2012). The yolk absorbs water from albumen and increases in size thereby weakening the vitelline membrane and the yolk becomes somewhat flattened. The flattening of the yolk is primarily due to increase in water content caused by osmotic migration from the albumen through the vitelline membrane. During storage, moisture from egg is lost through evaporation at a rate that is influenced by temperature of the storage environment (Nadia *et al.*, 2012). Carbon dioxide is also lost through the shell pores while oxygen gets into the egg and creates an air bubble inside in-place of moisture and carbon dioxide, causing the egg to float when placed in water due to loss of weight (Hassan and Aylin, 2009). The movement of carbon dioxide and moisture through the egg shell increases the pH of the albumen and the yolk, decreases moisture percentage of egg albumen and decreases the albumen weight. There is a marked increase of naturally occurring psychophilic bacteria, coliform, staphylococci, yeast and moulds on egg shell surface and in egg content during egg storage (Faris *et al.*, 2011). A properly handled and refrigerated intact egg will retain its nutritional value and wholesomeness for a considerable long time (longer than 5 weeks). This study was carried out to determine the effect of different storage conditions on the quality attributes of eggs.

Materials and Methods

Sample procurement

Four crates (120) of freshly laid eggs were purchased from the University of Agriculture Makurdi farm. Vegetable oil (Soya oil ex-Grand Cereals Limited) was purchased from Makurdi Modern Market.

Procedure

All the eggs were weighed using digital weighing scale (model: AX 1000) and the weight of each egg was recorded. The eggs were separated into three groups of thirty eggs each. The first group was stored under normal ambient condition without being oiled while the second group was stored under the same condition but with application of vegetable oil. The last group was stored under refrigeration.

Physical analysis

Thirty eggs were selected and the following parameters were determined:

Weight of egg: The weight of egg was taken, using a digital weighing scale (model: AX 1000) and the weight of each egg was recorded.

Appearance of egg: The egg size, egg shape, shell colour, shell texture, cleanliness/soundness of the eggs were assessed.

Haugh unit: Haugh Unit (HU) is the precise measurement of the opened egg quality. It is the albumen height adjusted according to the weight. The egg was cracked open on a flat surface plate. The albumen height was measured using a sliding caliper and recorded. Haugh Unit was calculated using the formula:

$$HU = 100 \log (H + 7.57 - 1.7W^{0.37}$$

Where: HU = Haugh Unit
H = Thick egg white (albumen) height (mm)
W = Egg weight (g)

Yolk index: The Yolk Index (YI) is the measure of the standing quality of the height and average diameter of the yolk measured using a caliper. The yolk index was calculated using the formula:

$$YI = \frac{\text{Height of yolk (mm)}}{\text{Diameter of yolk (mm)}}$$

Chemical analysis

The yolk was separated from the albumen and both were distributed into three replicates of glass beakers.

pH determination

The pH of the albumen and the yolk were measured with a pH meter (Electronic Instrument Ltd). About 2.0 g of the sample was homogenised in 20.0 ml of de-ionised water in a beaker. The pH meter was first standardised using buffer solution of pH 4.01 and 9.20. The electrode was then rinsed with de-ionised water and dipped into the homogenate allowing sufficient time for stabilisation before taking the reading.

Microbial analysis

Total plate count

The total plate count was done according to the method adopted by Adegoke (2004). Mould and yeast counts were determined using the method described by Collins *et al.* (1989).

Statistical analysis

One-way analysis of variance (ANOVA) was used to analyse significant difference among the samples. Fishers' Least Significant Difference (LSD) test was used to test differences between means. All calculations were performed according to the procedure outlined by Ihekoronye and Ngoddy (1985).

Results and Discussion

Change in egg weights during storage

The result in the changes in the egg weight during storage is as presented in Figure 1. Result showed a reduction in weight especially for eggs stored under ambient condition. The weight of egg used at the commencement of the experiment ranged between 60 and 69 g for all treatments which confirm that the eggs were extra large.

There was a significant loss of weight of eggs during the four (4) weeks of storage. This may be as a result of the increase in shell spores as the egg aged. This assertion is in agreement with Stadelman and Cotterill (2007). The increase in shell pores makes it easier for moisture and gases to escape from the eggs. The breakdown of carbonic acid in the egg white produces carbon dioxide (CO_2) and water (H_2O). The carbon dioxide escapes through the shell pores and the egg white loses in thickness and becomes watery and this results to loss of weight of eggs. There is a higher loss of weight in eggs stored under ambient condition than those stored under refrigeration and the ones that were oiled and stored under ambient. This is because the cuticle plugging the air pores of the shell of eggs stored at ambient condition dried faster and began to shrink, therefore, the shell pores increased in size at a faster rate making it easier for carbon dioxide and moisture to escape from the eggs. Oiling and

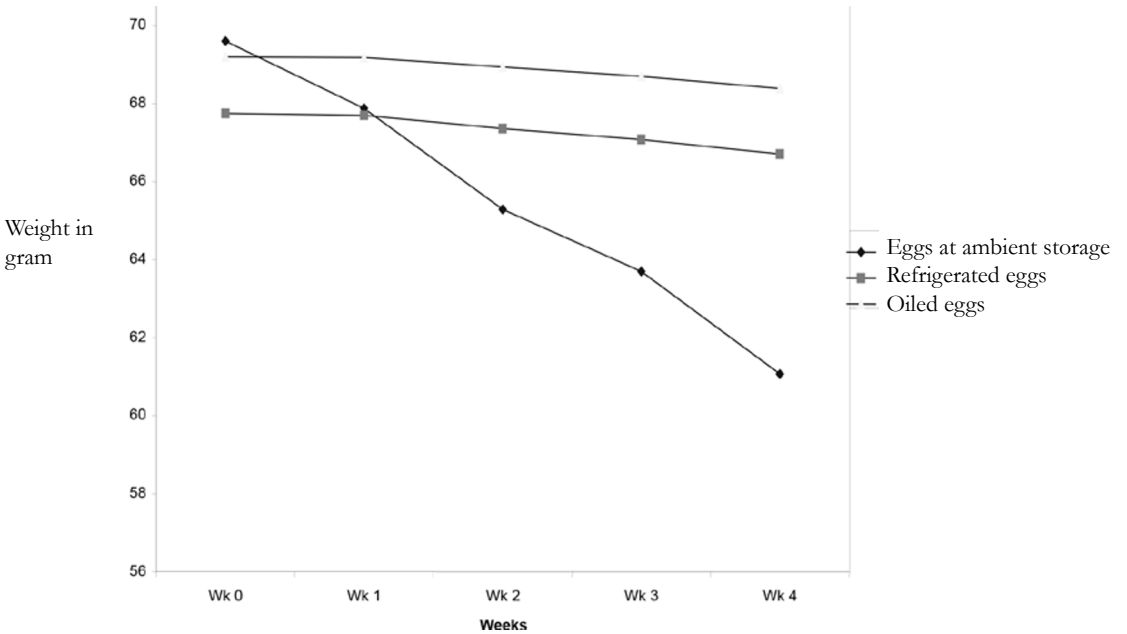

Fig. 1: Changes in egg weight during storage

refrigeration of eggs however prevents cuticle drying and very less carbon dioxide and moisture loss.

Changes in Haugh Unit during the storage of eggs

Figure 2 presents the results of the changes in Haugh Unit during the storage of the eggs. The initial Haugh Unit value for the fresh egg was 79.0 for all the storage conditions (ambient without oil, ambient with vegetable oil, refrigerated conditions). According to Stademan and Cotterill (2007), fresh eggs are known to have a Haugh Unit of 72-110. There was a significant loss of Haugh Unit during the four (4) weeks of storage ($P < 0.05$). The decline in the Haugh Unit of the eggs during storage is due to the breakdown of carbonic acid in the eggs white which produced carbon dioxide and water. The loss of carbon dioxide from the egg white and the change in pH due to alkaline state caused the mucin fibres which give egg white its gel structures to lose strength and structure and white became watery which led to loss in Haugh unit of eggs during storage. The result also showed that application of oil on the shell and refrigeration resulted in retention of high proportion of the original equality of eggs as measured by the Haugh Unit than eggs stored under ambient temperature.

Change in yolk index during storage

The result of the yolk index during storage for four (4) weeks is presented in Figure 3. The initial yolk index for the fresh eggs was determined to be 0.47. According to Ihekoronye and Ngoddy (1985), the yolk index of fresh eggs varies between (0.30-0.50) with a mean value of 0.42. There was a significant reduction in the yolk index values during the period of storage ($P < 0.05$). As the eggs aged, water migrated from the albumen to the yolk. According to Staldelman and Cotteril (2007), the breakdown of carbonic acid makes the albumen watery. The yolk absorbs water from the albumen through the vitelline membrane in an attempt to equalise the concentration (pressure) between the two phases (i.e. egg white and yolk) which leads to the swelling of the yolk which in turn exerts pressure on the vitelline membrane (Watkins, 2007). This pressure eventually causes the yolk to change from

a spheroid shape to a round flabby shape mass. The different treatments on the egg significantly ($P < 0.05$) influenced the yolk index values during the four weeks of storage. Oiled eggs and the eggs stored under refrigeration temperature maintained higher yolk index values while those stored under ambient condition recorded the lowest yolk index (0.37). The rate of changes in the yolk is a function of temperature and movement of carbon dioxide through the shell.

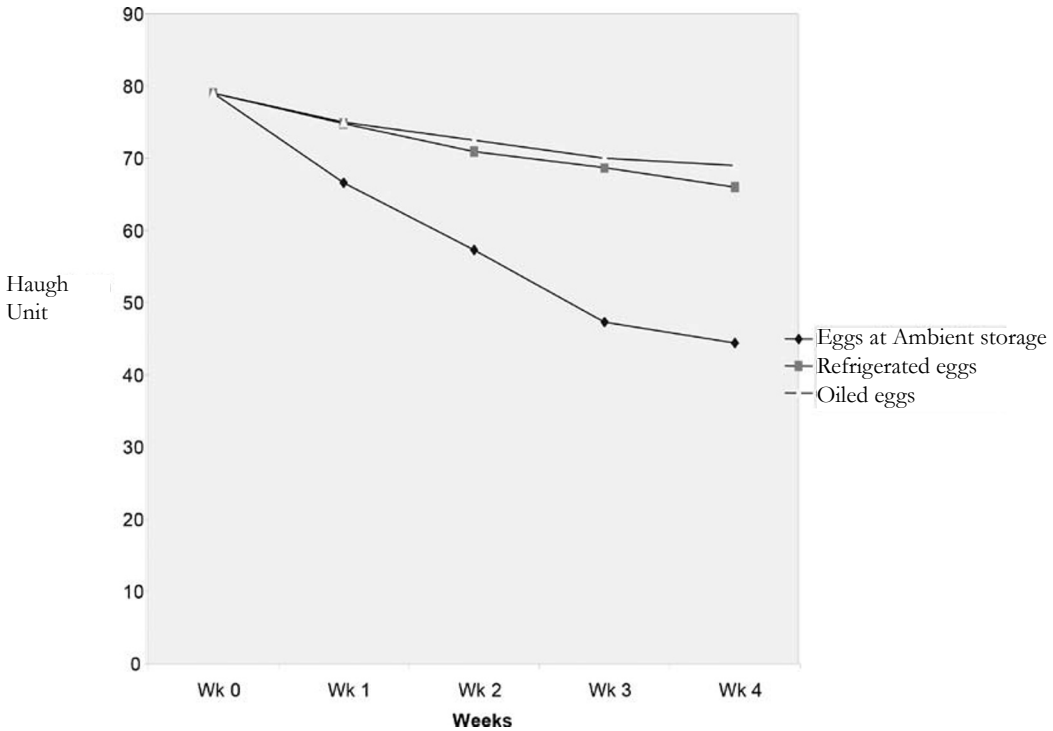

Fig. 2: Changes in Haugh Unit during storage

Change in pH of eggs during storage

The result of the changes in pH of eggs during storage is as presented in Figure 4. The pH of the fresh eggs for all treatment was measured to be 7.58 before storage. Staldelman and Cotteril (2007) stated that pH of fresh eggs should be 7.6. Result showed that there was a significant increase in pH of eggs during storage ($P < 0.05$). The rise in the pH of the eggs may be caused by the loss of carbon dioxide from the egg through the pores in the shell. The egg stored under ambient condition has a higher pH when compared to those that were oiled and refrigerated.

Microbiological properties of egg during storage

The result of the microbiological properties of the eggs during storage for four (4) weeks is as presented in Table 1. Result showed that eggs stored at ambient temperature had higher counts of bacteria, yeast and mould as compared to oiled eggs and eggs stored at refrigeration temperature. This is because the cuticle on the surface of the shell of the eggs stored at ambient temperature dries up faster and starts to shrink, which leads to increase in shell pore size, making it easier for microorganisms to pass in and out of the shell. The higher population of mould on eggs stored under ambient temperature could be due to the humid condition of the environment (Collin *et al.*, 1989).

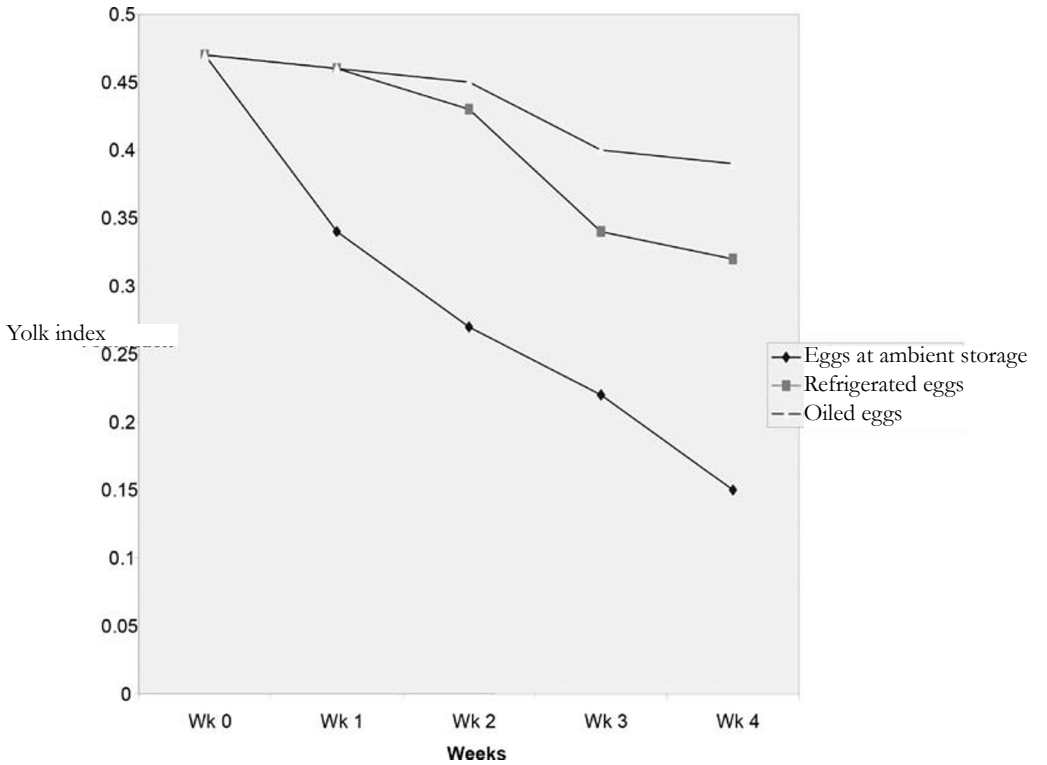

Fig. 3: Changes in yolk index during storage

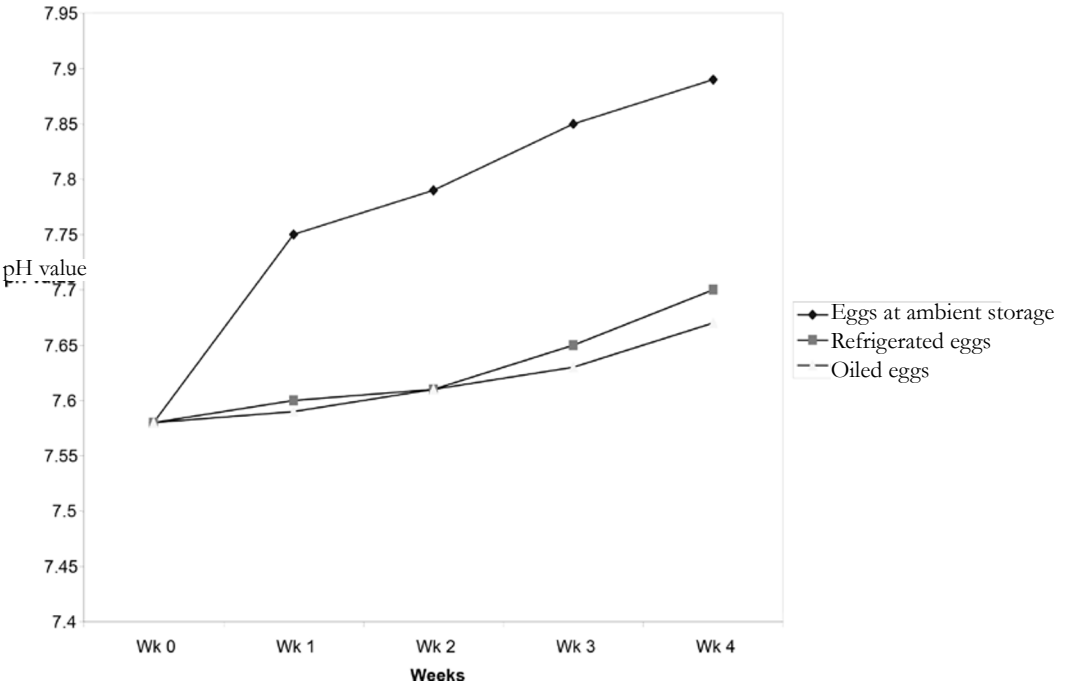

Fig. 4: Changes in pH during storage

Table 3: Microbial profile of eggs during storage

Treatment	WK0 (CFU/ml)	WK2 (CFU/ml)	WK4 (CFU/ml)
		TPC	
Ambient	5.0 x 10^3	1.4 x 10^5	2.8x 10^7
Refrigerated	5.0 x 10^3	2.0x 10^4	1.1 x 10^4
Oiled	5.0 x 10^3	3.0 x 10^3	7.2 x 10^4
		YMC	
Ambient	9.0 x 10^2	3.0 x 10^5	1.2 x 10^5
Refrigerated	9.0 x 10^2	1.0 x 10^4	
Oiled	9.0 x 10^2	9.0 x 10^2	1.5 x 10^3

TPC = Total plate count, YMC = Yeast and Mould Count, CFU/ml = colony forming unit per ml.

Conclusion

Eggs stored under ambient temperature (32.+2^{o}C) had faster rate of decline in quality indices as compared to those that were oiled and refrigerated. The oiled and refrigerated eggs had almost similar quality preservation indices but because of the erratic power supply, the oiled eggs are preferred to those refrigerated. Therefore in the tropics and most developing nations of the world, application of oil on eggs before storage can be practised to ensure retention of good quality eggs.

References

Adegoke, G.O. (2004). *Understanding Food Microbiology* 2nd Edition. Alleluia Venture Ltd, Ibadan, Nigeria.

Berardinelli, A.L., Ragni, A.G. and Gwarnie, R. (2008). Physical, mechanical modification of eggs for food processing during storage. *Poultry Science* 87: 2117 – 2125.

Collins, C.I.I., Patricia, M.I. and Grange, J.M. (1989). *Microbiological Methods* 6th Edition. Butterworth, 129 – 134, 214 – 215.

Faris, A.A. Shahrasad, M.J., Al-Shadedi and Rasheed, H.A. (2011). Quality, chemical and microbial characteristics of table eggs at retail stores in Baghdad. *International Journal of Poultry Science* 10 (5): 381 – 385.

Hassan, A. and Aylin, A.O. (2009). Effect of storage time, temperature and hen age on egg quality in free range layer. *Journal of Animal and Veterinary Advances – Medwell Journals.*

Howe, J.C., Williams, J.R. and Holden, J.M. (2004). *USDA Data Base for the Choline Content of Common Foods.* United States Department of Agriculture (USDA) p 10.

Ihekoronye, P.O. and Ngoddy, A.I. (1985). *Integrated Food Science and Technology for Tropics.* Macmillan Press, London.

Nadia, N.A.A., Bushra, S.R.Z., Layla, A.F. and Fira, M.A. (2012). Effect of coating materials (gelatin) and storage time on internal quality of chicken and quail eggs under refrigeration storage. *Poultry Science* 32 (1): 107 – 115.

Rovana, G. and Usturoi, M.G. (2012). Effect of storage time and temperature on hen egg quality.http//www./univagro-rasi-ro/revista200/20/document/pdf-vol57/Roxana Garvid.

Stadelman, W.J. and Cotterill, O.J. (2007). *Egg Science and Technology*, 4th Edition, Haworth Press Inc. New York.

USDA (2011). Shell eggs from farm to table. USDA food safety and inspection service.

Watkins, B.A. (2007). The nutritive value of egg. In W.J. Stadelman and O.J. Cotterill (eds.) *Egg Science and Technology* 4th Edition. Haworth Press Inc., New York, pp. 177 – 194.

Wikipedia (2012). Egg (Food). *The Free Encyclopedia.* Wikimedia Foundation Inc.