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Fruit morphological diversity and quality of pulasan (*Nephelium ramboutan-ake*) from six populations in Riau, Indonesia

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Abstract. *Mardaleni, Jumin HB, Nandariyah, Yunus A. 2022. Fruit morphological diversity and quality of* pulasan *(*Nephelium ramboutan-ake*) from six populations in Riau, Indonesia. Biodiversitas 23: 2526-2533. N. ramboutan-ake* (*Nephelium ramboutan-ake*), which belongs to the Sapindaceae family, has economic value, but information on the morphological diversity and quality of its fruit is unknown. Thus, this study aimed to characterize the morphology and quality of *N. ramboutan-ake* fruits from six populations in Riau Province, Indonesia and observe the kinship among populations. A total of 18 qualitative and 13 quantitative characteristics were evaluated on 67 *N. ramboutan-ake* cultivars. The difference among morphological characteristics was to analyzed using ANOVA and Duncan multiple range tests, while the kinship analysis used UPGMA. Results of the quantitative and qualitative characterization of *N. ramboutan-ake* fruits showed high diversity among populations. The fruit is oblong, and it has a uniform skin color, sweet taste, aril cream-white color, and aril that can be easily peeled from the seeds. These characteristics indicate good fruit quality. Dendrogram analysis divided the population into two large groups at 73% similarity. The first group consisted of the population of Kampar Kiri, Gunung Sahilan, and Kuok, whereas the second group consisted of the population of Bengkalis, Siak, and Kuansing. The results of this study provide baseline information to obtain potentially superior characteristics for breeding and conservation of genetic resources, which can be used as a basis for the conservation of the germplasm of *N. ramboutan-ake.*

Keywords: Fruit, morphology, *N. ramboutan-ake,* population, pulasan

INTRODUCTION

The genus of Nephelium consists of 22 species, 16 of which are found in Indonesia (Kuswandi 2014; Putri et al. 2022; Siebert 1991; Windarsih 2019), and 8 are endemic to Kalimantan (Milow et al. 2013). Among the *Nephelium* genus, pulasan (*Nephelium ramboutan-ake*) is a tropical fruit plant with original distribution in Indonesia and Malaysia (Tindall 1994; Milow et al. 2013; Nurhuda et al. 2013). This species is closely related to rambutan (*Nephelium lappaceum*). In general, the stems and leaves of *N. ramboutan-ake* are similar to those of *N. lappaceum*, but the *N. lappaceum* fruit has limp hairs, while the *N. ramboutan-ake* has stiff or tough hairs. The size of the fruit is more or less the same as *N. lappaceum*, the taste of the fruit is sour to sweet, the color of the ripe fruit is dark red, purplish and even blackish. *N. ramboutan-ake* grows in lowland areas, on mineral soils and near river flows. *N. ramboutan-ake* plants are also found in peat ecosystems, even in tidal areas with an altitude of 2 meters above sea level.

N. ramboutan-ake has a high economic value (Djuita 2016) because of its delicious and sweet taste, high nutritional value, and relatively higher selling price than *N. lappaceum.* Apart from being consumed as fresh fruit, *N. ramboutan-ake* skin (exocarp) is also used as a mixture of processed foods such as ice cream, puddings, jams, syrups, and mixed drinks such as cocktails, and the seeds can also be processed into cocoa powder (Lim 2013). In addition, the skin of *N. ramboutan-ake* has cytotoxic and apoptotic effects (Chan et al. 2012; Fadhli et al. 2018), phenolic, and flavonoid, which are good for the health. It also has antibacterial (Fatisa 2013; Johnson et al. 2013) and antioxidant activities (Fadhli 2018; Palinisamy 2008).

In Indonesia, *N. ramboutan-ake* has been reported to occur in West Sumatra (Ediwirman et al. 2011), West Java (Djuita 2016, 2017; and Manggabarani et al. 2018), and Kalimantan (Siebert 1991). Anecdotal evidence indicates that *N. ramboutan-ake* is also found in Riau Province. However, nowadays *N. ramboutan-ake* plants are difficult to find in the province because their habitat has been disturbed by forest and land fires, and even in some case, it has been converted into monoculture agricultural land, industrial areas, and housing. In addition, many *N. ramboutan-ake* trees are cut down by the community to take their wood as building materials, and *N. ramboutan-ake* plants have not been cultivated intensively. In a previous study, Salman et al. (2015) reported that *Nephelium ramboutan-ake* is considered a rare plant in three countries (Thailand, Malaysia, and Indonesia). To date, no study has been conducted on *N. ramboutan-ake* diversity in Riau Province, although information on *N. ramboutan-ake* characterization and identification is important to obtain potentially superior characteristics for

breeding and conservation of genetic resources, which can be used as a basis for the conservation of the germplasm of *N. ramboutan-ake N. ramboutan-ake*.

Analysis of plant diversity can be performed using morphological markers, cytology, isoenzymes, and DNA (Zulfahmi 2013). Plant genetic differences can be evaluated through morphological, molecular, and chemical characterization. Morphological characterization is the primary method used for plant identification because of the real manifestation of phenotypic diversity (Rosmaina 2021). This method is easy and quick because it can be observed directly, although the morphological characters could be influenced by the environment, plant age, season, and growth phase (Rosmaina et al. 2021; Zulfahmi et al. 2013). The use of morphological characteristics for plant identification and characterization has been widely reported, including in pineapples (Adje et al. 2019; Hadiati et al. 2009; Rodriguez et al. 2020; Rosmaina et al. 2019, 2021), mangosteen (Mansyah 2012; Sulassih 2011), *N. lappaceum* (Barreto et al. 2015; Kuswandi et al. 2014; Muhamed et al. 2019; Salman 2015; Windarsih 2019), pasak bumi (*Eurycoma apiculata*) (Zulfahmi et al. 2020), and chili plants (Rosmaina et al. 2016). This study aims to characterize the morphology and quality of *N. ramboutan-ake* fruit, and to investigate the taxonomical kinship among the *N. ramboutan-ake* population in Riau Province based on such characters.

MATERIALS AND METHODS

Study period and area

This research was conducted from August 2016 to July 2017 in *N. ramboutan-ake* production center in Riau Province in four districts, namely Kampar, Kuantan Singingi (Kuansing), Siak, and Bengkalis. Six research locations were sampled as *N. ramboutan-ake* population groups. Kampar had three populations, namely Kuok, Gunung Sahilan, and Kampar Kiri. The districts of Kuantan Singingi, Siak, and Bengkalis had a population group called the Kuansing, Siak, and Bengkalis populations, respectively (Table 1 and Figure 1). The sampling populations were located at 2-5 m asl and 30-60 m asl, with two types of soil, namely mineral (Kampar and Kuantan Singingi) and peat (Siak and Bengkalis; Table 1).

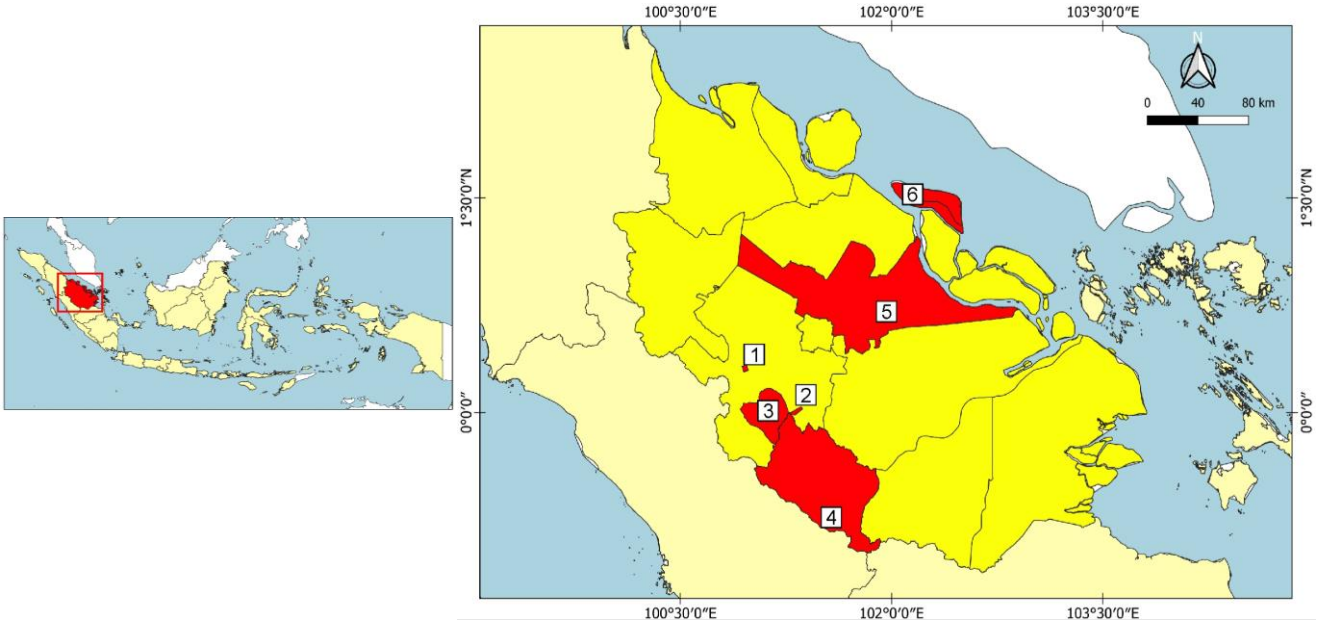

Figure 1. Sampling locations in six locations in Riau Province, Indonesia. 1. Kuok, 2. Mount Sahilan, 3. Kampar Kiri of Kampar District; 4. Kuantan Singingi District; 5. Siak District; and 6. Bengkalis District

Table 1. Number, origin, and location of *N. ramboutan-ake* samples at six locations/populations in four districts in Riau, Indonesia

District name	Location/ population	Geographical coordinates	Latitude (m. asl)	Soil type	Number of samples
Kampar	Kuok	0.33663, 100.95298	40	Mineral	16
Kampar	Gunung Sahilan	0.09340, 101.29400	30	Mineral	11
Kampar	Kampar Kiri	0.02982, 101.17971	60	Mineral	10
Kuantan Singingi	Kuansing	-0.51329, 101.57841	60	Mineral	16
Siak	Siak	0.80903, 102.07027	5	Peat	8
Bengkalis	Bengkalis	1.46355, 102.12369	2	Peat	6

Note: m asl: meters above sea level

Data collection

Identification and characterization were conducted on 67 plants that have already been producing fruits (Table 1). Each plant was harvested as many as 10 fruits that were physiologically ripe to be used as samples. A total of 670 fruit samples were collected. Characterization was conducted in accordance with the *Descriptors for Rambutan* (2003) standard, issued by the International Plant Genetic Resources Institute (IPGRI). In addition, characterization was performed to investigate qualitative and quantitative characteristics.

Thirteen quantitative characteristics were identified, including fruit length (cm), fruit weight (g), fruit diameter (cm), fruit skin thickness (mm), fruit skin weight (g), spine length (mm), number of spines (2×2 cm), aril weight (g), aril thickness (mm), total soluble solid content (TSSC, Brix), total dissolved acid (TDA), the ratio of TSSR/TDA, and edible part (%). Moreover, 18 qualitative characteristics were identified, including fruit shape, fruit skin thickness, fruit skin color uniformity, fruit color, fruit attractiveness, fruit quality, spine texture, spine distribution, spine color, spine flexibility, aril color, aril thickness, aril texture, aril taste, flavor strength, water content (juiciness), aril appearance in seeds, and aril scarcity in seeds.

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Data analysis

The data obtained were analyzed by ANOVA using the SAS 9.1 program and continued with the separation of the mean values using the Duncan multiple range test at a level of 5%. UPGMA cluster analysis was performed using MVSP 32.

RESULTS AND DISCUSSION

Quantitative characteristics of fruit

Quantitative characteristics are measurable and strongly influenced by the environment, generally polygenic (Rosmaina et al. 2021). Quantitative diversity is characterized by the continuous distribution of data that can be measured and influenced by the environment, as shown in the appearance of the marker and by many genes. In addition, quantitative characteristics that can contribute to the *N. ramboutan-ake* variability can be represented by fruit characteristics. Analysis of the variance of 13 quantitative characteristics showed significant differences among the tested genotypes (Table 2).

Analysis results showed that the length of *N. ramboutan-ake* fruit in the populations of Gunung Sahilan, Kampar Kiri, Kuok, and Bengalis was statistically the same, ranging from 5.21 cm to 5.36 cm. The fruit length of the four populations was longer than that of the Kuansing and Siak populations (4.80 and 4.87 cm, respectively, Table 2). Fruit length is affected by fruit shape. The weight of *N. ramboutan-ake* fruit from Riau in the six populations was studied. All populations had the same fruit weight, ranging from 39.05 g to 41.44 g, except for the fruit weight of the Kuansing population, which was the lowest with an average of 36.04 g. The *N. ramboutan-ake* fruit obtained from the island of Java reported by Djuita (2016) had an average fruit weight of 46.0 g. These data indicate the high diversity of *N. ramboutan-ake* fruit weight in Indonesia, which is influenced not only by genetic factors but also by environmental factors. When compared with the weight of *N. lappaceum* fruit, as reported by previous studies (Arenas et al. 2010; Windarsih et al. 2019), the weight of the *N. ramboutan-ake* fruit is heavier than that of *N. lappaceum*. However, the weight of *N. lappaceum* fruit from Thailand (Salman et al. 2015) had the highest weight of 48.2 g among six cultivars observed, which is heavier than the weight of *N. lappaceum* and *N. ramboutan-ake* from Indonesia.

Table 2. Quantitative morphological characteristics of *N. ramboutan-ake* fruit in six populations in Riau Province, Indonesia

Characteristics	Location/population name					
	Kuok	Gunung Sahilan	Kampar Kiri	Kuansing	Siak	Bengkalis
Fruit length (cm)	5.26a	5.21a	5.36a	4.80b	4.87b	5.15a
Fruit weight (g)	39.93a	41.03a	41.44a	36.04b	40.99a	39.05a
Fruit diameter (cm)	4.57b	3.43bc	4.59b	4.37c	4.94a	3.81d
Fruit rind thickness (cm)	0.58b	0.53bc	0.38d	0.43cd	0.61b	0.85a
Fruit rind weight (g)	24.83c	27.22ab	26.06bc	20.86d	28.69a	28.59a
Spine length (cm)	0.66a	0.64a	0.56b	0.51b	0.42c	0.36c
Number of spines (4 cm^2)	35.27b	27.81c	36.07b	38.96a	34.98b	39.36a
Weight of aril (g)	12.08a	12.60a	11.75a	11.85a	9.88b	9.70b
Aril thickness (mm)	6.34a	4.65c	5.00c	4.65c	5.29bc	5.93ab
TSSC (°Brix)	19.98b	21.13a	20.64ab	20.00b	17.29d	18.33c
Total dissolved acid (TDA)%	4.34c	5.03b	6.19a	3.60d	4.14c	1.83e
Ratio TSSC/TDA%	5.01c	4.88c	3.82c	8.23b	7.25b	11.15a
Edible Part (%)	32.18ab	32.60ab	29.10bc	34.75a	24.37c	24.90c

Numbers followed by a different superscript letter(s) indicate a significant difference based on Duncan's test results at the 5% level.
Notes: TSSC = Total Soluble Solid Content

The diameter of *N. ramboutan-ake* fruits from the population of Kuok, Gunung Sahilan, and Kampar Kiri was not statistically and significantly different, which was generally of medium size. The highest fruit diameter was found in *N. ramboutan-ake* fruit from the Siak population (4.94 cm), whereas the smallest fruit diameter was found in the Bengkalis population (3.81 cm). The weight of the *N. ramboutan-ake* fruit skin of the Siak and Bengkalis populations was 28.69 and 28.59 g, which was heavier than the other populations, followed by *N. ramboutan-ake* fruit from Kampar from the populations of Gunung Sahilan and Kampar Kiri (27.22 and 26.06 g). The *N. ramboutan-ake* fruit of all populations was significantly different from that of the Kuansing population, which had the lightest skin weight of 20.86 g. The weight of the fruit skin is influenced by its thickness. The thickness of the skin of *N. ramboutan-ake* fruit was significantly different among populations, where the fruit of the Bengkalis population had the thickest fruit skin at 0.85 cm (Table 2).

The populations of Kuok, Gunung Sahilan, Siak, and Bengkalis can be categorized as having a thick fruit skin (>5 mm), whereas the populations of Kampar Kiri and Kuansing were categorized as having a thin fruit skin, which had a skin thickness of less than 0.5 mm. Based on the standardization of the IPGRI description for *N. lappaceum*, which is used as the basis for *N. ramboutan-ake* characterization in this study, the thickness of the fruit skin is <5 mm, including the thin category. *N. ramboutan-ake* is the closest family to *N. lappaceum*, which has a fruit skin thickness that is thicker than *N. lappaceum*, but apparently, some have thin skin as found in the Kampar and Kuansing populations. Compared with the Mexican *N. lappaceum* reported by Joo-Perez et al. (2017), the average thickness of the fruit skin of 40 *N. lappaceum* plants was between 3.10 and 3.30 mm (classified as thin-skinned). Furthermore, Muhammad et al. (2019) reported that the thickness of the *N. lappaceum* skin of 100 types of *N. lappaceum* studied, which had a fruit skin thickness of >5 mm, was only 24.49%, and the rest was <5 mm. The weight of the fruit skin tends to match the thickness level. Therefore, thick fruit skin is heavier than thin fruit skin.

The length of the spine also varied. The fruit in the Kuok and Gunung Sahilan populations had a spine length of 0.66 and 0.64 cm, respectively. Statistically, it was longer than the fruit spine in the Kampar Kiri and Kuansing populations (0.56 and 0.51 cm). The shortest spine size was found in the Siak and Bengkalis populations, which were 0.42 and 0.36 cm, respectively (Table 2). The populations of Siak and Bengkalis occurred in peat soils; thus, these two populations showed a shorter spine size than the other four populations (Kuok, Gunung Sahilan, Kampar Kiri, and Kuansing), which grew in mineral soils. The length of the spine does not determine the density of the spine in each fruit, but it affects the diameter of the fruit. In general, a fruit that has a longer spine will increase the diameter of the fruit. The number of spines in the fruit surface area per 2 cm × 2 cm based on statistical analysis was significantly different among populations. Fruits from the Kuansing and Bengkalis populations had dense spines with 38.96 and 39.36 spines per 2 cm × 2 cm, respectively. The number of spines was small in the population of Siak (34.98), Kampar Kiri (36.07), and Kuok with 35.27 spines. Furthermore, the population of Gunung Sahilan had a smaller number of spines (27.81), and the distance between spines was less frequent.

The aril weights of *N. ramboutan-ake* fruit in the three populations in the Kampar district were statistically the same as those of the Kuansing population. The weight of aril ranged from 11.85 g to 12.60 g. The aril weight was heavier than the fruit from Siak and Bengkalis populations, with an aril weight of 9.70-9.88 g. The results indicated that the aril weights of all populations on mineral soils were heavier than those of the Siak and Bengkalis populations that grew in peat soils. However, the thickest aril was found in the fruit of the Kuok population (6.19 mm) and the Bengkalis population (5.93 mm). The Kuok and Bengkalis populations had thicker aril compared with the other four populations, probably because several species in the Bengkalis population were from the Kuok population of the Kampar District. According to the historical information, initially, several people migrated from Kampar and settled in Bengkalis; therefore, *N. ramboutan-ake* was one of the plants that were brought there. In Bengkalis, the *N. ramboutan-ake* were planted in the yard of a house in peat soils which were different from their initial habitat (mineral soils), and this *N. ramboutan-ake* plant grew and developed well until now. The Kuok and Bengkalis populations had different ecosystem types, but some cultivars generally had similarities with regard to aril thickness. Therefore, the thickness of aril is influenced not only by the type of soil, but also by genetic factors and microclimate.

The highest average TSSC was found in the population of Gunung Sahilan, which was 21.13 (^{0}Brix), followed by the populations of Kampar Kiri, Kuok, and Kuansing. These four populations occurred on mineral soils, where the dissolved solid content of the visible fruit was higher than the fruit of the Siak and Bengkali populations, which have an average TSSC of 17.81-18.33 (^{0}Brix). The TSSC of *N. lappaceum* from West Java reached 29 (^{0}Brix) (Windarsih et al. 2019), which was higher than that from India (17.80-20.40 [^{0}Brix]) (Arenas et al. 2010).

The TDA of the *N. ramboutan-ake* fruit from Riau varied widely among populations. The highest TDA was found in the fruit of the Kampar Kiri population (6.19%), and the lowest was found in the Bengkalis population (1.83%). Meanwhile, Gadalupe et al. (2010) reported that *N. lappaceum* fruit in India contained a lower total titrated acid of 0.20%-0.28%. TSSC (^{0}Brix) indicates the level of sweetness of the fruit, which is influenced by the TDA in fruit. Sweet taste is determined by TSSC/TDA; the higher the TSSC/TDA ratio, the sweeter the taste of the fruit (Rosmaina et al. 2019). The highest edible part (%) was obtained from the Kuansing population, reaching 34%, which was not significantly different from the Gunung Sahilan population (32.60%) and Kuok population (32.18%), followed by the Kampar Kiri population (29.10%). However, it was statistically different from the Siak and Bengkalis populations, which had a lower edible part percentage of 24.37% and 24.90%, respectively.

Quantitatively, the morphological characteristics of the *N. ramboutan-ake* fruit were diverse in the 13 observed characteristics. The high level of diversity among populations was indicated by the fruit diameter, fruit skin thickness, TSSC, and TDA. However, all populations had the same fruit weight, except for the Kuansing population. Populations of Kuok, Gunung Sahilan, Kampar Kiri, and Kuansing had the same weight, and they were heavier than the arils of the Siak and Bengkalis populations.

Qualitative characteristics

Qualitative diversity is characterized by a discontinuous or discrete distribution of data, clearly distinguishable by observation and usually controlled by a few genes and appearance with no or little environmental influence. The results of the identification of 18 qualitative characteristics of *N. ramboutan-ake* fruit showed diversity in 14 observed characteristics. In addition, the other four characteristics, namely, fruit rind color, spine texture, spine strength, and aril juiciness, were similar among the tested genotypes. The fourteen different characteristics included fruit shape, fruit rind thickness, uniformity of color on the fruit surface, fruit attractiveness, fruit quality, spine density, spine color, aril color, aril thickness, aril texture, aril taste, aril flavor, attachment of aril to seed, and adherence of epidermis to aril (Table 3). The taste of fruit in all locations was sour and sweet, but the sweet taste dominated, except for the dominant Siak population with a sour and sweet taste. Several qualitative characteristics contributed to the different phenotypes of *N. ramboutan-ake* plants, namely, spine distribution, spine color, fruit size, fruit shape, fruit skin thickness, fruit peel weight, aril color, and aril taste, and whether or not the aril is extracted from the seeds contribute to the determination of *N. ramboutan-ake* fruit quality.

The *N. ramboutan-ake* fruits in Riau had various forms. Based on the results of observations, three fruit shapes, namely globose, oval and oblong were identified. The color of the *N. ramboutan-ake* fruit was in a strong red to blackish gradation. Therefore, the color density on the exposed skin of each cultivar contained different concentrations of active ingredients in different percentages. Previous research revealed the content of antioxidants and anti-cancer compounds in *N. ramboutan-ake* skin (Chan et al. 2012; Fatisah 2013) and *N. lappaceum* skin (Palanisamy et al. 2008; Wutgulrag et al. 2010; Palanisamy et al. 2011; Nurhuda et al. 2013). Similar to the *N. lappaceum* fruit, which has hair on the outer skin of the fruit, the appearance is the same, but the hair has a stiff texture (spine). In general, the spines spread evenly on the surface of the fruit skin, from dense to very dense. The size can determine the size of the fruit, whereas the color of the spine and the shape of the fruit determine the attractiveness of the fruit (Figure 2). Fruit color is a qualitative characteristic that is controlled by one or two simple genes, and a small part is influenced by the environment (Stopskops et al. 1993). Rosmaina et al. (2021) reported that qualitative characteristics are good at distinguishing cultivars because they are slightly influenced by the environment, in contrast to quantitative characteristics that are strongly influenced by the environment or where the plant lives.

Fruit quality was assessed on the basis of fruit taste, flavor strength, and fruit attractiveness (fruit appearance). The taste of the fruit was sweet and delicious, and the characteristics of the arils were glaring. In addition, the colors were cream and white, and the arils were thick. Moreover, the arils were of good quality; thus, they looked attractive, and they were most favored by the panelists. Fruits that had white arils tended to be thin and less sweet (Figure 3), separates the aril from the seed is stretched is one of the genetic influences, not the environment.

Table 3. Qualitative morphological characteristics of *N. ramboutan-ake* fruit in six populations in Riau Province, Indonesia

Characteristics	Name of location/population					
	Kuok	**Gunug Sahilan**	**Kampar Kiri**	**Kuansing**	**Siak**	**Bengkalis**
Fruit shape	Oval	Oblong	Oval	Globose	Globose	Oblong
Fruit rind thickness	Medium	Medium	Medium	Thin	Thick	Medium
Fruit rind color	Dark-red	Dark-red	Dark-red	Dark-red	Dark-red	Dark-red
Uniformity of color on fruit surface	Uniform	Uniform	Not-uniform	Not- uniform	Uniform	Not-uniform
Fruit attractiveness	Good	Good	Good	Intermediate	Intermediate	Intermediate
Fruit quality	Good	Good	Good	Moderate	Medium	Good
Spine texture	Stiff	Stiff	Stiff	Stiff	Stiff	Stiff
Spine density	Dense	Dense	Dense	Very dense	Dense	Medium
Spine color	Dark-red	Dark-red	Dark-red	Dark-red	Dark-red	Red
Spine strength	Strong	Strong	Strong	Strong	Strong	Strong
Aril color	Dull-white	Cream-white	Cream-white	White	Dull-white	Cream-white
Aril thickness	Medium	Medium	Thick	Medium	Medium	Medium
Aril texture	Firm	Soft	Firm	Soft	Soft	Soft
Aril taste	Sweet	Sweet	Sweet	Sweet	Acid-sweet	Sweet
Aril flavor	Intermediate	Intermediate	Intermediate-strong	Intermediate	Intermediate	Strong
Aril juiciness	Juicy	Juicy	Juicy	Very juicy	Juicy	Juicy
Attachment of aril to seed	Good	Good	Good	Medium	Medium	Good
Adherence of epidermis to aril	Tight	Tight	Tight	Intermediate-strong	Poor	Tight

In glaring *N. ramboutan-ake*, the epidermis was attached to the seed, and it did not go along with the aril; thus, it is safe for the stomach if consumed in large quantities. In contrast to *N. lappaceum*, which is glazed, the epidermis is always attached to the aril; thus, it goes with the aril, and it can cause diarrhea if consumed in large quantities. Furthermore, the epidermis of *N. ramboutan-ake* seed was thinner and softer than the epidermis of *N. lappaceum* seed. The results of the study also revealed other characteristics of perfectly ripe fruit, and each genotype had a distinctive aroma in fruit. The characteristics that have been displayed can determine the quality of the *N. ramboutan-ake* fruit from Riau. In other studies, the qualitative characteristics of fruit can also be represented by several fruit phenotypic characteristics, as suggested by Rodriguez-Alfonso (2020) and Rosmaina et al. (2021) on the quality of pineapple fruit.

Cluster analysis

The characteristics of the Kuok, Gunung Sahilan, and Kampar populations in the same group included the fruit diameter and TSSC/TDA (%). These three populations are separated by 73% of the Siak, Bengkalis, and Kuansing populations (Figure 4). Several researchers reported minimal or major characteristics that could clearly distinguish cultivars, including Silva et al. (2017) and Rosmaina (2021), who reported on capsicum and pineapple plants.

The results showed that the *N. ramboutan-ake* morphological characteristics of the six populations had a similarity of 73%, indicating a diversity of 27%. At the 73% similarity level, the *N. ramboutan-ake* genotypes were separated into two large groups. The first group consisted of the genotypes of the Kampar Kiri, Kuok, and Gunung Sahilan populations. Meanwhile, the second group consisted of the genotypes of the Kuansing, Bengkalis, and Siak populations. All genotypes contained in the first group came from Kampar District, which is an area with mineral soils. In addition, the second group consisted of mineral soils and peat soils. In particular, the genotypes originating from Kuantan Singingi belonged to the peat soils group. The similarity in fruit morphology of the Kuansing population to that of the Siak and Bengkalis populations is shown in similar fruit shape, fruit length, and uniformity of fruit color when ripe (Figure 4). The results of this study revealed a 27% difference in fruit appearance based on the location of the mineral soils and peat soils. The *N. ramboutan-ake* appearance of the Siak population and the Bengkalis population, which grew on peat soils, had similarities in the shorter spine, lower edible part, and thinner aril than the *N. ramboutan-ake* appearance from mineral soils.

Differences in fruit characteristics are influenced not only by genetic factors but also by environmental factors such as soil factors and the nutrients contained therein. The difference in the light intensity of each cultivar was also different because the observed *N. ramboutan-ake* samples were obtained from the courtyards of people's homes; thus, some were shaded and some were in the open area. In addition, the accumulation of organic matter in peat soil can affect the sweetness level of the fruit. Characterization of other horticultural crops was reported by Rosmaina (2019) that pineapple plants grown on peat soil had higher fruit weight and pineapple fruit length than pineapples grown on mineral soils. This result might be due to the availability and uptake of nutrients in peat soils, which are higher than in mineral soils.

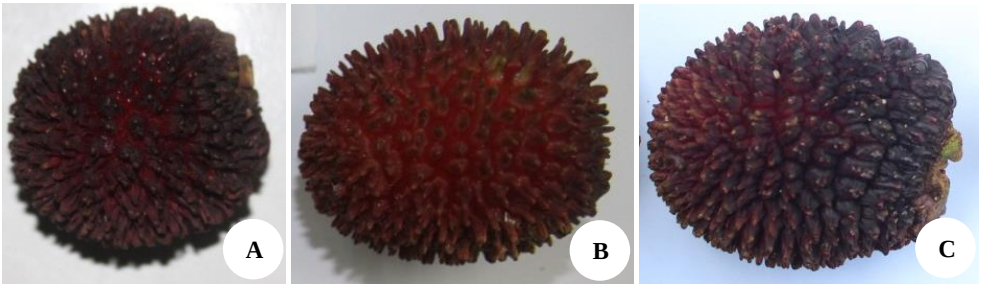

Figure 2. *N. ramboutan-ake* fruit morphology is based on different fruit shapes: A. globose, B. ovoid, and C. oblong

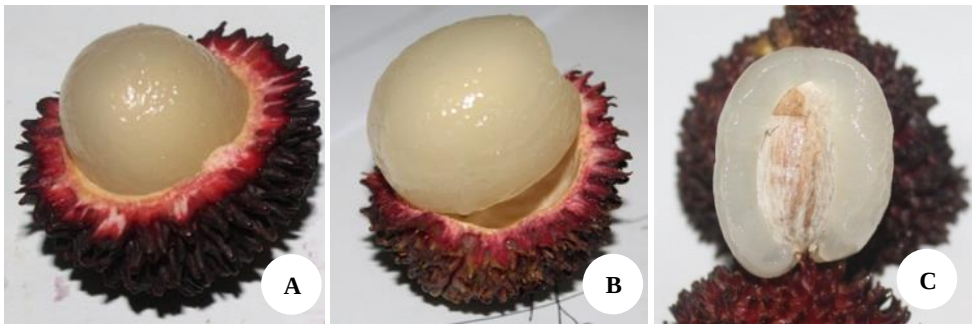

Figure 3. Morphology of *N. ramboutan-ake* fruit based on differences in aril color: A. cream-white, B. dull-white, and C. white

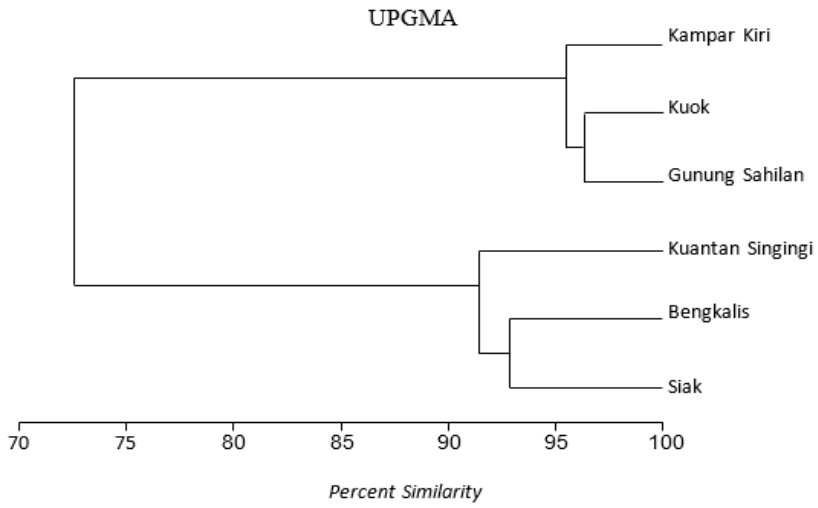

Figure 4. Dendrogram of the percentage of similarity of *N. ramboutan-ake* in six populations in Riau Province, Indonesia

In conclusion, quantitative analysis showed that the length of *N. ramboutan-ake* fruit in the populations of Gunung Sahilan, Kampar Kiri, Kuok and Bengkalis was statistically the same and longer than that of the Kuansing and Siak populations. The *N. ramboutan-ake* appearance of the Kuok, Gunung Sahilan, Kampar kiri and Kuansing populations had the same aril weight and higher than that of the Siak and Bengkalis populations. Among the 18 qualitative characters tested, all showed significant differences among populations except for fruit skin color, bone texture, and bone strength. Based on the UPGMA, *N. ramboutan-ake* in Riau Province had a genetic similarity of 73%, indicating the level of genetic diversity based on morphological characteristics and fruit quality of 27%.

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