

Effect of Sucrose Concentration and Immersion Time on Weight Loss and Shelf Life of Poultry Eggs

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ABSTRACT

Egg preservation is a serious problem in Nigeria, due to challenges of high ambient temperatures, expensive refrigeration facilities and erratic power supply. Osmotic preservation has been successfully used for fruits and vegetables. In this study, osmotic preservation was applied to poultry eggs; the effect of four (4) concentrations of sugar solutions (0.5-2.0 M) and four (4) immersion times (1-4 hour), on weight loss and shelf life of the eggs were investigated. The shelf-life at room temperature (28±2 °C) was determined using the candling method. Data obtained was subjected to two-way analysis of variance to determine significant (P<0.5) difference among the egg samples with respect to weight loss and shelf life. There were significant (P<0.05) differences in weight loss and shelf life of the eggs. Sucrose concentration and immersion time, as well as the interaction between the two factors had significant (P<0.001) effect on shelf life of the eggs. The lowest weight loss of 10% was observed with eggs immersed in sucrose solutions of 0.5 M for 4 hours and 1.0-2.0 M for 1 hour. The control eggs had a shelf life of 28 days while eggs immersed in sucrose solutions of 0.5 M for 2 hours, 1.0 M for 3 hours and 1.5 M for 1 hour had the highest shelf life of 61 days each. This study suggests that osmotic preservation could be an effective method for extending the shelf life of poultry eggs.

Keywords: osmotic preservation; shelf life; shell eggs; weight loss

INTRODUCTION

Eggs are one of the most nutritionally complete foods due to the excellent balance between fats, carbohydrates, minerals, vitamins and especially protein (Watkins, 2007). They are considered the second best source of protein available for human consumption, preceded only by maternal milk (Theron *et al.*, 2003). In recent times, eggs are widely recognized not only as a source of nutrients, they are reported to possess biologically active components and functional properties which can be exploited by pharmaceutical, food processing and cosmetic industries (Mine and Kovacs-Nolan, 2004; Hartmann and Wilhemson, 2001). However, eggs are highly perishable and can lose their quality rapidly (Theron *et al.*, 2003). From the moment of posture to the marketing of egg, quality loss occurs through gaseous exchange and moisture loss with the external environment, through the pores of the shell (Giampietro-Ganeco *et al.*, 2015). The porous shell of the egg allows escape of carbon dioxide and moisture resulting in weight loss. Weight of the egg is one of the quality factors that are important particularly to the producer. There are several categories of quality factors important to the producer, the consumer, as well as the processing industry (Giampietro-Ganeco *et al.*, 2015). Weight of egg has been associated with internal and external quality traits (Alkan *et al.*, 2013). Hence there is need to monitor egg weight vis-à-vis preservation of egg quality.

Several methods have been used for egg preservation; these include one or a combination of means such as refrigeration, sandblasting, water wash with or without an added bactericidal component, coating the shell of eggs with a sterile mineral oil, and the application of heat (Collier and McConnell, 1959). Each of these methods was reported to have one or more disadvantages. Refrigeration was expensive, while sandblasting removed only superficial or gross impurities but does not remove microorganisms effectively. Water wash may carry microorganisms from the exterior to the interior portions of egg shells while mineral oil is not effective against microorganisms except it is applied hot. Meanwhile, use of heat whether it is applied in the form of a hot mineral oil or otherwise, have the tendency to coagulate the albumen in eggs (Collier and McConnell, 1959). A process was invented by Collier and McConnell (1959) which involved the use of epoxide-water vapour to sterilize the egg shells without spreading infection while killing microorganisms. The process was reported to achieve this at a time and temperature which do not cause coagulation of albumen. Obanu and Mperi (1984) studied the efficacy of three dietary vegetable oils in preserving the internal quality of shell eggs under ambient tropical conditions (25-32 °C). The authors reported that groundnut oil, cottonseed oil and coconut oil significantly (P<0.01) limited diurnal weight losses among other quality parameters of the over 36 days

storage period. The preservative effects of the vegetable oils were attributed to their fatty acid component. Al-Hajo *et al.* (2012) also reported that coating of eggs reduces weight loss and gas (oxygen and carbon dioxide) transport as well as maintenance of albumen and yolk measurements, however, Al-Obaidi *et al.* (2011) argued that although oiling of eggs is very effective in slowing down reduction in albumen and yolk quality, it does not replace the need for cool storage. Giampietro-Ganeco *et al.* (2015) assessed the quality of eggs packed under modified atmosphere, they reported that vacuum packaging with oxygen gas and carbon dioxide gas generator were more efficient in maintenance of egg quality based on the values of Haugh's unit and yolk index.

Preserved egg also known as pidan or century egg is a popular egg product consumed in China and some other South East Asian Countries such as Thailand and Malaysia. Fresh eggs from duck, chicken and quail can become preserved for 4 to 5 weeks after preserving in mixture of alkali, salt, black tea, and metal ions at room temperature (Su and Lin, 1993; Wang and Fung, 1996). Zhao *et al.* (2014) reported that pickling with alkali and other additives can significantly produce preserved egg with characteristics of rich elements, brown colour, high springiness but low vitamin.

Application of osmotic preservation to shell eggs is limited in literature. Osmotic preservation is a pretreatment method which involves product immersion in a hypertonic aqueous solution leading to a loss of water through the cell membranes of the product and subsequent flow along the inter-cellular space before diffusion in the solution (Serenio *et al.*, 2001). The advantages of osmotic dehydration as a minimal processing technique includes retention of organoleptic qualities of treated food, prevention of loss of flavour compounds, prevention of cell damage that may be caused by excessive heat, retention of colour and nutritional characteristics of raw food items (Moazzam, 2012). Osmotic dehydration has been applied successfully to preservation of fruits and vegetables such as onion and strawberry (Ferrando and Spiess, 2003) and apple (Nieto *et al.*, 2004). It has been used for the improvement of processed fruit quality characteristics such as texture, pigment, vitamin and aroma (Torreggiani and Bertolo, 2001). Akerman (2014) applied a mixture of an edible acid and an osmotic agent to peeled hard-boiled as well as fried eggs, the product was reported to have acceptable aroma and taste. Duduyemi *et al.* (2015) applied osmotic dehydration to poultry eggs and reported that treated eggs had a shelf life of over 66 days. Application of osmotic preservation to shell eggs appears to be a relatively new area of research, hence the dearth of comprehensive information. Therefore, the objective of this study was to determine the weight loss and shelf-life of poultry eggs using different sucrose concentrations and immersion times.

MATERIAL AND METHODS

Chicken eggs

Freshly laid poultry eggs were obtained from MAITO Farms Nig. Ltd., Camp in Abeokuta. Sixteen eggs were used in all and the experiment was conducted in duplicate making a total of 32 eggs.

Sucrose solutions

Sucrose solution was used as the osmotic agent. Four concentrations (0.5, 1.0, 1.5, and 2.0 M) of sucrose solution were prepared. For each concentration, four different immersion times (1, 2, 3 and 4 hours) were employed; therefore, each of the four different sucrose solutions was further divided into four parts in 250 ml beakers to make a total of sixteen solutions.

Weight loss of eggs

Each egg was weighed separately using a weighing balance and the weight recorded against it. An egg was placed in each of the sucrose solutions. Each egg was withdrawn from each of the sucrose solutions after the appropriate immersion time. The egg was allowed to dry, re-weighed and the value obtained was recorded against the initial weight. The egg that was not immersed in the sucrose solution served as a control. Weight loss was calculated as

$$\text{Weight loss (\%)} = \frac{W_f - W_i}{W_i} \times 100$$

where W_f – final weight of egg, W_i – initial weight of egg

Shelf life of the eggs

The eggs were stacked in egg crates and closely monitored to observe any changes in the internal egg quality using the candling method (Kekeocha, 1985) as described below. Candling is a method of testing eggs for internal and external quality, without breaking the shell. It consists of inspecting an egg with a beam of light that makes the interior quality visible. The judgment of internal quality is based mainly on the visibility, ease of movement and shape of yolk. The quality of egg white is judged by the degree of movement of the yolk and by the definition of its outline (Kekeocha, 1985).

A very simple form of candling is placing a candle in a dark room and positioning an egg in front of the flame and looking at the interior quality. In the present study, a light bulb was used because electricity was available. The light bulb was placed in an enclosed box to serve as a candling box. A hole of about 3 cm in diameter was made in the box, sufficient to hold egg sizes ranging from 40 to 70 g. The egg was placed near the candling box hole with the large end of the egg held against the light and with the axis at a 45° angle so that the egg has light shining through it. The egg was twirled so as to observe defects which otherwise might not be observed. The main interior quality points of the eggs were observed as described by (Kekeocha, 1985) and the egg quality was recorded as good (G) or bad (B) against each day. The total number of good days was recorded as the shelf life of the eggs.

Statistical analysis

The experiment was conducted in duplicate. Data obtained were subjected to two-way analysis of variance to determine significant ($P < 0.5$) difference among the

egg samples with respect to weight loss and shelf life. Multivariate General Linear Model was used to determine the individual and interactive effect of the treatments on the weight loss and shelf life of the eggs. Significant effect was accepted at $P < 0.001$.

RESULTS AND DISCUSSION

Sucrose concentration, immersion time, as well as the interactive effect of both had a significant ($P < 0.001$) effect on weight loss and shelf life of the eggs. The weight loss of the eggs as influenced by sucrose concentration and immersion time is shown in Figure 1. The weight loss ranged between 10% and 40%. The

lowest weight loss of 10% was observed with eggs immersed in sucrose solutions of 0.5 M for 4 h and 1.0-2.0 M for 1 h. The highest weight loss of 40% was observed with sucrose solutions of 1.0 M for 3 h, 1.5 M for 4 h and 2.0 M for 4 h. A steady increase in weight loss with an increase in immersion time was observed with eggs immersed in 1.5 M and 2.0 M sucrose solutions. This suggests that at concentrations higher than 0.5 M, the osmotic gradient favours movement of water from the albumen at a faster rate which also increases with an increase in immersion time, consequently leading to weight loss of the egg. This means that a combination of lower concentration and longer immersion time or higher concentration and lower immersion time is required to reduce weight loss of eggs.

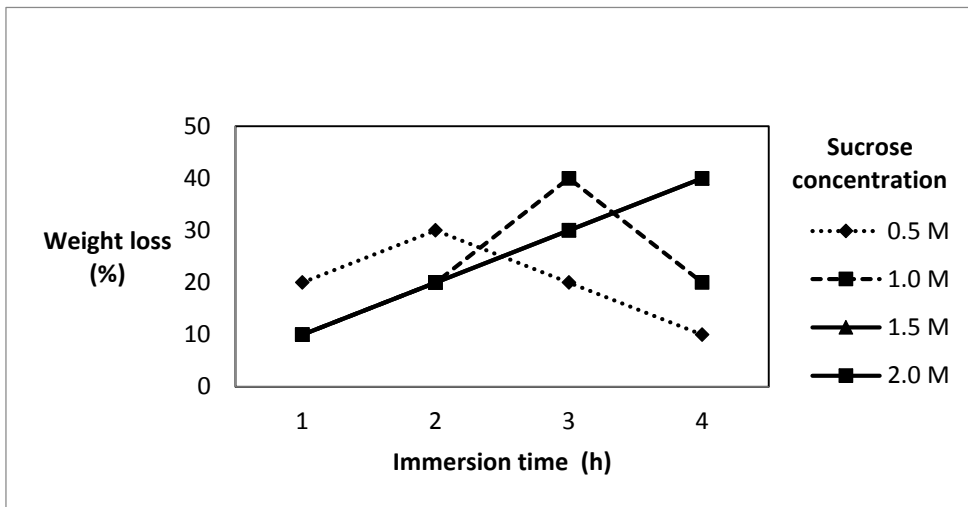


Figure 1: Weight loss of poultry eggs as influenced by sucrose concentration and immersion time.

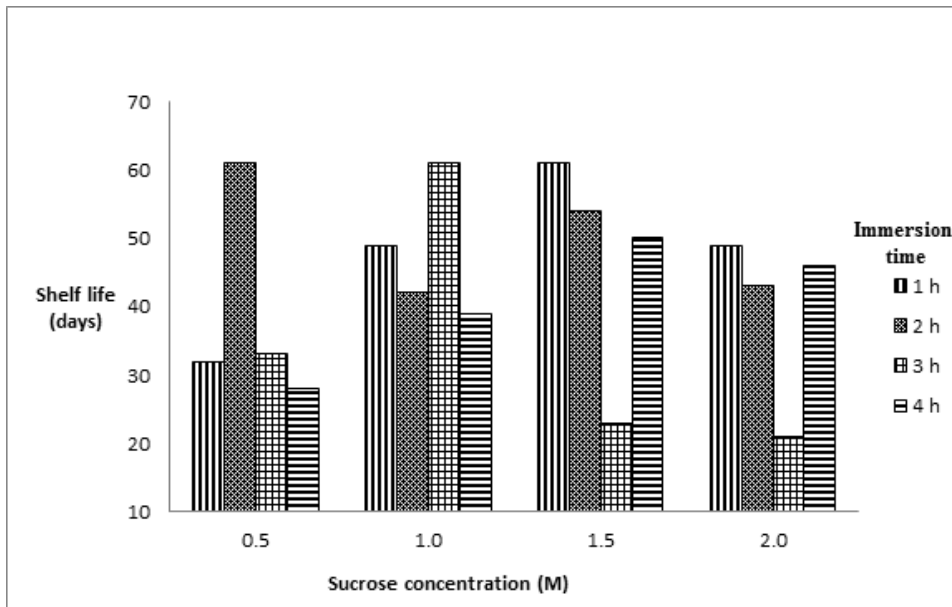


Figure 2: Shelf life of poultry eggs as influenced by sucrose concentration and immersion time

The consideration of cost involved in using either higher sucrose concentration or longer immersion time will be an important economic factor that will influence the decision of the end user for commercial adoption of this technology. Duduyemi *et al.* (2015) reported that at lower sugar concentrations (16 and 32 °Brix), weight loss was pronounced than at higher concentrations (43 and 54 °Brix).

It was observed that the eggs tend to float with an increase in sucrose concentration. This is in support of the observation by Duduyemi *et al.* (2015) that the eggs tend to float as the sucrose concentration increased particularly at 54 °Brix. The floating of the eggs even at low immersion times may be attributed to increase in density of the sucrose solutions with increase in concentration. The floating of the eggs may pose a challenge unless a device is developed to keep the eggs immersed in the solution for the required time.

The control eggs had a shelf life of 28 days while the eggs immersed in sucrose solutions had a shelf life of between 21 and 61 days (Figure 2). Duduyemi *et al.* (2015) reported that eggs immersed in sucrose solution of 42 °Brix for 30 min had a shelf life of over 60 days. In the present study, the eggs that had the highest shelf life of 61 days were those immersed in sucrose solutions of 0.5 M for 2 h, 1.0 M for 3 h and 1.5 M for 1 h. The shelf life of eggs immersed in 0.5 M sucrose solution were generally low (28-33 days) except for 2 h immersion time which achieved 61 days. At 1.0 M sucrose concentration the shelf life of the eggs was 39-61 days with 4 h and 3 h immersion time having the lowest and highest shelf life respectively. At 1.5 M, the shelf life of the immersed eggs was generally high (50-61 days) except for immersion time of 3 h which gave the lowest shelf life of 23 days. A shelf life of between 43 and 49 days was observed for sucrose concentration of 2.0 M except for immersion time of 3 h which resulted in a shelf life of 21 days. The results show that generally, concentrations higher than 0.5 M favour longer shelf life even though, as stated earlier, sucrose concentration of 0.5 M for 2 h gave the highest shelf life of 61 days among other combinations. It appears from this study that the combination of sucrose concentration and immersion time have an inverse effect on the weight loss and shelf life of poultry shell eggs. This suggests that the higher the weight loss, the longer the shelf life. Furthermore, it suggests that the presence of more water in the egg contributes to spoilage over time, particularly if not properly stored, while reduced water in the egg as indicated by weight loss favour an increased shelf life.

CONCLUSION

Weight loss and shelf life of poultry eggs were significantly affected by the combined effect of both sucrose concentration and immersion time. A combination of lower concentration and longer immersion time or higher concentration and lower immersion time reduced weight loss of eggs. The consideration of cost involved in using either higher sucrose concentration or longer immersion time will be

an important economic factor that will influence the decision of the end user for commercial adoption of this technology. The combination of sucrose concentration and immersion time have an inverse effect on the weight loss and shelf life of poultry eggs, suggesting that the higher the weight loss, the longer the shelf life. Osmotic preservation using sucrose solution has potentials for extending the shelf life of poultry eggs.

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