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Osmotic Dehydration of Garden Egg

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ABSTRACT
In this research work, osmotic dehydration, a growing food preservation technique was exploited for its potency in preserving garden eggs (Solanum aethiopicum) using sugar (sucrose) solution of various concentrations. Effects of parameters such as concentration, temperature and osmo-dehydration time were examined in order to elucidate the %weight gain, %solid gain and %weight reduction of the sample during the dehydration process. The sugar concentrations used are 20, 40 and 60 %w/w while studying the effects of time and concentration at a constant temperature of 40°C; and the effects of temperature for a constant time of 120 min was studied. The results obtained showed that concentration, temperature and osmo-dehydration time all had significant effect on the dehydration process as they affect the solid gain, water loss and weight reduction of the samples. The statistic results also revealed that these parameters have both linear and non-linear relationship with the variables: %weight gain, %solid gain and %weight reduction

Key Words: Osmotic Dehydration, Moisture Content, Preservation, Garden Egg

I. INTRODUCTION

Food preservation is the process of treating and handling food to stop or greatly slow down spoilage (loss of quality, edibility or nutritive value) caused or accelerated by microorganism. A large percent of fruit and vegetable productionin many countries of the world goes waste due to lack of proper retailing andadequate storage capacity. The name 'Garden egg' was derived from the shape of fruits of some varieties which are shaped like chicken eggs. The fruits of the plant cones in a wide array of the shapes and colour (Harish, B. N., Babu, P. A., Mahesh, T, and Venkatesh, Y. P., 2008). Solanum aethiopicum is one of the species of African egg plants or garden egg as it is commonly called in many parts of Nigeria where they are used for hospitality in place of cola nuts and as stew condiments. Solanum species are used in traditional medicine as antioxidants and laxative (Pessarakli, M. M., and Dris, R., 2003).

Osmotic dehydration found wide application in the preservation of food-materials since it lowers the water activity offruits and vegetables. Osmotic dehydration is preferred overother methods due to their color, aroma, nutritional constituents and flavor compound retention value. In osmotic dehydration the solutes used are generally sugarsyrup with fruit slices or cubes and salt (sodium chloride) orbrine with vegetables, this is multicomponent diffusion process. In this process water flow from fruits or vegetables tosolution and along with water, some components of fruits andvegetables such as minerals, vitamins, fruit acids etc. alsomove towards solution. (Tiwari, 2005).

(Tiwari, 2005),described the different application of osmo-air dehydration of tropical fruits and how this alternative could be beneficial in development of rural areas. However product quality wereinfluenced by factors like pretreatment, nature and concentration of osmotic solution, quality of raw material, maturityof fruits, shape and size of slices, duration of osmosis, sample to syrup ratio agitation, temperature and addictive's added. Osmotic dehydration could be very much beneficialfor banana, jackfruit, sapota, mango, guava and pineapple. The process of osmotic dehydration could be employed in rural areas as entrepreneurs, home scale or with NGO's (Non-Governmental Organizations) at commerciallevel since it is economical. (USDA, 2009)

Garden Egg

Garden egg plants are fruit vegetables of some varieties which are white and shaped like chicken eggs, hence the name 'garden egg'.(Yadav, A. K, and Singh, S. V, 2012) The fruits may be pear-shaped, round, long or cylindrical depending on the variety. The plant with the scientific name Solanumspp. is a vegetable with the increasing popularity in the world. It is an economic flowering plant belonging to the family Solanaceaeand genus Solanum. It exists in about 1,400 species found around the world most especially in the temperate

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and tropical regions (Pessarakli, M. M., and Dris, R., 2003). The genus Solanumcomprises over 1,000 species with at least 100 indigenous African species (FAO, 2008).Productionof
garden egg is highly concentrated with 85% of the output coming from five (5) countries of which China is the world largest producer (56% of garden egg
output), followed by India (26%), Egypt, Turkey and Indonesia (FAO, 2008).
Four cultivar groups are recognized within the Solanum species, three of which are important for Africa (Plant Resources of Tropical Africa) (Ozobia, A. P., Omaliko, E. P., Amusa, A. R., and Idacheba, N., 2013). They are the Gilo, Kumba, Shum and Aculeatum groups. The first three are the most important in Africa; Gilo and Kumba groups are produced for their fruits, especially in the humid zone of West Africa while Shum is cultivated for its leaves in the savannah area. African garden egg is one of the most commonly consumed fruit vegetable in the tropical Africa, in quantity and value and probably, the third after tomato and onions and before okra. In Nigeria, different local species/varieties are in existence and are grown by different ethnic groups for local consumption and other uses. The fruits can be eaten raw as a vegetable. It could also be boiled, fried and stuffed before consumption (Ozobia, A. P., Omaliko, E. P., Amusa, A. R., and Idacheba, N., 2013).

Garden egg vegetables are mostly annual crops belonging to the group of plants called horticultural crops which are diverse in nature. However, vegetables can be grouped into fruit and leafy vegetables depending on the nature of their consumable products or parts. Fruit vegetables are those that produce fruit such as okra, tomato, garden egg, etc. On the other hand, leafy vegetables are those whose leaves are the desired parts e.g. lettuce, spinach, cabbage, cauliflower, parsley, etc. Thus, the cultivation of vegetable during the dry season with the aid of irrigation is termed dry season vegetable farming. Consuming high amounts of garden eggs has been found to be beneficial for people with glaucoma because it lowers the eye pressure (Dauda, S. N., Aliyu, L. and Chiezey, U. F., 2005).
Eggplant nutritious value is comparable to the values of other common vegetables. Its fresh weight is composed of 92.7% moisture, 1.4% protein, 1.3% fibre, 0.3% fat, 0.3% minerals, and the remaining 4% consists of various carbohydrates and vitamins (A and C). It also contains water (about 92.5%), protein (1%), fat (0.3%), and carbohydrates (6%). Similarly, eggplant contains nutrients such as dietary fiber, folate, ascorbic acid, vitamin K, niacin, vitaminB6, pantothenic acid, potassium, iron, magnesium, manganese, phosphorus, and copper (USDA, 2009). The crop is usually intercropped with okra, tomato and hot pepper under rain-fed conditions and often results in reduction of yield of both component crops possibly due to similarity in the growth pattern and duration (Chenlo, F., Chaguri, L., Santos, F., and Moreira, R., 2006). Dry season vegetable farming has its origin in the northern region. It is a major economic activity during the dry season involving many youths (Castello, M. L., Fito, P. J., and Chiralt, A., 2010).

Garden egg is cultivated all year round in different parts of Nigeria and West Africa and serves as the main source of income for many rural farmers and households. Production is however constrained by a wide range of pests and diseases reducing total production as well as production quality. A great variety of insect species from different orders and families have been recorded on the garden egg of which very few are of economic importance. According to (Okito, A. B., Alves, J. R., Urquiaga, S., and Boddey, R. M., 2004) eggplant is most popular in southern Nigeria particularly in Igbo land, because of both cultural and traditional importance. In Nigeria, though there are no official figures recorded for Solanum giloproduction, the crop has a wide distribution as a garden crop (Dauda, S. N., Aliyu, L. and Chiezey, U. F., 2005).

II MATERIALS AND METHODS

Materials

Garden eggs (Solanum aethiopicum), sucrose solutions of varying concentrations, analytical weighing balance, oven, stop watch, distilled water, beakers, conical flasks, Aluminum foil, cotton wool and statistical software (ANOVA).

Methods

Sample collection and preparation:

The garden eggs (unripe) which have no defects were sourced from a local market in IworokoEkiti, Ekiti State, Nigeria and preparation was done by cleaning, washing with distilled water and air-dried at room temperature for 24 hours prior to further analysis.

Osmotic dehydration procedure

Osmotic solution was prepared using Analyticalgrade sucrose and distilled water. The solutionconcentrations (20, 40 and 60% w/w) throughout each experiment were monitored. Experiments wereperformed at 45 ºC using an agitated waterbath (Memmert, WNE14. Memmert GmbH Co. KG, made in Germany). The temperature was monitored using athermometer. Sampling was performed intime intervals of 20, 40, 60, 80, 100 and 120 min, and then the samples rinsed quickly with distilledwater (below 30 s) to eliminate the solution from thesurface and carefully blotted with cotton wool toremove the excess surface water (Najafi, H. A., Yusof, Y. A., Rahman, R. A., Ganjloo, A., and Ling, C. N., 2014) This was done to study the effect of time and concentration on the osmotic process. While effect of temperature was studied using solutionconcentrations of 20, 40 and 60% w/w at process time of 105 min and temperatures of 30, 45, 50 and 60°C. 10 g of the garden egg samples were used throughout the experiment.

Analytical Determination

Before and after treatment, when the temperatureof samples reached 25ºC, weights of garden eggcubes were measured using an analytical Mettler
Toledo balance (±0.0001 g) to determine mass changes.Moisture and solid contents were determined by thegravimetric method in oven at 105°C until a constant weight(24 h) was obtained (AOAC, 1990). All measurementswere carried out triplicate.

Determination of weight reduction, solid gain andwater loss

The fresh and dehydrated garden eggcubes aftereach contact times were placed in oven (HeraeusVacutherm VT6025, Germany) at 105°C until constantweight (24 h) in order to measure the moisture andsolids content according to Association of OfficialAnalytical Chemists (AOAC, 1990).

From these data, Weight Reduction (WR), SolidGain (SG) and Water Loss (WL) were determined in allthe cases at different times, t, in agreement with the following equations (Panagiotouet al., 1999).

$$\%WL = \frac{a-(b-c)}{A} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots \text{(i)}$$

$$\%WR = \frac{a-b}{a} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

$$\%SG = \frac{d-e}{e} \times 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(iii)}$$

Where
a= initial mass of fresh sample (g),
b=mass of sample after time (t) of osmoticdehydration (g)
c=is the solid gain,
d=is the dry mass of sample (g) aftertime (t) of osmotic dehydration
e =is the initial driedmass of sample (g).

%weight loss = weight loss x 100%

Weight loss = initial mass – final mass.

III. RESULTS AND DISCUSSION

Results

Table 1 Osmo-dehydration parameters with respect to time and concentration

Concentration (%w/w)	Time (min)	Weight after osmo-dehydration (g)	Weight after oven drying (g)	% water loss	Solid gain (g)	% solid gain	% weight reduction
% 20 Sugar	20	9.90	0.68	2.80	0.18	36.00	1.00
	40	9.48	0.73	7.50	0.23	46.00	5.20
	60	9.20	0.77	10.70	0.27	54.00	8.00
	80	9.15	0.81	11.60	0.31	62.00	8.50
	100	8.91	0.86	14.50	0.36	72.00	10.90
	120	8.62	0.90	17.80	0.40	80.00	13.80
% 40 Sugar	20	9.57	0.68	6.10	0.18	36.00	4.30
	40	9.14	0.82	11.80	0.32	64.00	8.60
	60	8.71	0.88	16.70	0.38	76.00	12.00
	80	8.51	0.91	19.00	0.41	82.00	14.90

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	100	8.23	0.95	22.20	0.45	90.00	17.70
	120	8.00	0.96	24.60	0.46	92.00	20.00
% 60 Sugar	20	9.10	0.76	11.60	0.26	52.00	9.00
	40	8.84	0.80	14.60	0.30	60.00	11.60
	60	8.26	0.85	20.90	0.35	70.00	17.40
	80	7.80	0.97	26.70	0.47	94.00	22.00
	100	7.66	1.00	28.40	0.50	100.00	23.40
	120	7.62	1.21	30.90	0.71	142.00	23.80

Table 2 Osmo-dehydration parameters with respect to temperature and concentration

Concentration (%w/w)	Temperature (^{o}C)	Weight after osmo-dehydration (g)	Weight after oven drying (g)	% water loss	Solid gain (g)	% solid gain	% weight reduction
% 20 Sugar	30	9.61	0.66	10.50	0.16	32.00	3.90
	45	8.47	1.08	26.10	0.58	116.00	15.30
	50	8.25	0.74	24.90	0.24	48.00	17.50
	60	8.54	0.69	21.50	0.19	38.00	14.60
% 40 Sugar	30	8.90	0.72	18.20	0.22	44.00	11.00
	45	8.11	1.11	30.00	0.61	122.00	18.90
	50	7.43	0.95	30.20	0.45	90.00	25.70
	60	8.77	0.70	19.30	0.20	20.00	12.30
% 60 Sugar	30	9.43	0.59	6.60	0.09	1.80	5.70
	45	7.22	0.75	30.30	0.25	44.00	27.80
	50	7.82	0.86	25.00	0.36	72.00	21.80
	60	8.50	1.02	19.80	0.48	96.00	15.00

Table 3 Statistical analysis for % Water loss with respect to temperature and concentration

	% 20 Sugar	% 40 Sugar	% 60 Sugar
Minimum	10.50	18.20	6.600
25% Percentile	13.25	18.48	9.900
Median	23.20	24.65	22.40
75% Percentile	25.80	30.15	28.98
Maximum	26.10	30.20	30.30
Mean	20.75	24.43	20.43
Std. Deviation	7.106	6.569	10.16
Std. Error	3.553	3.284	5.082
Lower 95% CI of mean	9.443	13.97	4.250
Upper 95% CI of mean	32.06	34.88	36.60
One sample t test			
Theoretical mean	0.0	0.0	0.0
Actual mean	20.75	24.43	20.43
Discrepancy	-20.75	-24.43	-20.43
95% CI of discrepancy	9.445 to 32.06	13.97 to 34.88	4.253 to 36.60
t, df	t=5.840 df=3	t=7.437 df=3	t=4.019 df=3
P value (two tailed)	0.0100	0.0050	0.0277
Significant (alpha=0.05)?	Yes	Yes	Yes

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Table 4 Statistical analysis for % Solid gain with respect to temperature and concentration

	% 20 Sugar	% 40 Sugar	% 60 Sugar
Minimum	32.00	20.00	1.800
25% Percentile	33.50	26.00	12.35
Median	43.00	67.00	58.00
75% Percentile	99.00	114.0	90.00
Maximum	116.0	122.0	96.00
Mean	58.50	69.00	53.45
Std. Deviation	38.90	45.74	40.46
Std. Error	19.45	22.87	20.23
Lower 95% CI of mean	-3.395	-3.780	-10.94
Upper 95% CI of mean	120.4	141.8	117.8
One sample t test			
Theoretical mean	0.0	0.0	0.0
Actual mean	58.50	69.00	53.45
Discrepancy	-58.50	-69.00	-53.45
95% CI of discrepancy	-3.386 to 120.4	-3.770 to 141.8	-10.93 to 117.8
t, df	t=3.008 df=3	t=3.017 df=3	t=2.642 df=3
P value (two tailed)	0.0573	0.0569	0.0775
Significant (alpha=0.05)?	No	No	No

Table 5 % Weight Reduction with Respect to Temperature and Concentration

	% 20 Sugar	% 40 Sugar	% 60 Sugar
Minimum	3.900	11.00	5.700
25% Percentile	6.575	11.33	8.025
Median	14.95	15.60	18.40
75% Percentile	16.95	24.00	26.30
Maximum	17.50	25.70	27.80
Mean	12.83	16.98	17.58
Std. Deviation	6.077	6.767	9.488
Std. Error	3.038	3.384	4.744
Lower 95% CI of mean	3.155	6.207	2.478
Upper 95% CI of mean	22.49	27.74	32.67
One sample t test			
Theoretical mean	0.0	0.0	0.0
Actual mean	12.83	16.98	17.58
Discrepancy	-12.83	-16.98	-17.58
95% CI of discrepancy	3.157 to 22.49	6.208 to 27.74	2.480 to 32.67
t, df	t=4.221 df=3	t=5.017 df=3	t=3.705 df=3
P value (two tailed)	0.0243	0.0153	0.0342
Significant (alpha=0.05)?	Yes	Yes	Yes

Table 6. %Water Loss With Respect To Temperature and Concentration

	% 20 Sugar	% 40 Sugar	% 60 Sugar
Minimum	2.800	6.100	11.60
25% Percentile	6.325	10.38	13.85
Median	11.15	17.85	23.80
75% Percentile	15.33	22.80	29.03
Maximum	17.80	24.60	30.90
Mean	10.82	16.73	22.18

Std. Deviation	5.258	6.846	7.825
Std. Error	2.147	2.795	3.195
Lower 95% CI of mean	5.299	9.549	13.97
Upper 95% CI of mean	16.33	23.92	30.40
One sample t test			
Theoretical mean	0.0	0.0	0.0
Actual mean	10.82	16.73	22.18
Discrepancy	-10.82	-16.73	-22.18
95% CI of discrepancy	5.298 to 16.34	9.548 to 23.92	13.97 to 30.40
t, df	t=5.039 df=5	t=5.987 df=5	t=6.944 df=5
P value (two tailed)	0.0040	0.0019	0.0010
Significant (alpha=0.05)?	Yes	Yes	Yes

Table 7 % Solid Gain With Respect To Temperature and Concentration

	% 20 Sugar	% 40 Sugar	% 60 Sugar
Minimum	36.00	36.00	52.00
25% Percentile	43.50	57.00	58.00
Median	58.00	79.00	82.00
75% Percentile	74.00	90.50	110.5
Maximum	80.00	92.00	142.0
Mean	58.33	73.33	86.33
Std. Deviation	16.37	20.93	33.12
Std. Error	6.682	8.543	13.52
Lower 95% CI of mean	41.16	51.37	51.58
Upper 95% CI of mean	75.51	95.29	121.1
One sample t test			
Theoretical mean	0.0	0.0	0.0
Actual mean	58.33	73.33	86.33
Discrepancy	-58.33	-73.33	-86.33
95% CI of discrepancy	41.15 to 75.51	51.37 to 95.30	51.57 to 121.1
t, df	t=8.730 df=5	t=8.584 df=5	t=6.386 df=5
P value (two tailed)	0.0003	0.0004	0.0014
Significant (alpha=0.05)?	Yes	Yes	Yes

Table 8 % Weight Reduction With Respect To Temperature and Concentration

	% 20 Sugar	% 40 Sugar	% 60 Sugar
Minimum	1.000	4.300	9.000
25% Percentile	4.150	7.525	10.95
Median	8.250	13.90	19.70
75% Percentile	11.63	18.28	23.50
Maximum	13.80	20.00	23.80
Mean	7.900	13.07	17.87
Std. Deviation	4.452	5.826	6.341
Std. Error	1.817	2.379	2.589
Lower 95% CI of mean	3.228	6.952	11.21
Upper 95% CI of mean	12.57	19.18	24.52
One sample t test			
Theoretical mean	0.0	0.0	0.0
Actual mean	7.900	13.07	17.87
Discrepancy	-7.900	-13.07	-17.87
95% CI of discrepancy	3.228 to 12.57	6.951 to 19.18	11.21 to 24.52

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t, df	t=4.347 df=5	t=5.493 df=5	t=6.902 df=5
P value (two tailed)	0.0074	0.0027	0.0010
Significant (alpha=0.05)?	Yes	Yes	Yes

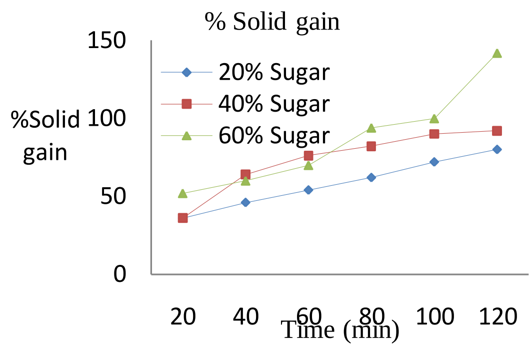

Fig.1: %solid gain with increase in time at varying sugar concentration

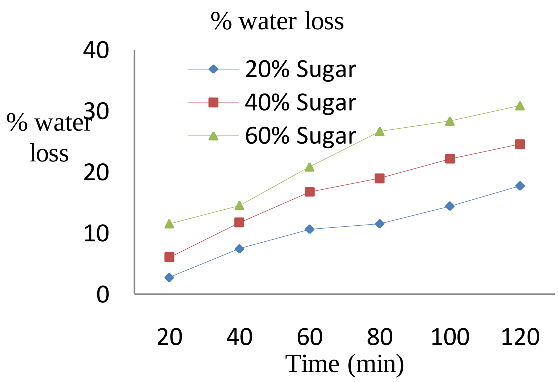

Fig. 2: %water loss with increase in time at varying sugar concentration

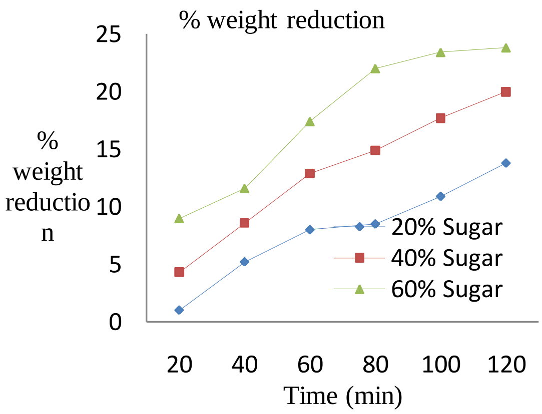

Fig.3: %weight reduction with increase in time at varying sugar concentration

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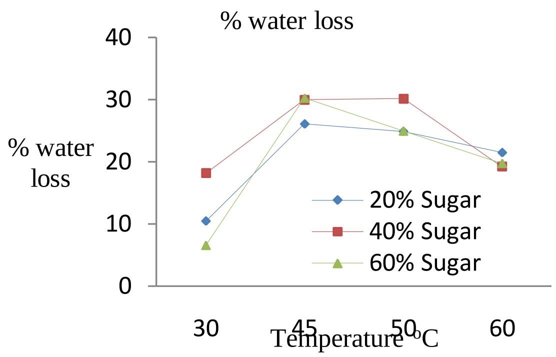

Fig. 4: %water loss at varying temperature

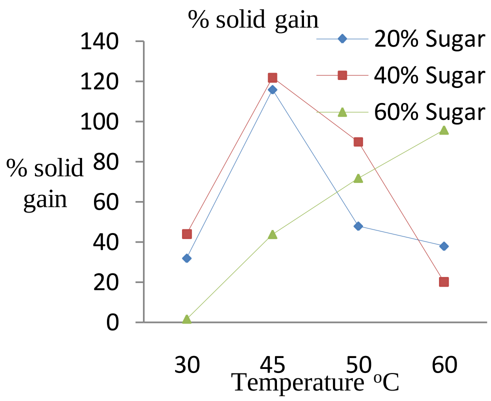

Fig. 5: %solid gain at varying temperature

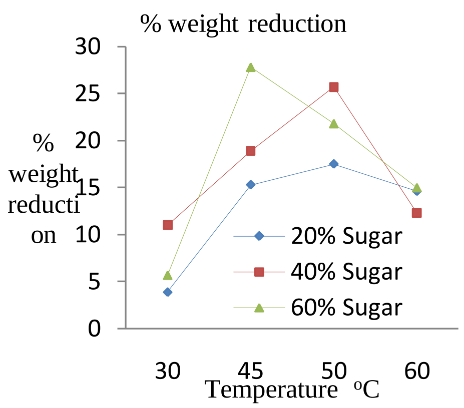

Fig. 6: %weight reduction at varying temperature

Proximate Analysis

Proximate analysis results reveals that the percentage moisture contents, crude fibre, ash, protein and carbohydrate increases as the concentration increases, while the fat decreases with increase in the concentration

Table 9 Proximate Analysis of Solanum aethiopicum at 10g

Concentration Sample % $\frac{w}{w}$	Moisture Content (%)	Fat (%)	Crude fibre (%)	Ash (%)	Protein (%)	Carbohydrate (%)
20	12.01	0.79	9.22	10.13	29.85	38
40	12.09	0.57	9.23	10.14	29.87	38.1
60	12.12	0.54	9.26	10.16	29.9	38.02

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DISCUSSION

The solution concentration and dehydration time is important factors that affect water loss(WL), weight reduction(WR) and solid gain(SG) of the garden egg slices with different percentage sugar solution concentration of 20, 40 and 60 w/w were used at different time of 20, 40, 60, 80, 100, and 120 min as shown in Figure 1, 2 and 3.

The results from the experiments as shown in Figure 1 and Table 1 revealed that the percentage sugar solution concentrationof solid gain for: 20 w/w solution concentrations are: 36, 46, 54, 62, 72 and 80; for 40 w/w solution, concentrations are: 36, 72, 38, 82, 90 and 92; and for 60 w/w solution concentrations are 52, 60, 70, 94, 100 and 142.At different time of 20, 40, 60, 80, 100, and 120 min respectively at temperature of 40^{o}C. This implies that percentage sugar solution concentration of solid gain ofgarden egg slices for all the concentrations of 20, 40 and 60 w/w increases with increase in dehydration time from 20 to 120 min. Also, the results showed that the moisture content is highest for solution with the highest sucrose concentration of 60 w/w) and higher for 40 w/w sucrose solution than that of 20 w/w sucrose solution. These findings confirmed that high concentration of sucrose solution (>50 w/w) is a mass transfer rate limiting parameter during osmotic dehydration process. These results corroborate to those obtained by several research groups for osmotic dehydration of mango slices.

The most important parameter to examine in osmo-dehydration process is the water loss.The amount of water loss expressed in percentage is shown in Figure 2 and Table 1. The percentages of water loss for percentage sugar solution concentration of20 w/w solution are: 2.8, 7.5, 10.7, 11.6, 14.5 and 17.8; for 40 w/w solution are: 6.1, 11.8, 16.7, 19, 22.2 and 24.6 while that of 60 w/w solution are 11.6, 14.6, 20.9, 26.7, 28.4 and 30.9; for the duration of 20, 40, 60, 80, 100 and 120 min respectively at the temperature of 40 ^{o}C.from these results, it can be seen that increase in osmo-dehydration time bring about increases in the amount of water loss. This stretches that there is linear relationship between water loss and osmo-dehydration time of the garden egg. More so, the results showed that the amount of water removed during this process is highest for percentage sugar solution of 60 w/w and higher for 40 w/w sucrose solution than that of 20 w/w sucrose solution. This also shows linearity of water loss with increased concentration of sucrose solution.

The results of this study shown in Figure 2 and Table 1, present the weight reduction of the garden egg samples in percentages. For percentage sugar solution concentration of 20 w/w weight reductionare: 1, 5.2, 8, 8.5, 10 and 13.8; for percentage sugar solution concentration of40 w/w weight reduction are: 4.3, 8.6, 12.9, 14.9, 17.7 and 20; and for percentage sugar solution concentration of 60 w/w the weight reduction are 9, 11.6, 17.4, 22, 23.4 and 23.8; at different time of 20, 40, 60, 80, 100 and 120 min respectively at temperature of 40^{o}C. These results showed that the percentage weight reduction of the garden egg slices for all the percentage sugar solution concentration of 20, 40 and 60 w/w, increases with increase in dehydration time from 20 to 120 min. the results also showed that the amount of weight reduced during this process is highest for solution with the highest percentage sugar solution concentration, 60 w/w and higher for percentage sugar solution concentration of 40 w/w sucrose solution and least at percentage sugar solution concentrationof 20 w/w. The weight reduction of the garden egg during the osmo-dehydration process could be best attributed to substantial changes in cellular tissues such as loss of cell tugor (plasmolysis).

The solution temperature is also an important factor that affects water loss(WL), weight reduction(WR) and solid gain(SG) by the garden egg slices with different sugar solution concentration and temperature of 30, 45, 50 and 60 ^{o}C for the duration of 120 min.

The results from the experiments shown in Figure 4 and Table 2 revealed that the percentages of water loss for percentage sugar solution concentration of20 w/w are: 10.5, 26.1, 24.9 and 21.55; for percentage sugar solution concentration of40 w/w are: 18.2, 30, 30.2 and 19.3; and for percentage sugar solution concentration of60 w/w are: 6.6, 30.3, 25 and 19.8 at time of 120 min respectively at the temperature of 30, 45, 50 and 60^{o}C. These results showed that percentage water loss by the garden egg slices for all the percentage sugar solution concentration of 20, 40 and 60 w/w increases with increase in dehydration temperature from 30 to 50^{o}C and reduced at 60^{o}C. Also, the results showed that the amount of water removed during this process was highest for percentage sugar solution concentration of20 and 60 w/w at the temperature of 45^{o}C,

The experimental results depicted in Figure 6 and Table 2, showed that the percentages of solid gain for percentage sugar solution concentration of 20 w/w are 3.9, 15.3, 17.5 and 14.6; for percentage sugar solution concentration of40 w/w are: 11, 18.9, 25.7 and 12.3; and for percentage sugar solution concentration of60 w/w are 5.7, 27.8, 21.8 and 15 for the duration of 120

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min respectively at the temperature of 30, 45, 50 and 60°C. These results showed that percentage weight reduction of the garden egg slices for the percentage sugar solution concentration of 20 and 40 w/w, increase with increase in dehydration temperature from 30 to 50°C and reduced at 60°C, while the percentage sugar solution concentration of60 w/w increases with increase in dehydration temperature from 30 to 45°C and reduced from 50 to 60°C as shown in Figure 6 and Table 2. The results show that weight reduction is temperature dependent.

The experimental results shown in Figure 2 and Table 2, showed that the percentages of solid gain for percentage sugar solution concentration of20 w/w are 32, 116, 48 and 38; for percentage sugar solution concentration of40 w/w are: 44, 122, 90 and 30.2; and for the percentage sugar solution concentration of60 w/w are 1.8, 44, 72 and 96 for time of 120 min respectively at the temperature of 30, 45, 50 and 60°C. These results showed that the percentage solid gain of the garden egg slices for percentage sugar solution concentration of 20 and 40 w/w increases with increase in dehydration temperature from 30 to 45°C and reduced from 50 to 60°C while that of percentage sugar solution concentration of 60%w/w increases with increase in dehydration temperature from 30 to 50°C and reduced at 60°C as shown in Figure 5 and Table 2.

The results of the statistical analysis of all the variables when subjected to Turkey's test with a 95% of confidence level ($p<0.05$), showed that there are significant differences in results obtained for all parameters generated for each of the osmotic dehydration experimental variables (percentage solid gain, percentage water loss and percentage weight reduction) with respect to concentration, temperature and time as shown in Table 3-8 except for those of percentage solid gain at varying degrees of temperature (Table 4). The results is shown as Significant (alpha=0.05)-Yes/No.

CONCLUSION

The results from this study reviewed that osmotic dehydration by sucrose solution could potentially reduce water activity of garden egg to promote its shelf life or could be employed as a pretreatment technique for further drying, wherefore, removal of excess sugar and rehydration of dried matter becomes a major advantage of this technique. The data from this study is an added value to the already existing information on conventional techniques for food preservation and osmotic dehydration processes. This study therefore, showed osmotic dehydration process to be a cheap, effective, alternative and beneficial technique for food preservation including garden egg most especially in rural areas.

It could also be concluded that during this process, water is loss and sucrose is gained simultaneously and weight reduction is observed.

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