

Morphological Characterization of Jackfruit (*Artocarpus heterophyllus* Lamk) in Kedurang District, Bengkulu, Indonesia



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Submission: May 03, 2025; Published: May 15, 2025

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Abstract

Jackfruit (*Artocarpus heterophyllus* Lamk) is a tropical plant species of high economic importance, widely consumed both as fresh fruit and as a processed food ingredient. The external appearance, which reflects fruit quality, is influenced by various morphological traits. Despite its value, the morphological diversity of jackfruit in Kedurang District, Bengkulu, Indonesia, remains insufficiently documented. This study aimed to characterize the morphological traits of jackfruit accessions in the region to support germplasm conservation and superior genotype selection. The research was conducted from May to October 2024 across five villages: Palak Siring, Keban Agung, Tanjung Alam, Karang Agung, and Lubuk Resam. An exploratory observational method was employed, using purposive sampling. A total of 33 morphological traits were recorded, comprising 15 qualitative and 18 quantitative characters, following the *Descriptors for Artocarpus heterophyllus* Lamk [1]. Data analysis involved descriptive statistics and cluster analysis using PBSTATCL version 2.1 to evaluate accession similarity. The analysis revealed two main groups: Group 1 included PS1, KA3, KA4, TA5, TA6, KR7, KR8, LR9, and LR10, while Group 2 consisted solely of PS2, which differed notably in leaf size and fruit sugar content. Observed morphological variation encompassed fruit weight (15-16kg), length (44-51cm), total soluble solids (13-21% Brix), and seed count (63-72). These findings contribute to the understanding of jackfruit diversity in the region and serve as a foundational reference for future germplasm management and selection of superior cultivars.

Keywords: Morphological traits; Cluster analysis; Germplasm; Genetic variation

Introduction

Jackfruit is a popular tropical fruit in Indonesia with significant economic value. Belonging to the Moraceae family, jackfruit is characterized by its large size, distinctive aroma, and sweet flavor. It is rich in vitamins, minerals, and calories, and its seeds are also highly nutritious [2]. One hundred grams of ripe jackfruit contains approximately 18.9g of carbohydrates, 0.8g of minerals, 30IU of vitamin A, and 0.25mg of thiamine [3]. In Bengkulu, jackfruit is commonly cultivated in home gardens or mixed-crop farms. While the fruit is consumed fresh, the seeds and rind are typically discarded as waste. Specialized or intensive cultivation remain sun common [4].

In Indonesia, jackfruit grows optimally in lowland areas up to 700 meters above sea level, under temperatures ranging from 16°C to 32°C, annual rainfall of 1,500–2,400mm, and relative humidity levels between 50% and 80%. Optimal growth occurs in sandy clay soils that are fertile, loose, rich in organic matter, well-

aerated, and well-drained, with a pH of 5–7.5 and groundwater depth ranging from 1 to 200 meters [5]. Jackfruit is a tree-type plant with a height ranging from 8 to 25 meters. It possesses a deep taproot system and a dense canopy, with a trunk diameter of approximately 80–120cm. The leaves are simple, spirally arranged, and equipped with large petioles that cover the floral buds. The species is considered a multipurpose fruit tree, as nearly all parts of the plant are utilized [6].

Jackfruit is a multiple fruit, with seeds accounting for approximately 8–15% of the total fruit weight. Each seed is encased in a white aril surrounding a thin brown endosperm and protected by a white cotyledonary flesh. The seeds are rich in nutrients, starch, and protein. Ripe jackfruit is characterized by a distinctive aroma and is commonly consumed as a dessert or used as a culinary ingredient [7]. Based on fruit texture, ripe jackfruit can be classified into two types: *varikka* and *koozha*. *Varikka* types exhibit a firmer texture with crisp flakes, while *koozha* types are

softer, more fibrous, and tend to melt easily. These differences are influenced by genetic traits and the degree of fruit ripeness [8].

Morphological characterization of jackfruit is essential for identifying superior traits, distinguishing among similar varieties, and managing populations for conservation purposes. Morphological variation influenced by environmental factors reflects the plant's adaptation to specific conditions [9]. Jackfruit exhibits considerable diversity in canopy shape, leaf form and size, growth habit, as well as fruit color, weight, shape, aroma, flavor, and both seed number and size. Both genetic and environmental factors shape these traits. Phenotypic characteristics that serve as distinguishing features among plant varieties can be identified through morphological analysis. Despite its economic importance, the morphological diversity of jackfruit in Kedurang District, Bengkulu, Indonesia, has not been thoroughly documented, limiting efforts in germplasm conservation and cultivar improvement. This study aims to investigate the genetic

and morphological diversity of jackfruit in Kedurang District, Bengkulu, Indonesia.

Materials and Methods

This study was conducted from May to October 2024 in Kedurang District, Bengkulu, Indonesia (Figure 1). Morphological identification was carried out on ten jackfruit trees distributed across five villages: Palak Siring, Keban Agung, Tanjung Alam, Karang Agung, and Lubuk Resam. The selected jackfruit trees were 10 years old, healthy, and productive, and served as the subjects for morphological data collection. Fruit morphological assessments were conducted at the Agroecotechnology Laboratory, Faculty of Agriculture, University of Bengkulu. The materials used in this study included jackfruit trees from the five villages, mature jackfruit fruits, and jackfruit seeds. The equipment utilized comprised a GPS device, ruler, caliper, penetrometer, refractometer, and digital scale.

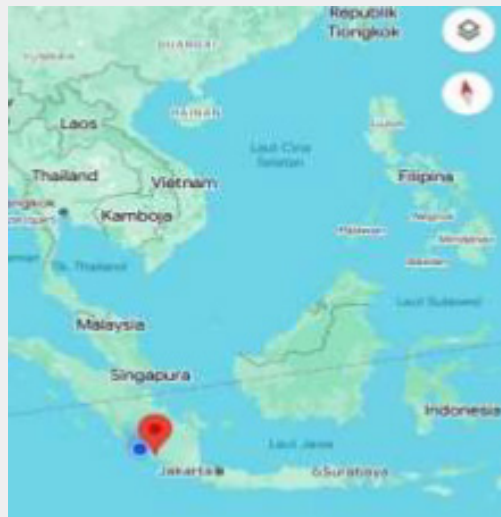


Figure 1: Geographical map of jackfruit in Kedurang District, Bengkulu, Indonesia.

Samples were selected using purposive sampling. Morphological characterization of jackfruit (*Artocarpus heterophyllus* Lamk) was conducted based on the *Descriptors of Artocarpus heterophyllus* Lamk [1]. A total of thirtythree (33) morphological traits were documented, comprising fifteen (15) qualitative and eighteen (18) quantitative characters, covering stem, leaf, fruit, and seed organs.

The study was conducted using both quantitative and qualitative approaches. Qualitative data included canopy shape, branch growth direction, leaf blade shape, leaf apex shape, leaf base shape, leaf color, fruit shape, peduncle attachment, flesh texture, seed shape, fruit skin color, flesh color, skin thickness, rind color, and rind flesh (dami) color. Quantitative data included

stem circumference (cm), leaf blade length (cm), leaf blade width (cm), whole fruit length (cm), whole fruit width (cm), whole fruit circumference (cm), whole fruit weight (kg), fruit firmness (kgf), fruit flesh weight (g), seed weight (g), rind weight (g), rind length (cm), rind width (cm), fruit stalk length (cm), total number of seeds (units), total soluble solids content (% Brix), and fruit thickness (mm).

Data Analysis

Data were analyzed to determine the variation among accessions and the pattern of genetic relationships. The analysis included Principal Component Analysis (PCA), which was performed on both qualitative and quantitative data to determine mean values, standard deviations, maximum values, and minimum

values. Descriptive data were analyzed using the PBSTATCL software version 2.1.

Results

Based on morphological characteristics, jackfruit accessions were grouped into two main clusters. The first group exhibited broadly pyramidal, spherical, or irregular canopy shapes, with branch growth directions varying from erect, opposite, vertical,

horizontal, to irregular (Figure 2). Leaves ranged from oblong to narrowly elliptical, with apices that were acuminate, acute, or retuse (Figure 3). Petioles were oblique, round, and decussate. The fruits were oval to oblong, with irregular or kidney-shaped seeds (Figures 4 & 5). This group had stem circumferences ranging from 70 to 95cm, fruit lengths from 44 to 51cm, and total soluble solids content between 13% and 21% Brix (Table 1).



Figure 2: Canopy morphology of jackfruit in Kedurang District, Bengkulu, Indonesia.



Figure 3: Leaf morphology of jackfruit in Kedurang District, Bengkulu, Indonesia

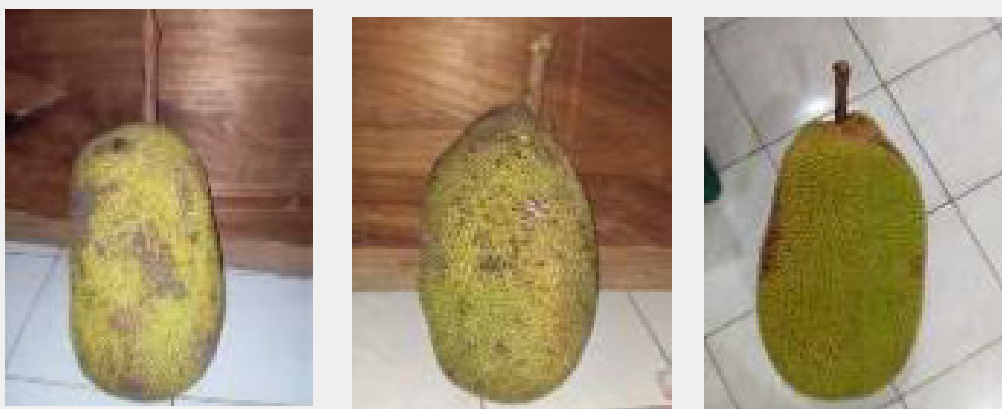


Figure 4: Whole fruit morphology of jackfruit in Kedurang District, Bengkulu, Indonesia



Figure 5: Jackfruit fruits from Palak Siring 1 (PS1), Palak Siring 2 (PS2), and Keban Agung 1 (KA1) villages

The second group was characterized by pyramidal canopy shape with horizontally oriented branches (Figure 2). Leaves were broadly elliptical with acute apices, and the petioles were round (Figure 3). The fruits were oval to oblong with kidney-shaped seeds (Figures 4 & 5). This group had a stem circumference of

80cm, a fruit length of 50cm, and a total soluble solids content of 17% Brix (Table 1). The genetic relationship among accessions was determined based on morphological character analysis (Figure 6).

Table 1: Morphological characteristics of jackfruit in Kedurang District, Bengkulu, Indonesia

Characteristics	Group 1	Group 2
Canopy shape	broadly pyramidal - spherical - irregular	pyramidal
Branch growth direction	erect - opposite - vertical - horizontal - irregular	horizontal
Leafblade shape	oblong - narrowly elliptical	broadly elliptical
Leaf apex shape	acuminate - acute - retuse	acute
Leaf color	dark green	dark green
Petiole shape	oblique - round - decussate	round
Fruit shape	oval - oblong	oval
Fruit peduncle attachment	flat	flat
Fruit skin color	yellow	yellow
Flesh color	yellow - deep yellow	yellow
Flesh shape	round - curved	oval
Seed shape	irregular - kidney-shaped	kidney-shaped
Seed coat color	brown - dull brown	brown
Rind color	pale white - light yellow	pale white
Skin thickness	medium - thick	medium
Stem circumference (cm)	70 - 95	80
Leaf width (cm)	9.06 - 9.74	11.14
Fruit weight (kg)	15 - 16	15
Fruit length (cm)	44 - 51	50
Fruit circumference (cm)	48 - 50	40
Fruit firmness (kgf)	2.62 - 12.4	5.25
Fruit width (cm)	24 - 28	26
Fruit flesh weight (g)	350.1 - 621.12	357.11
Seed weight (g)	50.13 - 198.45	158.21
Rind weight (g)	186.24 - 610.1	476.44
Rind length (cm)	1 - 7	5
Rind width (cm)	1 - 1.2	1.2
Fruit stalk length (cm)	9 - 10	13
Total number of seeds (units)	63 - 65	72
Number of seeds per kg (units)		13
Total soluble solids (% Brix)		17
Fruit flesh thickness (mm)	3	2

Discussion

The results of jackfruit morphological characterization revealed that most accessions in Kedurang District shared similar traits and were grouped into Cluster 1, while Palak Siring 2 (PS2) exhibited the most distinct morphological characteristics compared to the other accessions. Based on the dendrogram, the

cophenetic distance between accessions KA3, KR1, and PS1 was 0.1, whereas the distance between PS2 and LR9 was 0.6. A smaller cophenetic distance indicates a higher degree of similarity; therefore, KA3 and PS1 shared more comparable features in terms of canopy shape, branching pattern, leaf color, leaf blade shape, leaf apex shape, petiole shape, stem circumference, leaf length, and leaf width compared to PS2 and LR9 (Figure 6).

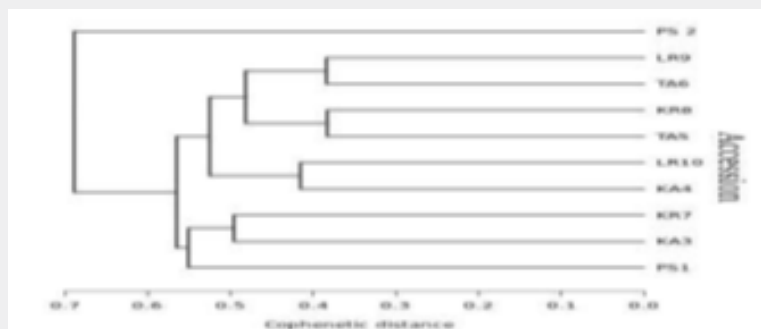


Figure 6: Dendrogram of 10 jackfruit accessions in Kedurang District, Bengkulu, Indonesia. Accessions include: Palak Siring 2 (PS2), Lubuk Resam 10 (LR10), Karang Agung 7 (KR7), Tanjung Alam 5 (TA5), Lubuk Resam 9 (LR9), Tanjung Alam 6 (TA6), Karang Agung 8 (KR8), Keban Agung 3 (KA3), Keban Agung 4 (KA4), and Palak Siring 1 (PS1).

The smaller the cophenetic distance, the greater the degree of similarity among accessions within a cluster. Conversely, a larger cophenetic distance indicates a lower level of similarity (Figure 6). The canopy shape of jackfruit trees varied, ranging from broadly pyramidal and irregular to pyramidal forms. Similarly, branch growth directions were observed as erect, opposite, vertical, horizontal, and irregular. Phaomei & Mathew [10] also reported variations in jackfruit tree branching directions—vertical, horizontal, and irregular—in the West Garo Hills District, Meghalaya. According to Rosanti [11], tree stem morphology can be utilized in designing plant architecture. These characteristics encompass diverse patterns of stem, branch, and twig growth.

The fruit exhibited morphological variation, predominantly ranging from oblong to oval-oblong shapes. The most common fruit shape was oval-oblong, observed in accessions PS1 and KA1. Simanjuntak et al. [12] reported extensive variation in jackfruit fruit shapes, including ellipsoid, oblong, round, and irregular forms. Such variation may result from the combined effects of genetic traits and pollination characteristics. Uniform pollination tends to produce symmetrical fruits, while inadequate pollination often leads to irregular fruit shapes.

Leaf shapes included oblong, narrow elliptical, and broad elliptical, with dark green coloration. Petiole morphology varied across accessions, displaying oblique, cylindrical, and crossing forms. The fruit skin color was predominantly yellowish-green. Suneel et al. [13] reported a wide range of skin color variation in jackfruit, including green, yellow, yellowish-green, greenish yellow, light green, light yellow, and brown. According to Sunarya

et al. [14], genetic relationships exist among two or more plant characters in jackfruit due to the quantitative nature of the traits. These characters are polygenically inherited, making them more likely to display genetic rather than phenotypic correlations.

The fruit weight in accessions PS1 and KA3 reached 16kg, while accession PS2 produced fruits weighing 15kg. Fruit length varied, with KA3 exhibiting the longest fruit at 52cm, followed by PS2 at 50cm, and PS1 at 44cm. Gomez et al. [15] reported that jackfruit length can range from 28.0cm to 67.8cm. The greatest fruit circumference was recorded in KA3 (50cm), followed by PS1 (48cm), and the smallest in PS2 (46cm). Fruit firmness also varied significantly among accessions, with PS1 recording the highest firmness (12.4kgf), followed by PS2 (5.25kgf), and KA3 (2.62kgf). Fruit width was highest in KA3 (28cm), followed by PS2 (26cm), and PS1 (24.5cm).

The edible pulp is one of the key components determining the quality of jackfruit. The results of the study showed that the pulp weight in accessions KA3, PS2, and PS1 was 621.12g, 357.11g, and 350.1g, respectively. The higher pulp weight observed in KA3 is likely influenced by superior genetic factors, which enable the development of larger fruits with thicker pulp tissue. In addition, environmental factors such as nutrient availability and adequate light intensity also support the optimal development of the pulp tissue. According to Dey [16], fruit weight has a significant positive correlation with leaf width, fruit length, and fruit diameter, indicating the genetic contribution to fruit size and quality.

Seed weight varied among accessions. Accessions KA3, PS2, and PS1 had seed weights of 198.45g, 158.21g, and 50.13g,

respectively. Dhakar et al. [17] reported a 4.81-fold range in fruit weight, from 3.84 to 18.50kg, across jackfruit genotypes. Core diameter ranged from 36.71 to 175.95mm, core weight from 0.20 to 1.16kg, and pulp weight from 0.43 to 10.07kg. The pulp percentage is a critical parameter for evaluating genotypes intended for consumption and processing. Variation in seed weight among jackfruit accessions reflects underlying genetic differences influencing seed size and endosperm quantity. Genotypes with heavier seeds generally exhibit better fertilization and embryo development. Maheswari & Nivetha [18] highlighted that heavier seeds contribute to more vigorous seedling growth, making seed weight an essential criterion in selecting rootstocks for propagation.

The “dami” component (non-edible pulp tissue) also exhibited variation. Accession PS1 showed the highest dami weight (610.12g), followed by PS2 (476.44g) and KA3 (186.24g). The length of dami in KA3 was 7cm, followed by PS1 at 6cm and PS2 at 5cm. The dami width was 1.2cm in PS2 and KA3, while PS1 had a dami width of 1cm.

The fruit peduncle length in accessions PS2, PS1, and KA3 was 13cm, 10.5cm, and 9cm, respectively. Regarding seed count, PS2 produced 72 seeds, while KA3 and PS1 both had 63 seeds per fruit. However, the number of seeds per kilogram differed: PS1 had 25 seeds/kg, KA3 had 16 seeds/kg, and PS2 had 13 seeds/kg. This contrasts with findings by Chandrashekar et al. [19], who reported a seed count per fruit ranging from 29.66 to 177.39, with an average of 82.73 seeds. The coefficient of variation for seed number per fruit was 39.07%, and the weight of 100 seeds in selected genotypes ranged from 291.88 to 739.54g, with an average of 522.38g. The higher number of seeds per fruit in accession PS2 may be attributed to efficient pollination processes and high fruit fertility.

Total soluble sugar content is one of the key parameters for evaluating the quality of jackfruit. The results of the study indicated that the total sugar content in accessions KA3, PS2, and PS1 were 21% Brix, 17% Brix, and 13% Brix, respectively. This finding is consistent with the study by Gayatri et al. [20], which reported total soluble solids (TSS) concentration varying from 19.16% Brix to 30.66% Brix, and the study by Wangchu et al. [21], which reported a TSS content of 7.93% Brix. The thickness of the fruit pulp varied, with accession PS1 having a pulp thickness of 5.8mm, KA3 with 5.5mm, and PS2 with 4.7mm.

The variation in pulp thickness among accessions reflects differences in genetic potential for pulp tissue formation. Accession PS1 exhibited a thicker pulp. In addition to genetic factors, water content and harvest age also influence pulp thickness. According to Palupi & Daryono [22], Indonesian jackfruit germplasm exhibits morphological variation in fruit pulp characteristics, including thickness, taste, and aroma, which reflects the genetic diversity

among accessions.

Conclusion

The study conducted in Kedurang District, Bengkulu, Indonesia revealed significant morphological variation in jackfruit (*Artocarpus heterophyllus* Lamk), classifying the accessions into two distinct clusters. Cluster 1 consists of the accessions Palak Siring 1 (PS1), Keban Agung 3 (KA3), Keban Agung 4 (KA4), Tanjung Alam 5 (TA5), Tanjung Alam 6 (TA6), Karang Agung 7 (KR7), Karang Agung 8 (KR8), Lubuk Resam 9 (LR9), and Lubuk Resam 10 (LR10). Cluster 2 consists solely of the accession Palak Siring 2 (PS2). These results can be utilized as a reference in the management of jackfruit germplasm for plant breeding to obtain superior jackfruit cultivars.

Acknowledgment

This research was funded by the Faculty of Agriculture, University of Bengkulu, in 2024 under grant number 2987/UN30.11/PT/2024.

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DOI: [10.19080/IJESNR.2025.35.556415](https://doi.org/10.19080/IJESNR.2025.35.556415)

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