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Quality of solar tunnel dried amla segments

U. Priyanka and A. Carolinrathinakumari

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See end of the Paper for authors' affiliation

Correspondence to :

U. Priyanka
University of Agricultural Sciences Bangalore, GKVK, **Bangalore (Karnataka) India**
Email: priyapreksha@gmail.com

■ **ABSTRACT :** In this study, Amla segments dried in different drying methods like sun drying and solar tunnel drying and with different pre-treatments like 2 per cent Sodium Chloride and 0.1 per cent Potassium metabisulphite solutions. The treated samples significantly showed variations in some quality parameter of amla segments. The samples dried in solar tunnel dryer gave lower moisture content compared with that of sun dried samples. The lowest water activity were found to be in 2 per cent Sodium Chloride pre-treated amla segments dried in solar tunnel drying. Solar drying of pre-treated amla segments in solar tunnel dryer resulted in 20-30 per cent reduction in drying time as compared to open-air sun drying. The highest rehydration ratio was found to be in 0.1 per cent Potassium metabisulphite treated amla samples. The quality of rehydrated amla segments dried in solar tunnel dryer was superior when compared to amla segments dried in open sun drying method. The highest vitamin C retention was found to be 125.68 (mg/100 g) in untreated amla samples dried in solar tunnel dryer. The quality of rehydrated amla segments dried in solar tunnel dryer was superior when compared to amla segments dried in open sun drying method. The problem of interruption by rain and cloudy period was solved. The samples dried in the solar tunnel dryer were completely protected from rain, insectsand contamination by dust and were of good quality dried product.

■ **KEY WORDS :** Solar tunnel dryer, Drying, Moisture content, Amla segments, Quality

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Amla (*Phyllanthus emblica* L.) is known as the Indian Gooseberry, aonla or amalki in different parts of India. It is grown in almost all parts of the country. A fully grown amla tree with good bearing habit yields from 187 to 299 kg fruit per year. Amla fruit is highly nutritive with a great medicinal use the richest source of vitamin 'C' among fruits. Amla fruits are highly perishable in nature as its storage in atmospheric conditions after harvesting is very limited *i.e.,* October to January. By applying several techniques at the time of processing (which can be done during peak production of amla fruits) can make available throughout the year in different forms such as jams, jellies, candies and this can enhance the interest among consumers. Indian gooseberry is a seasonal fruit thus, various preservation techniques have been developed such as freezing, pickling with salt, oil spices drying. Among the processes, dehydration offers many advantages, such as reduced weight, inexpensive packaging, dry shelf stability and negligible deterioration in quality due to enzymatic changes. Drying of Indian gooseberry as a whole is difficult hence before drying, the stone is removed and the pulp is cut into small pieces or slices. It is either dried under open sun or in suitable mechanical/solar dryer.

There are various drying methods available, open-sun drying is the most common preservation practice followed where solar radiation is high. The climatic adversities, contamination by insects and dust which constitutes a loss of quality of the dried product and need of a lot of manpower are the important reasons for shifting from open sun drying to controlled drier. Though electrical/ fuel fired dryers help the farmers in drying their products at a relatively faster rate, they are not popular among the poor farmers of most developing countries. Reasons are the higher initial cost of the dryers. Moreover, electricity, though costly, is not available in the rural areas uninterrupted. Use of solar dryer is the solution in this situation. Keeping the above points in view, the present study was taken up to dehydrate amla segments in solar tunnel dryer and analyze the quality attributes to compare with that of products obtained by sun drying.

■ METHODOLOGY

Studies on drying of amla segments were conducted at Indian Institute of Horticultural Research, Karnataka to determine the effect of pre-treatment and solar drying method on the quality of dry amla segments. Freshly harvested well matured, hard, greenish- yellow fruit free from physical damage and disease were procured from local market of Bengaluru district in Karnataka state. The raw materials were then thoroughly cleaned to remove any dirt or dust particles attached to the surface. The cleaned amla was divided into three lots. The first lot of amla selected for dehydration without treatment was flaked using sharp stainless steel knife and weighed into plastic trays holding 350 g of amla. Two lots were kept for pre-treatment with the selected chemicals. The second lot was weighed and blanched with 2 % sodium chloride solution in a stainless steel utensil for 8 minutes and then it is subsequently cooled in normal cold water for 3 minutes and segments were removed and stones were separated. Then the segments were equally divided and weighed in trays each holding 350 grams of amla. The third lot was weighed and water blanched in stainless steel utensils followed by cooling in normal cold water for 3 minutes to soften amla segments and remove seeds. The amla segments were soaked in 0.1 % potassium meta-bi-sulphite solution for 3 minutes. Then it is equally divided and weighed in trays each holding 350 grams of amla. The amla segments were dehydrated in solar tunnel dryer and in open sun.

The drying was performed by two methods *viz.*, open sun drying and in solar tunnel dryer of size 6×3 m raised on concrete floor with the hoop structure covered with UV-stabilized transparent polyethylene sheet to form the drying chamber to a height 3.3 m, with two fresh air inlets, each of 0.6 m x 0.3 m installed at the rear side of the dryer and at 0.15 m height from the ground level for entry of fresh air and two each of 50 watt axial flow exhaust fans fitted (9" diameter) at the front side of the dryer at 2 m height from the ground level, for easy escape of moisture ladden air from the dryer, for obtaining higher drying rate.

The quality parameters of dried amla segments were determined using standard methods. The moisture content of the fresh and dehydrated amla segments was determined by hot air oven method (AOAC, 2005). The water activity of fresh and dehydrated amla segments was measured by Rotronic Hygrolab 3 water activity analyser (Model: a_w-HP23). Before measuring the water activity, the instrument was calibrated for its accuracy by measuring the water activity of distilled water. Rehydration quality characteristic is one of the important characteristics of dehydrated product and was determined by rehydration test as described by Ranganna (2000). Vitamin C content was estimated by volumetric method as described by Ranganna (2000).All the experiments in the study were conducted in triplicate and mean values reported. Factorial Completely Randomised Design (FCRD) was used to analyse the data. After proper analysis, data were accommodated in the tables as per the needs of objectives for interpretation of results. The Microsoft Excel was used for analysis and interpretation. Analyses of variance (ANOVA) were conducted to determine whether significant effect exists on type of drying methods and pre-treatments on the quality of dehydrated amla segments.

■ RESULTS AND DISCUSSION

The moisture content of fresh amla (untreated), NaCl blanched and KMS soaked sample was found to be 82.42, 89.37 and 87.17 per cent (w.b), respectively. The quality parameters *viz.*, moisture content, water activity, rehydration characteristics and vitamin C content of dehydrated amla for different drying methods and pre-treatments were determined.

Effect of different pre-treatments and drying methods on moisture content (% d.b.) of dehydrated amla segments:

The moisture content of fresh amla was found to be 82.42% (w.b.).The moisture content of amla dried under different drying methods and pre-treatments are presented in Table 1. From the Table it was observed that in open yard sun drying, the moisture content % (d.b.) of amla varied from 17.23 to 17.61 per cent (d.b), among the different pre-treatments. Similarly in solar tunnel drying, the moisture content % (d.b.) of amla varied from 16.98 to 17.18 per cent (d.b), among the different pre-treatments. The effect of drying method and pretreatments and their interaction were found to be non-significant. The data indicated that in solar tunnel drying, untreated control amla samples had lowest moisture content value of 16.98% (d.b.) compared with all other treatments. In open yard sun drying, samples pre-treated with 2 per cent NaCl gave the highest moisture content of 17.6 per cent for amla. Considering solar tunnel drying, control samples gave lower moisture content compared with all other treatments. Blanching treatment reduced the final moisture content to some extent. This might be due to the reason that brining causes softening of the tissue structure thereby releasing slightly more moisture than the untreated samples reported by Mitra *et al*. (2011).

Effect of different pre-treatments and drying methods on water activity (a_w) of dehydrated amla segments:

The water activity of fresh amla was 0.87. The effect of different drying method and pre-treatment on water activity (a_w) values of dehydrated amla is presented in Table 2. From the Table it was observed that in open yard sun drying, the water activity (a_w) values of amla varied from 0.60 to 0.65 among the different pre-treatments. Similarly in solar tunnel drying, water activity (a_w) values of amla varied from 0.59 to 0.60 among the different pre-treatments. From the ANOVA, it is observed that the effect of single factors namely drying methods and pre-treatments were significant at one per cent level. The interaction effect of two the factors were also significant at one per cent level. The variation in water activity might be due to varietal difference of amla. Since the initial moisture content of fresh amla was more, the presence of available moisture is sufficient to grow micro-organisms. All treated samples

Table 1 : Moisture content (%d.b.) of dehydrated amla segments obtained from different drying methods and pre-treatments

Drying method	Moisture content % (d.b)			
	Pre-Treatments			
	P_1	P_2	P_3	Mean
OYSD	17.23	17.61	17.51	17.45
STD	16.98	17.16	17.18	17.11
Mean	17.10	17.39	17.35	
Source of Variation	F-Value	S.E.±	C.D. (P=0.05)	
Methods (M)	NS	0.10	-	
Pre-treatments (P)	NS	0.10	-	
Interaction (M x P)	NS	0.18	-	

NS– Non-significant; *– Significant; **– Highly significant, P_1- Untreated flaked, P_2- 2 % NaCl treated, P_3-0.1 % KMS treated

Table 2 : Water activity of dehydrated amla segments obtained from different drying methods and pre-treatment

Drying method	Water activity			
	Pre-Treatments			
	P_1	P_2	P_3	Mean
OYSD	0.65	0.60	0.60	0.62
STD	0.60	0.59	0.59	0.59
Mean	0.63	0.60	0.6	
Source of Variation	F-Value	S.E.±	C.D. (P=0.05)	
Methods (M)	**	0.00025	0.00075	
Pre-treatments (P)	**	0.00025	0.00092	
Interaction (M x P)	**	0.00043	0.00013	

NS– Non-significant; *– Significant; **– Highly significant, P_1- untreated flaked, P_2- 2 % NaCl treated, P_3-0.1 % KMS treated were dried up to safe moisture content so that there was not much difference in the combined effect. It was observed from the results that, in open yard sun drying, control amla segments had higher water activity value of 0.65 compared with all other treatments, followed by solar tunnel dried, pre-treated with 0.1 per cent KMS and 2 per cent NaCl with values of 0.609 and 0.606, respectively. The data indicated that solar tunnel dried samples, pre-treated with 2 per cent NaCl had lowest water activity value of 0.594, hence the shelf-life of the product was also more. The 0.1 per cent KMS pre-treatment gave good quality product among all other pretreatments. Reid and Fennema (2008) reported that the final powder of the Indian gooseberry had the water activity in the range of 0.331-0.337 at every inlet drying temperature, which was considered microbiologically stable.

Effect of different pre-treatments and drying methods on rehydration ratio of dehydrated amla segments:

The effect of different drying method and pre-treatment on rehydration ratio of dehydrated amla segments is presented in Table 3. From the Table it was observed that in open yard sun drying, the rehydration ratio of amla varied from 1.59-1.73 among the different pre-treatments. Similarly in solar tunnel drying, the rehydration ratio amla varied from 1.68-1.88 among the different pre-treatments. From the ANOVA, it was observed the effects of single factors namely drying methods and pre-treatments were significant at one per cent level for amla.

It was revealed from the results that, the solar tunnel dried, pretreated with 0.1 per cent KMS had higher rehydration ratio of 1.88 followed by tunnel dried samples, pretreated with 2 per cent NaCl and control samples as 1.76 and 1.68, respectively. The data indicated that open yard sun drying, pre-treated with 2% NaCl amla samples had lowest rehydration ratio of 1.68 compared with all other treatments because during rehydration, the absorbed salt might have been dissolved in water, which decreased the weight of the sample and hence reduced the rehydration ratio (Sutar and Prasad, 2011). This variation might be due to an increase in the proportion of ruptured and shrunken cells caused by pre-treatment which in turn reduced the ability of dried tissues to absorb water. As temperature increased, the rehydration ratio increased slightly resulting in a proportional increase in the rehydration efficiency.

Ascorbic acid:

The vitamin C content was found to be 431.25, 350 and 225 (mg/100g) for fresh flaked amla, 2 % NaCl treated and 0.1 % KMS treated amla samples, respectively. The vitamin C content was found to be more (431.25 mg/100g) in fresh amla as compared to pretreated amla samples. These results were in confirmation with those reported by Verma and Gupta (2004) who reported that the vitamin C content of fresh amla was more compared to treated amla samples. The varietal differences in various values of vitamin C are known to be extremely sensitive to temperature and climatic changes which was reported by Mota *et al.* (2010).

The effect of different different drying method and pre-treatment on Ascorbic acid content of dehydrated amla segments is presented in Table 3. From the Table, it is noticed that there was effect of different pre-treatments under STD and OYSD on the ascorbic acid content of amla. The amla dried under STD had higher

Table 3: Rehydration ratio of dehydrated amla segments obtained from different drying methods and pre-treatments

Drying method	Rehydration ratio			
	Pre-Treatments			
	P_1	P_2	P_3	Mean
OYSD	1.59	1.68	1.73	1.67
STD	1.68	1.76	1.88	1.77
Mean	1.63	1.72	1.81	
Source of variation	F-Value	S.E.±	C.D. (P=0.05)	
Methods (M)	**	0.0019	0.0057	
Pre-treatments (P)	**	0.0019	0.0070	
Interaction (M x P)	*	0.0033	0.01	

NS– Non-significant; *– Significant; **– Highly significant, P_1- untreated flaked, P_2- 2 % NaCl treated, P_3-0.1 % KMS treated

Table 4 : Ascorbic acid content of dehydrated amla segments obtained from different drying methods and pre-treatments

Drying method	Ascorbic acid (mg /100g)			
	Pre-Treatments			
	P_1	P_2	P_3	Mean
OYSD	114.02	53.55	109.03	92.20
STD	125.68	83.33	109.95	106.32
Mean	119.85	68.44	109.49	
Source of Variation	F-value	S.E.±	C.D. (P=0.05)	
Methods (M)	**	0.88	2.61	
Pre-treatments (P)	**	0.88	3.20	
Interaction (M x P)	*	1.52	4.53	

NS– Non-significant; *– Significant; **– Highly significant, P_1- untreated flaked, P_2- 2 % NaCl treated, P_3-0.1 % KMS treated

ascorbic acid content compared to OYSD and the results varied significantly. The highest ascorbic acid content was observed in control samples (125.68 mg/100g) followed by KMS treatment (109.956 mg/100g), and the lowest in NaCl treatment (83.33 mg/100g).

The ascorbic acid content of fresh amla samples was 431.25 mg/100g. The observed data on untreated amla segments (125.68 mg/100g) was high and was on par with control (114.02 mg/100g) dried under OYSD which significantly differed over KMS (109.03 mg/100g) and NaCl (53.55 mg/100g) dried under OYSD. This clearly shows that the sample dried under STD was found to have better retention of ascorbic acid content as compared with OYSD. Untreated flaked samples were found to have the highest concentrations of ascorbic acid. According to the revised guidelines by the Food and Nutrition Board of National Academy of Sciences, the recommended dietary allowance (RDA) of vitamin C has been proposed to be 120 mg per day.Similar results were also found by Mota *et al*. (2010) who reported that the vitamin C content decreased from 137 to 89 mg/100 g in dry solids, because vitamin C content is known to be extremely sensitive to temperature. The loss in vitamin C content during drying involves oxidation and hydrolysis. The ascorbic acid is oxidized to dehydro-ascorbic acid, followed by hydrolysis to 2, 3-diketogulonic acid and further oxidation and polymerization to form a wide range of other nutritionally inactive products (Gregory III, 2008).

Besides the effect of high temperature on the loss of vitamin C, the loss can occur by chemical degradation during preparation step. Because of the high solubility of vitamin C in aqueous solution, there was potential for significant losses by leaching from freshly cut fruit. The loss can also occur during storage and handling (Gregory III, 2008). This was in agreement with the work of Sethi (1986) who reported that the drying of vegetables led to some losses of ascorbic acid and some sensory characteristics. He added that more severe drying conditions in oven caused higher losses of ascorbic acid. Also this variation might be due to the leaching of the vitamin being water soluble and oxidation due to longer period of drying especially the conventional dried samples.

Conclusion:

The drying studies of amla segments dried in different drying methods and with different pre-treatments like 2 per cent NaCl and 0.1 per cent KMS solutions. The samples dried in solar tunnel dryer gave lower moisture content compared with that of sun dried samples. The lowest water activity were found to be in 2 per cent NaCl pre-treated samples and highest rehydration ratio was found to be in 0.1 per cent KMS treated amla samples dried in solar tunnel dryer. Solar drying of pre-treated amla segments in solar tunnel dryer resulted in 20-30 per cent reduction in drying time as compared to open-air sun drying. The highest vitamin C retention was found to be 125.68 (mg/100 g) in untreated amla samples dried in solar tunnel dryer. The samples dried in the solar tunnel dryer were completely protected from insects and dust and of good quality dried product.

Authors' affiliations:

A. Carolinrathinakumari, Indian Institute of Horticultural Research, Hessarghatta, **Bangalore (Karnataka) India** (Email : carolin.rathinakumari@gmail.com)

■ REFERENCES

AOAC (2005). *Official methods of analysis*. 18th Edn. Association of Official Analytical Chemists; Arlington, VA, USA.

Gregory III, J.F. (2008). Vitamins.In Damodaran, S., Parkin, K.L., and Fennema, O.R. (Eds.).Food Chemistry. Boca Raton, London, New York: CRC Press.

Mitra, J., Shrivastava, S.L. and Srinivasarao, P. (2011). Vacuum dehydration kinetics of onion slices. *Food & Bioproducts Processing*, **89**(1) : 1 - 9.

Mota, C.L., Luciano, C., Dias, A., Barroca, M.J. and Guine, R.P.F. (2010). Convective drying o fonion: kinetics and nutritional evaluation. *Food Bioprod Process*, **88** : 115–123.

Ranganna,S. (2000). *Handbook of analysis and quality control for fruits and vegetable products*, Tata McGraw Hill Publishing Co. Ltd., New Delhi.

Reid, D.S. and Fennema, O.R. (2008). Water and ice.In Damodaran, S., Parkin, K.L. and Fennema, O.R. (Eds.).Food Chemistry. Boca Raton, London, New York: CRC Press.

Sethi, V. (1986). Effect of blanching on drying of amla. *Indian Food Packer,* **40** (4) : 7–10.

Sutar, P.P. and Prasad, S. (2011). Modeling mass transfer kinetics and mass diffusivity during osmotic dehydration of blanched carrots.*Internat. J. Food Engg.*, **7**(4): 21.

Verma, R.C. and Gupta, A. (2004). Effect of pre-treatments on quality of solardried aonla. *J. Food. Engg.*, **65** : 397–402.

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