IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 10, Issue 7 Ver. I (July 2016), PP 117-123
www.iosrjournals.org

Effect of Process Parameters on Osmotic Dehydration of Guava Slices

M.D. Gaikwad[1], S.K. Jain [2], P.D. Jawake[3], L.K. Murdia[4], H.K. Jain[5], S.S. Lakhawat[6]

[1,3]Research Scholar, CTAE, MPUAT, Udaipur- 313001 (India)
[2] Professor, CTAE, MPUAT, Udaipur- 313001 (India)
[3]Research Scholar, CTAE, MPUAT, Udaipur-313001 (India)
[4]Professor, CDFST, MPUAT, Udaipur- 313001 (India)
[5,6]Professor, RCA, MPUAT, Udaipur- 313001 (India)

Abstract: *Guava slices were immersed in a solution containing sugar solution of 50, 60 and 70 °Brix for about 4 h, at three different osmotic solution temperatures 35, 45 and 55°C. The effect of process parameters (such as duration of osmosis, syrup concentration and syrup temperature) on mass transport data (such as water loss , solid gain and mass reduction) during osmotic dehydration were studied. After 4 hr of osmotic dehydration, the mass reduction, water loss and sugar gain were in the range of 14.05 to 23.8, 18.88 to 33.46 and 4.72 to 10.08 per cent corresponding to low level (35°C, 50°Brix) and high levels (55°C, 70°Brix) of syrup temperature and concentration, respectively.*

Keywords: *Osmotic dehydration, water loss, mass reduction, sugar gain*

I. Introduction

Guava (*Psidium guajava* L.), known as the poor man's apple of the tropics, has a long history of traditional use, much of which is being validated by scientific research. The fruit and its juice are freely consumed for its great taste, nutritional benefit and flavour content [1]. Guava is the fourth most important commercial fruit in India in area and production after mango, banana and citrus. At present it occupies nearly 0.15 million ha of land with production of 1.80 million tons and productivity 12t/ha fruit per year in India. In India, guava is grown in Bihar, Andhra Pradesh, Uttar Pradesh, Gujarat, Maharashtra and Karnataka on large scale [2].

The shelf life of guava fruits is short at ambient temperature. Generally wastage of guava fruits is high during the peak arrival period due to its perishable nature; the spoilage is primarily accorded before it reaches the consumer due to microbial activity and an improper transportation, as well as storage facilities. The post harvest losses are high in tropical countries particularly in India and it ranges between 25-30 per cent. One effective method of reducing this huge loss would be by converting guava into various commercial guava products as it can be utilized in many ways for making jelly, jam, paste, juice, puree, beverage base, syrup and wine. As fresh, guava is delicious and nutritious fruit. The fruit is an excellent source of pectin as well as rich in minerals like phosphorous (23-37 mg/100 g), calcium (14-30 mg/100 g), iron (0.6-1.4 mg/100 g) as well as vitamins like niacin, pathogenic acid, thiamine, riboflavin, vitamin A and C, Omega-3 and -6 poly unsaturated fatty acids and especially high levels of dietary fiber Hence, there is a worldwide growing demand for guava as a healthy and nutritive fruit [3].

Fruits and vegetables drying may cause the loss of flavor and nutritional components if exposed to high temperatures. The loss of aroma and volatiles, oxidation of pigments and vitamins, and case-hardening and woody texture, slow or incomplete rehydration and considerable shrinkage during drying have been reported by several researchers [4] [5] [6] [7] [8] [9].

The drying process should consume less fossil fuels and electricity, as well as it should be also maintained the quality of product. The applications of osmosis in food processing as a dehydration process have been primarily motivated by economical factors and the quality improvement of the final product. Osmotic dehydration (partial dehydration of the fruit and to a lesser extent to vegetables) process received attention in recent years as pretreatment for removal of excess water prior to drying in order to reduce energy consumption and heat damage [10] [11]. The studies on osmotic dehydration process of many fruits and vegetables *viz.,* apple [12], mango [13] [14], papaya [15], banana [16] [17] and yacon fruit [18] have been reported by several researchers.

II. Materials and Methods

2.1 Sample and Solution Preparation

Guava (var. *L-49*) were procured from Horticultural farm of Rajasthan College of Agriculture, MPUAT, Udaipur. Grading was performed manually by hand picking on the basis of its physical dimensions, colour and absence of surface defects. The graded guava were stored in cardboard box at ambient temperature for ripening. Ripen and graded guava were thoroughly washed under tap water and the surface moisture was removed using blotting paper. They were sliced (5±0.5mm thick) manually using stainless steel knife. Common sugar used as an osmotic agent, was procured from the local market of Udaipur. The sugar solution of desired concentration was prepared by dissolving the required quantity of sugar (weight/volume) in tap water.

2.2 Osmotic Dehydration

A water bath of 5 litres capacity was used for conducting experimental trials. Water bath consist water heating chamber and temperature controlling unit. Water heating chamber is made of stainless steel, has two immersion water heaters of capacity (1 kW) at the bottom. Osmotic dehydration of sliced guavas were conducted with three different syrup concentrations (50, 60 and 70^{o}Brix) and temperatures (35, 45 and 55^{o}C). The slice thickness of 5±0.5mm and sample to solution ratio (1:5) were used through out study. Weighed sugar syrup (250g) and guava samples (50g) were placed in a 500 ml beaker which was further placed into the constant temperature water bath for osmotic dehydration. One beaker was removed from the water bath at designated time (after every 40 min interval). Osmosed samples were taken out and rinsed in flowing water, placed on tissue paper to remove the moisture and excess syrup from the surface and weighed for determining the moisture contents by [19].

2.3 Calculation for Mass transport parameters of osmotic dehydration

The responses of osmotic dehydration *viz.*,water loss (WL), sugar gain (SG) and mass reduction (MR) were calculated on wet basis by equations 1, 2 and 3, respectively [20] [21].

Water loss: The water loss (WL) is defined as the net water loss of the fruit on initial weight basis and was estimated as

$$WL = \frac{W_i X_i - W_\theta X_\theta}{W_i} \qquad \text{... (1)}$$

Sugar gain: Sugar gain is the net uptake of sugar by the slices on initial weight basis and computed using following expression:

$$SG = \frac{W_\theta(1 - X_\theta) - W_i(1 - X_i)}{W_i} \times 100 \qquad \text{… (2)}$$

Mass reduction: Mass reduction (MR) can be defined as the net mass reduction of the fruit on initial weight basis. Mass reduction (MR) is the difference between water loss and solid gain computed using following expression

$$MR = \frac{W_i - W_\theta}{W_i} \qquad \text{... (3)}$$

Where,

WL = Water loss (g per 100 g mass guava slices).

SG = Solid gain (g per 100 g mass of guava slices).

MR = Mass reduction (g per 100 g mass of guava slices).

W_θ = Mass of guava slices after time θ, g

W_i = Initial mass of guava slices, g

X_θ = Water content as a fraction of mass of guava slices at time θ.

X_i = Water content as a fraction of initial mass of guava slices.

2.4 Statistical Analysis

The influence of process factors (syrup temperature and concentration) on different responses of osmotic dehydration process viz. water loss, sugar gain and mass reduction were analyzed using analysis of variance (ANOVA) technique with Completely Randomized Design (CRD) as suggested by [22]. The critical difference value at 1 per cent level of probability was used for comparison among all treatments.

III. Results and Discussion

3.1 Effect of Different Temperatures and Concentrations on Water Loss

The effect of temperature and concentration of syrup solution on water loss has been illustrated in Figs. 1, 2 and 3. The water loss was found 18.88, 22.85 and 25.45 per cent for 50ºBrix at 35, 45 and 55ºC temperatures, respectively when duration of osmotic dehydration increased from 0 to 240 min (Fig.1). Also for 60ºBrix, the water loss was found 23.14, 27.45, and 30.60 per cent at 35, 45 and 55ºC, respectively (Fig.2). Similarly for 70ºBrix concentration, the water loss was found 26.07, 30.54, 33.46 per cent at 35, 45 and 55ºC syrup temperatures, respectively (Fig. 3). It was found that a low temperature-low concentration condition (35ºC-50ºBrix) resulted in a low water loss (18.88 per cent after 240 min of osmosis) and a high temperature-high concentration condition (55ºC-70ºBrix) resulted in a higher water loss (33.46 per cent after 240 min of osmosis).

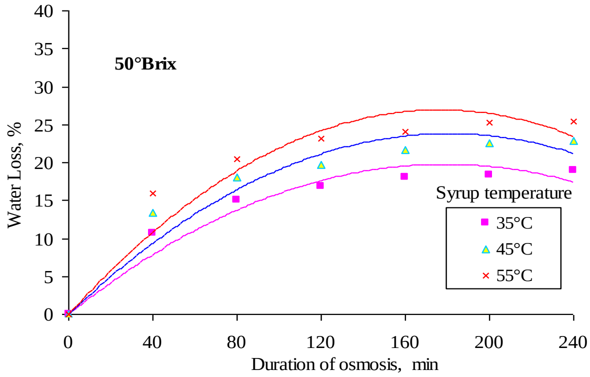

Fig.1 Variation in water loss with duration of osmosis for various syrup temperatures with 50°Brix syrup concentrations

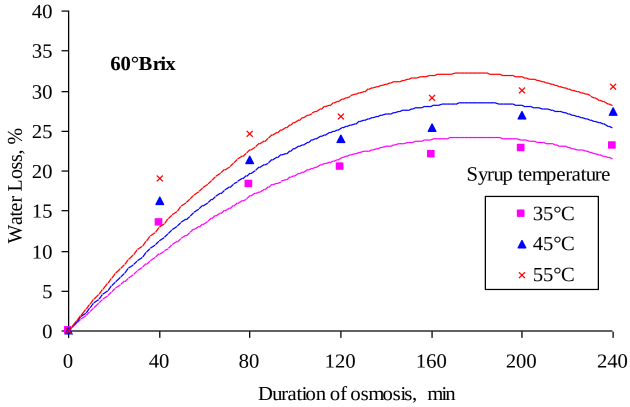

Fig.2 Variation in water loss with duration of osmosis for various syrup temperatures with 60°Brix syrup concentrations

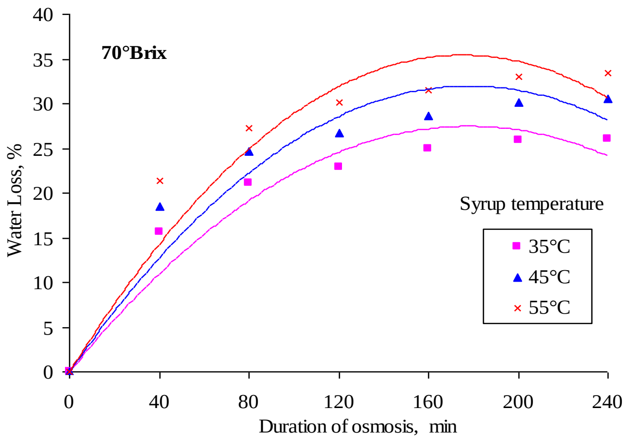

Fig.3 Variation in water loss with duration of osmosis for various syrup temperatures with70°Brix syrup concentrations

This indicates that water loss can be increased by either increasing the syrup temperature or concentration. The water loss at any concentration was affected by the temperature of the syrup as it was increased with increase in syrup temperature. This may be due to changes in semi-permeability of the cell membrane of the ripen guava fruit, allowing more water to diffuse out in a shorter period. Also increase in water loss with increase in syrup concentration may be due to increased osmotic pressure in the syrup at higher concentrations, which increased the driving force available for water transport. Similar trends were also reported by [23] [24] for osmotic dehydration of guava and papaya, respectively.

3.2 Effect of Different Temperatures and Concentrations on Sugar Gain

The effect of temperature and concentrations of syrup on sugar gain has been illustrated in Figs. 4, 5 and 6. The sugar gain of 4.72, 5.99 and 6.91 per cent was found for 50ºBrix at 35, 45 and 55ºC syrup temperatures respectively when duration of osmotic dehydration increased from 0 to 240 min (Fig.4). Also for 60ºBrix, the sugar gain was found to be 6.11, 7.59, 8.88 per cent at 35, 45 and 55ºC syrup temperature respectively (Fig.5). Similarly for 70ºBrix concentration, the sugar gain was found to be 7.23, 8.89, 10.08 per cent at 35, 45 and 55ºC syrup temperatures, respectively (Fig.6).

It was found that a low temperature-low concentration condition (35ºC-50ºBrix) resulted in a low sugar gain (4.72 per cent after 240 min of osmosis) and a high temperature-high concentration condition (55ºC-70ºBrix) resulted in a higher sugar gain (10.08 per cent after 240 min of osmosis). This indicates that sugar gain in ripen guava can be increased by either increasing the syrup temperature or concentration. Also it can be seen that sugar gain was increased with duration of osmosis and did not approach the equilibrium even after 4 hour of osmotic dehydration.

The sugar gain also increased when the concentration of the syrup was increased. This is because of the increased concentration difference between samples. The sugar gain also increased with increase in syrup temperature. It may be due to collapse of the cell membrane of ripen guava fruits at higher temperatures. Similar results have also been reported by [25] [26] and [17] for peas, blueberries and banana, respectively.

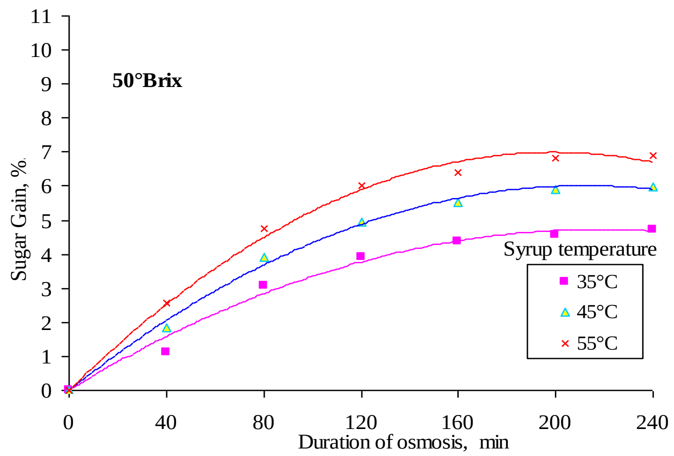

Fig.4 Variation in sugar gain with duration of osmosis for various syrup temperatures with 50°Brix syrup concentrations

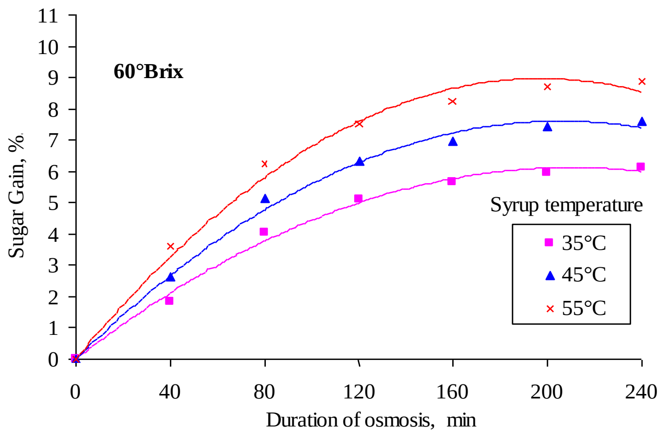

Fig.5 Variation in sugar gain with duration of osmosis for various syrup temperatures with 60°Brix syrup concentrations

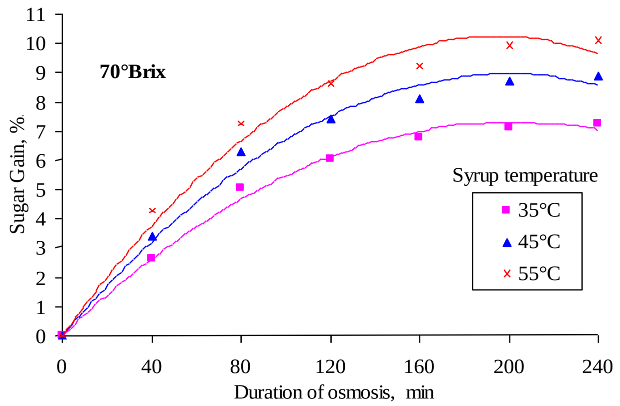

Fig.6 Variation in sugar gain with duration of osmosis for various syrup temperatures with 70°Brix syrup concentrations

3.3 Effect of Different Temperatures and Concentrations on Mass Reduction

The effect of temperature and concentrations of syrup on mass reduction has been illustrated in Figs. 7, 8 and 9. The mass reduction was found to be 14.15, 16.85 and 18.57 per cent for 50ºBrix at 35, 45 and 55ºC temperatures, respectively when duration of osmotic dehydration of ripen guava increased from 0 to 240 min (Fig. 7). Also for 60ºBrix, the mass reduction was found to be 17.03, 19.86 and 21.73 per cent at 35, 45 and 55ºC, respectively (Fig. 8). Similarly for 70ºBrix concentration, the mass reduction was found 18.84, 21.65 and 23.38 per cent at 35, 45 and 55ºC syrup temperatures respectively with increase in duration of osmosis of ripen guava from 0 to 240 min (Fig. 9).

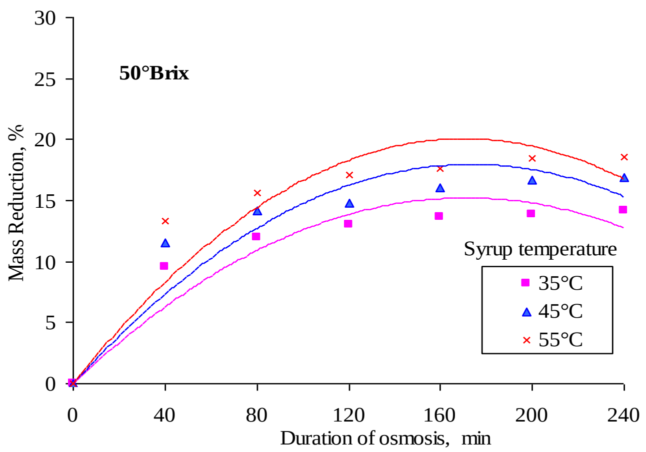

Fig.7 Variation in mass reduction with duration of osmosis for various syrup temperatures with 50°Brix syrup concentrations

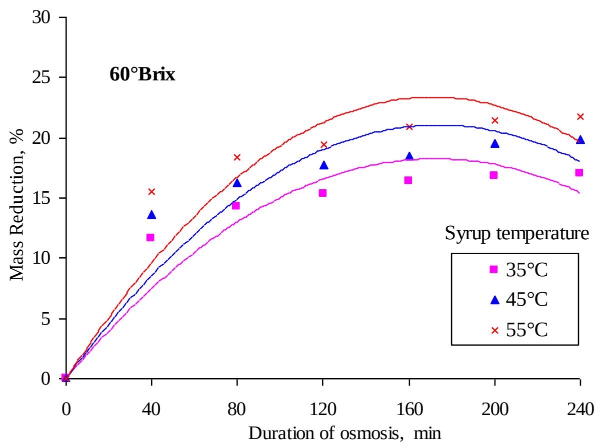

Fig. 8 Variation in mass reduction with duration of osmosis for various syrup temperatures with 60°Brix syrup concentrations

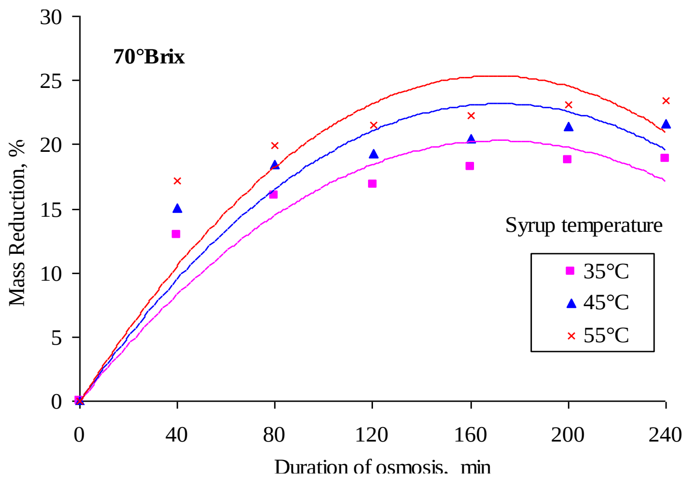

Fig.9 Variation in mass reduction with duration of osmosis for various syrup temperatures with 70°Brix syrup concentrations

It was found that a low temperature-low concentration condition (35ºC-50ºBrix) resulted in a low mass reduction (14.15 per cent after 240 min of osmosis) and a high temperature-high concentration condition (55ºC-70ºBrix) resulted in a higher mass reduction (23.38 per cent after 240 min of osmosis). This indicates that mass reduction can be increased by either increasing the syrup temperature or concentration. Similar results have also been reported by [25] [26] and [27] for peas, blueberries and banana, respectively.

3.4 Statistical Analysis

The standard statistical technique 'Analysis of Variance' (ANOVA) was applied for the water loss, sugar gain and mass reduction data from three replicates of 240 min osmotically dehydrated guava samples to study the effect of process variables, osmotic concentration and temperature on water loss characteristics. Critical difference and co-efficient of variances (CV) was evaluated for water loss and presented in Table 1, 2 and 3.

It is the revealed effect of temperature and concentration of syrup on water loss, sugar gain and mass reduction were significant at 1 per cent with critical difference of 1.213, 0.665 and 0.605. The co-efficient of variances (CV) were 3.37, 6.64 and 2.33 for water loss, sugar gain and mass reduction, respectively. The combine effect of temperature and syrup concentration on water loss, sugar gain and mass reduction were not found significant with critical difference of 2.101, 1.151and 1.048, respectively.

Table: 1 ANOVA for the effect of process variables on the water loss

S. No.	Source	DF	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	T	2	232.796	116.398	145.643**	0.298	1.213
2.	C	2	265.951	132.975	166.385**	0.298	1.213
3.	TxC	4	0.734	0.183	0.230 ^{ns}	0.516	2.101
4.	Error	18	14.386	0.799	1.000		
CV = 3.37, ** Significant at 1%., ns= Non significant							

Table: 2 ANOVA for the effect of process variables on the sugar gain

S. No.	Source	DF	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	T	2	30.572	15.286	63.699**	0.163	0.665
2.	C	2	37.069	18.535	77.237**	0.163	0.665
3.	TxC	4	0.415	0.104	0.433 ^{ns}	0.283	1.151
4.	Error	18	4.319	0.240	1.000		
CV = 6.64, ** Significant at 1%. ns= Non significant							

Table: 3 ANOVA for the effect of process variables on the mass reduction

S. No.	Source	DF	SS	MS	F (Calculated)	SE(m)	CD (1%)
1.	T	2	94.734	47.367	238.312**	0.149	0.605
2.	C	2	104.584	52.292	263.091**	0.149	0.605
3.	TxC	4	0.066	0.016	0.083 ^{ns}	0.257	1.048
4.	Error	18	3.578	0.199	1.000		
C.V = 2.33, ** Significant at 1%. ns= Non significant							

IV. Conclusion

Syrup concentration, temperature of solution and duration of osmosis had significant effect on the kinetics of osmotic dehydration of guava slices. Water loss from the guava slices was very rapid for the first half hour of osmosis and reduced subsequently with duration of osmosis. The water loss sugar gain and mass reduction were observed to increase with increased in sugar concentration and temperature during osmotic dehydration. . The minimum and maximum mass reduction, water loss and sugar gain were in the range of 14.05 to 23.8, 18.88 to 33.46 and 4.72 to 10.08 per cent corresponding to low level (35°C,50°Brix) and high levels (55°C,70°Brix) of syrup temperature and concentration, respectively. Osmosis can be used as a pretreatment prior to any drying to remove the moisture from guava slices and increase the sugar per cent in guava slices.

References

[1]. C.A. Chopda and D.M. Barrett. Optimization of guava juice and powder production. *Journal of Food Processing and Preservation,* 25(6), 2007, 411- 430.

[2]. S.K. Mitra, M.R. Gurung and P.K. Pathak. Guava production and improvement in India: an overview. *Acta Horticulture,* 787, 2007, 59-68.

[3]. T.K. Lim and K.C. Khoo. Guava in Malaysia: production, pests and diseases, Tropical press, Kuala Lumpur, Malaysia, 1990.

[4]. W.B.Van Arsdel. Drying phenomena. *In: Food dehydration* V (ed) W.B. Van Arsdel, M. Copley and Morgan, AVI Pub. Co. Westport, CT, 1973, p.22.

[5]. P. Fellows. Dehydration in Food Processing Technology, Ellis Harwood Ltd., Chichester, England, 1988, 281-311.

[6]. C. Ratti and A.S. Mujumdar. Drying of Fruits. In: Processing Fruits: Science and Technology-Biology, Principles, and Applications. Technomic Publication. Lancaster, 1996, 522.

[7]. S. Grabowski, M. Marcotte, M. Poirier, and T. Kudra. Drying characteristics of osmotically pretreated cranberries: Energy and quality aspects. URL: http://cetcvarennes.nrcan.gc.ca/eng/publication/r2002083e.html (2003/06/12).

[8]. M. K. Krokida and D. Marinos-Kouris. Rehydration kinetics of dehydrated products. *Journal of Food Engineering,* 57**,** 2003, 1-7.

[9]. T. Padmini, G.S.V. Raghavan and T. Thangaraj. Dehydration of sapota flakes. *Proceedings of 4th Asia-Pacific Drying Conference*; Kolkata, India, 13–15 December, 2, 2005, 1161-1165.

[10]. H. Kowalska and A. Lenart. Mass exchange during osmotic pretreatment of vegetables. *J. Food Eng*g., 49, 2001, 137-140.

[11]. Z. Pakowski and R. Adamski. The comparison of two models of convective drying of shrinking materials using apple tissue as an example. *Drying Technol*, 25, 2007, 1139-1149.

[12]. S.S. Sablani, M.S. Rahman, and D.S.A Sadeiri. Equilibrium distribution data for osmotic drying of apple cubes in sugar-water solution. *Journal of Food Engineering*, 52, 2002, 193-199.

[13]. A. Nieto, M.A. Castro and F. Alzamora. Kinetics of moisture transfer during air drying of blanched and/or osmotically dehydrated mango. *Journal of Food Engineering,* 50, 2001, 175-185.

[14]. W. Tedjo, K.A. Taiwo, M.N. Eshtiaghi and D. Knorr. Comparison of pretreatment methods on water and solid diffusion kinetics of osmotically dehydrated mangoes. *Journal of Food Engineering,* 53, 2002, 133-142.

[15]. A.P. Chaudhari, B.K. Kumbhar and M. Narain. Effect of some process parameters on osmotic dehydration of papaya. *Journal of Institution of Engineers (Agricultural Engineering division),* 81, 2000, 59-63.

[16]. K.N. Waliszewski, V.T. Pardio and M. Ramirez. Effect of chitin on colour during osmotic dehydration of banana slices. *Drying Technology,* 20(3), 2002, 719-726.

[17]. R. Kumari, R.N. Shukla and T. Joshi. Mass transfer during osmotic dehydration of banana slices for drying process. *International Journal of Scientific and Research Publications*, 2(7), 2012, 1-9.

[18]. B. Brochier, L.D. Ferreira Marczak and C.P. Zapata Norena. Use of Different Kinds of Solutes Alternative to Sucrose in Osmotic Dehydration of Yacon. *Braz. Arch. Biol. Technol*, 58(1), 2015, 34-40.

[19]. AOAC. Official Methods of Analysis. 14 th Ed. Edited by Sidney Williums. Published by the Association of Official Analysis Chemists, *Inc. Arlinton, Virginia, 22209*, USA, 2000.

[20]. E.T.F. Silveira, M.S. Rahman, and K. Buckle. Osmotic dehydration of pineapple: kinetics and product quality. *Food Research International,* 29(3-4), 1996, 227-233.

[21]. S. Kaleemullah, R. Kallippan and N. Varadhraju. Studies an osmotic air drying characteristics of papaya cubes. *Journal of Food Science and Technology,* 39(1), 2002, 82-84.

[22]. K.A. Gomez and A.A. Gomez. Statistical procedures for agricultural research (2 ed.). John wiley and sons, NewYork, 1984 p. 680.

[23]. G. Panades, D. Castro, A. Chiralt, P. Fito, M. Nunez and R. Jimenez. Mass transfer mechanisms occurring in osmotic dehydration of guava. *Journal of Food Engineering,* 87(3), 2008, 386-390.

[24]. S.K. Jain, R.C. Verma, L.K. Murdia, H.K. Jain and G.P. Sharma. Optimization of process parameters for osmotic dehydration of papaya cubes. *Journal of Food Science and Technology,* 48(2), 2011, 211-217.

[25]. F.K. Ertekin and T. Cakaloz. Osmotic dehydration of peas: 2 Influence of osmosis on drying behaviour and product quality. *Journal of Food Processing and Preservation,* 20, 1996, 105-119.

[26]. F. Nsonzi and H.S. Ramaswamy. Osmotic dehydration kinetics of blueberries. *Drying Technology*, 16(3-5), 1998, 725-741.