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Application of Osmotic Dehydration for Shelf Life Extension of Fresh Poultry Eggs

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Abstract- **This research work was aimed at applying osmotic dehydration which had suffice the treatment of agricultural produce especially fruits and vegetables with sustained organoleptic qualities. The effect of sucrose solution concentrations (16, 32, 42 and 54°Brix) at ambient temperatures of 30±2 °C for periods of 180min was investigated on fresh poultry eggs. Treated sample of eggs exposed to a worst scale of unstable environmental conditions 30±2 °C were monitored with candling and a control experiment in water glass solution. The investigation achieved extended shelf life of over 66 days without modifications to their internal and external structures, and taste using a six point hedonic scale. The effect of sucrose concentration and time of immersion were observed to be inversely dependent on effective periods of preservation of the poultry eggs by osmotic dehydration evaluated in percentage weight loss.**

Index terms-- **Fresh poultry eggs, Osmotic dehydration, Candling, Deterioration, Shelf life, Quality characteristics.**

I. INTRODUCTION

Poultry eggs have become one of the major sources of human supplementary diet worldwide. They are the basis for poultry regeneration and contain four basic parts: shell, membrane, albumen and the yolk. The yoke is rich in protein while the albumen is a potential energy giving content with other micronutrients. They are prepared boiled, fried, or at times taken raw or as food supplement prepared in different forms depending on locality. Eggs also enjoy industrial uses as ingredient it baking, confectionery and as alternatives to rising agents or binding materials in some non-food processes; egg substitutes are also made from white of the egg (albumen) for those who worry about high cholesterol and fat content in eggs [1].

Eggs quickly begin to decompose when the temperature is high and so are stored in cool dark places [2]. Deterioration associated with the internal qualities of eggs includes: sided displaced yoke, sticking of content on the shell; patchy or uneven colour due to heat spot; abnormal shapes, discolouration prone to cloudy, muddy or streaky, dark or greyish tinted grey, yellow, green or brown appearances induced by infection and embryonic development with blood spot in fertilized eggs. The demand for poultry products in recent times is increasingly high owing to population explosions, ceremonial events and festivities. These momentous demands coupled with influences of seasonal changes have made the production of poultry eggs for domestic and industrial food processing and its supply elastic. These accounted for the scarcity, hiked prices of poultry eggs at certain period of the year and have led to a number of processing methods to store eggs for protracted uses [3]. The need for poultry eggs preservation therefore becomes a necessity.

Eggs are stored in regular dry and cool conditions requiring constant supply of power, this is mostly non-feasible in developing countries because of erratic electricity supply. At temperatures between 35°F and 45°F (3° and 7°C), salt-cured eggs called '*hei dan'* and stored at a room temperature of about 65 to 68 °F has a shelf life of thirty days [4].

Other reported methods were; coating the eggs with petroleum jelly (Vaseline), immersions in limewater and water glass [5]. Coating of the egg shell takes a considerable duration of time to apply, it preserves the eggs for about 4 weeks at 25°C to 30°C and treating them with limewater is likely to give the eggs a limy flavour. Water glass or sodium silicate solution was adjudged most effective. However, large volume of liquid and space may be required from commercial viewpoint [6].

Osmotic dehydration has been successfully applied in food preservation since 1960s [7]. Osmotic dehydration involves immersion of fresh pieces of food in hypertonic (osmotic) solutions containing one or more solutes [8, 9]. It is effective when the water activity (a_w) of the solution is lower than that in the fresh food and it has been shown to give rise to two major simultaneous counter-current movement across the cell membranes [10-12].

Most pathogenic bacteria in food can be stopped if the water activity is reduced to a_w 0.90, but to stop yeasts and moulds it is necessary to lower water activity to as low as a_w 0.7 to 0.75 [13]. A reduction of 60 and 65% respectively, for moisture content and drying times of fruits and vegetables by using osmotic pre-dehydration process have been reported [14]. Osmotic dehydration can effectively reduce water content in fruits by 20 to 30% [15].

Osmotic dehydration as a minimal processing technique are increasingly been used because of its numerous advantages which include: retention of organoleptic qualities of treated food; prevention of loss of flavour compounds; prevention of cell damage that may be caused by excessive heat; high retention in colour and nutritional characteristics of raw food items [16-18]. Osmotic dehydration had been applied as pre-treatment to fruits like mango, Chestnut, tomatoes and vegetable like carrot [19, 20]. In addition, Osmotic dehydration was applied successfully for partial dehydration of other food materials including meat and fish before final drying [21]. However, the application of osmotic dehydration on poultry eggs for shelf life extension has not been reported. The effectiveness of osmotic dehydration in terms of water loss, solute gain, moisture content performance ratio, water activity and weight loss could be generally evaluated [22]. Some of the more common osmotic agents include: jams, jellies, fruit juice concentrates, sweetened condensed milk,

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sugar etc. Factors influencing the process of dewatering and solute impregnation are; time of immersion, temperature, surrounding pressure, medium of contact between solid material and solution, weight ratio of solid to solution, geometry of the solid material, and composition of the solution. The major objective of this research is to apply osmotic dehydration with sucrose solutions to fresh poultry eggs for an improved shelf-life.

II. MATERIALS AND METHODS

2.1 Materials

Fresh Poultry Eggs were purchased from Maspon Farms Nig. Ltd., Epe, Lagos State. The eggs were sorted according to size and average weight (average weight of 55.0±2g), and are placed large-end up in crates. The weight of the eggs were determined and labelled for easy identification. Sucrose concentrations of 16, 32, 42 and 54^{o}Brix respectively were prepared using an RFM300 refractometer at 20^{o}C and allowed to stay overnight to equilibrate.

2.2 Method

The eggs were immersed in sucrose solution of at liquor ratio of 1:5 (w/w) to ensure complete immersion and to minimize significant changes in concentration [23]. At intervals of 30, 60, 120 and 180min one egg each is drawn from the concentrated sucrose solution, rinsed, mopped with filter paper then re-weighed. The percentage weight loss by each egg sample at different times of immersion and in different concentrations of sucrose solutions was calculated according to equation 1.

$$Percentage \text{ weight Loss} = \frac{W_i - W_f}{W_i} \times 100 \qquad (1)$$

where: W_i-initial weight of egg sample (g), and W_f -final weight of dehydrated eggs).

Treated eggs were daily monitored with candling, in the open crate under a worst-case condition of preservation (open-ended environmental conditions). The controlled experiment consisting of eggs immersed in a crock of sodium silicate solution (water glass) were monitored in a cool, dry place simultaneously with other treated samples. The on-set of any sign of abnormality discarded the egg sample as infected. After 66 days of inspection, a few of the remaining egg samples were rehydrated by soaking in water of approximately 10 times the weight of treated samples at room temperature for 120min at room temperature [24]. The rehydration ratio was evaluated with equation 2.0 [25]:

$$\text{Re}hydration \text{ ratio} = \frac{W_r - W_d}{W_d} \qquad (2)$$

where W_r is the weight after rehydration (g), and W_d is the weight of dried material (g).

Observations and acceptability test on both interior and exterior quality of samples were conducted on a six factor hedonic scale and graded for the assessment and justification of the effects of osmotic dehydration on the poultry eggs.

III. RESULTS AND DISCUSSION

The tendencies of the eggs to float as the sucrose concentration increased were observed in the higher concentrated sucrose solution as observed in 54^{o}Bx. This showed the concentration dependency of density of the medium. The percentage weight loss by the eggs samples for the varying periods of immersion in each concentrated sucrose solution considered varied from one concentration to other. The plot of weight loss versus sucrose concentration observed for different immersion times is presented in Figure 1.

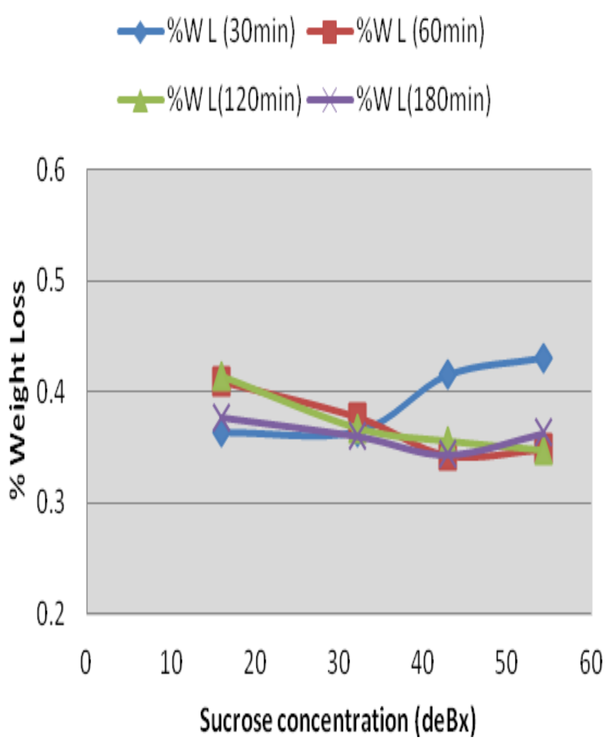

Figure 1: Percentage water loss in different sucrose concentrations with time

From figure 1, it could be deduced that the percentage weight loss decreases as the sucrose concentration increased for the immersion time except for 30min; higher sucrose concentration resulted in increased weight loss for short contact time. This may result from the initial solute impregnation of the egg shell which prevented dehydration at the beginning. This implies that eggshell may be porous and semi-permeable to facilitate osmotic dehydration observed in other conditions.

Hence, moderate sucrose concentration allowed continuous dehydration while very high concentration with high density may exhibit decreasing dehydration. This may be due to blockages of available pores by the sucrose molecules with a resultant reduced osmotic dehydration effect. The progressive reduction in the percentage weight of egg samples as function of time in each concentration of sucrose were plotted to show the effects of the time of immersion on water loss at the concentrations of 16, 32, 43 and 54^{o}Brix respectively as shown in Figure 2.

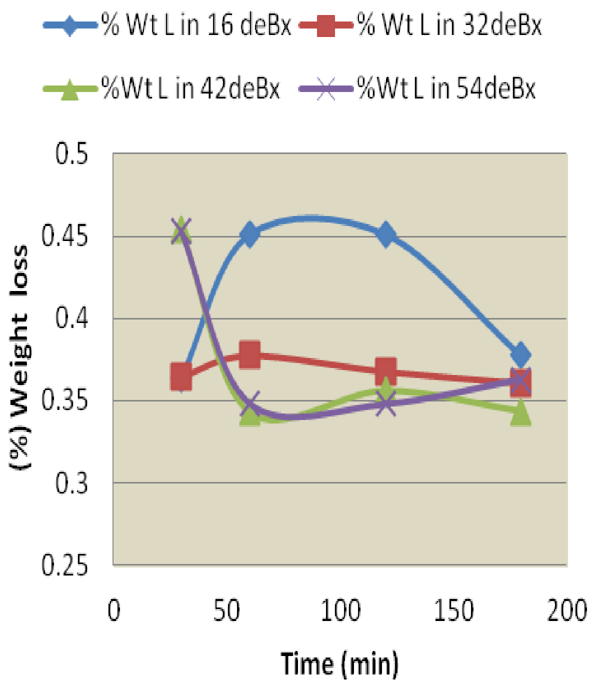

Figure 2: Effects of immersion time on weight loss at different sucrose concentrations.

The trends of weight loss in lower concentrations of 16 and 32 °Bx were pronounced than in higher concentration with time as could be observed in figure 2.0. However, for higher concentrations of 43°Bx and 54°Bx, the trend was in the reverse. It described perhaps the effect of solute impregnation was limited to the shell, which may be difficult to evaluate at this stage. It is associated with high solute concentrations and long durations of immersion.

The weight loss decreased more rapidly as immersion time increased in higher sucrose concentrations. This is an indication that in higher sucrose concentrations, solute impregnation superseded the dehydration process to reflect the gradual increase of the latter. The 43°Bx sucrose concentration attained highest dehydration in 30mins.The characteristic nature of egg shells and the underlying membranes is proven to be semi-permeable.

The candling method eggs for shelf-life elongation of treated labelled eggs stocked in an open crate are as indicated in Table 1.0:

Samples of treated eggs having traces of spoilage detected during candling revealed that the yolks of spotted eggs were stuck to one side of the egg shell and appeared dark in colour especially around the yolk broken. However, after a period of about two months, only three eggs appeared healthy and in a very good condition. These include sample in 16°Bx dehydrated for 120min; sample in 32°Bx for 180min and sample in 42°Bx for 30mins. These three eggs samples were rehydrated to equilibrate the content and dissolve adsorbed sucrose molecules before they were subjected to acceptability.

Table 1.0: Shelf life of the treated poultry eggs monitored with candling.

Treated Eggs S/N	Concentrations of sucrose solutions (M)	Time of immersion (min)	Shelf-life (days)
1	16	30	35
2		60	40
3		120	60
4		180	56
5	32	30	50
6		60	43
7		120	38
8		180	60
9	43	30	60
10		60	55
11		120	21
12		180	51
13	54	30	52
14		60	44
15		120	20
16		180	48

One of the eggs broken into a white crucible revealed coherence of the yolk as distinct from albumen without any form of discolouration and compared well with fresh egg sample and from silicate controlled samples. The outline definition of the shape of eggs indicated high quality and freshness.

The remaining two eggs boiled and de-shelled were dissected to into two equal halves with a clean sharp knife for proper assessment. The boiled eggs retained the usual conformation of cooked fresh egg but with an enlarged air space believed to have resulted from dehydration of the content. The test samples smelt fresh, the yolk was intact with its normal yellow colour and retained the normal shape. The pictorial transverse view of the treated boiled samples is shown in Figure 3.

Figure 3: Transverse view of treated and rehydrated boiled egg sample

The appraisal of sensory characteristics and shell life stability of high moisture fruits such as papaya, peach, pineapple and mango fruits is shown in Table 4.0. The texture received the highest scores followed by flavour, colour, and general impression, indicating that combined method technology is a viable alternative in fruit preservation [26].

Table 4.0: Sensory characteristics of shell life stable high moisture fruits (papaya, peach, pineapple, and mango).

Attribute	**Average score**
Flavour	6.65-7.70
Odour	5.80-6.80
Texture	6.70-8.07
Colour	6.46-7.10
Overall impression	6.73-7.63

Similar test used for the purpose was replicated for the acceptability test of the treated eggs on six factor hedonic scale. A scorecard prepared with similar hedonic scale ranging from 0 to 5 points for the judges for the acceptability test is presented in Table 5.0. The value of five (5) is the highest score, implying "very good", and zero (0) is the lowest score. The tastes of the treated eggs were adjudged as good as fresh as graded by testifiers using score card.

Table 5: Score card of acceptability test for treated and preserved egg sample

Acceptability Test

Name of Judge..

Qualities	**Average score**
External shape	
Internal look	
Texture	
Taste	
Colour	
Odour	

Comment...

Sign and Date:..

N.B: Grades: Very Good-5; Good-4; F: Fair-3; Indecisions-2; Dislike-1; zero (0) is Bad

16°Bx concentration of sucrose solution for 120min and 32°Bx concentration of sucrose solution for 3hrs preserved the eggs effectively well. High dehydration was also achieved within 30 minutes to 60min of treatment in a 42°Bx concentration of sucrose solution. Samples treated in 42°Bx sucrose solution for 30 minutes of treatment were preserved for over 60 days. However, the reduced process time makes the former more suitable for large-scale operations and adoption.

The eggs from controlled experiment in water glass were all in good grades. However, it may not be suitable for the tropics or in developing countries with relatively high storage temperature. The silicate hydrates formed will also require another processing technique for its regeneration and recovery which may be difficult than rehydration. Besides, the constraint of large volume and quantity of silicate solution required for large stock is prevented bt the application of osmotic dehydration process.

IV. CONCLUSIONS

In conclusion, egg product with less colour change and a more rigid and softer structure was obtained after 66 days of treatment by osmotic dehydration. Osmotic dehydration is successfully applied to poultry eggs shelf life elongation using sucrose solution. The percentage weight loss is influenced by the sucrose concentrations and times of immersion. This research shows that moderately high sucrose concentration of about (43 °Brix) is most appropriate and effective. Lower concentration required longer period of immersion to achieve the desired dehydration and vice versa. The post-treatment storage did not require special gadget for refrigeration or constant electricity, as treated samples were kept in open crate under normal ambient conditions. The application of osmotic dehydration to poultry eggs in the group of minimally processed food can be used to extend the shelf life without prejudice to the contents. It is suitable for large-scale preservation of fresh poultry eggs and making it possible for regular supply throughout the year.

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