RESEARCH ARTICLE

EFFECT OF DRYING METHODS ON ACIDITY AND SUGAR CONTENT OF SAPOTA (*MANILKARA ZAPOTA* L.)

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Abstract: Sapota (*Manilkara zapota* L.) is a tropical fruit found in several parts of India. Once ripe, it needs to be consumed within a couple of days due to the highly perishable nature of this exquisite fruit variety. Drying is effective method to convert this perishable fruit into stabilised dehydrated products that can be stored for an extended period of time. In this study, influence of solar and oven drying on the quality of sapota fruit was investigated. Acidity and non-reducing sugars increased in sapota pieces dried by different methods of drying during storage upto 90 days. Sapota pieces dried in solar dryer had maximum acidity (0.346%). Total and reducing sugars decreased during storage in both methods of drying. Solar dried sapota powder contained maximum total sugars (35.58%) and minimum reducing sugars (26.27%) whereas minimum total sugar (35.52%) and maximum reducing sugar content (28.58%) was recorded in oven dried sapota on all periods of storage. Sapota dried after cutting in 4 parts had maximum acidity, total and reducing sugars in both methods of drying.

Keywords: Sapota, Acidity, Drying methods, Solar, Oven, Sugars

INTRODUCTION

The reduction of losses and maintenance of quality of harvested products prior to consumption are extremely important. Drying is one of the widely used postharvest technologies which overcome problems related to over production, over supplied, postharvest handling and short shelf life. Drying is applied to lower the moisture content of fruit to a level that can prevent the growth of mould and fungi and thus minimize microbial degradation. Vijaya *et al.* (1997) reported that moisture content of sapota was reduced from 76% to 10-15% (wt basis) within 76 hrs by solar drying with time savings of 26.9% over sun drying. Drying can be applied to convert this perishable fruit into stabilised dehydrated products that can be stored for an extended period of time. Selection of drying method depends upon industries and economic factors. Among various drying methods commercially available, open sun drying and solar drying have been exploited to some extent (Pareek & Kaushik, 2012). Ganjyal *et al*. (2003) found that vacuum-oven drying (14 to 31 hrs) of Sapota was better than convection air-oven drying (15 to 35 hrs) at the temperatures tested (55^0C to 70^0C) in terms of drying duration. Sapota fruit (*Manilkara zapota*) is evergreen tree native to Mexico and Tropical America. The ripe fruit is eaten as a dessert fruit but only the pulp is usually consumed, although the skin is richer in nutritive value. Thus, production and commercialization of sapota fruit is rather limited due to the short shelf-life. Furthermore, there is lack of information on the physical and chemical characteristics of the fruit during postharvest storage. The sapota fruit can be processed into powdered form and used as natural flavor in jams, ice creams, and milk shakes. Sapota fruit has a high fiber content and hence the powder can be consumed as a fiber supplement for children as well as adults. Also, sapota fruit contains carotene, which is a known antioxidant and it can be consumed for its laxative property (Ganjyal *et al*., 2005). Thus, sapota powder can be considered as a complete food rich in vitamins, carbohydrates, fibers, and proteins. Thus, it is desired to process sapota to increase the shelf-life. Typically, the process includes controlled atmospheric storage and dehydration. The latter is the most cost effective and a viable method for the removal of a great part of constitutional water. Generally after drying the various metabolic activity of fruit stop or become negligible even then it is essential to find out various biochemical changes during storage of dried fruit to find out keeping quality of the dried fruit. For drying of fruits among the different methods the size of fruit pieces is also helpful to change in drying time and keeping quality. Therefore, the present study was carried out to see the effect of Sapota pieces dried by different methods on biochemical constituents.

MATERIAL AND METHOD

Sapota fruits (Var. Cricket Ball) of half ripe stage were harvested from ten year old trees and cut into quarter fruit (cut exactly into 4 parts along the longitudinal axis), slices of 5 mm and 10 mm thick. Samples were dried in solar and oven till constant weight was obtained. The dried fruit pieces of sapota in each of the drying method were ground in powder by grinding in grinder. The dehydrated sapota powder were sealed in air tight polyethylene with sealing machine and stored at room temperature. The sapota powder prepared by sapota dried by different methods of drying was used for the estimation of acidity and sugars just after drying and then at 15

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days of interval for 90 days. The total titrable acidity content was determined by the standard method (AOAC, 1990). Total sugars and reducing sugars were amount estimated by the method of Paleg (1960). Non-reducing sugars were determined by subtracting the amount of reducing sugar from the total sugars and expressed as percent. Observations were tabulated and statistically analysed.

RESULT AND DISCUSSION

Data presented in Table 1 indicate that acidity content of the sapota powder showed steady increase with increasing period of storage, i.e. 0.298%, 0.312%, 0.324%, 0.341%, 0.354%, 0.356% and 0.382% on 0, 15th, 30th, 45th, 60th, 75th and 90th day of storage, respectively. This increase in acidity content in fruit powder might be due to conversion of sugars (Clydesdale *et al*., 1972) and other substances which might be converted into acids during storage. Increase in acidity content has also been observed in dehydrated Mango pulp (Rao & Roy, 1980), Desi and Banarasi cultivars of Aonla (Ghorai & Sethi, 1996), Dates (Kumar, 1989) and Aonla (Kumari, 2016). Acidity content was higher in powder of sapota fruit dried by solar drying (0.346%) as compared to oven dried (0.334%). This could be attributed to different rate of various physiological processes which might have occurred at different rates in sapota dried by different methods of drying. Results of variations in acidity content in fruit powder prepared by different methods of drying have also been reported by Pareek & Kaushik (2012), Kumari (2016) and Pragati *et al*. (2003) in Aonla. Fruit cut in different sizes and converted into powder also significantly affected the acidity of fruits during storage. The maximum acidity (0.351%) was observed in sapota powder prepared after drying of fruits cut in 4 parts pieces and minimum in sapota powder prepared after drying of fruits cut in 5 mm pieces (0.328%). This might be due to de-esterification of pectin molecules during storage resulting in loss of jelly grade which might have lead to decrease in methoxy content and resulted in increase in acidity content. The maximum acidity (0.401%) was recorded in solar dried sapota powder prepared by drying of 4 parts cut pieces on 90th day of storage. However, minimum acidity was recorded in oven dried sapota powder prepared by drying of fruit cut in 5 mm pieces (0.278%) on initial day (0 day) of storage.

The data revealed that the total sugar content (Table 2) was affected by fruit cut in different sizes and different methods of drying during storage. It decreased from 35.83% which was recorded on 0 day of storage to 35.74% after 15 days, 35.62% after 30 days, 35.54% after 45 days, 35.43% after 60 days, 35.38% after 75 days to 35.30% after 90 days of storage. The decrease in total sugars during storage might be due to the non-specific hydrolysis of macromolecules and inter conversions of sugars (Patter, 1985). These results are in conformity with the previous findings of Ghorai & Sethi (1996) in Desi and Banarasi cultivars of dried Aonla and Kumari (2016) in Chakaiya cultivars of Aonla. Sapota powder dried in solar dryer had more content of total sugar (35.58%) than oven dried sapota powder (35.52%). This might be due to the reason that different drying methods might have affected various physiological processes to different extent. The variation in total sugar by different drying methods is in agreement with an observed by Pragati *et al.* (2003) and Pareek & Kaushik (2012) in aonla. Fruit cut in different sizes and converted into powder also significantly affected the total sugar of fruits during storage. Total sugar content in sapota dried in different sizes, lower total.

Table 1. Effect of Sapota pieces dried by different methods on acidity (%) during storage at room temperature

Drying Methods (M)	Days of storage (D)								
	Fruit Size (S)	0	15	30	45	60	75	90	Mean
Solar dryer	5 mm	0.278	0.291	0.313	0.347	0.351	0.357	0.372	**0.329**
	10 mm	0.303	0.312	0.326	0.351	0.372	0.380	0.385	**0.347**
	4 Parts	0.318	0.320	0.343	0.361	0.383	0.390	0.401	**0.359**
	Mean	**0.301**	**0.308**	**0.327**	**0.353**	**0.369**	**0.376**	**0.386**	**0.346**
Oven dryer	5 mm	0.271	0.314	0.321	0.325	0.331	0.350	0.374	**0.326**
	10 mm	0.305	0.316	0.323	0.331	0.341	0.353	0.379	**0.336**
	4 Parts	0.310	0.321	0.325	0.334	0.347	0.359	0.382	**0.340**
	Mean	**0.295**	**0.317**	**0.323**	**0.330**	**0.339**	**0.354**	**0.378**	**0.334**
Mean		**0.298**	**0.312**	**0.324**	**0.341**	**0.354**	**0.356**	**0.382**	
Mean of fruit parts		**5 mm = 0.328**			**10 mm = 0.341**			**4 Parts = 0.351**	
CD at 5%		**D=0.018**		**M=0.009**		**S=0.012**	**D×M=0.025**	**D×S=0.031**	
		M×S=0.016	**D×M×S=0.044**						

Table 2. Effect of Sapota pieces dried by different methods on total sugars (%) during storage at room temperature

Drying Methods (M)	Days of storage (D)								
	Fruit Size (S)	0	15	30	45	60	75	90	Mean
Solar dryer	5 mm	35.67	35.59	35.34	35.32	35.30	35.26	35.21	**35.38**
	10 mm	35.79	35.71	35.63	35.55	35.41	35.35	35.24	**35.53**
	4 Parts	36.13	36.01	35.93	35.81	35.73	35.68	35.61	**35.84**
	Mean	**35.86**	**35.77**	**35.63**	**35.56**	**35.48**	**35.43**	**35.35**	**35.58**
Oven dryer	5 mm	35.58	35.54	35.43	35.34	35.20	35.11	35.03	**35.32**
	10 mm	35.85	35.75	35.67	35.58	35.47	35.40	35.31	**35.58**
	4 Parts	35.97	35.86	35.74	35.64	35.48	35.49	35.41	**35.66**
	Mean	**35.79**	**35.72**	**35.61**	**35.52**	**35.38**	**35.33**	**35.25**	**35.52**
Mean		**35.83**	**35.74**	**35.62**	**35.54**	**35.43**	**35.38**	**35.30**	
Mean of fruit parts		**5 mm = 35.35**		**10 mm = 35.56**			**4 Parts = 35.75**		
CD at 5%		**D=1.12 M=0.50 S=1.08 D×M=N.S. D×S=N.S. M×S= N.S. D×M×S= N.S.**							

sugar content (35.35%) was observed in sapota powder prepared by drying fruits after cutting in 5 mm pieces and higher content of total sugar content (35.75%) was observed in Sapota powder prepared by drying of fruits cutting in 4 parts pieces. This might be due to the reason that drying might have affected various physiological processes to different extent in different sizes.

Table 3. Effect of Sapota pieces dried by different methods on reducing sugars (%) during storage at room temperature

Drying Mehods (M)	Days of storage (D)								
	Fruit Size (S)	0	15	30	45	60	75	90	Mean
Solar dryer	5 mm	27.56	26.33	25.94	25.77	25.43	25.18	24.98	**25.60**
	10 mm	27.12	26.81	26.56	26.15	25.89	25.67	25.45	**26.24**
	4 Parts	27.96	27.53	27.21	26.94	26.66	26.35	26.19	**26.98**
	Mean	27.21	26.89	26.57	26.28	25.66	25.73	25.54	**26.27**
Oven dryer	5 mm	29.91	28.68	28.41	28.04	27.79	27.53	27.29	**28.24**
	10 mm	29.99	28.71	28.44	28.07	27.88	27.56	27.34	**28.28**
	4 Parts	30.05	29.83	29.41	29.21	28.94	28.68	28.45	**29.23**
	Mean	29.98	29.07	28.75	28.44	28.20	27.92	27.69	**28.58**
Mean		**28.60**	**27.98**	**27.66**	**27.36**	**26.93**	**26.83**	**26.62**	
Mean of fruit parts		**5 mm = 26.92**		**10 mm = 27.26**			**4 Parts = 28.11**		
CD at 5%		**D=1.29 M=1.11 S=1.19 D×M=N.S. D×S=N.S. M×S= 0.26 D×M×S= N.S.**							

Reducing sugar content of Sapota powder during storage has been presented in table 3. Reducing sugar content was maximum in Sapota powder just after drying i.e. 28.60% whereas Sapota powder stored for 90 days had minimum reducing sugar content (26.62%). Decrease in reducing sugars might be due to the dehydration reactions causing sugars to become unsaturated and highly reactive. The hexose reducing sugars might have partially converted to 2-furaldehyde and 5-hydroxymethyl-2-furaldehyde, which might have remained undetected in reducing sugar test (Pragati *et al*,. 2003 and Fennema, 1985). Decrease in reducing sugar content during storage has also been reported by Pragati *et al.* (2003), Pareek & Kaushik (2012) and Mehta (1995) in Aonla. Oven dried sapota powder had maximum (28.58%) reducing sugar content and minimum reducing sugar content was observed in Sapota dried by solar dryer (26.27%) when considered on mean basis irrespective of storage period and fruit sizes. Sapota powder prepared by drying of fruit cut in different sizes also significantly affected the reducing sugar content of fruits during storage. This might be due to the reason that there might have been change in various physiological processes to different extent during drying by different methods. Similar reports of variation in reducing sugars by different methods of drying have been reported by Pragati *et al*. (2003) and Pareek & Kaushik (2012) in Aonla. Ghorai & Sethi (1996) have also reported variation in reducing sugars in dried Aonla of Desi and Banarasi cultivars. Reducing sugar content was lower (26.92%) in sapota powder prepared by drying fruits after cut in 5 mm pieces whereas higher content of reducing sugar content (28.11%) was observed in powder prepared by drying of fruits cut in 4 parts irrespective of

drying methods and storage period. This might be due to the reason that there might have been change in various physiological processes to different extent during drying of pieces in different sizes.

Non-reducing sugar content showed steady decrease during storage in Sapota powder prepared by fruits cut in different sizes and dried by different methods of drying (Table 4). Highest content of non-reducing sugar in Sapota powder was recorded on 0 day of storage i.e. 7.23%. Non-reducing sugar content decreased slightly during storage and minimum non-reducing sugars were recorded after 90 day of storage i.e. 8.69%. This may be due to the reason that during storage, total sugars decreased because of non-specific hydrolysis which might have been converted to non-reducing sugars as a result of which non-reducing sugar content increased. Results of increase in non-reducing sugars during storage in powder are in agreement with finding of Kumari (2016) in Aonla. Among different methods of drying, minimum non-reducing sugars was recorded in the sapota dried in oven dryer (6.43%) whereas maximum non-reducing sugars was observed in solar dried sapota powder (9.26%). This might be due to the reason that there might have been change in various physiological processes to different extent during drying by different methods. Different drying methods affect reducing sugars differentially in aonla during storage has also been observed by Kumari (2016) in aonla. Among fruit sizes, maximum non-reducing sugar content was observed in sapota powder obtained by drying of fruits cut in 5 mm pieces (8.47%) minimum content was observed in sapota powder prepared by drying of fruits cut in 4 parts (7.65%). This might be due to the reason that there might have been change in various rates of physiological processes to different extent during drying of different sizes.

CONCLUSION

Fruits drying is one of the oldest methods that are used to preserve some perishable fruit; in order to ensure their availability all year round, reduce post harvest losses and achieve food security. Sapota fruits dried by solar and oven drying can be stored up to 90 days at room temperature and maintained more content of acidity and total sugar when it was dried in solar dryer after cut in 4 parts. So among both drying techniques, solar drying was most cost effective for drying the fruits after cut in 4 parts than oven drying.

Table 4. Effect of Sapota pieces dried by different methods on non-reducing sugars (%) during storage at room temperature

Drying Methods (M)	Days of storage (D)								
	Fruit Size (S)	0	15	30	45	60	75	90	Mean
Solar dryer	5 mm	9.11	9.26	9.40	9.55	9.87	10.08	10.23	**9.64**
	10 mm	8.67	8.91	9.07	9.42	9.53	9.68	9.79	**9.29**
	4 Parts	8.17	8.48	8.72	8.85	9.07	9.33	9.42	**8.86**
	Mean	**8.65**	**8.88**	**9.06**	**9.27**	**9.49**	**9.70**	**9.81**	**9.26**
Oven dryer	5 mm	5.86	7.04	7.23	7.51	7.59	7.84	7.97	**7.30**
	10 mm	5.67	6.86	7.02	7.30	7.41	7.58	7.74	**7.08**
	4 Parts	5.92	6.03	6.33	6.43	6.54	6.81	6.96	**6.43**
	Mean	**5.81**	**6.65**	**6.86**	**7.08**	**7.18**	**7.41**	**7.56**	**6.94**
Mean		**7.23**	**7.98**	**7.96**	**8.18**	**8.51**	**8.56**	**8.69**	
Mean of fruit parts		**5 mm = 8.47**			**10 mm = 8.19**			**4 Parts = 7.65**	

REFERENCES

AOAC (1990). Official Methods of Analysis. Association of Official Analytical Chemists, Washington, D.C.

Clydesdale, F. M., Lin. Y. D. & Francis, F. J. (1972). Formation of 2-*pyrrolidone*-5-carboxylic acid from glutamine during processing and storage of spinach puree. Journal of Food Science. **37(1):** 45-47.

Fennema, O. R. (1985). Food Chemistry. New York and Basel: Marcel Dekher Inc.

Ganjyal, G. M., Hanna, M. A. & Devadattam, D. S. K. (2003). Processing of zapota (sapodilla): Drying. Journal of Food Science. **68**: 517-520.

Ganjyal, G. M., Hanna, M. A. & Devadattam, D. S. K. (2005). Processing of Sapota (sapodilla): Powdering. Journal of Food Technology. **3(3)**: 326-330.

Ghorai, K. & Sethi, V. (1996). Varietal suitability of Amla (Desi and Banarasi) fruits for storage and preservation. Indian Food Packer. **50(1):** 11-18.

Kumar, S. (1989). Studies on the Processing of Date Palm Fruits (*Phoenix dactylifera* L.). M.Sc. Thesis, CCS HAU, Hisar. India.

Kumar, S. (1989). Studies on the Processing of Date Palm Fruits (*Phoenix dactylifera* L.). M.Sc. Thesis, CCS HAU, Hisar. India.

Kumari, P. (2016). Studies on biochemical and antioxidant changes in aonla (*Emblica officinalis* G.) and its different products during storage. Ph.D Thesis, CCS HAU, Hisar, India.

Mehta, S. (1995). Evaluation of different cultivars of Aonla (*Emblica officinalis* G.) for Processing. M.Sc. Thesis, CCS HAU, Hisar. India.

Paleg, L. G. (1960). Physiological effect of Gibberellic acid on carbohydrates metabolism and amylase activity of barley endosperm. Plant Physiology. **35:** 293-299.

Pareek, S. & Kaushik, R. A. (2012). Effect of drying methods on quality of Indian gooseberry (*Emblica officinalis* Gaertn) powder during storage. Journal of Scientific and Industrial Research. **71:** 727-732.

Patter, H. E. (1985). Evaluation of quality of fruits and vegetables. AVI Publishing Company Westport, CT.

Pragati, Dahiya, S. & Dhawan, S. S. (2003). Effect of drying methods on nutritional composition of dehydrated aonla fruit (*Emblica officinalis* Gaertn) during storage. Plant Foods for Human Nutrition. **58:** 1-9.

Rao, V. S. & Roy, S. K. (1980). Studies on dehydration of Mango pulp: Standardization for making Mango sheetleather. Indian Food Packer. **34:** 72.

Vijaya, K., Pucho, V. & Gurbai, S. C. (1997). Evaluation of solar dryer for horticultural produce (B.Tech. Thesis). C.A.E. Raichur College Library.