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Utilization of star fruit (*Averrhoa carambola*) into value added products and their storage stability

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Abstract
Star fruit was an underutilized fruit crop in India. Star fruit was neglected due to perishable and higher moisture content, the fruit could not fetch good market and gone as waste. The study was conducted to evaluate nutritive composition and to develop food products from highly nutritious underutilized fruit. The fruit contain high amount of vitamin C (38.86 and 46.9 mg/100g for sour and sweet star fruit. The result shows that TSS , pH, ascorbic acid(mg/100g), total and non-reducing sugars (%) decreased from 75˚B – 74.37˚B, 3.06-2.96, 5.27-5.05, 64.67-62.49 and 8.26 – 5.32, respectively while acidity and reducing sugars(%) increased from 1.20 -1.37 and 55.98 -58.60 with the increase of storage intervals.
The prepared products viz., sweet star fruit and sour star fruit jam was subjected for sensory evaluation at different storage interval i.e.(fresh, 30 and 60 days of storage period) and products were found as acceptable in term of colour, taste and texture.

Keywords: star fruit, jam, *Averrhoa carambola*, nutritive value, shelf- life, sensory evaluation

Introduction
Fresh fruits and vegetables are very important part of our lives. They are also an important source of health promoting agents and known as protective foods as they provide vitamins, minerals and fiber required for maintaining good health.
In India we have diverse climate which provides the availability of fresh fruits and vegetables. India has tropical as well as subtropical fruits and vegetables one of such fruit is star fruit (*Averrhoa carambola)*. According to Press Information Bureau, Ministry of Agriculture, Government of India, India is the second largest producer of fruits in the world i.e. 82.632 million tonnes after china with 154.364 million tonnes. The post harvest losses during handling, transportation, storage, processing and distribution of fruits in India are between 17 to 35 per cent (Gajanan and Hedge, 2009; Fageria *et al.*, 2007). India has tropical as well as subtropical fruits and vegetables one of such fruit is star fruit (*Averrhoa carambola)*.
Averrhoa carambola has the highest antioxidant properties amongst the various Indian tropical fruits i.e. it is capable of fighting against free radicals as well as the damage caused due to free radicals (Amitabye *et al.*, 2003). Intake of fruits in the diet helps in lowering cholesterol, maintaining blood pressure and body weight. (Budhwar, S. 2008) [1]. The fruit exhibits potential antioxidants as it is a significant source of phenolic antioxidants (Saghir *et al*., 2013) [11]. This fruit have anti-inflammatory activity (Daniela Almeida Cabrini *et al*., 2011) [2], anti-ulcer activity (Ferreira *et al*., 2008) [3], hypoglycaemic activity as well as antimicrobial activity. In view of neutraceutical properties of Star fruits and to avoid their spoilage, the fruits can be processed into various products like jams, candy, pickles etc. This fruit if added in our diet can meet around 30% of our daily requirement of Vitamin C in just 100g.
By keeping in view the significance of this underutilized fruit attempts have been made to evaluate the nutritive composition and to develop food products for the benefit of the society

Materials and Methods
The fruit was procured from Delhi. The fruits were sorted, graded and washed under running tap water to remove adhering dirt etc. The fruit was analyzed for their physico-chemical analysis. The specific parameters viz fruit colour, flesh colour and shape were assessed by visual appearance. Physical methods viz., length and breadth of the fruit were assessed by using vernier caliper. The weight of the fruit was assessed by electronic weighing balance. The TSS and pH content was measured by hand refractometer and pH meter, respectively. The moisture, protein, fat, ash and fibre and sugars were estimated by (AOAC 1990). The carbohydrates were determined as (NIN 1983).
Total carbohydrates (%) = 100- (moisture %+ protein %+ fat % + fibre % + ash %)
The acidity, sugars and minerals were estimated (Ranganna 2007). The ascorbic acid, β-carotene, Vitamin A, anthocyannin and pectin were assessed by the method (Srivastava and Kumar 2003). The tannins, simple and total phenols were estimated by the method (Mekker *et al.*, 1993) [8, 9]. The NDF, ADF and hemicellulose contents were estimated by the method given by (Vansoest and Wine, 1967). The available/ digestible carbohydrates were determined by subtracting NDF from total carbohydrate. The unavailable/ indigestible carbohydrates were determined by subtracting available carbohydrate from total carbohydrate. The total energy was calculated by multiplying by the protein, fat and total carbohydrate by 4.0, 9.0 and 4.0, respectively and summing up the values. The available energy was calculated

by multiplying by the per cent protein, fat and available carbohydrate by 4.0, 9.0 and 4.0, respectively and summing up the values. The values were reported as KCal /100g on dry matter basis.

Sample Preparation

The procured fruits were washed thoroughly under running tap water. The juice was obtained by hot pulping method and stones were separated manually. The boiled material was cooled to room temperature and ground into a domestic grinder to obtain homogeneous pulp. The pulp was sieved with the help of muslin cloth. 1.0g sodium benzoate was added to 1 litre of pulp and stored in pre-sterilized glass bottles for preparation of functional beverages. The functional beverages were prepared as per the FPO specifications. The prepared beverages were heated to 85^0C, poured in to sterilized 200ml bottles, sealed with crown cork and heat processed by dipping in boiling water for 20 minutes at 85 ^{0}C. The beverages were assessed for their nutritional analysis as per the methods (Ranganna, 2007). The 9 point Hedonic scale (Larmond, 1977) [7] was employed for the sensory evaluation of prepared products. The prepared products were evaluated organoleptically for colour, taste, flavour, texture/consistency and overall acceptability to a panel of 10 judges by using 9 point Hedonic scale.

Result and Discussion

Quality evaluation of products

The recipe was standardized in the laboratory and prepared product was evaluated for its nutritional profile.

The total soluble solids in sour star fruit jam was 67 + 0.01 B and in sweet star fruit jam was 65 + 0.01 ºB which is similar to the FAO (food and agriculture organisation) United Nations standards for fruit jam. According to FAO, TSS of the fruit marmalade must be 65° Brix and above. Also According to FSSAI (2010) the total soluble solids in the fruit jam must not be less than 65.0° B Similar findings have been reported by Jena (2013) [5] who developed jam utilising passion fruit skin and passion fruit juice and quoted that the TSS of the jam must be 65-68 °Brix. Shekhawat *et al.* (2014) [12] and Singh *et al*. (2005d) [13] stated that the TSS of the jam should be 45-68%.

The data regarding pH content reveal that pH of sour and sweet star fruit jam was 1.63 + 0.01 and 3.58 + 0.01, respectively. According to FAO (Food and Agriculture organisation) United Nations standards for jam, the ideal pH for the fruit jam must be 3.2- 3.4. Jena (2013) [5] reported that the pH of the jam prepared from the passion fruit skin and passion fruit juice was 3.23- 2.69. The sour star fruit jam and the sweet star fruit jam have the titrable acidity of 1.00 + 0.01 and 0.98 + 0.01 respectively.

The sour star fruit jam and the sweet star fruit jam have the vitamin C content of 1.00 + 0.01 mg and 0.98 + 0.01 mg respectively this is in accordance with Trivedi *et al*. (2017) [14] who reported that the average Vitamin C content in the star fruit jam was 5 mg

The moisture content in sour and sweet star fruit jam was 25.96 + 0.43 and 17.37 + 0.31 g/100g this is similar to FAO (food and agriculture organization) United Nations regulations for jam which states that the ideal moisture content must be 29.8-29.6%. Similar findings have been reported by Gupta *et al*. (2016) [4].

The ash content in sour and sweet star fruit jam were noted as 0.32 + 0.02 and 0.23 + 0.02 g/100g, respectively.

The protein content in sour and sweet star fruit jam was1.27 + 0.05 and 1.30 + 0.01 g/100g this is in close agreement with Trivedi *et al*. (2017) [14] who observed average protein content in the star fruit jam was 0.88 g/100g. The fat content in sour and sweet star fruit jam was 0.38 + 0.02 and 0.78 + 0.01 g/100g. Our values for fat content are within the range (0.19 g/100g and 0.18 g/100 g) reported by Trivedi *et al*. (2017) [14] and Gupta *et al*. (2016) [4].

The average carbohydrate content in sour and sweet star fruit jam was 73.30 + 0.35 and 80.30 + 0.30 g/100g respectively. Trivedi *et al*. (2017) [14] evaluated the nutritional composition of star fruit jam and stated that the average carbohydrate content in the star fruit jam was 44.89 g/100g.

The total energy content of sour star fruit jam was 297.78 + 2.71 g/100g and in sweet star fruit jam was 333.49 + 1.15 g/100g. Similar findings have been reported by Gupta *et al*. (2016) [4] who observed the energy content in the papaya-gooseberry jam was 314 kcal.

Effect of storage on sensory evaluation of products

The sensory scores for Jam show that the colour scores decreased during 60 days of storage. Similar finding have been reported by Gupta *et al*. (2016) [4]. The taste, flavor and texture scores were also decreased with the enhancement of storage interval. The overall acceptability scores ranged within acceptable limits even up to storage of 60 days.

Table 1: Nutritional Quality assessment of jam prepared using Star Fruit. (*Averrhoa carambola*)

Sr. No.	Parameters	Sour Star Fruit Jam			Sweet Star Fruit Jam		
1.	Storage time	Fresh	30 Days	60 Days	Fresh	30 Days	60 Days
2.	TSS	67 + 0.01	67.6 + 0.01	68.0 + 0.01	65 + 0.01	66.5 +0.01	67.2 + 0.01
3.	pH	1.63 + 0.01	1.99 + 0.01	2.13 + 0.01	3.58 + 0.01	3.85 +0.01	4.26 + 0.01
4.	Titrable Acidity	1.00 + 0.01	1.44 + 0.01	1.68 + 0.01	0.98 + 0.01	1.22 +0.01	1.66 + 0.01
5.	Moisture	25.96 + 0.43	24.33 + 0.25	23.65 + 0.63	17.37 + 0.31	16.24 +0.56	15.36 + 0.51
6.	Total Ash	0.32 + 0.02	0.31 + 0.01	0.29 + 0.01	0.23 + 0.02	0.21 +0.01	0.19 + 0.02
7.	Crude Protein	1.27 + 0.05	1.16 + 0.06	1.12 + 0.01	1.30 + 0.01	1.26 +0.03	1.22 + 0.01
8.	Crude Fat	0.38 + 0.02	0.31 + 0.03	0.28 + 0.05	0.78 + 0.01	0.66 +0.04	0.59 + 0.03
9.	Total Carbohydrates	73.30 + 0.35	73.89 + 0.28	74.66 + 0.26	80.30 + 0.30	81.63 +0.66	82.64 + 0.43
10.	Total Energy	297.78 + 2.71	302.99 + 1.94	305.64 + 0.99	333.49 + 1.15	337.5 +1.00	340.75 + 0.96
11.	Vitamin C	32.7 + 1.1	31.22+ 1.2	31.92+ 1.2	35.7 + 1.1	35.1+ 1.4	34.90+ 1.3

Value are mean + SD; n=4

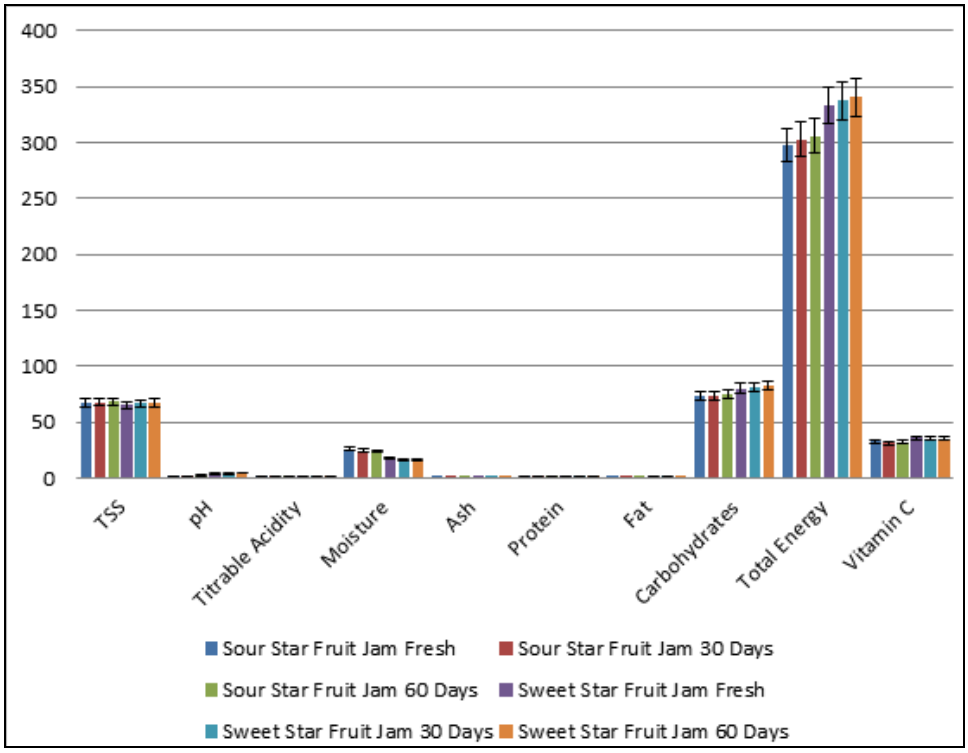

Fig 1: Nutritional Quality assessment of jam prepared using Star Fruit. (*Averrhoa carambola*)

Table 2: Sensory scores (on the basis of 9.0) of star fruit *Jam* as affected storage intervals

Sr. No.	Product	Sour Star Fruit Jam			Sweet Star Fruit Jam		
	Storage Time	Fresh	30 Days	60 Days	Fresh	30 Days	60 Days
1.	Colour	6.5 + 0.25	6.1 + 0.15	5.8 + 0.19	8.8 + 0.33	8.6 + 0.13	8.5 + 0.21
2.	Appearance	6.2 + 0.15	6.0 + 0.13	5.8 + 0.14	8.9 + 0.35	8.6 + 0.25	8.4 + 0.14
3.	Flavour	6.6 + 0.23	6.3 + 0.17	6.1 + 0.11	8.8 + 0.22	8.4 + 0.16	8.1 + 0.19
4.	Texture	6.4 + 0.29	6.0 + 0.14	5.7 + 0.18	8.3 + 0.09	7.9 + 0.14	7.4 + 0.20
5.	Taste	6.2 + 0.19	5.9 + 0.14	5.7 + 0.16	8.5 + 0.01	8.1 + 0.15	7.8 + 0.08
6.	Overall acceptability	6.4 + 0.22	6.01 + 0.11	5.7 + 0.12	8.9 + 0.05	8.6 + 0.17	8.1 + 0.21

Value are mean + SD; n=15

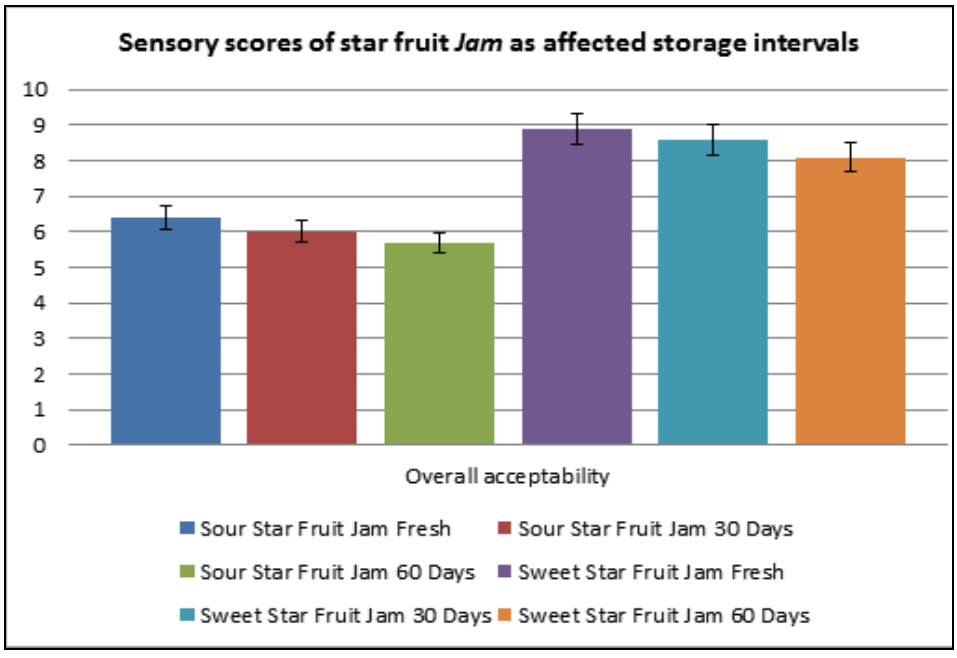

Fig 2: Sensory scores (on the basis of 9.0) of star fruit *Jam* as affected storage intervals

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