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Identification of elite jackfruit (*Artocarpus heterophyllus* Lam.) genotypes for fruit characters, bulb characters and biochemical parameters in Doddaballapur and Tumkur districts of Karnataka, India (in Indian province of Karnataka)

RK Suneel, SL Jagadeesh, BC Umesh, Netravati and Bharathkumar A

Abstract
Twenty-five jackfruit types identified through an extensive survey, during 2016 jackfruit season, were distributed in 2 districts *viz.*, Doddaballapur (2 types), and Tumkur (16 types) districts. Analysis of variance for 33 characters in 18 type jackfruits revealed a greater variability for fruit weight, rind colour, TSS, rind thickness, bulb weight. Twenty-three of 25 fruits studied were similar in shape and were accorded standard shape number *i.e.* 3. Rind colour varied from, green, yellow, greenish-yellow, yellowish-green, light green, light yellow and brown. Higher fruit weight was noticed in Type-32 (11.37 kg) along with maximum fruit length (47.80 cm) and fruit breadth (27.40 cm). Rind thickness ranged from 0.70 cm (Type-49) to 1.83 cm (Type-50). Similarly, rind weight was maximum in type-32 (6.13 kg) and minimum in type-44 (1.29 kg). The type-43 showed maximum cylinder weight (0.68 kg). Total Soluble Solids (TSS) content varied from 15.50ºBrix (Type-50) to 30.10ºBrix (Type-47). The TSS to Acid ratio was maximum in Type-32 (244.84) followed by Type-52 (174.90). The jackfruit Type-30 (8.58), Type-50 (8.59) and Type-38 (8.23) recorded maximum score for all the sensory parameters in comparison to other types covered in the study. Above mentioned parameters are considered to select the elite jackfruit genotypes for desert type.

Keywords: Jackfruit, type, selections, physico-chemical, elite

Introduction
Jackfruit (*Artocarpus heterophyllus* Lam., Family: *Moraceae*) is native to India and grows in many parts of Asia, but is abundant in India and Bangladesh. It grows wild in the Western Ghats of India. Its distribution is continuous in western coast with high rainfall up to Konkan and sporadic in the areas with low rainfall. In Western Ghats, it is found up to 1500 m and has tremendous diversity. Flakes of ripe fruits are rich in nutritive value containing 18.9 g carbohydrates, 0.8 g minerals, 30 IU vitamin A and 0.25 mg thiamine for every hundred gram (Samaddar, 1985) [14]. In spite of its richness in nutritive value, the jackfruit is unsuitably called 'Poor man's food' in Eastern and Southern parts of India. Productivity of the crop is relatively high (25.71 t/ha).

Jackfruit comprises innumerable trees differing from each other in fruit characteristics such as shape, size and quality. These types may be further divided depending on size of fruit, taste, and aroma of flesh, nature, shape and diversity of prickles on the rind for the maintenance of separate varieties (Singh, 1995) [15]. Singh and Srivastava (2000) [16] identified 18 clones of jackfruit as superior in various parts of eastern Uttar Pradesh based on physico-chemical qualities of fruits, bearing, yield and fruit maturity. A large variation in the chemical composition has been reported even within the dessert type jackfruit selections of Western Ghats of India (Jagadeesh *et al.* 2007a) [6]. Western Ghats of India, the treasure house of wide diversity of jackfruit, provides ample opportunities for survey, collection and evaluation of fruit quality and to identify the types suitable for a specific purpose (Jagadeesh *et al.* 2007b) [5]. Being highly cross pollinated and mostly seed propagated, the jackfruit has innumerable types or forms with different fruit characteristics. The types 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.

Such a wide diversity among clones in Western Ghats, the home of jack, offers tremendous scope for improvement of this crop by clonal selection. Due to cross pollination and predominance of seed propagation over a long period of time, there is high degree of genetic diversity within the species. This wide range of variation existing in nature aids in the selection of superior desirable types.

Due to cross pollination and predominance of seed propagation over a long period of time, there is high degree of genetic diversity within the species. This wide range of variation existing in nature aids in the selection of superior desirable types. A jackfruit nursery is maintained in College of Horticulture. Wide diversity among clones in Western Ghats of India, the home of jack, offers tremendous scope for studying the variability and for improvement of this crop by clonal selection, with this background the present has been took to identify superior jackfruit genotype based on its physic-chemical properties.

Material and Methods

Jackfruit types used for the study were selected based on a survey conducted with the assistance of farmers, fruit merchants, officials of State Department of Horticulture and Forestry, Government of Karnataka. During 2016 jackfruit season, 15 jackfruit types identified through an extensive survey were spread in 2 districts *viz.*, North Doddaballapur and Tumkur (Table-1). The fruits were brought to the laboratory of Post Harvest Technology at College of Horticulture, UHS, Udyanagiri Bagalkot for further studies with regard to morphological and biochemical features (Table 2, 3, 4).

Total mass of the fruit was recorded in kilograms. The fruit was cut and the mass of different components of fruit were recorded separately. Flake (weight of pulp without seeds) mass was recorded in kilograms after removing seeds from the bulbs. Five bulbs from each fruit were selected at random and cut across to facilitate measurement of flake thickness. Flake thickness for each bulb was measured in centimeter with the help of digital vernier calipers. Length and breadth (at the midpoint) of each bulb were recorded in centimeters. Colour of the bulb was visually observed and recorded. Total mass of bulbs of each fruit was divided by total number of bulbs in that fruit to work out average mass of bulb in grams. Per cent edible (flake) portion was calculated by dividing total mass of edible constituents (flakes = bulbs without seed) by total mass of fruit and expressed in percentage.

Similarly, the chemical parameters like TSS (°B), titratable acidity (%) and TSS: Acid ratio were analyzed by hand refractometer, titration method and by working out the ratio respectively.

Jackfruit bulbs of different jackfruit types under the study were evaluated for sensory quality by a panel that consisted of faculty and post graduate students of the University of Horticultural Sciences, Bagalkot. The sensory characters like colour and appearance, taste and flavour, mouth feel (crispness) and overall acceptability were evaluated on a 9 point Hedonic scale using the score card mentioned below.

9	Like extremely
8	Like very much
7	Like moderately
6	Like slightly
5	Neither like nor dislike
4	Dislike slightly
3	Dislike moderately
2	Dislike very much
1	Dislike extremely

Table 1: Selected jackfruits types located in 2 districts of Karnataka

Sl. No.	District surveyed	Types	Total types
1.	Doddaballapur	30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42	13
2.	Tumkur	43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54,	12

Results and discussion

A significant variation in physico-chemical characters of jackfruit bulbs was observed among the 15 jackfruit selections surveyed and studied from the Doddaballapur and Tumkur districts of Karnataka. The information related to these parameters enables to select the clones for crop improvement. The objective of the investigation was to find out the best dessert type jackfruit with ideal physico-chemical parameters and their organoleptic acceptability. The results pertaining to mean values of bulb characters and biochemical parameters, and quantities of physico-chemical constituents of 15 selections surveyed and studied from Doddaballapur and Tumkur are presented in Table 2, 3 and 4. However, a very few studies were carried out with respect to survey and characterization of suitable jackfruit types for dessert purpose (Guruprasad 1981, Muralidharan *et al*., 1997, Mitra and Mani, 2000 and Reddy *et al*., 2004) [3, 9, 8, 12].

Table 2: Mean values for fruit characters in selected dessert type jackfruits located in 2 districts of Karnataka (2016-18)

Tree No.	Fruit shape	Fruit colour	Fruit length (cm)	Fruit breadth (cm)	Fruit wt. (kg)	Rind thickness (cm)	Rind wt. (kg)	Rind (%)	Cylinder diameter (cm)		Cylinder wt. (kg)	Cylinder (%)
									Max.	Min.		
30	3	Yellow green	28.20	15.10	2.81	1.50	1.98	70.46	22.00	4.50	0.19	6.76
31	3	Green yellow	40.20	21.40	5.94	0.83	2.53	42.59	27.40	5.60	0.28	4.71
32	3	Green	47.80	27.40	11.37	1.67	6.13	53.91	32.60	5.80	0.56	4.93
33	3	Green yellow	32.50	18.40	3.96	1.10	2.07	52.27	16.60	4.50	0.09	2.27
34	3	Green yellow	28.35	19.45	5.02	0.97	2.56	51.00	20.50	5.40	0.25	4.98
35	3	Green yellow	40.50	23.50	7.51	0.93	3.41	45.41	28.00	7.20	0.52	6.92
36	3	Green	25.25	16.95	3.72	1.10	1.79	48.12	20.85	5.50	0.17	4.57
37	3	Green yellow	37.05	19.95	6.46	0.73	1.91	29.57	26.80	7.05	0.36	5.57
38	3	Green	38.00	19.00	6.11	0.87	2.46	40.26	30.50	4.80	0.29	4.75
39	3	Green	33.50	22.40	6.26	0.97	2.18	34.82	24.00	9.20	0.45	7.19
40	6	Green	37.20	23.40	6.48	1.70	4.17	64.35	24.00	4.80	0.32	4.94
41	3	Green	32.80	23.40	6.60	1.07	2.29	34.70	21.50	5.50	0.41	6.21
42	3	Green	26.65	34.20	2.52	0.80	1.33	52.78	21.95	3.75	0.13	5.16

43	3	Green yellow	42.50	24.50	10.18	1.27	4.75	46.66	27.90	5.70	0.68	6.68
44	3	Brown green	25.00	14.50	3.85	0.87	1.29	33.51	26.50	5.20	0.32	8.31
45	3	Green	26.50	21.50	4.79	1.23	1.89	39.46	16.50	8.50	0.29	6.05
46	3	Yellow green	31.50	20.50	4.41	0.90	2.32	52.61	21.50	6.50	0.17	3.85
47	3	Brown green/Light yellow	27.65	15.90	3.18	1.37	1.82	57.23	21.00	4.85	0.15	4.72
48	3	Brown green/Green yellow	26.50	14.60	3.37	1.42	1.87	55.49	20.15	5.00	0.19	5.64
49	3	Green yellow	38.05	18.95	5.12	0.70	1.75	34.18	27.20	4.05	0.30	5.86
50	3	Green brown	28.20	18.50	5.82	1.83	1.85	31.79	25.20	5.80	0.23	3.95
51	2	Green	24.50	18.50	3.63	1.17	1.77	48.76	12.50	6.20	0.17	4.68
52	3	Green	30.50	20.30	6.15	0.87	3.29	53.50	27.60	5.50	0.33	5.37
53	3	Green yellow	28.50	20.00	4.70	1.30	2.00	42.55	19.15	3.80	0.09	1.91
54	3	Green yellow	26.00	12.00	2.28	1.60	1.66	72.81	17.20	4.20	0.11	4.82
Mean			31.38	20.93	5.29	1.15	2.44	47.55	23.16	5.56	0.28	5.23
Maximum			47.80	38.00	11.37	1.83	6.13	73.05	32.60	9.20	0.68	8.31
Minimum			19.00	12.00	2.28	0.70	1.29	29.55	12.50	3.75	0.09	1.91

Table 3: Mean values for bulb characters in selected dessert type jackfruits located in 2 districts of Karnataka (2016-18)

Tree No.	Bulb colour	Bulb number	Bulb length (cm)	Bulb breadth (cm)	Bulb wt. (kg)	Bulb volume (ml)	Flake thickness (cm)	Flake wt. (kg)	Flake (%)	Seed wt. (kg)			No. of seeds
										Seed	Cover	Total	
30	Yellow	42	4.33	3.17	0.54	21.67	0.27	0.32	11.39	0.15	0.06	0.22	39.00
31	Light yellow	82	5.65	4.25	2.91	31.67	0.55	2.20	37.04	0.46	0.25	0.71	79.00
32	Light yellow	114	6.43	4.50	3.60	40.00	0.53	2.69	23.66	0.67	0.24	0.91	114.00
33	light orange	74	5.80	3.77	1.72	33.33	0.63	1.40	35.35	0.22	0.10	0.32	74.00
34	Light orange	79	5.92	4.15	1.97	34.17	0.40	1.32	26.29	0.44	0.22	0.66	78.00
35	Cream (orange tinge)	97	6.13	5.13	3.43	36.67	0.67	2.58	34.35	0.68	0.16	0.85	95.00
36	Yellow	67	5.28	3.63	1.66	24.17	0.52	1.13	30.38	0.39	0.14	0.53	69.00
37	Yellow	146	6.55	3.97	3.86	29.58	0.75	3.05	47.21	0.62	0.20	0.81	137.50
38	Orange	68	5.77	5.13	3.16	45.00	0.97	2.47	40.43	0.54	0.15	0.69	67.00
39	Orange	206	5.37	3.07	3.47	20.00	0.37	2.69	42.97	0.62	0.16	0.78	190.00
40	Light orange	45	6.90	4.83	1.91	63.33	0.70	1.49	22.99	0.37	0.04	0.42	45.00
41	White	90	7.33	4.10	3.11	38.33	0.57	2.25	34.09	0.50	0.35	0.85	91.00
42	Cream (whitish)	29	4.95	4.42	1.07	36.67	0.98	0.80	31.75	0.20	0.06	0.27	26.00
43	Light yellow	57	8.67	5.60	5.12	93.33	1.37	4.53	44.50	0.51	0.07	0.58	54.00
44	Yellow	94	4.83	3.67	2.06	25.00	0.50	1.53	39.74	0.45	0.08	0.53	93.00
45	Light orange	136	5.43	4.00	2.48	20.00	0.43	1.88	39.25	0.41	0.18	0.60	131.00
46	Yellow	46	5.53	5.63	1.92	41.67	0.50	1.50	34.01	0.24	0.18	0.42	46.00
47	Light yellow	52	4.30	4.02	1.33	33.33	0.65	0.94	29.56	0.28	0.11	0.39	51.00
48	Yellow	47	5.67	4.02	1.20	32.50	0.53	0.85	25.22	0.21	0.14	0.35	45.00
49	Yellow	114	5.77	3.70	2.96	24.17	0.55	2.10	41.02	0.62	0.23	0.86	112.50
50	Light orange	148	5.23	2.83	3.78	26.67	0.73	3.16	54.30	0.42	0.20	0.62	145.00
51	Light yellow	32	5.30	5.67	1.60	46.67	0.87	1.27	34.99	0.22	0.12	0.34	32.00
52	Yellow	76	6.70	3.97	2.22	28.33	0.47	1.76	28.62	0.31	0.16	0.46	74.00
53	Light Orange	89	5.40	4.02	2.48	30.33	0.62	1.94	41.28	0.44	0.10	0.54	87.00
54	Yellow	11	4.57	5.10	0.44	43.33	0.75	0.26	11.40	0.07	0.11	0.18	11.00
Mean		81.56	5.75	4.25	2.40	36.00	0.63	1.85	33.67	0.40	0.15	0.55	79.77
Maximum		206	8.67	5.67	5.12	93.33	1.37	4.53	54.30	0.68	0.35	0.91	190.00
Minimum		11	4.30	2.83	0.44	20.00	0.27	0.26	11.39	0.07	0.04	0.18	11.00

Table 4: Mean values for biochemical and sensory characters of bulbs in selected dessert type jackfruits located in 2 districts of Karnataka (2016-18)

Tree No.	TSS^{O}B	Titratable acidity (%)	TSS:Acid	Colour and appearance	Crispiness	Aroma	Taste and flavour	Overall acceptability
30	28.33	0.27	104.94	8.50	8.00	8.67	8.83	8.58
31	26.80	0.24	112.45	7.90	6.20	6.60	6.36	6.69
32	25.30	0.10	244.84	7.10	7.30	7.10	7.40	7.52
33	12.70	0.33	38.48	6.13	6.50	5.88	6.00	6.22
34	19.53	0.38	52.09	6.38	6.63	5.25	5.50	5.56
35	22.13	0.28	78.12	6.90	6.50	6.60	6.80	6.80
36	26.12	0.20	130.58	7.42	6.08	7.00	6.92	6.94
37	18.02	0.23	80.07	8.50	7.90	7.40	7.20	7.80
38	18.60	0.17	111.60	8.80	7.60	7.80	7.90	8.23
39	23.80	0.19	123.10	8.40	8.00	7.30	8.10	7.68
40	17.27	0.17	103.60	7.70	7.00	6.70	7.00	6.98
41	12.03	0.12	100.28	4.40	4.40	3.40	4.00	3.30
42	25.22	0.28	91.70	7.60	7.55	7.92	7.32	7.94
43	14.07	0.11	127.88	6.90	6.70	5.20	5.00	5.75

44	20.47	0.63	32.32	7.40	7.70	7.00	7.30	7.32
45	20.20	0.15	131.74	7.40	7.50	6.80	6.70	7.58
46	28.93	0.28	103.33	7.50	7.70	7.50	8.30	7.40
47	30.10	0.37	80.63	5.00	3.25	6.17	6.69	4.72
48	21.70	0.35	61.42	7.50	6.45	6.70	6.50	6.80
49	22.50	0.15	150.00	7.51	6.83	6.99	6.56	7.06
50	15.50	0.16	94.90	8.75	8.63	8.50	8.50	8.59
51	16.13	0.37	43.60	7.40	7.40	6.00	5.00	5.68
52	29.73	0.17	174.90	7.50	7.40	7.60	7.96	7.59
53	16.92	0.11	153.79	7.96	7.67	7.54	7.83	7.66
54	16.87	0.37	45.59	7.30	7.50	6.70	6.60	6.74
Mean	21.16	0.25	102.88	7.35	6.98	6.81	6.89	6.92
Maximum	30.10	0.63	244.84	8.80	8.63	8.67	8.83	8.59
Minimum	12.03	0.10	32.32	4.40	3.25	3.40	4.00	3.30

Fruit characters

Among the physical parameters of fruit studied, variation was remarkable for shape of the jackfruit and it was assigned the number from 1 to 6 according to IBPGR descriptor for jackfruit. Twenty-three of 25 types of jackfruits studied were similar in shape and were accorded standard shape number *i.e.* 3. None of the trees researched in this study showed the shape 1 and 6. The fruits of tree type 40 and 51 were assigned fruit shape as 5 and 2 respectively. Fruit rind colour exhibited diversity. It varied from, green, yellow, greenish-yellow, yellowish-green, light green, light yellow and brown. Fruit weight had a range from 2.28 kg (Type-53) to 11.37 kg (Type-32). The type-32 also recorded maximum fruit length (47.80 cm) and fruit breadth (27.40 cm). Similarly, the jackfruit type-53 showed minimum fruit length (26.00 cm) and breadth (12.0 cm).

Rind thickness ranged from 0.70 cm (Type-49) to 1.83 cm (Type-50). Similarly, rind weight was maximum in type-32 (6.13 kg) and minimum in type-44 (1.29 kg). The type-43 showed maximum cylinder weight (0.68 kg). A minimum cylinder weight of 0.09 kg was noted in the type-53 followed by 0.11 cm in Type-54.

Bulb characters

The identified jackfruit types exhibited much variation for colour of bulb. It was *cream* to *white* in Type-41 and Type-42. *Yellow* colour was noticed in a majority of the types studied (9 jackfruit types). Five types recorded *light yellow* coloured bulbs, two types were *orange* in colour and six types were *light orange* in colour. The maximum bulb number of 206 was noticed in the Type-39 followed by Type-50 with 148 bulbs. A small sized spherical fruit of Type-54 had just 11 bulbs. The seed number was same as the bulb number.

Bulb weight was maximum in Type-43 (5.12 kg) and minimum in Type-54 (0.44 kg). Bulb length showed a range from 8.67 cm (Type-43) to 4.30 cm (Type-47). Similarly bulb breadth was maximum in Type-43 (5.60 cm) and minimum in Type-50 (2.83 cm). Flakes were thicker in Type-43 (1.37 cm) and thinner in Type-30 (0.27 cm). Seed weight ranged from 0.91kg (Type-32) to 0.18 kg (Type-54). Published reports indicated the presence of variation for bulb characters in jackfruit clones (Muralidharan *et al*., 1997; Mitra and Mani, 2000; Reddy *et al*., 2004, Jagadeesh *et al*., 2007b and Jagadeesh *et al.*, 2010) [9, 8, 12, 5, 4].

Biochemical parameters

Total Soluble Solids (TSS) content varied from 15.50°Brix (Type-50) to 30.10°Brix (Type-47). The type-52 with 29.73°Brix was the second highest. Titratable acidity content ranged from 0.10% (Type-32) to 0.63% (Type-44). The TSS to Acid ratio was maximum in Type-32 (244.84) followed by Type-52 (174.90). The minimum TSS to Acid ratio was noted in Type-44 (32.32) followed by Type-33 (38.48). Jackfruit types with TSS and total sugar more than 25°Brix and 20 per cent respectively were found suitable for dessert purpose (Mitra and Mani, 2000) [8]. The total acidity in jackfruit is low (0.13% as citric acid) at ripe stage and it showed little change during ripening (Bhatia *et al.*, 1955) [2]. The low acidity level and high free sugars are responsible for the sweet taste of jackfruit. Nandini (1989) [10] reported that firm types have lower acidity (0.300%) than soft (0.550%) types. A large variation in the chemical composition has been reported within the dessert type jackfruit selections of Western Ghats of India (Jagadeesh *et al.* 2007a) [6].

Sensory evaluation

None of the collected jackfruit types scored below 6.00 in this study, indicating their acceptability in the score range more than 6.00. However, the Type-41 was an exception with the overall score of 3.30 indicating its rejection at the outset in the study. In general, orange and light orange coloured bulbs obtained higher score for colour. The maximum score for crispness was noted Type-50 (8.63) followed by Type-30 and Type-39 (8.00). The score for taste and flavour was maximum in Type-30 (8.83) followed by Type-50 (8.50). The jackfruit Type-30 (8.58), Type-50 (8.59) and Type-38 (8.23) recorded maximum score for all the sensory parameters in comparison to other types covered in the study. The Types 9, 10 and 17 have scored maximum for colour and appearance. Even though all the types of season-2 are firm flesh types, their score for crispness varied among the types. Crispness of the flakes is partly dependent upon the presence or degradation of pectin. The integrity of the tissue depends on the activity of pectolytic enzymes. Higher the activity of these enzymes, lower will be the integrity. A certain amount of starch in flakes at edible ripe stage is important for imparting desirable texture. A total conversion of starch during ripening will ensure rise in TSS, total and reducing sugars, but the texture becomes undesirably soft. The soft form when ripe shows a greater loss of starch, perianth cell wall and pectic polysaccharide than the firm flesh form (Rahman *et al.*, 1995) [11]. A high variation in the TSS: Acid ratio is attributed to the variation in titrable acidity level rather than the TSS. Reddy *et al.* (2004) [12] declared ACC No.18 with highest TSS, lowest acidity and highest reducing sugars as the superior type for table purpose.

Identification of dessert type jackfruits in 2 (15 types) jackfruit growing districts of Karnataka (India) revealed a high variation for fruit characters such as weight, length, breadth, rind thickness and rind weight. Fruit shape showed

minimum variation with 23 types out of 25 collections exhibiting same shape. Bulb parameters such as bulb weight, length, breadth, colour, and flake thickness also exhibited great variation. Besides, the biochemical parameters namely TSS content, titrable acidity and TSS: Acid ratio exhibited a wide variation. All these fruit characters and physico-chemical parameters of bulbs may be given due consideration to operate selection procedure for identifying elite jackfruit types for dessert purpose.

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