

6-20-2019

Characteristics and Ideotype Formulation of Pulasan (*Nephelium ramboutan-ake*) Fruit Landrace from West Java, Indonesia

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Djuita, Nina Ratna; Hartana, Alex; Chikmawati, Tatik; and Dorly (2019) "Characteristics and Ideotype Formulation of Pulasan (*Nephelium ramboutan-ake*) Fruit Landrace from West Java, Indonesia," *Makara Journal of Science*: Vol. 21 : Iss. 2 , Article 3.

DOI: 10.7454/mss.v21i2.7304

Available at: <https://scholarhub.ui.ac.id/science/vol21/iss2/3>

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Cover Page Footnote

This research was funded by the Directorate General of Higher Education with Dr. Ir Tatik Chikmawati, MSi as the researcher chairperson. We would like to thank the Center for Tropical Horticulture Studies of Bogor Agricultural University, PT Mekar Unggul Sari, Mekarsari Fruit Garden, and Cipaku Experimental Garden for the facilities. We are also grateful to Prof. Mien A. Rifai for his suggestions on this research.

Characteristics and Ideotype Formulation of Pulasan (*Nephelium ramboutan-ake*) Fruit Landrace from West Java, Indonesia

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Received November 9, 2015 | Accepted December 22, 2016

Abstract

Pulasan (*Nephelium ramboutan-ake*) is a unique tropical fruit, but its morphological variations have not been well characterized. This study was conducted to obtain data on the characteristics of pulasan landrace in West Java, Indonesia, and to formulate the ideotype of pulasan with superior characteristics, such as high fruit weight, sweet taste, and thick and easily peelable aril from the seed. Based on the descriptors of rambutan, 61 fruit variants were observed. The results showed that the average fruit weight was 46.0 g, with the highest at 103.5 g and the lowest at 23.1 g. The °Brix level variation of pulasan fruit was 16.8–29.6, and its vitamin C content was 14.0–24.0 mg/100 g. Five variants with superior fruit characters were identified among the sample collections used in the study.

Abstrak

Karakteristik dan Formulasi Ideotipe Kultivar Lokal Kapulasan (*Nephelium ramboutan-ake*) dari Jawa Barat, Indonesia. Kapulasan (*Nephelium ramboutan-ake*) merupakan buah tropis yang unik, namun variasi morfologi buahnya belum diketahui dengan baik. Penelitian ini bertujuan untuk mendapatkan data karakteristik buah dari kultivar lokal kapulasan yang ada di Jawa Barat, Indonesia, dan untuk memformulasikan kapulasan yang ideal yang memiliki ciri-ciri unggul seperti bobot buahnya tinggi, rasanya manis, arilusnya tebal dan mudah dilepaskan dari biji. Berdasarkan deskriptor rambutan, sebanyak 61 pohon kapulasan telah diamati. Hasilnya menunjukkan bahwa rata-rata bobot buah kapulasan 46,0 g paling tinggi 103,5 g dan paling rendah 23,1 g. Kandungan °Brix buah kapulasan adalah 16,8–29,6 dan kandungan vitamin C adalah 14,0–24,0 mg/100 g. Lima varian buah yang mempunyai ciri-ciri unggul ditunjukkan di antara koleksi yang diamati dalam penelitian.

Keywords: °Brix level, morphological variations, Sapindaceae, vitamin C

Introduction

Pulasan is a tropical fruit belonging to the soapberry (Sapindaceae) family, and it is closely related to rambutan. The fruit of pulasan is unique. Its good flavor and sweet taste are similar to those of rambutan, but pulasan has a thick and a rigid bulging rind. This trait reminds people of “babat,” the reticulated tripe of ruminant animals. This characteristic makes pulasan in Java known as “rambutan babat.” Pulasan is widely used as fresh fruit, and its seeds are also edible. As the aril of pulasan has a variety of tastes, namely, sour, sweet and sour, and sweet, this fruit has the potential to be developed into different products, such as jams, jellies, canned fruit [1], fruit dessert, beverage, and snack chips.

Selection and characterization are required to develop fruit with good quality. In the Sapindaceae family, the characterization of rambutan and longan fruits was conducted [2,3]. Agronomical characteristics, such as the amount of vitamin C in the fruit, were analyzed in longan, lychee, and rambutan [4,5]. The quality of shelf life was investigated in longan [6], lychee [7], and rambutan [8]. However, research on the characterization of pulasan fruit is limited [9-10]. Previous research on pulasan emphasized on the morphological variation of flower and type of pollination [11]. Other studies discussed the use of rind and seed of pulasan as medicine [12] and as an antibacterial [13]. Therefore, this study was undertaken to (1) obtain data on the fruit characteristics of pulasan landrace and to (2) identify the ideotype of pulasan with superior characteristics,

such as high fruit weight, sweet taste, and thick aril that is easily removed from the seed. Landrace is a local cultivar existing in an area. Ideotype is the ideal type that has characteristics according to predetermined criteria.

Materials and Methods

A total of 61 pulasan trees (19–22 fruit per tree) were sampled from various areas encompassing the Bogor Regency (subdistricts of Babakan Madang, Cibinong, Cileungsi, Ciomas, Dramaga, and Sukaraja), Bogor Municipality (subdistricts of East Bogor, North Bogor, and South Bogor), and Ciamis Regency (subdistricts of Baregbeg and Cijeungjing), West Java, Indonesia (Figure 1). Bogor is situated in the southern part of Jakarta. Bogor Regency is located at coordinates of 6°18'0"–6°47'10" LS and 106°23'45"–107°13'30" BT with an area 298.838.304 ha. The types of morphological regions vary from relatively low plains in the north to the highlands in the south. According to Schmidt and Ferguson, Bogor has type A climate in the

south and type B climate in the north, with an average rainfall of 2500–5000 mm/year [14]. Bogor Municipality is located at the center of Bogor Regency. Ciamis is one of the districts of West Java. It has an area of 244,479 ha and coordinates of 7°40'–7°41' LS and 108°20'–108°40' BT. According to the climate classification of Schmidt and Ferguson, Ciamis regency generally has type C climate and an average rainfall of 3600 mm/year [15].

Fourteen fruit characteristics, namely, shape, weight, diameter, length, pericarp thickness, pericarp weight, pericarp bump length, density of bumps on the bulging pericarp, fruit ripening, skin color, texture, bulge rind color, storage period, and strength of bulge rind, were observed. Seven aril characteristics were also examined: weight, thickness, texture, flavor, stickiness of aril testa, Brix, and vitamin C content. Seeds were characterized for their length, width, thickness, seed weight, seed shape, and seed color. Data were analyzed using Pearson or Kendall's tau_b correlation, SPSS version 22, and regression analysis using Minitab version 16.

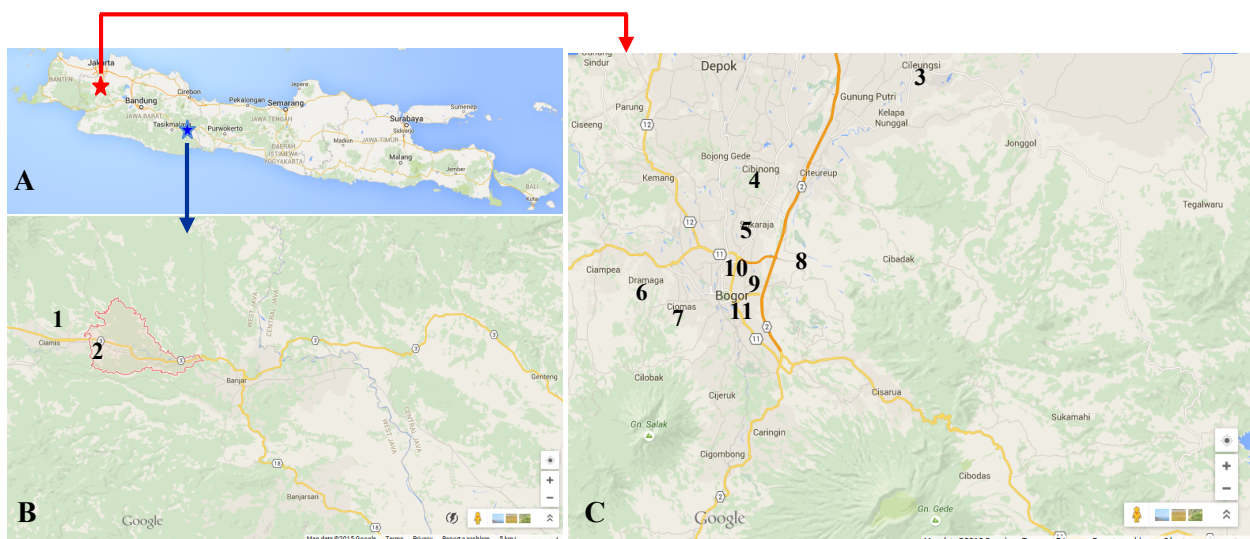


Figure 1. Map Sampling of Pulasan Fruit. A) Java Island, B) Ciamis, C) Bogor, ★ = Ciamis, ★ = Bogor, 1) Baregbeg 2) Cijeungjing 3) Cileungsi 4) Cibinong 5) Sukaraja 6) Dramaga 7) Ciomas 8) Babakan Madang 9) East Bogor 10) North Bogor 11) South Bogor (Source: google.co.id)

Results and Discussion

Existing Pulasan Landrace in West Java. The pulasan fruit found in Bogor comes in two shapes: spherical and ovoid (Figure 2). The spherical fruit is smaller than the ovoid one; it comes in orange, red, red-brown, or green color; and its aril may or may not be easily peeled off from the seed. Pulasan trees with spherical fruits are less common than those with ovoid fruits. The ovoid fruits have larger fruit weight and a red or dark red color. Pulasan from Ciamis also comes in spherical and ovoid shapes. The spherical fruits have an orange color, and the ovoid ones come in red or dark red.

Pulasan in Bogor used to come in white, red, and sibabat. White pulasan has become rare and difficult to find [16]. Recent observations in the field have indicated that the white pulasan cultivar cannot be found anymore, whereas the red pulasan and sibabat still exist. Pulasan trees have decreased in number since 2014. Prasetyo [17] reported 39 trees could be found in the Jabon Mekar Village, a subdistrict of Parung, Bogor, but now only one pulasan tree exists. In the other subdistricts, some trees were cut down because of old age, low production, or sour taste. Some were also replaced by other crops.

Characteristics of Pulasan Fruit. The pulasan fruit consists of fruit rind, aril, and seed. Fruit rind (pericarp) occupies the largest portion of the fruit weight, with an average of 67.4%. Aril weight (edible portion) ranges from 18.8–39.5% at an average of 26.9%. The seed occupies the smallest portion of the fruit weight at an average of 5.7% (Table 1). The edible portion of pulasan is lower than that of longan (69.9%), rambutan (50%), and lychee (74.7%) [3,18,19]. The pulasan aril has a sour, sweet and sour, or sweet taste, and its texture is soft to crunchy.

The size and color of pulasan fruit vary. Fruit length is 3.8–7.5 cm, and fruit diameter is 3.4–6.1 cm. The

pulasan fruit comes in orange, red, dark red, and green. These characteristics are different from those observed by Pohlan et al. [20], who reported that the fruit size of pulasan was 5–6 cm long and 2.5–4 cm in diameter with yellow or red color. The largest fruit size (103.5 g) was obtained from the collection at Gunung Batu Village, subdistrict of West Bogor, and the smallest fruit (23.1 g) came from the collection in Karadenan, subdistrict of Cibinong. Compared with that of rambutan, the size of pulasan can either be larger or smaller. The skin of the fruit has many rigid bumps. These bumps can be solitary or in groups. Bump density varies at 21.9–71.2, with an average of 46.5 per $2 \times 2 \text{ cm}^2$ (Table 1).



Figure 2. Shapes of Pulasan Fruit A) Spherical, B, C) Ovoid

Table 1. Characteristics of Pulasan Fruit

Fruit Characteristics	Min	Max	Average
Fruit weight (g)	23.1	103.5	46.1
Pericarp weight (g)	13.6	77.4	31.3
Aril weight (g)	5.9	23.2	12.3
Seed weight (g)	1.9	2.7	2.1
Ratio of pericarp and fruit weight (%)	56.6	76	67.4
Ratio of aril and fruit weight (%)	18.8	39.5	26.9
Ratio of seed and fruit weight (%)	1.1	10.8	5.7
Fruit length (cm)	3.8	7.5	5.2
Fruit diameter (cm)	3.4	6.1	4.5
Pericarp thickness (mm)	4.3	9.4	6.4
Aril thickness (mm)	3	6.5	4.5
Bump density	21.9	71.2	46.5
Bump length (mm)	2	4.9	3.3
Seed length (cm)	1	3.5	2.5
Seed width (cm)	0.5	1.9	1.6
Seed thickness (cm)	0.2	1.7	1
°Brix	16.8	29.6	23.5
Vit C (mg/100 g)	14	24	18.9

The °Brix content of pulasan fruit ranges from 16.8–29.6 (Table 1). Its °Brix level is higher than those of the closest relatives of pulasan, for example, rambutan (17.8–20.9) [2]. A previous study reported that the °Brix content increases along with the age of the fruit (Pohlan et al. 2008). Brix degrees in fruits are influenced by the storage period. In rambutan, a long storage period could reduce the °Brix level [21,8].

Pulasan is a non-climacteric fruit. This kind of fruit is harvested only when it has ripened on its tree. After harvesting, fruit quality does not improve [22]; the fruit does not continue to ripen and sugar accumulation ceases [4]. Other examples of non-climacteric fruits are the relatives of pulasan, such as lychee [23], longan, and rambutan [4].

Vitamin C content of the pulasan fruit varies from 14.0–24.0 mg/100 g depending on the variant, but it has an average vitamin C content of 18.9 mg/100 g (Table 1). Compared with those of other Sapindaceae plants, such as longan, lychee, and rambutan, the vitamin C content of the pulasan fruit is low. The vitamin C content of longan, lychee, and rambutan is 60.1, 27.6, and 36.4 mg/100 g [4], respectively. Several factors affect the amount of vitamin C in fruit, such as differences in plant genotypes, climatic conditions, stage of fruit

ripening, harvesting methods, and post-harvest handling [24]. Room temperature can also affect the stability of vitamin C [25]. High temperatures [24] and a long storage period may reduce the vitamin C level [26].

Shelf Life of Pulasan Fruit. Pulasan fruit stored at room temperature can last four to five days. At a longer storage period, the skin of the fruit changes color to brown and may become moldy. The aril becomes juicier but turns sour taste and becomes flabby. Compared with pulasan, the rambutan fruit has a shorter storage period of two to three days; afterwards, its hair will begin to wither although the aril is still good [21]. The rambutan fruit can deteriorate during the storage period because of decreased fruit quality, reduced organoleptic quality, and the presence of diseases [27]. These conditions also occur in the pulasan fruit.

Several methods, such as lowering the temperature and controlling and modifying the atmosphere of the storage room [7], can be used to extend the storage period of fruits. Previous study showed that rambutan stored at 8–15 °C with relative humidity of 90–95% remained in good condition for 14–16 days [28]. Wrapping rambutan cv Binjai using 0.09 mm low-density polyethylene film at 10 °C extended its shelf life to 20 days [8]. Chitosan and *Lactobacillus* can preserve the quality of rambutan [29].

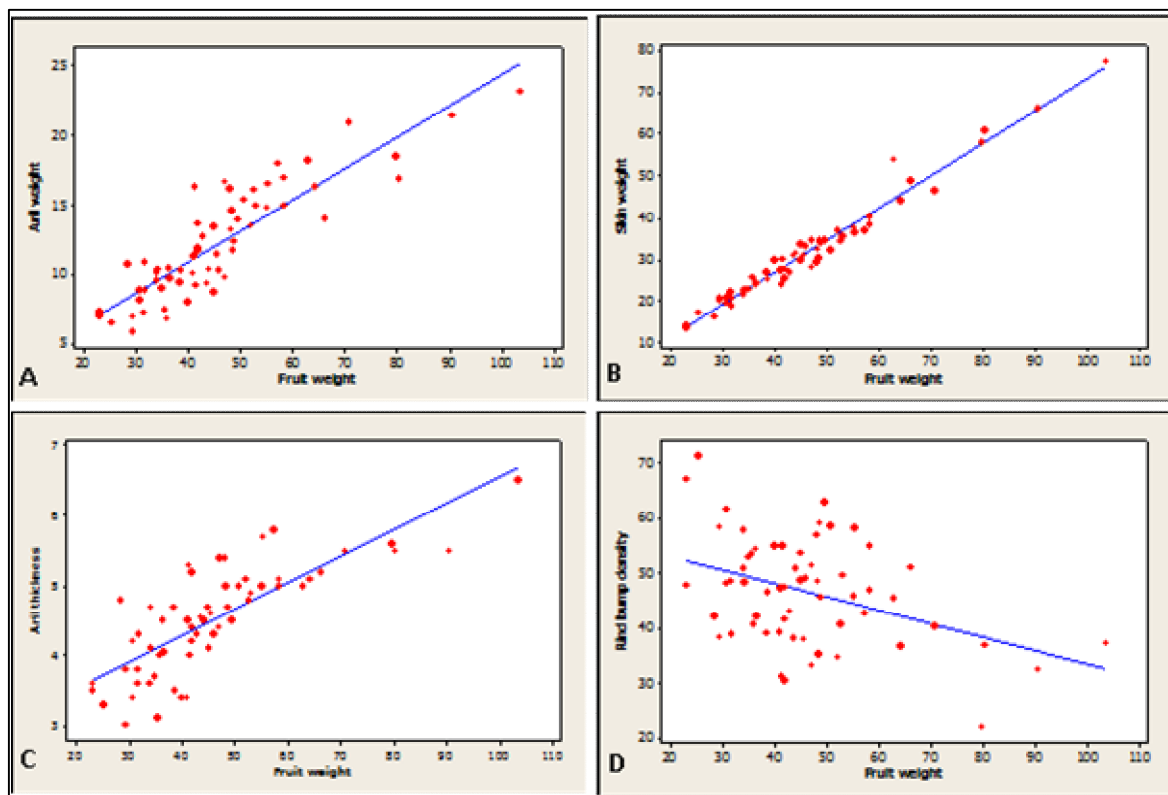


Figure 3. Regression between Fruit Weight and other Morphological Characteristics A) Aril Weight and Fruit Weight, Regression $y = 1.89 + 0.225x$, $r = 0.876$, B) Skin Weight and Fruit Weight, Regression $y = -3.97 + 0.772x$, $r = 0.980$, C) Aril Thickness and Fruit Weight, Regression $y = 2.78 + 0.038x$, $r = 0.786$, D) Rind Bump Density and Fruit Weight, Regression $y = 57.7 - 0.243x$, $r = 0.396$

Lychee treated with chitosan was prevented from rotting for 12 days [30]. The quality of longan stored at 10 °C was better than that stored at 20 °C and 15 °C [6]. No specific research is available on fruit treatments for pulasan that can be used to extend its shelf life. Therefore, information on its shelf life is limited.

Correlation of Pulasan Fruit Characteristics. Pulasan fruit weight in Bogor and Ciamis (Indonesia) varies at 23.1–103.5 g, with an average of 46.1 g. This size is larger than that of the rambutan (22.4–34.7 g) in Mexico [2] or the rambutan (15.0–36.0 g) in Sri Lanka [31]. Rambutan fruit weight in Indonesia also varies: var. Binjai weighs 33.8 g, Lebak Bulus weighs 25.5 g, and Antalagi weighs 42 g [32]. Pulasan fruit is also larger than that of lychee (15.2–23.1 g) [33].

According to the results of the regression analysis, pulasan fruit weight was positively correlated with aril weight, skin weight, and aril thickness, and negatively correlated with rind bump density (Figure 3). With high fruit weight, the fruit had high skin (pericarp) and aril weight, and a thick aril. With an even higher fruit weight, the fruit had low-density fruit pericarp bulge. Fruit shape had a positive correlation with fruit weight (Table 2). Compared with the spherical fruit, the ovoid fruit generally had higher fruit weight and thicker aril. Fruit shape was not correlated with the length of fruit skin bump or density of bulge skin. The ovoid fruit could have a longer or shorter protrusion rind. High or low density of rind bulge could be present in both fruit types. Fruit shape was not correlated with aril thickness (Table 2). Round or ovoid fruit shape could be associated with thick or thin aril.

Table 2. Correlation between Fruit Shape and Other Morphological Characteristics

Correlation		Fruit weight	Skin bump length	Density of skin bump	Pericarp thickness	Aril weight	Aril thickness
Fruit shape	Pearson correlation	.420**	.140	.051	.327*	.328**	.194
	Sig (2-tailed)	.001	.283	.697	.010	.010	.133
	N	61	61	61	61	61	61

** correlation is significant at the 0.01 level * correlation is significant at the 0.05 level

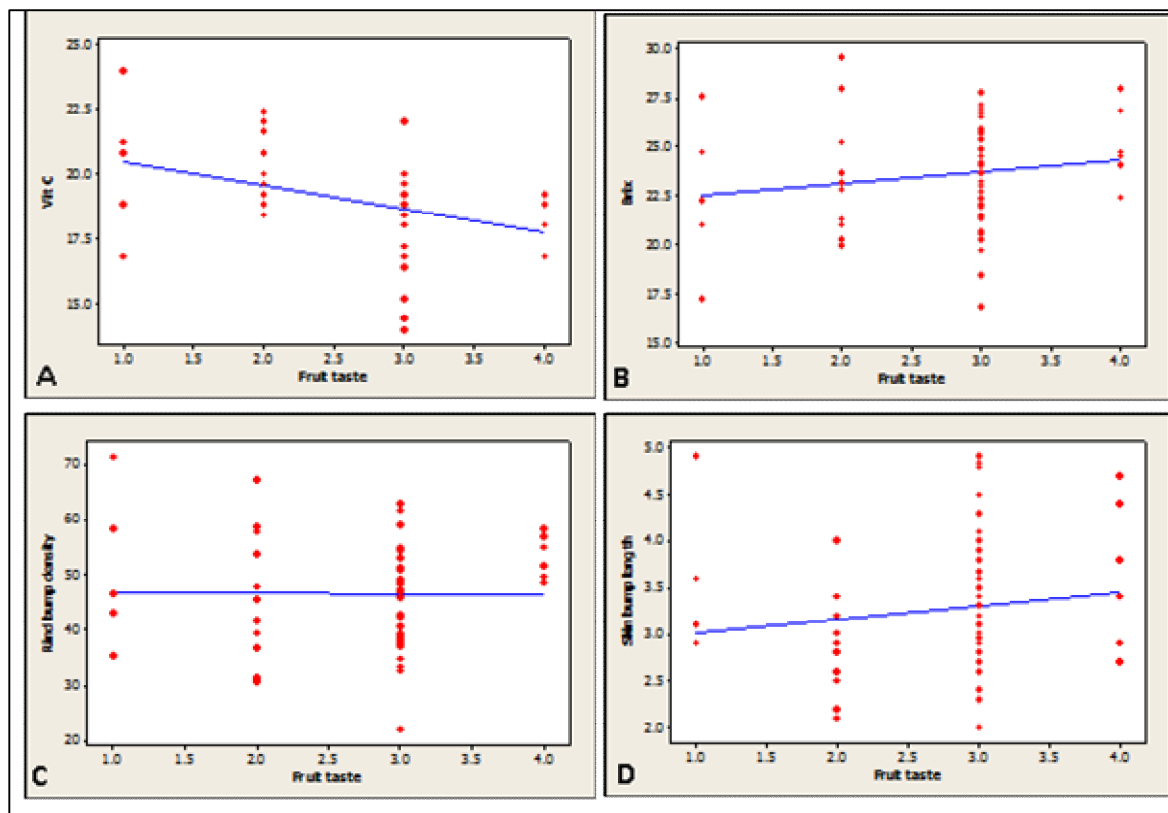


Figure 4. Regression between Fruit Taste and other Morphological Characteristics A) Vitamin C Content and Fruit Taste, Regression $y = 21.3 - 0.892x$, $r = 0.355$, B) Brix Level and Fruit Taste, Regression $y = 21.9 + 0.588x$, $r = 0.161$, C) Rind Bump Density and Fruit Taste, Regression $y = 47.1 - 0.20x$, $r = 0.00$, D) Skin Bump Length and Fruit Taste, Regression $y = 2.87 + 0.146x$, $r = 0.145$

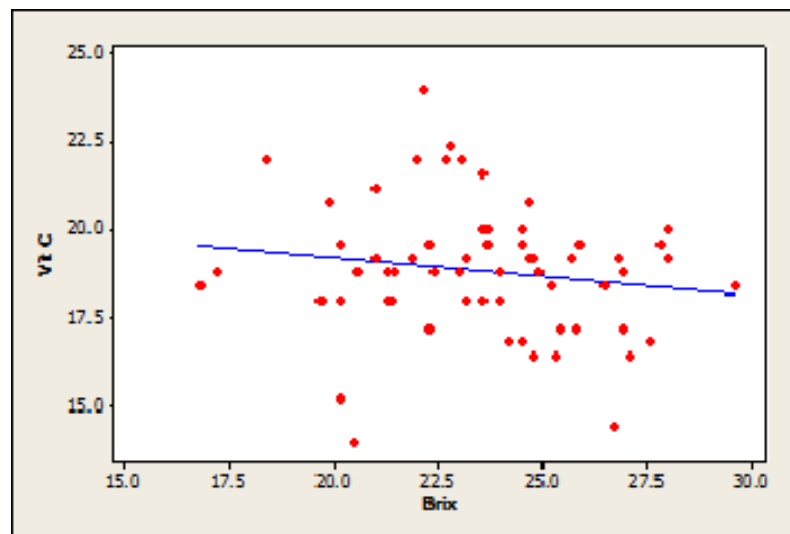


Figure 5. Regression between Vitamin C and °Brix level, Regression $y = 21.5 - 0.113x$, $r = 0.163$

Table 3. Recommended Pulasan Variant

No	Location	Fruit weight (g)	Aril weight (g)	Aril thickness (g)	°Brix	Vit C	Aril taste	Aril sticking to testa
1	Gn Batu	103.5	23.2	6.5	25.8	17.2	Sweet	Easily separated
2	Cibalagung	90.5	21.4	5.5	25.7	19.2	Sweet	Easily separated
3	Cikeas 1	80.2	16.9	5.5	24.5	20.0	Sweet	Easily separated
4	Cipaku 1	79.7	18.4	5.6	22.3	19.6	Sweet	Easily separated
5	Ciamis 7	70.7	20.9	5.5	16.8	18.4	Sweet	Easily separated

The pulasan aril can have a sour, sweet and sour, or sweet taste, and it has a soft or crunchy structure. Thick and creamy aril did not always have a sweet taste, and crispy arils did not always taste sweet. Fruit taste was not correlated with the levels of °Brix and vitamin C (Figures 4A and B). A sweet aril flavor may produce various °Brix levels at either high or low. Fruits with sweet and sour arils may have various vitamin C levels. Fruit taste was not correlated with rind bump density and skin bump length (Figures 4C and D). Fruits with sweet and sour and sweet arils have various skin bump lengths and rind bump densities.

The degree of fruit Brix was not correlated with vitamin C content (Figure 5). The lack of correlation between these two characteristics was also found in longan, lychee, and rambutan (Wall 2005). A high degree of Brix did not always produce high vitamin C.

Ideotype of Pulasan Fruit. The characteristics used to determine the criteria of fruit ideotype vary depending on the type of fruit and consumer demand. Some fruits, such as pineapple [34], melon [35], and papaya [36], already have ideotype characteristics. Unfortunately,

pulasan has no specific criteria for determining its ideotype. Therefore, in this study, we attempted to formulate a pulasan fruit expected by consumers. In general, consumers prefer pulasan fruit to have high fruit weight, sweet taste, and thick and easily peelable aril from the seed, so that it can be considered to be the type of fruit that has the potential to be developed. This study found five variants from Gunung Batu Village and Cibalagung Village in the subdistrict of West Bogor, Cikeas Village 1 in the subdistrict of Sukaraja, Cipaku Village in the subdistrict of South Bogor, and Ciamis 7 in the subdistrict of Baregbeg with good fruit characteristics that meet these criteria (Table 3). Fruit variants were also derived from Cikaret 1, 2, and 3 and from the Experimental Farm Cipaku (Kp Cipaku 2) in subdistrict South Bogor. Although the fruits had a medium size, they had the potential to be developed because they met the above criteria and their trees were fruitful.

Conclusion

Pulasan has various fruit characteristics. Its shapes are spherical and ovoid, and its colors are orange, red, dark red, and green. Fruit rind occupies the largest portion of

the fruit weight. The edible portion of pulasan ranges from 18.8%–39.5% at an average of 26.9%. Rigid bumps on the fruit skin are solitary or in groups. The pulasan aril has sour, sweet and sour, or sweet taste, and its structure is soft or crunchy. Sweet aril flavor may produce various °Brix levels at either high or low. Fruits with sweet and sour arils may have various vitamin C levels. Fruits with sour, sweet and sour, and sweet aril have various skin bump lengths and rind bump densities. Pulasan fruit stored at room temperature can last four to five days. Generally, the type characteristics of an ideal pulasan are high fruit weight, sweet taste, and thick aril that is easily peelable aril from the seed.

Acknowledgment

This research was funded by the Directorate General of Higher Education with Dr. Ir Tatik Chikmawati, MSi as the researcher chairperson. We would like to thank the Center for Tropical Horticulture Studies of Bogor Agricultural University, PT Mekar Unggul Sari, Mekarsari Fruit Garden, and Cipaku Experimental Garden for the facilities. We are also grateful to Prof. Mien A. Rifai for his suggestions on this research.

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