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Studies on osmotic dehydration of banana cv. Poovan and Dwarf Cavendish

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Abstract

The study was undertaken on osmotic dehydration of banana varieties *viz.*, Poovan (AAB) and Dwarf Cavendish (AAA) to investigate the effect of temperature, sample thickness and osmotic time on the rate of osmosis. The results revealed that the maximum water loss and solid gain after osmosis were 57.9 and 15.5 per cent in Poovan and 53.1 and 11.8 per cent in Dwarf Cavendish. The moisture content of Poovan slices reduced from 2.03 kg H_2O kg^{-1} dry matter (DM) to as low as 0.31kg H_2O kg^{-1} DM when osmosed in 60 ºB syrup at 75 ºC. In case of Dwarf Cavendish, the moisture content reduced from 2.84 to 0.38 kg H_2O kg^{-1} DM under similar conditions. Subsequent air dehydration resulted in further loss of moisture and the moisture content was reduced to a range of 0.03 to 0.18 kg H_2O kg^{-1} DM after 4 to 8 h of drying.

Key words: Banana, post harvest loss, osmotic dehydration, value addition.

Introduction

Banana is one of the most important sustaining fruits in India and its higher productivity demands good soil sturcture, nutrients and water. The lands on which it can be successfully grown on a commercial scale are therefore limited in extent. The banana varieties grown on a commercial scale in Tamil Nadu are Poovan, Dwarf Cavendish, Nendran, Red Banana, Robusta and Rasthali. Among these varieties, Poovan is popularly consumed for relief from constipation while Dwarf Cavendish assumes significance due to its excellent flavour and taste.

The agro climatic conditions in India favour the cultivation of wide variety of fruits. India is second largest producer of fruits after after China with a production of 57.6 million tones (MT) from 5.2 million ha (National Horticultural Board, 2005). However, for various reasons this abundance of production is not fully or satisfactorily utilized as it should be. About 25 to 35 per cent of this is wasted due to improper handling, lack of transportation and storage facilities. To avoid the wastage, the surplus fuir could be processed and preserved properly. Fruits are generally preserved by canning, freezing, refrigeration or by drying (Simmonds, 1966). Dehydration is one of the easiest methods of preservation and is practiced from earliest times. A dried fruit product, apart from increased shelf life, offers the advantage of decreased weight and saves the cost of packaging, handling and transporting the product.

Osmotic dehydration has received greater attention in recent years as an effective method for preservation of several fruits (Tiwari, 2005) and specially of banana (Gaspartero *et al*., 2003; Chavan and Amarowicz, 2012). Osmotic dehydration is a two-stage dehydration process. The first step consists of immersing food piece in a concentrated osmotic solution or in a dry osmotic material. To produce a stable dehydrated product, the concentrated food may be vacuum dried or air dried in the second stage (Contreras and Smyrl, 1981). The main principle involved in osmotic dehydration is dewatering of fruits by osmosis at comparatively lower temperature which reduces the severity of the thermal treatment and produces dehydrated fruit product very near to natural fruit in colour, flavour and textural qualities. The sugar or syrup has a protective effect on the retention of fresh fruit flavour during the process. Enzymatic and oxidative browning reactions which normally occur during drying are prevented in osmotic drying as the fruit pieces are surrounded by sugar, making it possible to retain good colour (Chaudhari *et al.,* 1993). With growing importance of preservation, the present study was carried on osmotic dehydration of banana varieties *viz.*, Poovan (AAB) and Dwarf Cavendish (AAA) and the effect of temperature, sample thickness and osmotic time on the rate of osmosis.

Materials and methods

The study was carried out using two varieties of banana *viz.,* Poovan (AAB) and Dwarf Cavendish (AAA). The variety Poovan (AAB) was obtained from the Department of Horticulture, Annamalai University, Annamalainagar and Dwarf Cavendish was procured from farmer's field. Fully matured fruits were procured, washed in tap water to remove the extraneous matter and shade dried. Damaged and bruised fruits were culled out. The fruits were taken for peeling and sizing when the total soluble solids (TSS) reached 17 to 22 ºBrix for Poovan (AAB) and 22 to 25 ºBrix for Dwarf Cavendish (AAA). Osmosis was carried out on 5, 7.5 and 10 mm thickness of fruits in 40, 50 and 60 ºBrix concentration of sugar syrup maintaining a fruit to syrup ratio of 1:4. Potassium metabisulphite and citric acid of 0.1 per cent concentration each were added to the sugar syrup to enhance the shelf life of dehydrated product. Observations on moisture content, weight reduction and solid gain were recorded for every 2, 1 and 0.5 h dehydration at room temperature (RT), 50 and 75 ºC, respectively. Each treatment was repeated three times and the average values were determined.

The observations were statistically anaylsed in factorial completely randomized design in (FCRD) to study the influence of osmosis time, thickness of material, concentration of syrup and temperature on water loss and solid gain. At the end of every 2, 1 and 0.5 h at RT, 50 and 75 ^{o}C, respectively, the slices were blotted out to remove the syrup adhering to it and weighted. Sample of 5 g were taken from each treatment and kept in the oven for the determination of moisture content and solid gain. The water loss and solid gain in the osmotic process were calculated using the following formula: Weight reduction (WR) in (%) = ((Initial fruit weight - final weight)/ (Initial fruit weight)) x 100. Solid gain (SG) = ((Total solids-Initial solids) / (Initial fruit weight)) x 100. Water loss = WR+SG.

After osmosis, the slices were taken out from the syrup and blotted completely with a tissue paper to remove the syrup adhered in the pieces. The slices were then weighed and either dried or directly packed in 100 mm thick polyethene bags as intermediate moisture food. The slices were spread uniformly on aluminum trays in a single layer and dried in a cabinet dryer at 65 ^{o}C until constant weight was reached. In the dryer, the hot air temperature could be adjusted thermostatically from RT to 250 ^{o}C. The weight of the slices was recorded at every 1 h time interval. In case of control, the fresh slices were directly dehydrated in the cabinet dryer.

In vacuum drying, the slices were dried in a vacuum oven at 70 ^{o}C and 600 mm of vacuum. Drying was continued till the slices reached constant weight. Similar to air drying, the slices were taken out and weighed at every 1 h time interval. The air and vacuum dried fruits were allowed to reach room temperature and packed in polyethene bags of 100 mm thickness. The experiment was replicated thrice and average values were obtained. For the determination of moisture content, 5 g of sample was dried in a vacuum drier at 70 ^{o}C and 660 mm of vacuum till it attained constant weight. The data were subjected to statistical analysis as outlined by (Panse and Sukhatme, 1964). Wherever possible the statistical significance was tested by 'F' values at 5 percent level of probability and the critical differences were worked out for the significant effects

Results and discussion

The results obtained revealed that water loss in banana slices was significantly influenced by osmosis time, thickness of slices, concentration of sugar syrup and temperature. The interaction effect of thickness, concentration and temperature also favored water loss significantly. During the period of osmosis the water loss increased with increase in osmosis time while the rate of water loss decreased, at all the temperature levels. It was observed that more than 50 per cent of the dewatering occurred within the 4th, 2nd and 1st hrs of osmosis at RT, 50 and 75 ^{o}C, respectively. The time required for maximum dewatering reduced by half to one fourth at higher temperature (Table 1 & 2).

Table 1. Water loss (per cent) during osmosis in Poovan and Dwarf Cavendish at different interval

Thickness (mm)	Osmosis temperature (^{o}C)	Syrup concentration (^{o}B)	Poovan					Dwarf Cavendish				
			1	2	3	4	5	1	2	3	4	5
5	RT	40	10.93	19.06	23.70	28.20	31.36	13.10	22.23	29.23	39.83	31.36
		50	12.90	22.00	28.53	33.93	38.40	17.06	28.70	36.46	43.36	47.43
		60	15.00	26.30	34.73	41.06	44.70	19.70	32.40	42.73	49.00	52.93
	50	40	12.83	21.86	28.60	33.80	36.36	14.30	23.93	31.40	37.30	41.70
		50	17.40	29.00	37.03	43.50	46.03	18.53	13.70	39.40	55.10	49.16
		60	18.36	32.03	41.96	48.23	52.02	21.70	35.73	44.53	51.53	54.63
	75	40	16.00	26.00	32.80	37.60	40.70	14.96	26.40	35.26	40.53	44.66
		50	18.26	31.10	40.63	47.10	49.70	17.56	30.50	41.10	47.46	50.90
		60	18.53	33.10	42.63	48.43	53.10	20.00	35.70	46.33	52.96	57.90
7.5	RT	40	9.93	17.43	22.73	26.03	28.33	11.22	20.26	25.53	29.20	32.16
		50	11.50	19.56	25.46	30.36	33.26	14.86	24.86	31.13	35.66	38.66
		60	13.60	23.16	29.53	35.36	39.66	17.33	29.26	37.30	42.76	46.36
	50	40	11.76	20.66	26.27	29.83	32.50	12.56	22.13	27.80	31.96	34.66
		50	13.00	21.46	28.90	32.46	35.40	15.33	25.30	33.60	38.83	41.93
		60	14.03	23.93	31.26	36.70	41.10	18.53	30.93	41.56	47.63	49.66
	75	40	13.13	22.66	28.83	33.56	35.23	13.56	23.40	29.33	33.88	36.06
		50	15.23	26.03	33.56	38.76	40.90	16.00	27.00	34.36	40.26	42.06
		60	16.96	27.93	35.50	40.46	43.00	18.60	31.33	14.63	47.80	50.60
10	RT	40	8.76	15.40	19.93	22.70	24.70	9.80	16.46	21.36	24.30	26.43
		50	10.96	19.40	24.40	27.80	31.13	11.90	19.86	25.30	28.66	32.30
		60	12.80	21.76	28.46	34.00	37.90	14.60	25.43	32.03	37.10	39.53
	50	40	10.70	18.46	23.36	27.23	39.53	11.13	19.26	24.53	28.33	30.60
		50	12.83	21.70	26.96	31.13	34.06	14.36	24.36	31.20	35.90	38.83
		60	14.03	24.33	30.96	35.30	38.43	16.76	27.90	36.06	41.23	43.73
	75	40	12.83	19.36	25.10	29.20	31.36	12.60	20.26	25.63	30.03	31.93
		50	14.93	24.86	31.90	36.60	39.53	15.00	24.90	32.10	36.50	38.86
		60	16.66	27.13	33.90	38.86	42.06	17.26	28.73	36.30	41.16	44.26

Table 2. Solid gain (per cent) during osmosis in Poovan and Dwarf Cavendish at differnt intervals

Thickness (mm)	Osmosis temperature (°C)	Syrup concentration (°B)	Poovan					Dwarf Cavendish				
			1	2	3	4	5	1	2	3	4	5
5	RT	40	2.03	3.40	4.13	4.86	5.23	2.63	4.53	5.76	6.76	7.56
		50	2.46	4.16	5.10	5.66	6.10	2.70	5.10	6.50	7.30	8.16
		60	2.63	4.70	6.10	7.00	7.43	3.03	5.03	6.76	7.76	8.56
	50	40	2.46	4.26	5.30	6.06	6.60	3.33	5.63	7.23	8.56	9.33
		50	3.03	5.40	6.73	7.66	8.53	3.50	6.16	7.96	8.96	9.66
		60	3.26	5.80	7.33	8.46	9.36	3.93	6.60	8.43	9.56	10.50
	75	40	3.93	6.60	8.43	9.56	10.50	4.83	8.96	11.83	13.26	13.93
		50	4.76	7.56	9.66	10.73	11.36	5.43	9.36	12.46	13.90	14.43
		60	5.10	7.53	9.50	10.90	11.80	5.96	10.13	13.16	14.53	15.50
7.5	RT	40	1.73	3.00	3.63	4.13	4.66	2.46	4.23	5.33	6.20	6.63
		50	2.23	3.50	4.43	5.26	11.36	2.53	4.53	5.50	6.23	7.16
		60	2.46	4.26	5.20	5.83	11.80	2.76	5.00	6.33	7.16	7.63
	50	40	2.50	4.36	5.50	6.20	6.86	3.10	5.33	6.70	7.66	8.43
		50	2.86	4.73	5.80	6.70	7.56	3.26	5.46	7.16	8.40	9.13
		60	3.10	5.33	6.70	7.66	8.43	3.63	6.40	8.30	9.10	9.66
	75	40	3.63	6.40	8.30	9.10	9.66	4.20	6.93	8.63	9.70	10.53
		50	4.16	6.90	8.63	9.70	10.53	4.73	7.56	9.66	10.73	11.36
		60	4.80	7.60	9.23	10.60	11.50	5.10	7.83	9.86	11.46	12.26
10	RT	40	1.53	2.63	3.36	3.83	4.16	2.16	3.63	4.73	5.30	5.80
		50	2.16	3.36	4.16	4.76	5.80	2.43	3.93	4.96	5.70	6.36
		60	2.46	3.96	4.96	5.70	6.43	2.63	4.50	5.70	6.40	6.86
	50	40	2.43	4.20	4.96	5.70	6.23	2.80	4.90	5.86	6.80	7.33
		50	2.80	4.70	5.83	6.90	7.46	3.10	5.33	6.90	8.06	9.06
		60	3.03	5.23	6.70	7.60	8.36	3.46	5.96	7.90	8.76	9.60
	75	40	3.46	5.70	7.50	8.36	8.90	3.83	6.63	8.26	9.16	9.90
		50	3.93	6.60	8.43	9.60	10.30	4.26	6.93	8.86	9.96	10.50
		60	4.63	7.73	9.63	10.73	11.46	4.73	7.60	9.16	10.36	11.26

The water loss was higher in both rate and extent at 50 and 75 °C when compared to RT in all syrup concentrations. The increase in rate and extent of dewatering at high temperature might be due to the changes in semi permeability of the cell membrane of the fruit, allowing more water to diffuse out and rather in a short period. This finding is in confirmation with the results obtained by Ponting *et al.* (1966). Besides, at higher temperature, the viscosity of the syrup decreased causing convention currents in the syrup, which in turn eliminate local dilution and osmosis.

It was observed that the water loss increased with increase in syrup concentration. The maximum water loss was found to occur in slices treated with 60 °B syrup, at all the temperatures. This might be due to the increased osmotic pressure in the sugar syrup at higher concentration, which increased the driving force available for water transport (Table 1). The increase in water loss might be due to the increase in the surface area available for mass transfer to take place when the slice thickness decreased. The analysis showed the significant influence of time, concentration, temperature and thickness on solid gain. The interaction of time, temperature, concentration and thickness was also found to have significant influence on the water loss.

From the Table 1, it is evident that the highest and lowest water losses obtained for Dwarf Cavendish were 57.9 and 26.43 per cent, respectively. It was approximately 2 to 4 per cent higher compared to Poovan (AAB) and the effect was higher at elevated temperature. The higher water loss realized in Dwarf Cavendish (AAA) might be because of the higher initial moisture content than Poovan (AAB). The water loss increased with increase in osmosis time, temperature, and concentration in Poovan (AAB). However, the increased in water loss with respect to thickness was marginal.

Similar to water loss, the rate of solid uptake was higher during the initial stages of osmosis. This is in agreement with the results obtained by Conway *et al.* (1983) for apples. Changes in solid gain might be because of the higher concentration difference between solids in fruits and syrup at higher syrup concentrations. Besides, temperature also influenced solid gain. Collapse of the cell membrane resulted at 75^{o}C. The semi permeable nature of the membrane was affected which allowed more amount of solids to get penetrated into the fruit. Similar to Poovan (AAB), the solute gain in Dwarf Cavendish (AAA) increased with increase in osmosis time, temperature and concentration. Unlike water loss, the solute gain in Dwarf Cavendish (AAA) was influenced by the thickness and had inverse relationship. It could be observed that the water loss and gain were higher for Dwarf Cavendish (AAA) than Poovan (AAB) (Table 2). This might be due to the lower initial total soluble solids content of Dwarf Cavendish, and was in agreement with the results obtained by Dalla-Rosa *et al.* (1982).

The optimum values for maximum water loss with minimum solid intake for Poovan (AAB) and Dwarf Cavendish (AAA) were at slice thickness of 5 mm and osmosis in 60 ^{o}Brix sugar syrup at 50 ^{o}C for 5 h. Similar results were obtained by Bongirwar and Sreenivasan (1977). The moisture content of the slices decreased during osmosis. The moisture content in 5 mm thick Poovan and Dwarf Cavendish was reduced to as low as 0.310 and 0.383 kg H_2O kg^{-1} DM from an initial value of 2.03 and 2.84 kg H_2O kg^{-1} DM, respectively. Maximum moisture reduction occurred in slices with minimum thickness and treated at higher temperatures (Table 3).

Studies conducted on osmotic dehydration of banana using sugar syrup revealed that the moisture loss and solid gain during osmotic dehydration of banana slices are influenced positively by the temperature and concentration of sugar syrup. The maximum water loss was found to occur in slices treated with 60^{o}B syrup, at all the temperatures. The results also suggest that for bananas osmotic dehydration, temperature is an important variable. Due to the soft texture of bananas, osmotic treatment of bananas needs not to be done at extreme conditions of temperature and concentration. Results also suggest that a product for further drying could be obtained by treating the slices at temperatures not more than 50 ^{o}C and using osmotic syrup at 60 ^{o}Brix for 5 h.

Table 3. Moisture content (kg H_2O kg^{-1} DM) in Dwarf Cavendish during osmosis at different interval

Thickness (mm)	Osmosis temperature (^{o}C)	Syrup concentration (^{o}B)	Poovan					Dwarf Cavendish				
			1	2	3	4	5	1	2	3	4	5
5	RT	40	1.599	1.317	1.166	1.025	0.932	2.216	1.693	1.410	1.189	1.018
		50	1.525	1.210	1.010	0.855	0.731	1.984	1.456	1.179	0.920	0.777
		60	1.459	1.079	0.825	0.648	0.551	1.869	1.329	0.954	0.740	0.609
	50	40	1.527	1.211	1.002	0.850	0.774	2.035	1.583	1.282	1.064	0.914
		50	1.376	0.489	0.761	0.577	0.505	1.880	1.346	1.019	0.827	0.697
		60	1.341	0.900	0.621	0.455	0.350	1.741	1.174	0.856	0.632	0.531
	75	40	1.380	1.035	0.825	0.691	0.605	1.913	1.361	1.024	0.852	0.726
		50	1.291	0.855	0.618	0.455	0.390	1.769	1.230	0.848	0.660	0.571
		60	1.272	0.836	0.573	0.423	0.310	1.706	1.060	0.706	0.519	0.383
7.5	RT	40	1.643	1.377	1.208	1.103	1.026	2.205	1.777	1.547	1.392	1.282
		50	1.575	1.300	1.110	0.958	0.870	2.073	1.610	1.361	1.190	1.066
		60	1.504	1.178	0.981	0.815	0.694	1.970	1.443	1.135	0.942	0.814
	50	40	1.556	1.240	1.058	0.948	0.865	2.111	1.655	1.414	1.250	1.142
		50	1.500	1.207	0.979	0.870	0.789	2.005	1.551	1.218	1.022	0.904
		60	1.467	1.123	0.900	0.745	0.625	1.882	1.330	0.946	0.751	0.682
	75	40	1.470	1.125	0.924	0.794	0.745	2.001	1.536	1.290	1.126	1.038
		50	1.381	0.998	0.772	0.629	0.581	1.890	1.400	1.122	0.919	0.855
		60	1.313	0.944	0.746	0.609	0.541	1.782	1.261	0.931	0.700	0.613
10	RT	40	1.687	1.448	1.294	1.203	1.131	2.280	1.940	1.713	1.587	1.496
		50	1.594	1.309	1.144	1.038	0.924	2.183	1.808	1.573	1.444	1.288
		60	1.528	1.224	1.015	0.853	0.738	2.073	1.504	1.321	1.139	1.049
	50	40	1.589	1.305	1.150	1.028	0.955	2.183	1.772	1.552	1.392	1.301
		50	1.513	1.197	1.031	0.899	0.814	2.049	1.586	1.330	1.118	1.006
		60	1.475	1.160	0.908	0.781	0.691	1.943	1.442	1.119	0.931	0.850
	75	40	1.485	1.231	1.035	0.914	0.850	2.057	1.647	1.411	1.240	1.172
		50	1.421	1.096	0.883	0.758	0.655	1.950	1.490	1.202	1.041	0.963
		60	1.338	0.979	0.776	0.643	0.574	1.850	1.347	1.072	0.903	0.798

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