Preservation of Quality Indices of Commercial Eggs in Different Packing Materials at Control Temperature in Sri Lanka

S.M.S.D. SENANAYAKE[1], K.H.M.I. KARUNARATHNE[2] and H.K.J.P. WICKRAMASINGHE[1]

[1] *Department of Plantation Management, Faculty of Agriculture and Plantation Management,* [2]*Information and Communication Technology Center, Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 60170, Sri Lanka*

ABSTRACT

Quality characteristics [Haugh unit, weight loss (%), albumin pH, yolk index, yolk pH and air cell depth] of packed (paper molded egg carton and plastic/PVC egg carton) and unpacked (control) chicken eggs were evaluated during four weeks of storage at control temperature (24 °C) in Sri Lanka. There was a clearly negative effect ($p<0.05$) of storage time on Haugh unit, yolk index while, weight loss (%), albumin pH, yolk pH and air cell depth significantly ($p<0.05$) increased regardless of the treatment with increased storage time at 24 °C. The results of the present study suggested that plastic/PVC packing material was better and stable to store eggs in preserving most of the tested quality characteristics [Haugh unit, weight loss (%), yolk index and air cell depth] at least for four weeks compared to all other treatments at 24 °C but, mold growth could be observed in plastic/PVC carton. Meanwhile, out of tested functional properties (foaming capacity, foaming stability and gelling strength) foaming capacity, foaming stability and gelling strength significantly ($p<0.05$) decreased regardless of the treatment with increased storage time at 24 °C. The results revealed that there is no any effect of packing material for preserving tested functional properties during four weeks of storage at control temperature.

KEYWORDS: Control temperature, Egg cartons, Functional Properties, Quality characteristics, Storage

INTRODUCTION

The chicken egg is a perfectly preserved biological item found in nature and also considered as the best source of protein, lipids, vitamins and minerals (Abeyrathne *et al.*, 2013). Meantime, eggs can add many positive attributes to food such as emulsification, leavening, and smoothness and flavor (Jones, 2007).

When laid, eggs are ready-packed in a shell which not only facilitates handling, but also affords a considerable degree of protection from outside contamination and adulterates (Winton and Winton, 2003). Nevertheless, eggs are perishable quickly, losing their quality in the prolonged storage (Wardy *et al.*, 2010). To overcome this condition, a protective barrier against transfer of moisture and carbondioxide (CO_2) is needed to preserve the egg quality during storage period (Wickramasinghe *et al.*, 2012). The major function of the egg packing is the protection of the egg by prevention of shell breakage and provide protection to the internal qualities of the egg by restricting gas exchange through the shell membrane (Seydim and Dawson, 1999).

There are more studies has been done to evaluate the physico-functional properties of chicken eggs stored under room temperature (Samli *et al.*, 2005; Eke *et al.*, 2013; Wickramasinghe *et al.*, 2012). To date, there is scarce information available on the effect of storage temperature and time on the physico-functional properties of chicken eggs packaged with different packaging materials during storage under control temperature conditions in Sri Lanka. Thus the major objective of this study was to evaluate the effect of packing material on physico-functional properties and functional properties of chicken eggs during storage at control temperature (24 °C) since, most of the eggs which are packed in egg cartons are sold at supermarket level in Sri Lanka. Meantime, specific objective of this study was to find out the most effective and appropriate egg carton which can be used to packing of table eggs with minimum changes (compare with fresh eggs) of internal and external egg qualities and functional properties during storing at control temperature conditions in Sri Lanka.

MATERIALS AND METHODS

Experimental Site

The study was conducted from January to February 2016, in the laboratory of the Department of Plantation Management, Faculty of Agriculture and Plantation Management and laboratory of Livestock, Fisheries and Nutrition, Wayamba University, situated in low country intermediate zone (IL_{1a}). Values of the average temperature and the average relative humidity throughout the research study in the experimental room were 24 °C and 80% respectively.

Eggs

The eggs used in this study were obtained from Switz Lanka Layer farm, Puttlam. They were fresh, brown shelled eggs of 38 weeks old Hyline layers belonging to the same flock. All the eggs were 'Large' (56-63 g) in grade.

Packing Materials-Egg Cartons

The cartons used in this experiment were paper molded egg cartons obtained from Nell Farm, Walahapitiya, Dankotuwa and plastic/PVC egg cartons obtained from Burhani Traders, Peoples Park, Colombo.

Store Room

The room used to store eggs was completely cleaned, free of any other stuffs/disturbances, sealed and air conditioned. Temperature inside the room was adjusted to 24 °C.

Selection, Preparation, Storing and Measurement of Quality Characteristics of Eggs

Immediately after collecting from the farm and screening for defects and desirable weight range, total of 585 eggs were selected, out of which 540 eggs were subjected to three treatments (unpacked, paper molded and plastic/PVC egg cartons) with three replicates per treatment while ten eggs were packed in one carton. All the eggs were weighted after brought. To take initial data, 45 eggs were taken randomly and data were taken on the day eggs were brought itself. Haugh unit, albumin pH, yolk index, yolk pH and air cell depth were measured as quality indices while foam capacity, foam stability and gelling strength were measured as functional properties. Thereafter in each week, eggs were weighed from a top loading electronic balance (Shimadzu, Type BL-2200 H, Capacity 2200 g) and all quality parameters besides weight loss (%) and functional properties were measured as did for initial data.

Measurement of Haugh Unit (HU)

Haugh Unit was determined as described by Haugh (1937).

Measurement of Weight Loss %

Weight Loss (%) was measured as described by Caner and Canziz (2008).

Measurement of Albumin pH, Yolk pH

Albumin and Yolk pH was measured by the method as described by Wickramasinghe *et al.* (2012), by using a digital pH meter (Model ST 3000, Ohaus Co., USA).

Measurement of Yolk Index (YI)

Yolk Index was measured according to the procedure given by Stadelman (1994).

Measurement of Air Cell Depth

As described by Wickramasinghe *et al.* (2012), air cell depth was measured.

Measurement of Functional Properties of Eggs

As functional properties, foaming capacity, foaming stability and gelling strength were measured according to the methods as described by Ferreira *et al.* (1995).

Statistical Analysis

The data generated from the experiment were statistically analyzed using the General Linear Model (GLM) procedure of Statistical Analysis System (SAS Version 9.4). Means were compared using Least Significant Difference (LSD; $p < 0.05$).

RESULTS AND DISCUSSION

Effect of Egg Carton Type on Haugh Unit and Egg Grading Value during Storage at 24 °C

Haugh Unit (HU) value is an index of albumen quality, calculated on the basis of albumen height and egg weight. Higher the HU better the albumin quality (Stadelman, 1994). The HU was decreased ($p<0.05$) with increased storage period at 24 °C regardless of the treatment, in agreement with previous investigations (Samli *et al.*, 2005; Wickramasinghe *et al.*, 2012). During storage of eggs, the gelatinous structure of the thick albumen gradually deteriorates, changing into thin albumen, which is associated with either ovomucin-lysozyme interactions, disulfide bonds of ovomucin, carbohydrate moieties of ovomucine, or interrelations between α and β ovomucines (Abdou *et al.*, 2013).

In this study, control eggs exhibited significantly lower ($p<0.05$) HU than that of the packed eggs during storage (Table 1). Even though HU is decreased with storage time, the eggs were in grade 'B' in all treatments at the end of the 2nd week. That means eggs can be stored without any packing up to 2nd week under 24 °C temperature. Meantime, results revealed that Plastic/PVC packed eggs showed a much slower rate of decreasing of HU compared to other two treatments.

Effect of Egg Carton Type on Weight Loss (%) during Storage at 24 °C

In present study, regardless of the treatment, egg weight loss was increased significantly ($p<0.05$) during storage at 24 °C for four weeks (Table 1), which was in agreement with the findings of other researchers (Samli *et al.*, 2005; Wickramasinghe *et al.*, 2012) who stated that the weight loss (%) of eggs progressively increased with increased storage periods and weight loss (%) is directly related to storage temperature. 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 CO_2 and water. The CO_2 escapes through the shell pores and the egg white loses in thickness and becomes watery and this results to loss of weight of eggs (Eke *et al.*, 2013). The control group showed an increasing level of weight loss than packed eggs. The plastic carton has shown some better properties in preventing the evaporation of moisture and gases by showing significant difference with other two treatments.

Effect of Egg Carton Type on Albumin pH of Eggs during Storage at 24 °C

Freshly laid eggs have an albumen pH value of 7.5 to 8.5. Within a short time, the albumen pH increases to 9 owing to their lease of CO_2 from the breakdown of carbonic acid in the albumen, resulting in changes to the bicarbonate buffer system (Yuceer and Caner, 2014). In this study also, overall, albumin pH significantly ($p<0.05$) increased with the storage period at 24 °C (Table 1). In eggs of paper molded carton, first week showed high increment of pH and then gradually decreased. The decrease in albumin pH during storage may be due to the breakdown of the constituents in egg white and/or a change in the bicarbonate buffer system (Obanu and Mpieri, 1989).

Effect of Egg Carton Type on Yolk pH of Eggs during Storage at 24 °C

The yolk pH in freshly laid eggs is generally about 6.0, but during storage of eggs, the pH gradually increases to 6.5 (Caner and Y¨uceer, 2014). In this study overall, yolk pH significantly ($p<0.05$) increased with the storage period at 24 °C (Table 1). Paper molded packed eggs showed a much slower rate of increasing of yolk pH compared to other two treatments. In accordance with the findings from the current study, the yolk pH is less prone to change with increasing storage time and the pH increment is not as large as in albumin during storage.

Effect of Egg Carton Type on Yolk Index (YI) during Storage at 24 °C

The spherical nature of egg yolk can be expressed as a yolk index value, an indication of freshness (Yuceer and Caner, 2014). During egg storage, the quality of the vitelline membrane declines, making the yolk more susceptible to breaking. The yolk absorbs water from albumen and increases in size, thereby weakening the vitelline membrane and the yolk becomes somewhat flattened (Nadia *et al.*, 2012). Present study results revealed that significant decrement ($p<0.05$) of mean YI values with increasing storage time (Table 1). Results obtained in this study were in agreement with the other studies of Abdou *et al.* (2013) and Stadelman (1994) after four weeks of continuous storing of eggs under 24 °C.

Effect of Egg Carton Type on Air Cell Depth during Storage at 24 °C

Egg air cell size increases with increased storage time and temperature (Samli *et al.*, 2005). In the current study regardless of the treatment, depth of egg air cell showed a significant increase ($p<0.05$) from its initial value (4.69 mm) during storage at 24 °C for four weeks (Table 1). This increase of air cell depth was affected by the treatments and storage period. As an egg ages it loses moisture and the contents contract even more, enlarging the air cell (Pescatore and Jacob, 2011).

Moreover, eggs can be classified in to three grades based on air cell depth; AA (<3.2 mm), A (3.2-4.8 mm) and B (>4.8 mm). It was clearly observed that, day 0-fresh eggs were at grade 'A' (4.69 mm). However, eggs packed in different egg cartons showed similar variation in egg grading value based on the depth of air cell with time at 24 °C storage from 1st week to the end of 4th week. Eggs in plastic carton showed significantly ($p<0.05$) lower value compared with other treatments.

Effect of Egg Carton Type on Functional Properties

Foaming Stability and Foaming Capacity during Storage at 24 °C

The whip ability of egg albumen can be assayed by measurement of foam volume and foam stability. The thick albumen foam overrun has a logarithmic behavior, whereas the essential effect on the foam stability against liquid drainage as a function of storage time is exerted by thin albumen only (Hammershŕj and Qvist, 2001). In this study significantly negative ($p<0.05$) effect was observed in both foam capacity and foam stability. According to these results obtained from the present study, there was no any significant difference between three treatments at the end of 4th week.

Effect of Egg Carton Type on Gelling Strength during Storage at 24 °C

Meantime, viscosity of the egg albumen is one of the important characteristics that determine functional properties such as

Table1. Effect of the packing materials on quality parameters of eggs during storage at 24 °C

Parameter	Week 0	Week 1	Week 2	Week 3	Week 4
Haugh Unit (egg grades*)					
Unpacked	$66.98\pm1.84^{a.x}$/ A	$52.24\pm20.92^{a.xy}$/B	$40.59\pm16.11b^{a.y}$/B	-	-
Paper Molded	$66.98\pm3.56^{a.x}$/A	$52.95\pm4.01^{a.y}$/B	$36.25\pm14.09^{b.z}$/B	-	-
Plastic/PVC	$66.98\pm4.70^{a.x}$/A	$59.62\pm10.96^{a.x}$/B	$49.17\pm7.22^{a.y}$/B	-	-
Weight loss (%)					
Unpacked	-	$1.09\pm0.23^{a.p}$	$2.68\pm1.69^{a.q}$	$3.01\pm0.88^{a.q}$	$4.27\pm0.80^{a.s}$
Paper Molded	-	$1.06\pm0.17^{a.p}$	$2.36\pm0.56^{a.q}$	$2.92\pm0.94^{a.q}$	$4.03\pm0.47^{a.s}$
Plastic/PVC	-	$0.58\pm0.16^{b.p}$	$1.07\pm0.40^{b.q}$	$1.81\pm0.33^{b.s}$	$2.65\pm0.67^{b.r}$
Albumin pH					
Unpacked	$7.99\pm0.15^{a.s}$	$8.94\pm0.36^{a.r}$	$8.99\pm0.27^{a.qp}$	$9.14\pm0.10^{a.qp}$	$9.17\pm0.13^{a.p}$
Paper Molded	$7.99\pm0.23^{a.r}$	$8.19\pm0.17b^{a.p}$	$9.07\pm0.06^{a.qp}$	$9.00\pm0.12^{ba.q}$	$9.01\pm0.11^{ba.q}$
Plastic/PVC	$7.99\pm0.15^{a.r}$	$8.97\pm0.08^{b.q}$	$8.99\pm0.05^{b.q}$	$9.08\pm0.09^{b.pq}$	$9.13\pm0.21^{b.p}$
Yolk pH					
Unpacked	$5.70\pm0.06^{a.q}$	$6.07\pm0.35^{a.p}$	$6.09\pm0.07^{a.p}$	$6.25\pm0.35^{a.p}$	$6.30\pm0.32^{a.p}$
Paper Molded	$5.70\pm0.06^{a.r}$	$5.79\pm0.38^{a.rq}$	$5.85\pm0.28^{a.rq}$	$6.02\pm0.30^{a.q}$	$6.41\pm0.30^{a.p}$
Plastic/PVC	$5.70\pm0.06^{a.s}$	$6.05\pm0.10^{a.sr}$	$6.12\pm0.55^{a.qr}$	$6.42\pm0.71^{a.qp}$	$6.53\pm0.22^{ba.p}$
Yolk index					
Unpacked	$38.28\pm1.25^{a.p}$	$30.29\pm0.89^{c.q}$	$23.23\pm2.25^{b.r}$	$15.61\pm2.14^{b.s}$	$15.44\pm0.80^{c.s}$
Paper Molded	$38.28\pm1.25^{a.p}$	$33.50\pm2.41^{a.q}$	$24.18\pm2.52^{ba.r}$	$20.90\pm0.83^{a.r}$	$16.93\pm0.69^{b.s}$
Plastic/PVC	$38.28\pm1.25^{a.p}$	$31.81\pm1.35^{b.q}$	$25.40\pm1.41^{a.r}$	$19.72\pm2.58^{a.s}$	$18.40\pm2.18^{a.s}$
Air cell depth (mm)					
Unpacked	$4.69\pm0.47^{a.s}$	$6.24\pm0.51^{a.r}$	$7.43\pm0.58^{b.q}$	$9.88\pm1.25^{a.p}$	$10.43\pm0.97^{a.p}$
Paper Molded	$4.69\pm0.46^{a.t}$	$6.38\pm0.35^{a.s}$	$7.74\pm0.55^{a.r}$	$8.66\pm0.64^{b.q}$	$9.82\pm1.25^{a.p}$
Plastic/PVC	$4.69\pm0.49^{a.s}$	$5.47\pm0.62^{b.r}$	$5.93\pm0.63^{c.r}$	$7.56\pm0.61^{c.q}$	$8.76\pm0.66^{b.p}$

*Data are expressed as Means± standard deviations; a–c Means in the same column with different superscripts letters are significantly different ($p<0.05$); p-t Means in the same raw with different superscripts letters are significantly different ($p<0.05$); *Egg grades: AA, HU>72, A, HU=71–60, B, HU=59–31, C, HU<30*

emulsification, whip ability, and the gelling properties of the eggs.

Moreover, the liquefaction of albumen happens due to the increment in pH during storage and is influenced by the presence of ovomucin-lysozyme complex (Kannan *et al.*, 2013). Present study results revealed that gelling strength of eggs under treatments at 24 °C gradually decreased during storing for three weeks ($p>0.05$), as in agree in earlier results obtained by Kannan *et al.* (2013). At the end of 3rd week, there was no any significant difference between three treatments.

CONCLUSIONS

Eggs stored in Plastic/PVC egg carton showed less changes for Haugh Unit, weight loss (%), yolk index and air cell depth, and eggs stored in paper molded carton showed less changes for yolk pH after storage for four weeks under 24 °C temperature. Even though Plastic/PVC carton as it is found to be better and stable in preserving tested quality characteristics of packed eggs compared to paper molded carton and unpacked eggs for maximum four weeks of period of storage at 24 °C, mold growth could be observed after 2nd onward. Meantime, there was no any effect of packing material observed when preserving tested functional properties after four weeks of storage under control temperature.

ACKNOWLEDGEMENTS

Authors wish to express their special gratitude for Mr. Zaffar Jeevunjee and Mr. Susantha Yatawella, Switz Lanka Layer Farm, Puttlam for providing eggs required for the research. Authors would like to extend their profound gratitude to Nell Farm, Dankotuwa for providing paper molded egg cartons. All the Academic and Non-academic staff members of Department of Plantation Management and Department of Livestock and Avian Sciences of Wayamba University are also acknowledged for their continuous support throughout the research.

REFERENCES

Abdou, A. M., Kim, M. and Sato, K. (2013). Functional proteins and peptides of hen's egg origin. *Bioactive Food Peptides in Health and Disease*. Eds. B.H. Ledesma and C.C. Hsieh, InTech Publisher.

Abeyrathne, E.D.N.S., Lee, H. Y. and Ahn, D. U. (2013). Egg white proteins and their potential use in food processing or as nutraceutical and pharmaceutical agents- A review. *Poultry Science*, **92** (12), 3292-3299.

Caner, C. and Cansız, O. (2008). Chitosan coating minimizes eggshell breakage and improves egg quality. *Science of Food and Agriculture*, **88**, 56–61.

Caner, C. and Y¨uceer, M. (2014). Efficacy of various protein-based coating on enhancing the shelf life of fresh eggs during storage. *Poultry Science*, **94**, 1665–1677.

Eke, M.O., Olaitan, N.I. and Ochefu, J.H. (2013). Effect of Storage Conditions on the Quality Attributes of Shell (table) Eggs. *Nigerian Food Journal*, **31**, 18-24.

Ferreira, M., Benringer, R. and Jost, R. (1995). Instrumental method for characterizing protein foams. *Journal of Food Science*, **60**, 90–93.

Hammershřj, M. and Qvist, K.B. (2001). Importance of hen age and egg storage time for egg albumen foaming. *Lebensmittel-Wissenschaft and Technologies*, **34**, 118-120.

Haugh, R.R. (1937). The Haugh unit for measuring egg quality. *US Egg and Poultry Magazine*, **43**, 552–573.

Jones D.R. (2007). Egg functionality and Quality during long-term storage. *International Journal of Poultry Science*, **6**,157.

Kannan, S., Dev, S.R.S., Gariepy, Y. and Raghavan, G.S.V. (2013). Effect of radiofrequency heating on the dielectric and physical properties of eggs. Progress in Electromagnetics Research. **51**, 201–220.

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**, 107–115.

Obanu, Z.A. and Mpieri, A.A. (1989). Efficiency of dietary vegetable oil in reserving the quality of shell eggs under ambient tropical conditions. *Journal Science Food and Agriculture*, **35**, 1311-1317.

Pescatore, T. and Jacob, J. (2011). Grading Table eggs. Cooperatve Extention Service, University of Kentucky College of Agriculture, Lexington, UK.

Samli, H.E., Agma, A. and Senkoylu, N. (2005). Effects of Storage Time and Temperature on Egg Quality in Old Laying Hens. *Journal of Applied Poultry research*, **14**, 548 – 553.

Seydim, A.C. and Dawson, P.L. (1999). Packing Effect on Shell Breakage Rates during simulated transportation. *Poultry science*, **78**, 148-151.

Stadelman, W.J. (1994). Quality Identification of Shell Eggs. *Egg Science and Technology,* Eds. W.J. Stadelman and O.J. Cotterill, New York, USA, Haworth Food Products Press,

Wardy, W., Torrico, D.D., No, H.K., Prinyawiwatkul, W. and Saalia, F.K. (2010). Edible coating affects physico-functional properties and shelf life of chicken eggs during refrigerated and room temperature storage. *International Journal of Food Science and Technology*, **45**, 2659 –2668.

Wickramasinghe, H.K.J.P., Vidanarachchi, J. K., Himali, S.M.C. and Fernando, P.S. (2012). Effect of Different Packing materials on quality characteristics of chicken eggs during storage at room temperature in Sri Lanka. Proceedings of the 13th ASEAN Food Conference, 9-11 September 2013, Max Atria, Singapore.

Winton, A.L. and Winton, K.B. (2003). *Poultry eggs.* Ed. R.L. Lakhotia, India, Agrobios Press,

Yuceer, M. and Caner, C. (2014). Antimicrobial lysozyme–chitosan coatings affect functional properties and shelf life of chicken eggs during storage. *Journal of the Science of Food and Agriculture*, **94**, 153-162.