Int.J.Curr.Microbiol.App.Sci (2017) *6*(10): 4816-4824

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 10 (2017) pp. 4816-4824**
Journal homepage: http://www.ijcmas.com

Original Research Article https://doi.org/10.20546/ijcmas.2017.610.449

Osmotic Dehydration of Plantain Cultivar French (Agnrin) in Binary Solution (Sucrose or Glucose)

Loa Jean François Régis Bilo[1], Kouamé Akissi Françoise[1] and Yao N'Zué Benjamin[2]

[1]Laboratory of Food Biochemistry and Tropical Products Technologies, Dept. of Food Science and Technology, Nangui-Abrogoua University, 02 BP 801 Abidjan 02, Côte d'Ivoire, Africa
[2]Dept. of Agroforesterie, University Jean Lorougnon Guede, BP 150 Daloa, Côte d'Ivoire, Africa
**Corresponding author*

Keywords

Osmotic dehydration, Plantain, Experimental design, Influence of parameters.

Article Info

Accepted:
29 September 2017
Available Online:
10 October 2017

A B S T R A C T

The objective of this work was to study the influence of parameters (temperature, solute and concentration) on kinetics of water loss (WL) and on interaction effect of these parameters on water loss (WL), solute gain (SG) and weight reduction (WR) on osmotic dehydration of plantain cultivar French. The study was carried out using a factorial experimental design. This experimental design was composed of two factors with three levels and one factor with two levels, which gives a total of 18 tests to be carried out. Three parameters were considered: solute (glucose and sucrose), temperature (30, 50 and 70 °C) and concentration (50, 60 and 70 °Brix). Results showed that the increase of the concentration of solution and the temperature entraine an increase of WL. WL varies from 16.06-42.06 % and 18.48-44.87 % respectively with glucose and sucrose. WL, SG and WR after 8 h of immersion of the whole of the 18 tests were respectively of 36.41-65.86 %; 12, 66-19.66 % and 22.52-50, 40 %. Sucrose gives the most important water losses that glucose. The factors taken into account in this study (solute, temperature and concentration) showed significant effects on WL, SG and WR of plantain.

Introduction

Plantain is a basic food for the populations of some African countries. It is an excellent minerals source (iron and potassium), of vitamins (K, C, A and B6) of fibers and carbohydrates. It constitutes in particular a significant source of income for the populations which cultivate it. The annual production of plantain from Côte d'Ivoire is estimated at 1.6 million tons, which classifies it in the 3rd position of food-producing behind yam and rice (FAO, 2012).

Generaly, the pulp of Plantain is directly used for the transformation. The conservation of pulp is generally done by drying. Pulp is cut out in section and is dehydrated by drying, to obtain cossettes or is crushed to obtain flour (Ukhum and Ukpebor, 1991). Drying is usually a long process that requires high temperatures, leading to degradation and oxidation of some nutrients. Other techniques such as osmotic dehydration are also used to reduce or eliminate partially water in food.

Osmotic dehydration (OD) can be considered as an important step prior to drying, since it provides a reduction in nutrient losses and an improvement in product quality (Mandala *et* *al.*, 2005; Riva *et al.*, 2005). In such processes, the product is soaked in a hypertonic solution, where two main countercurrent mass transfer flows take place: a water flow from the product to the solution and a solute migration from the solution to the product. OD consists of partial elimination of water contained in a food by immersing it in a hypertonic solution of sugar and / or salt (Shingh and Meheta, 2008). It has several advantages such as the stabilization of color, conservation of flavor (Mavroudis *et al.*, 2005). Several studies have been conducted on the OD of many fruits and vegetables, authors such as Derossi (2015) have worked on the DO of tomato sauces; Fernades (2008) on melon; Kejian Zou (2013) on mango chips; Amami (2005) on potatoes; N'goran (2012) on tropical fruits (mango and papaya). Particularly for bananas, the OD has focused on the Cavendish variety (Mauro and Menegalli 1995; Rastogi *et al.*, 1997; and Fernandes *et al.*, 2006). However, few studies have focused on plantain. It is important to point out that plantain occupies the third place of food products in Côte d'Ivoire. The cultivars most cultivated in Côte d'Ivoire are the cultivar Corne and the cultivar French (*Agnrin*), they represent 90 % of the production (N'Da Adopo, 1998).

The objective was to analyse the influence of temperature, solute and concentration of the osmotic solution on the mass transfer process during the osmotic dehydration of cultivar French (Agnrin), in order to propose the osmotic dehydration as an alternative conservation solution or pretreatment method for the conservation of this cultivar.

Materials and Methods

Preparation of Sample

Plantains (French) were purchased from a local market. They were selected according to the quality attributes: color (yellow), uniformity, solids solubles (8-9 °Brix), water content (63-65 %).

Osmotic dehydration

For the osmotic dehydration, sucrose and glucose solutions with 50, 60 and 70 °Brix were used at three different temperatures (30, 50 and 70 °C). Plantain was cut, weighed (10 g) and immersed whole into the osmotic solution in glass jars, which were then covered with lids to reduce moisture loss. The solution-to-sample ratio is 10:1(w/v). The process was carried out for 8 h. Fruits were removed from the jars at 1-h intervals, quickly rinsed and gently blotted with tissue paper to remove excess solution from the surface, then weighed and returned to the osmotic solution to continue the dehydration process. Each experiment was carried out in triplicate. Water loss (WL), Weight reduction (WR) and solid gain (SG) of the sample was calculated based on its weight, moisture content, according to following Equations:

$$WL = \frac{Me_{(0)} - Me_{(t)}}{M} \times 100$$

$$WR = \frac{(M_i - M_f)}{M_i} \times 100$$

$$SG = WL - WR$$

With: WL: water loss, WR: weight reduction, SG: solids gain. Me (0): mass of water of the sample before treatment, M (t): mass of water of the sample after treatment at time t, M: initial mass of the sample before treatment, Mi: initial mass of the fruit, Mf: final mass of the fruit.

Experimental design

A factorial design on mixed levels was used to carry out this experimentation, it composite to three factors (independent variables): solute (sucrose and glucose), temperature (30, 50 and 70°C) and solution concentration (50, 60 and 70 %). This experimental design includes two factors with 3 level and one factor with 2 level, giving a total of 18 tests. Table 1 presents the matrix experimental, the coded values X1, X2 and X3 respectively designate the solute, the temperature and the concentration of the solution.

Table 1 summarizes all 18 tests to be carried out. Each test carried out depends on the experimental conditions described in this Table. Thus, water loss (Y1), solute gain (Y2) and weight reduction (Y3) are the responses taken into account and given by the following equation:

$$Y = f(X_1, X_2, X_3, X_4)$$

From the expected responses of the different tests, the global effect, principal and interaction effects of the different factors were calculated using the multiple linear regression equation performed by Microsoft Excel 2013 software (Microsoft Inc. Texas, USA). A coefficient is significant if its probability is less than 10 % (Feinberg, 1996). The first column of Table 1 shows the tests, the next three columns represent the coded values of the tests and the last three columns indicate the reel values of the tests.

Results and Discussion

Influence of process variables

Influence of solute concentration

Fig. 1 and 2 show respectively the influence of the concentration of glucose and sucrose on the water loss of plantain. With glucose (Fig. 1), WL varies from 16.06 to 42.06 % and with sucrose (Fig 2.), WL varies from 18.48 to 44.87 %. According to FIGS. 1 and 2, the increase in the concentration of the osmotic solution leads to a significant ($p < 0.05$) increase in WL. The highest water losses for both solutes (sucrose and glucose) are obtained at 70 °Brix. Similar results have been reported by Fernandes *et al.,* (2008); Ismail *et al.,* (2007) and N'goran *et al.,* (2012) in their respective studies on melon, potato and tropical fruits (mango and papaya). According to Ispir and Togrul (2009), the increase in the concentration gradient leads to an increase in the osmotic pressure exerted by the solution on the fruit, which leads to a higher water loss.

Influence of temperature

The influence of temperature on the water loss is illustrated by Figs. 3 and 4. According to these figures, WL are not significantly different between 30 and 50 °C, which explains why the curves of 30 °C and 50 °C are almost confused. On the other hand, WL increases significantly for both solutes between 50 and 70 °C. Temperature has a significant influence ($p < 0.05$) on the duration of osmotic dehydration. WL after 1 h of treatment at 70 °C (26.43 %) are obtained after 3 h of treatment at 30 °C (26.25 %) and at 50 °C (27.57 %). The increase in the temperature of the osmotic solution does not systematically lead to an increase in the water loss. Similar results have been reported by Chenlo (2006). The influence of temperature in the OD phenomenon divides many authors. Some authors such as Sablani and Shafur Rahman, (2003) and Corzo and Gomez, (2004) have shown in their work that temperature does not have a significant effect on OD, whereas other authors such as Khoyi *et al.,* (2007); Azoubel *et al.,* (2008) estimate that the increase in temperature leads to an increase in water loss. The debatable effect of temperature on the OD would explain the variation of the influence of temperature between 30 °C and 50 °C observed.

Influence of solute

The study of the influence of the type of solute on the water loss during OD was carried out with sucrose and glucose (FIG. 5), the water losses obtained with sucrose are higher than those of glucose throughout the treatment. Significant differences between the water losses of these two solutes were observed from the 4th hour. Sucrose seems to be the ideal solute for OD. The influence of the type of solute could be explained by the size and the molecular weight of the solute. Low molecular weight molecules result in low water loss as high molecular weight solutes (Dermesonlouoglou, 2007). Sucrose with a molecular weight of 342.3 g compared with 182 g for glucose, obviously gives greater water losses than glucose.

Fig.1 Influence of glucose concentration

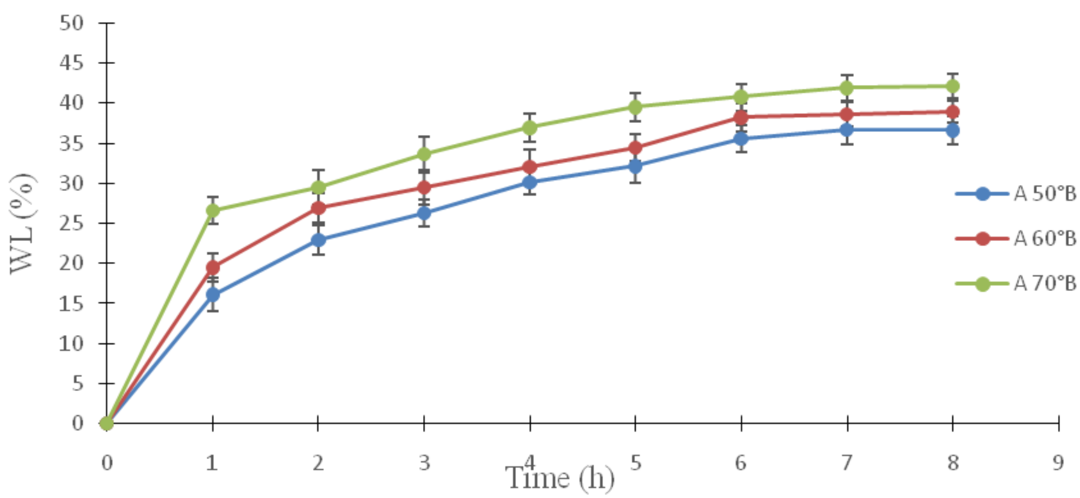

Fig.2 Influence of sucrose concentration

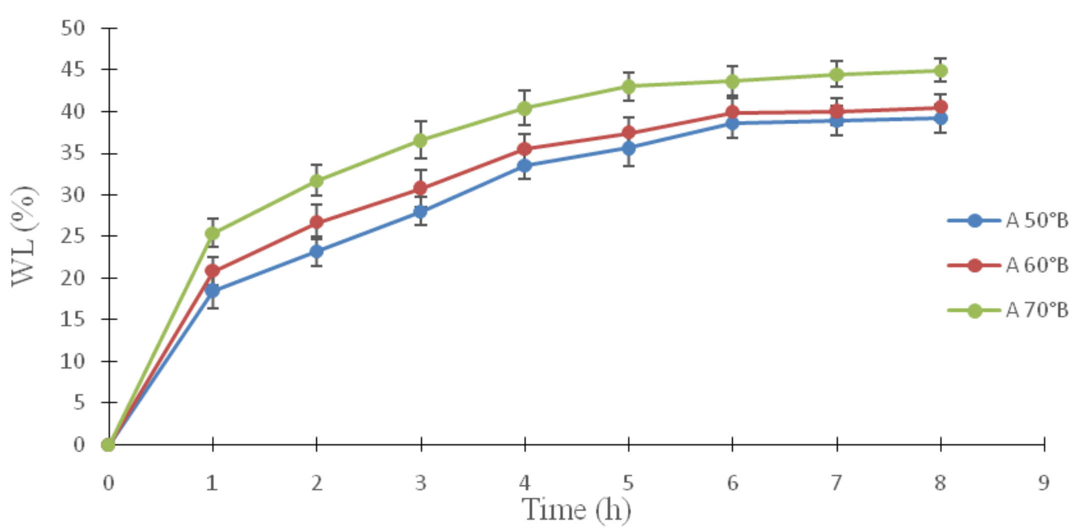

Fig.3 Influence of the température on OD with glucose (50 °B)

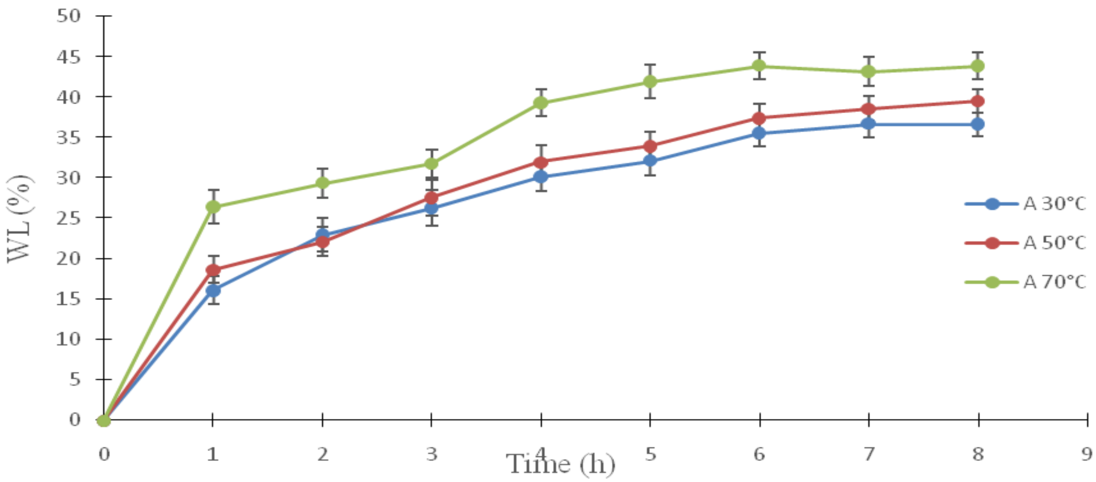

Fig.4 Influence of the température on OD with sucrose (50°B)

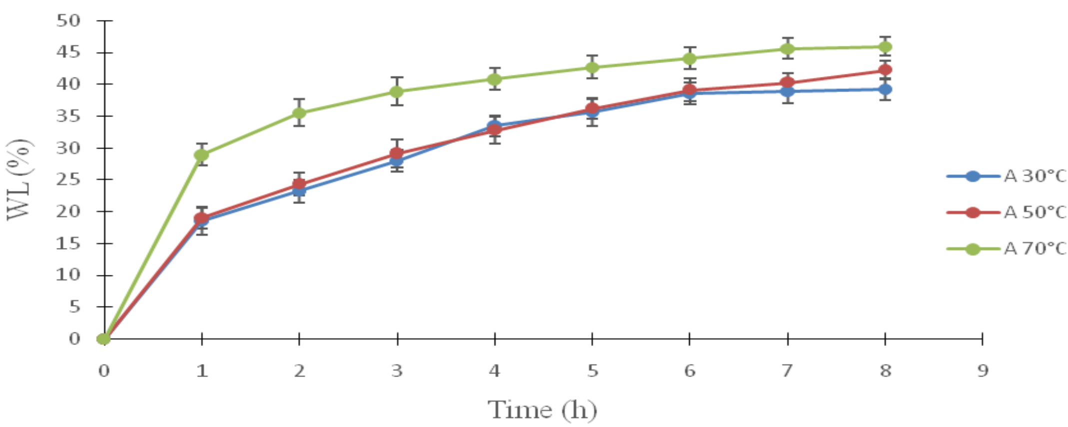

Fig.5 Influence of solute

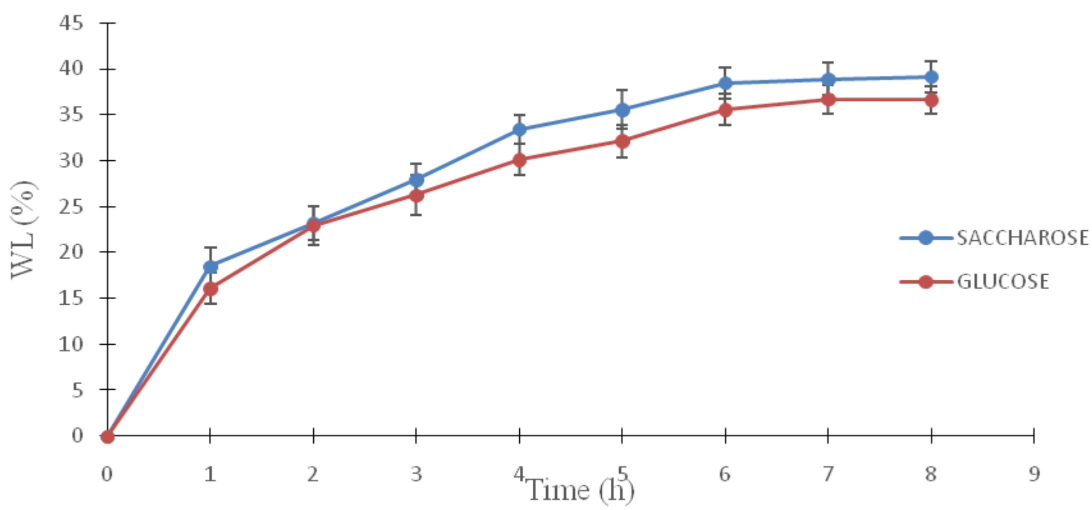

Table.1 Matrix of tests of OD of plantain

Coded values				Reel values		
Tests	X_2	X_3	X_4	**Soluté**	**Température (°C)**	**Concentration (°Brix)**
1	1	-1	-1	Saccharose	30	50
2	1	-1	0	Saccharose	30	60
3	1	-1	1	Saccharose	30	70
4	1	0	-1	Saccharose	50	50
5	1	0	0	Saccharose	50	60
6	1	0	1	Saccharose	50	70
7	1	1	-1	Saccharose	70	50
8	1	1	0	Saccharose	70	60
9	1	1	1	Saccharose	70	70
10	-1	-1	-1	Glucose	30	50
11	-1	-1	0	Glucose	30	60
12	-1	-1	1	Glucose	30	70
13	-1	0	-1	Glucose	50	50
14	-1	0	0	Glucose	50	60
15	-1	0	1	Glucose	50	70
16	-1	1	-1	Glucose	70	50
17	-1	1	0	Glucose	70	60
18	-1	1	1	Glucose	70	70

Table.2 Experimental designs and values of WL, SG and WR after 8 h of immersion

Tests	Solute	Temperature (°C)	Concentration (°Brix)	WL (%)	SG (%)	WR (%)
1	Sucrose	30	50	39,12	12,66	26,46
2	Sucrose	30	60	40,46	13,13	27,33
3	Sucrose	30	70	44,87	15,77	29,10
4	Sucrose	50	50	42,19	16,58	25,61
5	Sucrose	50	60	59,90	15,17	44,73
6	Sucrose	50	70	55,78	16,33	39,45
7	Sucrose	70	50	45,90	15,68	30,22
8	Sucrose	70	60	60,10	15,34	44,76
9	Sucrose	70	70	65,86	15,46	50,40
10	Glucose	30	50	36,41	12,73	24,08
11	Glucose	30	60	38,93	16,41	22,52
12	Glucose	30	70	42,07	16,33	25,74
13	Glucose	50	50	39,54	17,76	21,78
14	Glucose	50	60	50,62	18,32	32,30
15	Glucose	50	70	53,48	18,66	34,82
16	Glucose	70	50	43,87	16,66	27,21
17	Glucose	70	60	55,69	19,25	36,44
18	Glucose	70	70	63,45	19,66	43,79

Table.3 Effect of factors on WL, SG and WR of plantain

	WL		SG		WR	
	Coeff	*P*	*Coeff*	*P*	*Coeff*	*P*
Constante	48,79	**0.000**	16.21	**0,000**	32.59	**0,000**
Solute (S)	1,67	**0.078**	-1.09	**0.004**	2.74	**0.011**
Temperature (T)	7,75	**0.000**	1.25	**0.005**	6.46	**0.000**
Concentration (C)	6,54	**0.000**	0.84	**0.040**	5.66	**0.000**
S × T	0,15	0.888	-0.43	0.258	0.61	0.583
S × C	0,01	0.992	-0.4	0.287	0.44	0.688
T × C	3,51	**0.020**	-0.49	0.291	4.05	**0.010**
S × T × C	0,03	0.977	-0.34	0.457	0.32	0.810

Coeff: coefficience; P: probability

Experimental design for the osmotic dehydration tests

Results of different runs of osmotic dehydration are shown in Table 2. WL is between 36.61 and 65.56 %. According to Table 2, the highest WL are obtained in test 9, the solute used in this test is sucrose and the temperature and concentration are taken at their highest levels (70 °C and 70 °Brix). On the other hand, the lowest WL are obtained in test 10, where the solute is glucose and the temperature and concentration are at their lowest levels (30 °C and 50 °B). The lowest WR were obtained in test 13, with glucose 50 °C and 50 °B and the highest WR were obtained in test 8 with sucrose at 70 °C and 60 °B. For SG, Test 1 gives the lowest SG where the solute is sucrose and the temperature and concentration are at their lowest (30 °C and 50 °B). On the other hand, the highest SG are obtained in test 18 with glucose at 70 °C and 70 °B Generally, the highest WL and WR masses were obtained under the optimum conditions. With regard to the gain of solute, the highest were obtained with glucose as solute. Similar results have been reported by Fadale *et al.,* (2007); N'goran *et al.,* (2012). According to Raoult-Wack (1994), the concentration gradients generated during the OD result in a double cross transfer of matter: the water is released from the product to the solution (dehydration) and the solute enters the solution into the food impregnation).

Effect of factors on WL, SG and WR of plantain

Table 3 shows that all factors (solute, temperature and concentration) have a positive and significant influence (p <0.1) on WL and WR during the osmotic dehydration of the banana. The effects of interactions have a positive influence, but only the interaction of order 2 temperature-concentration is significant (p <0.1). Similar results have been reported by Singh *et al.,* (2010); Mercali *et al.,* (2011); N'goran *et al.,* (2012). The increase in temperature facilitates the transfer of matter and the high concentrations increase the water loss. With regard to SG, only the temperature and the concentration of the osmotic solution had a positive and significant influence (p <0.1) on the SG of the plantain. The influence of temperature and concentration on solute gain during OD has been reported by several authors (Singh *et al.,* 2007; Eren *et al.,* 2007; Singh *et al.,* 2010; Mercali *et al.,* 2011 and N'goran *et al.,* 2012).

The study of osmotic dehydration of plantain (French cultivar) consisted in evaluating the influence of parameters such as concentration, temperature and type of solute on the loss of water. This study shows that increasing the concentration and temperature of the osmotic solution leads to an increase in water loss. Sucrose gives the most important water losses that glucose. The factors taken into account in this study (solute type, temperature and concentration) showed significant effects on water loss, solute gain and loss of banana mass. On the other hand, only the interaction effect between concentration and temperature was both positive and significant.

References

Amami, E., Vorobiev, E. and Kechaou, N. 2005. Effect of Pulsed Electric Field on the Osmotic Dehydration and Mass Transfer Kinetics of Apple Tissue. *Drying Technology: An International Journal*. 23, 581-595.

Azoubel, P., and Da Silva F. 2008. Optimisation of osmotic dehydration of 'Tommy Atkins' mango fruit. *International Journal of Food Science and Technology*. 43, 1276-1280.

Chenlo, F., Moreira, R., Fernández-Herrero, C. and Vásquez, G. 2006. Experimental results and modeling of the osmotic dehydration kinetics of chestnut with glucose solutions. *J. Food Eng*. 74, 324–334.

Dermesonlouoglou, E., Giannakourou, M. and Taoukis, P. 2007. Kinetic modelling of the degradation of quality of osmo-dehydrofrozen tomatoes during storage. *Food Chemistry*. 103, 985-993.

Derossi, A., Severini, C., Del Mastro, A. and De Pilli T. 2015. Study and optimization of osmotic dehydration of cherry tomatoes in complex solution by response surface methodology and desirability approach. *Food Science and Technology*. 60, 641-648.

Eren, I., and Kaymak-Ertekin, F. 2007. Optimization of osmoticdehydration of potato using response surfacemethodology. *Journal of Food Engineering*. 79, 344-352.

Falade, K. O., Igbeka, J. C. and Ayanwuyi, F. A. 2007. Kinetics of mass transfer, and colour changes duringosmotic dehydration of watermelon. *Journal of Food Engineering*. 80, 979–985.

FAO. 2012. Agricultural statistics. Food and agriculture organization of the United Nations, Rome.

Feinberg, M., 1996. La Validation des Méthodes d'Analyse: Une Approche Chimiométrique de l'assurance qualité au laboratoire. Paris, France: Masson.

Fernandes, F., Gallao, M. and Sueli, R. 2008. Effect of osmotic dehydration and ultrasound pre-treatment on cell structure: Melon dehydration *Food Science and Technology*. 41, 604-610.

Fernandes, F., Rodrigues, S., Gaspareto, O. and Oliveira, L. 2006. Optimization of osmotique dehydration of bananas followed by air-drying. *Journal of Food Engineering*. 77, 188-193.

Ismail, E., and Figen, K. 2007. Optimization of osmotic dehydration of potato using response surface methodology. *Journal of Food Engineering*. 79, 344–352.

Ispir, A., and Togrul, I. 2009. Osmotic dehydration of apricot: Kinetics and the effect of process parameters. *Chemical Engineering Research and Design*. 87, 166-180.

Kejian Zou, J., Teng, L., Xinwei D. and Baoyao, W. 2013. Effect of osmotic pretreatment on quality of mango chips by explosion puffing drying. *Food Science and Technology*. 51, 253-259.

Khoyi, M. R., and Hesari, J. 2007. Osmotic dehydration kinetics of apricot using sucrose solution. *J. Food Eng. 78*, 1355–1360.

Mandala, I. G., Anagnostaras, E. F. and Oikonomou, C. K. 2005. Influence of osmotic dehydration conditions on apple air-dryingkinetics and their quality characteristics. *Journal of Food Engineering.* 69 (3), 307–316.

Mauro, M. A., & Menegalli, F. 1995. Evaluation of diffusion coefficients in osmotic concentration of banana (Musa Cavendish Lambert). *International Journal of Food Science and Technology*. 30, 199-213.

Mavroudis, N.E., Gekas, V and Sjoholm, I. 2005. Osmotic Dehydration of Apples-Effects of Agitation and Raw Material Characteristics. *Journal of Food Engineering*. 35, 191 – 209.

Mercali, G. D., Marczak, D. F., Tessaro C., Noreña C. 2011. Evaluation of water, sucrose and NaCl effective diffusivities during osmotic dehydration of banana (Musa sapientum, shum.). *Food Science and Technology*. 44, 82-91.

N'da Adopo, A., Amafon, G., Kehe, H., Kamara, F., et Fofana, V. 1998. Les perspectives d'évolution du circuit de distribution de la banane plantain en Côte d'Ivoire. In: Banana and Food Security. International symposium, Douala, Cameroon, 10-14.

N'Goran, Z. E. B., Aw, S., Assidjo E. N. ET Kouame P. 2012. Influence des paramètres de la osmotique déshydratation sur la perte d'eau dans la papaye *et al.,* mangue. *Journal of Applied Biosciences* 59, 4330– 4339.

Raoult-Wack, A. L., 1994. Recent advances in the osmotic dehydration of foods. Trends in *Food Scienceand Technology*. 5, 255-260.

Rastogi, N., Raghavarao, K., and Niranjan, K. 1997. Mass transfer during osmotic dehydration of banana: fickian diffusion in cylindrical configuration. *Journal of Food Engineering*. 31, 423-432.

Riva, M., Campolongo, S., Leva, A., Maestrelli, A., and Torreggiani, D. 2005. Structure-property relationships in osmo-air-dehydrated apricot cubes. *Food Research International.* 38 (5), 533–542

Sablani, S.S., and Rahman, M.S. 2003. Effect of syrup concentration, temperature and sample geometry on equilibrium distribution dehydration of mango. *Food Res. Int. 36*, 65–71

Singh, B. and Mehta, S. 2008. Effect of osmotic pretreatment on equilibrium moisture content of dehydrated carrot cubes. *International Journal of Food Science and Technology*. 43, 532-537.

Singh, B., Kumar, A. And Gupta, A.K. 2007. Study of mass transfer kinetics and effective diffusivity during osmotic dehydration of carrotcubes. *J. Food Eng*. *79*, 471–480.

Singh, B., Panesar, P S., Nanda V, Kennedy J. 2010. Optimisation of osmotic dehydration process of carrot cubes in mixtures of sucrose and sodium chloride solutions. *Food Chemistry*. 123,590–600.

Ukhum, M., and Ukpebor, I. 1991. Production of instant plantain flour, sensory evaluation and physico-chemical changes during storage. *Food Chemistry*. 42, 287-299.

How to cite this article:

Loa Jean François Régis Bilo, Kouamé Akissi Françoise and Yao N'Zué Benjamin. 2017. Osmotic Dehydration of Plantain Cultivar French (Agnrin) in Binary Solution (Sucrose or Glucose). *Int.J.Curr.Microbiol.App.Sci.* 6(10): 4816-4824.
doi: https://doi.org/10.20546/ijcmas.2017.610.449