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Studies on physico-chemical properties of developed jackfruit squash from different genotypes

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Abstract
Jackfruit (*Artocarpus heterophyllus*. L) is an important fruit of India grown in most of the southern and north-eastern states of India. A study was conducted to develop squash from different genotypes viz., (*HV-1, Swarna halasu, Muttom varikka, Lalbagh madhura and HRS*) and storing for 3 months at ambient and refrigerated temperatures. The results of the study revealed that the squash stored under refrigerated temperature maintained intact all the biochemical parameters such as pH, TSS, acidity, ascorbic acid, reducing and total sugars throughout the storage period when compared to samples stored at ambient condition which was stable up to one-two month in all selected genotypes with some significant differences at both storage conditions respectively.

Keywords: jackfruit, genotype, squash, bio-chemical analysis, shelf-life, storage

1. Introduction

Jackfruit (*Artocarpus heterophyllus*. L) is a minor fruit crop of the tropics. It is popular in north-eastern and Southern India and widely cultivated in Karnataka, Kerala, Andhra Pradesh, Tamil Nadu, Maharastra, Assam, Andaman and Nicobar Islands. In Karnataka, jackfruit is cultivated in an area of about 11,333 ha, mostly in the southern plains and Western Ghats producing about 2.6 lakh tones of fruits annually (Anon 2000) [1]. Due to its abundant availability during monsoon season in the coastal regions and consequent to non-availability of vegetables during that season has earned jackfruit the name *"poor man's food"*. Delicious jackfruit is rich in energy, dietary fiber, minerals and vitamins. The fruit is high in calories and contains no saturated fats or cholesterol, making it one of the important healthy fruits to relish.

To ensure year round availability of products of jackfruit, viable processing technology need to be developed and promoted which enables continuous supply and availability of jackfruit products and also to reduce post-harvest losses, transforming raw material into edible products, increasing food security, improving nutrition and health, generating increased income, etc. One such value added product will be development of jackfruit squash which could also be taken to commercialization. This product can be prepared by a medium level entrepreneur and the consumers are benefited by getting tasty and nutritionally rich drink.

Squash is a non - alcoholic concentrated syrup that is usually fruit flavoured and made from fruit juice, water and sugar or sugar substitute. Modern squash may also contain food coloring, additional flavouring and some preservatives. Some traditional squashes contain herbal extracts, most notably, elder flower and ginger. It contains at least 25 per cent fruit juice/pulp, 40 per cent TSS (°Brix) and 1.0 per cent acidity with 350 ppm potassium meta-bisulphate or 600 ppm sodium benzoate (Indian Standards). Squash is popular in most of the countries like India, USA, United Kingdom, Malta, Ireland, Scandinavia, South Africa, Kenya, Australia, New Zealand, Hong Kong, etc. Also, squash commands a large share of the fruit juices and in the soft drink market.

Being highly cross pollinated and mostly seed propagated, the jackfruit has innumerable genotypes or forms with different fruit characteristics. The genotypes differ among themselves in the shape and density of spikes on the rind, bearing size, shape, latex, flake size, flake colour, quality and period of maturity. Innumerable variations in sweetness, acidity, flavour and taste are observed in jackfruit growing areas.

Keeping in view the demand and to explore the possibility of developing and preserving squashes, a research study was undertaken to develop jackfruit squashes from five different

genotypes to identify the best genotype(s) in and around of University of Agricultural Sciences, Bangalore and their storage for commercialization.

2. Material and Methods

Five popular jackfruit genotypes, namely, *HV-1, Swarna halasu, Muttom varikka, Lalbagh madhura and Horticulture Research Station (HRS)* were selected for developing squashes. Matured jackfruits of the above genotypes were procured from UAS, GKVK campus and from jackfruit growers in Doddaballapur Taluk of Bangalore Rural District, Karnataka.

The experiment details for processed jackfruit squashes from five genotypes developed as per FSSAI standards as followed:

Jackfruit Genotypes (G)	HV-1 (G1), Swarna halasu (G2), Muttom varikka (G3), Lalbagh madhura (G4) and Horticulture Research Station (HRS) (G5)
Packaging material	Glass bottles
Preservatives	Potassium meta-bisulphate (KMS-350 ppm)
Storage temperature	Ambient temperature (28-30ºC) Refrigeration temperature (2-3ºC)
Storage period (D)	90 days (3 months)

Storage of squash

The jackfruit squash filled bottles was stored in two environments, namely, ambient and refrigerated temperatures up to 90 days to study shelf-life and quality during storage. The biochemical attributes like pH (Pocket pH meter), TSS (Pocket Refractometer), acidity, vitamin C, reducing and total sugars was analyzed as per standard procedures at every one month interval (Ranganna, 1986, Sadasivam and Manickam, 1992) [9, 10].

Statistical analysis

For the statistical analysis, Factorial Completely Randomized Design (FCRD) was adopted. Observations on various parameters was recorded with three replications. The data was analyzed and main and interaction effects were studied (Sundararaj *et al*., 1972) [12].

3. Results and Discussion

The bio-chemical properties of jackfruit squash stored under ambient and refrigerated temperatures are presented in Tables 1 to 6. The results revealed that the squashes was found to be stable for a period of 90 days with respect to biochemical parameters - pH, TSS, acidity, reducing sugar and total sugar, except ascorbic acid content, showed slight decreasing trend under refrigerated storage. Whereas, the bio-chemical properties of squashes was found to be stable up to 30-60 days of storage and started decreasing thereafter in squashes stored at ambient temperature.

pH

The squash samples stored at ambient temperature showed decreasing trend, in all the genotypes, where, the squash stored under refrigerated temperature showed an increasing trend in pH content during storage. A corresponding decrease in acidity during storage might be responsible for changes of pH in the squashes. Similar observations were reported by (Krishnaveni *et al.*, 2001) [7].

Table 1: Influence of genotypes on pH of jackfruit squashes during storage

Genotype (G)	pH									
	Storage period (days)									
	Ambient temperature (28-30°C)				Mean	Refrigerated temperature (2-3°C)				Mean
	0	30	60	90		0	30	60	90	
G-1	3.2	3.2	3.0	2.9	3.0	3.2	3.3	3.5	3.6	3.4
G-2	3.6	3.6	3.4	3.2	3.4	3.6	3.6	3.7	3.7	3.7
G-3	4.5	4.4	4.4	4.3	4.4	4.5	4.4	4.5	4.6	4.5
G-4	4.0	4.0	3.9	3.7	3.9	4.0	4.1	4.2	4.2	4.1
G-5	3.9	3.8	3.8	3.8	3.8	3.9	4.0	4.0	4.1	4.0
Mean	3.8	3.7	3.7	3.6	-	3.8	3.9	4.0	4.0	-

Statistical analysis	**Room temperature**			**Refrigerated temperature**		
	G	**D**	**G×D**	**G**	**D**	**G×D**
F-test	*	*	NS	*	*	NS
SEm±	0.0253	0.0226	0.0506	0.0289	0.0285	0.0577
CD at 5%	0.0722	0.0646	-	0.0825	0.0738	-
CV (%)	2.3527			2.5411		

*Significant at 5 %, G – Genotype, D – Days

TSS

The results of TSS (°Brix) of processed jackfruit squashes during storage are presented in Table 2. The increase in TSS was greater in samples stored under refrigerated temperature. This might be due to increase in total soluble sugars caused by hydrolysis of polysaccharides like starch, cellulose and pectin substances into simpler soluble substances. This indicates that during storage, there was a change in juice composition. However, the samples stored at ambient temperature, showed a downward trend in TSS content during storage. Similar observations was noticed in the squashes prepared from litchi, melon and kiwifruit (Sethi 1993, Jasim 1996, Thakur and Barwal 1998, Bhatia *et al*., 1956, Palaniswamy and Muthukrishnan 1974) [11, 6, 13, 2, 8].

Table 2: Influence of genotypes on TSS content of jackfruit squashes during storage

Genotype (G)	TSS (°Brix)									
	Storage period (days)									
	Ambient temperature (28-30 °C)				Mean	Refrigerated temperature (2-3 °C)				Mean
	0	30	60	90	-	0	30	60	90	
G-1	37.7	37.7	35.0	35.0	36.4	37.7	38.0	39.0	39.0	38.4
G-2	39.1	39.1	37.0	36.0	37.8	39.1	39.1	40.0	40.0	39.6
G-3	40.0	40.0	38.5	37.7	39.0	40.0	41.0	42.0	43.0	41.5
G-4	39.5	39.5	38.3	38.4	38.9	39.5	39.5	40.0	40.3	39.8
G-5	37.7	37.8	37.0	36.0	37.1	37.7	38.0	39.0	39.0	38.4
Mean	38.8	38.2	37.1	36.6	-	38.8	39.1	40.0	40.3	-

Statistical analysis	Room temperature			Refrigerated temperature		
	G	D	G×D	G	D	G×D
F-test	*	*	NS	*	*	NS
SEm±	0.1831	0.1638	0.3663	0.2444	0.2186	0.4889
CD at 5%	0.5234	0.4681	-	0.6985	0.6248	-
CV (%)	1.6761			2.1411		

*Significant at 5 %, G – Genotype, D – Days

Acidity

The results of acidity of processed jackfruit squashes from different genotypes during storage are presented in Table 3. Changes in acidity of jackfruit squashes was noticed during the storage period. The squash samples at ambient showed upward trend in all the genotypes. This might be attributed to hydrolysis of polysaccharides and non-reducing sugars where acid was utilized for converting them to hexose sugar or complexing by metal ions. Whereas, squash samples stored under refrigerated temperature demonstrated a decreasing trend in the acidity content during storage. Results were in comparison with (Jain *et al*., 1884) [5].

Table 3: Influence of genotypes on acidity content of jackfruit squashes during storage

Genotype (G)	Acidity (%)									
	Storage period (days)									
	Ambient temperature (28-30 °C)				Mean	Refrigerated temperature (2-3 °C)			Mean	
	0	30	60	90		0	30	60	90	
G-1	0.50	0.50	0.61	0.63	0.56	0.50	0.50	0.50	0.50	0.50
G-2	0.39	0.39	0.39	0.46	0.41	0.39	0.39	0.39	0.37	0.38
G-3	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.34	0.33	0.34
G-4	0.39	0.39	0.40	0.46	0.41	0.39	0.39	0.39	0.36	0.38
G-5	0.50	0.50	0.58	0.61	0.55	0.50	0.50	0.50	0.50	0.50
Mean	0.42	0.43	0.45	0.50	-	0.42	0.43	0.42	0.41	-

Statistical analysis	Room temperature			Refrigerated temperature		
	G	D	G×D	G	D	G×D
F-test	*	*	*	*	*	*
SEm±	0.0010	0.0009	0.0019	0.0007	0.0006	0.0014
CD at 5%	0.0027	0.0024	0.0054	0.0020	0.0018	0.0040
CV (%)	0.7191			0.5747		

* Significant at 5%, G – Genotype, D – Days

Ascorbic Acid

The results of ascorbic acid content of jackfruit squashes of different genotypes are presented in Table 4. Ascorbic acid content in all the genotypes decreased or remained unchanged in the squash samples stored both under refrigerated and ambient storages. (Chin and Dudek 1988) [3] opined that, vitamin C is relatively unstable to heat, oxygen and light.

Table 4: Influence of genotypes on ascorbic acid content of jackfruit squashes during storage

Genotype (G)	Ascorbic acid (mg/100g)									
	Storage period (days)									
	Ambient temperature (28-30 °C)				Mean	Refrigerated temperature (2-3°C)				Mean
	0	30	60	90		0	30	60	90	
G-1	5.0	4.9	4.9	4.8	4.9	5.0	5.0	4.9	4.9	4.9
G-2	4.5	4.5	4.5	4.0	4.4	4.5	4.5	4.5	4.5	4.5
G-3	4.2	4.2	4.0	4.0	4.0	4.2	4.1	4.0	4.0	4.0
G-4	3.8	3.7	3.0	3.0	3.4	3.8	3.7	3.7	3.7	3.7
G-5	3.6	3.6	3.5	3.5	3.5	3.6	3.6	3.5	3.5	3.5
Mean	4.2	4.2	4.0	3.9	-	4.2	4.2	4.1	4.1	-

Statistical analysis	Room temperature			Refrigerated temperature		
	G	D	G×D	G	D	G×D
F-test	*	*	*	*	NS	NS
SEm±	0.0195	0.0174	0.0389	0.0938	0.0839	0.1876
CD at 5%	0.0556	0.0498	0.1113	0.2680	-	-
CV (%)	1.6604			7.8072		

*Significant at 5 %, G – Genotype, D – Days

Reducing sugars

The results of reducing sugar/total sugar in processed jackfruit squash during storage are presented in Table 5. In all squash samples there was a considerable rise in reducing sugar level. Reducing sugar was the major component contributing to sweetness. This could be due to inversion of non-reducing sugar to reducing sugar caused by acids present in the product. If excess water is present in the storage environment, the rate of disappearance of sucrose is faster and thus the rate of increase in the reducing sugar content of the product. These results are in line with the observations made by (Sethi, 1993) [11] in litchi squash.

Table 5: Influence of genotypes on reducing sugar of jackfruit squashes during storage

Genotype (G)	Reducing sugar (%)									
	Storage period (days)									
	Ambient temperature (28-30 °C)				Mean	Refrigerated temperature (2-3°C)				Mean
	0	30	60	90		0	30	60	90	
G-1	25.00	25.00	24.00	22.00	24.00	25.00	26.00	28.00	30.00	27.25
G-2	22.72	22.72	21.00	21.00	21.86	22.72	25.00	30.00	30.00	26.93
G-3	35.71	35.71	34.00	33.00	34.60	35.71	35.71	40.00	40.00	37.85
G-4	30.00	30.00	29.00	25.00	28.50	30.00	30.00	32.00	32.00	31.00
G-5	25.00	25.00	22.00	22.00	23.50	25.00	25.00	25.50	30.00	26.37
Mean	27.68	27.68	26.00	24.60	-	27.68	27.68	31.10	32.40	-

Statistical analysis	Room temperature			Refrigerated temperature		
	G	D	G×D	G	D	G×D
F-test	*	*	*	*	*	*
SEm±	0.2582	0.2309	0.5164	0.2583	0.2310	0.5166
CD at 5%	0.7378	0.6599	1.4757	0.7381	0.6602	1.4761
CV (%)	3.3760			2.9941		

* Significant at 5 %, G – Genotype, D – Days

Total sugar

Total sugar contents of jackfruit squashes of all the varieties increased slightly during storage. This might be attributed to hydrolysis of polysaccharides resulting in production of soluble compounds like sugars. Total sugar content of the product was dependent on the total soluble solids.

Whereas, in case of squash samples stored at ambient temperature showed an increase both in reducing and total sugars up to 30 days and then decreased thereafter considerably. These results are in line with the studies reported by (Thakur and Barwal 1998 and Devarajiah 1987) [13, 4] in kiwifruit and jackfruit, respectively.

Table 6: Influence of genotypes on total sugar of jackfruit squashes during storage

Genotype (G)	Total sugar (%)									
	Storage period (days)									
	Ambient temperature (28-30 °C)				Mean	Refrigerated temperature (2-3°C)				Mean
	0	30	60	90		0	30	60	90	
G-1	50.00	50.00	49.00	47.00	49.00	50.00	50.00	52.00	52.00	51.00
G-2	45.45	45.45	40.00	40.00	42.72	45.45	46.00	48.00	48.00	46.86
G-3	71.42	71.42	62.50	60.00	66.33	71.42	71.42	72.00	74.00	72.21
G-4	62.50	62.50	60.00	57.00	60.50	62.50	62.50	64.00	65.00	63.50
G-5	55.56	55.00	52.00	50.00	53.14	55.56	56.00	56.00	58.00	56.39
Mean	56.98	56.87	52.70	50.80	-	56.98	57.18	58.40	59.40	-

Statistical analysis	Room temperature			Refrigerated temperature		
	G	D	G×D	G	D	G×D
F-test	*	*	*	*	*	NS
SEm±	0.2238	0.2001	0.4475	0.2417	0.2162	0.4834
CD at 5%	0.6394	0.5719	1.2788	0.6907	0.6178	-
CV (%)	1.4264			1.4438		

*Significant at 5 %, G – Genotype, D – Days

4. Conclusion

Irrespective of genotype (G), storage period (D) and interaction between G and D, all bio-chemical parameters of developed squashes showed more or less significant results except in few cases. But at the end of the day each and every minute differences counts, so in this regard by considering all the parameters studied with respect to bio-chemical analysis it could be summarized that G-3 (Muttom varikka) was best compared to other genotypes respectively.

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