Effect of Different Packaging Materials on Quality Characteristics of Chicken Eggs during Storage at Room Temperature (32°C)

H. K. J. P. Wickramasinghe[1*], Janak Vidanarachchi[1], S. M. C. Himali[1] and P. S. Fernando[2]
[1]Department of Animal Science, Faculty of Agriculture, University of Peradeniya, 20400, Sri Lanka.[2]Bacteriology Division, Veterinary Research Institute, Gannoruwa, Peradeniya, 20400, Sri Lanka

Abstract

The chicken egg is a perishable food product, which could lose its quality rapidly during storage. With the objective of determining the effect of different egg cartons and storage time and their interaction on change of quality characteristics of chicken eggs during storage at room temperature (32°C), internal quality characteristics (weight loss (%), Haugh unit, yolk index, yolk pH, albumin pH, yolk color and air cell depth) of packed [with paper molded cartons, polystyrene cartons, plastic/PVC (polyvinyl chloride) cartons] and unpacked (control) chicken eggs during 4 weeks of storage were evaluated. *Salmonella, Escherichia coli* and Total Viable Plate Counts were enumerated from the internal content of eggs. There was a negative effect ($P<0.05$) of storage time on Haugh unit, yolk index, albumin pH and yolk color regardless of the treatment at 32°C while, weight loss (%), yolk pH and air cell depth significantly ($P<0.05$) increased regardless of the treatment (paper molded cartons, polystyrene cartons, plastic/PVC cartons and the control) with increased storage time at 32°C. Results of microbiological analysis showed that the eggs which were subjected to different treatments were all microbiologically safe throughout the four weeks of storage at 32°C. Therefore, results support the conclusion that the internal quality of the egg diminishes according to the storage time at room temperature. Plastic/PVC packaging material was better in preserving the quality parameters [Haugh Unit, Weight Loss (%)] of packed eggs at least for four weeks, compared to all the other treatments at 32°C.

Key words: Cartons, Eggs, Haugh Unit, Storage

Introduction

The egg industry of the world is primarily based on the chicken eggs (Jayasena *et al.*, 2012). Eggs are one of the few foods consumed throughout the world and this character makes the egg industry an important section of the world food industry (Stadelman, 1994). Even today, eggs remain a food within the human diet, consumed by people throughout the world due to facts that the eggs are an important and inexpensive source of high quality protein, vitamins and minerals (Wardy *et al.*, 2010).

Internal quality of eggs starts to deteriorate immediately after they have been laid due to loss of moisture and carbon dioxide through the minute pores on the shell surface (Cancer *et al.*, 2008; Kim *et al.*, 2009). Therefore, a protective barrier against transfer of moisture and carbon dioxide is needed to preserve the egg quality. Nature has given the egg a natural package, the shell and an inner liner, the membrane. The egg shell has a natural covering or cuticle that seals its pores helping to prevent the entry of bacteria and loss of moisture (Stadelman, 1995). In many developing countries refrigeration of eggs is seldom practiced due to high costs and none availability of such facilities. Hence, packaging of eggs with available inexpensive materials could reduce both qualitative and economic losses.

Quality changes of eggs during storage are affected by various factors and one of them could be storage temperature. To date, there is scarce information available on the effect of storage temperature; time and their interaction on the quality characteristics of chicken eggs packaged with different packaging materials during storage under tropical humid conditions in Sri Lanka. Thus, the main objective of this study was to evaluate the effect of different egg cartons and storage time and their interaction on change of quality characteristics of chicken eggs during storage at room temperature (32 °C). Meanwhile, the specific

Corresponding author: janakawick.1986@gmail.com

objective of this study was to find out the most effective and stable egg carton that can be used for packaging of table eggs with minimum changes of egg quality parameters during storage at room temperature conditions in Sri Lanka.

Materials and Methods

Unwashed, faeces-free, brown-shell eggs (from 40-weeks old, Shaver Brown hens; a weight range of 50–70 g) were obtained. Immediately after collecting from the farm and screening for defects and desirable weight range, total of 500 eggs were selected, out of which 480 eggs were subjected to four treatments (paper molded egg cartons, polystyrene egg cartons, plastic/PVC egg cartons and unpacked) with three replicates per treatment while ten eggs were packed in one carton. Eggs were sampled fresh and stored for 4 weeks at 32°C in Switz Lanka Layer Farm, Puttalam, Sri Lanka. In each week, eggs were weighed and yolk index (YI = yolk height/yolk diameter), yolk pH, yolk color (By ROCHE Yolk Color Fan), air cell depth, Haugh unit (HU) (by the equation $HU = 100 \times log\,(h - 1.7w^{0.37} + 7.6)$, albumin pH, number of damaged eggs and weight loss (%) were determined and separate samples from each treatment were subjected to microbiological enumerations for the detection of *Salmonella*, *Escherichia coli* and Total Viable Plate Count (TVPC) values in the internal content of eggs.

For internal quality indices (weight loss (%), Haugh unit, yolk index, albumen pH, yolk pH, air cell depth and yolk color) of eggs; the highest and lowest values were detected. Experimental design was Completely Randomized Design (CRD); means and standard deviations for egg weights were based on thirty (30) measurements (eggs) per treatment (three replicates and ten measurements per replicate) while remaining internal quality indices were based on fifteen (15) measurements per treatment (three replicates and five measurements per replicate). Treatment means were calculated using General Linear Model procedure (PROC GLM) and the means were compared by Least Square Means (LSM) multiple comparisons test at $\alpha = 0.05$. Repeated measures analysis of variance (Repeated Measures ANOVA) was used to determine whether overall difference existed between packed and unpacked eggs, considering all variables (Haugh unit, weight loss, yolk index, albumen pH, yolk pH, air cell depth and yolk color) simultaneously. The statistical analysis software package (SAS Institute, 2003) was used to analyze the data.

Results and Discussion

Haugh Unit

Changes in the Haugh unit of unpacked (control) and packed eggs during four weeks of storage at 32°C were

Table 1. Change of Haugh Unit* and Grades** of Eggs Packaged in Different Packaging Materials

Egg Packaging Material	Week 00	Week 1	Week 2	Week 3	Week 4
A (Paper molded)	71.4 ± 5.3^{Aa}	$71.4 \pm 5.3^{A,a}$	$52.0 \pm 13^{C,a}$	$44.6 \pm 2.6^{D,a}$	$19.7 \pm 2.7^{E,b}$
	A	A	B	B	C
B (Polystyrene)	71.4 ± 5.3^{Aa}	$53.9 \pm 6.7^{B,a}$	$52.4 \pm 3.6^{B,a}$	$37.4 \pm 3.9^{C,ab}$	$17.2 \pm 2.1^{D,b}$
	A	B	B	B	C
C (Plastic/PVC)	71.4 ± 5.3^{Aa}	$59.8 \pm 5.4^{B,a}$	$52.2 \pm 3.5^{C,a}$	$43.6 \pm 4.8^{D,a}$	$26.3 \pm 3.1^{E,a}$
	A	B	B	B	C
D (Unpacked)	71.4 ± 5.3^{Aa}	$56.4 \pm 4.6^{B,a}$	$50.3 \pm 0.5^{C,a}$	$36.2 \pm 3.9^{D,b}$	$17.7 \pm 1.9^{E,b}$
	A	B	B	B	C

*A-E Means ± Standard Deviations of three replicates with ten measurements per replicate. Means with different superscripts within a row indicate significant differences ($P < 0.05$). a-b Means with different superscripts within a column indicate significant differences ($P < 0.01$).

** Based on the Haugh unit values: AA > 72, A (72 – 60), B (60 – 31) and C < 31.

observed throughout the experiment [interaction between egg cartons (treatments) × storage periods (weeks), $P>0.05$]. The Haugh unit was decreased ($P<0.05$) with increased storage periods at 32 °C regardless of the treatment. The negative effect of storage time on the albumen quality (Haugh unit) of eggs was significant at 32 °C ($P<0.0001$) (Table 1).

Meanwhile, regardless of the treatment, yolk pH values increased ($P<0.05$) from its initial value of 6.15 to an average of 7.08 after four weeks of storage at 32°C. A significant interaction between egg cartons (treatments) × storage periods (weeks) ($P<0.05$) was observed, yet treatment effect was not significant ($P>0.05$) for four weeks of storage at 32 °C.

Weight Loss (%)

Differences in the weight loss (%) among the control (unpacked) eggs and those subjected to different treatments were found [interaction between egg carton (treatments) × storage periods (weeks), $P<0.05$] during 4 weeks of storage at 32 °C. Regardless of the treatment, weight loss (%) of eggs progressively increased with increased storage periods at 32 °C (Figure 1).

Yolk Index

The yolk index values significantly decreased with increase in storage periods at 32°C ($P<0.05$). The yolk index values (0.15) of eggs packaged with plastic/PVC egg cartons after four weeks of storage at 32°C were all higher than that of yolk index values of eggs packed in polystyrene egg cartons (0.14) and equal to unpacked eggs (0.15) after three weeks of storage at 32°C. In the present study, decrease of yolk index values were

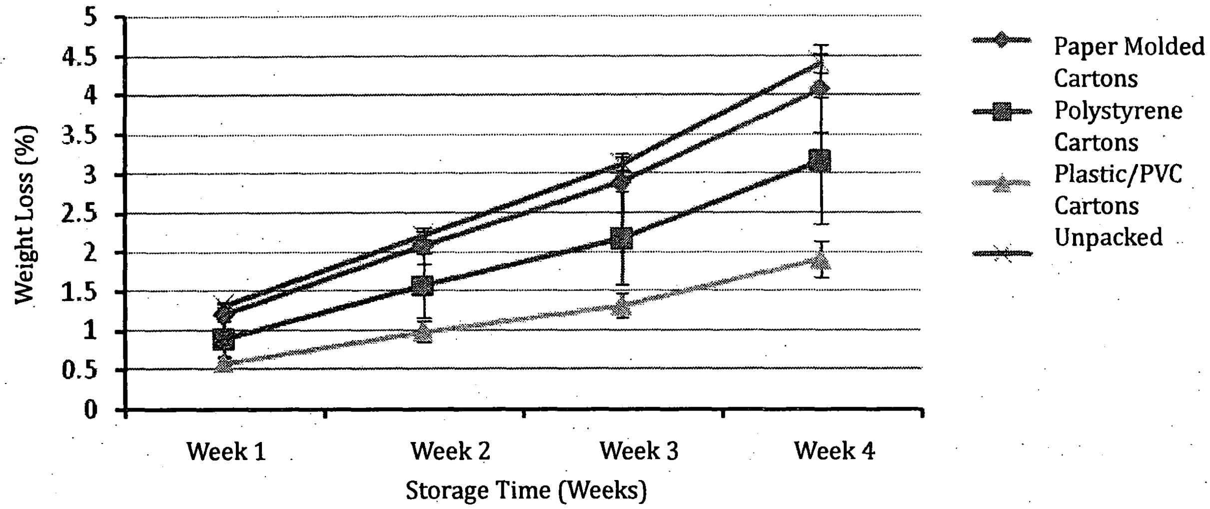

Figure 1. Effect of different egg cartons on egg weight loss (%) during 4 weeks of storage at 32°C

Albumin pH and Yolk pH

At the end of the four weeks of storage at 32 °C, eggs in all the treatments and the control showed a decrease ($P<0.05$) in albumin pH when compared to the initial pH value of 9.24. At the end of the four weeks of storage at 32 °C, the lowest albumen pH value was showed by eggs from the unpacked (7.55) and the highest albumen pH value was observed in eggs packed in the plastic/PVC egg cartons (8.63).

affected ($P<0.05$) by the treatments and storage period at 32°C (interaction between treatments × storage periods).

Air Cell Depth

In the current study regardless of the treatment, depth of egg air cell showed a significant increase ($P<0.05$) from its initial value (1.75 mm) during storage at 32 °C for four weeks. This increase of air cell depth was affected by the treatments and storage period at 32 °C (interaction between treatments × storage periods, $P<0.0001$). Eggs packed in plastic/PVC egg cartons had lower ($P<0.05$) air cell depth value (8.98 mm) than eggs packed in paper molded egg cartons (13.38 mm), polystyrene egg cartons (10.99 mm) and unpacked eggs (13.82 mm) after four weeks of storage at 32°C. Present study results show that the air cell depth values (8.98 mm) of eggs packed with plastic/PVC egg cartons after four weeks of storage at 32 °C were lower than that of eggs packed in polystyrene egg cartons (9.62 mm), paper molded egg cartons (11.28 mm) and unpacked eggs (11.72 mm) after three weeks of storage at 32°C.

Yolk Color

At the end of four weeks of storage at 32°C, there was not any significant difference ($P>0.05$) observed among treatments regarding yolk color of eggs.

Microbiological Analysis

A continuous increase of TVPC value of unpacked eggs and eggs packed in different egg cartons were observed and it was clearly observed that eggs packed in plastic/PVC egg cartons had significantly ($P<0.05$) the highest microbial count (TVPC) value at the end of each week of storage at 32 °C. In the present study, TVPC values for freshly laid eggs (day 0) was not detectable by the pour plate method. After four weeks of storage, unpacked eggs and eggs subjected to different treatments showed an increase of TVPC from not detectable levels to 4.39, 4.35, 4.51 and 4.79 log CFU/mL, respectively in each treatment by the pour plate method ($P<0.05$).

Meanwhile, no *Salmonella* colonies and *Escherichia coli* colonies were detected in all treatment groups up to two weeks of storage at 32 °C.

Conclusion

The most effective egg carton is plastic/PVC carton as it is found to be better and stable in preserving quality indices of packed eggs at least for four weeks compared to other egg cartons (polystyrene and paper molded) and the control (unpacked) at 32 °C.

References

Caner, C. and Cansiz, O. 2008. Chitosan coating minimises eggshell breakage and improves egg quality. Journal of the Science of Food and Agriculture, 88: 56-61.

Jayasena, D.D., Cyril, H.W. and Cheorun, J. 2012. Evaluation of Egg Quality Traits in the Wholesale Market in Sri Lanka during the Storage Period. Journal of Animal Science and Technology, 54: 209-217.

Kim, S.H., Youn, D.K., No, H.K., Choi S.W. and Prinyawiwatkul, W. 2009. Effect of chitosan coating and storage position on quality and shelf life of eggs. International Journal of Food Science and Technology, 44: 1351-1359.

SAS Institute 2003. SAS User's Guide. SAS Institute Inc., Cary, NC, USA.

Stadelman, W.J. 1994. Quality Identification of Shell Eggs. pp. 37-65. In: WJ Stadelman and OJ Cotterill (Eds.) Egg Science and Technology. 4th edition. Haworth Food Products Press, New York, USA.

Stadelman, W.J. 1995. The Preservation of Quality in Shell Eggs. pp. 67-79. In: WJ Stadelman and OJ Cotterill (Eds.) Egg Science and Technology. 4th edition. Haworth Food Products Press, New York, USA.

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.