

Effect of Storage Conditions on Quality of Ready-to-Serve Beverage from Residual Osmotic Solution of Star Fruit

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Abstract. Increasing urbanization has boosted the demand for health related drinks based on indigenous fruits. Star fruit due to its high antioxidant potentials along with abundance in nutritional and medicinal qualities has been recently scrutinized for producing commercialized value added products. Present investigation is undertaken with a view to augment the use of resulting osmotic solution with fresh carambola juice for preparation of ready to serve beverage and to determine their storability with respect to quality characteristics. The formulated ready-to-serve (RTS) beverage stored for six months under ambient (25°-43°C) and refrigerated (10°C) condition exhibited overall sensory parameters within the limits of acceptance. With increasing storability, the ascorbic acid content decreased from a mean value of 23.94 to 18.42 mg/100mL (ambient) and 21.86 mg/100mL (refrigerated). Similarly, oxalic acid was reduced from 90.88 mg/100mL to 63.85 mg/100mL (ambient) and 88.55 mg/100mL (refrigerated). After 4 months of storage the scores of the sensory properties of RTS were found to be reduced to below 7.5 for ambient and below 8.3 for refrigerated samples. The refrigerated stored sample showed higher retaining property for flavor attributes. Moreover, the stored samples manifested the presence of bacteria, mold and yeast, yet within the limit of acceptance.

Keywords: Star fruit, residual syrup, RTS beverage, antioxidant, sensory properties.

1 Introduction

Star fruit (*Averrhoa carambola*) is one of the tribal fruits grown in India. It is a multipurpose fruit which is gaining lot of priority for its therapeutic potentials. The fruit contains an edible pulp, exhibiting similar flavor properties as that of green sour apple. Moreover, it has been used for making commercialized products such as pickles, jams, jelly and beverages [1, 2]. The fruit contains huge variety of bio-active components such as antioxidants, minerals, total phenolics, and dietary fibers. It is also a good source of potassium, copper, as well as folate and panthothenic acid [1]. High perishability during its harvesting has heavily restricted its utilization, producing wastes due to non-availability of adequate storage and processing [3]. Yet, the lack of technical knowledge for its further processing has rendered its potentials unutilized which makes it the most overlooked fruit for extracting essential therapeutic uses in the entire region [4]. Therefore, transportation, handling and, processing within a short span are major concerns in commercial scale processing [5]. There is a need to preserve their potentials through procuring acceptable techniques for safe storage with efficient nutrient retention [6].

In recent years, formulation of value added products has gathered essential priority for the use as a commercialized product [7, 8]. Value added products manufactured during the harvesting seasons of a particular seasonal fruit are expected to be consumed throughout the year. With substantial promotions and research evidences, this underutilized fruit could play an important role as one of the alternative food sources to the world and in improving human health. Today, development of an elementary and economical process for star fruit preservation is highly solicited. A concern for osmo-dehydration in industries is the problem for the management of the resulting osmotic solution. Reuse by solute addition may lead to complete utilization of resulting syrup, thereby saving a major part of the investment in the osmo-dehydration process. Further, there is a growing demand for health drinks based on indigenous fruits [9]. Ready-to-serve (RTS) is a type of beverage containing at least 10% fruit juice besides less

than 0.3% acid according to the FPO Standard [10]. It is normally not diluted before serving and hence known as RTS beverage.

To the best of our knowledge, no work has been done in the reuse of the residual osmotic star fruit syrup for the preparation of ready to serve the beverage. Hence the present work is undertaken with the objective for effective utilization of residual osmotic syrup which would otherwise be wasted and to determine its storability with respect to quality characteristics in terms of biochemical, microbial and sensory attributes.

2 Materials and Methods

2.1 Sample Preparation and Pretreatment

Star fruits “golden star variety” samples at proper maturity were procured from the Orissa University of Agriculture and Technology premises, Bhubaneswar during the month of January for relevant experimentations. The maturity stage was decided on the basis of their color and textural property [11]. The collected whole fresh fruits (Figure 1) were properly washed in the running water to remove dirt and foreign particles; surface moisture was wiped with a clean towel.



Figure 1. Whole star fruit

2.1.1 Preparation of RTS from Fresh Starfruit

The fruits were subjected to proper unit operations for extraction of fresh juice [12]. The cleaned star fruits were chopped into small pieces followed by the juice extraction by a screw type juice extractor. The extracted juice was strained through a double layer muslin cloth to obtain the clarified juice devoid of seeds and fiber particles. In a separate container, sugar syrup was prepared by mixing commercially available sugar so as to provide adequate textural property to the juice. Then RTS was prepared by mixing sugar syrup and fresh star fruit juice at required proportions (Figure 2). The final TSS (Total Soluble Solids) and juice percentage were maintained as per the FPO specification. For flavoring, the RTS was mixed with ginger juice at an amount of 15-16 mL per liter of RTS. Sterilized glass bottles of 200 mL capacity were filled with RTS and sealed by a crown cork sealing machine followed by re-sterilization for 20 min. The mass flow chart for the RTS beverage prepared from the fresh sugar syrup is given in Figure 3.



Figure 2. Prepared RTS beverage



Figure 3. Mass flow chart for RTS beverage preparation from fresh sugar syrup

2.1.2 Preparation of RTS Beverage Using Resulting Osmotic Solution

For proper management of the left-over osmotic sugar solution, residual sugar syrup obtained from osmo-dehydration was mixed with distilled water and allowed to boil till leather foam formation was observed. The boiled syrup was filtered through 120 mesh sieve to remove the scum. Filtrate syrup was added to the fresh juice as per the requirement. A number of trials were made in order to meet the FPO specification and sensory acceptance. Adopting this method, some value-added beverage was prepared along with osmo-dehydrated slices. The flow chart of the osmo-dehydration along with RTS preparation is shown in Figure 4. The prepared RTS beverage was stored for six months under ambient (25 to 43°C) and refrigerated (10°C) condition and the quality characteristics were evaluated. Since the experiment was continued for the month of January to June, the average temperature and RH ranged in this period was 25 to 43°C and 60 to 88%, respectively.

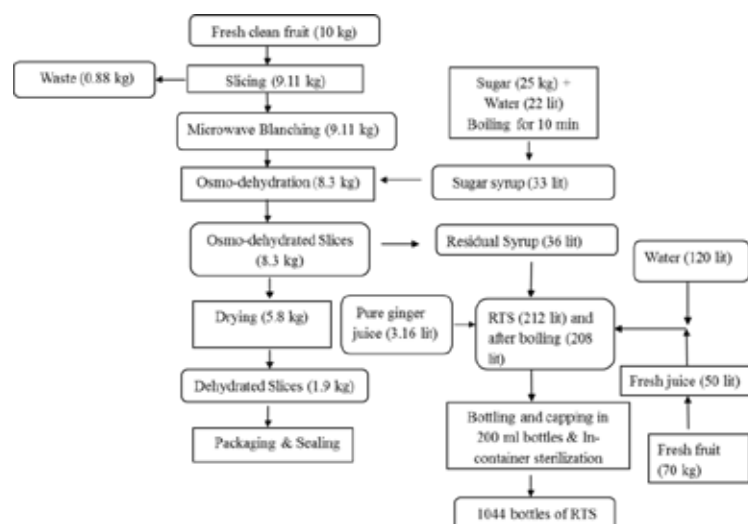


Figure 4. Mass flow chart for RTS beverage preparation from residual osmotic syrup

2.2 Organoleptic Quality Analysis

Storage experiments were carried out for a period of six months and the quality analysis was made [5]. The periodical observations on biochemical qualities were evaluated by opening three bottles from each storage condition randomly. Both biochemical and microbial analysis were observed at every 60 days. The biochemical analysis included pH, TSS, total sugar, ascorbic acid and, oxalic acid. The pH was measured using a digital pH meter (model No L1 120, ELICO, INDIA). The TSS was determined using hand-held refractometer (Atago 2363 MASTER 500 ranging from 0.0-90.0% Brix value) at 20°C. Total reducing sugar was estimated by phenol-sulfuric acid method [13]. Ascorbic acid content (AA) was determined by using 2, 6-dichloroindophenol titrimetric method [14]. The oxalic acid (OA) content was evaluated by titration method [15]. In the microbial analysis, plate count method was used in which surface microbial load was calculated for bacteria in nutrient agar media while yeast and mold count was determined in potato dextrose media [16].

2.3 Sensory Evaluation

Sensory evaluation of the star fruit beverage was performed using nine-point hedonic scoring test. Ten trained panel members were considered for the purpose. Taking the weight factor for different organoleptic attributes like flavor, color, taste, overall acceptability was calculated using composite scoring. The scoring system considered was a 9-point scale system with the quality index like extremely (9) to dislike extremely (1). Eventually, weighting factor has been determined from priority percentage data collected from a semi-trained panel consisting of professors, technicians and students of the university. The arithmetic average factor for color, flavor and, the taste was determined to be 30, 40, and 30% respectively.

2.4 Statistical Evaluation

All biochemical and microbial qualities of the developed RTS were subjected to measures of central tendency, and the mean and standard deviation of biochemical qualities were determined. Analysis of variance (ANOVA) was performed for biochemical qualities using the Microsoft Excel (version 2013). All the determinations were carried out in triplicate.

3 Results and Discussion

3.1 Quantification of Juice and RTS Beverage

Results indicated that among the trials with different juice content, a beverage with juice content of 22% was rated best on the basis of flavor and overall acceptability sensory parameters and was considered as the beverage base. A number of trials were conducted using different ingredient proportions. Then based on the results of sensory evaluation, the beverage formulation was standardized and the corresponding RTS was quantified. In the case of RTS prepared from fresh sugar syrup, it was observed that from 70 kg of fresh starfruit, 25 kg sugar with distilled water and ginger juice, 195 liters of RTS beverage can be prepared (Figure 3). But in the case of RTS prepared from residual sugar syrup, from 70 kg of fresh star fruit and osmotic fluid from osmosis of 10 kg of fruit, 208 liters of RTS beverage can be prepared along with 1.9 kg of dried slices, for which no more sugar is required (Figure 4). Lastly, it concluded the formulated objective to proliferate the use of resulting osmotic syrup in the preparation of RTS beverage followed by good acceptability and added potentials for health related issues [1, 2].

3.2 Effect of Storage Conditions on Different Quality Characteristics of the Prepared RTS

The quality of RTS prepared from fresh sugar syrup did not differ significantly from the one prepared using residual syrup. Hence no biochemical analysis was performed for the former juice sample. The

quality characteristics of the RTS prepared from residual syrup were evaluated for a period of 2, 4 and, 6 months as mentioned in Table 1.

Table 1. Quality characteristics of developed RTS from residual syrup

Parameters	RTS prepared from residual syrup						
	Control	Ambient condition			Refrigerated condition		
		2 months	4 months	6 months	2 months	4 months	6 months
Total soluble solids (°Brix)	15.17 ± 0.05	15.56 ± 0.41	16.50 ± 0.36	16.57 ± 0.42	15.10 ± 0.1	15.23 ± 0.05	15.37 ± 0.06
pH	4.46 ± 0.01	4.41 ± 0.03	4.39 ± 0.04	3.88 ± 0.05	4.43 ± 0.02	4.36 ± 0.04	4.31 ± 0.01
Ascorbic acid (mg/100ml)	23.91 ± 0.03	22.42 ± 0.04	20.28 ± 0.07	18.41 ± 0.03	23.70 ± 0.03	22.42 ± 0.01	21.10 ± 0.11
Oxalic acid	90.83 ± 0.07	85.84 ± 0.01	77.32 ± 0.02	63.85 ± 0.01	90.1 ± 0.10	89.17 ± 0.01	88.54 ± 0.02
Total plate count	ND	ND	ND	5 × 10 ³	ND	ND	ND
Total yeast and mold count	ND	ND	ND	1 × 10 ³	ND	ND	ND

ND denotes not detected

3.2.1 TSS

The initial value of TSS of the RTS beverage prepared from residual syrup was found to be 15.17 ± 0.05 °Brix which was increased to 16.57 ± 0.42 and to 15.37 ± 0.06 °Brix for ambient and refrigerated storage condition, respectively after six months of storage. The increase in TSS could be due to the enzymatic hydrolysis of polysaccharides into sugars during storage. Similar findings were reported for lime RTS and papaya-pine apple blended RTS beverages by Thamilselvi et al. [17] and Sindumathi and Premalatha [18], respectively. Two-way ANOVA (Table 2) indicated a significant variation in TSS of the refrigerated stored beverage over ambient storage irrespective of the storage period ($p < 0.01$).

3.2.2 pH

The initial value of pH of the RTS beverage prepared from residual syrup was found to be 4.46 ± 0.01 which was decreased to 3.88 ± 0.05 and to 4.31 ± 0.01 for ambient and refrigerated storage condition, respectively after six months of storage. A slight decrease in pH was observed for refrigerated stored RTS compared to ambient condition. Nidhi et al. [19] and Sindumathi and Premalatha [18] were also reported similar results for bael-guava blended RTS and papaya-pine apple blended RTS beverages, respectively. Two-way ANOVA showed a significant difference between both the storage condition and storage period at an error level of 1 per cent (Table 2).

3.2.3 Ascorbic Acid

The initial value of ascorbic acid of the RTS beverage prepared from residual syrup was found to be 23.91 ± 0.03 mg/100mL which was decreased to 18.41 ± 0.03 and to 21.10 ± 0.11 mg/100mL for ambient and refrigerated storage condition, respectively after six months of storage. AA reduction could be attributed to oxidation due to oxygen present in the head space of RTS bottle. Further, the ambient storage had more detrimental impact on the decrease of AA compared to refrigerated storage. This result was in accordance with the findings of Sindumathi and Premalatha [18], Thamilselvi et al. [17], Baljeet et al. [20]. Two-way ANOVA (Table 2) indicated a significant variation in TSS of the refrigerated stored beverage over ambient storage irrespective of the storage period ($p < 0.01$). An interactive p value of < 0.01 indicated that the both storage condition and the storage period were also significant.

3.2.4 Oxalic Acid

The initial value of oxalic acid of the RTS beverage prepared from residual syrup was found to be 90.83 ± 0.07 mg/100mL which was decreased to 63.85 ± 0.01 and to 88.54 ± 0.02 mg/100mL for ambient and refrigerated storage condition, respectively after six months of storage. Statistical analysis of the data indicated that the oxalic acid of the RTS stored in ambient storage condition had high

significant difference ($p < 0.01$) when compared to refrigerated stored RTS (Table 2). An interactive p value of < 0.01 indicated that the both storage conditions and the storage period were also significant.

3.2.5 Microbial Qualities

Initially there was no microbial load in RTS beverage after preparation and continues the same status till four months of storage. But the total plate count and total yeast and mold count increased to 5×10^3 and 1×10^3 , respectively in ambient storage after six month of storage period (Table 1). The RTS stored in the refrigerated condition showed no microbial load even after six months of storage and was within the safe limits [21]. The negligible change in the RTS beverages might due to the anti-microbial properties of ginger juice added in the time of preparation. Similar results were also reported for Tulsi and Arugampul by Thamilselvi et al. [17] and for ginger juice by Rayaguru et al. [5].

Table 2. ANOVA Summary table for biochemical properties

TSS						
Source of Variation	SS	df	MS	F	P-value	F _{crit}
Storage conditions	4.302	1	4.302	52.324	1.04E-5	4.747
Storage period	1.391	2	0.696	8.459	0.00510	3.885
Interaction	0.591	2	0.296	3.595	0.0598	3.885
Within	0.987	12	0.082			
Total	7.271	17				
pH						
Source of Variation	SS	df	MS	F	P-value	F _{crit}
Storage conditions	0.087	1	0.087	74.405	1.72E-06	4.747
Storage period	0.380	2	0.190	162.948	2.01E-09	3.885
Interaction	0.188	2	0.094	80.462	1.12E-07	3.885
Within	0.014	12	0.001			
Total	0.669	17				
Ascorbic acid (mg/100mL)						
Source of Variation	SS	df	MS	F	P-value	F _{crit}
Storage conditions	18.707	1	18.707	5018.219	4.16E-17	4.747
Storage period	32.747	2	16.373	4392.256	6.44E-18	3.885
Interaction	1.520	2	0.760	203.827	5.46E-10	3.885
Within	0.045	12	0.004			
Total	53.018	17				
Oxalic acid (mg/100mL)						
Source of Variation	SS	df	MS	F	P-value	F _{crit}
Storage conditions	832.184	1	832.184	475533.717	5.82E-29	4.747
Storage period	421.578	2	210.789	120450.727	1.52E-26	3.885
Interaction	319.894	2	159.947	91398.384	8.00E-26	3.885
Within	0.021	12	0.002			
Total	1573.677	17				

3.2.6 Sensory Evaluation

Table 3 shows the composite score of the prepared RTS in terms of color, flavor, and taste. The overall acceptability was initially in the range of 8.2 to 8.5. After four months of storage, the scores of the sensory properties were found to be reduced to below 7.5 for ambient and below 8.3 for refrigerated RTS. However, the refrigerated stored sample could retain the flavor to a greater extent. This might have influenced the overall acceptability for which remarkable differences could be observed.

Storage study revealed that though there was a change in biochemical qualities of RTS samples after four and six months of storage, the changes were less remarkable in refrigerated storage as compared to those of ambient storage. This is for the obvious reason of low-temperature storage with the less degrading environment. However, these changes were not remarkable to the extent that it could be

considered as a loss and thus the product may be inferred to be within the limits of acceptance [5]. The microbial load was well within safe limits up to four months of storage in both ambient and refrigerated condition. Sensory attributes were also above 7 in the case of ambient storage up to four months and above 8 for refrigerated stored beverage after four months which confirms an acceptable sensory score.

Table 3. Organoleptic properties of developed RTS beverage from residual syrup

Parameters	RTS prepared from residual syrup						
	Control	Ambient condition			Refrigerated condition		
		2 months	4 months	6 months	2 months	4 months	6 months
Colour	8.2	7.9	7.3	7.2	8	8	8
Flavour	8.4	8.1	7.7	7.3	8.4	8.4	8.2
Taste	8.5	8	7.8	7.4	8.5	8.5	8.4
Overall acceptability	8.37	8.01	7.61	7.3	8.31	8.31	8.2

4 Conclusion

The average percentage fraction of usable part (sliced pieces), both end stalk and seed along with fibre were found to be 67%, 7% and 26%, respectively in a star fruit. 70 kg of fresh starfruit, 25 kg sugar with distilled water, ginger juice gave rise to 195 liters of RTS beverage. Whereas, from 70 kg of fresh fruit and prepared osmotic syrup from 10 kg of fruit, 208 liters of RTS beverage was prepared, devoid of any extra sugar. All the biochemical qualities changed with storage period irrespective of the storage conditions. pH, ascorbic acid and oxalic acid of RTS reduced with storage period where as an increasing trend was observed for TSS. However, the changes were maximum in ambient stored RTS beverages. The total mold count and total yeast and mold count were well within the safe limits till the end of a storage period of six months. The results suggest that addition of ginger juice not only makes the beverage nutraceutical but also increases the shelf life. This possibility may be explored further for enhancement of shelf life of suitable fruit products.

Acknowledgement. The work was supported by the Indian Council of Agricultural Research (ICAR), New Delhi.

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