

Morphological Variability of Jackfruit (*Artocarpus Heterophyllus* Lamk) in Taba Penanjung District, Central Bengkulu Regency

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ABSTRACT: Jackfruit (*Artocarpus heterophyllus* Lamk) is widely cultivated in Indonesia and has potential source as food, fruit, vegetable, and industrial raw material. However, scientific information on morphological variation in local jackfruit remains limited, including in Central Bengkulu Regency. This study aimed to describe the morphological characteristics of local jackfruit originated from Taba Penanjung District, Central Bengkulu. Ten jackfruit trees representing five accessions were evaluated. Thirty-eight characters, consisting of 14 qualitative and 24 quantitative characters, were observed based on the descriptor of the International Plant Genetic Resources Institute (IPGRI). Data were analyzed using the Gower dissimilarity coefficient and the Average Linkage method with PBSTAT-CL version 2.2.1. The five accessions were grouped into two clusters at a cophenetic distance of 0.6. Cluster I consisted of Penum, Lubuk Sini, Tanjung Heran, and Bajak accessions, with variations in crown shape (oblong, spherical, elliptical, and broadly pyramidal), leaf blade shape (elliptic, oblong, and narrowly elliptic), and fruit shape (clavate, ellipsoid, spheroid, and oblong). Fruit length in this cluster ranged from 29,75 to 37,10 cm, flesh weight from 425,81 to 460,92 g per 1 kg of fruit, and total soluble solids from 15 to 16,5 °Brix. Cluster II consisted of the Taba Penanjung accession, characterized by a semicircular crown, obovate leaves, and oblong fruit, with a fruit length of 40,6 cm, flesh weight of 300,25 g per 1 kg fruit, and total soluble solids of 11 °Brix. Tanjung Heran, Bajak, and Taba Penanjung showed a superior potential as germplasm sources for total soluble solids, flesh weight, and fruit size, respectively, for jackfruit breeding program.

KEYWORDS: biodiversity, climate change, cluster analysis, germplasm, IPGRI

INTRODUCTION

Jackfruit (*Artocarpus heterophyllus* Lamk) is a fruit crop originating from India and is widely distributed throughout tropical regions, including Indonesia. Jackfruit is a perennial fruit crop belonging to the family Moraceae and the order Urticales. In Indonesia, several major species of the genus *Artocarpus* include *A. heterophyllus* (jackfruit), *A. altilis* (breadfruit), and *A. camansi* (breadnut). The genus is widely distributed across different regions of the world, indicating its adaptability to various environmental conditions [1].

Jackfruit is known to contain various nutrients, including carbohydrates, vitamin, fiber, and minerals in its flesh. In addition to the flesh, jackfruit seeds contain considerable amounts of protein, fat, and carbohydrates and have potential as an alternative food source [2]. Jackfruit wood is also of high quality and can be used for furniture, construction, and building foundations [3]. The utilization of various parts of the jackfruit plant indicates that this species has potential not only as a food source but also as a valuable plant resource. Furthermore, the adaptability of jackfruit to environmental conditions indicates its potential as an alternative species that can be utilized in response to climate change [4]. The utilization of jackfruit flesh, seeds, and wood can also increase its economic value while supporting sustainable agricultural practices and reducing food waste [5].

Geographically, Taba Penanjung District is characterized by sloping or hilltop topography [6]. The area has a highly humid tropical climate, with annual rainfall ranging from approximately 2,500 to 3,000 mm, average relative humidity of 80-85% and temperatures ranging from 22 to 32 °C [7]. This area has considerable potential for jackfruit cultivation. Jackfruit trees grow and are distributed across several locations with different environmental and growing conditions, which may result in differences and similarities in morphological characteristics among accessions.

Morphological identification is one of the initial approaches that can be used to recognize and describe the characteristics of jackfruit species. Through morphological identification, differences and similarities among accessions can be identified, thereby providing an overview of phenotypic variation in local jackfruit. Morphological diversity can also be considered when identifying accessions with potentially useful characteristics for selection and plant breeding [8]. This information can provide a basis for supporting

breeding program, conservation of superior varieties, and expansion of the utilization of local jackfruit. However, information on morphological variation among local jackfruit accessions in Taba Penanjung District has still been limited. Therefore, identification of morphological characterization of jackfruit grown in Central Bengkulu is required. This study aimed to describe the morphological variation of local jackfruit in Taba Penanjung District.

MATERIALS AND METHODS

The study was conducted from October 2025 to March 2026 in Taba Penanjung District, Central Bengkulu Regency, Indonesia. Five local jackfruit accessions originating from Penum ($3^{\circ}40'40.97''\text{S}$, $102^{\circ}27'22.17''\text{E}$), Lubuk Sini ($3^{\circ}41'17.39''\text{S}$, $102^{\circ}28'52.34''\text{E}$), Bajak ($3^{\circ}41'14.72''\text{S}$, $102^{\circ}30'04.72''\text{E}$), Taba Penanjung ($3^{\circ}43'30.05''\text{S}$, $102^{\circ}29'58.19''\text{E}$), and Tanjung Heran ($3^{\circ}42'08.97''\text{S}$, $102^{\circ}30'41.31''\text{E}$) were evaluated.

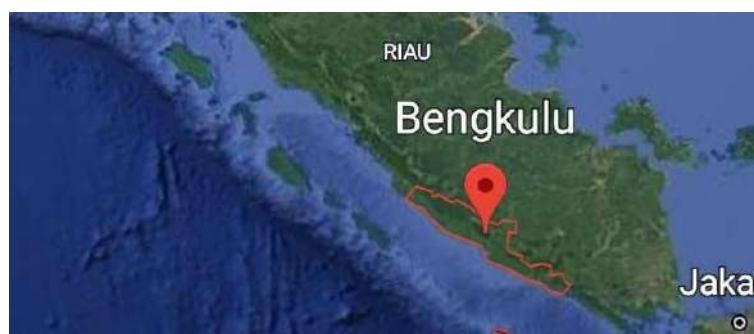


Figure 1. Map of Bengkulu Province
(Source: Google Earth, 2026)

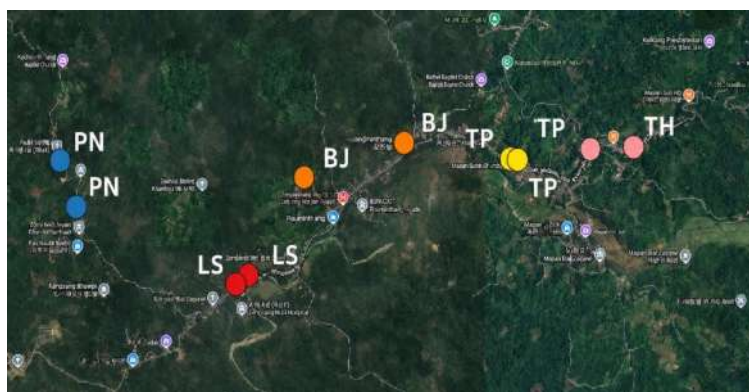


Figure 2. Distribution of jackfruit sampling sites in Taba Penanjung District. PN (Penum), LS (Lubuk Sini), BJ (Bajak), TP (Taba Penanjung), and TH (Tanjung Heran)

Tree Sample Selection

The study was conducted using exploration, field observation, and morphological identification. A total of 10 jackfruit trees were evaluated, with each accession represented by two trees. Purposive sampling was used to select the trees based on the criteria of productive, healthy, at least five years old, and had complete morphological organs (leaf, flower, and fruit). An initial field survey was conducted to determine jackfruit trees in each study area, followed by morphological observations of trees.

Morphological Characterization and Measurements

Morphological characterization was conducted using 38 characters, consisting of 14 qualitative and 24 quantitative characters, based on the *Descriptors for Jackfruit* published by the International Plant Genetic Resources Institute (IPGRI) [9]. The equipment used included a GPS device for recording the coordinates of the sampled trees, a smartphone camera for field documentation, and a measuring tape, ruler, penetrometer, refractometer, vernier caliper, Munsell colour chart, Sartorius digital balance, and Tora scale

for morphological characterization and measurement. The qualitative characters included crown shape, branching pattern, leaf blade shape, leaf apex shape, leaf base shape, fruit shape, stalk attachment to fruit, flake shape, seed shape, leaf colour, fruit rind colour, pulp colour, seed coat colour, and perianth colour.

The quantitative characters included trunk circumference, leaf blade length, leaf blade width, fruit stalk length, fruit circumference, fruit length, fruit width, rachis length, rachis width, perianth length, perianth width, whole-fruit weight, fruit firmness, flesh weight, seed weight, perianth weight, rind weight, rachis weight, flesh thickness, rind thickness, seed hardness, number of seeds per kilogram of fruit, total number of seeds per fruit, and total soluble solids.

RESULTS

Morphological identification of the five jackfruit accessions from Penum, Lubuk Sini, Tanjung Heran, Bajak, and Taba Penanjung showed variation in both vegetative and generative characteristics. Penum demonstrated an oblong crown, irregular branching pattern, and elliptic leaf blades. Lubuk Sini had a spherical crown, opposite branching pattern, and elliptic leaf blades. Tanjung Heran indicated an elliptical crown, irregular branching pattern, and oblong leaf blades. Bajak had a broadly pyramidal crown, verticillate branching pattern, and narrowly elliptic leaf blades. Taba Penanjung had a semicircular crown, horizontal branching pattern, and obovate leaf blades (Figure 3).

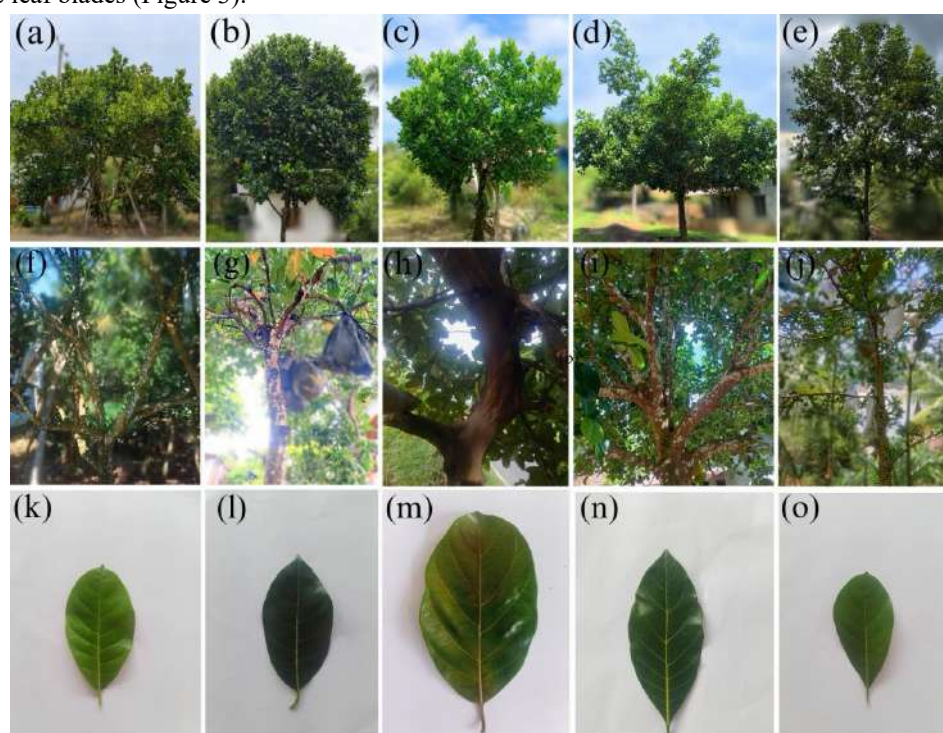


Figure 3. Morphological characteristics of crown shape, branching pattern, and leaf blade shape of five jackfruit accessions in Taba Penanjung District. Crown shape: (a) Penum, oblong; (b) Lubuk Sini, spherical; (c) Tanjung Heran, elliptical; (d) Bajak, broadly pyramidal; and (e) Taba Penanjung, semicircular. Branching pattern: (f) Penum, irregular; (g) Lubuk Sini, opposite; (h) Tanjung Heran, irregular; (i) Bajak, verticillate; and (j) Taba Penanjung, horizontal. Leaf blade shape: (k) Penum, elliptic; (l) Lubuk Sini, elliptic; (m) Tanjung Heran, oblong; (n) Bajak, narrowly elliptic; and (o) Taba Penanjung, obovate.

Generative characteristics also varied among the five accessions. Penum showed a clavate fruit, cordate flake, and oblong seed. Lubuk Sini indicated an ellipsoid fruit, rectangular flake, and elongate seed. Tanjung Heran demonstrated a spheroid fruit, twisted flake, and ellipsoid seed. Bajak had an oblong fruit, obovate flake, and spheroid seed. Taba Penanjung pointed out an oblong fruit, an oblong flake with a curved tip, and a reniform seed (Figure 4).

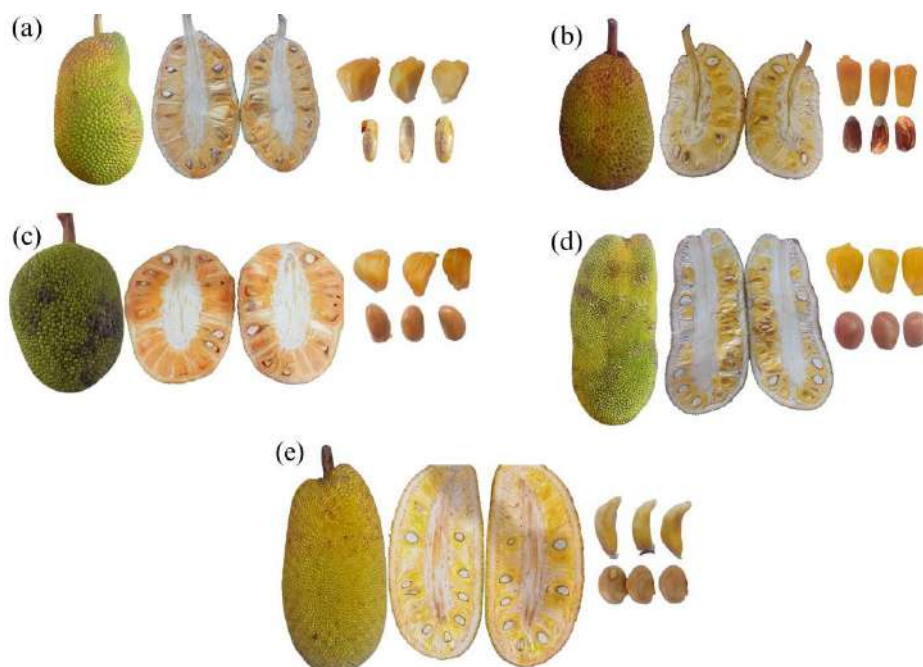


Figure 4. Fruit, flake, and seed shapes of five jackfruit accessions in Taba Penanjung District: (a) Penum, clavate fruit, cordate flake, and oblong seed; (b) Lubuk Sini, ellipsoid fruit, rectangular flake, and elongate seed; (c) Tanjung Heran, spheroid fruit, twisted flake, and ellipsoid seed; (d) Bajak, oblong fruit, obovate flake, and spheroid seed; and (e) Taba Penanjung, oblong fruit, oblong flake with a curved tip, and reniform seed.

Based on the Gower dissimilarity coefficient, the five jackfruit accessions were grouped into two clusters at a cophenetic distance of 0.6. Cluster I consisted of Penum (PN), Lubuk Sini (LS), Tanjung Heran (TH), and Bajak (BJ), whereas Cluster II consisted of Taba Penanjung (TP). In the dendrogram, Penum and Lubuk Sini related closer, followed by Tanjung Heran and Bajak, while Taba Penanjung remained separated from the other four accessions and formed Cluster II (Figure 5).

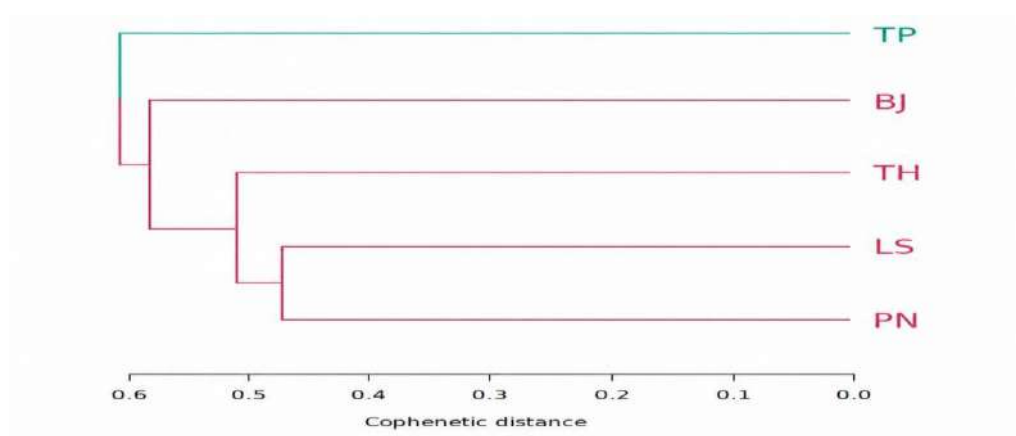


Figure 5. Dendrogram of jackfruit accessions in Taba Penanjung District.

Cluster I, covering the accession of Penum, Lubuk Sini, Tanjung Heran, and Bajak showed crown shape from oblong to broadly pyramidal, branching pattern from irregular to verticillate, leaf blade shape from elliptic to narrowly elliptic, and fruit shape from clavate to oblong. Meanwhile, Cluster II, which consisted only of the Taba Penanjung accession, demonstrated a semicircular

crown shape, horizontal branching pattern, obovate leaf blade, and oblong fruit shape. In terms of quantitative characters, Cluster I had a trunk circumference of 45.2–78.5 cm, leaf blade length of 15.3–16.1 cm, fruit length of 29.75–37.1 cm, whole-fruit weight of 7–8.5 kg, flesh weight of 425.81–460.92 g per kg of fruit, and total soluble solids of 15.0–16.5 °Brix. In contrast, Cluster II showed a trunk circumference of 70 cm, leaf blade length of 13 cm, fruit length of 40.6 cm, whole-fruit weight of 9 kg, flesh weight of 300.25 g per kg of fruit, and total soluble solids of 11 °Brix (Table 1).

Table 1. Morphological characteristics of jackfruit clusters in Taba Penanjung District

Characteristic	Cluster I PN, LS, TH, BJ	Cluster II TP
Crown shape	Oblong, spherical, elliptical, broadly pyramidal	Semicircular
Branching pattern	Irregular, opposite, verticillate	Horizontal
Leaf blade shape	Elliptic, oblong, narrowly elliptic	Obovate
Leaf apex shape	Acuminate, acute, obtuse	Acuminate
Leaf base shape	Pointed, tapering, narrowed	Pointed
Leaf colour	Green, dark green, pinkish green	Green
Fruit shape	Clavate, ellipsoid, spheroid, oblong	Oblong
Stalk attachment to fruit	Flattened and depressed	Inflated
Flake shape	Cordate, rectangular, twisted, obovate	Oblong with curved tip
Seed shape	Oblong, elongate, ellipsoid, spheroid	Reniform
Fruit rind colour	Greenish yellow, green	Yellow
Pulp (flake flesh) colour	Deep yellow, yellow	Yellow
Seed coat colour	Creamish, dull brown, brown	Brown
Perianth colour	Yellow, cream	Yellow
Trunk circumference (cm)	45,2-78,5	70
Leaf blade length (cm)	15,3-16,1	13
Leaf blade width (cm)	7,05-8,9	7,05
Fruit stalk length (cm)	5,5-10,2	8
Fruit circumference (cm)	66,05-75,15	74,15
Fruit length (cm)	29,75-37,1	40,6
Fruit width (cm)	19-21,75	20,5
Rachis length (cm)	21,75-29	25
Rachis width (cm)	5,85-7,25	5
Perianth length (cm)	6,2-8	5,85
Perianth width (cm)	0,35-1,1	1,1
Whole-fruit weight (kg)	7-8,5	9
Flesh weight (g)	425,81-460,92	300,25
Seed weight (g)	74,5-97,81	72,12
Number of seeds per kg	10-12	6
Perianth weight (g)	121,55-223,85	240,3
Rachis weight (g)	49,99-94,71	79,53
Rind weight (g)	198,8-262,61	307,81

Flesh thickness (mm)	5,45-9,55	8,1
Rind thickness (mm)	12,4-24,55	20
Fruit hardness (kgf)	2,25-3,35	2
Seed hardness (mm)	79,5-98	79
Total number of seeds	79-98	81
Characteristic	Cluster I PN, LS, TH, BJ	Cluster II TP
Total soluble solids (°Brix)	15-16,5	11

DISCUSSION

Cluster analysis based on 38 morphological characters of five jackfruit accessions in Taba Penanjung District resulted in two main clusters. Cluster I comprised PN (Penum), LS (Lubuk Sini), TH (Tanjung Heran), and BJ (Bajak), whereas Cluster II consisted only of TP (Taba Penanjung). The dendrogram showed that Penum and Lubuk Sini related closer, followed by Tanjung Heran and Bajak, while Taba Penanjung remained separated from the other accessions. This clustering pattern indicates a lower level of morphological similarity between Taba Penanjung and the other four accessions, whereas Penum and Lubuk Sini showed greater morphological similarity.

The four accessions in Cluster I showed variation in vegetative morphological characteristics, including oblong, spherical, elliptical, and broadly pyramidal crown shapes, as well as opposite, verticillate, and irregular branching patterns. Variation was also observed in leaf blade shape, including elliptic, oblong, and narrowly elliptic forms, together with differences in leaf apex and base characteristics. These qualitative characters are important components of morphological characterization because they can describe phenotypic variation and assist in distinguishing plant accessions [10], [11]. Differences in crown shape and branching pattern may affect light interception and distribution within the canopy [12]. In addition, leaf morphological characteristics, including size and shape, may contribute to plant responses to drought conditions and water-use efficiency [13].

In addition to vegetative characters, Cluster I also showed variation in qualitative generative characteristics. Fruit shapes included clavate, ellipsoid, spheroid, and oblong forms, while fruit rind colour varied between green and greenish yellow. Variation was also observed in flake and seed shapes. Such variation reflects differences in fruit appearance and edible fruit components, which are relevant characteristics in the physical evaluation of jackfruit quality [14].

Quantitatively, accessions in Cluster I showed relatively close ranges for several vegetative and generative characteristics. Trunk circumference ranged from 45.2 to 78.5 cm, leaf blade length from 15.3 to 16.1 cm, and leaf blade width from 7.05 to 8.9 cm. Wider and larger leaves have been associated with higher net photosynthetic rates [15]. Whole-fruit weight ranged from 7 to 8.5 kg, flesh weight from 425.81 to 460.92 g per 1 kg of fruit, seed weight from 74.5 to 97.81 g per 1 kg of fruit, and total soluble solids from 15.0 to 16.5 °Brix. These relatively close quantitative ranges accompanied the grouping of the four accessions within Cluster I.

Variation in leaf, trunk, and fruit-component dimensions among accessions may be related to differences in assimilate partitioning between source and sink organs. Differences in flesh and seed weight may therefore reflect variation in sink strength among accessions [16]. Morphological characteristics may also result from interactions between genotype and environmental conditions, thereby contributing to phenotypic variation among accessions [17]. Similar variation in fruit length, fruit weight, flesh weight, and total soluble solids has been reported in morphological studies of jackfruit in Muara Bangkahulu District, Bengkulu City, even when the accessions were grouped within the same cluster [18].

The Taba Penanjung accession formed a separate Cluster II. Qualitatively, this accession was characterized by a semicircular crown, horizontal branching pattern, obovate leaf blades, an acuminate leaf apex, green leaves, an oblong fruit, an oblong flake with a curved tip, a reniform seed, and a yellow fruit rind. Some of these characteristics were also found in other accessions, whereas others differs from those observed in Cluster I. Similar qualitative morphological characters have also been used to distinguish jackfruit accessions in previous characterization studies [19].

Quantitatively, the Taba Penanjung accession had a trunk circumference of 70 cm, leaf blade length of 13 cm, leaf blade width of 7.05 cm, fruit length of 40.6 cm, and fruit width of 20.5 cm. Its flesh weight was 300.25 g per 1 kg of fruit, seed weight was 72.12 g per 1 kg of fruit, and total soluble solids were 11 °Brix. Although Taba Penanjung had a longer and heavier fruit than the accessions in Cluster I, it had lower flesh weight per kilogram of fruit and lower total soluble solids. This pattern indicates that larger external fruit dimensions are not necessarily accompanied by a greater amount of edible flesh. Previous studies have similarly reported that

increases in jackfruit size or length do not always correspond to increases in flesh weight [20]. There was a stronger correlations of fruit length with rind weight ($r = 0.88$) and core weight ($r = 0.71$) than with flesh weight ($r = 0.24$), supporting the observation that longer fruit may contain proportionally greater non-edible components rather than greater flesh weight [21].

Overall, the clustering of the five jackfruit accessions was determined by the combined contribution of qualitative and quantitative morphological characteristics rather than by a single character. Penum, Lubuk Sini, Tanjung Heran, and Bajak remained within Cluster I despite variation in several individual characteristics, whereas Taba Penanjung formed Cluster II because of its different overall combination of morphological traits. Qualitative and quantitative characters provide complementary information in morphological characterization: qualitative characters describe variation in organ shape and colour, while quantitative characters provide measurable information on morphological differences among accessions [22]. The integration of both types of characters therefore provides a more comprehensive description of morphological relationships among accessions, consistent with studies showing that cluster analysis based on multiple morphological characters can describe phenotypic similarity among plant accessions [23].

A strength of this study was the combined evaluation of qualitative and quantitative morphological characters across local jackfruit accessions, allowing their morphological relationships to be assessed using a mixed-data clustering approach. However, the study was limited to five accessions represented by 10 trees within Taba Penanjung District. In addition, morphological characters may be influenced by environmental conditions; therefore, the observed differences cannot be interpreted solely as genetic differences. Further studies should include a larger number of accessions, wider geographical sampling, evaluations across different seasons or environments, and molecular characterization to clarify the genetic basis of the observed morphological variation. The present findings provide initial information for the evaluation and utilization of local jackfruit germplasm, particularly Tanjung Heran for total soluble solids, Bajak for flesh weight, and Taba Penanjung for fruit size, as potential germplasm sources for further evaluation in jackfruit breeding programs.

CONCLUSION

The five jackfruit accessions in Taba Penanjung District showed morphological variation and were grouped into two clusters. Cluster I consisted of Penum, Lubuk Sini, Tanjung Heran, and Bajak, with whole-fruit weight ranging from 7 to 8.5 kg, flesh weight from 425.81 to 460.92 g per 1 kg of fruit, and total soluble solids from 15.0 to 16.5 °Brix. Cluster II consisted of the Taba Penanjung accession, characterized by a semicircular crown, horizontal branching pattern, obovate leaf blades, oblong fruit, reniform seeds, and yellow fruit rind, with a fruit length of 40.6 cm, whole-fruit weight of 9 kg, flesh weight of 300.25 g per 1 kg of fruit, and total soluble solids of 11 °Brix. The findings provide morphological information on local jackfruit diversity in Taba Penanjung District and indicate the potential of Tanjung Heran, Bajak, and Taba Penanjung as germplasm sources for total soluble solids, flesh weight, and fruit size, respectively, for further evaluation in jackfruit breeding programs.

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