South Asian J. Food Technol. Environ., 5(1): 791-796 (2019)
ISSN 2394-5168(Print), 2454- 6445(online)
www.sweft.in

Effect of tray drying on the moisture kinetic and drying rate of osmo-dried papaya slices

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Abstract

The experiment was conducted to determine the drying rate, drying time, moisture content of osmotically papaya samples. Drying of papaya samples in a tray dryer takes only 540 minutes for drying from an initial moisture content of 89% (wb) to a final moisture content of 2.4, 5.3 and 1.7% (db) of 55^{o}Brix and the final moisture content were recorded of 65^{o}Brix that 3.66, 3.12 and 5.9% (db) for T_1, T_2 and T_3 samples. The drying temperature is the main factor controlling the rate of drying. It is an important parameter for internal water transfer in the product.

Keywords: Tray Dryer, Osmo-dried Papaya Slices, Moisture Content, Drying Rate, Drying Time.

Paper Cited: Kumar, V., Singh, J., Chandra, S., Chauhan, N., Kumar, R., Sunil and Chaudhary, V. (2019). Effect of tray drying on the moisture kinetic and drying rate of osmo-dried papaya slices. *South Asian Journal of Food Technology and Environment*, 5(1): 791-796.

Introduction

The drying of fruits permits longer storage periods, reduces shipping weights, and minimizes their packaging requirements (Yeomans and Yang, 2014). 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). The mechanism of drying process consist of the transport of (mass) moisture from the interior of the solid to the surface, the vaporization of liquid at the surface (diffusion) and the transport of the vapor into gas phase (Seyed *et al*., 1999). The drying operation reduces the moisture content of solids to a condition favorable for safe storage without deteriorations. The most significance reason for the popularity of dried products is that in dehydrated foods, microorganisms practically do not grow due to the presence of a minimum amount of water and thus they are immune to enzymatic reactions that could spoilage in the food (Agarry and Owabor 2012; Hatamipour *et al*., 2007 and Gumus and Ketebe, 2013). This helps to shorten the dehydration time and control undesirable biological transformations. The objective of this study was calculation of moisture content and drying rate during drying process. Drying is a simultaneous heat and mass transfer process, where heat is supplied to wet papaya by heated air and the evaporated moisture is carried away by the air (Akhtaruzzaman *et al*., 2013). The drying rate is a function of product moisture content. In the drying rate period the most surface of product behaves like a free water surface. This period continues till the rate of evaporation of water from the surface is equal to the rate of moisture migration from interior of product to its surface. The constant drying period continues till critical moisture content is

reached. The critical moisture content is dependent on product and its thickness (Sahay and Singh 1994).

Materials and Methods

Experimental Plan: Papaya slices were pretreatment with treatments (T_1 = Potassium Metabisulphate, T_2 = Sodium bisulphate and T_3 = Blanching at 95^{o}C for 4 min.) in osmotic solution at temperature of 50°C. Then the samples were dried under tray drier at 60^{o}C temperature. During the process, osmosis was carried out in sucrose solution at a varying concentration of 55°Brix and 65°Brix. At each experimental condition, osmotic dehydration was carried out for 180 minutes and data are observed at each 30 min intervals.

Experimental procedure: The papaya was procured from the local market of Meerut (UP) in 2018. The papaya was then washed, and decides into 2.5x2.5x2.5 cm Size. The papaya slices were treated above decided treatments for 30 minutes and then the sample were removed from treated solution and placed at room temperature for 15 minutes and then weighted by electrical balance. After that the samples were osmosed with sugar solution (55 ^{o}Brix and 65 ^{o}Brix) for 180 minutes at 50 ^{o}C temperature and then the osmotically papaya slices were dried in tray drying at 60 ^{o}C.

Moisture content: Moisture content of the sample was determined by standard air oven method (Rangana, 2001). Test sample of 5 g was kept for 16-18 hr in a hot air electric oven maintained at 100ºC. After 16-18 hr, sample was drawn from the oven and placed in a desiccator for cooling. After cooling the weight of the sample was taken precisely. The loss in weight was determined and moisture content was calculated using the following expression:

$$\text{M C\% (wb)} = \frac{\text{M1 – M2}}{M0} \times 100$$

$$\text{M C\% (db)} = \frac{M.C.(wb)}{1 - M.C.(wb)} \times 100$$

Where,

M_0 = Initial weight of sample taken, 5 g

M_1 = Weight of sample before tray drying and weight of dish with cover, g

M_2= Weight of the dish with cover containing dried and desiccated sample, g

Drying Rate: Drying rate will be calculated as weight of water removed per unit time per unit weight of the bone dry matter.

$$\text{Drying rate (\%)} = \frac{\text{Weight of water removed(g)}}{\text{time(min.)} \times \text{bone dry weight of the sample(g)}}$$

Results and Discussion

Effect on moisture content

Fresh Papaya of good and uniform quality was obtained from a local market (Modipuram). The average initial moisture content was 89% (wb) and soluble solids content was 15^{o}Brix. The effects on moisture content during drying of osmosed dried papaya slices under tray dryer at 60^{o}C. The result presented in Table 1 and Fig. 1 & 2. Moisture content followed a slight decreasing trend as the drying period increases. The variations in moisture content of osmosed dried papaya slices with time were ranged from 236.2 to 2.4 (T_1), 254.1 to 5.3 (T_2) and 166.9 to 1.7 (T_3) of 55^{o}Brix from 0 to 540 minutes, while the variations of moisture content were ranged from 205.33 to 3.66 (T_1), 259.72 to 3.12 (T_2) and 198.72 to 5.9 (T_3) of 65 ^{o}Brix from 0 to 540 minutes. The moisture content decreased as time increases but tend to be constant with further increase in time. The loss in water content of a sample is depending on drying time. In general the time of treatment increase, the weight loss increased but the rate at which this occur decrease (Kumari *et al.*, 2013).

Effect on drying rate

The drying behavior of osmo-dehydrated papaya slices was analyzed using the experimental data of moisture of product. Time interval varies from 0 to 540 minutes at 60^{o}C temperature. The experimental data of the drying behavior of dried papaya slices with relation to moisture content, and drying rate are show in table 2 and figure 3 to 4. It was observed from the curves that the drying rate was higher in the initial period of drying and subsequently it was reduced with decrease in moisture content. The drying in falling rate period indicates that internal mass transfer occurred by diffusion.

Similar results have been reported for the drying studies on onion slices (Rapusas and Driscoll, 1995) and apricots (Doymaz, 2004). The variations in drying rate of osmosed dried papaya slices with time were ranged from 0.699 to 0.0061 (T_1), 0.52 to 0.0041 (T_2) and 0.75 to 0.0073 (T_3) of 55 ^{o}Brix from 60 to 540 minutes, while the variations of drying rate were ranged from 1.003 to 0.006 (T_1), 1.379 to 0.013 (T_2) and 0.776 to 0.015 (T_3) of 65^{o}Brix from 60 to 540 minutes. The drying rate cure decreased as time increases but tend to be constant with further increase in time. The higher drying rate at the start of drying is due to high surface moisture availability, which evaporates rapidly. Further decrease in drying rate is owed to decrease in available moisture due to low driving force and low moisture diffusion from center to surface of the dried product. Similar results were found by (Rocha *et al*., 1992). Drying time provides an indication of drying rate. Drying rate of the samples was high initially when the moisture content was highest (Kumari, *et al*., 2013). The entire osmotic as well tray drying took place in falling rate period. The final moisture content of samples basically depends upon initial moisture content of the samples, if all conditions are steady.

Table 1: Effect of treatments and tray drying (60^{o}C) on moisture content (%) of osmosed dried papaya slices.

Time (min.)	T_1		T_2		T_3	
	55^{o}Brix	65^{o}Brix	55^{o}Brix	65^{o}Brix	55^{o}Brix	65^{o}Brix
0	236.2	205.336	254.1	259.721	166.9	198.724
60	194.8	145.147	228.9	177.008	121.9	152.367
120	111.6	106.171	158.0	129.017	99.0	117.293
180	83.8	83.3907	120.5	101.525	75.0	96.3254
240	41.9	45.2591	78.5	56.7572	36.9	62.4065
300	28.5	33.1735	47.2	44.6625	27.9	54.2215
360	20.5	26.7732	33.4	29.1923	19.0	35.5011
420	9.7	13.0676	12.2	18.2058	9.3	24.5575
480	5.7	6.87411	7.5	10.3633	5.7	14.1486
540	2.4	3.66656	5.3	3.12345	1.7	5.96059

Description: (T_1 = Potassium Metabisulphate, T_2 = Sodium bisulphate and T_3 = Blanching)

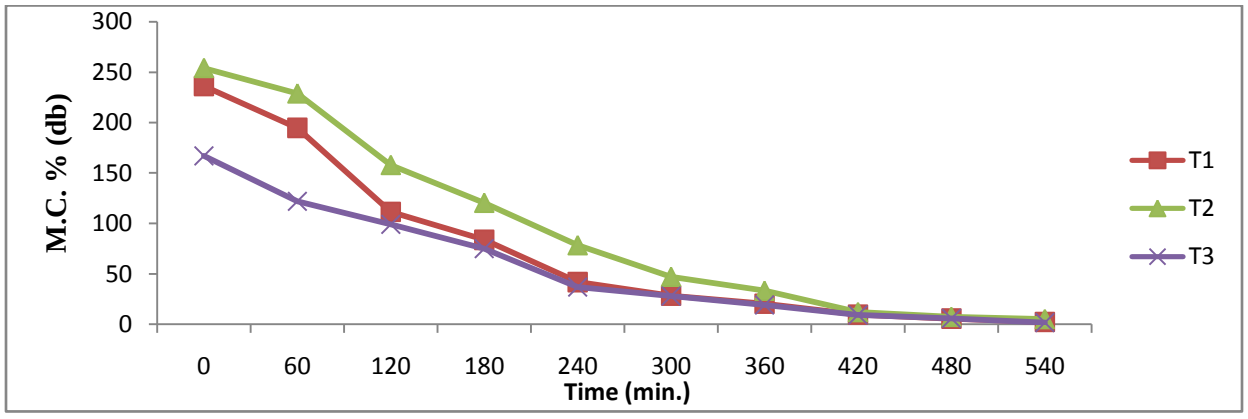

Fig. 1: Effect of treatments and tray drying (60 ^{o}C) on moisture content (%) of osmosed (55 ^{o}Brix) dried papaya slices.

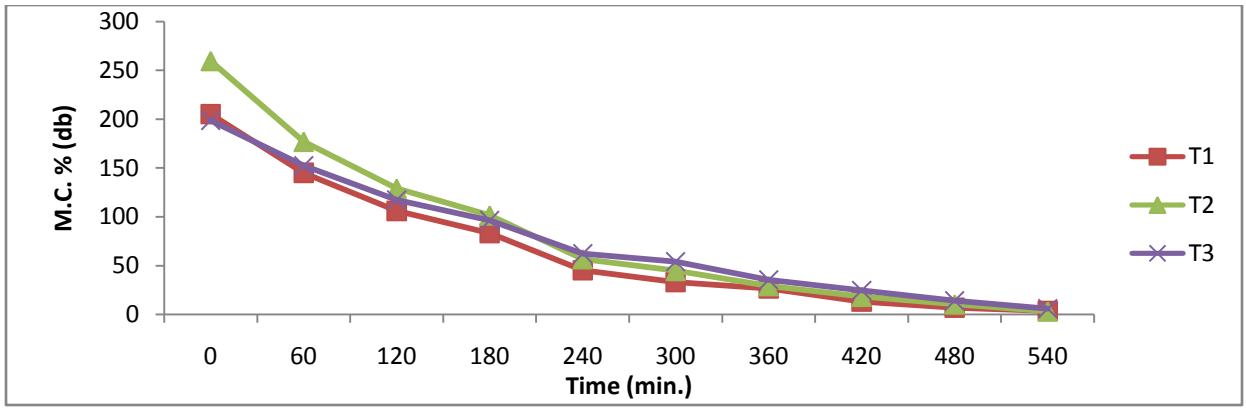

Fig. 2: Effect of treatments and tray drying (60°C) on moisture content (%) of osmosed (65 °Brix) dried papaya slices.

Table 2: Effect of treatments and tray drying (60 °C) on drying rate of osmosed dried papaya slices.

Time (min.)	T_1		T_2		T_3	
	55°Brix	65°Brix	55°Brix	65°Brix	55°Brix	65°Brix
60	0.69912	1.00315	0.52114	1.379	0.74889	0.77261
120	0.68385	0.32479	0.49052	0.39992	0.19061	0.29228
180	0.17438	0.15656	0.20857	0.18273	0.15346	0.14649
240	0.15412	0.14888	0.17482	0.15653	0.13903	0.11133
300	0.04487	0.1029	0.10422	0.04232	0.03003	0.05728
360	0.02518	0.03778	0.05837	0.04097	0.02457	0.02601
420	0.02268	0.02263	0.03046	0.02616	0.02311	0.02206
480	0.00836	0.0129	0.00985	0.01634	0.00753	0.02169
540	0.00607	0.00594	0.00413	0.01341	0.00732	0.01516

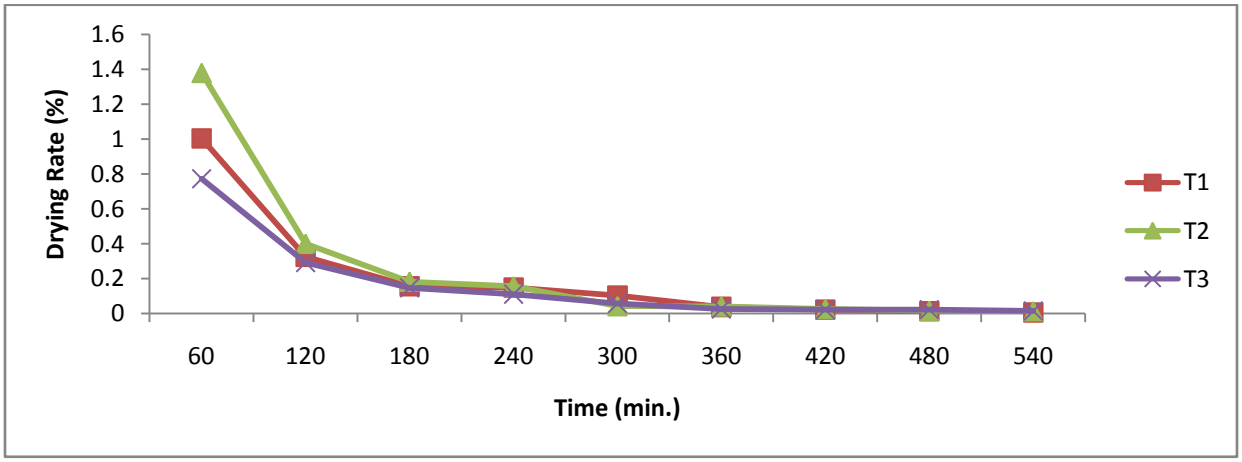

Fig. 3: Effect of treatments and tray drying (60 °C) on drying rate of osmosed (55 °Brix) dried papaya slices.

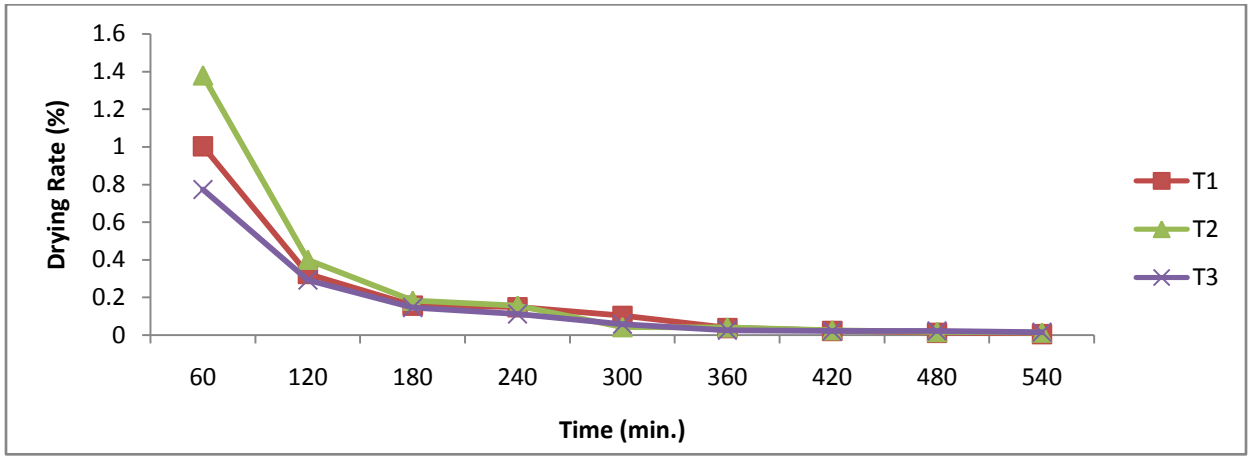

Fig. 4: Effect of treatments and tray drying (60 ^{o}C) on drying rate of osmosed (65 ^{o}Brix) dried papaya slices.

Conclusion

In this study, the kinetics drying of papaya slices were experimentally studied under 60^{o}C temperature. The drying temperature has an essential role in the characterization of drying behavior of papaya samples. The increase in drying time consequently decreases the drying rate.

Acknowledgements

We would like to acknowledge the department of agricultural engineering (S.V.P. Uni. Agri. and Tech. Meerut, UP, India) for providing facilities to conduct the experiment.

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Received	: March, 2019
Revised	: April, 2019
Published	: June, 2019