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Effect of Hot Air Oven Drying on the Moisture Kinetics and Drying Rate of Osmo-Dried Papaya (*Carica papaya* L.) Slices

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A B S T R A C T

The experiment was conducted to determine the drying rate, moisture content of osmo-dried papaya slice. Drying of papaya slices in a hot air oven dryer takes only 660 minutes for drying from an initial moisture content of 89% (wb) to a final moisture content of 6.92, 4.84, 7.19 and 2.79% (db) of 55 ^{o}Brix and the final moisture content were recorded of 65 ^{o}Brix that 16.30, 4.12, 9.32 and 9.76% (db) for T_1, T_2, T_3 and T_4 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.

Introduction

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 (Zaki *et al*., 2007). In the process, more water than solute is usually removed due to the deferential permeability of cellular membranes (Mauro and Menegalli, 2005). 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). Water removal is the main task while preserving food (Lenart, 1996) 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 *et al.,* 1992). The increase in drying rate and decrease of heat transfer provide energy saving of microwave drying. Drying is perhaps the oldest, most common and most diverse of chemical engineering unit operations in the preservation of agricultural food materials or products (Dincer, 1996). It is the process moisture (water) removal from substances due to simultaneous heat and mass transfer (Waewsak *et al*., 2006). 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 provoke alterations or spoilage in the food (Agarry and Owabor, 2012; Hatamipour *et al*., 2007; Gumus and Ketebe, 2013).

Materials and Methods

Experimental plan

Papaya slices were pretreatment with treatments (T_1 = Control, T_2 = Potassium Metabisulphate, T_3 = Sodium bisulphate and T_4 = Blanching at 95^{o}C for 4 min.) in osmotic solution at temperature of 50°C. Then the samples were dried under Hot Air Oven 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 osmo-dried papaya slices were dried in Hot Air Oven 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:

$$\mathbf{M\ C\%\ (wb)} = \frac{\mathbf{M1 - M2}}{\boldsymbol{M0}} \times \mathbf{100}$$

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

Where,

$\mathbf{M_0}$ = Initial weight of sample taken, 5 g
$\mathbf{M_1}$ = Weight of sample before tray drying and weight of dish with cover, g
$\mathbf{M_2}$= 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.

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

Results and Discussion

Effect of moisture content during drying

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 (Singh, 2015). 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 figure 1 and 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 750.79 to 6.92 (T_1), 223.67 to 4.84 (T_2), 245.52 to 7.19 (T_3) and 235.93 to 2.79 (T_4) of 55^{o}Brix from 0 to 660 minutes, while the variations of moisture content were ranged from 772.73 to 16.30 (T_1), 251.81 to 4.12 (T_2), 371.89 to 9.32 (T_3) and 297.36 to 9.76 (T_4) of 65^{o}Brix from 0 to 660 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).

Table.1 Effect of treatments and hot air oven drying (60^{o}C) on moisture removal of osmo-dried papaya slices

Time (min.)	T_1		T_2		T_3		T_4	
	55^{o}Brix	65^{o}Brix	55^{o}Brix	65^{o}Brix	55^{o}Brix	65^{o}Brix	55^{o}Brix	65^{o}Brix
0	750.794	772.73	223.674	251.814	245.521	371.893	235.928	297.36
60	693.107	717.014	192.081	204.029	211.71	265.386	179.933	223.055
120	644.87	661.43	150.099	164.984	172.269	192.958	145.531	177.847
180	457.556	569.834	109.918	117.122	137.12	153.733	98.2839	116.904
240	337.358	456.806	82.46	76.4046	105.985	104.066	65.694	78.4525
300	207.882	312.347	63.0009	56.3851	80.1418	67.1157	49.9151	62.9765
360	155.705	243.708	48.4005	47.3862	60.6738	52.293	39.2297	47.4985
420	86.2215	156.356	36.7031	35.4526	48.4046	37.4874	31.3507	36.0728
480	58.5348	113.161	27.1505	28.2689	34.6726	30.3976	23.5977	29.0476
540	30.8531	71.2687	21.7458	18.9684	28.9341	22.3196	16.2551	22.8556
600	15.1898	53.6365	14.5062	11.2199	19.4922	16.4158	9.1887	16.6661
660	6.91823	16.3039	4.83995	4.11503	7.18553	9.32241	2.78857	9.76178

Table.2 Effect of treatments and hot air oven drying (60°C) on drying rate of osmos-dried papaya slices

Time (min.)	T_1		T_2		T_3		T_4	
	55°Brix	65°Brix	55°Brix	65°Brix	55°Brix	65°Brix	55°Brix	65°Brix
60	1.6144	2.06522	0.52655	1.23842	0.56351	0.92855	0.9333	0.79642
120	0.90198	0.8629	0.34985	0.37673	0.32867	0.56321	0.2867	0.32537
180	0.54063	0.4187	0.22323	0.33857	0.19527	0.48887	0.2625	0.26590
240	0.50083	0.2784	0.11441	0.16022	0.12973	0.47195	0.1358	0.16966
300	0.43159	0.1696	0.06486	0.05159	0.08614	0.47053	0.0526	0.06673
360	0.16494	0.0648	0.04056	0.04299	0.05408	0.29066	0.0297	0.02800
420	0.14544	0.0478	0.02785	0.02720	0.02921	0.20798	0.0188	0.02641
480	0.05768	0.0278	0.01990	0.01464	0.02861	0.08999	0.0162	0.01797
540	0.05126	0.0221	0.01401	0.01147	0.01863	0.07758	0.0136	0.01422
600	0.02611	0.0208	0.01207	0.01056	0.01574	0.05939	0.0118	0.01291
660	0.01253	0.0187	0.01065	0.01046	0.01065	0.02656	0.0097	0.01076

Fig.1 Effect on moisture content (db%) at 55°Brix during hot air oven

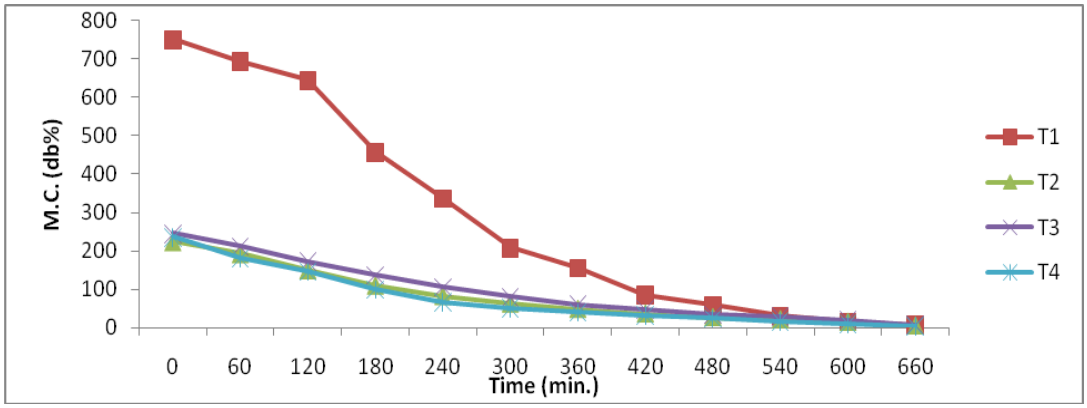


Fig.2 Effect on moisture content (db%) at 65°Brix during hot air oven drying

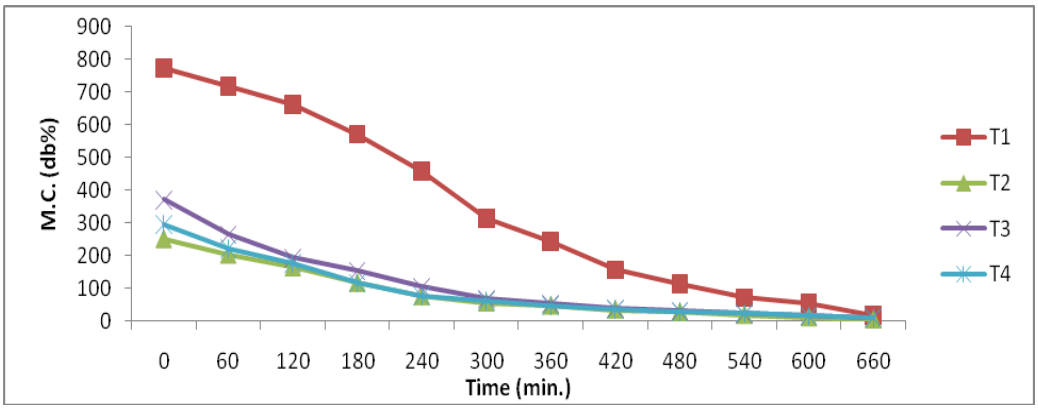


Fig.3 Effect on drying rate at 55°Brix during hot air oven drying

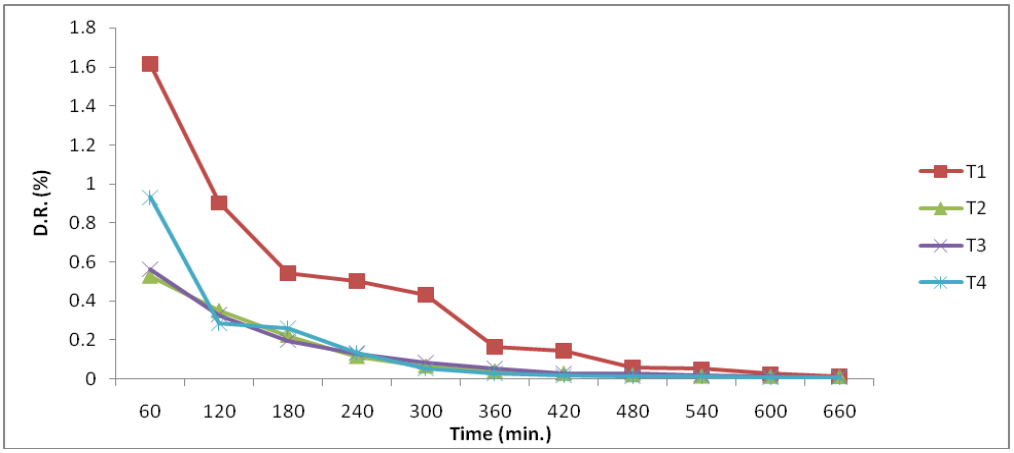
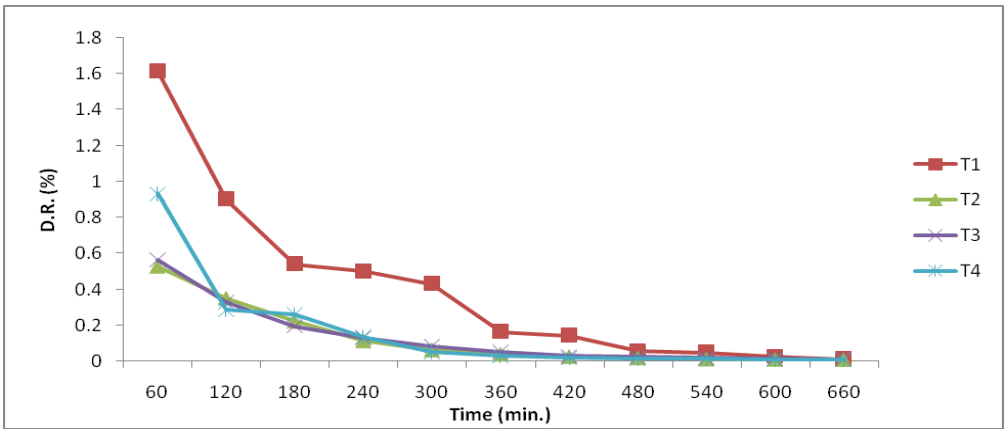


Fig.4 Effect on drying rate at 65°Brix during hot air oven drying



Effect of drying rate during drying

The drying behavior of osmo-dehydrated papaya slices was analyzed using the experimental data of moisture of product. Time interval varies from 0 to 660 minutes at 60°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 osmo-dried papaya slices with time were ranged from 1.61 to 0.013 (T_1), 0.53 to 0.011 (T_2), 0.56 to 0.011 (T_3) and 0.93 to 0.009 (T_4) of 55°Brix from 60 to 660 minutes, while the variations of drying rate were ranged from 2.065 to 0.019 (T_1), 1.238 to 0.010 (T_2), 0.928 to 0.026 (T_3) and 0.796 to 0.011 (T_4) of 65°Brix from 60 to 660 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.

In conclusion, the drying curves were affected by the drying air temperature. Drying rate 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. 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. The higher drying rate at the start of drying is due to high surface moisture availability, which evaporates rapidly.

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