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ORIGINAL ARTICLE

Preparation of osmotic dehydrated ripe banana slices

Chavan U. D. · Prabhukhanolkar A. E. · Pawar V. D.

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Abstract Process for preparation of ripe banana slices using osmotic dehydration was standardized. Fully ripe banana fruits were peeled and slices of 8 mm thickness were prepared. The slices were divided into 5 lots and pretreated with sulphur fumigation @ 2 g/kg of slices for 2 h then each lot was soaked in 60 ^{0}Brix sugar syrup containing 0.1% KMS + 0.1 % citrate, 0.1% KMS + 0.1% citrate + 0.2%, 0.4% and 0.8% ascorbic acid and control respectively. After 16 h soaking, quick washing, blotting and then cabinet drying at 55 ^{0}C for 10 h up to 18% moisture content was done. The dried products were packed in 200 gauge polypropylene bags and stored at ambient condition for 6 months. The chemical, microbial and organoleptic changes were monitored for 6 months. The osmo-dried banana slices prepared with sulphur fumigation @ 2 g /kg slices for 2 h followed by soaking in 60°Brix sugar syrup containing 0.1% KMS + 0.1% citrate + 0.2% ascorbic acid were found better with respect to colour and appearance, flavour, texture, taste and overall acceptability with non-stickiness of the product. Storage study showed that there was marginal decrease in moisture content and organoleptic quality and increase in TSS, total sugars and reducing sugars content of osmo-dried banana slices. The products were found microbiologically safe and sensorily acceptable up to 6 months storage at ambient condition.

Keywords Banana slices · Sulphur fumigation · Osmotic dehydration · Sensory quality · Storage study

Chavan U. D. · Prabhukhanolkar A. E. · Pawar V. D.
Department of Food Science and Technology,
Mahatma Phule Krishi Vidyapeeth,
Rahuri - 413 722, India

Chavan U. D. (✉)
E-mail: uttamchavan08@gmail.com

Introduction

The banana (*Musa paradisica* L.) belonging to family *Musaceae* is an important fruit of the world, especially of the tropics. In India it is cultivated in 0.482 M ha area with production of 16.167 MMT and productivity of 33.5 MT/ha (Anonymous 2007). However India's share in the global market is less than 1%, indicating a vast potential to emerge as a major exporter of banana (Phuke et al. 2005). Moreover, post harvest losses of banana are estimated to be more than 25% (Srivastav and Sanjeev Kumar 2002). Though India is second largest producer of banana, processing of banana is less than 2%. As banana is available throughout the year in tropical countries like India, there is a vast potential to utilize for processing (Srivastav and Sanjeev Kumar 2002). It could be processed into different products like powder, chips, wine and fig etc. Drying and dehydration are the most important methods that are widely practiced for fruits and vegetables because of considerable saving in packaging and storage.

Osmotic dehydration has received greater attention in recent years as an effective method for fruits and vegetables preservation. Being a simple process, it facilitates processing of tropical fruits like banana, sapota, mango, pineapple etc, with retention of their initial fruit characteristics viz. colour, aroma and nutritional compounds. Osmotic dehydration is a process of water removal from fruits, because cell membrane is semi-permeable and allows water to pass through them more rapidly than sugar. The driving force for water removal is the concentration gradient between the solution and intracellular fluid. Osmotic parameters like sugar gain and water loss are correlated with osmosis time. It involves the dehydration of fruit slices in two stages, removal of water using sugar syrup as osmotic agent and subsequent dehydration in the air drier where moisture content is further reduced to about 15% to make the product shelf stable. The quality of osmotically dehydrated product is near to fresh fruit in terms of colour, flavour and texture. Ponting et al. (1966)

first studied the osmotic dehydration process and influence of its process variables such as pre-treatments, temperature of solution and additives on the mass transfer in osmotic dehydration of various fruits and reported 50% reduction in weight in apples, using sugar solution of 60–70°Brix. The process resulted in superior quality product and there was no need of SO_2 treatment to prevent loss of flavour. Bolin et al. (1983) reported that osmotic syrups could be re-concentrated and reused for osmotic water removal through at least five complete cycles without adversely affecting the quality of product. Gurumeenakshi et al. (2005) reported the osmotic concentration process for mango and papaya slices in sugar syrup of 60°Brix for 18 h and packed in metalized polypropylene covers for storage up to 6 months. There were little changes in chemical, physical and sensory properties and consumer acceptability was high during storage period. Madan and Dhawan (2005) prepared osmo-dried carrot slices by soaking in sugar syrup (65°Brix) for 3 h and drying at 60°C for 15 h and reported higher retention of carotene than the slices, which were air dried without osmosis. Rashmi et al. (2005) studied on osmo air dehydration of pineapple fruits in 70°Brix sugar syrup and reported removal of significant amount of moisture. Sachadev et al. (2007) studied the osmotic dehydration of apple slices by using 50 and 70^0Brix osmotic solution and KMS and blanching as pretreatments and reported that samples treated with KMS for 15 min with 50°Brix osmotic syrup found to be better for the retention of fruit colour, appearance and taste. Dhingra et al. (2008) reviewed that osmotic dehydration of fruits and vegetable has the potential to extend their shelf life. The products obtained by osmotic dehydration are more stable during storage due to low water activity imparted by solute gain and water loss. Osmotic dehydration, preceding the air-drying preserves fruits and vegetables from undesirable colour changes and increases the retention of flavour during drying. In this context, very limited research has been carried out on osmotic dehydration of ripe banana slices. The objective of present study was to develop the technology of production of osmo-dried ripe banana slices and to study their shelf life so as to make the banana available round the year.

Materials and Methods

Banana (*Musa paradisica*) (cv. 'Grand Naine') fruits of good quality and well matured and ready for ripening were procured from the local farmers banana garden and were allowed to ripe under natural conditions. Fully ripe, yellowish coloured banana were used for preparing osmo-dried banana slices. Preliminary trails were conducted to optimize the osmotic dehydration conditions with respect to pretreatments with or without sulphur fumigation as detailed below.

Osmotic dehydration of banana slices was conducted based on standardized conditions of preliminary trials viz. using 8 mm thickness of banana slices, then subjecting with or without sulphuring @ 2 g/kg of slices for 2 h followed by immersing in 60°Brix sugar syrup containing 0.1% potassium meta-bisulphate (KMS), 0.1% citrate (T_1) and 0.2% (T_2), 0.4% (T_3) and 0.8% (T_4) ascorbic acid at (1:2 w/v) ratio of fruit slices to syrup for 16 h. The slices without sulphuring and no syruping were treated as control (T_0). The slices were dried in cabinet drier at 55°C for 10 h and tested sensorily for most desirable and acceptable finished product and storage study.

Packaging and storage: The osmo-dehydrated and dried banana slices were immediately packed in polypropylene bags (200 gauge) and stored under ambient condition (27 ± 2^0C) for 6 months. One bag of each sample was analysed at the end of each month.

Rate of mass transfer: To predict water loss (WL) and sugar gain (SG) during osmotic concentration, the phenomenon of mass transfer was studied. The weight reduction (WR) and sugar gain (SG) percentages were calculated as per the method of Sharma et al. (2004). The water loss percentage was calculated by summing WR+SG.

Sensory and chemical analysis: Banana slices were evaluated for sensory colour and appearance, flavour, texture, taste and overall acceptability on a 10-point Hedonic scale by a semi-trained panel of 10 members as per the method of Amerine et al. (1965). Moisture and TSS, reducing sugars and total sugars and ascorbic acid contents were determined as reported by Ranganna (1986).

Microbial safety: Microbial assessment was done by colony forming units (cfu) of banana slices with pour plate techniques by using nutrient agar (NA) and potato dextrose agar as media for bacteria and fungi, respectively (Harrigan and Mccance 1966, speck 1976).

Statistical analysis: All the results in triplicate were analyzed for confidence limits using factorial complete randomized design as per the method of Panse and Sukhatme (1967).

Results and discussion

Mass transfer: Weight of slices reduced in all treatments following osmosis (Table 1). The significant ($p < 0.05$) effect of both treatments and duration of osmosis on weight reduction (WR) was observed. The interaction between treatments and duration of osmosis was also significant ($p < 0.05$). The maximum WR were 36.0, 36.1, 36.1 and 35.8% in treatment T_1, T_2, T_3 and T_4 respectively. There was also a significant ($p < 0.05$) effect of treatments and duration of osmosis on SG by osmo-dried banana slices. Maximum SG was 13.1, 13.1, 13.0 and 13.0% respectively for treatments T_1, T_2, T_3 and T_4. The interaction between treatment and time of osmosis was also significant. The maximum (WL) was 49.1, 49.3, 49.2 and 48.7% in treatment T, T_2, T_3 and T_4 respectively. There was a significant ($p < 0.05$) effect of treatments and time of osmosis and also of interaction between two on WL. It was observed, in general, that weight reduction, sugar gain and water loss were increased with increase in contact time up to first 1 h

Table 1 Effect of duration of osmosis and treatments on mean weight reduction (WR), sugar gain (SG) and water loss (WL) by banana slices during osmotic process

Duration of osmosis(O), h	Treatments (T)				
	T_1	T_2	T_3	T_4	Mean
			Weight reduction, %		
2	10.8	10.9	10.9	10.8	10.8
4	17.1	17.3	17.1	17.3	17.2
6	21.8	21.9	21.9	21.9	21.8
8	25.9	26.0	26.0	26.0	25.9
10	28.4	28.5	28.5	28.4	28.4
12	33.5	33.6	33.6	33.3	33.5
14	35.4	35.5	35.5	35.3	35.4
16	36.0	36.1	36.1	35.8	36.0
Mean	26.1	26.2	26.2	26.0	
SE± for			T = 0.005 O = 0.008 T × O = 0.015		
CD at 5% for			T = 0.014 O = 0.021 T × O = 0.042		
			Sugar gain, %		
2	3.8	3.9	3.9	3.9	3.9
4	6.1	6.1	.6.1	6.1	6.1
6	7.7	7.8	7.8	7.8	7.8
8	10.1	10.2	10.2	10.2	10.2
10	10.2	10.2	10.2	10.2	10.2
12	12.0	12.0	12.1	12.0	12.0
14	12.8	12.8	12.8	12.8	12.8
16	13.1	13.1	13.0	13.0	13.0
Mean	9.5	9.5	9.5	9.5	
SE± for			T = 0.005 O = 0.008 T × O = 0.015		
CD at 5% for			T = 0.014 O = 0.021 T × O = 0.042		
			Water losses, %		
2	14.6	14.7	14.7	14.6	94.6
4	23.2	23.4	23.2	21.1	22.7
6	29.5	29.7	29.7	29.7	29.6
8	35.9	36.2	36.2	36.2	36.1
10	38.5	38.7	38.7	38.6	38.6
12	45.5	45.7	45.6	45.2	45.5
14	48.1	48.3	48.3	48.0	48.1
16	49.1	49.3	49.2	48.7	49.0
Mean	31.8	29.4	32.5	32.2	
SE± for			T = 0.006 O = 0.009 T × O = 0.019		
CD at 5% for			T = 0.018 O = 0.027 T × O = 0.054		

T_1-T_4 : As in text

of osmosis in nearly all treatments and thereafter the values increased with decreasing rate and approached to equilibrium with length of contact. Similar results were reported by Panda et al. (2005) for osmo-dried grapes and Jain et al. (2004) for osmo connective drying of papaya.

Sensory quality: Banana slices prepared after sulphur fumigation (2 g/kg for 2 h) and soaking in 60ºBrix sugar solution for 16 h (T_1) resulted into highest score for all the sensory attributes like colour and appearance, flavour, texture, taste and overall acceptability (Table 2). Gurumeen-

Table 2 Sensory quality of osmo-dried banana slices during storage

Treatments (T)	Storage (S) period, days							Mean
	Initial	30	60	90	120	150	180	
				Colour and appearance				
T_0	7.0	6.9	6.9	6.6	6.2	6.0	5.6	9.1
T_1	9.2	9.2	9.2	9.2	9.1	9.0	9.0	9.2
T_2	9.2	9.2	9.2	9.2	9.2	9.2	9.1	9.1
T_3	9.2	9.2	9.2	9.2	9.2	9.1	9.0	9.1
T_4	9.2	9.2	9.2	9.2	9.1	9.0	9.0	8.6
Mean	8.8	8.7	8.7	8.7	8.6	8.5	8.3	-
				Flavour				
T_0	6.3	6.2	5.8	5.2	5.1	4.8	4.7	5.4
T_1	8.4	8.4	8.4	8.4	8.4	8.4	8.3	8.4
T_2	9.1	9.0	9.0	9.0	9.0	8.9	8.9	9.0
T_3	9.0	8.9	8.9	9.0	8.9	8.9	8.9	9.0
T_4	8.4	8.4	8.4	8.4	8.3	8.3	8.2	8.4
Mean	8.2	8.2	8.1	8.0	7.9	7.7	7.8	-
				Texture				
T_0	8.0	8.0	8.0	8.0	7.3	7.0	5.2	7.3
T_1	8.4	8.4	8.3	8.2	8.2	8.2	8.2	8.2
T_2	8.4	8.4	8.4	8.4	8.4	8.4	8.3	8.4
T_3	8.4	8.4	8.3	8.3	8.2	8.2	8.2	8.2
T_4	8.4	8.4	8.2	8.0	8.0	7.9	7.9	8.1
Mean	8.4	8.4	8.2	8.2	8.0	7.9	7.6	-
				Taste				
T_0	7.3	7.3	7.2	7.0	6.7	5.7	5.5	6.7
T_1	8.3	8.3	8.3	8.0	8.0	8.0	7.9	8.1
T_2	9.0	9.0	9.0	9.0	8.7	8.6	8.6	8.8
T_3	9.0	9.0	9.0	8.5	8.3	8.3	8.2	8.6
T_4	8.1	8.1	8.1	8.0	7.8	8.7	7.5	7.9
Mean	8.3	8.3	8.3	8.1	7.9	7.6	7.5	-
				Overall acceptability				
T_0	7.1	7.1	7.0	6.7	6.4	5.8	5.3	6.5
T_1	8.6	8.6	8.5	8.4	8.4	8.4	8.3	8.5
T_2	8.9	8.9	9.0	8.9	8.8	8.8	8.7	8.9
T_3	8.9	8.9	8.8	8.7	8.7	8.6	8.5	8.6
T_4	8.5	8.5	8.4	8.4	8.3	8.2	8.2	8.4
Mean	8.4	7.0	8.3	8.2	8.1	8.0	7.8	-
SE± for				T = 0.027 S = 0.031 T × S = 0.070				
CD at 5% for				T = 0.075 S = 0.089 T × S = 0.200				

T_1-T_4 : As in text

akshi et al. (2005) also reported gradual decrease in colour and appearance of osmo-dried papaya slices during storage. The reduction in flavour score of slices during storage could be due to hardening of slices because of water loss as well as oxidation of ascorbic acid. However, the sugar syrup might have helped in retention of flavour to some extent. The loss of flavour during storage was also reported in papaya slices (Aruna et al. 2000). Texture was also affected due to storage and it could be due to hardening effect resulting in loss of moisture during storage. The taste score also decreased ($p < 0.05$) and this could be also due to the same effect of hardening and loss of moisture. The decrease

Table 3 Moisture and total soluble solids (TSS) of osmo-dried banana slices during storage

Treatments (T)	Storage(S) period, days							Mean
	Initial	30	60	90	120	150	180	
				Moisture, %				
T_0	18.3	18.3	17.7	17.6	17.6	17.6	17.5	17.8
T_1	18.3	18.2	17.8	17.7	17.7	17.2	17.1	17.7
T_2	18.3	18.2	17.8	17.8	17.7	17.3	17.2	17.8
T_3	18.3	18.2	17.9	17.8	17.8	17.5	17.3	17.8
T_4	18.4	18.2	17.9	17.9	17.8	17.4	17.4	17.9
Mean	18.3	18.2	18.3	17.8	17.8	17.4	17.3	17.8
SE ± for	T = 0.019 S = 0.022 T × S = 0.050							
CD at 5% for	T = 0.053 S = 0.063 T × S = 0.141							
				TSS, %				
T_0	65.0	65.7	66.4	66.4	66.5	66.6	66.6	66.0
T_1	66.7	66.8	68.0	68.1	68.3	68.4	68.5	67.8
T_2	67.0	66.8	68.0	68.2	68.6	69.3	69.4	68.2
T_3	67.0	66.8	68.0	68.7	68.8	69.1	69.5	68.2
T_4	67.0	66.8	68.0	68.6	69.0	69.4	69.6	68.3
Mean	66.5	66.4	67.7	68.0	68.2	68.6	68.7	67.7
SE± for	T = 0.089 S = 0.106 T × S = NS							
CD at 5% for	T = 0.2530 S = 0.299 T × S = NS							

T, S : As in Table 2, NS = Not significant, T_1-T_4 : As in text

Table 4 Reducing sugar, total sugars, ascorbic acid and microbial quality of osmo-dried banana slices during storage

Treatments (T)	Storage(S) period, days							Mean
	Initial	30	60	90	120	150	180	
				Reducing sugars, %				
T_0	10.2	10.3	10.3	10.5	10.6	10.7	11.0	10.5
T_1	10.3	10.4	10.4	10.7	11.1	11.2	11.4	10.8
T_2	10.4	10.4	10.6	10.7	11.3	11.5	11.5	10.9
T_3	11.2	11.2	11.4	11.5	11.6	11.8	11.8	11.5
T_4	11.4	11.4	11.5	11.6	11.8	11.8	11.9	11.6
Mean	10.7	10.7	10.8	11.0	11.3	11.4	11.5	11.1
SE±	T = 0.025 S = 0.029 T × S = 0.66							
CD at 5%	T = 0.070 S = 0.083 T × S = 0.187							
				Total sugars, %				
T_0	61.2	61.5	62.3	62.5	63.3	63.4	63.4	62.5
T_1	63.4	63.3	63.4	64.1	64.4	65.0	65.0	64.1
T_2	63.4	63.4	63.6	64.3	65.7	65.1	65.1	64.4
T_3	63.4	63.5	63.8	64.4	65.1	65.5	65.5	64.5
T_4	63.5	63.5	63.8	64.8	65.6	65.6	65.7	64.6
Mean	63.0	63.0	63.3	64.0	64.8	64.9	64.9	64.0
SE±	T = 0.085 S = 0.101 T × S = NS							
CD at 5%	T = 0.241 S = 0.285 T × S = NS							
				Ascorbic acid, mg/100 g				
T_0	11.1	11.1	10.4	10.4	10.4	10.4	10.3	10.6
T_1	11.1	11.1	10.4	10.3	10.3	10.3	10.9	10.6

Table 4 *(Continued)*

T_2	11.2	11.2	11.0	11.0	10.9	10.9	10.9	11.0
T_3	11.2	11.2	11.0	11.0	11.0	11.0	10.9	11.0
T_4	11.2	11.2	11.0	11.0	11.0	11.0	10.9	11.0
Mean	11.2	11.2	10.8	10.8	10.7	10.7	10.7	10.4
SE±	T = 0.034 S = 0.0406 T × S = 0.090							
CD at 5%	T = 0.096 S = 0.113 T × S = 0.252							
Bacterial count, log cfu/g								
T_0	0	4.4	4.6	4.6	4.8	4.9	4.9	4.7
T_1	0	4.3	4.5	4.6	4.7	4.8	4.9	4.6
T_2	0	4.3	4.5	4.6	4.7	4.8	4.8	4.6
T_3	0	4.3	4.5	4.6	4.7	4.8	4.8	4.6
T_4	0	4.3	4.5	4.6	4.7	4.8	4.8	4.6
Mean	0	4.3	4.5	4.6	4.7	4.8	4.8	4.6
SE±	T = 0.185 S = 0.188 T × S = NS							
CD at 5%	T = 0.668 S = 0.765 T × S = NS							
Fungal count, log cfu/g								
T_0	0	4.3	4.5	4.6	4.7	4.8	4.9	4.6
T_1	0	4.3	4.4	4.6	4.7	4.8	4.8	4.6
T_2	0	4.3	4.4	4.6	4.7	4.8	4.8	4.6
T_3	0	4.3	4.4	4.6	4.7	4.8	4.8	4.6
T_4	0	4.3	4.4	4.6	4.7	4.8	4.8	4.6
Mean	0	4.3	4.4	4.6	4.7	4.8	4.8	4.4
SE±	T = 0.187 S = 0.198 T × S = NS							
CD at 5%	T = 0.651 S = 0.694 T × S = NS							

T, S : As in Table 2, NS = Not significant, T_1-T_4 : As in text

in overall acceptability of osmo-dried banana slices during storage was evident and significant ($p < 0.05$) and could be because of reduction in the score of all sensory parameters of banana slices. Gurumeehakshi et al. (2005) also reported similar results on osmo-dried papaya.

Moisture and TSS: Significant decrease in moisture and concomitant increase in TSS content in all the osmo-dried banana slices during storage was observed (Table 3). The moisture loss could be due to evaporation during storage. Moisture content was 18.3%, which reduced to 17.3%. There was a gradual increase in TSS content in all the samples and this might be due to reduction in moisture content during storage. The TSS content increased from 66.5% to 68.7% at the end of 6 months.

Reducing sugar, total sugars and ascorbic acid: Reducing sugars contents gradually increased which might be due to hydrolysis of total sugars into reducing sugars (Table 4). The effect of treatment, duration of osmosis and their interaction were significant ($p < 0.05$). Sharma et al. (1997) and Palve et al. (2007) reported similar results in osmo-dried apple candy and figs on storage, respectively. As expected, the total sugars content increased ($p < 0.05$). This increase during storage was a mass reduction effect due to loss in moisture content. Treatment, duration of osmosis and their interaction effects were also significant ($p < 0.05$). Similar results were reported by Palve et al. (2007) in osmo-dried figs. The ascorbic acid content decreased gradually during storage in all the samples, possibly due to oxidation of ascorbic acid to dehydro-ascorbic acid during storage. The effect of storage was significant ($p < 0.05$).

The osmo-dried banana slices on storage for 6 months were microbiologically found safe (Table 4), which could probably be because of addition of KMS, citrate, low moisture and high concentration of sugar. The higher TSS and acidity of the product might have also played a role in preservation of the product.

Considering about 20% yield of osmo-dried banana slices, the cost of production of osmo-dried banana slices was nearly Rs 65/kg.

Conclusion

Ripe banana slices could be successfully osmo-dried by using sulphur fumigation @ 2g/kg for 2 h followed by soaking in 60°Brix sugar syrup (1:2 w/v) + 0.1% KMS + 0.1% citrate + 0.2% ascorbic acid with better colour and appearance, flavour, texture, taste and overall acceptability and could be stored for 6 months at ambient condition without any adverse effect on quality.

References

Amerine MA, Pangborn PM, Rosseler EB (1965) Principles of sensory evaluation of food. Academic Press, New York, p 350–480

Anon (2007) National Committee on Plasticutlure Application in Horticulture (http://nepahindia.com/ banana php), Accessed in January 2008

Aruna K, Vimala V, Dhanalaxmi K (2000) Studies on preparation and keeping quality of papaya. Bev Food World 27: 15–20

Bolin HR, Hux Soll, CC, Jackson R (1983) Effect of osmotic agents and concentration on fruit quality. J Food Sci Technol 48:202–205

Dhingra D, Singh J, Patil RT, Uppal DS (2008) Osmotic dehydration of fruits and vegetables. A review. J Food Sci Technol 45: 209–218

Gurumeenakshi G, Manimegalar G, Maragatham S, Jaberaj S (2005) Ascorbic acid and KMS as new food additives for osmo-dried foods. Bev Food World 32:50–51

Harrigan WF, Mccance ME (1966) Laboratory methods in microbiology. Academic Press, London, p 14–16

Jain SK, Murdia LK, Dashora PK (2004) Statistical analysis for mass transport and drying characteristics of osmotically dehydrated papaya cubes followed by air-drying. Bev Food World 12:34–39

Madan S, Dhawan SS (2005) Studies on the development of bottled carrot slices. Bev Food World 32(5):15–19

Palve SS, Chavan UD, Kadam SS (2007) Preparation and storage of dried figs. Bev Food World 34:58–59

Panda PG, Surjeet MK, Grewal RB (2005) Osmo air drying (Cv. Perlette) for raisin preparation. Bev Food World. 32:51–54

Panse VS, Sukhatme PV (1967) Statistical methods for agricultural workers. Indian Council of Agricultural Research, New Delhi, p 347

Phuke KD, Pawar ND and Waghmare PR (2005) Export potential of Indian banana. J Agric Business Food Ind 10:18–22

Ponting JD, Watters GG, Forrey RR, Stangly WL, Jackson R (1966) Osmotic dehydration of fruits. J Food Sci Technol 20: 125–128

Ranganna S (1986) Handbook of analysis and quality control for fruit and vegetable products, 2nd edn, Tata Mc Graw-Hill, New Delhi, India, p 1–30, 594–645

Rashmi HB, Doreyappa Gowda IN, Mukanda GK (2005) Studies on osmo-air dehydration of pineapple fruits. J Food Sci Technol 42:64–67

Sachadev PA, Kaur A, Padda GA (2007) Effect of pretreatments and concentration of osmotic agents on the quality of osmotically dehydrated apple slices. Food Pack 3:12–15

Sharma KD, Kunen R, Kaushal BBL (2004) Mass transfer characteristics of yield and quality of five varieties of osmotically dehydrated apricot. J Food Sci Technol 42:264–275

Sharma S, Dhaliwal YS, Kalia M (1997) Preparation and storage of candied apples. J Food Sci Technol 35:79–82

Speck ML (1976) Compendium of methods for the microbiological examination of foods. Academic Public Health Association, Washington DC

Srivastav RP, Sanjeev Kumar (2002) Fruit and vegetable preservation: Principles and practices. 3rd edn, Army Printing Press, Lucknow, India, p 11–20