

Development and quality evaluation of antioxidant rich star fruit beverages (*Averrhoa carambola*)

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Consumption of various types of fruit provides excellent health benefits because they are good source of phytochemicals and prevent many diseases. The protective action of fruits and vegetables has been attributed to the presence of antioxidants. In this view of above, the present study had been planned with the objectives to develop and assess the nutritional, antioxidant and shelf-life properties of antioxidant rich healthy beverages formulated using star fruit. Moisture, crude protein, crude fat, total ash and carbohydrate content present in *Squash* was 48.71 ± 0.19 g, 0.2 ± 0.01 g, 0.17 ± 0.005 g, 50.87 ± 0.20 g per 100 g, respectively. Crude fibre was not present in *Squash*. The energy value was 204.63 ± 0.77 kcal per 100 g. Developed *Squash* had contained 19.17 ± 0.21 mg calcium, 0.05 ± 0.01 mg potassium and 1.27 ± 0.04 mg magnesium per 100 g. In this sequence, proximate composition of *Cordial* was; moisture 54.03 ± 0.02 g, total ash 0.15 ± 0.01 g, carbohydrate 45.82 ± 0.01 g and energy 183.28 ± 0.06 kcal per 100 g. Crude protein, crude fat and crude fibre was detected in *Cordial*. Mineral content in *Cordial* which includes calcium, potassium and magnesium was 0.05 ± 0.005 mg, 0.05 ± 0.01 mg and 0.02 ± 0.005 mg per 100 g, respectively. The total antioxidant activity, total phenolic content and ascorbic acid present in *Squash* was 70.91 ± 0.38 %, 261.71 ± 0.49 and 2.09 ± 0.19 mg per 100, g respectively. Total antioxidant capacity in *Cordial* was 67.82 ± 0.26 %. The total phenolic content and ascorbic acid value of *Cordial* was 244.03 ± 0.49 and 1.46 ± 0.14 mg per 100 g, respectively. The organoleptic scores for *Squash* and *Cordial* during storage were slightly decreases during the storage period (0th to 90th days) but the scores were between “liked moderately” to “liked very much”. The effect of storage on total antioxidant capacity of *Squash* and *Cordial* revealed that during the storage period the total antioxidant activity was decreases, but it was in the range from 70.91 ± 0.38 % to 64.65 ± 0.11 % for *Squash* and 67.82 ± 0.26 % to 60.26 ± 0.15 % for *Cordial*. So, it was concluded that developed *Squash* and *Cordial* were found highly acceptable when they were developed using Star Fruits.

Key Words : Star fruit, Phy- tochemicals, Antioxidant, Phenolic compound, Vitamin C, Shelf-life, Organoleptic evaluation

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INTRODUCTION

Antioxidants could reduce oxidative damages to biomolecules by modulating reactive free radicals. An increasingly growing market for nutraceuticals and functional foods has triggered the study on natural sources of antioxidants and their potential for nutraceutical and functional foods (Cevallos-Casals and Cisneros-Zevallos,

2003; Lachance, 2002 and Lachance *et al.*, 2001). Star fruit which is also known as 'Carambolas' one of the underutilized tropical fruits that belongs to Oxalidaceae family and popular in Southeast Asia countries (Lim *et al.*, 2007). Star fruits have a unique aroma volatile profile contributing to a sweet floral flavour. Star fruits is valued as a rich source of both primary and secondary polyphenolic antioxidants (Shui and Leong, 2006 and Shinzo *et al.*, 2008) and several studies revealed that star fruit containing as high antioxidant level as guava, papaya and banana (Lim *et al.*, 2007). In India, the ripe star fruit is administered to stop bleeding hemorrhoids. It is also used to calm the stomach, cure diarrhea and is even used as a hangover cure.

Today due to major concern of people on their healthy diet, food industries developed different types of nutritional food products by using different types of underutilized food items. As according to Avinash *et al.* (2010) the fresh star fruits are used in jelly making, for garnishing salads and to prepare drinks. In some Asian countries, the green mature fruit is relished and consumed fresh and used in pickle preparations. Considering the all above facts, the present study was planned with the objectives to develop and assess the nutritional, antioxidant and shelf-life properties and effect of storage on antioxidant rich healthy beverages formulated with star fruit.

METHODOLOGY

Development of antioxidant rich healthy beverages using star fruits:

Procurement of sample:

Fresh star fruit samples were collected from the local fruit markets in Udaipur, Rajasthan during the months between October to December. The purchase was made in single lot from the market. The green fruits were selected to avoid effect of maturity of fruit, if any.

Preparation of products:

Squash and *Cordial* were prepared through modification into the basic recipes. The star fruit was

Ingredients	Amount
Star fruit juice	350 ml
Sugar	400 g
Water	250 ml
Potassium meta bisulfate	522.85g

added in an amount which was suitable for the product and recipe. Designed recipes of the formulated products have been presented below:

Procedure:

Take fresh fruits; wash them thoroughly in running water and remove the seeds and edges and cut them into pieces. Take the fruits in mixer and blend them and strain the juice through muslin cloth to remove the pulp. Add sugar in the juice and potassium meta bisulfate in small amount of water and mix it with the rest of the product. Store it in airtight bottle.

Ingredients	Amount
Star fruit juice	310 ml
Sugar	380 g
Water	310 ml
Potassium meta bisulfate	2.10 ram

Procedure:

Take fresh fruits and wash them thoroughly in tap water and remove seeds and edges from the fruit and blend it in a mixture. Extract the juice through muslin cloth to remove the pulp and store the juice in a glass container to settle for about 10-15 days after adding 975 mg of potassium meta bisulfate. Decant the clear juice without disturbing the sediment and strain it through fine muslin cloth. Mix the ingredients thoroughly and strain the product through fine muslin cloth. Add rest of potassium meta bisulfate of the finished product. Bottle and store finished product in a cool dry place.

Nutritional evaluation of developed antioxidant rich healthy beverages by using star fruits:

The developed beverages were analyzed for their nutrient contents such as proximate and mineral contents of developed products.

Total antioxidant capacity:

The developed beverages were analyzed for their total antioxidant capacity such as total anti-oxidant activity (%), phenolic component and vitamin C using standardized procedure.

Shelf-life assessment:

In present study, the formulated star fruit products

i.e. Squash and Cordial were packed in plastic air tight bottles and kept in ambient temperature and subjected to sensory analysis by a selected group of panelists for their individual sensory attributes, at monthly intervals for a period of three months. The sensory scores assigned by the panel members at nine-point Hedonic Rating Scale during entire storage duration were statistically analyzed. Again their total antioxidant capacity was analyzed at monthly intervals for a period of three months using standardized procedure.

Statistical analysis:

Mean and Standard deviation were used to assess the nutritional, antioxidant and shelf -life characteristics of the developed beverages.

OBSERVATIONS AND ASSESSMENT

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Nutritional evaluation of developed antioxidant rich beverages:

Star fruit used in a number of innovative ways to make *Squash, Cordial*, juice etc. Moisture, crude protein, crude fat, total ash and carbohydrate content present in *Squash* was 48.71 ± 0.19 g, 0.2 ± 0.01 g, 0.17 ± 0.005 g, 50.87 ± 0.20 g per 100 g, respectively. Crude fibre was not present in *Squash*. The energy value was 204.63 ± 0.77 kcal per 100 g. Monalisa *et al.* (2014) also studied that the proximate values of *Squash* including moisture, protein, fat, ash, fibre, carbohydrate and energy was $57.20\pm 0.02\%$,

0.29 ± 0.01 %, $0.08\pm 0.02\%$, $0.47\pm 0.01\%$, 0.08 ± 0.01 %, 42.04 ± 0.01 % and 170.04 ± 0.08 % per 100 g, respectively. Developed *Squash* had contained 19.17 ± 0.21 mg calcium, 0.05 ± 0.01 mg potassium and 1.27 ± 0.04 mg magnesium per 100 g. Iron was in negligible amount. In this sequence, proximate composition of *Cordial* was; moisture 54.03 ± 0.02 g, total ash 0.15 ± 0.01 g, carbohydrate 45.82 ± 0.01 g and energy 183.28 ± 0.06 kcal per 100 g. Crude protein, crude fat and crude fibre was detected in *Cordial*. Mineral content in *Cordial* which includes calcium, potassium and magnesium was 0.05 ± 0.005 mg, 0.05 ± 0.01 mg and 0.02 ± 0.005 mg per 100 g, respectively and iron was in negligible amount present in *Cordial*.

Total antioxidant capacity of developed antioxidant rich beverages:

Phenolic compounds are closely associated with the sensory and nutritional quality of foods, contributing directly or indirectly to desirable or undesirable aroma and taste. Phenolics may protect food from oxidative deterioration in low concentration, thus, they are good antioxidants and substrates for prevention of oxidative browning. However, at high concentrations, they (or their oxidative products) may participate in discoloration of foods, and interact with proteins, carbohydrates and minerals (Imeh and Khokhar, 2002). The total antioxidant capacity of developed beverages of star fruits are presented in Table 2. The table shows the total antioxidant activity, total phenolic content and ascorbic acid present in star fruit *Squash* and *Cordial*. The total antioxidant activity, total phenolic content and ascorbic acid present

Table 1: Nutritional composition of developed antioxidant rich beverages

Nutrients (per 100 g)	<i>Squash</i>	<i>Cordial</i>
Moisture (g)	48.71 ± 0.19	54.03 ± 0.02
Crude protein (g)	0.2 ± 0.01	0
Crude fat (g)	0.03 ± 0.005	0
Total ash (g)	0.17 ± 0.005	0.15 ± 0.01
Crude fibre (g)	0	0
Carbohydrates (g)	50.87 ± 0.20	45.82 ± 0.01
Energy (kcal)	204.63 ± 0.77	183.28 ± 0.06
Calcium	19.17 ± 0.21	0.05 ± 0.005
Potassium	0.05 ± 0.01	0.05 ± 0.01
Magnesium	1.27 ± 0.04	0.02 ± 0.005
Iron	0	0

in *Squash* was 70.91 ± 0.38 %, 261.71 ± 0.49 and 2.09 ± 0.19 mg per 100 g, respectively. Total antioxidant capacity in *Cordial* was 67.82 ± 0.26 %. The total phenolic content and ascorbic acid value of *Cordial* was 244.03 ± 0.49 and 1.46 ± 0.14 mg per 100 g, respectively.

Shelf-life assessment:

The effect of storage on organoleptic attributes of *Squash* and *Cordial* has been presented in Table 3. The score of colour attribute of *Squash* ranged from 7.8 ± 0.42 to 7.35 ± 0.33 during the period of 0th to 90th days. Taste and flavor ranged from 8.0 ± 0.40 and 8.0 ± 0.40 on 0th days by the panelist slightly decreases during the storage period (0th to 90th days) but the scores were between “liked moderately” to “liked very much”. The overall acceptability of the *Squash* was between the range of “liked moderately” to “liked very much” during the whole storage period. The scores of sensory attributes of *Cordial* indicates that the product was also in the range of “liked moderately” to “liked very much” during the whole storage period. The taste of the *Cordial* during

the storage period (0th to 90th day) was between 7.85 ± 0.47 to 7.3 ± 0.25 . The flavour and appearance scores of the *Cordial* during the storage period (0th to 90th day) was 7.4 ± 0.39 to 7.05 ± 0.36 and 7.35 ± 0.41 to 7.0 ± 0.33 respectively, which indicates that the product was acceptable even after ninety days of the storage. The overall acceptability scores were found 7.63 ± 0.19 on 0th days and 7.21 ± 0.12 on 90th days of the storage. The results clearly indicate that the scores of *Squash* and *Cordial* were found to follow a reducing trend with the progression of the storage period. However, even after significant reduction developed beverages were in the acceptability zone even at three months of their storage.

The effect of storage on total antioxidant capacity of *Squash* and *Cordial* has been presented in Table 4. The table consists of total antioxidant activity, total phenolic content and ascorbic acid values of *Squash* which indicate that the antioxidant activity during storage was in the range of 70.91 ± 0.38 % (zero days) to 64.65 ± 0.11 % (ninety days). The total phenolic content was ranged

Table 2 : Total antioxidant capacity of developed antioxidant rich beverages

Anti-oxidants	Squash	Cordial
Total anti-oxidant activity (%)	70.91 ± 0.38	67.82 ± 0.26
Phenolic component	261.71 ± 0.49	244.03 ± 0.49
Vitamin C	2.09 ± 0.19	1.46 ± 0.14

Table 3: Effect of storage on organoleptic attributes of developed antioxidant rich beverages

Parameters	Effect of storage on organoleptic attributes							
	0 days		30 days		60 days		90 days	
	<i>Squash</i>	<i>Cordial</i>	<i>Squash</i>	<i>Cordial</i>	<i>Squash</i>	<i>Cordial</i>	<i>Squash</i>	<i>Cordial</i>
Colour	7.8 ± 0.42	7.95 ± 0.36	7.75 ± 0.48	7.85 ± 0.33	7.5 ± 0.40	7.7 ± 0.34	7.35 ± 0.33	7.45 ± 0.36
Taste	8.0 ± 0.40	7.85 ± 0.47	7.9 ± 0.31	7.65 ± 0.33	7.8 ± 0.48	7.45 ± 0.36	7.5 ± 0.40	7.3 ± 0.25
Consistency	7.55 ± 0.43	7.6 ± 0.39	7.45 ± 0.36	7.55 ± 0.36	7.25 ± 0.26	7.35 ± 0.33	7.15 ± 0.33	7.25 ± 0.26
Flavour	8.0 ± 0.40	7.4 ± 0.39	7.85 ± 0.33	7.25 ± 0.26	7.7 ± 0.25	7.15 ± 0.33	7.4 ± 0.31	7.05 ± 0.36
Appearance	7.9 ± 0.39	7.35 ± 0.41	7.85 ± 0.41	7.25 ± 0.26	7.75 ± 0.48	7.2 ± 0.34	7.45 ± 0.36	7.0 ± 0.33
Overall acceptability	7.85 ± 0.20	7.63 ± 0.19	7.76 ± 0.27	7.51 ± 0.19	7.6 ± 0.29	7.37 ± 0.16	7.37 ± 0.18	7.21 ± 0.12

Table 4: Effect of storage on total antioxidant capacity of developed antioxidant rich beverages

Parameters	Effect of storage on total antioxidant capacity							
	0 days		30 days		60 days		90 days	
	<i>Squash</i>	<i>Cordial</i>	<i>Squash</i>	<i>Cordial</i>	<i>Squash</i>	<i>Cordial</i>	<i>Squash</i>	<i>Cordial</i>
Total antioxidant activity	70.91 ± 0.38	67.82 ± 0.26	68.30 ± 0.16	65.83 ± 0.29	65.65 ± 0.21	63.32 ± 0.30	64.65 ± 0.11	60.26 ± 0.15
Total phenolic content	261.71 ± 0.49	244.03 ± 0.49	252.34 ± 0.32	238.31 ± 0.32	238.29 ± 0.30	218.53 ± 0.21	228.30 ± 0.23	194.59 ± 0.29
Vitamin C	2.09 ± 0.19	1.46 ± 0.14	1.58 ± 0.34	1.30 ± 0.11	0.88 ± 0.09	1.05 ± 0.04	0.80 ± 0.07	0.89 ± 0.05

between 261.71 ± 0.49 (zero days) mg per 100 g to 228.30 ± 0.23 (ninety days) mg per 100 g. Similarly, the ascorbic acid values were ranged between 2.09 ± 0.19 (zero days) mg per 100 g to 0.80 ± 0.07 (ninety days) mg per 100 g. The table indicates that during the storage period the total antioxidant capacity was decreases.

Regarding the total antioxidant capacity of *Cordial*, the effect of storage has been presented in the Table 4. The table shows the antioxidant activity during storage of 0, 30, 60 and 90 days were 67.82 ± 0.26 , 65.83 ± 0.29 , 63.32 ± 0.30 and 60.26 ± 0.15 %, respectively. Similarly the values of total phenolic content were for 0 days 244.03 ± 4.49 and 90 days was 194.59 ± 0.29 mg per 100 g. The ascorbic acid during the storage ranged from 1.46 ± 0.14 (zero days) to 0.89 ± 0.05 (ninety days) mg per 100 g. The table shows significant decrease of total antioxidant capacity.

Summary and conclusion:

Thus, in present study the quality evaluation like nutritional properties, total antioxidant activity and effect of storage of developed antioxidant rich healthy beverages revealed that developed *Squash* and *Cordial* were found highly acceptable when they were developed using Star Fruit. These drinks may add freshness in summers and can serve as ready source of energy.

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