International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(1): 635-640

Received: 09-11-2018
Accepted: 13-12-2018

Vikrant Kumar
Department of Agricultural Engineering SVPUAT, Meerut, Uttar Pardesh, India

Jaivir Singh
Department of Agricultural Engineering SVPUAT, Meerut, Uttar Pardesh, India

Neelash Chauhan
Department of Agricultural Engineering SVPUAT, Meerut, Uttar Pardesh, India

Suresh Chandra
Department of Agricultural Engineering SVPUAT, Meerut, Uttar Pardesh, India

Ratnesh kumar
Department of Agricultural Engineering SVPUAT, Meerut, Uttar Pardesh, India

Sunil
Department of Agricultural Engineering SVPUAT, Meerut, Uttar Pardesh, India

Correspondence
Vikrant Kumar
Department of Agricultural Engineering SVPUAT, Meerut, Uttar Pardesh, India

Osmo-convective dehydration of papaya slices and quality evaluation: A review

Vikrant Kumar, Jaivir Singh, Neelash Chauhan, Suresh Chandra, Ratnesh Kumar and Sunil

Abstract
Osmotic dehydration (OD) is one of most important complementary treatment and food preservation technique in the processing of dehydrated foods, since it presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decrease the energy costs. Osmotic dehydration results in increased shelf-life, little bit loss of aroma in dried and semidried food stuffs, lessening the load of freezing and to freeze the food without causing unnecessary changes in texture. Drying is a technique of conservation that consists of the elimination of large amount of water present in a food by the application of heat under controlled conditions, with the objective to diminish the chemical, enzymatic and microbiological activities that are responsible for the deterioration of foods. Hot air drying often degrades the product quality, provides low energy efficiency and lengthy drying time during the falling rate period. It has been reported that hot-air drying of food materials, involving their prolonged exposure to elevated drying temperatures, results in substantial deterioration of such quality attributes as color, nutrient concentration, flavor and texture. Papaya (*Carica papay* L.) is an important fruit crop grown widely in tropical and subtropical low land regions. Excellent in vitamin C, pro-vitamin A, minerals as well as rich in dietary fiber, papaya is emerging as a popular fresh fruit which offers health benefiting properties. The desire to eliminate this problem, prevent significant quality loss and achieve fast and effective thermal processing, has resulted in the increasing use of microwaves for food drying.

Keywords: papaya, osmotic dehydration, drying and papaya fruit

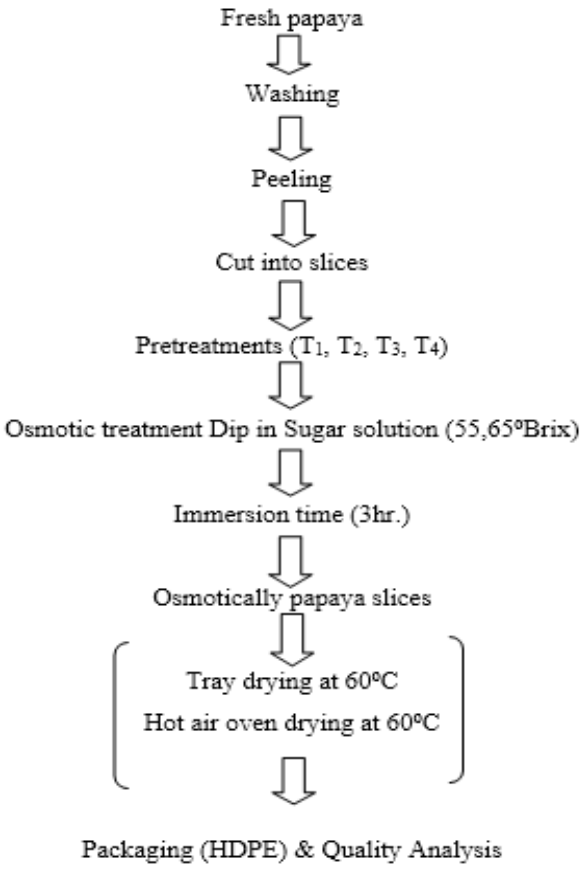
Introduction
Osmotic dehydration (OD) is one of most important complementary treatment and food preservation technique in the processing of dehydrated foods, since it presents some benefits such as reducing the damage of heat to the flavor, color, inhibiting the browning of enzymes and decrease the energy costs (Alakali *et al*., 2006; Torres *et al.*, 2006) [6, 32]. Osmotic dehydration results in increased shelf-life, little bit loss of aroma in dried and semidried food stuffs, lessening the load of freezing and to freeze the food without causing unnecessary changes in texture (Petrotos and Lazarides, 2001) [20]. It has been reported that osmotic dehydration reduced up to 50% weight of fresh vegetables and fruits (Rastogi and Raghavararo, 1997) [24]. Papaya (*Carica papaya* L.) is a tropical fruit having commercial importance because of its high nutritive and medicinal value. Total annual world production is estimated at 6 million tonnes of fruits. India leads the world in papaya production with an annual output of about 3 million tonnes. Alone in Andhra Pradesh the total area under cultivation is 11.2 thousand hectare and productivity is 100 MT/Hactare. Despite large acreage of land devoted to papaya the fruit loss is reported to be between 40-100 per cent of total annual produce. (*Source*: Database of National Horticulture Board, Ministry of Agriculture, Govt. of India).

The use of the osmotic dehydration process in the food industry has several advantages: quality improvement in terms of color, flavor and texture, energy efficiency, packaging and distribution cost reduction, no chemical pretreatment, providing required product stability and retention of nutrients during storage (Rahman & Perera, 1999; Sablani *et al*., 2002) [22, 25].

In the process of osmotic dehydration, fruit is placed into a hypertonic solution where water is drawn out of the produce and into the solution due to the differences in their concentrations. In this fashion, osmotic dehydration removes a proportion of the water content in the fruit leading

to a product of intermediate moisture content. Osmotic dehydration of fresh produce can also be used as a pre-treatment to additional supplementary drying processing to improve sensory, Functional and even nutritional properties. Water removal in the dehydration process is influenced by many factors such as type and concentration of osmotic agents, temperature, circulation/agitation of solution, solution to sample ratio, thickness of food material, and pre-treatment. The actual osmotic process contributes only minimal thermal degradation to the nutrients due to the relatively low temperature water removal process. Simultaneously a transport of solids takes place between the fruit and the solution. Water removal from fruit and vegetables by drying is one of the oldest forms of food preservation known to man and is the most important process to preserve food. Water, being one of the main food components, has a decisive direct influence on the quality and durability of foodstuffs through its effect on many physico-chemical and biological changes. Water removal is the main task while preserving food (Lenart, 1996) [16] reducing the moisture contents to a level, which allows safe storage over an extended period of time. Dried foods also present low storage and transportation cost when compared to the fresh ones (Okos, Narsimham, Singh, & Witnauer, 1992) [18]. Osmotic dehydration involves the immersion of foods (fish, vegetables, fruits and meat) in osmotic solution such as salts, alcohols, starch solutions and concentrated sugars, which some extent to dehydrates the food (Erle and Schubert, 2001) [11]. Different types of solutes such as fructose, corn syrup, glucose, sodium chloride and sucrose are used as osmotic agent for OD (Azuara and Beristain, 2002) [4]. Low molar mass saccharides (sucrose, glucose and fructose) make easy the sugar uptake due to high diffusion of molecules. It has proved to be a good quality method to get modestly processed fruits, due to the much sensory resemblance between the natural and dehydrated products. The different types of osmotic agents such as glucose, sorbitol, sucrose and salts are used according to the final products (Singh *et al.*, 2008) [27]. However combination of different solutes can be used (Taiwo *et al.*, 2003) [30]. Water loss from vegetables and fruits took place in first two hours and maximum sugar gain within 30 minutes (Conway *et al.*, 1983) [9]. Osmotic dehydration is used with other drying methods such as freezing and deep fat frying to make available better quality final product (Torreggiani and Bertolo, 2001a; Behsnilian and Speiss, 2006) [31, 6]. Temperature and concentration of osmotic syrups increased the rate of water loss during OD. However higher temperature has the significant effect on the structure of tissues (Lazarides, 2001) [20]. Drying is a technique of conservation that consists of the elimination of large amount of water present in a food by the application of heat under controlled conditions, with the objective to diminish the chemical, enzymatic and microbiological activities that are responsible for the deterioration of foods (Barnabas *et al*., 2010) [5]. Fruit dehydration by immersion in osmotic solutions has been of rising interest during the last decades since it can improve food quality when combined with other type of dehydration method (Mauro and Menegalli, 2003) [17].

The process flow chart for osmo-convective dehydration of papaya slice



Application of Osmosis

The osmotic dehydration process and influence of its process variables such as pretreatment, temperature of sugar solution and additives on the mass transfer in osmotic dehydration of various fruits was studied by Ponting *et al*. (1966) and reported that the apple slices reduced to 50 per cent of original weight by using 60 – 70ºBrix sugar solution and superior quality. The study also indicated that there was no

need of sulphur dioxide treatment to prevent loss of colour. The osmotic air-dried products were high in superior quality and reported that the osmosis process removed water from fruits and vegetables slices to the extent of 40 – 50 per cent of the weight, but not enough for storage. Therefore, to remove water up to safe levels further drying is needed. Bongirwar and Sreenivasan (1977) [7] indicated that the high temperature above 60º modifies the tissue characteristics favoring impregnation phenomena and thus solid gain. Rahman and Lamb (1991) [21] reported the rate of sucrose diffusion is a function of solute concentration and temperature.

Osmotic Process Parameters

1. Pretreatments
2. Immersion time
3. Temperature of the osmotic solution
4. Osmotic agents
5. Concentration of osmotic solution
6. Circulation
7. Fruit pieces to osmotic solution

Osmotic dehydration treatment:

The osmotic agent used was sucrose and the osmotic solution was prepared by dissolving the required quantity of sugar in distilled water to make 50, 55 and 60ºbrix solution. Papaya fruit slices, previously weighed and identified, were immersed in the osmotic solution of given concentration (50%, 55%, and 60%, w⁄w) and temperature (50^0C) during a given immersion time (30 min). The weight ratio of osmotic medium to fruit samples was 5:1 to avoid significant dilution of the medium and subsequent decrease of the driving force during the process. After removed from the sugar solution, samples were drained and the excess of solution at the surface was removed with absorbent paper for posterior weight. The moisture content of the samples was gravimetrically measured using a vacuum oven at 70^0C for 24 h.

Chemical Analysis of Dehydrated papaya Slices:

1. Moisture Content.
2. Estimation of Fat.
3. Estimation of protein.
4. Estimation of Total Ash.
5. Estimation of Crude Fiber.
6. Estimation of Vitamin A.
7. Estimation of Vitamin C.

Moisture Content

Moisture content (w.b.) of the osmotically treated papaya slices was determined according to oven method (AOCC, 1990) [5]. 1 g of sample was accurately weighed into a clean dry petri dish and dried in an oven at 105 0C for 6 - 8 hrs. It was then cooled in a desiccator and weighed. This was repeated till a constant weight was obtained. The moisture content was expressed as% of sample mix.

$$\text{Moisture\%(Wb.)} = \frac{W1-W2}{W1-W0} \times 100$$

Where,

W_0 = Weight of petri dish (g),

W_1 = Weight of petri dish + sample (g),

W_2 = Weight of petri dish + dried sample (g).

Estimation of Fat

Crude fat will be estimated by standard method of analysis (AOAC, 1990) [5] using Soxhlet extraction apparatus

Procedure

Transferred a weighed amount (2g) of dry sample to an extraction thimble which will be pre-dried overnight at 105 °C. Placed the thimble in a soxhlet extractor fitted with a condenser and flask containing sufficient petroleum either (boiling point 60-80°C). After 6 hours extraction, thimble will be removed from extraction apparatus and dried in the hot air oven to a constant weight, cooled in desiccators to room temperature and weighed. Loss of weight of thimble indicated the amount of fat in the sample.

$$\text{g of fat/100 sample} = \frac{\text{final wt of beaker} - \text{empaty wt of beaker}}{\text{weight of sample}} \times 100$$

Estimation of protein

The crude protein will be estimated by the micro Kjedahi Method (AOAC, 1990) [5].

Reagents:

1. Conc. H_2SO_4
2. Boric acid (4%)
3. Sodium hydroxide (40%)
4. Hydrochloric acid (N/100)
5. Mixed indicator solution: 0.5 g bromocresol green and 0.1 g methyl red will be taken and diluted in 100 ml 95 per cent ethanol.
6. Digestion mixture 10 g potassium sulphate (K_2SO_4), 0.5 g copper sulphate ($CuSO_4$,$5H_2O$) and 2 g ferrous sulphate ($FeSO_4$) will be mixed together and ground to a fine powder

Procedure

Two gram sample will be weighed and transferred to a Kjeldahi flask. Twenty ml conc. H_2SO_4, a pinch of digestion mixture and a few glass beats will be added to it. The digestion will be carried out till a clear solution will be obtained. The flasks will be cooled and about 15 ml water will be added Flasks will be rinsed 2-3 times and volume will be made 50 ml with distilled water. For instillation, 10 ml boric acid will be taken in a conical flask and 2-3 drops of mixed indicator will be added. Flask will be attached to the distillation apparatus. Known volume of digested will be distilled with 40% NaOH in Kjedahl apparatus and ammonia liberated will be trapped in the boric acid all the volume increased 2-3 times. The boric acid containing ammonia will be extracted against N/100 HCl. The end point will be indicated by change of color. Per cent nitrogen will be then calculated as:

$$\text{Nitrogen (\%)} = \frac{0.00014 \text{ x vol. of } \frac{N}{100} \text{ Hcl used x vol. of digested sample made (ml)}}{\text{Wt. of sample taken(g) x Vol. of aliquot taken (ml)}} \text{ x } 100$$

The protein will be calculated by multiplying the nitrogen content with a factor of 6.25.

Estimation of Total Ash

The ash content was estimated according to the method described by AOAC. 5g of samples were accurately weighed into cleaned, dried, weighed, tare silica crucible (W2). The initial ashing was carried out over a low flame to char the sample. The crucible was then transferred to a muffle furnace maintained at 500- 550 0C to get ash. The crucible was then cooled until a constant weight (W1) was achieved and expressed as g/100 g of sample.

$$\text{Ash content\%} = \frac{\text{weight after ashing}}{\text{weight before ashing}} \times 100$$

Where
W1= weight before ashing
W2= weight after ashing

Estimation of Crude Fiber
Crude fibre will be estimated by employing standard method of analysis (AOAC, 1990) [5].

Reagents
1. Sulphuric acid stock solution (10% w/v): 55 ml conc. H_2SO_4 will be taken and diluted to one litre.
2. Sulphuric acid working solution (1.25%): 125 ml of stock solution will be diluted to one litre.
3. Sodium hydroxide stock solution (10% w/v): 100 g NaOH will be diluted to one liter with distilled water.
4. Sodium hydroxide working solution (1.25%): 125 ml of stock solution will be diluted to one liter.
5. Antifoam: 2% silicon antifoam in CCl_4.

Procedure
One g of fat free dried sample will be put in one liter tall beaker. Added 200ml 1.25% H_2SO_4 and few drops of antifoam. Kept the solution boiling for 30 min under bulb condenser? Beaker will be rotated occasionally to mix the contents and removed the particles from the sides. The contents of beaker will be filtered through funnel. Washed the sample back into tall beakers with 200 ml 1.25% sodium hydroxide and again brought to boiling point. Boiled exactly for 30 min. transferred all insoluble matter to the sintered crucible by means of boiling distilled water and washed till acid free. Washed twice with alcohol and thrice with acetone. Dried at 100°C to constant weight. Ashed in a muffle furnace at 550 ± 10°C for 1 hour. Cooled the crucible in a dessicator, reweighed and the percentage of crude fiber in the sample will be calculated.

$$\text{Crude fiber (\%)} = \frac{dried\ weight - \text{ashed weight}}{\text{weight of sample}} \times 100$$

Estimation of Vitamin A
Reagents: Acetone, Anhydrous sodium sulphate, Petroleum ether.

Procedure: Take 5 gm of fresh sample and crush in 10-15ml acetone, adding a few crystals of anhydrous sodium sulphate, with the help of pestle and mortar. Decant the supernatant into a beaker. Repeat the process twice and transfer the combined supernatant to a separator funnel, add 10-11ml petroleum ether and mix thoroughly. Two layers will separate out on standing. Discard the lower layer and collect upper layer in a 100 ml volumetric flask, make up the volume to 100 ml with petroleum ether and record optical density at 452nm using petroleum as blank.

Calculations

$$\beta - carotene = \frac{OD \times 13.9 \times 100000 \times 100}{wt.of\ sample \times 560 \times 1000}$$

$$Vitamin\ A = \frac{\beta - carotene(\frac{\mu g}{100})}{0.6}$$

Estimation of Vitamin C
In the absence of interfering substances that may reduce the dye or oxidize ascorbic acid during sample preparation, the capacity of a sample to reduce a standard dye solution, as determined by titration, is directly proportional to the ascorbic acid content.
Reagents:
i. Metaphosphoric acid solution (3%).
ii. Dye solution: Dissolve 50mg of 2, 6-dichlorophenol-indophenol in approximately 150 ml of hot distilled water containing 42mg of sodium bicarbonate cool and dilute with distilled water to 200ml. Store solution in brown bottle in a refrigerator at about 3 degree centigrade, Standardize every day and prepare afresh every week.
iii. Standard ascorbic acid solution. Dissolve 100 mg of L-ascorbic acid in a small volume of 3% Metaposphoric acid solution and make up to 100 ml with same solution. Dilute 10ml this of stock solution to 100ml with 3%metaphosphoric acid (0.1 mg ascorbic acid per ml).
Standardization of Dye: Dilute 5ml of standard ascorbic acid solution with 5ml of 3% meta- phosphoricacid. Titrate with dye solution till pink color persists for 10 sec. calculate the dye factor as follows:

$$\text{Dye factor (D.F.)} = \frac{0.5}{Titre}$$

In case of liquid or juice sample, take 10 ml sample and make upto 100ml with 3%HPO3 and then make up to 100ml and filter. Pipette 10 ml of filtrate into a conical flask and titrate with the standard dye to a pink end point. If a sample contains sulphur dioxide which reduces the dye and thus interferes with the ascorbic acid estimation, the following procedure is followed.
Take 10 ml of filtrate, add 1ml of 40% formaldehyde and 0.1ml of HCl, and allow standing for 10 minutes and then titrating.

$$\text{Ascorbic acid} = \frac{\text{titrate} \times \text{dye factor} \times \text{volume made up} \times 100}{\text{volume of filtrate taken} \times \text{weight of volume of sample taken}}$$

Value of ascorbic acid is mg/100g.

Drying methods
Cabinet tray dryer
A Cabinet type mechanical tray dryer will be used to conduct drying experiment. The heating air circulated inside the cabinet with the help of circulating fan. The thermostatic controller (50-250℃) will be also attached with the heating unit to control the desired temperature for the drying experiment.

Hot air oven drying
The fruit will be kept on hot air oven at 60±5°C till no further weight loss occurred. Hot air oven (Instron, IN-301 Model) is a double walled chamber of size 78×27×116 (cm).
Outer chamber is made of stainless steel. Hot air ovens are electrical devices used in sterilization. The oven uses dry heat to sterilize articles. Generally, they can be operated from 50 to 300 ℃(122 to 572°F). There is a thermostat controlling the temperature. An air circulating fan helps in uniform distribution of the heat. These are fitted with the adjustable wire mesh plated trays or aluminium tray and may have an on/off rocker switch, as well as indicators and controls for temperature and holding time.

Packaging of osmo dehydrated product

In order to prevent absorption of moisture from atmosphere and to prevent spoilage due to contamination, good quality, food grade and airtight containers can be used to store osmotically dried foods. Aluminum foil, laminated polypropylene pouches are suggested as ideal packing materials (Sagar & Khurdiya, 1999) [26]. Ahemed and Choudhary (1995) [1] used high-density polyethylene pouches for osmo-dried papaya. Dried products were kept at room temperature for six months and it was accepted with little changes.

Strorage of osmo dehydrated product

The storage stability of osmotically dehydrated products varies from six months to one year. The papaya product obtained from osmotic dehydration process remains stable up to six months of storage at room temperature (Ahemed & Choudhary, 1995) [1]. (Bongirwar and Sreenivasan 1977) [7] Reported that the osmotically dehydrated banana products can be preserved up to one year or more depending upon the storage conditions and packaging materials used. Storage studies on osmo-dehydrated mango slices showed that the keeping relative humidity between 64.8 to 75.5 per cent would be conducive for the retention of colour, flavour, texture and taste.

Advantages of osmotic dehydration

1. It minimizes the effect of temperature on food quality and preserves the wholeness of the food, as no high temperature/phase change is required in the process.
2. Mild heat treatment favors color and flavor retention resulting in the product having superior organoleptic characteristics. It is more when sugar syrup is used as osmotic agent.
3. It increases resistance to heat treatment.
4. The process is quite simple and economical.
5. It prevents the enzymatic browning and inhibits activities of polyphenol oxidases.
6. It improves the texture and rehydration properties.
7. The blanching process may be eliminated by this process, which reduces cost of processing.
8. Acid removal and sugar uptake by fruits modifies the composition and improves the taste and acceptability which is called candying effect.
9. The process could prove to be good for production of the ready to eat foods such as raisins etc.
10. The process reduces volume of the products thereby saving in the cost of processing, storage and transport.
11. Constant immersion of product in osmotic agents avoids the O2 exposure, the product retains better color.
12. It protects against the structural collapse of the product during subsequent drying. It helps to retain the shape of the dehydrated products.

Conclusion

Osmotic dehydration is simple and effective treatment and preservation technique for preserve the food for long storage period. Osmotic dehydration having some profits like as reduces the damage of heat to the color and flavor, in this process the product having its real color, flavor, taste, and nutritional qualities as compare to other drying and preservation techniques. The osmotic dehydration process also concerned the quality and nutrition value of food product.

References

1. Ahemed J, Choudhary DR. Osmotic dehydration of papaya. Indian Food Pack. 1995; 49:5-11.
2. Alakali JS, Ariahu CC, Nkpa NN. Kinetics of osmotic dehydration of mango. Journal of Food Processing and Preservation. 2006; 30:597-607.
3. AOAC. Official methods of analysis. 14th Edition. Edited by Sidney williums. Published by. The Association of official analysis chemists, Inc. Arlinton, Virginia, 22209, USA, 1990.
4. Azuara E, Beristain CI. Osmotic dehydration of apples by immersion in concentrated sucrose matlodextrin solution. Journal of Food Processing hesewation. 2002; 26:295-306.
5. Barnabas M, Siores E, Lamb A. Non-thermal microwave reduction of pathogenic cellular population. Int. J Food Eng. 2010; 6:1-18.
6. Behsnilian D, Spiess WE. Osmotic dehydration of fruits and vegetables. IUFOST, 2006.
7. Bongirwar DR, Sreenivasan A. Osmotic dehydration of banana. J Food Sci. Technol. 1977; 14 (3):104-112.
8. Chavan UD. Osmotic dehydration process for preservation of fruits and vegetables. Journal of Food Research. 2012; 1(2):202-209.
9. Conway J, Castaigne F, Picard G, Vovan X. Mass transfer consideration in the osmotic dehydration apples, journal of food science and technology. 1983; 16:25-29.
10. El-Aouar AA, Azoubel MP, Jr Barbosa Lj, Murr XEF. Influence of the osmotic agent on the osmotic dehydration of papaya (*Carica papaya L.*). Journal of Food Engineering. 2006; 75:267-274.
11. Erle U, Schubert H. Combined osmotic and microwave-vacuum dehydration of apples and strawberries. Journal of Food Engineering. 2001; 49:193-199.
12. Geohive. Geohive World Crop Production, 2014. www.geohive.com/charts/ag_crops.aspx
13. Kalyani BSB, Reddy SB, Kalyani UP, Devi HV, Ravi L, Shanti M, Singh E. Study On Dehydration of Papaya Slices Using Osmotic Dehydration Mediated Hot Air Oven Drying. 2015; 9(2):72-95.
14. Khan Rafiq Moazzam. Osmotic dehydration technique for fruit preservation. Pakistan journal of food science. 2012; 22(2):71-85.
15. Lazarides HN. Reasons and possibilities to control solids uptake during osmotic treatment of fruits and vegetables, 2001, 33-42.
16. Lenart A. Osmo-convective drying of fruits and vegetables: technology and application. Drying Technology. 1996; 14:391-413.
17. Mauro MA, Menegalli FC. Evaluation of water and sucrose diffusion coefficients in potato tissue during osmotic concentration. J Food Eng. 2003; 57:367-374.
18. Okos MR, Narsimham G, Singh RK, Witnauer AC. Food dehydration. In D. R. Heldman & D. B. Lund (Eds.), Handbook of food engineering. New York: Marcel Dekker, 1992.
19. Petchi M, Manivasagan R. Optimization of osmotic dehydration of radish in salt solution using response surface methodology. Int. J Food Eng. 2009; 5:1-11.
20. Petrotos KB, Lazarides HN. Osmotic concentration of liquid foods. Journal of Food Engineering. 2001; 49:201-206.
21. Pointing JD, Watterss GG, Forrey RR, Stangly WL, Jackson R. Osmotic dehydration of fruits. J Food Sci. Technol. 1966; 20(10):125-128.

22. Rahman MS, Lamb J. Air-drying behaviour of fresh and osmotically dehydrated pineapples. J Food Process Engi. 1991; 14:163-171.
23. Rahman MS, Perera CO. Drying and food preservation. In M. S. Rahman (Ed.), Handbook of food preservation New York: Marcel Dekker, 1999, 173-216.
24. Rastogi NK, Raghavarao K. Water and solute diffusion coefficients of carrot as a function of temperature and concentration during osmotic dehydration. Journal of Food Engineering. 1997; 34:429-440.
25. Sablani SS, Rahman MS, Al-Sadeiri DS. Equilibrium distribution data for osmotic drying of apple cubes in sugar-water solution. Journal of Food Engineering. 2002; 52:193-199.
26. Sagar VS, Khurdiya DS. Studies on dehydration of Dashehari mango slices. Indian Food Pack. 1999; 53(1):5-9.
27. Singh B, Panesar PS, Nanda V. Osmotic dehydration kinetics of carrot cubes in sodium chloride solution. International Journal of Food Science and Technology. 2008; 43:1361-1370.
28. Singh B, Panesar PS, Nanda V. Osmotic dehydration kinetics of carrot cubes in sodium chloride solution. International Journal of Food Science and Technology. 2008; 43:1361-1370.
29. Sousa PHM, Souza Neto MA, Maia GA, Souza Filho MSM, Figueiredo RW. Desidratação osmótica de frutos. Boletim da Sociedade Brasileira de Ciência e Tecnologia de Alimentos. 2003; 37:94-100.
30. Taiwo KA, Eshtiaghi MN, Ade-Omowaye BIO, Knorr D. Osmotic dehydration of strawberry halves: influence of osmotic agents and pretreatment methods on mass transfer and product characteristics. International Journal of Food Science and Technology. 2003; 38:693-707.
31. Torreggiani D, Bertolo G. Highquality fruit and vegetable products using combined processes. In Osmotic Dehydration and Vacuum Impregnation, Fito. P., Chiralt. A., Bara.t J. M., Spiess. W. E., and Behsnilian. D. (Editors). Lancaster, PA: Technomic Publishing Company, Inc, 2001a.
32. Torres JD, Talens P, Escriche IA. Chiralt Influence of process conditions on mechanical properties of osmotically dehydrated mango. Journal of Food Engineering. 2006; 74:240-246.
33. Yeomans SJ, Yang SX. Determining optimal osmotic drying parameters for papaya using the firefly algorithm. Lecture notes in management science. 2014; 6:32-39.
34. Yousefi A, Niakousari M, Moradi M. Microwave assisted hot air drying of papaya (*Carica papaya* L.) pretreated in osmotic solution. African journal of Agricultural Research. 2013; 8(25):3229-3235.