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Athira M Nair

Ph.D. Scholar, Department of Postharvest Management, College of Agriculture, Kerala Agricultural University, Thiruvananthapuram, Kerala, India

PR Geetha Lekshmi

Assistant Professor, Department of Postharvest Management, College of Agriculture, Kerala Agricultural University, Thiruvananthapuram, Kerala, India

Changes in sugar and acid content of freeze-dried pulp of *Annona* species stored at ambient temperature

Athira M Nair and PR Geetha Lekshmi

Abstract

Annonaceous fruits are one of the most nutritious crops with great potential to develop value-added products. Freeze drying is a preservation technique to retain the nutrients in the fruit pulp during the drying process and provides the finished product with excellent stability during the storage period. The present research was focused to develop the freeze-dried fruit pulp from *Annona* species (*Annona squamosa*, *Annona reticulata* and *Annona muricata*) and evaluated its soluble sugars and acidity during ambient storage for 90 days. The result of the study revealed that total soluble solids, acidity, total sugar and reducing sugar content of all the freeze-dried pulp of *Annona* species decreased during 90 days of storage. It was observed that the highest values of TSS (25.75⁰Brix), total sugar (24.94%) and reducing sugar content (21.24%) were exhibited in freeze-dried *Annona squamosa* pulp, whereas the highest acidity (1.25%) was found in freeze-dried *Annona muricata* pulp at the end of 90 days of ambient storage. Hence, freeze drying is the best dehydration method to preserve the nutrient parameters of *Annona* fruit pulp during storage.

Keywords: *Annona*, freeze drying, sugars, acidity, ambient storage

Introduction

Annona fruits are one of the most important crops in India, with a potential source of nutrients and bioactive compounds. The major *Annona* species viz., *Annona squamosa* (Custard apple), *Annona reticulata* (Rampal) and *Annona muricata* (Soursop) are grown in the homesteads of Kerala. The fruits of these species are rich sources of bioactive compounds viz., acetogenins, antioxidants, carotenoids, ascorbic acid and phenols (Bezerra *et al.*, 2018) [3]. The presence of these compounds in fruits contributes to several pharmacological activities like antitumoral, anti-inflammatory, antidiabetic, analgesic, antiulcer and antidepressant (Bhardwaj *et al.*, 2019) [4]. The fruits are generally eaten fresh and are used for the preparation of several processed products like nectar, juice, ready-to-serve beverages, syrup, ice cream and milkshakes.

The preservation techniques such as freeze drying, freezing and packaging are widely used. Freeze drying is a process in which the moisture is removed in the form of ice from the sample through sublimation (Verma *et al.*, 2015) [10]. In terms of appearance, nutrient retention, and sensory attributes, it is the ideal drying method for producing the highest-quality food products. Therefore, the current study was undertaken to evaluate the changes in sugar and acid content in freeze-dried pulp of *Annona* species during ambient storage conditions.

Materials and Methods

Fully ripened fruits of *Annona squamosa*, *Annona reticulata* and *Annona muricata* were collected and the pulp was extracted. The fresh fruit pulp was subjected to freeze drying. The freeze-dried pulp was packed into aluminium pouches and stored for 90 days at ambient storage (27 °C to 30 °C) conditions for further analysis. The biochemical parameters such as total soluble solids, titratable acidity, total sugar and reducing sugar content of the freeze-dried sample were analysed for 90 days at a thirty day interval at ambient temperature during storage. Total soluble solids (TSS) of freeze-dried samples were estimated by using a digital refractometer and expressed as degree brix (⁰Brix). The titratable acidity was estimated following the methodology of Ranganna (2005) [7] and expressed as percentage. The total sugar and reducing sugar content were determined by the Lane and Eyon method and expressed as percentage (AOAC, 2010) [2].

Corresponding Author:**Athira M Nair**

Ph.D. Scholar, Department of Postharvest Management, College of Agriculture, Kerala Agricultural University, Thiruvananthapuram, Kerala, India

Results and Discussion

Total Soluble Solids

The total soluble solids (TSS) content of all the freeze-dried *Annona* pulp observed a decreased trend during the storage period of 90 days (Table 1). The TSS of freeze-dried *Annona squamosa* pulp decreased from 27.55⁰Brix at 30 days of storage to 25.75⁰Brix after 90 days of storage. Similarly, the freeze-dried pulp of *Annona reticulata* showed a declining trend from 22.55⁰Brix to 20.63⁰Brix, and in *Annona muricata*, it was reduced from 19.45⁰Brix to 17.59⁰Brix at the end of 90 days of storage. The decrease in total soluble solids of dried pulp might be due to the breakdown of soluble solids during storage (Adetoro *et al.* 2020) ^[1]. These results are also supported by the findings of Farooq *et al.* (2020) ^[6] in freeze-dried tomato powder during ambient storage.

Table 1: Total soluble solids (⁰Brix) of freeze-dried *Annona* pulp stored at room temperature

Freeze-dried <i>Annona</i> pulp	Days after storage		
	30	60	90
<i>Annona squamosa</i>	27.55	26.02	25.75
<i>Annona reticulata</i>	22.55	21.03	20.63
<i>Annona muricata</i>	19.45	18.05	17.59
Mean (S)	23.18	21.70	21.32
SE _± (m)	0.274	0.264	0.269
CD (0.05)	0.948	0.914	0.930

Titrateable acidity

There was a decreased trend in titrateable acidity was noticed in freeze-dried *Annona* pulp during the room temperature storage of 90 days (Table 2). The acidity decreased from 0.47% at the 30 days of storage to 0.35% after 90 days of storage in the freeze-dried pulp of *Annona squamosa*. The freeze-dried *Annona reticulata* and *Annona muricata* pulp showed a reduction in acidity from 0.87% to 0.74% and from 1.44% to 1.25% at the end of 90 days of room temperature conditions respectively. The decline in acidity during storage of freeze-dried custard apple pulp has also been reported by Sondarva *et al.* (2016) ^[9]. Similar observations of decreasing acidity in freeze-dried pulp have been reported by Adetoro *et al.* (2020) ^[1] in freeze-dried aril of pomegranate.

Table 2: Titrateable acidity (%) of freeze-dried *Annona* pulp stored at room temperature

Freeze-dried <i>Annona</i> pulp	Days after storage		
	1	2	3
<i>Annona squamosa</i>	0.47	0.41	0.35
<i>Annona reticulata</i>	0.87	0.84	0.74
<i>Annona muricata</i>	1.44	1.40	1.25
Mean (S)	0.93	0.88	0.78
SE _± (m)	0.018	0.008	0.027
CD (0.05)	0.061	0.027	0.095

Total sugar

The total sugar content of all the freeze-dried *Annona* pulp decreased during the room temperature storage of 90 days (Table 3). The freeze-dried *Annona squamosa* pulp showed a reduction in total sugar content from 26.95% at 30 days of storage to 24.94% after 90 days of storage at room temperature. Also, the total sugar content of freeze-dried pulp of *Annona reticulata* showed a decrease from 20.36% to 18.72%, and in *Annona muricata*, it was reduced from 17.51% to 15.98% at the end of 90 days of storage. The

decrease in total sugar content might be due to the reduction in total cell wall polysaccharides in freeze-dried apples (Dalmau *et al.*, 2017) ^[5]. Similar findings of decreased total sugar content were reported in dried apricot fruits (Wani *et al.* (2018) ^[11] and tomato powder (Farooq *et al.*, 2020) ^[6] during storage.

Table 3: Total sugar (%) of freeze-dried *Annona* pulp stored at room temperature

Freeze-dried <i>Annona</i> pulp	Days after storage		
	1	2	3
<i>Annona squamosa</i>	26.95	25.99	24.94
<i>Annona reticulata</i>	20.36	20.11	18.72
<i>Annona muricata</i>	17.51	17.24	15.98
Mean (S)	21.61	21.11	19.88
SE _± (m)	0.041	0.101	0.477
CD (0.05)	0.143	0.351	1.650

Reducing sugar

There was a reduction in reducing sugar content was observed in freeze-dried *Annona* pulp during the room temperature storage of 90 days (Table 4). The reducing sugar content in freeze-dried pulp of *Annona squamosa* was noticed a decrease from 22.98% at thirty days of storage to 21.24% after 90 days of room temperature storage. The freeze-dried *Annona reticulata* and *Annona muricata* pulp showed a decrease in reducing sugar content from 19.15% to 17.55% and from 15.71% to 13.96% at the end of 90 days of room temperature conditions respectively. Sondarva *et al.* (2016) ^[9] found a similar decrease in reducing sugar content of freeze-dried custard apple pulp during the storage period of 90 days. This decrease in reducing sugar content of freeze-dried product might be due to the degradation of total cell wall carbohydrates during storage (Sokolowska *et al.*, 2020) ^[8]. These findings were in conformity with the reports of Farooq *et al.* (2020) ^[6] on tomato powder during storage.

Table 4: Reducing sugar (%) of freeze-dried *Annona* pulp stored at room temperature

Freeze-dried <i>Annona</i> pulp	Days after storage		
	1	2	3
<i>Annona squamosa</i>	22.98	22.05	21.24
<i>Annona reticulata</i>	19.15	18.12	17.55
<i>Annona muricata</i>	15.71	14.93	13.96
Mean (S)	19.28	18.37	17.58
SE _± (m)	0.173	0.094	0.215
CD (0.05)	0.598	0.324	0.744

Conclusion

The sugar and acid content of freeze-dried *Annona* pulp were analyzed for a period of 90 days at ambient storage conditions. The result showed that there was a good retention of TSS, acidity, total sugar and reducing sugar content in all the freeze-dried pulp of *Annona* species. However, the freeze-dried pulp of *Annona squamosa* retained the highest TSS (25.75⁰Brix), total sugar (24.94%) and reducing sugar (21.24%), while the highest acidity (1.25%) was observed in the freeze-dried *Annona muricata* pulp after 90 days of ambient storage conditions. Therefore, it was concluded that freeze drying is an effective method to retain the nutrients present in the fruit pulp of *Annona* species.

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