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ORIGINAL ARTICLE

Development of Osmo-Tray Dried Ripe Jackfruit Bulb

Shrikant Baslingappa Swami[1], and N.J.Thakor[2], Sanjay Orpe[3], S.B.Kalse[4]

[1,2,4] Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Distt. Ratnagiri. (Maharashtra State) (India) Pin: 415712.
[3]M/s Hardikars Food Technologies Pvt. Ltd, Pune.

*Corresponding Author:

ShrikantBaslingappa Swami

Email: swami_shrikant1975@yahoo.co.in

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Abstract

Jackfruit (*Artocarpus heterophyllus L.)* is one of the most popular tropical fruits grown in Asia. The objective of this study was suggested ways and means for production of good quality dehydrated jackfruit bulbs. There were two osmosis treatments at 40 °B and 60 °B and one without osmosis treatment i.e. tray drying at 60 °C. The jackfruit bulbs exposed to the osmosis were further dried in tray dryer at 60 °C. The fruit to Syrup proportion was taken as 1:3. The chemical (Acidity, pH, TSS, Reducing Sugar, Non reducing sugar and Total sugar) and sensory (Texture, colour, flavour and overall acceptability) analysis was carried. From study it was revealed that the treatment 60 °B was best treatment and secured maximum sensory score colour (7.67), flavour (7.56), texture (7.89) and overall acceptability (7.78).

Keywords: Jackfruit, dehydrated jackfruit bulb, osmotic dehydration, tray drying.

Introduction

The Jackfruit (*Artocarpus heterophyllus L.*), which is believed to have origin from India is largely cultivated throughout many countries in the Middle East such as Burma, Ceylon, Malaya and Southern China. Present area under Jackfruit at Konkan region of Maharashtra is 100 ha. A mature tree produces up to 700 fruits per year, each weighting 0.5 to 50 kg. The rind of the compound fruit is greenish yellow when fully ripe. Inside, the fruit is made up of large, yellow bulbs enclosing an oval light-brown seeds. There are 100-500 seeds in a single fruit. The flesh of the jackfruit is starchy, fibrous and is a source of dietary fiber. Varieties of jackfruit are distinguished according to the characteristics of the fruits' flesh. In Konkan region, two varieties of jackfruit predominate i.e. Kapa and Barkha. Kapa has slightly hard inner flesh when ripe, while the inner flesh of the ripe Barakhais very soft and almost dissolving. The pulp of the Barkha jackfruit is ground and is made into a paste. It is then spread over a mat and is allowed to dry in the sun to create a natural chewy candy.

Jackfruit is heavy and bulky and actual recovery of bulbs or edible portion varies from 20% to 25%. After cutting the fruit in several pieces, the fruit contains highly sticky latex, so that small quantity of vegetable oil is applied on hands and then bulbs are removed manually.

Fresh fruit has small amounts of vitamin-A and flavonoid pigments such as carotene-ß, xanthin, lutein and cryproxanthin-ß these compounds play vital roles in anti-oxidant and vision functions. Consumption of jackfruit rich in vitamin-A and carotenes has been found to protect from lung and oral cavity cancers. Jackfruit is also good source of anti-oxidant vitamin-C, provides about 13.7 mg or 23% of RDA. Consumption of foods rich in vitamin C helps body develop resistance against infectious agents and scavenge harmful free radicals. It is one of the rare fruits that is rich in B-complex group of vitamins. It contains very good amounts of vitamin B-6 (pyridoxine), niacin, riboflavin and folic acid. Fresh fruit is a good source of potassium, magnesium, manganese and iron. Potassium is an important component of cell and body fluids that helps controlling heart rate and blood pressure. A number of products have been developed from jackfruit like Nectar, Jam, curry in combination with other vegetables, dehydrated products (e.g. papad, pickles, bulbs, chips).

However, the fruit is perishable and cannot be stored for long time because of its inherent compositional and textural characteristics. In every year, a considerable amount of jackfruit, specially obtained in the glut season (June-July) goes waste (30 to 34 %) due to lack of proper post-harvest knowledge during harvesting, transporting and storing. Processing is important technique for the preservation of jackfruit;

it adds diversified and attractive food items in dietary menu as well as contributes to income generation and employment.

Drying of fruits and vegetables is achieved by various techniques (Giri *et al.,* 2014), however osmotic dehydration is used for partial removal of water from materials such as fruits and vegetables by immersing in aqueous solutions of high osmotic pressure such as sugar and salts (Sutar and Sutar, 2014). The most commonly used osmotic agents are sucrose for fruits and sodium chloride for vegetable. The main advantages of osmotic dehydration include better colour, texture and flavour retention along with minimum heat damage (Ponting *et al,* 1996). Kinetics of dewatering and mass transfer properties during osmotic dehydration process have been investigated for onions (Sutar and Gupta, 2007) carrots (Rastogi *et al.,* 1997; Sutar and Prasad, 2011), mushrooms (Karand Gupta, 2003), apple (Conway *et al.,* 1983), pineapple (Parjoko *et al.,* 1996), green beans (Biswal *et al.,* 1991) and banana (Pokharkar and Prasad, 1998) and reviewed for many other products (Sutar and Sutar, 2014).

However, no systematic attempt has been reported on osmo-tray drying of jackfruit bulbs. Therefore, the objective of the study was to investigate the effect of osmotic treatment on ripe jackfruit bulbs and convective drying followed by the packaging and storage, quality aspect of jackfruit bulbs and thus, suggests ways and means for production of good quality dehydrated jackfruit bulb.

Material and Methods

Raw Material

Jackfruit was purchased at the University Farm of Dr. B.S.K.K.V. Dapoli. To obtain a good quality product, fully ripe fruits of uniform size were used.

Osmotic and Tray Drying of Ripe Jackfruit Bulbs

The jackfruit (Kappa) was the basic study material to investigate the dehydrated jackfruit bulb. The two types of variety were available Kappa and Barkha. Kappa type of jackfruit has a good firmness and its cells are also strong. The Barkha type of jackfruit has was very poor firmness and cells are not strong. Therefore, Kappa type of variety was used for investigation. Fresh, well mature and diseases free jackfruits were procured from the university farm and local supplier. The moisture content of jackfruit procured was in the range 72-78 %. The process for preparation of dehydrated jackfruit bulb is shown in Fig 1.

The ripe bulbs without seed were dried by convective and osmo-convective method at 60°C. The seed is removing manually from Jackfruit bulb and it was used for preparation of dehydrated Jackfruit bulb. In convective drying method, the jackfruit bulbs were dried at 60°C by convective air dryer. The Jackfruit bulb was dried by using two levels of osmosis dehydration in sugar solution that is 40 and 60°B. The Fruit-Solution proportion was taken as 1:3. After addition bulbs to the sugar solution the mixture was kept for 3 hours of osmosis and then dried in tray dryer at 60°C. The prepared dried Jackfruit bulb was packed 3 packaging materials (i.e. Pet Bottles, Transparent Poly pouch and Met pet poly packets). 50 g sample was packed in these packets. The packets were kept at ambient temperature. Various quality attributes of these samples like Titrable acidity, pH, TSS, Reducing sugar and Total sugar were determined at 3, 6, 9 and 12 month duration. The sensory analysis of these samples was also carried out at these durations.

Moisture Content

The moisture content of bulb was calculated by following formula,

$$\text{Moisture Content (\%)} = \frac{(\text{Initial Weight - Weight of Dry Matter})}{\text{Initial Weight}} \times 100 \quad \ldots(1)$$

Quality analysis of jackfruit powder

Titrable Acidity

It was determined by titrating with 0.1 N NaOH.

$$\text{Titrable Acidity} = \frac{\text{Burate Reading} \times 0.1 \times 0.064 \times 100}{\text{Weight of sample}} \ldots(2)$$

TSS of bulb

The TSS of the jackfruit bulbs is total soluble solids present in the bulb powder**.** The TSS of jackfruit bulb powder was measured by standard procedure suggested by Ranganna (2009). TSS content was determined by Digital Refractometer.

pH of bulb

The pH of Jackfruit bulb powder was measured by standard procedure (Ranganna, 2009). It was determined by pH meter.

Reducing Sugar

Sugars, as reducing sugars and total sugars were determined by the Lane and Eynon method (AOAC, 1984). The formulas are given below.

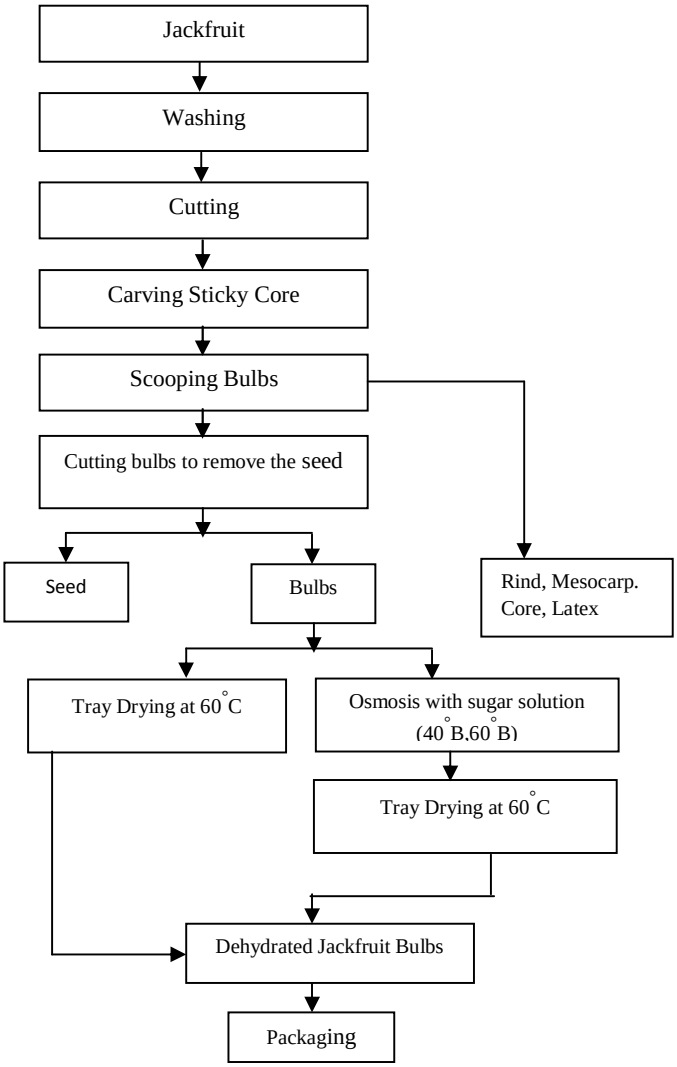

Fig 1: Flow chart for preparation of Dehydrated Jackfruit bulbs.

$$\text{Reducing Sugar} = \frac{\text{mg of invert sugar} \times \text{dilution} \times 100}{\text{Titrate} \times \text{Wt. of volume of sample} \times 100} \quad \ldots(3)$$

$$\text{Percentage of total sugar as invert sugar} = \frac{\text{mg of invert sugar} \times 100}{\text{Titrate} \times \text{Wt.of sample} \times 100} \quad \ldots(4)$$

% Non Reducing Sugar = (% Total sugar as invert sugar × 0.95) …(5)

Total Sugar:

= % Reducing Sugar + % Non reducing sugar …(6)

Colour

The colour of jackfruit bulb was measured using a Hunter's Lab colour analyzer. In the Hunter's lab colourimeter, the colour of a sample is denoted by the three dimensions, L*, a* and b*. The L*, a* and b* readings were then recorded in the software provided in an attached PC. The L* value gives a measure of the lightness of the product colour from 100 for perfect white to 0 for black, as the eye would evaluate it. The redness/greenness and yellowness/blueness are denoted by the a* and b* values, respectively. The colour of the samples was measured after putting the samples in front of smallest aperture.

Results and Discussion

Osmotic dehydration of jackfruit bulbs

Fig 2 shows the solid gain of the ripe jackfruit bulbs during osmotic drying at 40°B and 60°B osmotic concentration of the sugar syrup. The jackfruit bulb deeped at 40°B and 60°B sugar solution for 3 hours had solid gain 11.16 % and 14.41 % and weight loss 19.86 and 38.83 %, respectively. Fig 3 shows the water loss during osmotic dehydration of ripe jackfruit bulbs. During 3 hours of osmotic dehydration in 40°B and 60 °B solution the moisture content was reduced from 75.29 - 55.25 and 73.82 - 33.66 %, respectively.

The osmotically treated jackfruit bulb at 40°B and 60 °B sugar solutions for 3 hours having water loss 19.86 % and 38.82 %, respectively. In 3 hours of osmotic dehydration water loss was maximum at 60 °B sugar solution.

Fig 4 shows the effect of various Treatments on that is 60°C convective drying, and osmo-convective drying i.e. at 40°B and 60°C; and 60°B and 60°C that is moisture content on the drying time of drying of ripe Jackfruit bulbs. The jackfruit bulbs dried at 60 °C in tray dryer required 330 min to dry the bulbs from moisture content 82.13 - 20.75 % w.b. and osmotically dried jackfruit bulbs at 40°B and 60°B required 270 and 240 min. respectively, to dry the bulbs from moisture content 82.13 - 24.42 % and 82.13 - 27. 32% w.b. respectively.

Chemical Analysis of Jackfruit bulbs

Table 1 shows the chemical analysis of Dehydrated Jackfruit bulbs. The Titrable Acidity of dried jackfruit bulb decreases as the sugar solution increases and it was maximum at (T_1) 60°C tray drying, pH of jackfruit bulb was maximum at T_3 (60 °B). Reducing sugar of dried jackfruit bulb get decreases at Treatments T1, T2, (6.76, 6.42 %) respectively and increases at Treatment T3 (8.15). The non-reducing sugars and the total sugars increases as the osmotic concentration increased.

Sensory Evaluation

Table 2 shows the sensory evaluation of the dehydrated ripe Jackfruit bulbs at various treatments. The treatment at sugar solution of 40°B secure maximum score for colour, flavour, texture and overall acceptability that means the jackfruit bulbs osmosis at 40°B sugar solution and dry at 60°C in tray dryer gives quality dehydrated jackfruit bulbs. All the attributes indicated that the colour, flavor, texture and overall acceptability has significantly different at each Treatments at $p \leq 0.01$.

Statistical Analysis of sensory evaluation obtained by various judges

The statistical analysis was performed on the basis of grade score. The data collected during the sensory analysis. The statistical analysis was carried out in MS-excel programme and ANOVA (Analysis of variance) tables were prepared. It is evident from the tables that all the organoleptic qualities were significantly affected at 5 % level of significance.

The results of analysis of variance (Table 2) show that $F_{cal} = 9.26 > F_{crit} = 3.40$ ($n_1 = 3$). It means that there is significant difference in the colour of dehydrated jackfruit bulb. The results of analysis of variance (Table 2) show that $F_{cal} = 9.29 > F_{crit} = 3.40$ ($n_1 = 3$), which means that there is significant difference in flavour of dehydrated jackfruit bulbs. The results of analysis of variance show that $F_{cal} = 4.14 > F_{crit} = 3.40$ ($n_1 = 3$), which means that there is significant difference in texture of dehydrated jackfruit bulb.Likewise the result of analysis of variance show that $F_{cal} = 6.75 > F_{crit} = 3.40$ ($n_1 = 3$), which means that there is difference in overall acceptability of jackfruit bulb powder.

Colour Analysis of Dehydrated Jackfruit Bulbs

Table 3 shows the L, a and b values of dried ripe Jackfruit bulbs dried at varied Treatments. The lightness (L*) of the jackfruit bulb at Treatment T_2 (40 °B) was maximum (23.84 $\pm$ 4.75) followed by Treatment T_1 (23.22 $\pm$ 4.57), redness (a*) of the dried jackfruit bulb is maximum (8.7 $\pm$ 2.76) at T_1 (60°C Tray Drying) and yellowness (b*) of the dried jackfruit bulb was maximum at T_2 (40°B). It can be seen that the colour of the dried jackfruit bulbs in respect of Lightness, Redness and Yellowness is better at T_2 (40 °B).

Fig 5 shows the yellowness of dried ripe Jackfruit bulbs at varied treatments. It indicated that the yellowness was maximum at 40°B Fig 5, shows the chemical analysis of the best treatment among all the treatments. Fig 6 shows the sensory analysis of the best Treatment. Table 4shows the effect of storage duration and packaging material on quality parameters of dried Jackfruit bulbs. Fig 6 and Fig 7 shows the Chemical analysis of Dehydrated jackfruit bulbs prepared from 40°B sugar solution (T_2) and sensory analysis of dehydrated jackfruit bulbs prepared from 40°B sugar solution (T_2).

Effect on Acidity and pH on stored dried ripe jackfruit bulbs

The acidity of the dehydrated jackfruit bulb was found to increase gradually as a result of acid -

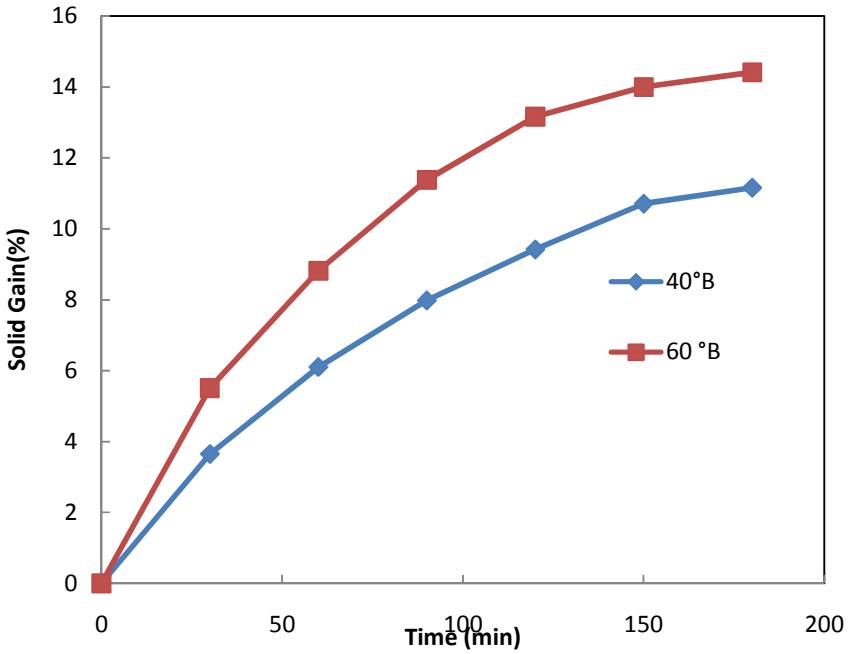

Fig 2: Effect of osmotic concentration of sugar solution on the solid gain of ripe Jackfruit bulbs

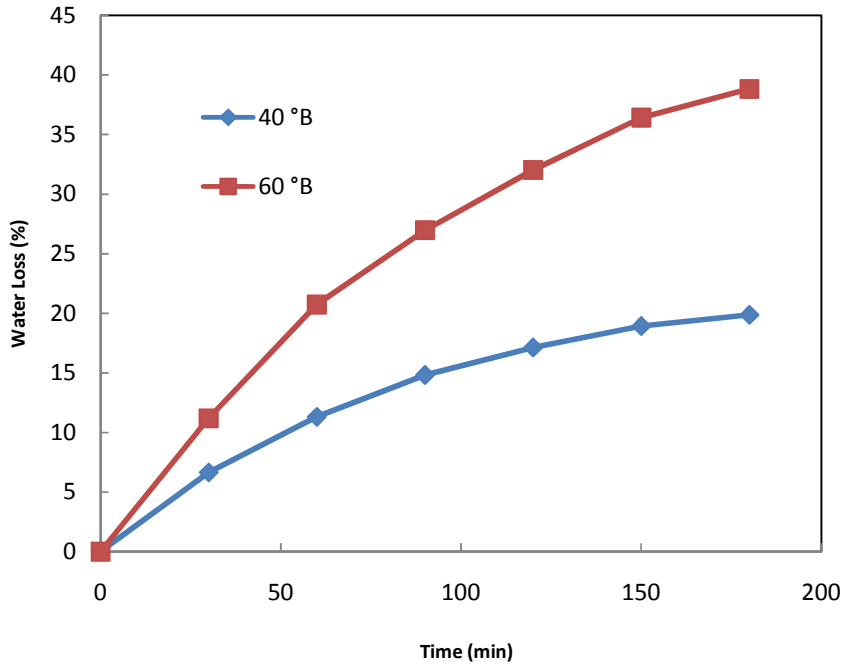

Fig 3: Effect of osmotic concentration of sugar solution on Water Lossof jackfruit bulbs

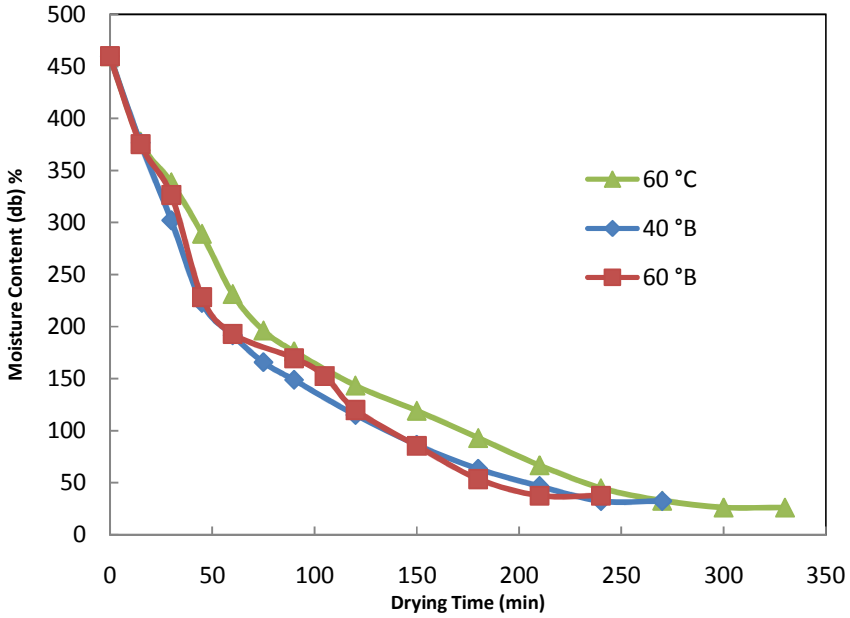

Fig 4: Effect of moisture content on drying time of Jackfruit bulbs at varied treatments of drying.

hydrolysis. However, the increase in acidity was marginal as shown in Table 4. The acidity of dehydrated jackfruit bulb after 12 month of storage was to be 0.94, 0.53 and 0.53%.

Effect on Reducing sugar and Total sugars

The results as shown in Table 5 revealed that, during prolonged storage period, there was a decreasing trend in both the total as well as reducing sugars. This might be attributed due to the breakdown of polysaccharides into monosaccharides as a result of acid hydrolysis (Muralikrishna *et al*., 1969). The reducing sugar of dehydrated jackfruit bulbs was gradually decreased after every 3 months upto 12 months storage period.

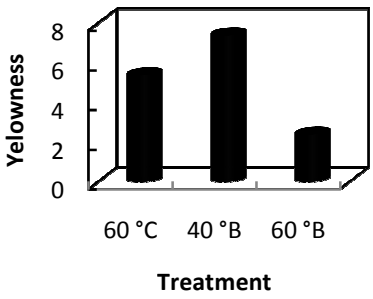

Fig 5: Yellowness of the dried ripe Jackfruit bulbs at varied treatments

Table 5 shows the ANOVA for the chemical analysis of dried ripe jackfruit bulbs for 3 month and 12 month storage duration. It indicated that the all the chemical parameters are highly significant at $p \leq 0.01$.

Table 6 shows the Sensory Analysis of the dehydrated jackfruit bulb stored up to 12 month of storage in different packaging material like Pet Bottles, Transparent Poly pouch and Met pet poly packets. It was observed that the sensory scores were highest in Met-poly pack. The bulbs can be stored in good condition up to a period of 6 months at ambient condition. Table 7 shows the ANOVA for the sensory analysis of the stored ripe Jackfruit bulbs in various packaging materials. It was observed that the sensory scores were non-significant at $p \leq 0.01$ for pet bottles and met-polypack, the sensory scores were highly significant for transparent polypouch.

Conclusions

The yellowness which is important for judging the colour of jackfruit bulbs was more at Treatment T_2 (40°B-60°C). Consumer acceptance test indicated that the dehydrated jackfruit bulb packed in met-pet poly pack obtained highest rating as it was better in terms of color, flavor, texture and overall acceptability. Ripe jackfruit bulbs dipped in 40°B sugar solution and dried at 60°C followed by packing in met-pet poly pack was resulted in to chemical and sensory scores during 12 month of storage period.

Table 1: Chemical Analysis of Dehydrated Jackfruit Bulbs

Sr. No	Treatments	Acidity (%)	pH	TSS	Reducing sugar (%)	Non-reducing sugar (%)	Total sugar
1	60 ^{o}C	1.09	4.73	22.07	6.76	15.39	21.81
2	40 ^{o}B	0.94	4.80	20.77	6.42	19.31	26.07
3	60 ^{0}B	0.64	5.09	15.03	8.15	23.21	31.36

Table 2: Sensory evaluation of dehydrated jackfruit bulb powder

Sr. No	Treatments	Colour	Flavour	Texture	Overall Acceptability
1	60 ^{0}C	6.11	6.00	6.62	5.75
2	40 ^{0}B	8.22	7.55	8.12	7.87
3	60 ^{0}B	7.22	6.55	7.12	7.00
		ANOVA			
Sum of square		20.07	11.18	9.33	18.25
df		2	2	2	2
Mean Square		10.03	5.59	4.66	9.12
F		9.26	9.29	4.14	6.75
P		0.001	0.001	0.030	0.005
F_{crit}		3.40	3.40	3.40	3.40

Table 3: L, a, b Values of treatment at 60 ^{0}C, 40 ^{0}B, 60 ^{0}B.

Sr No	Treatment	L*	a*	b*
1	60°C	23.22 $\pm$ 4.57	8.7 $\pm$ 2.76	5.37 $\pm$ 3.45
2	40°B	23.84 $\pm$ 4.75	3.89 $\pm$ 1.90	7.38 $\pm$ 2.05
3	60°B	16.56 $\pm$ 2.62	7.05 $\pm$ 2.67	2.38 $\pm$ 1.59

Table 4: Effect of storage duration and packaging material on quality parameters of Jackfruit bulbs

	Storage Periods (Months)			
Pet Bottles	**3**	**6**	**9**	**12**
Acidity	0.41	0.53	0.55	0.94
pH	4.79	4.78	4.65	4.65
TSS	22.6	20.77	14.4	12.5
Reducing sugar	11.36	10.40	10.08	6.42
Non reducing sugar	19.31	17.46	17.20	12.23
Total Sugar	40.84	27.86	27.28	18.65
Transparent Poly pouch				
Acidity	0.40	0.41	0.45	0.53
pH	4.73	4.67	4.40	4.36
TSS	27.2	24.7	14.6	15.7
Reducing sugar	10.80	10.00	10.00	7.96
Non reducing sugar	18.46	20.83	16.04	12.49
Total Sugar	29.26	30.83	26.04	20.45
Met Pet Polypack				
Acidity	0.39	0.43	0.52	0.53
pH	4.76	4.74	4.71	4.67
TSS	26.3	24.8	12.3	11.2
Reducing sugar	10.60	9.39	8.99	7.81
Non reducing sugar	21.20	18.12	17.90	14.22
Total Sugar	31.8	27.21	26.89	22.03

Table 5: Statistical Analysis of Variance for chemical parameters during storage

ANOVA for 3rd Month						
Parameter	SS	df	MS	F value	P	F_{crit}
Acidity	0.0004	2	0.0002	3.8	0.085	5.14
pH	0.0038	2	0.0019	11.4	0.009	5.14
TSS	33.68	2	16.84	286.01	1.12×10^{-06}	5.14
Reducing Sugar	0.93	2	0.46	16.7	0.003	5.14
Non-Reducing sugars	11.8	2	5.9	416.54	3.66×10^{-07}	5.14
Total Sugar	222.081	2	111.04	918.87	3.45×10^{-08}	5.14
ANOVA for 12th month						
Acidity	0.33	2	0.16	630.3	1.06×10^{-07}	5.14
pH	0.18	2	0.09	41.04	0.0003	5.14
TSS	32.18	2	16.09	89.38	3.42×10^{-05}	5.14
Reducing Sugar	4.32	2	2.16	12978.6	1.23×10^{-11}	5.14
Non-Reducing sugars	6.73	2	3.36	275.83	1.25×10^{-06}	5.14
Total Sugar	16.14	2	8.07	491.22	2.24×10^{-07}	5.14

Table 6: Sensory Analysis of the Dehydrated Jackfruit bulb up to 12 month of storage

Packaging material	Quality Attributes	Storage duration (Months)				
		0	3	6	9	12
Pet Bottles	Colour	7.3	7.0	6.0	6.1	6.1
	Flavour	7.4	7.3	6.0	5.0	6.1
	Texture	7.4	7.1	6.0	6.0	6.0
	Overall Acceptability	8.0	7.0	6.8	6.3	6.0
Transparent Poly pouch	Colour	7.2	7.1	7.0	7.0	6.8
	Flavour	7.1	7.1	7.0	6.8	6.7
	Texture	7.2	7.0	7.0	6.8	6.7
	Overall Acceptability	7.0	6.8	6.5	6.5	6.4
Met Pet Polypack	Colour	8.1	8.0	8.0	8.0	7.9
	Flavour	8.9	8.5	8.2	8.1	7.9
	Texture	8.9	8.5	8.1	8.0	7.5
	Overall Acceptability	9.0	8.8	8.4	8.3	7.5

Excellent (9-10), Very good (7-8), Good (5-6), Fair (3-4), Poor (1-2)

Table 7: Analysis of Variance for the sensory analysis of the Jackfruit bulbs

Parameter	SS	df	MS	F value	P	F_{crit}
Pet Bottles	1.7576	4	0.4394	0.088091	0.98514	2.866081
Transparent Poly pouch	0.4215	3	0.1405	3.602564	0.036765	3.238872
Met pet poly	0.454	3	0.151333	0.784111	0.52008	3.238872

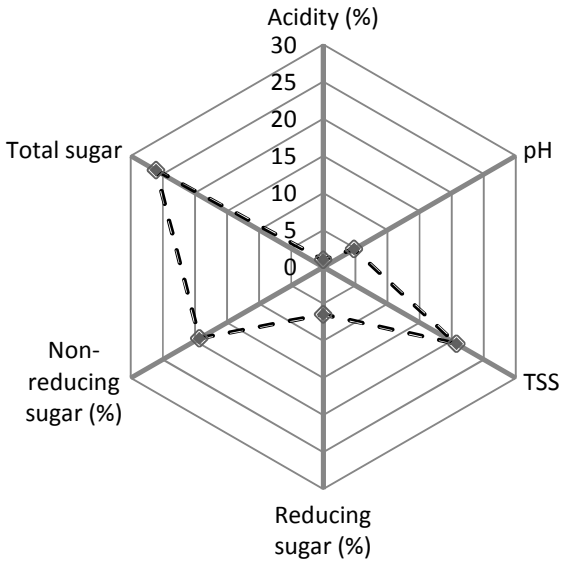

Fig 6: Chemical analysis of Dehydrated jackfruit bulbs prepared from 40 °B sugar solution (T_2).

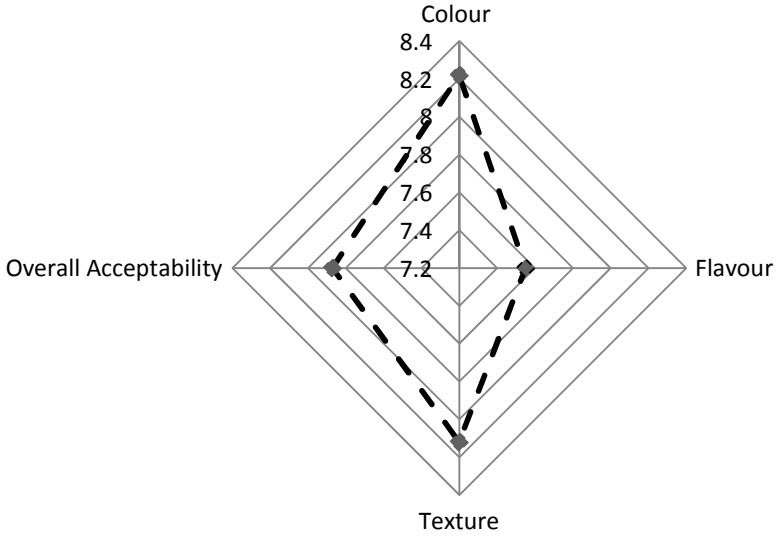

Fig 7: Sensory analysis of dehydrated jackfruit bulbs prepared from 40 °Bsugar solution (T_2).

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