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Development and standardization of dragon fruit based squash and its stability during storage

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ABSTRACT

India is aiming to become self-reliant in production of dragon fruit within a decade and also it gained much potential to match China's production. The cultivation of the fruit in India has been planned to rise from 3000 hectare to 50000 hectare in 5 years. Hence in order to absorb the stockpile in future, the development of value added products of dragon fruit is necessary. Hence, investigations were conducted to develop dragon fruit squash and evaluate the standardized squash for 60 days period. Initially, the squash was prepared using different proportion of dragon fruit pulp (30, 40 and 50 percent) and total soluble solids (40, 42 and 45 ºBrix) to finalise the base recipe. After optimizing base recipe, the squash further subjected to standardization process by blending different proportions of Dragon-Gauva with 400 ppm sodium benzoate. Thus in this process, the treatment T-7 i.e Dragon-Gauva (30:10) at 45º Brix with 400 ppm sodium benzoate was awarded best even at 60 days of refrigerated storage, based on nutritional containment such as TSS, titratable acidity, total sugars, reducing sugars, total acidity and sensory score such as color, taste, aroma and over all acceptability.

Keywords: Dragon fruit, fruit beverage, postharvest, storage.

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INTRODUCTION

Every year more than 500 edible fruits are cultivated in tropical and subtropical regions, but only less than 15 of them are commercially processed (Luu *et al*. 2021). Dragon fruit (genus *Hylocereus*, family Cactaceae) is one of the upcoming fruit in these regions; its market is growing at a robust rate, and is projected to register a CAGR of 3.7% over the forecast period. Additionally, the demand for this exotic tropical fruit is on rise in recent years due to various health benefits (Mordor Intelligence, 2022). In the developing countries the fruit gained immense popularity due to due to its commercial scope, least inputs for

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cultivation, easy adaptation to variable light intensities and temperatures, high tolerance to drought and soil salinities, it also reported to provide nutraceutical as well as pharmaceutical benefits to human health (Nobel and La Barrera 2004; Nie et al. 2015; Crane et al. 2017; Mercado-Silva 2018). Considering the expected future production of dragon fruit which requires urgent and unquestionably processing technologies for development of various value added products and also subsequent reliable adaptation to these technological innovations, will be will not only diversify the fruit product but also limits post harvest losses in fruits. The commercially fruit comes in three varieties i.e. *Hylocereus undatus* (with white pulp), *Hylocereus polyrhizus* (with red pulp), and *Selenicereus megalanthus* (with yellow) these species are long, ovoid or cylindrical (Paul and Duarte 2012).

Dragon fruit has unique nutritional and functional components as it contains significant amounts of minerals such as, phosphorus, potassium, magnesium and sodium. Among the vitamins, vitamin C and vitamin B3 are at higher concentrations whereas, vitamins B1, B2 and vitamin A at lower. The sugars in dragon fruit are glucose, fructose and lower amount of sorbitol. Dragon fruit is classified as low acid food as its pH values varies between 4.4 and 5.1 which is due to malic acid being the major acid in the fruit. The moisture content of dragon fruit is high amount i.e 83-89 g/100 g fresh weight, which accounts for the juicy attribute of the fruit. The estimated energy value of dragon fruit varies between 130 kJ/100 g to 283 kJ/100 g. owning these nutritional attributes, the dragon fruit got much attention from the researchers and can be processed into different products. At present minimal processing of dragon fruit can been practiced for the preparation of products to preserve the essential sensory attributes. The fruit has better scope for development of process technologies for development of squash to make RTS juice and to preserve for extended period. Guava is a seasonal tropical fruit and is highly perishable, which is widely consumed as a fresh or processed food product. But the utility of guava is still very low due to the post-harvest losses and causes disposal problems (Pommer *et al*. 2009; Mercado-Silva *et al*. 1998) apart from these constraints guava also has a unique pleasant aroma and is good source pectin which can act as perfect natural stabilizer for the squash preparation. Another fruit blend, Kokum (*Garcinia indica*) is an ancient fruit which is widely consumed in a western ghat of India. Kokum is a fruit tree of culinary, pharmaceutical, nutraceutical uses. It has a long history in Ayurvedic medicine as it was traditionally used for treatment of different health related problems like sores, dermatitis, diarrhea, dysentery, ear infection and to facilitate digestion. Kokum fruit is rich in antioxidant, acidulant and appetite stimulant properties that help to fight against cancer, paralysis, ageing, obesity, ulcer etc (Manoj et al. 2019). It also aids good coloring agent and hence can be a good blending additive for the preparation of dragon fruit squash. Blending of dragon fruit pulp (white) with guava and kokum fruit pulp offers wide scope to develop healthy blended squash with improved color, taste, and flavor and over all acceptability. The findings of present study would be useful for producers, processors, marketing agencies and consumers.

MATERIALS AND METHODS

Materials: All chemicals and reagents used in the experiments were of analytical grade and purchased mostly from Fisher Scientific, Sigma Aldrich and Himedia, India.

Sample Collection: The fully ripened dragon fruits were procured from local market of Raichur, Karnataka, India. The scales were removed from the fruit, washed; air dried, and then pulped using a mechanical pulper. The pulp was packed in low-density polyethylene (LDPE) bags and stored at −10 °C till further beverage preparation and analysis.

Development and standardization of recipe for the preparation of dragon fruit squash

The pulp is strained to separate any unwanted material from the pulp before it is subjected to blending process using a homogenizer (Model: Scientech SE-151 Emulsifiers Homogenizer) FSSAI specifications were followed for preparation of dragon fruit squash from ripe pulp. Preliminary standardization of squash using different combinations of dragon pulp (%) and sugar solution (TSS, ºB) were used as mentioned in table 1. The concentration of acid is kept constant at 1.2% using citric acid in all the combinations. The squash was filled in a sterilized glass bottles leaving sufficient head space and sealed. Dragon fruit squash of different combinations after dilution (1:4) was served to 7 sensory panelists for sensory evaluation. The combination which received the highest overall acceptability score was selected as a base recipe for further studies.

Table 1: Treatment detail of dragon fruit squash

Treatment (G)	Dragon Pulp (%)	TSS (ºB)
G_1	30	40
G_2	40	40
G_3	50	40
G_4	30	42
G_5	40	42
G_6	50	42
G_7	30	45
G_8	**40**	**45**
G_9	50	45

In process of standardization of squash prepared from pulp and TSS, panelist recommended to improve the product in terms of flavor, color and stabilization. Hence, further standardization of dragon fruit squash was done by blending with proportion of guava pulp which acts as natural stabilizer, kokum fruit as natural colorant and preservative sodium benzoate as shown in the table 2. The physic-chemical and sensory characteristics of all the products were estimated at 0, 30 and 60 days of storage

Table 2: Detail of treatment combinations

Treatment combinations	Symbols
Control (40% Dragon pulp with 40 (ºB) TSS	T-0
Dragon-Gauva (20:20) with 40 (ºB) TSS	T-1
Dragon-Gauva (25:15) with 40 (ºB) TSS	T-2
Dragon-Gauva (30:10) with 40 (ºB) TSS)	T-3
Dragon-Gauva (35:05) with 40 TSS	T-4
Dragon-Gauva (20:20) with 45 (ºB) TSS	T-5
Dragon-Gauva (25:15) with 45 (ºB) TSS	T-6
Dragon-Gauva (30:10) with 45 (ºB) TSS)	**T-7**
Dragon-Gauva (35:05) with 45 (ºB) TSS	T-8

Physico-chemical analyses

The viscosity of the squash was determined by using rheometer (Anton Paar). Total soluble solids was measured by using ERMA company made hand refractometer at ambient temperature whereas, the titratable acidity was determined by titrating known quantity of sample against 0.1 N sodium hydroxide solution using phenolphthalein as an indicator and expressed in per cent anhydrous citric acid (AOAC, 2012). The total and reducing sugars were analysed by using Fehling's solution A and B and methylene blue as an indicator (AOAC, 2012) and the total acids were estimated by titration against N/10 sodium hydroxide (Ranganna, 1977).

Sensory analyses

A panel of 10 semi trained judges evaluated RTS for its color, body, taste, aroma and overall acceptability on 9-point Hedonic scale. The data for quantitative analysis of various physico-chemical attributes were analysed by Completely Randomized Design (CRD) while the data on sensory evaluation were analysed by Randomized block design (RBD).

Statistical analysis

Data on physico-chemical characteristics of squash were analysed by completely randomized design (CRD) before and during storage whereas data pertaining to the sensory evaluation were analyzed by using randomized block design (RBD) as described by O'Mahony (1985). The experiments on recipe standardization and for storage studies were replicated three times.

RESULTS AND DISCUSSION

Standardization of recipe for preparation of dragon squash

The recipes of different treatments as mentioned in the table no. 1 were subjected to sensory evaluation and the results (Figure 1) indicated that treatment G_8 (40 % pulp and 45 ºB TSS) was accorded the highest scores among all the sensory characteristics. Therefore, this treatment (G_8) was selected as a base for further studies to optimize process technology for dragon fruit squash considering the feedback by the panelists which revealed that the flavor, stability and color of the product is required to be improved. Keeping the remarks provided by panelist in view, the squash was prepared by blending dragon fruit pulp with different proportions of guava pulp which acts as natural stabilizer, kokum concentrate as the natural color as well as preservative sodium benzoate. Further, the prepared squash samples with different combination as shown table 2 were subjected to sensory evaluation by a panel of 7 judges. The data showed that significantly higher score for color (8.2), taste (8.13), aroma (7.97) and overall acceptability (8.49) was awarded to T_7 i.e [Dragon-Guava squash of (30:10) with 400 ppm sodium benzoate]. Whereas, T_3 and T_6 scored second and third higher score respectively. The prepared squash was kept at refrigerated condition (5-8ºC) for further analysis. The physico-chemical and sensory characteristics of best three results T_3, T_6 and T_7 were estimated at 0, 30 and 60 days of storage.

Fig 1: Concentrated Kokum blended Dragon-Guava Squash

Total soluble solids

The data pertaining to the effect of different treatments on TSS of Dragon-Guava squash during storage is given in Table 3. From the table it is evident that among the different treatments maximum mean value of 46.37 °B was recorded in T_3 (Dragon-Guava) squash of 30:10 at 40° brix with 400 ppm sodium benzoate and minimum mean value of 46.80 °B in T_4 (Dragon-Gauva) squash of 35:05 with 400 ppm sodium benzoate Reducing sugars of squash showed a significant increase in TSS might be due to the hydrolysis of polysaccharides like pectin and starch into monosaccharides and soluble disaccharides i.e simple sugars. The results are in conformity with the findings of Diwedi and Pathak (2012) in mulberry squash, Kayshar et al. (2014) in mixed fruit squash and Shahid et al. (2015) in mango-mandarin squash.

Table 3: Effect of different treatments and storage on total soluble solids (ºB) and titratable acidity (%) of Dragon-Gauva squash

Treatment (T)	Total soluble solids (ºB) Storage interval, S (days)				Titratable acidity (%) Storage interval, (S) (days)			
	0	30	60	**Mean**	0	30	60	**Mean**
T_3	45.00	46.40	47.72	**46.37**	1.3	1.24	1.19	**1.24**
T_6	45.00	46.62	46.80	**45.87**	1.3	1.20	1.12	**1.20**
T_7	45.00	46.40	46.91	**46.10**	1.3	1.19	1.06	**1.18**
Mean	45.00	46.47	47.14		1.3	1.21	1.12	
$CD_{0.05}$	T (Treatments)= 0.04				T (Treatments)= 0.05			
	S (Storage interval)= 0.04				S (Storage interval)= 0.05			
	Interaction (TxS)= 0.06				Interaction (TxS)= 0.08			

Titratable acidity (%)

A general decrease in titratable acidity of squash was observed during storage, from table 3 it depicts that the maximum treatment in T_3 i.e 1.24 % (Dragon-Guava) squash of 30:10 at 40°Brix with 400 ppm sodium benzoate) and minimum mean of 1.18 % in T_7 (Dragon-Gauva) squash of 30:10 at 45° Brix with 400 ppm sodium benzoate were obtained. The increase trend might be due to co-polymerization of organic acids with sugars and amino acids. The results are in conformity with the findings of Chavan et al (2011) in pomegranate squash.

Total sugars (%)

There was a significant increase in total sugars of squash during 60 days of storage period (Table 4). The highest mean value (34.88 %) for total sugars was recorded in T_7 (Dragon-Guava) squash of 30:10 with 45 °Brix and 400 ppm sodium benzoate and the lowest (32.12 %) in T_3 squash of 30:10 and 400 ppm sodium benzoate. During storage of 60 days, the mean value for total sugars was found to increase significantly from 31.93 to 35.03 per cent. The increase in total sugars might be due to hydrolysis of starch into sugars as well as conversion of complex polysaccharides into simple sugars. Similar increase in sugars during storage has been reported by Ali et al. (2011) in seabuckthorn squash and Relekar et al. (2013) in sapota squash.

Reducing sugars (%)

The data collected on the effect of different treatments and storage intervals on reducing sugars of squash are appended in Table 4. The mean maximum (17.31%) and mean minimum (15.64%) reducing sugars were recorded for T_7 and T_3 respectively. The proportion in T_7 (Dragon-Gauva) is 30:10 with 45ºBrix and T_3 (Dragon-Gauva) is 30:10 were 400 ppm sodium benzoate used as preservative. The reducing sugars of pumpkin-guava squash increased from 15.26 to 17.42 per cent during the entire storage period of 60 days. Increase in reducing sugars may be due to hydrolysis of non-reducing sugars like sucrose in to reducing sugars (glucose and fructose) during storage. Similar observations have been reported by Sethi (1993) for litchi squash, Krishnaveni et al. (2001) for jack fruit squashes and Sood et al. (2009) had similar results in increased in reducing sugars of mango squash.

Table 4: Effect of different treatments and storage on Total sugars (%) and reducing sugars (%) of Dragon-Gauva squash

Treatment (T)	Total sugars (%) Storage interval, S (days)				Reducing sugars (%) Storage interval, (S) (days)			
	0	30	60	**Mean**	0	30	60	**Mean**
T_3	30.52	31.51	34.32	**32.12**	14.13	15.89	16.92	**15.64**
T_6	31.83	32.61	34.49	**32.98**	15.22	16.46	17.11	**16.26**
T_7	33.45	34.90	36.28	**34.88**	16.45	17.25	18.24	**17.31**
	31.93	**33.00**	**35.03**		**15.26**	**16.53**	**17.42**	
$CD_{0.05}$	T (Treatments)= 0.05				T (Treatments)= 0.04			
	S (Storage interval)= 0.05				S (Storage interval)= 0.04			
	Interaction (TxS)= 0.08				Interaction (TxS)= 0.07			

Table 5: Effect of different treatments and storage on Total sugars (%) and reducing sugars (%) of Dragon-Gauva squash

Treatment (T)	Apparent viscosity (poise) Storage interval, S (days)				Total acidity (%) Storage interval, (S) (days)			
	0	30	60	**Mean**	0	30	60	**Mean**
T_3	29243	32243	32146	**31210**	1.57	1.50	1.32	**1.46**
T_6	28223	30113	32111	**30149**	1.44	1.35	1.24	**1.34**
T_7	27149	29229	32002	**29460**	1.41	1.32	1.26	**1.33**
	28205	30528	32086		1.47	1.39	1.27	
$CD_{0.05}$	T (Treatments)= 0.05				T (Treatments)= 0.03			
	S (Storage interval)= 0.05				S (Storage interval)= 0.03			
	Interaction (TxS)= 0.08				Interaction (TxS)= 0.06			

Apparent viscosity

There was a significant increase in apparent viscosity of squash during storage period of 60 days (Table 5). This increase in apparent viscosity may be due to the increase in TSS and soluble sugars which increased strain and shearing rate and decreased the flow index. As the flow index decreases it helps in increases the apparent viscosity of the product and to develop pseudo-plasticity in the squash (Bal et al., 2014).

Total acidity (%)

Table 6 reveals that the acidity of the squash was higher in the T_7 (1.33%) treatment followed by T_6 (1.34), T_3 (1.46) squash, but it decreased with the increase in the storage period. After 60 days of storage, respectively. As depicted in the table the blending dragon fruit squash resulted in significant ($p \leq 0.05$) decrease in the value of acidity. Kannan and Thirumaran (2001) also opined that reduction in acidity during storage might be due to chemical reaction taking place between organic acids and pigments.

Table 6: Effect of different treatments and storage on sensory scores

Treatment (T)	Color				Taste				Aroma			
	Storage interval, S (days)				Storage interval, (S) (days)				Storage interval, (S) (days)			
	0	30	60	**Mean**	0	30	60	**Mean**	0	30	60	**Mean**
T_3	8.0	7.2	6.9	**7.37**	7.5	7.1	6.6	**7.07**	7.9	7.5	7.1	**7.50**
T_6	8.1	7.5	7.1	**7.57**	7.8	7.5	6.9	**7.40**	7.6	7.4	7.0	**7.33**
T_7	8.2	8.0	7.6	**7.93**	8.1	7.6	7.2	**7.63**	7.5	7.1	6.6	**7.07**
	8.1	7.5	7.2		7.8	7.4	6.9		7.67	7.33	6.9	
$CD_{0.05}$	T (Treatments)= 0.16 S (Storage interval)= 0.16 Interaction (TxS)= NS				T (Treatments)= 0.10 S (Storage interval)= 0.10 Interaction (TxS)= 17				T (Treatments)= 0.28 S (Storage interval)= 0.28 Interaction (TxS)= NS			

Table 7: Effect of different treatments and storage on overall acceptability

Treatment (T)	Overall acceptability Storage interval, S (days)			Mean
T_3	8.1	7.7	7.5	**7.77**
T_6	8.0	7.1	7.0	**7.37**
T_7	8.3	8.0	7.7	**8**
	8.13	7.6	7.4	
$CD_{0.05}$	T (Treatments)= 0.14 S (Storage interval)= 0.14 Interaction (TxS)=24			

Changes in sensory characteristics

The data from Table 6 and 7 reflect the sensory evaluation scores for Dragon-Gauva squash. The storage period as well as treatments had significantly affected the average scores for colour, taste and overall acceptability of dragon fruit squash. The highest scores were awarded to T_7 treatment of Dragon-Gauva squash (30:10 with 45 °Brix and 400 ppm sodium benzoate) for colour (8.2), taste (8.1), aroma (7.9) and overall acceptability (8.0). However, the average scores showed a decreasing trend in recipes of all the treatments for different attributes during storage but were found to be well above the acceptable limits. The mean scores were found to be decrease from 8.1 to 7.2 for colour, 7.8 to 6.9 for taste, 7.67 to 6.9 for aroma and 8.13 to 7.4 for overall acceptability during sixty days of storage. This decrease in sensory scores might be attributed to chemical changes or certain enzymatic and non-enzymatic reactions. A significant decreasing trend in sensory attributes has also been observed by Prasad and Mali (2000) in ber squash, Nidhi et al. (2008) in bael-guava beverage and Sood et al. (2009) in mango squash and Thakur (2014) in box myrtle squash during storage. Dragon fruit squash was highly acceptable and rich in nutritional components such as ascorbic acid, total sugars, TSS etc . Dragon-guava and kokum blended squash in a ratio of 30:10 with 45º Brix TSS was highly acceptable by the panelist (Table 7). During the storage study, it was observed that there was slight deterioration in the chemical composition of the squash as well as in sensory parameters but they were all in the acceptable limit.

CONCLUSION

The treatment G_7 where the dragon fruit of 40 per cent pulp with 45 TSS °Brix is used for preparation of squash and was analysed and suggested best in terms of flavor, stability and color based on the feedback provided by panelists. Further, the optimized treatment i.e G_7 was taken as a base to prepare 8 more samples (including control) with blend of dragon fruit pulp, guava pulp, kokum concentrate and sodium benzoate. Thus, among all T_7 i.e (Dragon-Guava) squash of 30:10 with 400 ppm sodium benzoate) was awarded best even after 60 days in terms in containing nutrition such as TSS, titratable acidity, total sugars, reducing sugars, total acidity and sensory score such as color, viscosity, taste, aroma and over all acceptability.

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