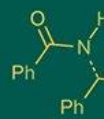


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Comparative evaluation of physicochemical and colour attributes of differently coloured jackfruit (*Artocarpus heterophyllus* L.) accessions

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Abstract

Jackfruit (*Artocarpus heterophyllus* L.) exhibits considerable variability in fruit quality and pulp colour characteristics, offering opportunities for selection of superior genotypes for fresh consumption and processing. The present investigation was undertaken to comparatively evaluate the physical, physicochemical and instrumental colour characteristics of six jackfruit accessions representing three pulp colour groups, namely orange [Tubugere 2 (G11) and MRS (G8)], yellow [Tubugere 7 (G6) and Kerala (G31)] and white [Gumless (G3) and IIHR-1 (G12)] maintained in the Jackfruit Germplasm Block of ICAR-Indian Institute of Horticultural Research, Bengaluru. Significant variation was observed among the accessions for all the traits studied. Fruit weight ranged from 4.74 kg in MRS to 9.92 kg in Kerala, while pulp recovery varied from 27.82 to 40.15 percent. Instrumental colour analysis revealed marked differences among the accessions, with L* values ranging from 42.40 to 68.01, a* values from 0.24 to 5.40 and b* values from 19.27 to 39.17. Chroma and hue angle values further distinguished the accessions into white, yellow and orange pulp groups. Total soluble solids ranged from 24.60 to 29.31 °Brix, titratable acidity from 0.29 to 0.40 percent and TSS: acid ratio from 70.78 to 95.07. Kerala recorded the highest fruit and pulp weight, whereas Tubugere 2 and MRS exhibited superior pulp recovery. Gumless recorded the highest TSS, while IIHR-1 and Tubugere 7 exhibited higher TSS: acid ratios. The results revealed substantial variability among the evaluated accessions and highlighted their potential for fresh consumption, processing and utilization in future jackfruit improvement programmes.

Keywords: Jackfruit, pulp colour, physicochemical characteristics, colour parameters, germplasm evaluation, TSS, fruit quality

1. Introduction

Jackfruit (*Artocarpus heterophyllus* L.) is an important tropical fruit crop belonging to the family Moraceae and is widely cultivated in India and several Southeast Asian countries. The crop is valued for its high productivity, adaptability to diverse agro-climatic conditions and rich nutritional composition. India is considered one of the major centres of diversity for jackfruit, where considerable variation exists among local and introduced genotypes. Despite its economic and nutritional importance, the crop remains underutilized compared with several other tropical fruits (Hittalmani, 2016) [4].

Jackfruit exhibits remarkable variability in fruit size, shape, flake texture, sweetness, aroma and pulp colour. The edible bulbs vary from white and cream to yellow and deep orange, reflecting differences in pigment accumulation among genotypes. Pulp colour is one of the most important quality attributes influencing consumer preference, market acceptance and processing suitability. Colour variation also serves as a useful descriptor in germplasm characterization and selection programmes (Elevitch and Manner, 2006; Aswini *et al.*, 2015) [3, 2].

Physicochemical characteristics such as fruit weight, pulp recovery, seed proportion, total soluble solids (TSS), sugars and acidity are important indicators of fruit quality and eating acceptability. Fruits possessing higher edible portion, desirable sweetness and balanced acidity are generally preferred for fresh consumption and processing. Instrumental colour evaluation using CIE L*, a* and b* coordinates provides an objective and reproducible

method for quantifying colour differences among genotypes and complements visual classification based on pulp colour. Several studies have reported substantial variability among jackfruit genotypes with respect to fruit morphology, edible portion and quality attributes. Jagadeesh *et al.* (2007) [5], Akter and Rahman (2017) [1] and Aswini *et al.* (2015) [2] reported considerable differences in fruit weight, pulp recovery, seed characteristics and pulp colour among diverse jackfruit germplasm, highlighting the existence of substantial genetic variability within the species. Such variability provides opportunities for identifying superior accessions for fresh consumption, processing and breeding programmes.

However, comparative information on physicochemical and instrumental colour characteristics of accessions representing distinct pulp colour groups is still limited. Characterization of such accessions is important for identifying superior genotypes suitable for fresh consumption, processing and future crop improvement programmes. Therefore, the present investigation was undertaken to comparatively evaluate selected jackfruit accessions differing in pulp colour for their physical, physicochemical and instrumental colour characteristics.

2. Materials and Methods

The present investigation was carried out at the Division of Postharvest Technology and Agricultural Engineering, ICAR-Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bengaluru, Karnataka, during 2017-2019. Six jackfruit (*Artocarpus heterophyllus* L.) accessions representing three distinct pulp colour groups, namely orange [Tubugere 2 (G11) and MRS (G8)], yellow [Tubugere 7 (G6) and Kerala (G31)] and white [Gumless (G3) and IIHR-1 (G12)], were selected from the Jackfruit Germplasm Block of IIHR.

Mature fruits were harvested at full physiological maturity and transported to the Postharvest Handling Laboratory of the Division of Postharvest Technology and Agricultural Engineering. The fruits were allowed to ripen under ambient laboratory conditions. After ripening, fruits were dissected and evaluated for various physical, colour and physicochemical characteristics.

Fruit weight, pulp weight, total seed weight, individual seed weight and waste weight were recorded using an electronic balance (Sartorius GPA 5202, Germany) and expressed in kilograms, except individual seed weight, which was expressed in grams. Pulp percentage, seed percentage and waste percentage were calculated based on the relative contribution of each component to the total fruit weight.

Pulp colour was measured using a colourimeter (Konica Minolta CR-10, Japan) and expressed in terms of CIE L*, a* and b* colour coordinates, where L* represents lightness, a* represents the green (-) to red (+) axis and b* represents the blue (-) to yellow (+) axis. Ten readings were recorded for each accession and mean values were calculated.

Chroma (C*), which indicates colour saturation or intensity, and hue angle (h°), which represents the visual colour tone, were calculated from the measured colour coordinates using the following equations:

$$C^* = \sqrt{(a^*)^2 + (b^*)^2}$$

$$h^\circ = \tan^{-1} \left(\frac{b^*}{a^*} \right)$$

Hue angle was expressed in degrees (°).

Total soluble solids (TSS) were determined using a hand refractometer and expressed as °Brix. Titratable acidity was estimated following the method of Ranganna (1986) [10] and expressed as percentage citric acid. The TSS: acid ratio was calculated by dividing TSS by titratable acidity.

The experiment was laid out in a Completely Randomized Design (CRD) with ten replications. The data generated were subjected to analysis of variance (ANOVA), and treatment means were compared using the Critical Difference (CD) test at the 1 percent level of significance.

3. Results and Discussion

3.1 Physical characteristics of jackfruit accessions

Significant variation was observed among the six jackfruit accessions for fruit weight, pulp weight, seed weight, individual seed weight, waste weight and recovery percentages (Table 1). Fruit weight ranged from 4.74 kg in MRS (G8) to 9.92 kg in Kerala (G31), with a mean value of 6.90 kg. Kerala (G31) and IIHR-1 (G12) produced comparatively larger fruits, whereas MRS (G8) recorded the lowest fruit weight. Similar variability in fruit size among jackfruit accessions has been reported by Muralidharan *et al.* (1997) [9], Mitra and Mani (1998) [8] and Jagadeesh *et al.* (2007) [5]. Karunakaran *et al.* (2025) [6] further reported fruit weights ranging from 1.04 to 13.42 kg among 94 jackfruit accessions collected from dry zones of Karnataka, highlighting the wide genetic diversity existing within the species.

Pulp weight ranged from 1.89 to 2.76 kg, while pulp percentage varied from 27.82% in Kerala (G31) to 40.15% in Tubugere 2 (G11). Although Kerala produced the largest fruits, Tubugere 2 and MRS exhibited the highest pulp recovery, indicating superior edible yield. Similar variation in edible portion among jackfruit accessions has been reported by Mannan Sabiha *et al.* (2006) [7], Aswini *et al.* (2015) [2] and Akter and Rahman (2017) [1].

Total seed weight ranged from 0.21 to 0.93 kg and individual seed weight from 3.78 to 8.22 g. Seed percentage varied from 4.05% in Tubugere 2 to 11.39% in MRS, while waste percentage ranged from 48.74% in MRS to 64.82% in Tubugere 7. The observed differences in seed and waste components indicate substantial genetic variability among the accessions and suggest opportunities for selecting genotypes with higher edible recovery and improved processing efficiency.

3.2 Instrumental colour characteristics of pulp

Significant differences were observed among the jackfruit accessions for instrumental colour parameters, namely L*, a*, b*, chroma and hue angle (Table 2), indicating substantial variation in pulp pigmentation. The visual differences in pulp colour among the selected accessions are presented in Figure 1.

The L* value, representing lightness, ranged from 42.40 in MRS to 68.01 in IIHR-1, with a mean of 50.95. The higher L* values recorded in IIHR-1 and Gumless indicated lighter pulp colour typical of white-fleshed accessions, whereas the lower values observed in MRS and Tubugere 2 reflected darker and more intensely pigmented pulp. The a* value ranged from 0.24 in IIHR-1 to 5.40 in Tubugere 2, with a mean of 2.44. Higher positive a* values recorded in Tubugere 2 and MRS indicated greater reddish-orange

pigmentation, whereas the white-pulp accessions exhibited very low a^* values.

Similarly, b^* values ranged from 19.27 in IIHR-1 to 39.17 in Kerala, with a mean of 27.47. Higher b^* values observed in Kerala and Tubugere 7 indicated greater yellow pigmentation. Chroma (C^*), which represents colour saturation or intensity, ranged from 19.27 in IIHR-1 to 39.21 in Kerala. The yellow-pulp accessions recorded higher chroma values, indicating more vivid colour expression, whereas the white-pulp accessions exhibited lower chroma values. Hue angle (h°) ranged from 77.80° in Tubugere 2 to 89.29° in IIHR-1. Lower hue angle values observed in Tubugere 2 and MRS confirmed their orange pigmentation, while higher values recorded in Gumless and IIHR-1 corresponded to pale yellow-white pulp colour.

The combined L^* , a^* , b^* , chroma and hue angle profiles enabled clear classification of the accessions into white (IIHR-1 and Gumless), yellow (Tubugere 7 and Kerala) and orange (Tubugere 2 and MRS) pulp groups. Similar variation in pulp colour among jackfruit genotypes has been reported by Elevitch and Manner (2006) [3] and Aswini *et al.* (2015) [2].

3.3 Physicochemical characteristics

Significant differences were observed among the selected jackfruit accessions for total soluble solids (TSS), titratable acidity and TSS: acid ratio (Table 3), indicating considerable variability in fruit quality attributes.

The TSS content ranged from 24.60°Brix in Kerala (G31) to 29.31°Brix in Gumless (G3), with a mean value of 27.69°Brix . Gumless recorded significantly higher TSS followed by Tubugere 2 (28.28°Brix), MRS (28.23°Brix) and Tubugere 7 (28.21°Brix), whereas Kerala recorded the lowest value. Total soluble solids are an important indicator of sweetness and consumer acceptability and are largely influenced by sugar accumulation during fruit ripening. The TSS values recorded in the present study fall within the

range reported for ripe jackfruit by Reddy *et al.* (2004) [11], Jagadeesh *et al.* (2007) [5] also reported considerable variation in TSS ($15.50\text{--}30.10^\circ\text{Brix}$), titratable acidity and TSS: acid ratio among elite jackfruit genotypes of Karnataka, indicating substantial diversity for fruit quality traits.

Titratable acidity varied significantly among the accessions, ranging from 0.29% in IIHR-1 to 0.40% in Tubugere 2, with a mean value of 0.328%. The orange-pulp accession Tubugere 2 recorded the highest acidity, followed by MRS (0.35%), while the lowest acidity was observed in IIHR-1 and Tubugere 7. Acidity is an important quality parameter influencing flavour balance and overall fruit palatability. The relatively low acidity recorded in all accessions is characteristic of ripe jackfruit and contributes to its sweet taste. Similar acidity ranges have been reported by earlier workers in jackfruit germplasm evaluation studies.

The TSS: acid ratio, which represents the balance between sweetness and acidity and is considered an important indicator of eating quality, ranged from 70.78 in Tubugere 2 to 95.07 in IIHR-1, with a mean value of 85.36. IIHR-1 and Tubugere 7 recorded significantly higher TSS: acid ratios, indicating superior sweetness perception and desirable flavour characteristics. In contrast, the lower ratio observed in Tubugere 2 was mainly due to its comparatively higher acidity despite having high TSS. The variation observed in TSS: acid ratio among the accessions highlights the influence of genotype on flavour attributes and consumer preference.

Overall, the results demonstrated substantial variability among the evaluated jackfruit accessions for physicochemical characteristics. Accessions such as Gumless, Tubugere 7 and IIHR-1 exhibited desirable quality attributes with higher TSS and TSS: acid ratio, suggesting their suitability for fresh consumption and potential utilization in breeding programmes aimed at improving fruit quality.

Table 1: Physical characteristics of jackfruit accessions differing in flake colour

Genotype	Fruit weight (kg)	Pulp weight (kg)	Total Seed weight (kg)	Individual seed weight (g)	Waste weight (kg)	Pulp %	Seed %	Waste %
Tubugere 2 (G11)	5.18	2.08	0.21	3.78	2.89	40.15	4.05	55.80
MRS (G8)	4.74	1.89	0.54	6.09	2.31	39.87	11.39	48.74
Tubugere 7 (G6)	7.42	2.24	0.37	5.91	4.81	30.19	4.99	64.82
Kerala (G31)	9.92	2.76	0.93	8.22	6.23	27.82	9.38	62.80
Gumless (G3)	5.91	2.15	0.52	4.26	3.24	36.38	8.80	54.82
IIHR-1 (G12)	8.26	2.71	0.69	5.54	4.86	32.81	8.35	58.84
Mean	6.90	2.30	0.54	5.63	4.06	34.54	7.83	57.64
S.Em $\pm$	0.272	0.066	0.014	0.183	0.128	1.223	0.215	2.14
CD (P = 0.01)	1.027	0.25	0.055	0.691	0.482	4.620	0.81	8.08

Table 2: Instrumental colour characteristics of jackfruit pulp

Genotype	L^*	a^*	b^*	Chroma(C^*)	Hue angle(h°)
Tubugere 2	44.70	5.40	24.97	25.55	77.80
MRS	42.40	4.24	24.77	25.13	80.29
Tubugere 7	50.21	2.49	34.37	34.46	85.86
Kerala	47.60	1.74	39.17	39.21	87.46
Gumless	52.80	0.52	22.27	22.28	88.66
IIHR-1	68.01	0.24	19.27	19.27	89.29
Mean	50.95	2.438	27.47	27.65	84.89
S.Em $\pm$	0.067	0.033	0.067	0.069	0.064
CD(P = 0.01)	0.251	0.126	0.251	0.261	0.241



Fig 1: Pulp colour variation among selected jackfruit accessions representing orange, yellow and white pulp groups.

Table 3: Physicochemical characteristics of selected jackfruit accessions

Genotype	TSS (°Brix)	Acidity (%)	TSS: acid ratio
Gumless	29.31	0.32	91.78
Tubugere 2	28.28	0.40	70.78
Kerala	24.60	0.31	79.51
Tubugere 7	28.21	0.30	94.25
MRS	28.23	0.35	80.78
IIHR-1	27.50	0.29	95.07
Mean	27.69	0.328	85.36
S.Em±	0.21	0.004	1.00
CD (P = 0.01)	0.79	0.016	3.78

Conclusion

The present investigation revealed significant variability among the six jackfruit accessions for physical, colour and physicochemical characteristics. Kerala (G31) recorded the highest fruit and pulp weight, whereas Tubugere 2 (G11) and MRS (G8) exhibited superior pulp recovery. Instrumental colour analysis clearly differentiated the accessions into white, yellow and orange pulp groups, with white-pulp accessions exhibiting higher L^* values and orange-pulp accessions recording higher a^* values and lower hue angles. Significant differences were also observed for TSS, acidity and TSS: acid ratio. Gumless recorded the highest TSS, while IIHR-1 and Tubugere 7 exhibited higher TSS: acid ratios, indicating superior sweetness perception and eating quality. The observed variability among the accessions highlights their potential for selection in fresh consumption, processing and future jackfruit improvement programmes aimed at enhancing fruit quality.

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