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Research Article

Analysis of Physico-Chemical Properties of Osmotic Dehydrated Star Fruit (*Averrhoa carambola*)

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Abstract

Around the world, tropical and subtropical environments support the growth of star fruit, scientifically known as *Averrhoa carambola*. Star fruit is a perishable item with high moisture content that can cause significant post-harvest losses due to chemical and microbiological deterioration. To increase the shelf life and to preserve star fruit for longer time, drying of star fruit was carried out and the effects of tray drying and freeze drying on physio-chemical properties of star fruit was investigated in this study. Significant differences in the antioxidant activity and vitamin C were observed in tray drying as well as freeze drying. The results of DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging and reducing power assays revealed that freeze drying samples of dehydrated star fruit had relatively higher antioxidant activity compared to tray dried dehydrated star fruit.

Keywords: Star fruit, dehydration, drying, carbohydrate, radical scavenging, sensory properties.

Introduction

The star fruit (*Averrhoa carambola*) belonging to family Oxalidaceae is popularly recognized as tribal fruit of India. The evergreen tree could for multipurpose and may be a good resistant to drought (Behera, 2020). It is assumed to have originated in Ceylon and the Moluccas; however, it has been cultivated in Southeast Asia and Malaysia for loads of years (Hitesh, 2016). Star fruit contains approximately 60% of cellulose, 27% of hemicelluloses, and 13% of pectin (Khoo *et al*., 2010, 2016; Muthu *et al*., 2016). The acidity and composition of nutrients vary with the advance in maturity. As fruits develop, their pH levels grow less acidic (Narain, 2001). Vitamin C, beta-carotene, and gallic acid are among the natural antioxidants found in abundance in star fruits (Khoo *et al*., 2010, 2016; Muthu *et al*., 2016). Additionally, it is a good supplier of phosphorus, magnesium, iron, zinc, manganese, and potassium (Khoo *et al*., 2010, 2016; Muthu *et al*., 2016). Additionally, it has a lot of fibre and few calories, which may help with blood sugar (Khoo *et al*., 2010, 2016; Muthu *et al*., 2016). Following clinical ailments are treated with star fruits in Ayurvedic and Traditional Chinese Medicine (TCM): fever, cough, diarrhoea, persistent headache, inflammatory skin conditions (eczema), and fungal skin infections (Patel *et al*., 2015; Wang *et al*., 2016).

In some nations, the ripe fruit are to treat bleeding haemorrhoids. Star fruit generally stored at room temperature for maximum of two to five days. You can also store them in the refrigerator for up to 2 weeks and star fruit can store in freezer for 10 to 12 months (Hitesh, 2016).
Food drying is a most important process for preserving food products since it has a great effect on the quality of the dried products. Drying prevents occurrence of undesirable changes due to microbial activity. It also lowers the product mass and volume, which improves the efficiency of packaging, storing and transportation. Osmatic dehydration is a water removal technique, which is applied to horticultural products such as fruits and vegetables to reduce the water content while increasing soluble solid content (Kaymak-Ertekin *et al*., 2000). In the drying process known as "freeze-drying" (also known as "lyophilization"), the solvent (often water) and/or the suspension medium are first crystallized at a low temperature directly transitioned into the vapour phase after sublimating from the solid state (Liu *et al*., 2008). One of the most crucial procedures for the preservation of biological material that is sensitive to heat is freeze-drying (George Datta, 2002; Dincer, 2003; Liu *et al*., 2008).

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Against these backdrops, the main objective of this study was to evaluate the effect of different drying methods on physio-chemical properties of two drying techniques of star fruit.

Materials and methods

Materials: The mature fresh star fruit were collected from local markets of Bangalore, India during 2022 (Fig. 1). The fruits were washed thoroughly with running tap water, wiped with a clean towel for removal of surface moisture to avoid microbial growth and stored at -4°C for the whole experiments.

Fig. 1. Hedonic scale of sensory analysis.

Name of the product: _____ Cooking Method: _____
Evaluation Method: The 9 - Point Hedonic Scale

Directions: Check one score for each of the following attributes: Appearance, Taste/Flavor, Texture/Consistency, Aroma/Smell, and Overall Acceptability

Degree of like/dislike	Score
Like Extremely	9
Like very much	8
Like moderate	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Appearance	Taste / Flavor	Texture/ Consistency	Aroma/ Smell	Overall Acceptability

Panellist Name:		Date:	

***Osmotic dehydration*:** The fruits were cut into slices of 4 mm thickness and were soaked in osmotic solvents (sugar, salt) in 30% concentration for 8 hours. When fresh samples are dipped in a hypertonic solution, the cells in the first layer of the material contacts the solution and start to lose water due to the concentration gradient between the hypertonic solution and the cells, which leads to shrinkage of the material (Lewicki *et al*., 2014) The osmotic mass transfer rate is also affected by the size and shape of the produce due to variation in surface area to thickness ratio (Tortoe, 2010).

Tray drying: In this study, the drying procedure of star fruit slices were performed in a laboratory scale convective tray dryer (Aghabashlo *et al*.., 2013). The sliced fruit samples has been placed in plates in layers over the trays of the drier and drying of samples become completed at distinctive temperature of warm air and stuck air velocity. Initial weights of the samples were taken and samples were kept in the pre-heated drying chamber until constant weight is achieved.

The pattern plates were taken out for weighing at each 1-hour interval until steady weight is achieved. Each test was replicated thrice and common observations values were recorded for further analysis. This test was conducted at a temperature interval of 30, 40 and 50°C.

***Freeze-drying*:** Fresh fruits have been analyzed immediately. For the freeze-drying experiment, the samples were packaged in polypropylene plastic containers and frozen at −40°C ± 1°C for 24 hours. The frozen samples were placed inside the freeze-drier (Labconco, USA) for three days until they have been absolutely dried and reached to its equilibrium state (Figs. 2-5).

Fig. 2. Freeze dried (-40°C) star fruit with sugar concentration (30%).

Fig. 3. Freeze dried (-40°C) star fruit with salt concentration (30%).

Fig. 4. Tray dried star fruit with sugar concentration (30%).

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Fig. 5. Tray dried star fruit with salt concentration (30%).

Determination of ascorbic acid content: The standard procedure was followed in the estimation of ascorbic acid content (Verma, 1996). The standard method was based on the reduction of 2,6-diclorophenol indophenols dye by ascorbic acid. The dried fruit sample (2g) was taken and grounded by adding 10 mL of distilled water in a pestle and mortar and the whole mixture was filtered and centrifuged for separation of the supernatant fluid. The supernatant was taken in a volumetric flask and titration was done with 2,6-diclorophenol indophenol solution until a rose-pink colour appears. The ascorbic acid content was estimated using the standard formula.

Determination Of DPPH (2,2-Diphenyl-1-Picrylhydrazyl) radical scavenging activity: The antioxidant activity in terms of free radical scavenging activity was done for dehydrated star fruit (Plank, 2012). The star fruit samples were estimated using 2,2-diphenyl-1-picrylhdrazyl. Different concentrations of star fruit extract were mixed with 1ml of 0.1 mm DPPH in ethanol solution and incubated for 45 minutes in dark condition. After incubation, the reduction in the number of DPPH free radicals was monitored by spectrophotometric measurement of the absorbance loss at 517 nm. Antioxidant activity was quantified relative to a dilution series of vitamin E analog standards, which were analyzed in parallel simultaneously with the samples.

Determination of carbohydrates: The carbohydrates activity was tested for dehydrated star fruit. The star fruit samples were evaluated using Phenol-sulphuric acid (Dubois *et al..,* 1956) Different standard concentrations (2-10 mL concentration) of working standard (with 0.1 mg/mL conc.) of glucose was taken in boiling tubes and the final volumes of each tube was made 1ml by adding distilled water. About 1 mL of 5% Phenol and 5 mL of 96% sulphuric acid was added one by one in each tube and shook well so that the phenol and sulphuric acid get mixed thoroughly with working standard. After 10 minutes, all the tubes were placed in water bath at 25-30°C for 15 minutes. Blank was set with 1 mL of distilled water and O.D. of each tube was taken at 490 nm with the help of spectrophotometer. Then the whole process following phenol and sulphuric acid method was repeated with 0.2 mL of different samples of dried fruit and the OD of sample solutions were recorded.

Estimation of protein by Lowry's method: The Lowry protein assay is a scientific method for figuring out how much protein is present overall in a solution (Waterborg, 2009). A colour change in the sample solution is proportional to the protein concentration indicates the total protein concentration, which may subsequently be determined using colorimetric methods. The blue colour developed by the reduction of the phosphomolybdic-phosphotungstic components in the folin-ciocalteau reagent by the amino acid tyrosine and tryptophan present in the protein plus the colour developed by the biuret reaction of the protein with the alkaline cupric tartrate are measured in the Lowry method. The 0.2 mL of working standard were taken in 5 test tubes and make up the volume to 1ml by using distilled water and the test tube with 1 mL distilled water serve as blank. The 5 mL of copper reagent was added and incubated in dark for 10 minutes. After incubation, 0.5 mL of FC reagent is added to all test tubes and incubated for 30 minutes in dark prior to measurement of absorbance at 660 nm.

Determination of moisture content: Standard Official Methods of Analysis to determine moisture by using hot air oven method (AOAC, 1990). This involved drying to a constant weight at 130°C and calculating moisture as the loss in weight of the dried star fruit samples. The crucible was thoroughly washed and dried in an oven at 100°C for 30 minutes and allowed to cool inside desiccators. After cooling, they were weighed using weighing balance and their various weights recorded as (W1). Then, 2.0 g of the finely ground samples were put into the crucibles and weighed to get W2. Thereafter, the sample plus crucible were placed inside the oven and dried at 130°C for 1 hour, cooled and weighed at the same temperature for 30 minutes until constant weights were obtained to get W3. Then, the moisture content of the sample was calculated from the equation:

$$\% \text{ Moisture} = (W_2 - W_3) / (W_2 - W_1) \times 100$$

Where, W1 = Initial weight of empty crucible, W2 = Weight of crucible + sample before drying and W3 = Final weight of crucible + sample after drying. The drying temperature and the time for moisture estimation depend of the type of sample.

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Table 1. Physico-chemical properties of osmotic dehydrated star fruit.

Samples	DPPH (mg/100 g)	Ascorbic acid (mg/100 g)	Carbohydrates (g/100 g)	Proteins (g/100 g)	Moisture (%)
30°C Salt	24.6± 0.35	4.74 ± 0.24	2.53 ± 0.02	0.122 ±0.002	25.11± 0.14
30°C Sugar	20.10±0.35	4.63 ±0.28	2.69 ± 0.04	0.125 ± 0.001	20.37 ± 0.12
40°C Salt	17.70±0.25	3.95 ± 0.21	2.55 ± 0.06	0.134 ±0.001	17.65 ± 0.1
40°C Sugar	16.50±0.25	3.75 ± 0.19	3.04 ± 0.03	0.139 ±0.002	16.55 ± 0.01
50°C Salt	12.50 ± 0.1	3.16 ± 0.15	2.69 ± 0.06	0.116 ±0.002	16.50± 0.01
50°C Sugar	12.00±0.45	3.02 ± 0.13	3.05 ± 0.03	0.115± 0.002	15.50± 0.11
-40°C Salt	37.24±0.01	5.25 ± 0.39	2.91 ± 0.05	0.142 ± 0.003	14.80± 0.02
-40°C Sugar	33.12±0.03	5.23 ± 0.29	3.05 ± 0.02	0.153 ± 0.004	14.80± 0.02

Mean± standard deviation. Mean values within a column followed by a different letter are significantly different.

Table 2. Sensory analysis of osmotic dehydrated star fruit.

Criteria	T1	T2	T3	T4	T5	T6	D1	D2	D3
Appearance	6±0.4	6±0.8	6±0.5	6±0.7	7±0.4	8±1.1	7±0.4	8±0.7	7±0.7
Taste	6±0.4	5±0.5	6±0.5	6±0.7	6±0.4	7±1.1	7±0.4	7±0.7	9±0.7
Texture	7±1.0	5±0.5	7±0.5	5±0.7	7±0.4	5±1.1	7±0.4	8±0.7	8±0.7

Sensory analysis: The dehydrated samples were coded with different numbers and followed by sensory evaluation by ten trained panel members of food technology department. The panelists were asked to rate each sensory attribute using the control sample as the basic for evaluation. The products were evaluated for taste, colour, flavour, body and texture, consistency and overall acceptability on a 9-point hedonic scale following the procedure of ISI (1997) (Hooda and Jood, 2005). The sensory evaluation was conducted for colour and shape i.e. like extremely 9, like very much 8, like moderately 7, like slightly 6, neither like nor dislike 5, dislike slightly 4, dislike moderately 3, dislike very much 2 and dislike extremely 1. The comparison was performed among all the dehydrated samples prepared.

Statistical analysis: All data were expressed as mean values ±Standard deviation (SD). Statistical analysis was performed by calculating coefficient of variance (CV) and standard error (SE).

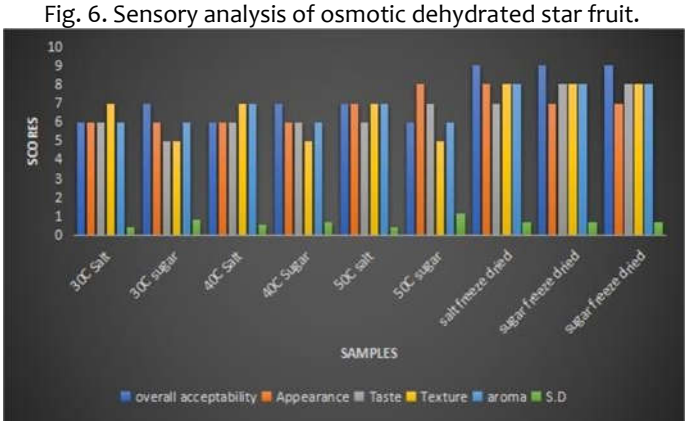
Results and discussion

Between two drying methods (tray drying and freeze-drying), freeze-drying shows the better quality and nutritional parameters compared to tray drying. During freeze drying effective moisture content was lost compared to tray drying. In addition, nutritional parameters (antioxidant activity, vitamin C, carbohydrates, protein, and fat) were seen good results in freeze-drying compared to tray drying.

Physico-chemical analysis of dehydrated star fruit: The results of DPPH, ascorbic acid, carbohydrates, proteins and moisture content of freeze- dried and tray dried star fruit are shown in Table 1.

According to the results, antioxidant activity, Ascorbic acid and protein content of dehydrated star fruit is significantly different from that of fresh star fruit. Compared to tray dried dehydrated star fruits freeze-dried star fruits shows more antioxidant activity, ascorbic acid and protein. In tray dried dehydrated star fruits 30°C variation method has more antioxidant activity compared to 50°C variation. While, total carbohydrates of dehydrated star fruit are significantly different from that of fresh star fruit. Compared to tray dried dehydrated star fruits sugar immersed freeze-dried star fruits shows more carbohydrate content (Table 1). Besides, moisture lost was seen more in freeze dried dehydrated star fruit compared to tray dried dehydrated star fruit (Table 1).

Fig. 6. Sensory analysis of osmotic dehydrated star fruit.



Sensory analysis of dehydrated star fruit: Sensory evaluation was carried out by a trained panel of 10 judges of different age groups, having different eating habits. Sensory characteristics of the dehydrated samples were determined as composite score of the 10-member consumer panel using 9-point Hedonic scale following the procedure of ISI (1997).

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According to the results, based on appearance taste, texture, colour, aroma, overall acceptability of freeze-dried star fruit was accepted by more people compared to the tray dried star fruit (Table 2 & Fig. 6).

Conclusion

The present study was done to preserve the star fruit for longer shelf life by removing the moisture content. Dehydrated star fruit using osmotic dehydrated method was developed using tray drying and freeze-drying equipment's. The results of present study revealed, freeze-drying may be a practical option for processing star fruits while preserving the most ascorbic acid and antioxidant activity from their original state. Based on the analysis of physical (appearance and colour), chemical properties (antioxidant activity, ascorbic acid, carbohydrates, protein, fat) and sensory analysis freeze dried product gives the best result. However, further studies on complete nutritional analysis can be done and product can be developed using salt immersed and sugar immersed dehydrated star fruit.

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